FLOODPLAIN MAPPING OF RIVER GANGA BETWEEN RAOLI AND NARORA USING MULTI TEMPORAL SATELLITE DATA

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ABSTRACT

Floodplains of the rivers are extensively cultivated and densely populated. Because of the ever increasing human interference in the floodplains, many changes have been taking place in the flood-plains. Monitoring of such changes has become an easy task with the availability of temporal satellite data. In this study flood plain mapping of river Ganga between Raoli and Narora was taken up using temporal satellite data at 1:25,000 scale in false colour mode. The Landsat MSS and TM imagery were visually interpreted to map various flood plain characteristics. The analysis of the data with an interval of three years i.e.1981, 1984 and 1987 was done to detect the changes that have taken place in the flood plain of the river during the period 1981-84 and 1981-87.

1.0 INTRODUCTION

The floodplain is an area adjoining a river, stream or other water course which gets flooded during periods of high water when stream flow exceeds the carrying capacity of normal channel. It results from the deposition of sediments transported by the stream during the process of river bed deformation.

Natural floodplains provide a temporary storage for attenuating floods significantly. They generally provide excellent areas for agricultural, aquacultural and forestry production, are pleasing settings for homes, and provide excellent transportation corridors that make them attractive for intense human activities. Due to the encroachments, capacity of floodplains to store water temporarily gets reduced which results in increased flood peaks downstream necessitating expenditures for protection works.

Before taking up any protection work detailed maps depicting extent of floodplains and water features are required. Also, to assure the effectiveness of existing flood protection works investigations are to be carried out at regular intervals. Such studies help in detecting the change in the terrain condition, land cover etc. due to developmental activities in the floodplains and to design suitable steps to deal with flood problems.

The conventional approaches to collect such information have been ground based surveys which are both uneconomical and time consuming. Remote sensing can be used with advantage over conventional methods because of its capability to provide broad synoptic and repetitive coverage of the area in multispectral mode. The synoptic coverage of the data helps in studying the integrated effects of various aspects of the ecosystem and it is often possible to correlate the causes-effects of changes which are being monitored. Monitering of dynamic features of floodplain is possible with the repetitive data available from satellites.

2.0 REVIEW OF LITERATURE

Mapping of floodplains by remote sensing is based on the permanent or long term features caused by floods. The indicators such as river levees, Oxbow lakes, sediment deposits, swamps etc. are well recorded on aerial photographs. Therein appear more details if photographs are taken during the flooding and recession period. However, in forested areas floodplain delineation becomes difficult. Further stereoscopic viewing is helpful in such areas.

In identification of floodplain features black-and-white infrared film is superior to the black-and-white panchromatic film. The addition of colour aids interpretation in both the visual and near-infrared wave lengths. Where heavy vegetation is encountered colour infrared film appears to be the best available film for inundation mapping (Hoyer et al.,1973).

Airborne multi-spectral scanner data has also been used for floodplain mapping by many researchers. It has been reported that a continuous floodplain boundary could not be delineated on the basis of computer analysis of the airborne MSS data. However, the computer analysis indicated a break between floodplain and non-floodplain within small areas (Sollers, et al.,1978).

Airborne surveying of floodplains requires the favourable coincidence of the inundation level needed for flooding and suitable weather for taking photographs. These difficulties considerably limit the use of aerial photographs for studying floodplain inundation over long river reaches. The use of satellite survey and observation is encouraging because of its advantages of continuous tracking of land surface, broad coverage and quick receipt of information. The high degree of generalisation of details in the case of satellite surveys facilitates regional investigations and allows the monitoring of most characteristic processes of flooding along the whole river from its head to its mouth.

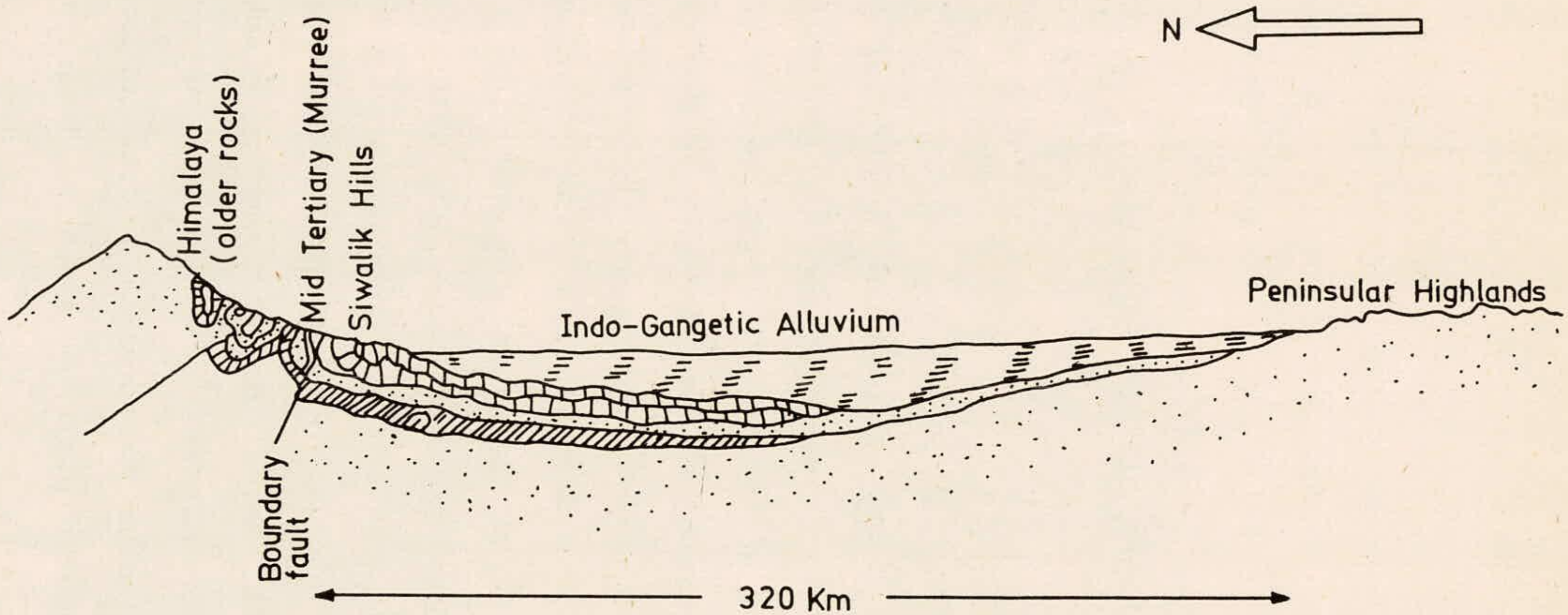
Polar orbiting satellites like NOAA can be used to identify areas of flooding in the case of large floods. Wiesnet et al.(1974) in a study of the 1973 Mississippi river concluded that NOAA VHRR/IR can be used to prepare flood maps for river having floodplains not less than 3 Km. in width. Further, in 1979, Berg et al.reported that computer enhanced NOAA VHRR/IR data can be successfully used for floodplain mapping of small rivers that have wide flood plains. It was also demonstrated that thermal band of VHRR is well suited for mapping of floods during spring season which are mainly due to excessive snow melt.

The capability of Landsat series of satellites to assess flooding was indicated by Rango and Anderson (1974) and Deutsch et al.(1974). Analysis of data collected during flood periods compared with periods of any or normal conditions makes possible assessment of a variety of hydrological features, including areas of flood damage. Temporal composites may be used to show the changes in the flooded area between two dates of image acquisition. Deutsch and Ruggles (1978) has reported that temporal composite produced by projecting preflood and flood image in band 7 through red and green filters respectively, depicts the flooded areas clearly. The areas which were under water in both dry and flood scene appear as black where there was no water in the dry scene but water during flood appear red in colour. Similar observations were made by Kruus et al.(1979) while carrying out studies on floods of the Susquehanna River in October 1975 and the Red River in July 1975.

Dhanju (1976) interpreted landsat imagery to study shifting, meandering and flooding of Kosi river. He was able to map inundated areas, flood boundaries and other features. Chakraborty (1979) reported that band 7 imagery alone is sufficient for delineating interlacing river channels. Band 5, however was found to be good for floodplain details. Analysis of airborne multispectral scanner data was found to be useful in obtaining detailed information regarding flood protection works. Further, floodplain studies by Dhanju (1979), Sharma et al.(1985) confirmed the observations made by earlier researchers.

3.0 STATEMENT OF THE PROBLEM

This study has been taken up for floodplain mapping of river Ganga between Raoli and Narora. This area is one of the most fertile area of western Uttar Pradesh. Because of the availability of flat terrain, vast alluvium deposits and irrigation facilities, intense cultivation has been practicised in the area. This has resulted in rapid economic growth of the area. Because of ever increasing human activities more and more areas of natural floodplains are being encroached. This has resulted in appreciable changes in the plains of the river. The main object of the study is to identify the extent of floodplain and its characteristics and to monitor the changes in the floodplains and river course during the period 1981-87.



1 Pre tertiary
2 Nummulitic
3 Murree
4 Siwalik
5 Sub recent and Recent Alluvium

FIG. 1- DIAGRAMMATIC SECTION ACROSS THE INDO GANGETIC PLAIN (Vertical scale exaggerated)

4.0 DESCRIPTION OF STUDY AREA

4.1 LOCATION AND EXTENT

Floodplain of river Ganga downstream of Raoli to Narora has been taken up for the study. The area lies between the latitudes $28^{\circ}75'$ N to $29^{\circ}24'$ N and longitudes 78° 0 E to $78^{\circ}45'$ E covering parts of districts of Muzaffar Nagar, Meerut, Mooradabad, Bulandshahr, Bijnor, Saharanpur, Ghaziabad and Badaun.

4.2 GEOLOGY

Geologically the area forms a part of Indo-Gangetic alluvial plain intervening between the Deccan peninsula and extra peninsular Himalayan region. The area was originally a deep depression, lying between the peninsula and the mountain region. Geologically, it belongs to pleistocene and recent periods. The deposition of the alluvium commenced after the upheavel of the Himalayas and Siwaliks and has continued through the Pleistocene age upto the present times. The alluvial deposits are very deep, varying in depth from less than 1000 m to over 3000 m. Quartz, Feldspar, Muscovite, Biotite, Amphibole, Pyroxence, Garnet, Mica and Galcite are common mineral constitutents of the alluvium, together with calcium Carbonate. A diagrammatic section across the Indo-Gangetic plain is shown in figure 1.

4.3 NATURAL VEGETATION AND AGRICULTURE

Cultivation in this area has reached a very high level of development due to introduction of canal and tube well irrigation systems, improved drainage and mechanized farming. The natural vegetation in this area is mostly extinct owing to the impact of human interference through clearance of forests for various purposes. Clearance of natural vegetation, however in the dunal areas and in the dissected terrace fringes, as well as in the lower alluvial plain, is of comparatively recent times.

Some important natural vegetation species growing in area are Khair, Babul, Shishm, Palsh, Neem, Beri, Dub, Moth, Aak, Bath etc.(Manchenda and Ahuja, 1972).

The agriculture in this area is the back bone of economy. With the improved techniques of farming, including release of high yielding varieties of seeds, use of fertilizers and other management practices, intensive cropping is being increasingly adopted in area. Paddy-wheat is the most common crop rotation, where soil type and water facilities are favourable. Besides sugarcane, potato, oil seeds, and cotton are also grown intensively as cash crops.

The main crops being adopted in the area are wheat, gram, oil seeds, maize, jawar, pada, cotton, sugarcane etc.

4.4 CLIMATIC CONDITIONS

The location of the study area in the north-west of

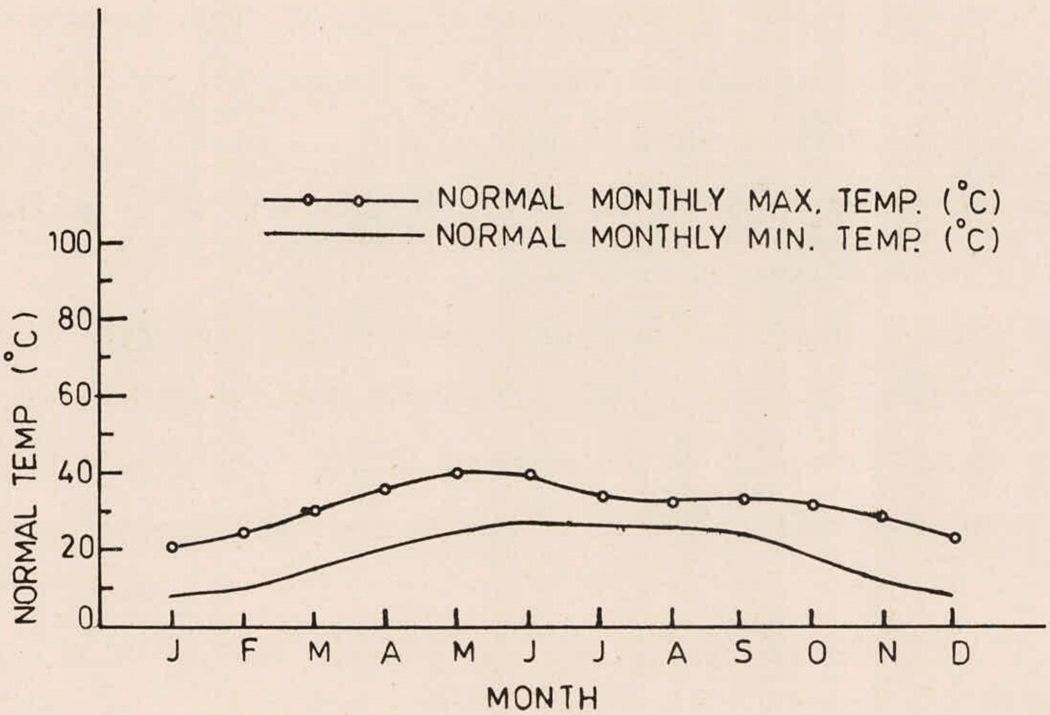


FIG.2 - NORMAL MONTHLY MAX. AND MIN. TEMPRETURES

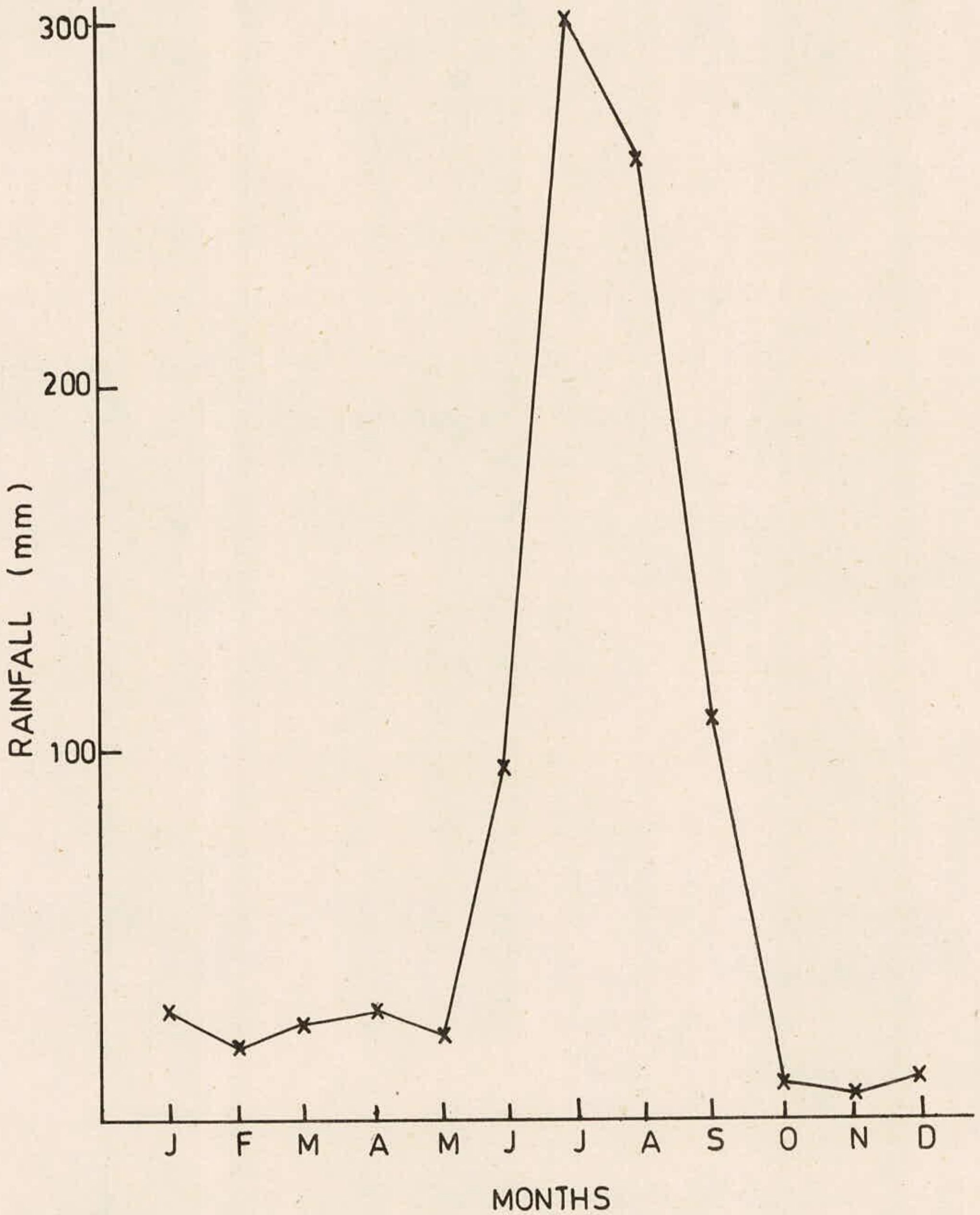


FIG. 3 NORMAL MONTHLY RAINFALL

India with Himalayas in the north, determines its climatic conditions. It receives much needed rain bearing depressions, during the rainy season, which last from June to September. From October to the end of May next year, generally dry conditions prevail, except for some light showers received from the westerly depressions coming across the Middle East and yielding little moisture, on being lifted against the Himalayas. The climate of the area can be broadly referred to as sub-tropical and semi-arid with a wet monsoon and a dry sub-humid winter. The normal monthly maximum and minimum temperature and normal monthly rainfall are presented in figures 2 and 3 respectively.

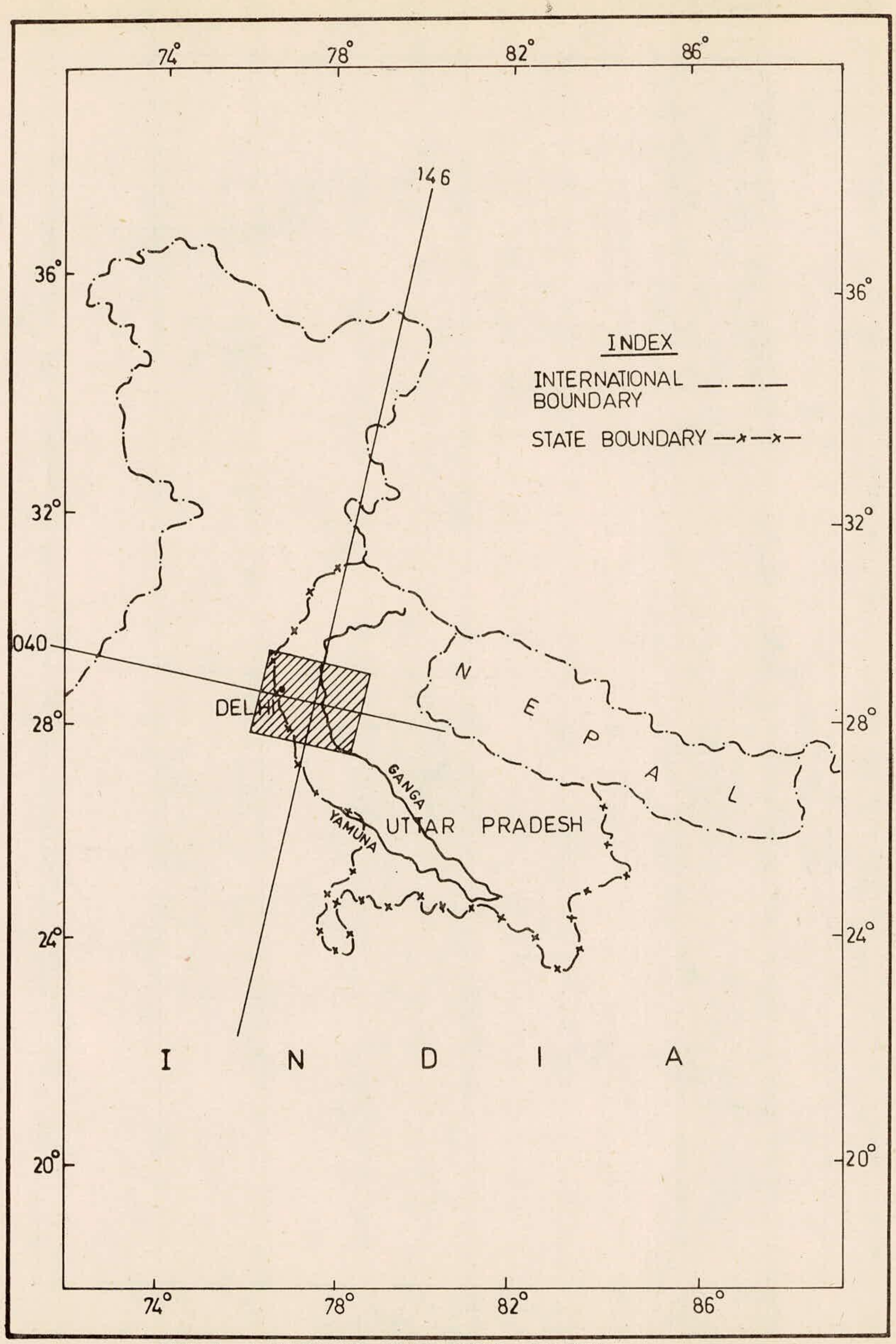


FIG.4 - LANDSAT IMAGERY INDEX

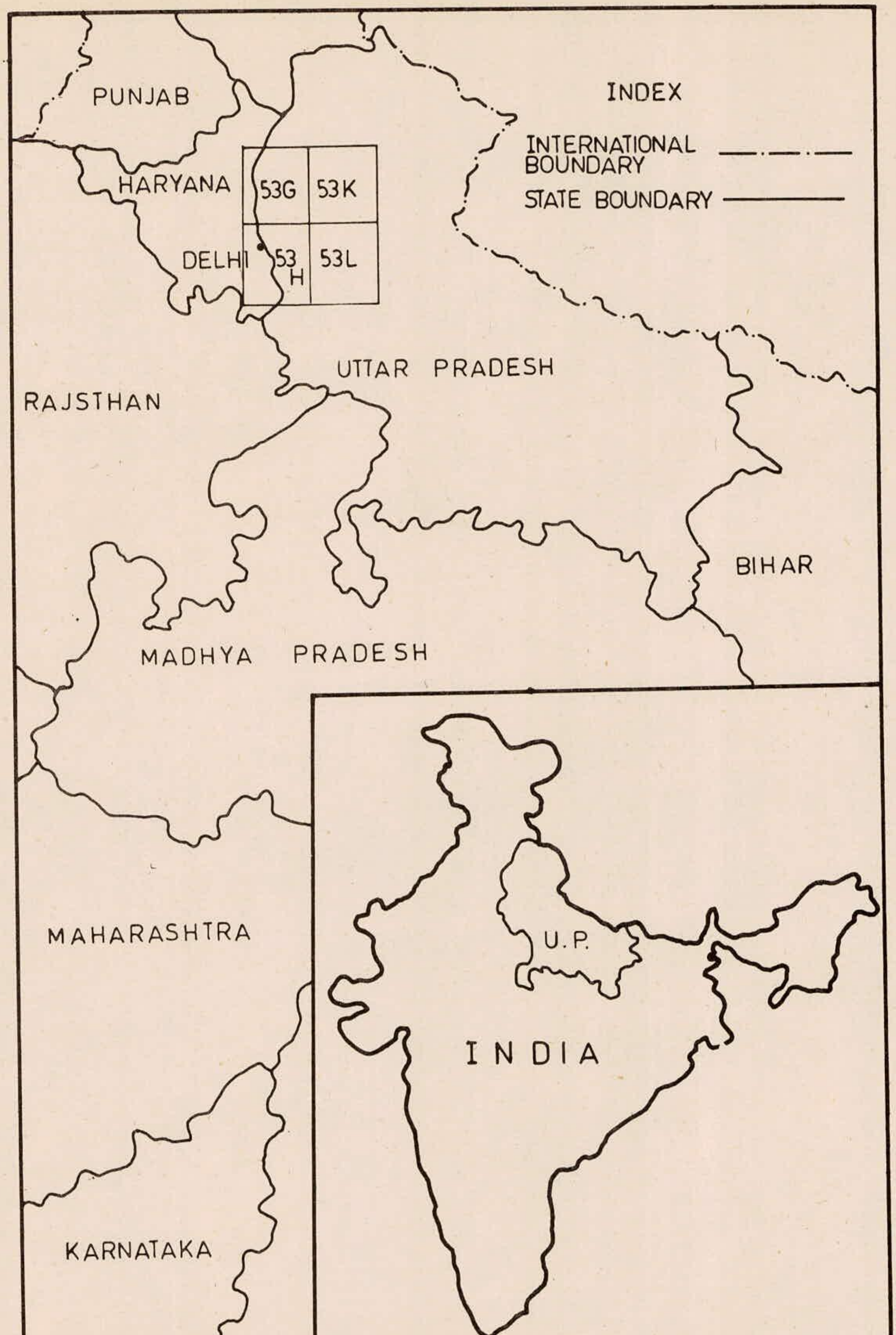


FIG. 5 - TOPOSHEET INDEX

5.0 DATA USED

This study was carried out using Landsat MSS imagery together with conventional data such as Survey of India toposheets and other reference material on the subject.

5.1 LANDSAT IMAGERY

The study area is covered in one frame of Landsat imagery. Imagery of years 1981, 84 and 87 available at the Institute were used for interpretation. An index for Landsat coverage is presented in figure 4. A brief description of Landsat data products used is given in Table 1.

Table 1: Description of Landsat Data

S.N.	Path &	Date	Satellite	Sensor	Data type
1.	146-040	27-10-81	L3	MSS	FCC 1,2,4
2.	146-040	13-11-84	L4	MSS	FCC 1,2,4
3.	146-040	13-10-87	L5	TM	FCC 2,3,4

5.2 TOPOSHEETS

The study area is covered in four Survey of India toposheets at 1:250,000 scale. A suitable base map of the study area was prepared from these toposheets. Index for these toposheets is shown in fig.5.

5.3 OTHER REFERENCE MATERIAL

Various types of information such as agriculture and vegetation, forest cover, geology and rocks, soils etc. pertaining to study area have been collected from Agricultural Atlas of India. Climatological information for the area has been obtained from report of the Irrigation Commission.

6.0 METHODOLOGY

Visual interpretation methods were attempted to delineate flood plain features on Landsat false colour composites. In visual interpretation tone-texture variation froms the basis of identification. The flood plain maps prepared from imagery were found to have slight geometric distortions. These distortions were corrected by optical projection techniques with reference to a base map prepared from Survey of India topographic maps.

The flood plain maps prepared for the years 1981, 84 and 87 were studied for detecting any changes during the study period. Change in river course was measured from offsets from a reference line joining Raoli and Narora. Change in channel area and flood plain area was also computed.

7.0 ANALYSIS AND RESULTS

The flood plain maps prepared for the years 1981, 84 and 87 are presented in figures 6,7, and 8 respectively. Two flood plain boundaries could be identified on the imageries; (i) recent flood plain boundary and (ii) ancient flood plain boundary. From the flood plain maps shifting in river channel and its banks has been measured by drawing offsets from a reference line (Table 2). The shifting in left bank, right bank and mid channel is pictorially represented in figures 9,10 and 11 respectively. It is observed that max. shifting in mid channel is 3.75 km. whereas max. left and right bank shiftings are 3.0 km and 3.25 km respectively. The total channel area downstream of Raoli between 5.0 km segment are given in Table 3.

The changes in flood plain boundary has also been determined. The offsets from reference line, shifting and area downstream of Raoli at every five km are given in Table 4. The changes in flood plain boundaries are also presented in figure 12. It is observed that the total area confined in recent flood plain was 2399.81 in 1981, 2397.25 sq.km in 1984 and 2393.8 sq.km in 1987. It was also found that ancient flood plain boundary was seen only on eastern bank side. The area lying between recent flood plain boundary and ancient flood plain boundary was 1228.91 sq.km in 1981, 1254.84 sq.km in 1984 and 1213.84 sq km in 1987.

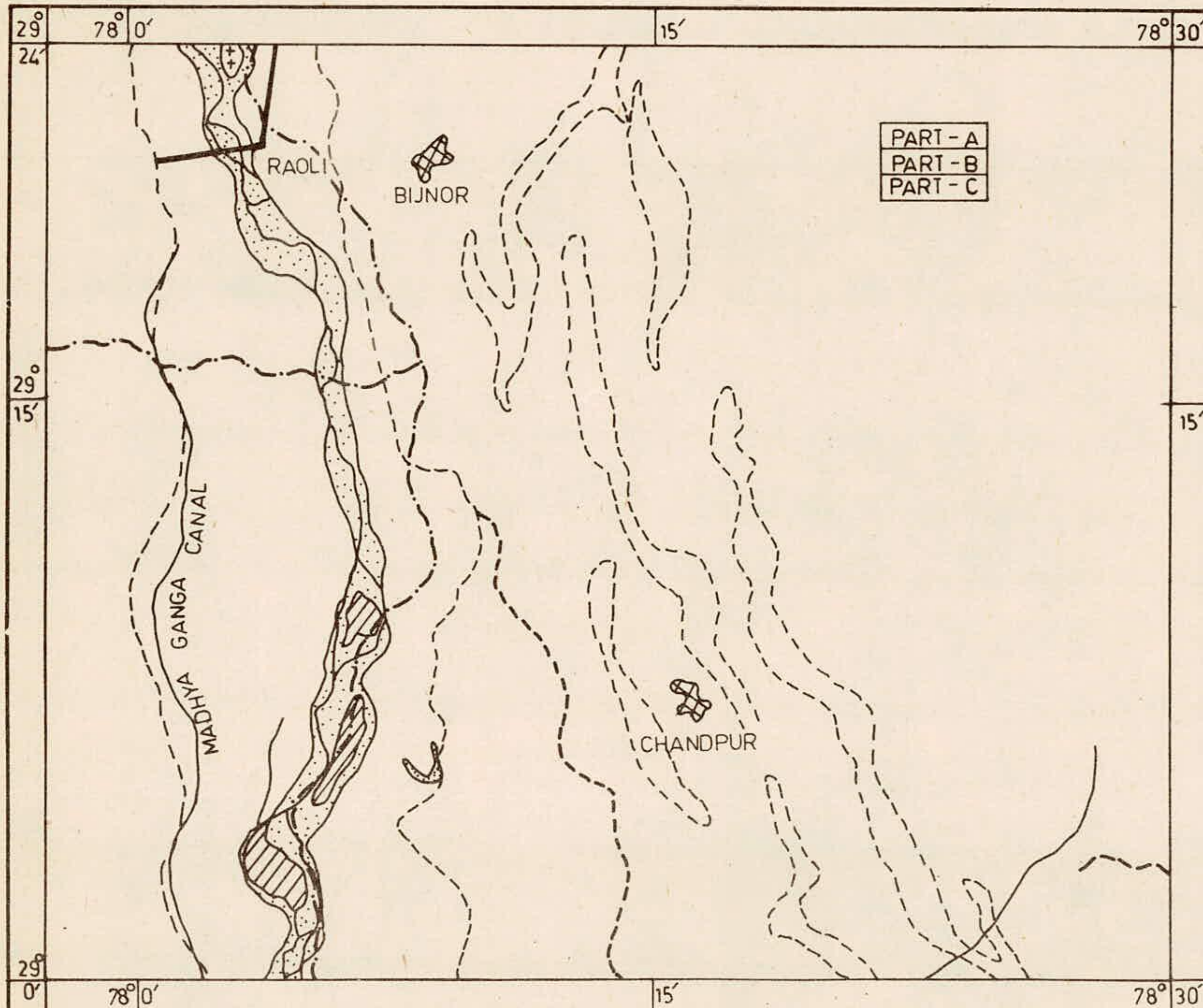


FIG. 6-PART-A

FLOOD PLAIN MAP OF RIVER GANGA BETWEEN RAOLI AND NARORA

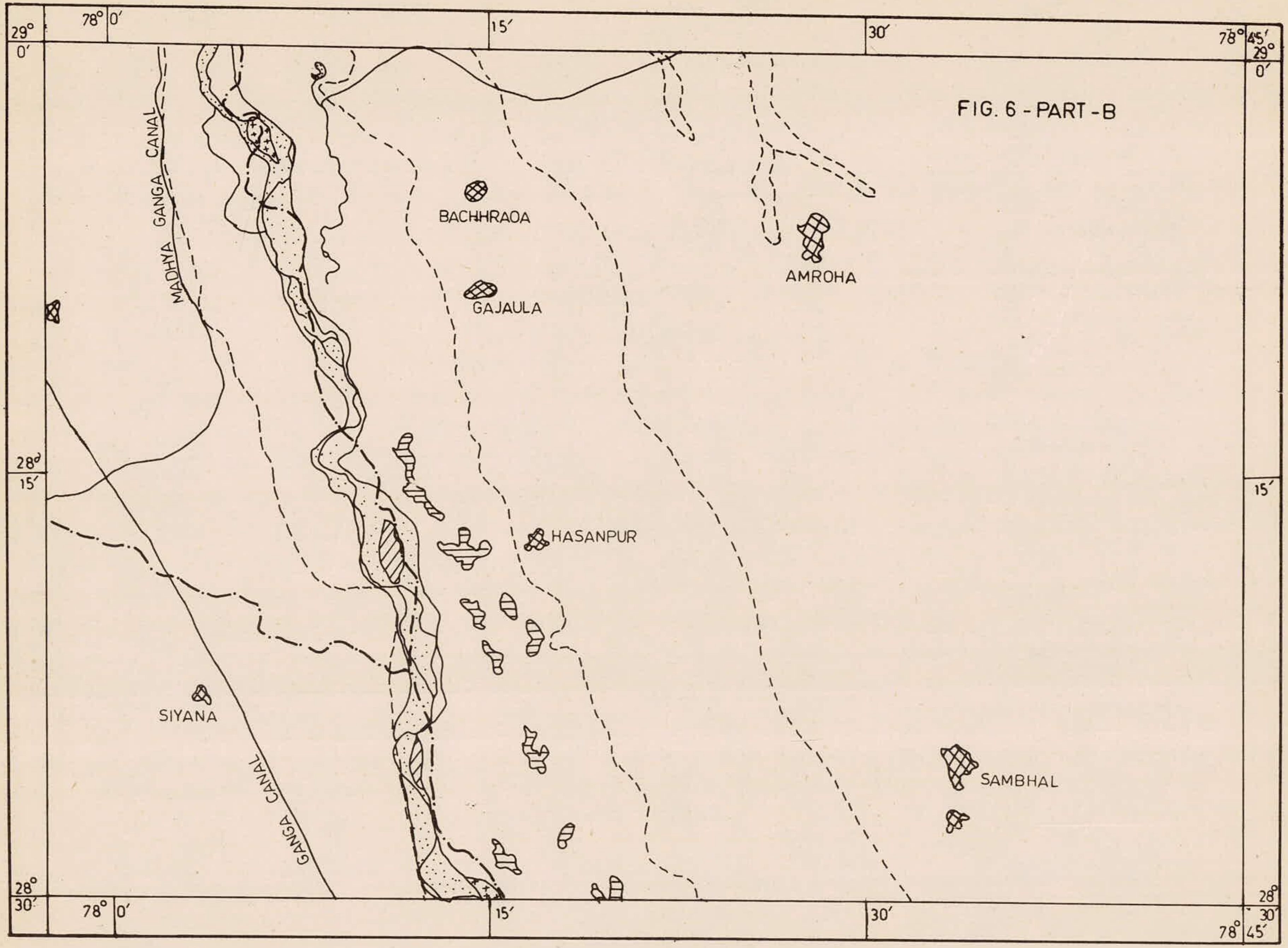
(PREPARED FROM LANDSAT MSS FALSE COLOUR COMPOSITE)
PATH-ROW : 146-040, DATE: 27-10-81

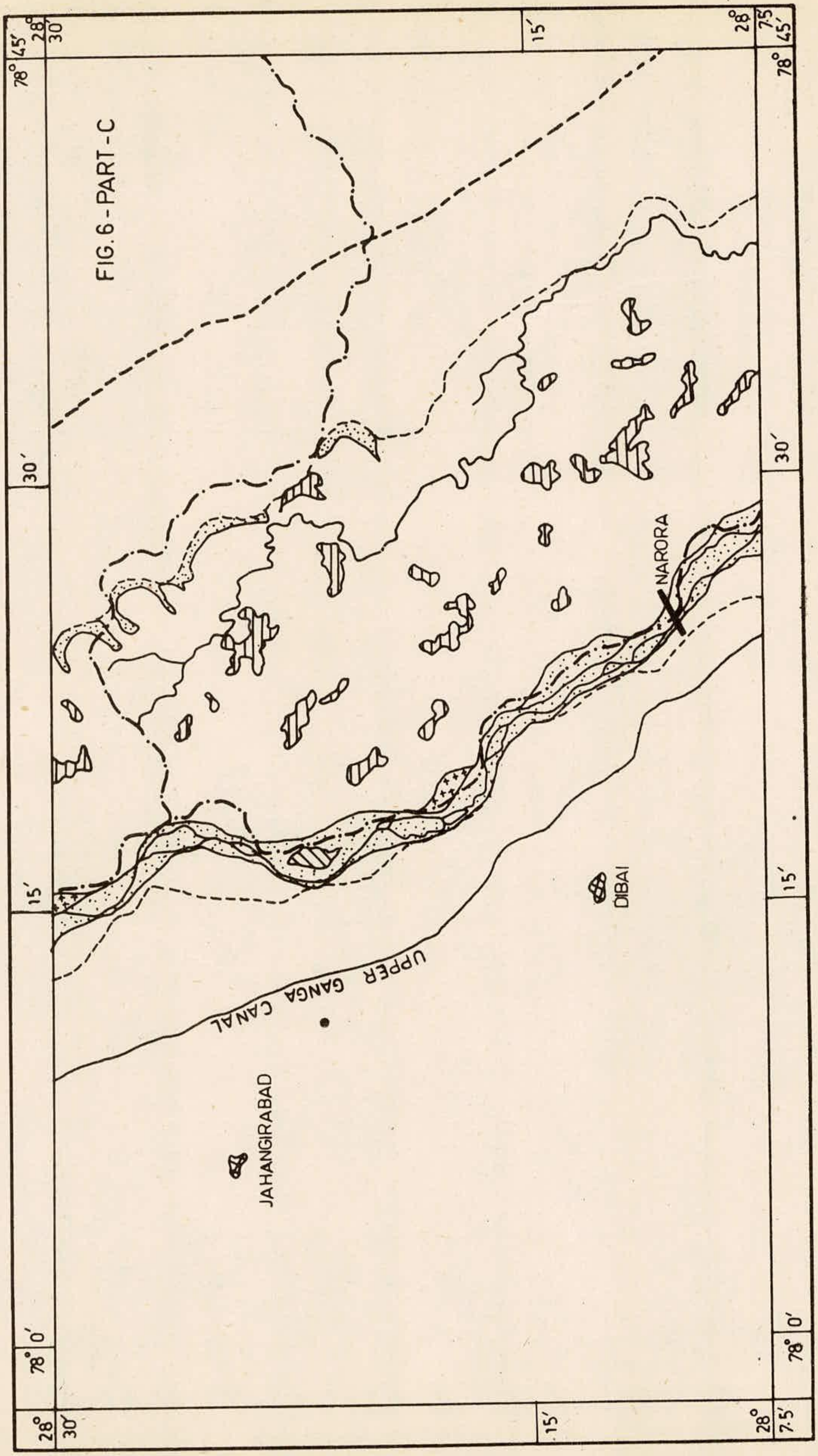
LEGEND

- RECENT FLOOD PLAIN BOUNDARY
- ANCIENT FLOOD PLAIN BOUNDARY
- DISTRICT BOUNDARY
- STREAMS, CANALS
- SEDIMENT DEPOSITS
- WET AREAS
- SANDY AREAS
- BUILT UP AREAS
- OXBOW LAKES
- SALT AFFECTED BARREN AREAS
- PALEO CHANNELS

SCALE 1:250000

FIG. 6 - PART - B


29°
0'
78° 0'
15'
30'
78° 45'
29°
0'
BACHHRAOA
GAJAULA
AMROHA
MADHYA GANGA CANAL
28°
15'
15'
HASANPUR
SIYANA
GANGA CANAL
SAMBHAL
28°
30'
78° 0'
15'
30'
28°
30'
78° 45'


78° 45'
28° 30'
15'
28° 7.5'
30'
15'
78° 0'
NARORA
DIBAI
UPPER GANGA CANAL
JAHANGIRABAD
FIG. 6 - PART - C

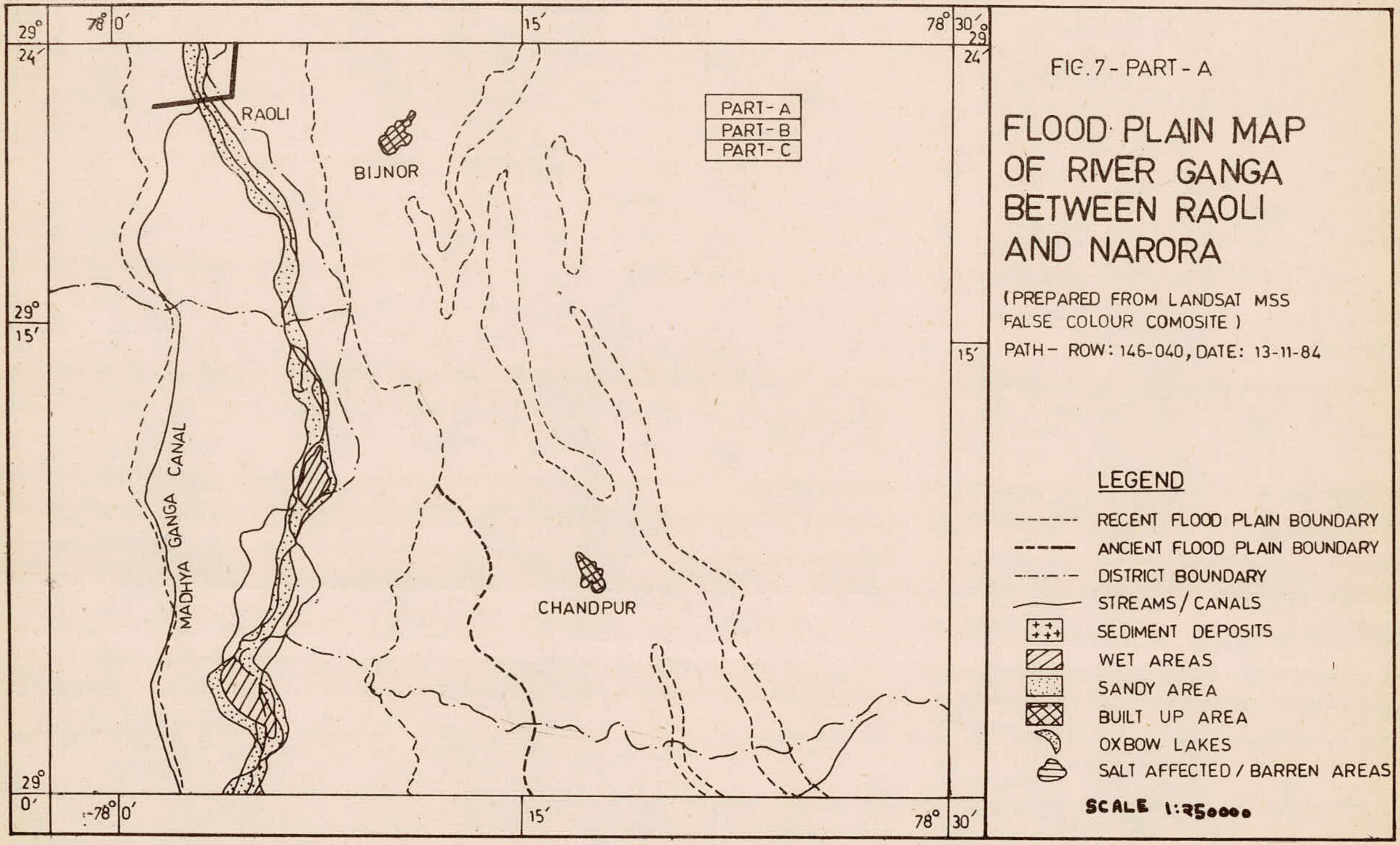
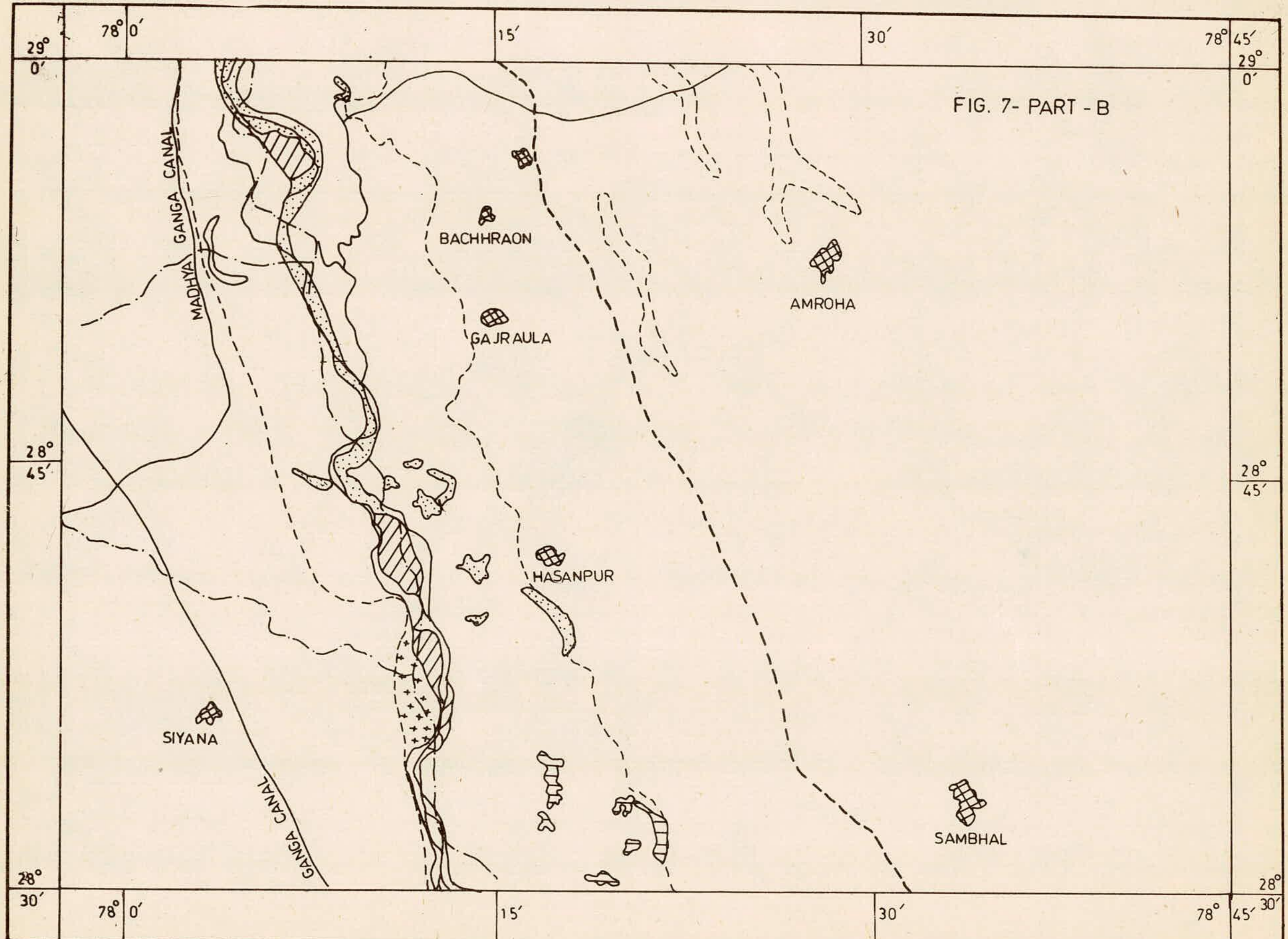


FIG. 7 - PART - A

FLOOD PLAIN MAP OF RIVER GANGA BETWEEN RAOLI AND NARORA

(PREPARED FROM LANDSAT MSS FALSE COLOUR COMOSITE)

PATH - ROW: 146-040, DATE: 13-11-84



29° 0′
78° 0′
15′
30′
78° 45′
29° 0′
28° 45′
28° 45′
28° 30′
28° 30′
MADHYA GANGA CANAL
GANGA CANAL
BACHHRAON
GAJRAULA
AMROHA
HASANPUR
SIYANA
SAMBHAL

FIG. 7- PART - B

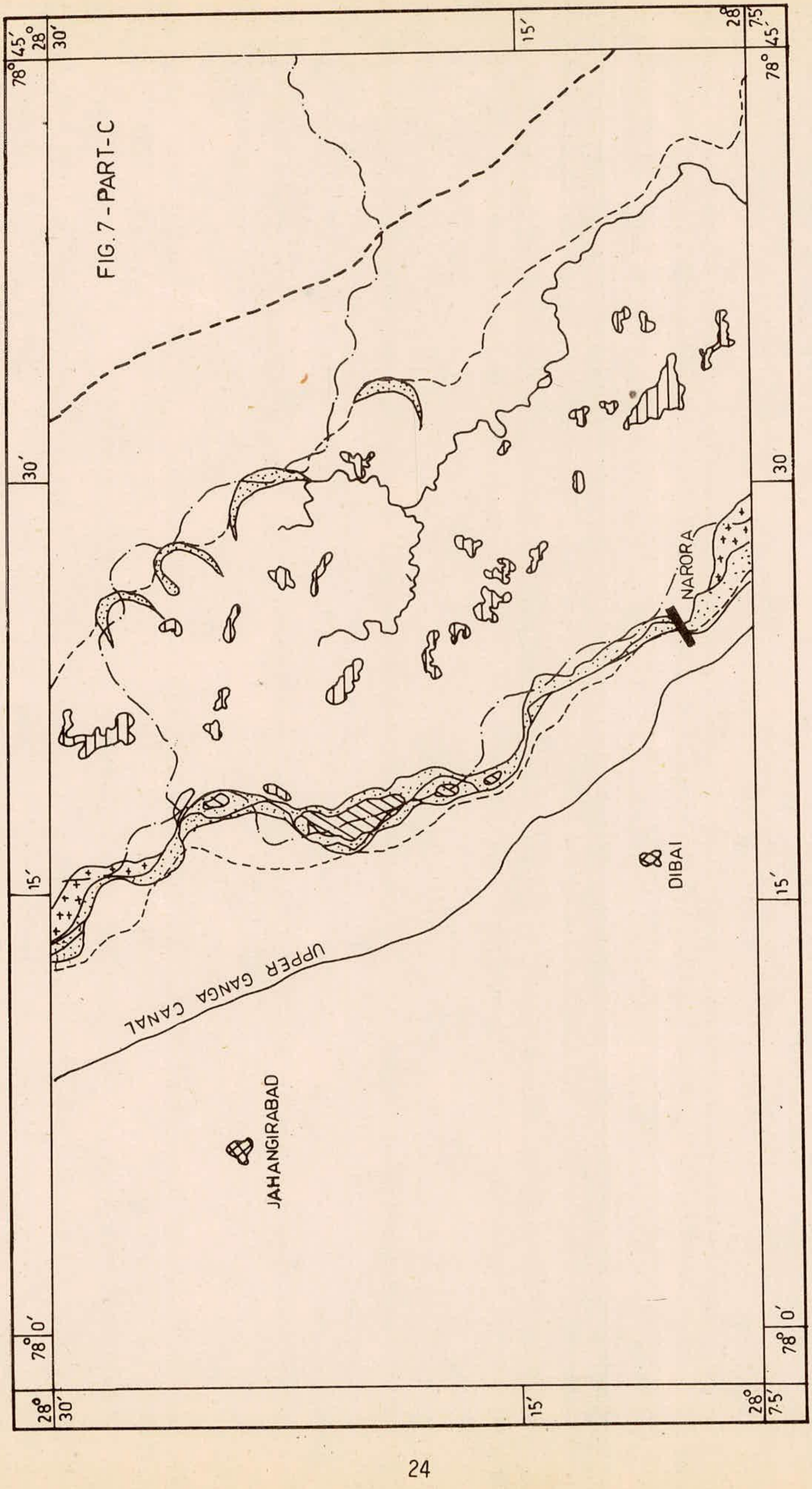


FIG. 7 - PART-C
UPPER GANGA CANAL
NARORA
DIBAI
JAHANGIRABAD
78° 45'
28° 30'
15'
28° 7.5'
78° 0'
30'
15'

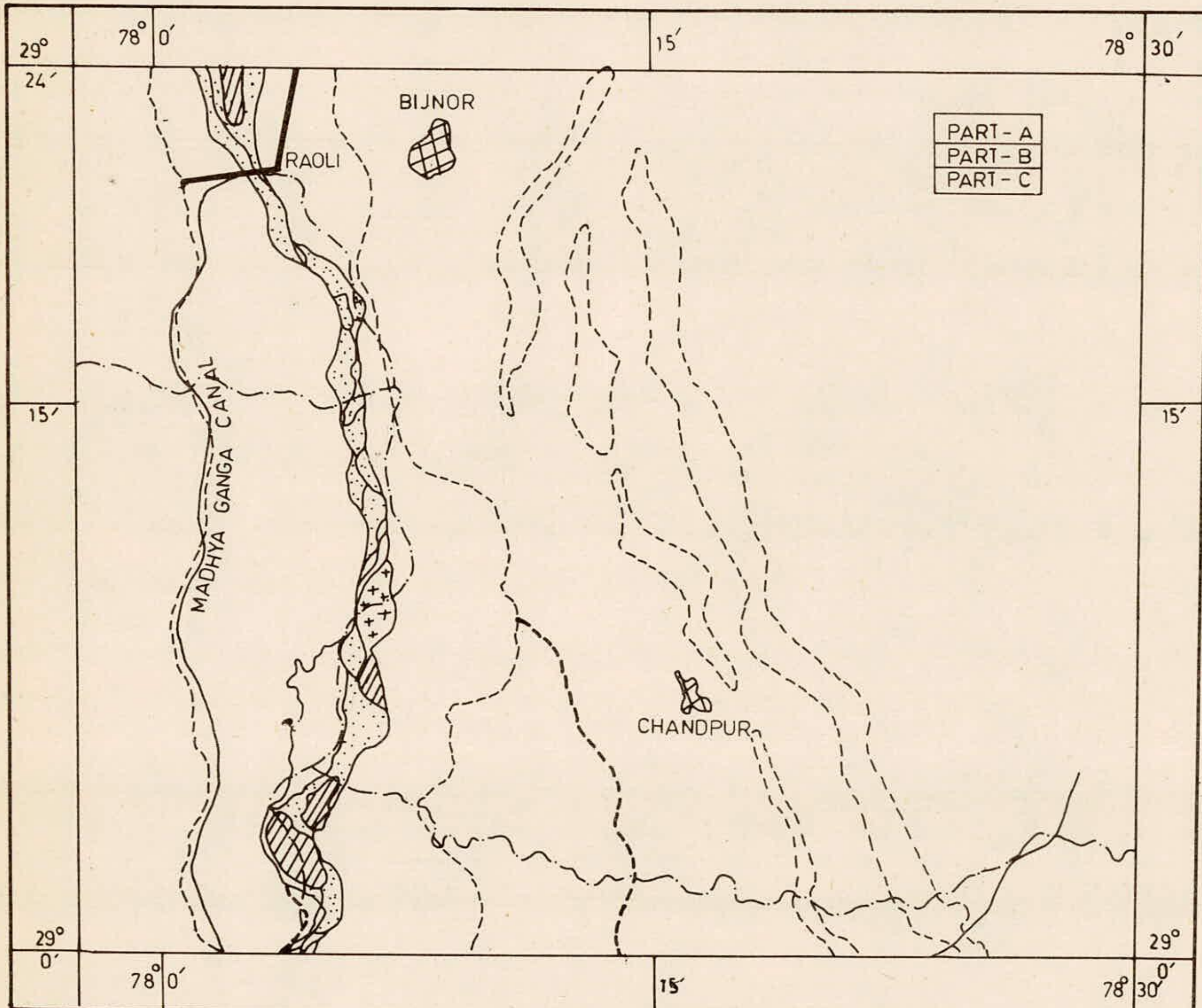


FIG. 8 - PART - A

FLOOD PLAIN MAP OF RIVER GANGA BETWEEN RAOLI AND NARORA

(PREPARED FROM LANDSAT TM FALSE COLOUR COMPOSITE)
PATH-ROW 146-040 DATE : 13·10·1987

LEGEND

- RECENT FLOOD PLAIN BOUNDARY
- ANCIENT FLOOD PLAIN BOUNDARY
- DISTRICT BOUNDARY
- STREAMS, CANALS
- SEDIMENT DEPOSITS
- WET AREAS
- SANDY AREA
- BUILT-UP AREA
- OXBOW LAKES
- SALT AFFECTED / BARREN AREAS

SCALE - 1:250000

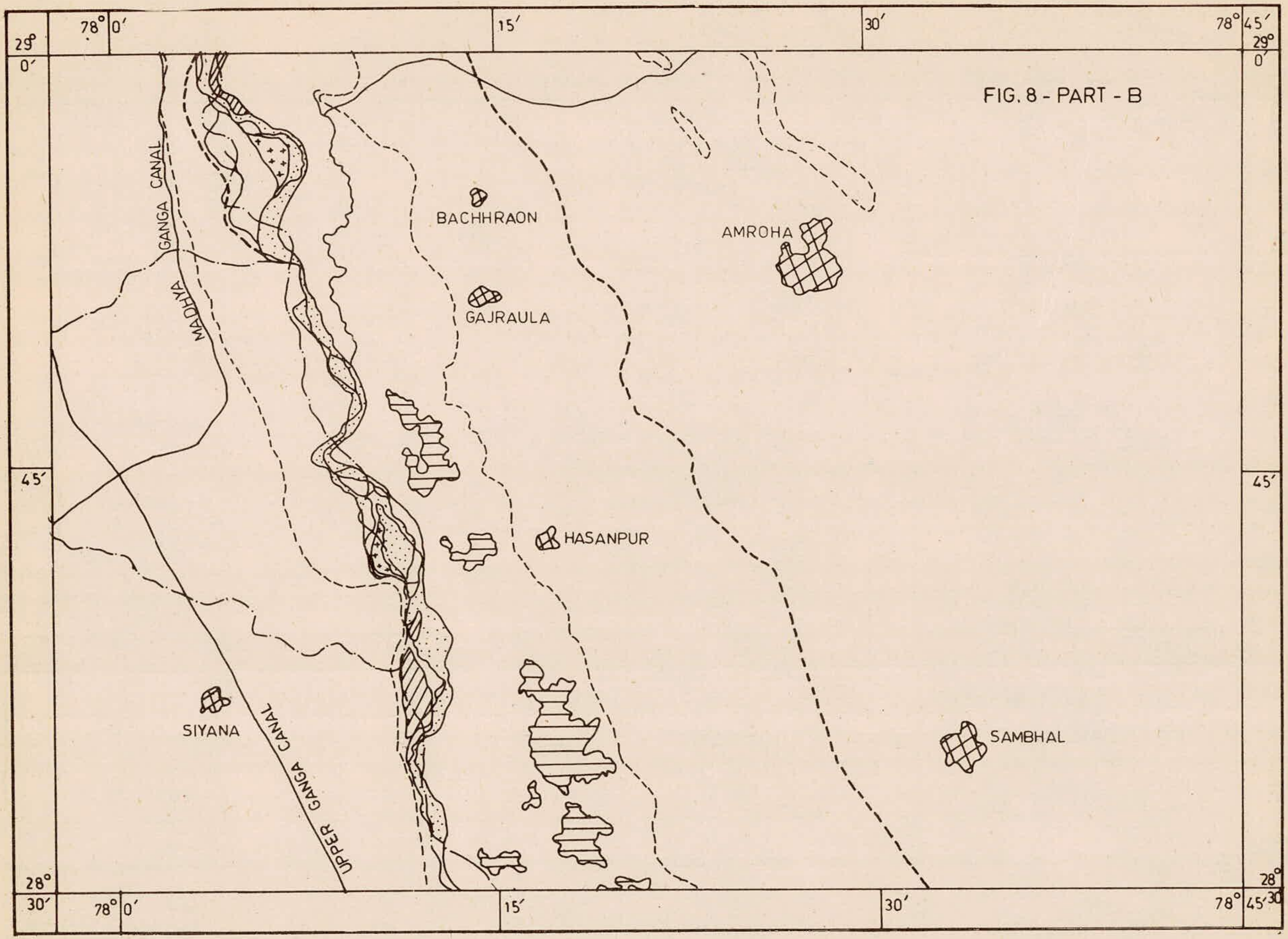


FIG. 8 - PART - B
BACHHRAON
GAJRAULA
AMROHA
HASANPUR
SAMBHAL
SIYANA
MADHYA GANGA CANAL
UPPER GANGA CANAL
78° 0'
15'
30'
78° 45'
29° 0'
45'
28° 30'

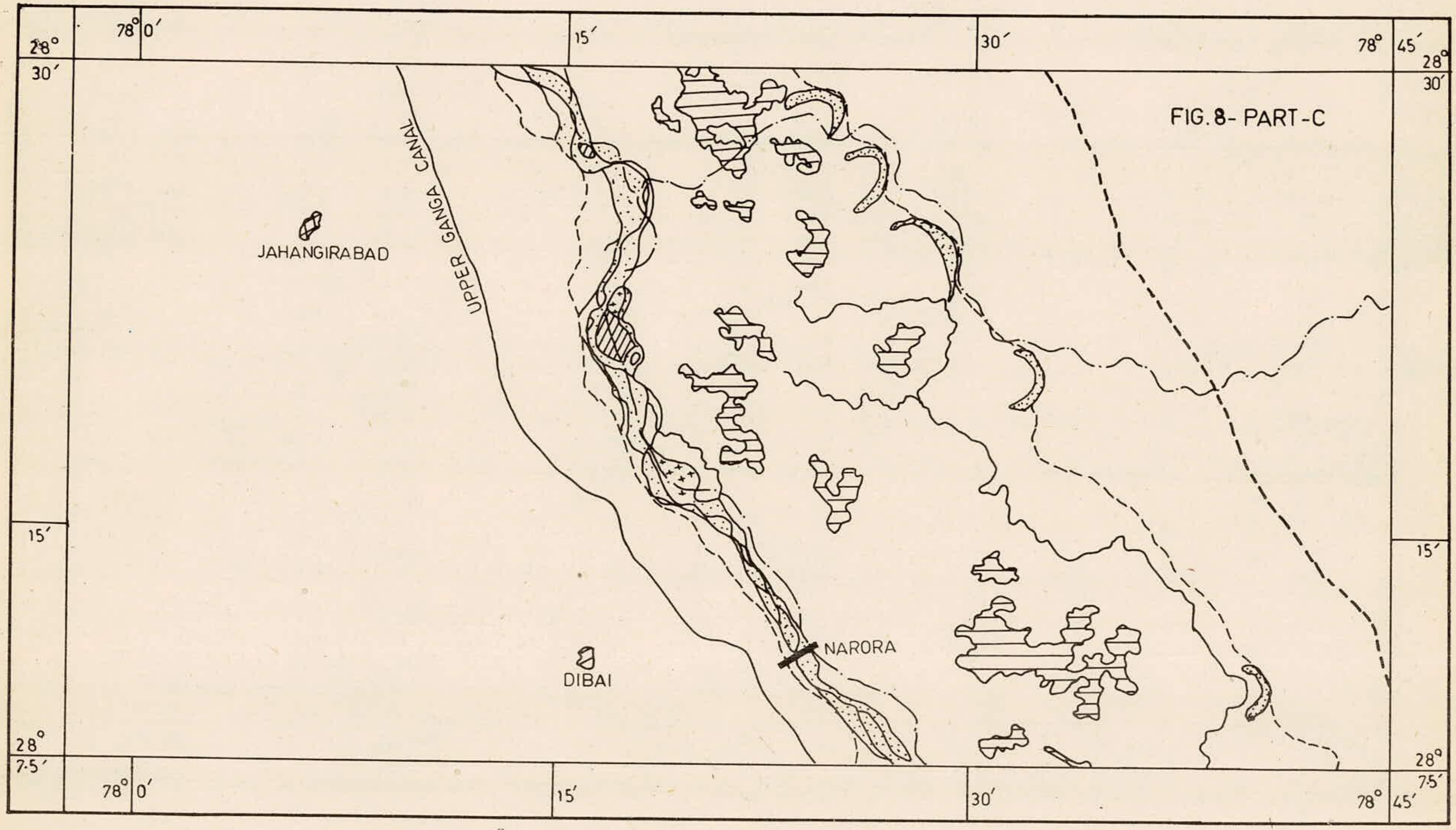

78° 0′
15′
30′
78° 45′
28° 30′
15′
28° 7·5′
JAHANGIRABAD
UPPER GANGA CANAL
DIBAI
NARORA

FIG. 8- PART-C

TABLE-2 : SHIFTING IN RIVER GANGA BETWEEN RAOLI AND NARORA

DISTANCE FROM RAOLI IN(KM)	OFFSET TO LEFT BANK FROM REFERENCE LINE (KM)			OFFSET TO RIGHT BANK FROM REFERENCE LINE (KM)			OFFSET TO MIDCHANNEL FROM REFERENCE LINES (KM)			SHIFTING WITH RESPECT TO 1981(KM) 1984			1987		
	1981	1984	1987	1981	1984	1987	1981	1984	1987	LEFT BANK	RIGHT BANK	MIDCH-ANNEL	LEFT BANK	RIGHT BANK	MIDCHA-NNEL
0.0	4.25	4.5	4.5	5.5	5.5	5.5	4.87	5.0	5.0	0.25	0.0	0.12	0.25	0.0	0.12
5.0	6.5	6.0	5.75	7.75	7.25	6.75	6.37	6.62	6.25	-0.5	-0.5	0.25	-0.75	-1.0	-0.12
10.0	6.75	7.0	7.25	8.25	8.0	8.25	7.5	7.5	7.75	0.25	-0.25	0.0	0.5	0.0	0.25
15.0	6.0	6.0	6.5	7.5	7.25	7.75	6.75	6.62	7.12	0.0	-0.25	-0.12	0.5	0.25	0.37
20.0	6.0	6.0	6.25	7.25	7.0	7.25	6.62	6.5	6.75	0.0	-0.25	-0.12	0.25	0.0	0.12
25.0	3.25	3.5	3.5	6.5	6.25	6.0	4.87	4.87	4.75	0.25	-0.25	0.0	0.25	-0.5	-0.12
30.0	0.25	1.25	1.75	3.75	2.25	4.5	1.62	1.75	3.12	1.0	-1.5	0.12	1.5	0.75	1.5
35.0	-2.0	-3.0	-2.75	0.25	0.0	0.25	-0.87	-1.5	-1.25	-1.0	-2.5	-0.62	-0.75	0.0	-0.37
40.0	-4.25	-4.0	-3.25	-1.75	-2.25	2.25	-3.0	-3.12	-0.5	0.25	-0.5	0.12	1.0	-0.5	2.5
45.0	-2.5	-4.25	-2.75	0.25	-1.62	-1.5	-1.75	-2.93	-2.12	-1.75	-1.87	-1.81	-0.25	-1.75	-1.0
50.0	-2.75	-2.25	-1.75	-0.50	-0.50	0.0	-1.62	-1.37	0.87	0.5	0.0	0.25	1.0	0.5	0.75
55.0	-2.5	-3.5	-2.5	-0.87	-2.75	-1.25	-1.68	-3.12	-1.87	0.0	-1.87	-1.45	0.0	-0.31	-0.18
60.0	-1.62	-2.5	-1.5	0.75	-1.75	-0.75	-4.37	-2.12	-1.25	-0.87	-2.5	2.25	0.12	-1.5	3.25
65.0	-0.75	-1.0	-0.75	0.50	0.0	0.50	-0.12	-0.5	-0.12	-0.25	-0.5	-0.37	0.0	0.0	0.0
70.0	-1.75	-4.25	-2.25	0.75	-2.5	-0.25	-0.5	-3.37	-1.2	-2.5	-3.25	-2.87	-0.5	0.0	-0.75
75.0	-1.75	-2.75	-2.25	1.62	1.0	1.50	-0.06	-0.87	-0.37	1.0	-0.62	-0.81	-0.5	-0.12	-0.31
80.0	-0.75	-2.0	-1.0	1.37	0.0	1.75	0.31	-1.0	0.31	-1.25	-1.37	-0.68	-0.25	0.37	0.01
85.0	-2.75	-2.5	-2.75	0.0	0.0	0.75	-1.37	-1.25	-1.0	0.25	0.0	0.12	0.0	0.75	0.37
90.0	-3.5	-4.5	-3.25	-1.75	-3.75	-2.25	-2.62	-4.12	-2.75	-1.0	-2.0	-1.5	0.25	-0.5	0.12
95.0	-3.75	-4.5	-4.0	-1.25	-3.0	-2.5	-2.25	-3.75	-3.25	-0.75	-1.75	-1.5	0.25	-1.25	-1.0
100.0	-0.87	-2.5	-1.0	0.75	-0.25	0.5	-0.06	-1.37	-2.5	-1.62	-1.0	-1.31	-0.12	-0.12	-1.87
105.0	1.25	-1.75	1.0	3.5	0.0	3.5	2.37	-0.87	2.25	-3.0	-3.5	-3.25	-0.25	0.0	-0.12
110.0	-1.0	1.0	0.0	0.75	2.5	1.50	-0.12	1.75	0.75	2.0	1.75	-1.62	1.0	0.75	0.87
115.0	-1.75	-2.25	-2.25	0.62	0.25	0.25	-0.56	-1.0	-1.15	-0.5	-0.37	-0.43	-0.5	-0.37	-0.56
120.0	1.5	-1.25	-2.0	0.25	0.0	0.25	-0.62	-0.62	-0.85	0.25	-0.25	0.0	-0.5	0.0	-0.25
125.0	1.75	-1.75	-0.5	3.5	-0.50	2.5	2.62	-1.12	1.0	-3.0	-4.0	-3.75	-2.25	-1.0	-1.62
130.0	3.5	1.25	2.0	4.75	3.5	4.0	4.12	2.37	3.0	-2.25	-1.25	-1.75	-1.5	-0.75	1.12
135.0	4.75	3.5	4.25	6.5	5.0	5.5	5.62	4.25	4.85	-1.25	-1.5	-1.35	-0.50	-1.0	-0.75

TABLE-3

TABLE-3: CHANNEL AREA BETWEEN VARIOUS CHANNEL SEGEMENTS

DISTANCE FROM RAQLI(KM)	CHANNEL AREA(SQ.KM.)			CHANGE IN CHANNEL AREA(SQ.KM.)	
	1981	1984	1987	1984	1987
0.0					
	6.875	5.625	4.750	-1.250	-2.125
5.0					
	8.593	7.000	6.000	-1.593	-2.593
10.0					
	8.625	7.312	6.187	-1.312	-2.437
15.0					
	6.875	5.500	6.750	-1.375	-0.125
20.0					
	6.000	11.875	10.062	5.875	4.063
25.0					
	6.500	10.781	13.125	4.281	6.625
30.0					
	12.250	14.000	20.812	1.750	8.562
35.0					
	15.437	17.812	31.875	-2.375	16.437
40.0					
	14.437	13.125	16.875	1.312	2.437
45.0					
	13.750	14.218	8.625	0.468	-5.125
50.0					
	9.687	7.187	8.625	-2.500	-1.062
55.0					
	11.500	4.500	5.500	-7.000	-6.000
60.0					
	9.900	6.125	2.625	-3.775	-7.275
65.0					
	14.062	8.937	8.437	-5.125	-5.625
70.0					
	14.687	17.875	14.375	3.187	-0.312
75.0					
	15.812	20.125	18.687	4.312	2.875
80.0					
	14.635	15.750	15.625	1.125	1.000
85.0					
	11.250	10.156	10.000	-1.093	-1.250
90.0					
	11.156	6.187	6.250	-4.968	-4.906
95.0					
	11.859	11.718	8.625	-0.140	-3.234
100.0					
	17.531	12.000	10.000	-5.531	-7.530
105.0					
	19.500	9.343	14.000	-10.156	-5.500
110.0					
	11.859	13.000	12.200	1.140	0.390
115.0					
	10.312	10.750	12.500	0.437	2.187
120.0					
	10.937	15.625	15.750	4.687	4.182
125.0					
	9.000	10.062	14.375	1.062	5.375
130.0					
	6.375	11.250	9.312	4.875	2.937
135.0					

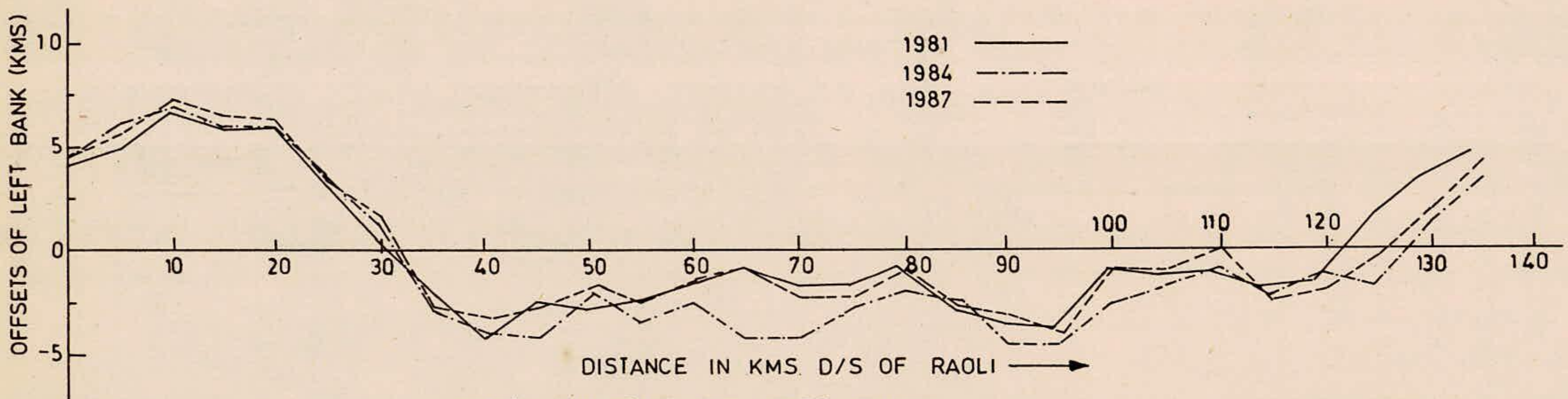


FIG.9 -SHIFTING OF LEFT BANK

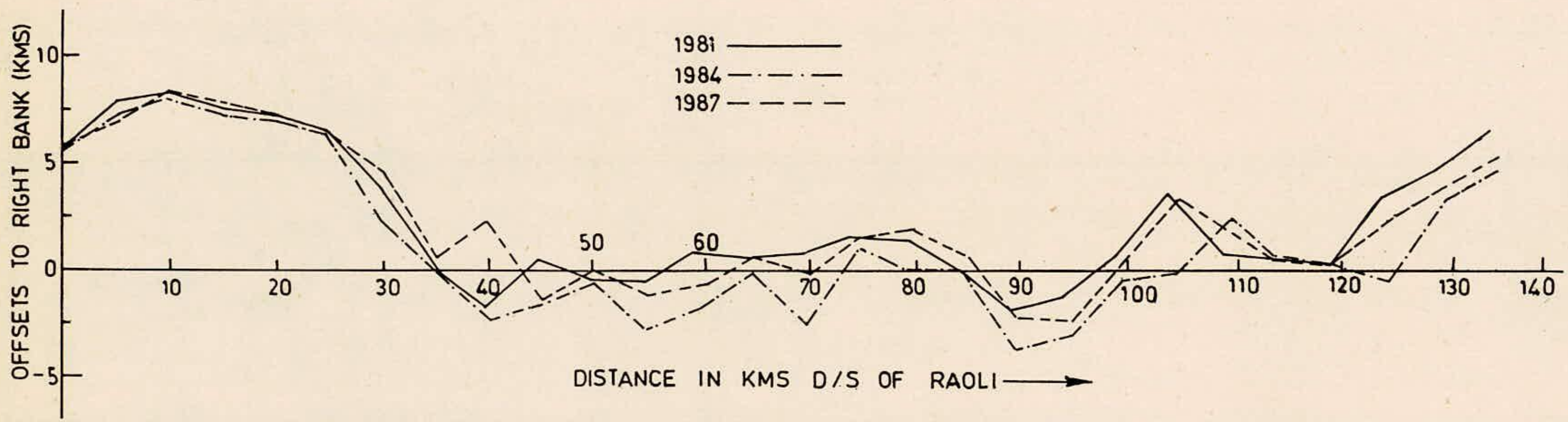


FIG.10 - SHIFTING OF RIGHT BANK

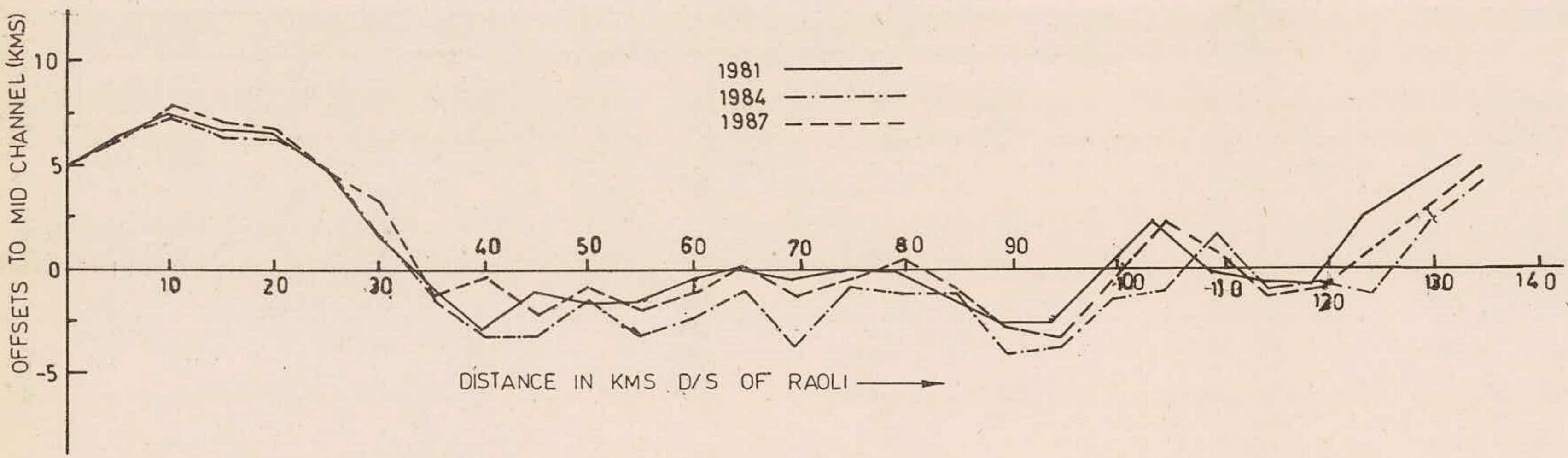


FIG. 11 - SHIFTING OF MID CHANNEL

TABLE-4

CHANGE IN FLOOD PLAIN BOUNDARY AND FLOOD PLAIN AREA

DISTANCE FROM RAOLI IN KM	OFFSET TO FLOOD PLAIN BOUNDRY(KM)									CHANGE TILL 1984 (KM)KM			CHANGE TILL 1987 (KM)		
	RECENT FLOOD PLAIN BOUNDRY ON LEFT			RECENT FLOOD PLAIN BOUNDRY ON RIGHT			ANCIDENT FLOOD PLAIN BOUNDRY			RECENT LEFT	RECENT RIGHT	ANCIENT	RECENT LEFT	RECENT RIGHT	ANCIDENT
	1981	1984	1987	1981	1984	1987	1981	1984	1987						
0.0	1.5	0.25	1.75	10.0	11.25	10.25	-	-	-	-1.25	1.25	-	0.25	0.25	-
5.0	0.25	1.0	1.25	9.5	10.75	10.5	-	-	-	0.75	1.25	-	1.0	1.0	-
10.0	-0.5	-1.25	-0.75	9.5	10.25	9.5	-	-	-	- 0.75	0.75	-	-0.25	0.0	-
15.0	-1.75	-1.50	-1.0	9.25	10.25	9.0	-	-	-	0.25	1.0	-	0.75	-0.25	-
20.0	-5.0	-4.75	-3.75	12.25	12.75	12.79	-	-	-	0.25	0.50	-	1.25	0.50	-
25.0	-5.0	-4.75	-4.75	8.75	13.0	12.25	-	-	-	0.25	4.25	-	0.25	3.5	-
30.0	-5.25	-5.0	-5.0	8.0	9.5	7.75	14.0	14.25	14.25	0.25	1.5	-0.25	0.25	-0.25	-0.25
35.0	-6.5	-7.0	-8.0	5.5	5.75	5.0	15.0	12.25	15.0	-0.5	0.25	-2.75	-1.5	-0.5	0.0
40.0	-6.5	-7.0	-6.5	6.25	7.25	6.75	14.0	14.5	14.5	-0.5	1.0	0.5	0.0	0.5	-0.5
45.0	-8.0	-8.0	-7.5	4.25	6.0	3.0	13.75	13.25	13.0	0.0	1.75	-0.5	0.5	-1.25	-0.75
50.0	-7.5	-8.75	-8.0	7.75	6.25	7.5	14.75	15.0	14.75	-1.25	-1.5	0.25	-0.5	-0.25	0.0
55.0	-8.0	-8.75	-7.75	5.25	6.0	6.25	17.75	14.0	16.5	-0.75	0.75	-3.75	0.25	1.0	-1.25
60.0	-7.0	-7.0	-7.25	7.5	7.0	7.75	19.0	16.0	17.25	0.0	-0.5	-3.0	-0.25	0.25	-2.25
65.0	-6.25	-7.5	-6.25	7.25	5.75	6.0	18.0	16.75	18.25	-1.25	-1.5	-1.25	0.0	-1.25	-0.25
70.0	-6.25	-7.25	-6.75	7.0	6.0	7.0	18.0	17.125	18.0	-1.0	-1.0	-0.875	-0.25	0.0	0.0
75.0	-4.25	-7.0	-6.5	8.0	7.25	7.5	20.25	18.5	20.0	-2.75	-0.75	-1.75	-2.25	-0.5	0.25
80.0	-1.75	-2.0	-1.0	10.0	7.0	9.0	21.5	19.75	21.75	-0.25	-3.0	-1.75	0.75	-1.0	0.25
85.0	-2.75	-4.0	2.75	10.25	8.5	10.0	22.0	21.0	24.25	-1.25	-1.75	-1.0	-5.5	-0.25	2.25
90.0	-3.5	-4.5	-3.25	10.5	9.0	10.75	21.75	21.0	24.25	-1.0	-1.5	-0.75	0.25	0.25	2.5
95.0	-3.75	-4.5	-4.0	11.75	10.75	12.0	26.75	21.0	24.25	-0.75	-1.0	-5.75	-0.25	-0.25	-2.5
100.0	-1.75	-5.0	-3.25	13.5	10.75	12.0	25.25	23.75	25.75	-3.25	-2.75	-1.5	-1.5	-1.5	0.50
105.0	-0.75	-1.75	-0.25	16.25	13.25	15.75	27.0	26.0	27.75	-1.0	-3.0	-1.0	0.50	-1.25	0.75
110.0	-3.0	-1.50	-2.25	17.25	16.75	16.75	29.0	28.0	29.0	1.50	-0.5	-1.0	0.75	-0.5	0.0
115.0	-2.75	-3.0	-3.25	19.25	19.0	20.0	30.5	30.0	30.5	-0.25	-0.25	-1.5	-0.5	-0.75	-1.0
120.0	-1.50	-1.25	-2.0	22.25	20.25	21.25	30.25	30.0	30.15	0.25	-2.0	1.75	-0.5	-1.0	-0.5
125.0	1.75	1.75	-0.5	21.25	23.5	22.0	32.5	30.25	32.75	0.0	2.25	-2.25	-1.25	-0.75	0.0
130.0	3.5	1.25	2.0	25.5	21.0	25.0	33.0	32.75	32.0	2.25	-4.5	0.75	1.5	-0.5	0.0
135.0	4.75	-3.5	4.25	26.75	27.0	28.0	34.75	34.0	35.0	1.25	0.75	-0.75	-0.50	-1.75	0.25

TABLE-4 CONT.

DISTANCE FROM RAOLI (KM)	AREA IN RECENT FLOOD PLAIN (SQ. KM.)			AREA IN ANCIENT FLOOD PLAIN (SQ.KM.)			CHANGE IN FLOOD PLIAN AREAS BETWEEN CHANNEL SEGMENTS (SQ.KM.)			
							RECENT FLOOD PLAIN		ANCIENT FLOOD PLAIN	
	1981	1984	1987	1981	1984	1987	1984	1987	1984	1987
0.0										
	43.812	56.817	42.1562	-	-	-	8.062	-6.656	-	-
5.0										
	60.156	66.8435	58.5		-	-	6.687	- 1.656	-	-
10.0										
	60.375	63.937	55.687	-	-	-	3.562	-4.687	-	-
15.0										
	70.625	80 437	79.5	-	-	-	9.812	8.875	-	-
20.0										
	93.000	105.75	96.312	-	-	-	12.75	3.312	-	-
25.0										
	87.750	92.718	74.375	-	-	-	4.968	-13.375	-	-
30.0										
	94.625	93.375	103.0	54.25	39.375	66.0	0.75	8.375	-14.875	11.75
35.0										
	80.437	77.625	98.435	51.118	51.160	66.5625	-2.812	18.0	-0.02	15.37
40.0										
	74.375	84.75	59.375	39.812	43.576	44.375	10.375	15.0	3.69	4.56
45.0										
	81.875	87.0	74.75	45.375	48.60	49.593	5.125	-7.462	3.23	4.21
50.0										
	83.750	85.531	99.565	48.75	48.156	59.0635	1.781	15.812	-0.59	10.31
55.0										
	77.625	78.093	79.75	71.156	42.968	54.31	0.468	2.125	-28.19	-16.84
60.0										
	83.250	70.625	71.535	61.187	50.093	57.09	-12.625	-11.718	-11.90	-4.10
65.0										
	100.312	86.125	107.25	81.562	71.906	73.84	-14.187	6.937	-9.65	-7.72
70.0										
	63.75	85.937	72.843	58.25	69.921	60.378	22.187	9.093	11.67	2.13
75.0										
	69.0	66.437	69.0	68.281	69.0	72.593	-2.156	0.0	0.72	4.31
80.0										
	86.75	56.437	62.562	63.50	65.981	74.25	-30.312	-24.187	2.48	10.75
85.0										
	73.75	74.75	70.218	61.25	70.437	72.84	1.0	-3.531	9.19	11.59
90.0										
	83.687	71.875	75.0	68.906	55.625	58.125	-11.812	-8.187	-6.09	-10.71
95.0										
	94.656	96.875	97.656	76.906	72.656	69.375	2.218	3.0	-20.75	-7.53
100.0										
	94.937	92.25	78.125	63.25	77.25	66.00	2.687	-16.812	-14.87	2.75
105.0										
	117.25	95.593	123.75	63.50	69.0	64.275	21.656	6.5	5.5	0.77
110.0										
	127.718	125.781	125.781	66.131	66.406	62.431	-1.937	-1.937	0.28	-3.70
115.0										
	114.375	113.937	116.25	56.625	56.975	52.125	19.562	1.875	0.36	-4.50
120.0										
	151.562	116.875	137.25	40.875	40.00	42.125	34.687	-14.312	46.87	-4.75
125.0										
	133.5	129.375	130.812	47.25	53.187	48.125	-4.125	-2.687	5.937	0.875
130.0										
	91.906	118.937	134.406	35.531	51.56	41.375	27.031	42.5	16.03	5.84
135.0										

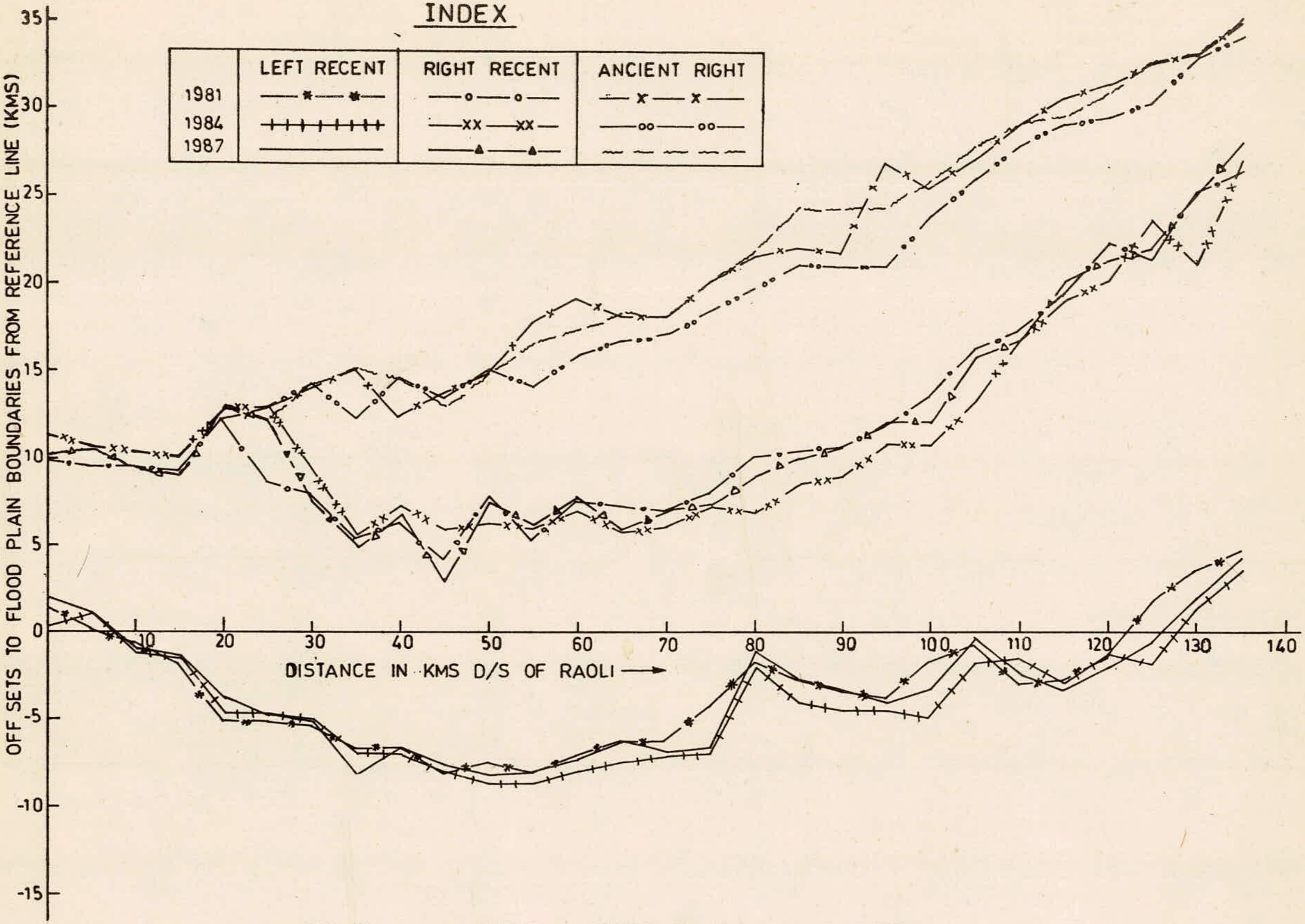


FIG. 12— CHANGES IN FLOOD PLAIN BOUNDARIES

8.0 CONCLUSION

The floodplain studies using visual interpretation are one of the operational uses of remote sensing. Floodplain boundaries are very distinctly visibly on imagery. From this study it is concluded that multidate imagery could provide temporal information thus facilitating change detection. Once areas subjected to appreciable changes are detected detailed investigation could be undertaken using aerial photographs and ground surveys.

Some of the specific findings of the study are mentioned below:

1. Maximum channel shifting was about 3.75 km. between 1981-84 and 1.25 km between 1984-87.
2. The channel area showed -4.03 percent change in period 1981-84 and + 4.78 percent during the period 1984-87.
3. Change in flood plain area was -0.11 percent during the flood 1981-84 and it is as -0.14 percent during the period 1984-87.

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