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FLOODED AREAS AND FLOOD PLAIN CHARACTERISTICS OF PUNPUN RIVER BASIN USING SATELLITE DATA

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PREFACE

The studies relating to earth including land, oceans, atmosphere and their interactions have made rapid advances in recent times due to continuous regional and global observations through airborne and space based remote sensing. Space based remote sensing is the process of obtaining information about earth from instruments mounted on Earth Observation Satellites. In remote and inaccessible areas remote sensing can substitute conventional measurements. In case of natural disasters, remote sensing can offer prior information on forecasting the consequences and saving of lives and forecasting consequence. There are several areas in the field of water resources where remote sensing can find ways for effective applications, particularly in surveying and inventorying. In particular, remote sensing technique can be used very effectively for mapping and monitoring of flood boundaries and inundated areas including tributary floods at confluences, changes in flood plain and catchment characteristics, and configuration of river.

The Ganga Plains Regional Center of the Institute is situated at Patna ans is taking up scientific studies in hydrology relating to Ganga Plains covering the states of Bihar, Uttar Pradesh, West Bengal and

Madhya Pradesh. The Ganga river is one of the most important rivers in the Indian sub-continent and the Punpun river is one of its important tributary. For this season, the Punpun catchment is selected in the present study for investigation of flooded areas, flood plain features, and flood plain characteristics. Satellite data were used for the study of the catchment.

This report entitled " FLOODED AREAS AND FLOOD PLAIN CHARACTERISTICS OF PUNPUN RIVER BASIN USING SATELLITE DATA" is prepared by Ramakar Jha, Scientist'B', Regional Center, Patna under the guidance of Dr. K.K.S.Bhatia, Scientist 'F'& Head, Regional Center, Patna. Technical assistance was given by A.K.Sivadas, Technician for the preparation of the report.

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ABSTRACT

Damage to property, human suffering and loss of life resulting from floods have been increasing annually despite decade of effort and expenditure of over Rs. 3500 million for flood control measures. This losing battle has prompted increased public concern for suitable methods to effectively manage flood prone areas.

Effective flood control measures require current information on the flood plain that its response to floods. It is this context that remote sensing techniques can play an important role, since conventional ground based surveys prove inadequate in providing time effective data over large areas. Especially, after the advent of satellite era, remote sensing methods opened new vista in acquiring flood inundation data because of synoptic repetitive coverage of the satellite. These admirably suit to monitor and study the dynamic nature of flood over space and time.

The report presented herein deals with the measurement of flood areas, information about flooded areas, the flood plain features, flood damage and flood plain land use of Punpun rive basin of Ganga river system using Landsat MSS satellite data . The flood plain boundary and other features are delineated and depicted on 1:250,000 scale base map.

1.0 INTRODUCTION

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 areas most affected by the flood are:

(i) the inland flood plains of major and minor rivers,

(ii) gently sloping coalescent piedmont plains in the foot slopes of large mountains, and

(iii) deltas with their distributaries, tidal inlets and estuaries.

Floods have become an unfailing event every year in India, causing damage to millions of hectares of crop area and total value of damage to crop, houses and utilities is on an average about 2500 crores (Fig.1). As per the rough estimate of National Flood Commission is about 40 million of hectares, which is about 1/8 th of geographical area of India is prone to recurring floods. The major chronic flood prone basins in India are the Ganga and Brahmaputra which

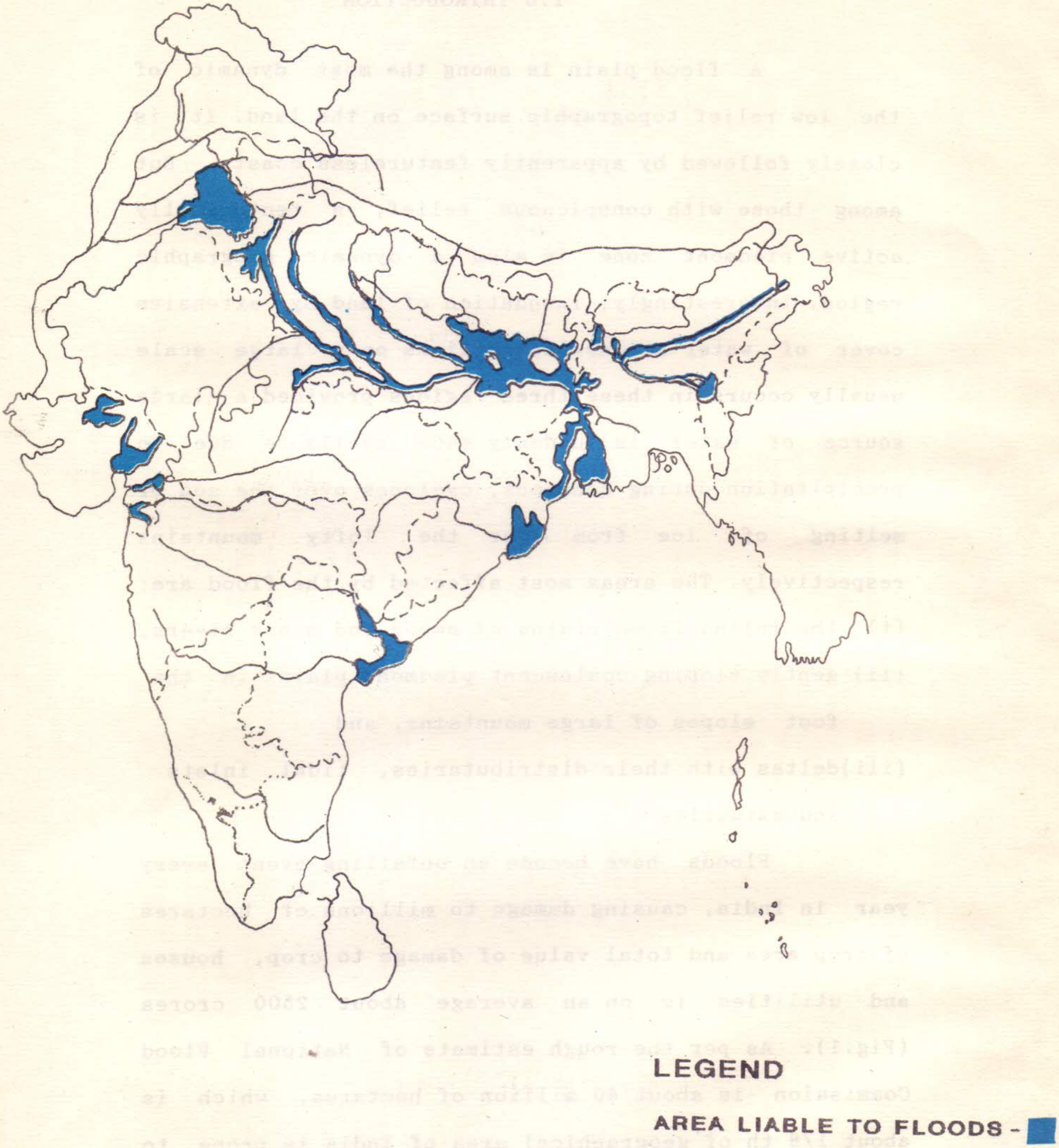

FIG.1 : AREA LIABLE TO FLOODS IN INDIA

originating 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 down stream 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.

Measures of flood management are identified as structural and non-structural. It is required to assess the flood problem case by case for suggesting a suitable flood control measure based on adequate and reliable data available on topographical and hydrological features of the flood plains, hydrology of the river, configuration of the river in different reaches, information of existing flood control works etc.

Permanent protection at all flood prone areas and for all magnitudes of flood by structural means may be neither feasible nor economical. Further, by controlling the river by structural measures like embankments, the flood damage may be minimized to some extent but on the other hand the flood waters are going waste, silt may be deposited on the bed of the river (reducing its channel capacity). At present, the country is suffering with floods in one part, (due to vast amount of water) and in another part with drought (due to lack of water). Therefore, engineers attention is being focused on various methods to mitigate the floods to reduce the damage and at the same time to best utilize the flood waters. Management of floods should to considered in this context of the overall plan for management of water resources planning, the basin must be treated as unit since flood do not pay any regard to artificial district boundaries. In order to take appropriate flood control measure to mitigate the losses due to floods it is necessary to plan flood control works scientifically. For this purpose, it is necessary to acquire timely and reliable information about the flood inundated areas, river configuration, flood control works, drainage congested area, erosion prone areas etc. Collection of latest information required for making a comprehensive flood management plan by conventional method could be difficult, time consuming and not cost-affective. In this context, satellite remote sensing plays on important role by providing accurate, reliable, timely and multi-date information in a cost effective manner.

In the present study an attempt is made to map and collect statistical information about flooded areas, flood damages and landuse of the flood plain in Punpun river basin of Ganga river system using remote sensing techniques.

2.0 REVIEW OF LITERATURE

A flood is any relatively high flow that over tops the natural or artificial banks in any reach of a stream. When banks are over topped, water spreads over the flood plain and generally comes into conflict with man. Since the flood plains in a desirable location for man and his activities, it is important that floods be controlled as that the damage done does not exceed an acceptable amount.

Identification and mapping of flood prone areas is a necessity for flood insurance and land use planning studies. Current methods for developing this information are costly and time consuming. Remote sensing can be a cost effective alternative to conventional methods in planning level studies aimed at screening large areas to identify studies requiring intensive analysis, through the proper selection of platform and sensor. Synoptic coverage of the extent of flooding can be obtained very quickly. Remotely sensed imagery has been successfully used on many rivers and in different regions, using colour infra-red photography, Landsat data, IRS-1A data, and to a limited degree, thermal infra-red data.

Myers, Waltz and Smith (1972) evaluated the disastrous flood of June 9,1972 that hit the Rapid city, South Dakota with colour and colour infra-red aerial photography and a thermal imagery.

Limits of Gila river flooding was delineated by Morrison and Cooley (1973) from Landsat and found it in good agreement from maps prepared by ground survey and aerial photography.

Hallberg et al (1973) made experimental low altitude study of flood inundated area for September 1972 flood on the Nishnabotna river in Western Iowa. They suggested suitability of different spectral bands of electromagnetic spectrum for flood mapping (Table 1)

Rango and Andereson (1974) examined the potential of land use imagery for flood plain delineation by using images of an area of Mississippi river obtained before flooding that occurred in 1973. They used 1:100,000 scale image and successfully delineated the boundaries of the artificial levee system, soil differences, agricultural and vegetation pattern, upland boundaries, and back water areas. Deutsch and Ruggles (1974) and Williamson (1974) mapped floods for Mississippi river valley.

Flood inundation mapping is done by Wilsnet et al(1974). The successful application of this approach derives from the distinctive charges induced by additional water in the area. This includes soil moisture, moisture stressed vegetation and standing water.

Dhanju (1976) mapped the Kosi river flood plain using Landsat imagery of 1972 and 1975. Aerial photograph at a scale of 1:7000 taken on May, 1974 near Pembina, North Dakota in an area of dark soils and low relief. This made the measurement of flood extend difficult except for the debris lines which show white and indicates maximum extent of flood inundation (Moore and Rusche,1976).

Harker and Rouse (1977) developed a computer technique for flood plain delineation using multi spectral reflectance data. He digitized colour infra-red photographs to classify the data into one of the four categories; low vegetation not in flood plain, low vegetation in flood plain, trees not in flood plain, and trees in flood plain. Flood plain boundaries were then drawn using the classified output. The best results were obtained in the low vegetation areas.

Sollers et al (1978) used both aircraft and Landsat MSS data to delineate the flood plain for a watershed in Pennsylvania. They found that it is easier to use Landsat data because of the problem of the data reduction involved with the air craft data.

McKim et al (1978) analyzed the colour infrared photographs of six reservoir impoundment area in Vermount and New Hampshire, USA along with corroborative ground suryeys. Pal and Bhattacharya (1979) studied the magnitude and direction of channel changes between 1935 and 1975 in the middle Ganges plain and have indicated its gradual shift to the south at an alarming rate of 100 meters per year.

Bhattacharya and Mankhand (1979) have delineated geomorphic units in the flood plains of Ganga-Gomti in Azamgarh and Ghazipur districts in Uttar Pradesh.

Chopra (1980) had delineated an abandoned meander belt close to the Ganga river in the district Lakhimpur, Assam using aerial photographs.

Chakraborti (1980) made study to map flood plain, land use of Lower Barak flood plain in Cachar district of Assam using digital analysis of Landsat MSS data of a pre-flood scene using maximum likelihood classifier.

Dhanju (1980) has made a regional study of Gangetic basin and by visual interpretation of Landsat scenes has mapped some of the prominent features of the flood plain between Varanasi and Patna along the Ganga and in the tributaries coming from the north.

Multi-stage remote sensing data has been used to study the flooded coastal areas of Andhra Pradesh during November 1977 by Narain and Patil (1980)

Chakraborti (1980) used multi-spectral scanner imagery of Kosi river in visible and near infra-red channels along with Landsat MSS false colour composite (FCC) image to map river configuration study effectiveness of flood protection works of the river.

Nayak and Sahai (1983) made a study of shore line changes along with the changes in the coarse of river Sabarmati and Mahi using Landsat MSS bands on 1:1

million scale.

Ramamoorthi and Subba Rao (1983) employed both digital and visual interpretation techniques in flood plain mapping. The Landsat digital data in the computer compatible tape (CCT) has been analyzed in the multi-spectral data analysis system.

Chaturvedi (1983) delineated the flood inundated areas in parts of southern and eastern Uttar Pradesh. During the peak flood of September 1982 on the basis of sharp tonal contrast between the water spread and the adjacent areas.

Srinivas (1983) used Bhaskara satellite T.V. data for evaluation of water body features like water spread of Tungbhadra, Paithan, Ukai, Ujjaini, Koyna reservoirs and Hooghly river mouth.

Jacob (1985) used Landsat B/W and FCC imageries for mapping normal course of river Kosi and the inundated area because of the flood occurred in Kosi river. Even if the satellite overpass is not simultaneous with flood peak or the cloud cover is much, the residual effects like high moisture can still be recognized and used for the mapping inundated area.

Sharma et al (1985) visually analyzed the band 7 (IR) of Landsat for mapping flood plains and allied features in the Ganges river between Allahabad, U.P. to Chapra, Bihar. The features were identified in the 1:250,000 scale enlargement of band 7 imagery.

Singh and Singh (1985) studied flood affected areas of ephermal streams. Conventional aerial photographs coupled with the old and present topographical maps were used to map the flood affected areas of ephermal streams in Hoshiarpur district, Punjab.

Ormsby et al (1985) detected low land flooding using microwave system.

Imhoff et al (1987) developed monsoon flood boundary and damage assessment using space borne imaging radar and Landsat data. The approach used was that land cover classification maps derived from Landsat SIR-B data acquired at different times were compared to derive flood water inundation measurements.

Yamagata and Akiyama (1988) described flood damage analysis using multi-temporal Landsat Thematic Mapper (TM) data.

Zevenbergen (1988) developed a relationship between satellite data and hydrologically defined curve number (CN) for a limited number of watersheds.

Ali and Quadir (1989) studied river flood hydrology in Bangladesh with AVHRR data and concluded that the flooding conditions can be studied with Landsat imagery which has much higher spatial resolution than the AVHRR.

3.0 DESCRIPTION OF THE CATCHMENT

3.1 The Punpun River System

The Punpun catchment, one of the important right bank tributaries of river Ganga, was considered in the study. It originate from Chottanagapur hills of Palamu district in Bihar and lies approximately between longitude 84^{0} 10' to 85^{0} 20'E and latitude 24^{0} 11' to 25^{0} 25' N (Fig.2). It flows, for most of its portion, in a north east direction and join the Ganga at Fatwah, about 25 km downstream of Patna. The river is rainfed and carries little discharge during non- monsoon period.

The shape of the Punpun river system is roughly trapezoidal. The length of the catchment is about 180 km and the average width in upper and lower reaches of the river system is 60 km. and 25km. respectively. The total catchment area of the Punpun river system is about 8530 sq. km. which is one percent of total area of Ganga sub-basin in the country.

The length and the catchment area in respect of all the important tributaries have been worked out separately and shown in line diagram (Fig 3). The level of the land varies from 300 m near origin of the river to about 50 m near out fall into the river Ganga.

3.1.1 Land Use

The general information about land use of Punpun basin indicate that the area under agriculture

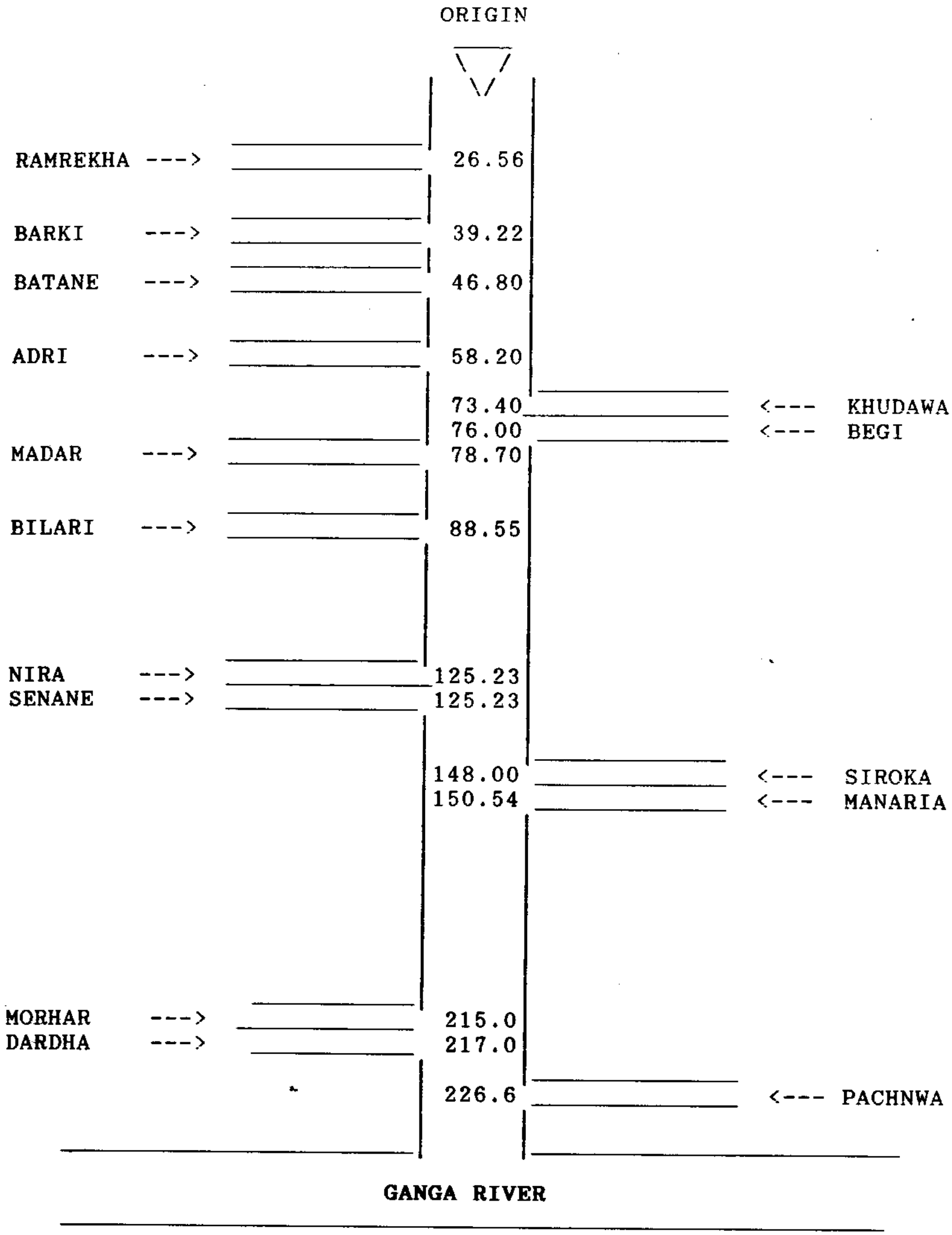

FIG.3 : LINE DIAGRAM OF PUNPUN RIVER SYSTEM

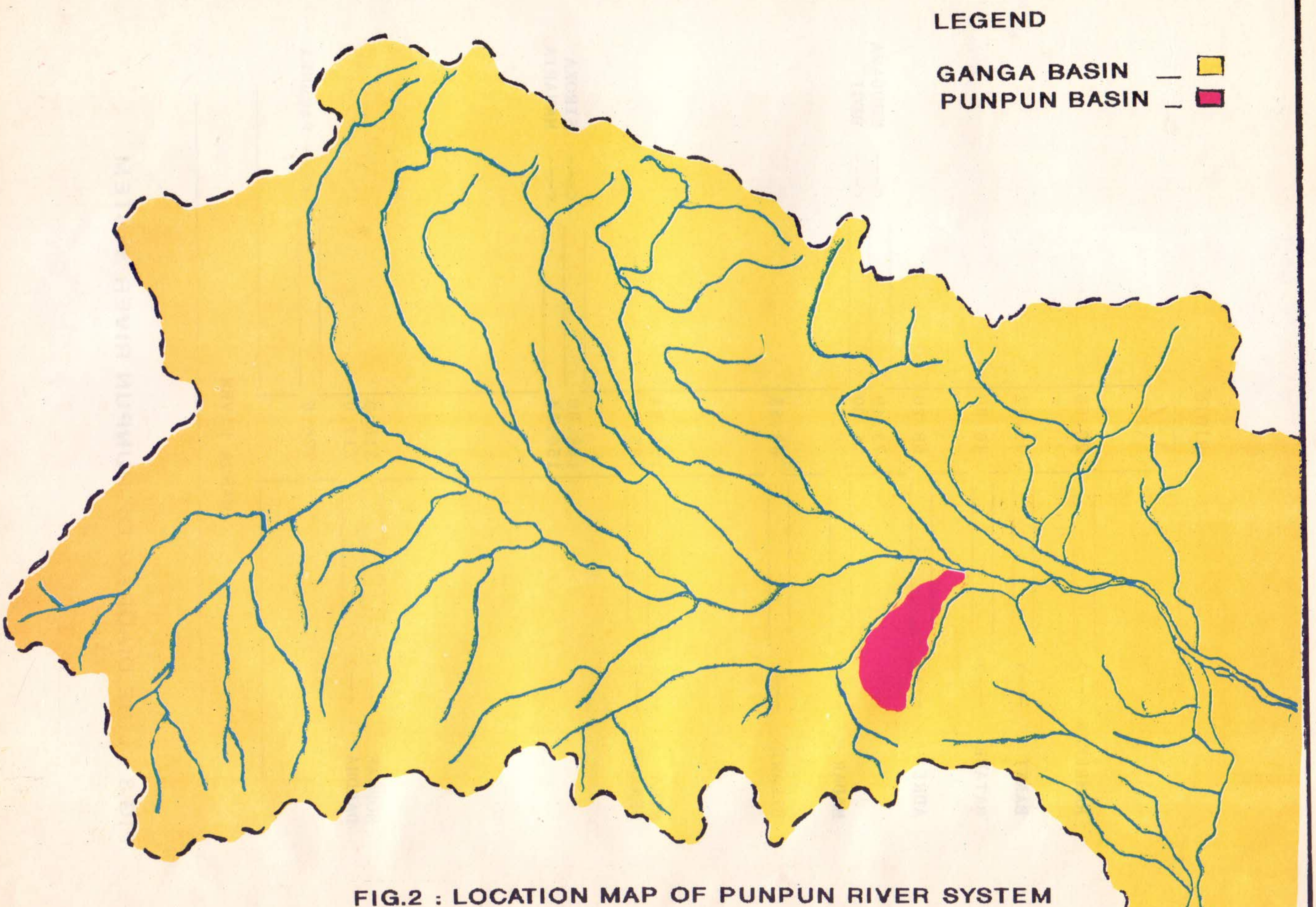

FIG.2 : LOCATION MAP OF PUNPUN RIVER SYSTEM

in the Punpun river system is about 5,000 sq.kms. and that under forest is about 2500 sq.kms.. The remaining area of 1000 sq.kms. is under miscellaneous use constitute 59%, 29%, and 12% of the total area of river system (Fig.4).

3.1.2 Agriculture and Irrigation

The gross cropped area and net area sown in river system are 527 Th.ha. and 399 Th.ha. respectively. The gross and net irrigated area of the river system are 3080 sq.kms. and 2640 sq.kms. respectively. Bhadai, Aghani, and Rabi are three crop seasons in practice in the river system.

On the basis of available data, intensities of cropping and irrigation system for the river system have been worked out as given below (Fig.5):

$$\text{Intensity of cropping} = \frac{\text{Gross cropped area}}{\text{Net area sown}} \times 100$$

and,

$$\text{Intensity of irrigation} = \frac{\text{Gross irrigated area}}{\text{Net irrigated area}} \times 100$$

3.1.3 Soil and geology

Broadly the geology of the area varies from granite, gneiss, charnokites in the hills to the recent alluvium in the plains. The broad soil groups are calcium and non-calcium, recent and old alluvium and brown forest soils, red soil podzowe, lateritic soils

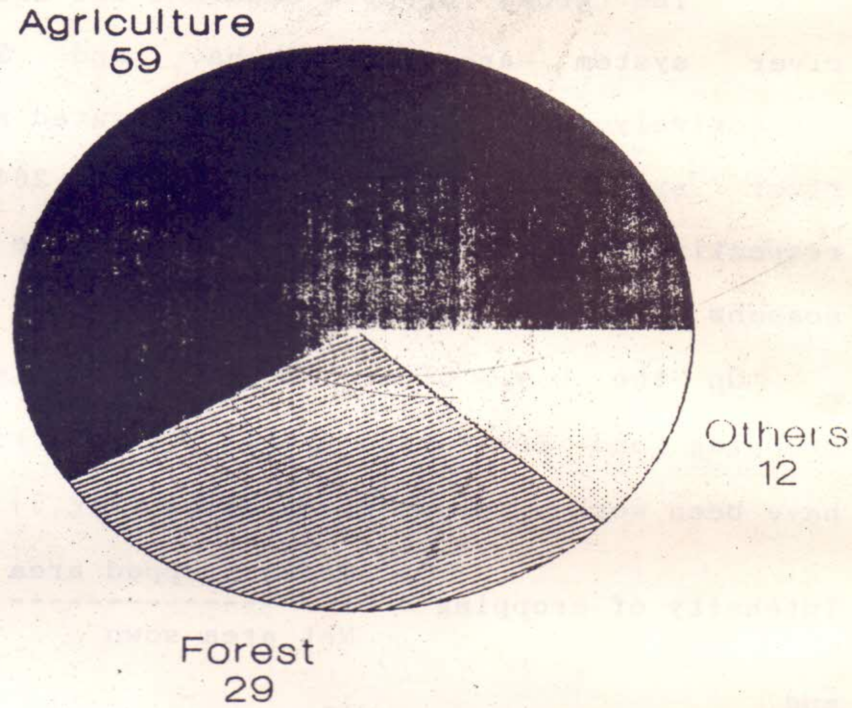

FIG.4 : A REPRESENTATIVE DIAGRAM SHOWING VARIOUS ASPECTS OF LAND USE IN PUNPUN RIVER SYSTEM

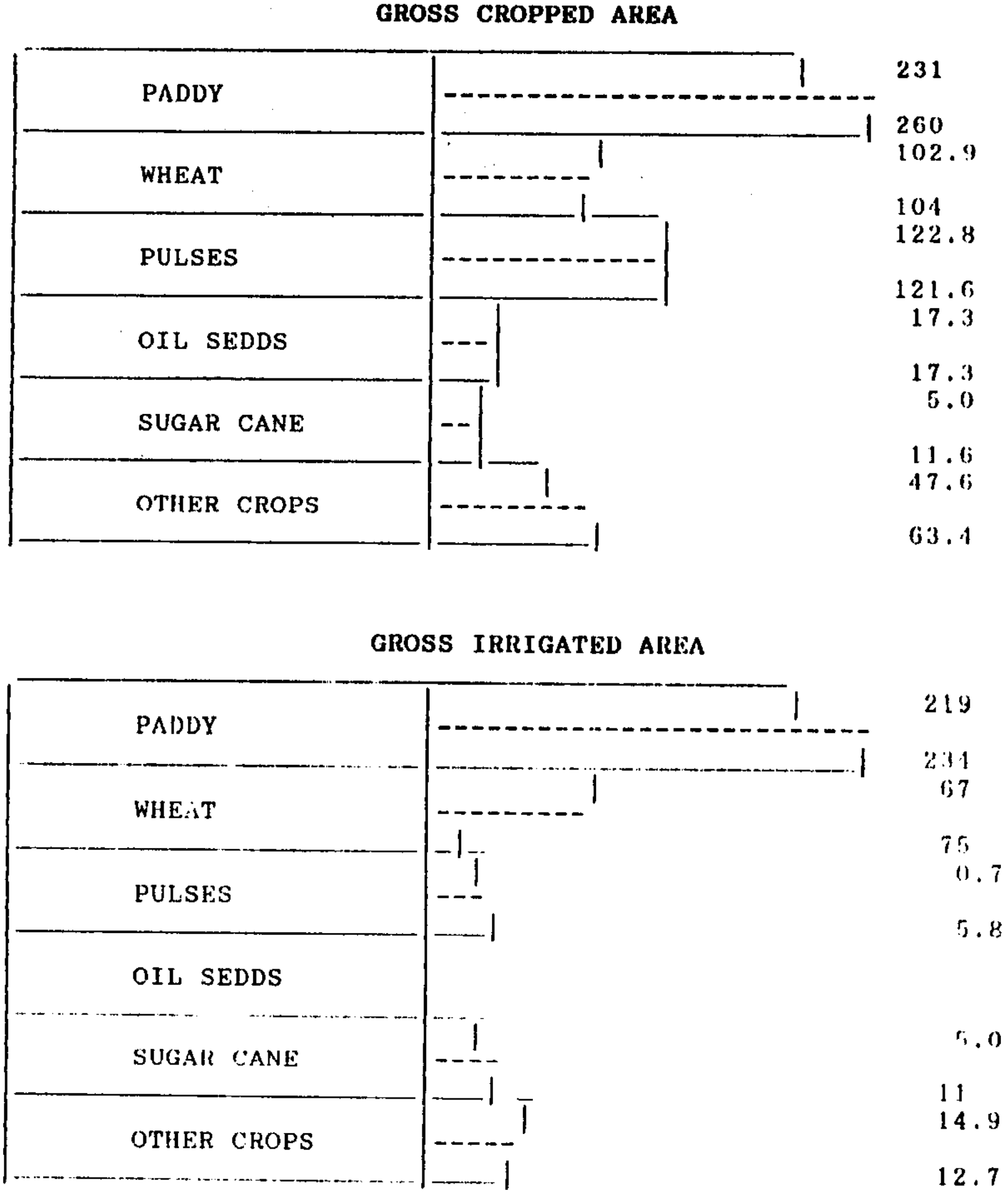

FIG.5 : CROPPING AND IRRIGATION PATTERNS IN PUNPUN RIVER SYSTEM

with cover being very deep in plains and deep to shallow in hills.

3.1.4 Geohydrology

An approximate estimate of total groundwater potential has been made by applying Chaturvedi's formula. On this basis the total gross recharge in the Punpun river system comes to be 1.6 lakh ha.m.. However, only 70 % of the total gross recharge can be made available for utilization. The geography of the river system has been shown in Fig.6.

3.1.5 Hydrometeorology and climate

The river system receives about 85 to 87 percent of its annual rainfall during the South - West monsoon period which occurs from June to September. Average annual rainfall varies from 992 mm, near confluence with the Ganga (Patna District) to 1335 mm in the upper most reach (Palamu District). The average annual rainfall over the entire river system works out to 1181 mm.

3.2 Data Base for the Study

Remote sensing data of various types are utilized to evaluate and extract the meaningful information to flood control and river engineering problem studies of Punpun river.

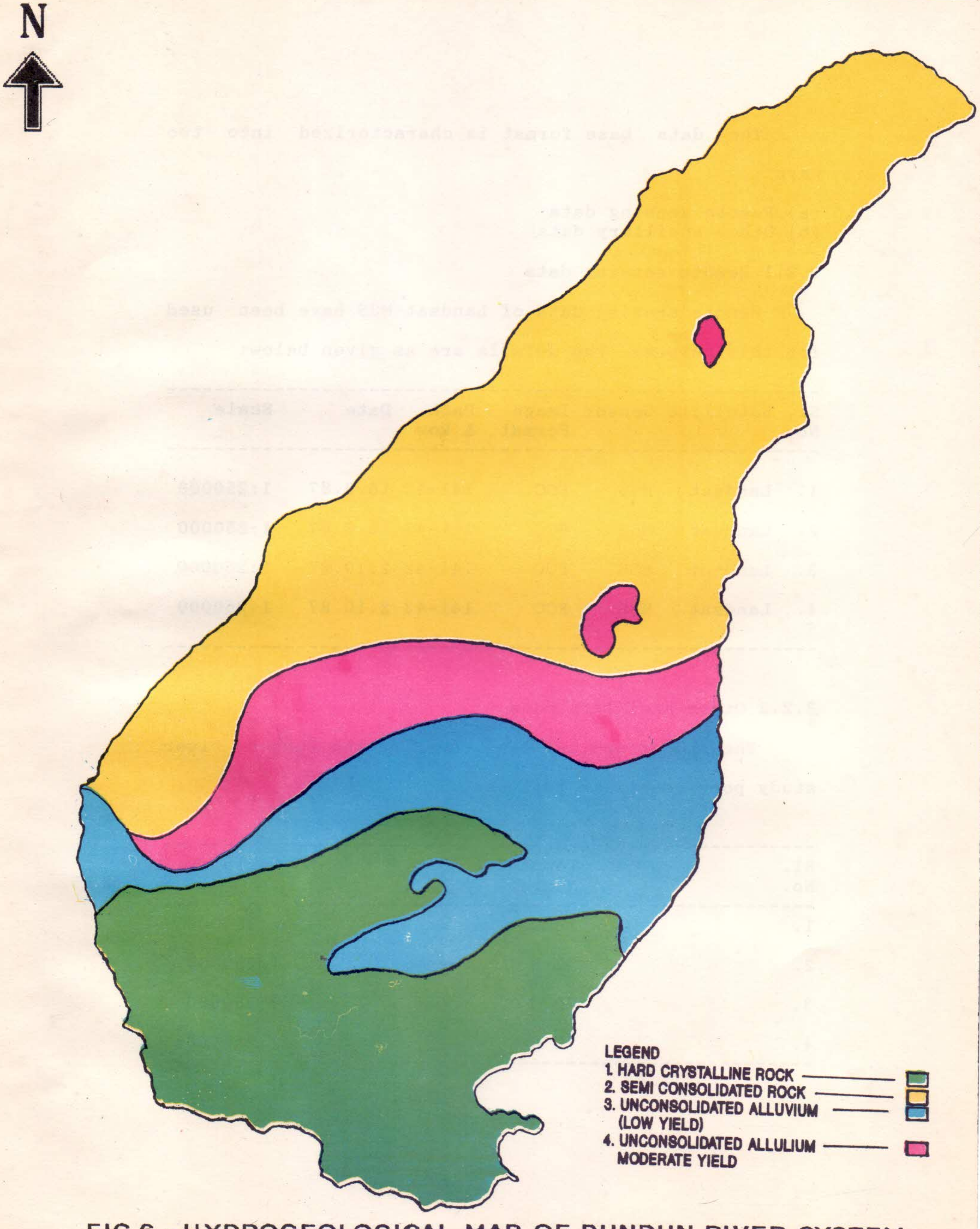

FIG.6 : HYDROGEOLOGICAL MAP OF PUNPUN RIVER SYSTEM

The data base format is characterized into two ways:

(a) Remote sensing data
(b) Other ancillary data

3.2.1 Remote sensing data

Remote sensing data of Landsat MSS have been used for this purpose. The details are as given below:

Sl. No.	Satellite	Sensor	Image Format	Path & Row	Date	Scale
1.	Landsat	MSS	FCC	141-42	16.9.87	1:250000
2.	Landsat	MSS	FCC	141-43	16.9.87	1:250000
3.	Landsat	MSS	FCC	141-42	2.10.87	1:250000
4.	Landsat	MSS	FCC	141-43	2.10.87	1:250000

3.2.2 Other ancillary data

The topographical maps covering the Punpun river study portion are as follows:

Sl. No.	Toposheet Number	Scale
1.	72 C	1:250000
2.	72 D	1:250000
3.	72 G	1:250000
4.	72 H	1:250000

4.0 REMOTE SENSING FOR FLOOD PLAIN MAPPING

4.1 Physical Basis of Remote Sensing

The most commonly measured variation in Remote Sensing is the reflectance/emittance of objects due to electromagnetic radiations. Three important types of variations which form the basis for remote sensing are:

(i) Spectral variations : The intensities of reflected/ emitted radiations as a function of wavelengths.

(ii) Spatial variations : Changes in radiation with location i.e., difference in SHAPE and POSITION.

(iii) Temporal variations : The changes in radiation with time i.e. difference over TIME.

In order to derive information from these variations onè has to (i) measure variations and (ii) relate these measurements to those of known objects. For example, if one desires to prepare a map showing all water bodies in a certain region, it may not be possible to sense water directly from very high attitude like that of space craft. However, manifestations of these bodies can be sensed from such an altitude. These manifestations in the form of response to the electromagnetic radiation, can be measured and analyzed to determine points on the earth where water bodies are located.

4.1.1 Electromagnetic spectrum (EMR)

Remote Sensing is largely concerned with the measurement of object responses to EMR from the sun.

The Sun's energy, commonly referred as Electromagnetic Spectrum (EMR) is a continuum of electromagnetic radiation of different wavelengths, traveling with constant velocity, and characterized by wavelength or frequency. It ranges from cosmic rays to radio/ television broadcast waves (Fig. 7).

The commonly used wavelength range for remote sensing measurement known as optical wavelengths, extends from 0.30 to 15 µm. At these wavelengths, EMR is reflected and refracted by lenses and mirrors. Based on the interaction of EMR with the earth's surface, the entire spectrum can be divided into (i) reflective (0.38 to 3.0 µm) and (ii) radiative spectrum (3.0 to 15 µm).

The reflective portion of the spectrum is further divided into visible and reflective infrared energy. 0.38 to 0.72 µm is known as visible portion and in these wave lengths human eye is sensitive to the objects (0.55 µm green color being the peak). Infrared region starts after visible region towards longer wavelength side and extends as follows :

(a) 0.72 µm to 3.0 µm - Reflective infrared
(b) 0.72 to 1.3 µm - Near Infrared
(c) 1.3 to 3.0 µm - Middle Infrared
(d) 7 to 15 µm - Far Infrared Region.

The distinctive responses of objects for different

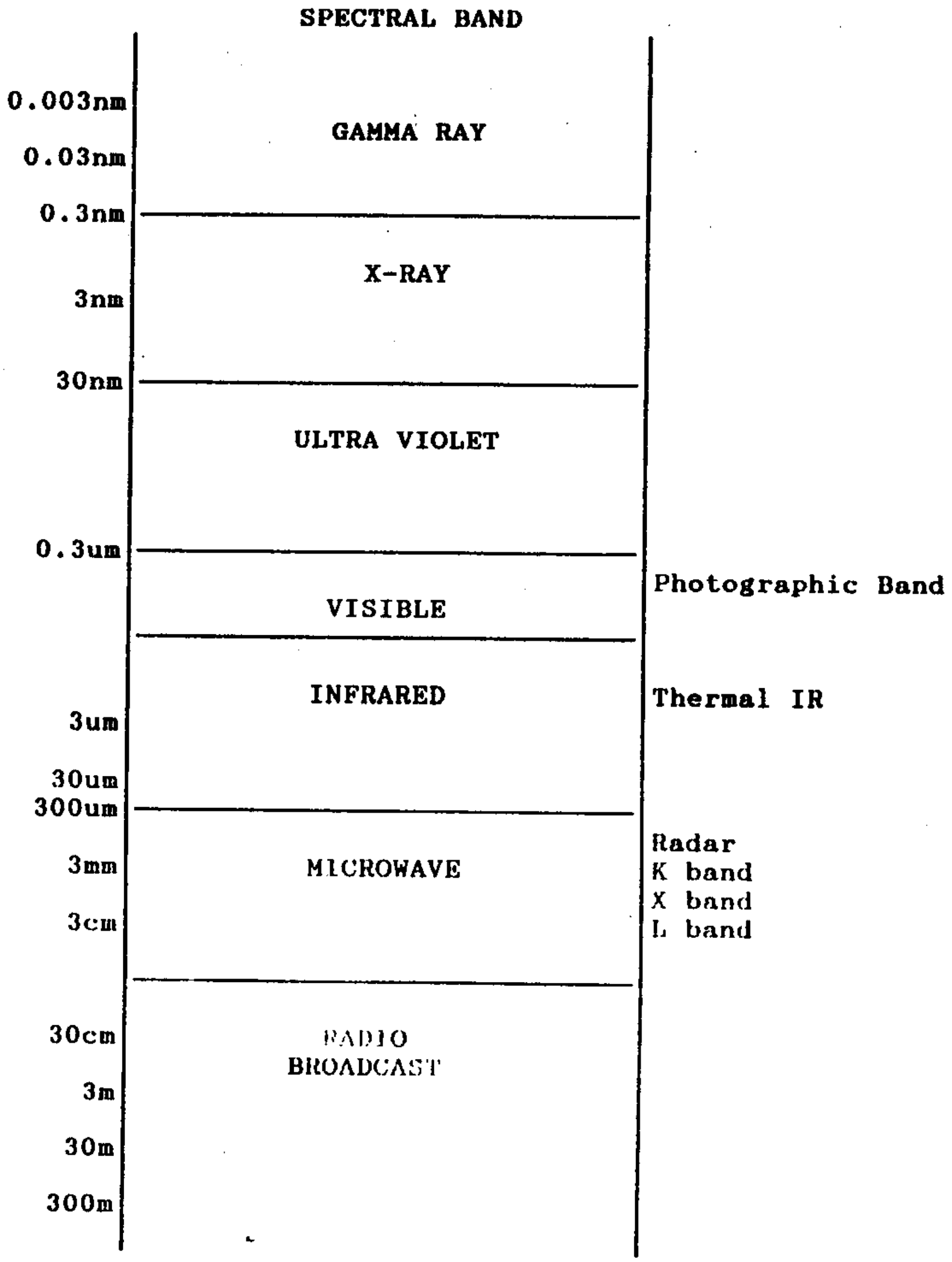

FIG.7 : ELECTROMAGNETIC SPECTRUM

wavelengths when EMR interacts with them, allows and stresses the need to acquire the data in different wavelength ranges (usually called acquire) and helps in identifying the objects by comparing in different bands.

4.2 Data Collection Systems :

4.2.1 Sensors and Platforms

On-board sensors from various platforms such as ground air borne and space borne can be used to measure the reflected and emitted electromagnetic radiations.

Based on the sensors and the type of data acquisition two major branches of remote sensing are recognized.

(a) Image Oriented System
(b) Numerical Oriented Systems

Image Oriented Systems(aircraft)

It is the oldest and very popular normally uses a photographic camera fixed to a aircraft to record the data onto a film in a limited wavelength region (0.3 to 0.9 µm). Ex: Black and White panchromatic B/W and color infrared photographs. The data can be obtained at various resolutions or sales in single or multiple bands depending on the purpose. Interpretation of this data is done visually using photo interpretation techniques, consequently a slow and laborious process.

However, this technique has proved to be reliable for a wide variety of applications.

Numeric Oriented System (Aircraft and satellite)

In this relatively new, but very fast method, the sensor views the area of interest in various strips perpendicular to the line of flight. The data obtained through sensor are stored on magnetic tapes in digital format. The forward motion of the aircraft/space craft will match with the tape advancement of the recording system, producing a continuous strip of the ground. The sensor systems are capable of collecting spectral data in narrow bands of various regions of EMR (UV, visible and infrared) and the data can be analyzed rapidly with the aid of suitable computer system. Today, several fields of application through numerical approach has reached near operational level, gaining increased attention, however much progress is awaited in some fields of application. Ex: Multispectral Scanner (MSS), Thematic Mapper (TM), Linear Imaage self Scanning (LISS), High Resolution visible (HRV) etc.

Another type of sensor which is in developmental stage is microwave sensor. Microwave sensor can be of both active and passive types. In the former case, the energy is transmitted from the system and received after interaction with the object of interest while in the later, the system is built to receive the incoming signals. Example of active microwave sensor is SAR (Synthetic Aperture Radar). Example of passive microwave sensor is Microwave Radiometer.

SAR is an active which can obtain images under all weather conditions (day or night). The system carries its own illumination source that transmits a radar beam to the ground and detects reflections from the ground objects. The microwave radiometers are passive sensors which receive EMR emitted from the ground object.

Today there are several earth observation satellites carrying both types of sensors to provide multispectral information on synoptic view basis in real time at periodic intervals.

4.3 Flood Plain Features

Mapping of flood plains of a river system is based on identification of various features connected with flood plains. These features are : river course, drainage pattern, alluvial fans oxbow lakes, marshy areas and back swamps, points bar deposits, river levees and flood plain deposits.

4.3.1 River course

Three distinct patterns of river course are identified viz: (i) braided stream, (ii) straight stream, (iii) meandering streams.

A braided stream can be defined as one which flows in two or more channels around alluvial islands.

Braided pattern develops after local deposition of coarser material which can not be transported under local conditions existing in the reach. Straight reach is rarely found in streams over large lengths. Rivers flowing through alluvial material follow a zig zag path. This phenomenon is known as meandering. These streams follow a more or less sinusoidal path.

4.3.2 Drainage pattern

The pattern may be defined as the arrangement of surface drainage ways and shallow sub-surface drainage ways covering an area, in the complete details of their density, orientation, uniformity and plan etc. The surface drainage pattern is probably the most consistently reliable indicator of ground conditions available.

4.3.3 Alluvial fans

When there is a reduction either in the discharge or in the slope of an equilibrium stream, the stream can not transport the material carried by it and the excess materials will be deposited. These deposits depending upon the mode of deposition are called alluvial fans.

4.3.4 Oxbow lakes

As meanders grow, a narrow neck of land is often cut through from two sides, thus causing the stream to straighten its course. The ends of the meander that have been cut off are then likely to be chocked with sediments. Water from the main stream seeps into this meander and forms what is commonly known as oxbow lakes.

4.3.5 Marshy areas and backswamps

Low lying areas that get inundated during flood turn into marshes when floods recedes. Sediment of marshes consists of organic clays. Burrows and plant roots are the more features. Backswamps are developed behind the levees when they are over topped by flood waters.

4.3.6 Point bar deposits

Bed forms having lengths of the same order as channel width or greater and heights comparable to the mean depth of flow are known as bars. A bar occurring on the inside of the bed in an alluvial channel is called a point bar.

4.3.7 Flood plain deposits

During the floods, river water rises above the banks and as it moves away from the main current, its velocity is reduced. As a result a large part of the sediment load of stream gets deposited as the bank line in passed. These deposited are called flood plain deposits.

4.3.8 River levees

River levees are formed by the deposition of sediments when flood water over tops the river bank. The velocity is reduced causing deposition of much of the suspended sediment near the channel. The maximum height of a levee indicates the water level reached during the highest flood.

4.4 Flood Mapping and Damage Assessment

In India vast areas are inundated by floods every year and it has become absolutely necessary to collect timely and reliable information so that the flood problem could be tackled by planning comprehensive basin wise control measures. Since the conventional ground survey methods are in vogue and not been able to meet the requirements. It is in this context that one finds the data obtained from remote sensing (satellite/areal) are very useful. Since water and wet materials have very low reflectance in the near infrared regions of the electro- magnetic spectrum, flood affected areas can be identified very well in contrast with adjacent dry soil, vegetation etc., with exhibits higher spectral reflectances.

Airborne surveys have the advantages of high ground resolution and control over data collection, but it covers only small area. On the contrary satellite borne sensors are time effective and also provide synoptic overview of the rivers causing the floods in the region. They also provide repetitive coverage of the same area at definite intervals, there by enabling monitoring of the conditions prior to during and after the floods. In particular satellite data can be used very effectively for mapping and monitoring of the following :

(i) Configuration of rivers and channel changes
(ii) flood boundaries and inundated areas including tributary floods at confluences
(iii) effectiveness of flood control works and
(iv) changes in flood plain and catchment characteristics.

Through the 16-day repetition of satellite data might seem to be inadequate to map the flood at its peak, it is still possible to delineate the areas inundated demarcate the maximum flood affected areas. This is made possible due to the fact that changes in reflectivity caused by standing water, high soil moisture, water inundated vegetation and temperature changes from ambient, last for some time even after the peak flood and the damage can be detected.

4.5 Factors Affecting Flood Plain Mapping

The surface water is one of the features most detectable by remote sensing. In a complimentary way, its spectral signature is as typical as that of vegetation because of its great absorption of solar radiation in the red and infra-red positions of the spectrum (Fig.8). Therefore, the locating and delineating the water bodies although sometimes appearing difficult, is one of the most reliable

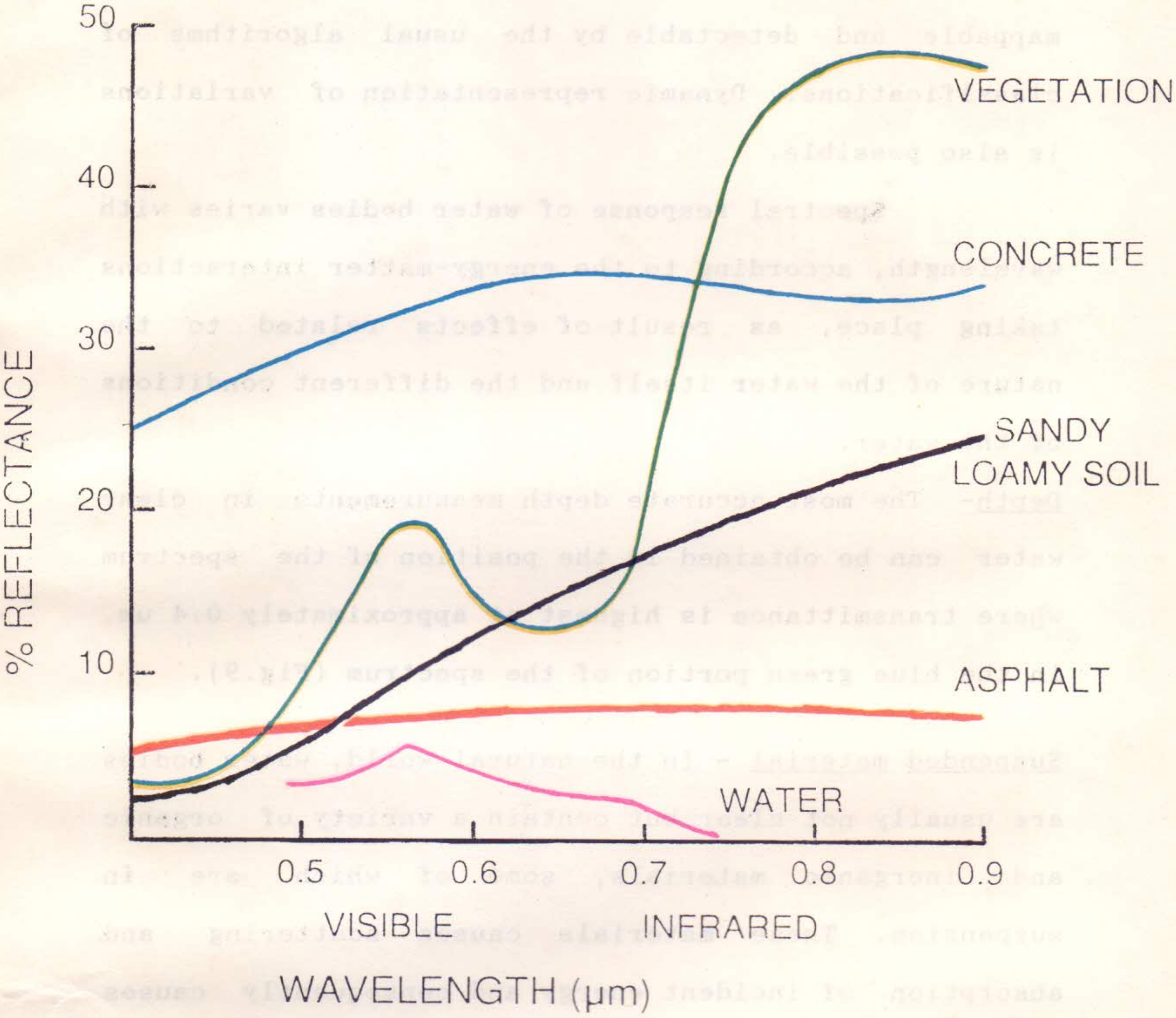

FIG.8 : SPECTRAL REFLECTANCE CURVE FOR SELECTED FEATURES

operation that can be done by space of satellite imageries and multi spectral data. The mapping of water depends upon the evidence, so we have various possibilities too. The surface water is directly mappable and detectable by the usual algorithms of classifications. Dynamic representation of variations is also possible.

Spectral response of water bodies varies with wavelength, according to the energy-matter interactions taking place, as result of effects related to the nature of the water itself and the different conditions of the water.

Depth- The most accurate depth measurements in clear water can be obtained in the position of the spectrum where transmittance is highest at approximately 0.4 um, in the blue green portion of the spectrum (Fig.9).

Suspended material - In the natural world, water bodies are usually not clear but contain a variety of organic and inorganic materials, some of which are in suspension. These materials causes scattering and absorption of incident energy and consequently causes significant variations in the transmission of energy through water.

Chlorophyll - The concentration of Chlorophyll in water also affects the spectral response. As the Chlorophyll concentration increases, there is significant decrease in the relative amount of energy reflected in the blue

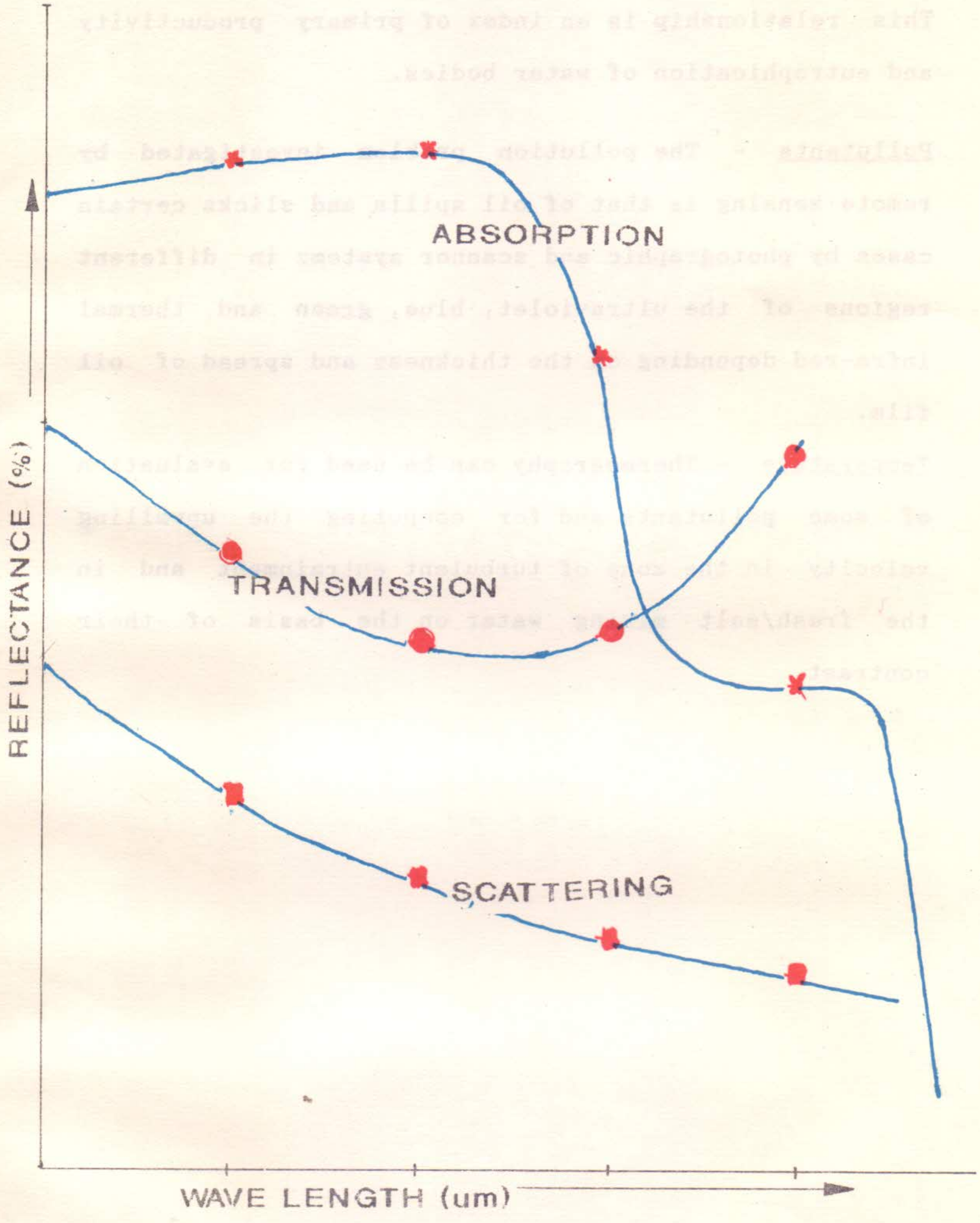

FIG.9 : SPECTRAL RESPONSE OF CLEAR WATER

wave lengths but an increase in the green wave lengths. This relationship is an index of primary productivity and eutrophication of water bodies.

Pollutants - The pollution problem investigated by remote sensing is that of oil spills and slicks certain cases by photographic and scanner systems in different regions of the ultraviolet, blue, green and thermal infra-red depending on the thickness and spread of oil film.

Temperature - Thermography can be used for evaluation of some pollutants and for computing the upwelling velocity in the zone of turbulent entrainment and in the fresh/salt mixing water on the basis of their contrast.

5.0 METHODOLOGY

In the present problem, Punpun river in Ganga sub-basin system has been taken up for the study. Temporal data from Landsat MSS satellite images have been used in the study and visual interpretation technique was employed to delineate various flood plain features and inundated areas.

Field verification for flood plain, land use, land cover and study of flood plain characteristics have been conducted to make more meaningful information updating using remote sensing data.

The study has been carried out in three phases :

(i) Pre-field image interpretation,

(ii) Ground truth data collection & field verification,

(iii) Post-field analysis.

5.1 Pre-Field Work

Pre-field work consists the following steps for image interpretation :

(a) Base map preparation,

(b) Interpretation and preparation of flood plain, land use maps using satellite images.

5.1.1 Base map preparation

The base map covering the river portion has been prepared on the scale of 1:250,000 with the help of topographical map of the study area. Certain ground control points such as barrage portions, Railway lines, canal, main course of river Ganges and river Sone, permanent river features like oxbow lakes etc. are used for transferring details into these base map.

5.1.2 Interpretation and preparation of flood plain, land use maps using satellite image.

Temporal image of satellite are used in the flood plain mapping,land use mapping using light table,optical enlarger and procom image enlarger by visual interpretation technique. The interpretation has been done using interpretation keys and image characteristics such as tone, texture, pattern, shape, size and association. These pre-field interpretation maps have been taken to the field for verification of information with respect to the field condition.

5.2 Ground Truth Data collection and Field Verification

Limited ground truth was obtained by consulting toposheets and other reference materials available. A few sites were visited to check and verify various features wherever any confusion derived during interpretation of imageries.

5.3 Post Field Work

After interpretation and ground truth, all the data has been analyzed updating all the maps and a broad statistical information was obtained.

6.0 PRESENTATION AND DISCUSSION OF RESULTS

Satellite data of different dates had been used in the study. As mentioned earlier these data consists of FCC from Landsat MSS satellite. From these satellite data the flooded area, flood plain features and land use of Punpun river basin have been interpreted.

6.1 Flooded Areas

The topography of the Punpun river system is such that its area can be divided into two parts: hilly and plains. Due to hilly characteristics, the upper areas are not affected by floods whereas the lower part of the river system are frequently affected by floods.

In this study, a comparison of satellite scenes for two different dates were made to improve the interpretation of flooded areas. A flood inundation map of the Punpun river basin, based on Landsat MSS imageries, is shown in Fig. 10.

Based on the analysis, the flood affect to crops, houses and public utilities in the Punpun catchment worked out to be 0.4 lakh hectares. In general it is seen that low banks and inadequate channel capacities of the river and inadequacy of waterways in structures across it in the lower reaches are the main causes of heavy spilling, as a result of which a vast track of land is inundated (Fig.11).

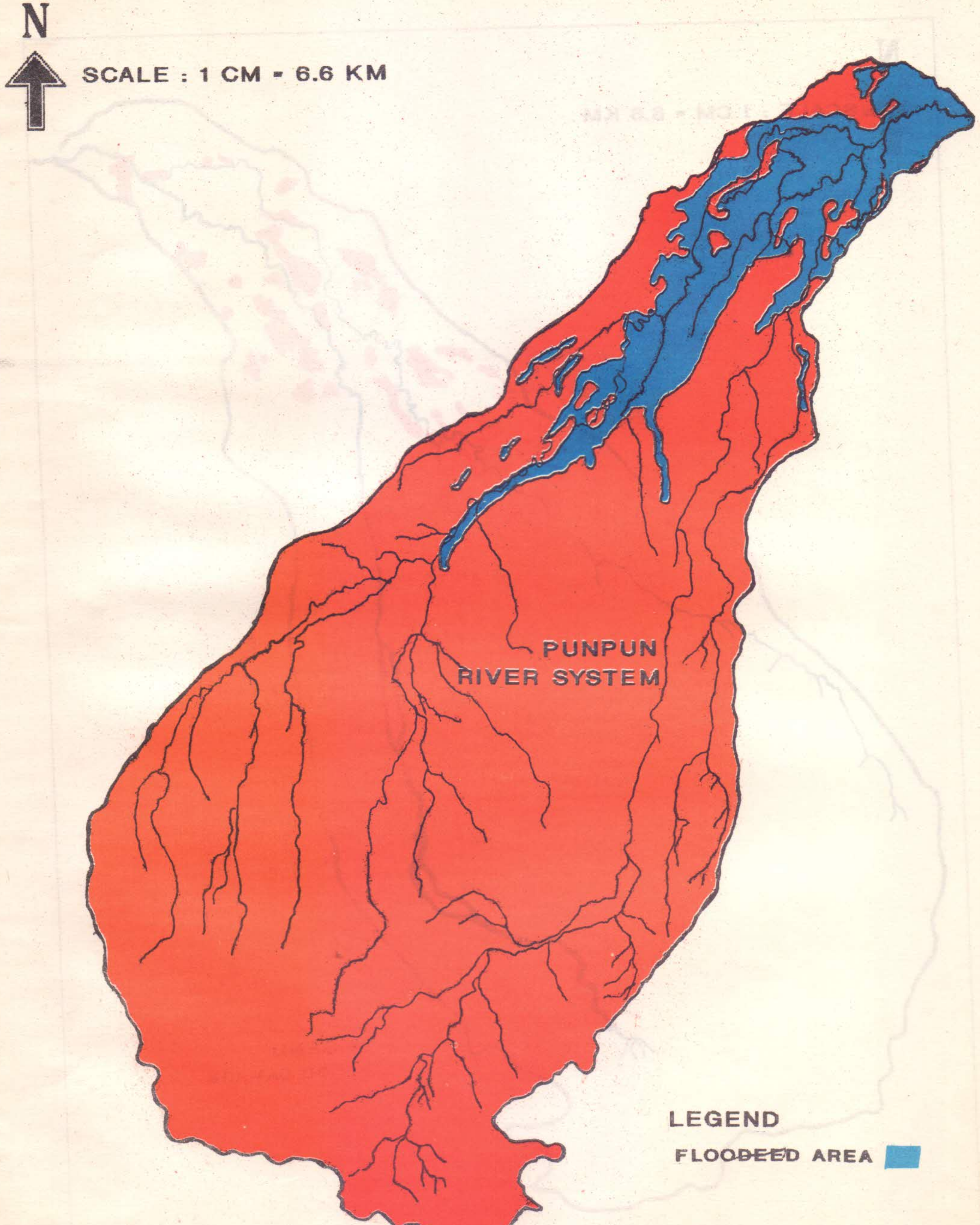

FIG.10 : FLOOD INUNDATION MAP

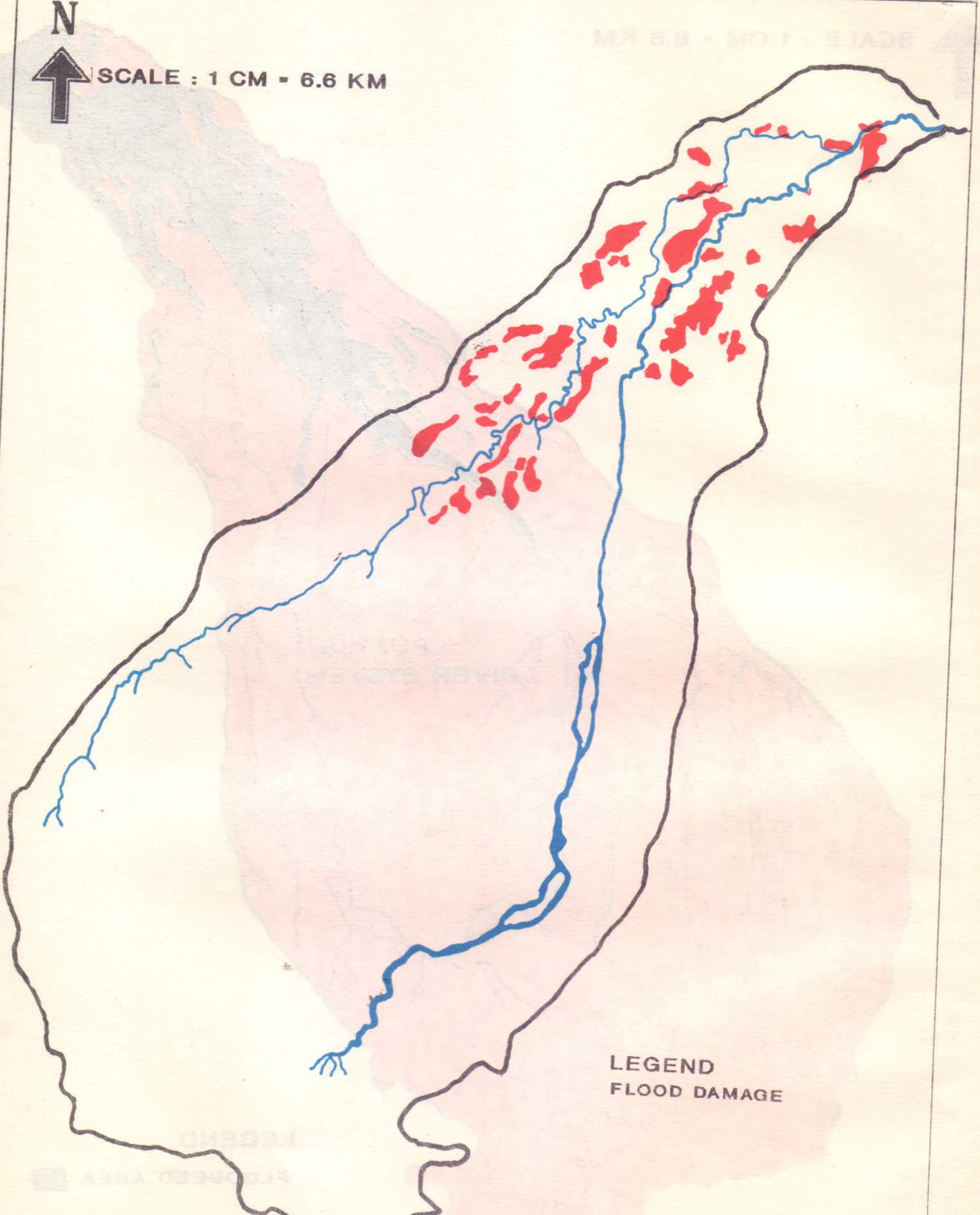

FIG.11 : FLOOD DAMAGE MAP

6.2 Flood Plain Land use

To develop any land use classification system it is essential to consider certain criteria and limitations of satellite data and study area pertaining to Indian conditions. In the present study, land use categories are generalized other inherent characteristics such as seasonal effects spectral separatibility of the features etc. are adequately considered while deciding upon a suitable classification scheme (Fig.12). Aerial extent of various land use categories was measured from the map prepared by interpretation of Landsat MSS imagery at 1:250,000 scale. A digital planimeter was used for measurement of areas under various types of land cover.

Following interpretation can be made from a careful study of land use map prepared:

1. The upper part of the river system constituting about 30 % of total area is hilly with forest.
2. The lower part of river system is generally gently sloping to almost plain.
3. Most of the areas are cultivated in the lower part of river system. This area is frequently affected by floods.
4. The area under agriculture is in the Punpun river system is about 2500 sq. kms.. The remaining area of 1000 sq. km. is under miscellaneous uses such as industries, roads, residential buildings etc.. It

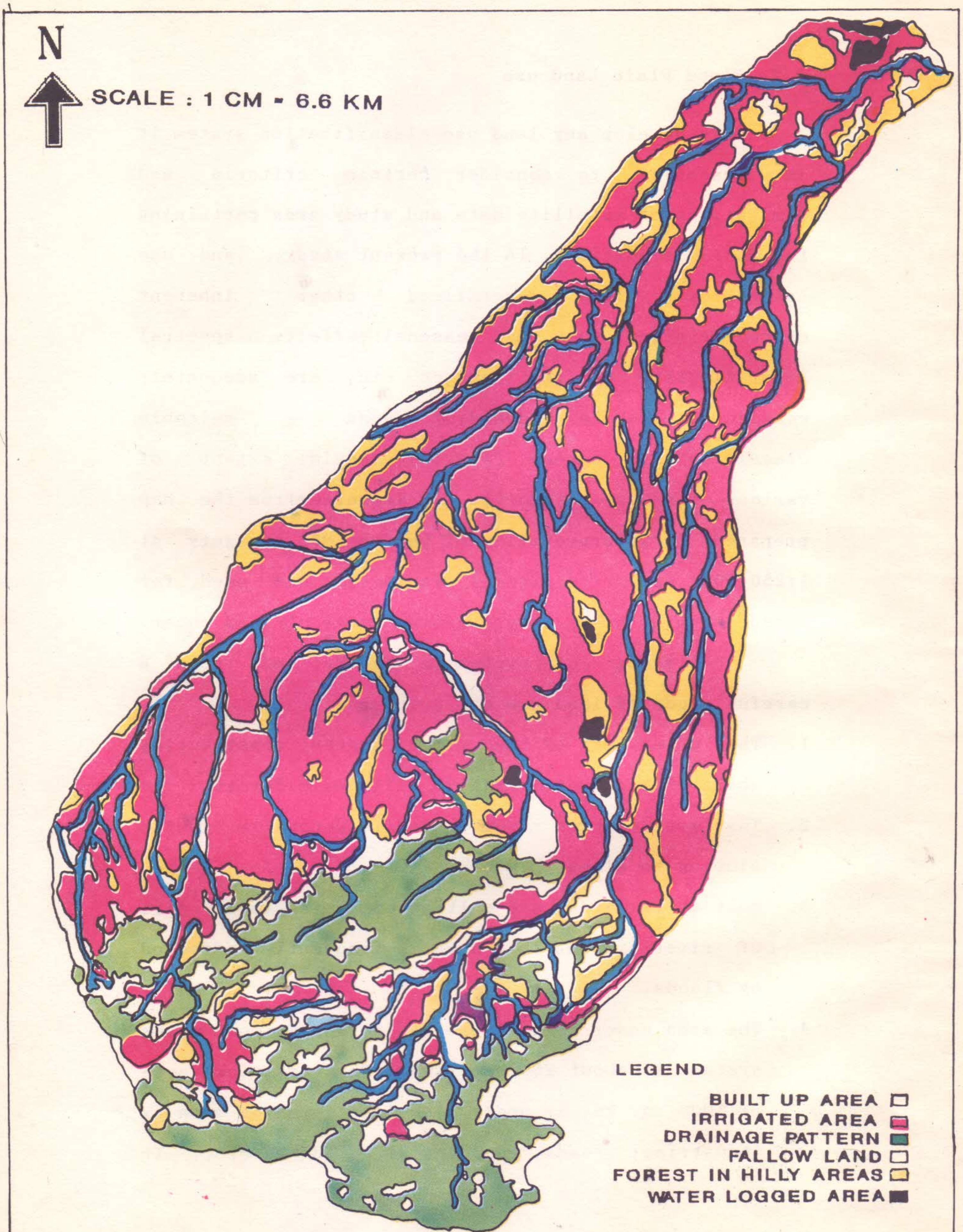

FIG.12 : LAND USE/ LAND COVER MAP

shows that agricultural area, forest area and area under miscellaneous uses constitute 59 %, 29 %, and 12 % of the total area of the river system, respectively.

6.0 CONCLUSION

Surface water is one of the features most detectable by remote sensing. In a complementary way, its spectral signature is typical because of its great absorption of solar radiation in the red and infra-red portions of spectrum. Therefore, the locating and delineating the water bodies, although sometimes appearing difficult, is one of the most reliable operations that can be done by space imageries and multi-spectral data.

In the present study remote sensing applications to flood plain mapping is categorized as an operational technique.

It concludes that :

1. Interpretation could be improved using multi-date, pre-flood and post-flood data.

2. The FCC identifies the flood plain characteristics satisfactorily. But the presence of numerous colours and hues on false colour composite creates some confusion in the mind of interpreter.

3. The geocoded and even precisely corrected satellite scene would be very much needed for the study.

4. Satellite scenes during the flooding situation is

an extremely valuable information to understand the effectiveness of flood control works and vulnerable reaches of the river under flood attack.

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