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Creation of Hydrogeomorphological Map from Satellite Imagery for Ground Water Prospect Evaluation: A Case Study from Harishchandrapur, West Bengal

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ABSTRACT - Ground water is an important source of water supply throughout the world. Seasonal fluctuation of ground water table leads to many problems to mankind. Such problems are much pronounced in the northern part of West Bengal i.e. Malda District. The area comprises of many geomorphic features such as channel bar, alluvial plain, levee etc. To address the problems an attempt has been made by creation of hydrogeomorphological map of ground water potential using remote sensing data which acts as a very useful guide and an efficient tool for regional and local ground water exploration, in a cost effective manner.The entire study has been carried out in and around Harishchandrapur, Malda district, West Bengal, which represents the above mentioned problem more prominently.

In the present work, various aspects, including the geomorphologic, lithological and finally hydrogeomorphological maps have been prepared from Remote Sensing data by using an Image Processing and GIS (Geographic Information System) software to find out the ground water potential zones of the study area and thereby manage the ground water resource. Later the analyzed data were validated by field work. The field work was conducted in order to collect ground truth information. Ground water table measurement has been performed from the domestic wells. Finally a ground water prospect map was generated. After integrating all the results, it provided that the channel bars and palaeochannels of flood plain have excellent ground water potential, whereas back swamps have very poor potential. Overall alluvial plain younger have more potential than alluvial plain older and flood plain region has very good ground water potential.

Keywords: Geomorphology, GIS, Groundwater resource management, Hydrogeology, Remote Sensing

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1.0 Introduction:

Ever increasing demand for ground water resources in a region with limited renewable potential poses a serious threat to development activities of that region. This precious resource therefore needs to be evaluated properly and therefore manage the resource judiciously for sustainable development.

To address the challenges, an attempt has been made to optimize the ground water resource management using remote sensing, GIS techniques and groundtruthing. The present study has been carried out in and around Harishchandrapur, Malda District, West Bengal, India (Fig. 1). The study area is located between 25º30´N to 25º15´N latitude and 87º45´E to 88º E longitudes. The study area lies in flat Quarternary alluvium terrain, and the overall slope is towards south. The geological setting of the area is a result of the tectonic history and subsequent sedimentation in the Garo-Rajmahal Gap, which divides the Bengal Basin into a northern foredeep in front of the Himalayas and a southern delta (Dasgupta, 1997). The area is thus covered by Quaternary alluvium of two different ages: the Older (Barind) Alluvium and the Newer (Rarh) Alluvium (Pal and Das, 1992; Deshmukh, 1973). The objectives of the study are preparing a) lithological map, b) geomorphological map and c) integrated hydro-geomorphological map for ground water potential to establish the prospective zones.

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1.1 Application of Remote Sensing Images in Ground water exploration

The surface morphological-hydrological-geological regime, which primarily governs the subsurface water conditions, can be well studied and mapped on remote sensing data products (Jensen, 2005). Therefore, remote sensing acts as a very useful guide and an efficient tool for regional and local ground water exploration, particularly as a fore-runner in a cost effective manner.

2.0 Materials and Methods:

The present study was carried out using Satellite Remote Sensing data (Table-1) and GIS software which provide an opportunity for better observation and more systematic analysis of geological structure and geomorphic feature, hydro-geomorphic unit, land forms etc. over a large area. The workflow of the present study covers the following major steps: georeferencing, dizitization, map preparation which are shown in Fig. 2. Further an intensive fieldwork was conducted in and around Harishchandrapur in order to collect ground truth information. The varied land forms were traversed and several geomorphologic features have been observed throughout the studied area.

2.1 Drainage and Geomorphological map

Fig. 3 and 4 shows the dominance of flood plain of the Kalindri river and its tributaries which are running from north to south. The channel is highly meandering as evidenced by the dominance of oxbow lakes and cut-off meanders. Along the sides of the Kalindri river, many linear sand bars called channel bars and crescent shaped sand bars called point bars are present throughout the channel. Visible water bodies like back swamps are also found which bears some remnant water in rainy season and are dry for rest of the year may be covered by vegetation.

2.2 Lithological map

Based on physiographic map, field work and alluvium types, the study area has been divided into three distinct zones viz. Flood Plain, Alluvial Plain Younger and Alluvial Plain Older (Fig. 5). In line with the background information, the lithology for each geomorphic feature is shown in the Table-2.

2.3 FCC analysis

This study is based on elements of photo recognition and geotechnical elements. The digitized map is analyzed in geomorphologic perspective. Based on FCC, different geographical and geological information can be identified (Table-3).

2.4 Visual interpretation

A systematic study of remote sensing image usually involves several basic characteristics of features shown on images. These few features are very important for image analysis. The interpretations are based on elements of photo recognition and geotechnical elements. Many applications of visual interpretation require use of multiple images (we can use different scales, color, image).Personal experience about features of the earth surface is very important in case of visual interpretation. Many earth surface features of interest can be identified, mapped, and studied on the basis of their spectral characteristics. Based on FCC, different geomorphic units and landforms were identified (Table-4).

2.5 Ground Truthing (Field Work)

Ground truth implies reference for field data collection to control and help remote sensing image interpretation. In the early days of remote sensing research, ground investigations were used to verify the results of remote sensing interpretation e.g. lithology, soil type, condition of agricultural crops, water bodies etc. Hence the term ground truth came into vogue.

The main purposes of the field data collection are as follows:

To compare remote sensing data and field observations.

To help in remote sensing data collection, analysis and interpretation.

To verify the thematic maps generated from remote sensing.

The fieldwork was undertaken in the study area to collect ground truth information. Results were validated with the remote sensing data. Based on the image, the interpretation key for classification of water bodies, geomorphologic features, lithology, habitation, land use etc were identified and ten different patterns were marked on the image. The doubtful areas (due to spectral response and spectral signature) were identified during the preliminary image classification and were listed out before ground verification. After finalizing the ground traverse plan, the doubtful areas were noted.

Based on the ground information collection, corrections, modifications of misclassified objects and doubtful areas, further analysis was carried out on enhanced imageries for final classification.

Ground water table measurements has also been performed from the domestic wells and compiled with field data. The ground measurements have been taken during the field work. The data collected from domestic dug wells and tube wells. It is observed that groundwater occurs under unconfined condition in a thick (108 –117 m) zone of saturation within the alluvial sediments. At the upper part of the sedimentary column (within a depth of 10 m) there is a mixture of silt, clay and fine sand. Below this there is a thick sandy horizon comprising fine to coarse material. Based on the data collections from hand pump domestic wells, it is inferred that the potential aquifers occur in the depth range of 44 m - 69 m and 73 m - 89 m where coarse sand and gravel is encountered.

2.6 Validation with Remote Sensing data and Field information

At Basant Narahatta, it is found that the area between Kalindri and Mahananda river is flood plain. In the satellite imagery the similar geomorphic feature has been observed as bluish tone. One levee system was found along the Mara Mahananda River. In the satellite imagery it appears in Reddish tone. Thus bluish tone in the imagery is indicative of flood plain and reddish tone is for Levee system. Similarly, all the other geomorphic features were validated.

3.0 Result and discussion:

After analyzing the Remote Sensing data, multiple geomorphic features have been identified. Detailed image analysis reveals that the overall study area falls within alluvium (both older and younger alluviums) and flood plain region. The flood plain is present extreme west of the study area. Furthest towards east of the flood plain region there is a patch of older alluvium. Rest of the area is covered by younger alluvium. There are multiple water bodies with various shape and sizes throughout the region, like oxbow and serpentine lakes. This area is also characterized by few paleochannels and numerous natural levees. Both braided river and meandering river profile is present. Few Meandering scars were found to occur in this region. The streams have switched over to new courses, leaving many dead or dying channels that only retain water flow during the monsoon. Consequently, the study area is strewn with innumerable marshes, back swamps, lakes, and oxbow lakes. Interbraided streams with multiple channels occur quite commonly along the Kalindri river. Because of lack of gradient and consequently of runoff, most of the floodplain region remains submerged under considerable depths of water during the monsoon. Apart from the features identified from satellite imagery, many other geomorphic features were observed during the course of field work. The presence of significant point bars and channel bars indicate the meandering nature of the Kalindri river. Both the analyses were integrated to create the hydrogeomorphological map (Fig. 6).

The overall study reveals that visible water bodies are less potential for groundwater. This is due to the fact that as clay is impermeable and does not allow water to seep to the lower layers thus water is retained in the streams, channels and water bodies. In areas where water can percolate in, there they are stored as groundwater as subsurface water. The groundwater potential of the area depends on the lithology of each geomorphic unit in that area and hence shows a gradation of groundwater potential, highest in coarser size i.e. sand and lowest in finer size i.e. clay. The study also depicts that the channel bars and palaeochannels of flood plain have excellent ground water potential, whereas back swamps have very poor potential. Overall alluvial plain younger have more potential than alluvial plain older and flood plain region has very good ground water potential (Fig. 6).

The present ground water potential map will serve as a baseline data for the future development and management of water use strategies in the area. It can be concluded that remote sensing and GIS technology has great potential to revolutionize the ground water monitoring and management in the future by providing unique and new data to supplement the conventional field data.

References

[1] Dasgupta, A.B. (1997) Geology of Bengal Basin, Indian Journal of Geology, 69(2), 161-176.

[2] Deshmukh, D.S. (1973) Geology and Groundwater Resources of the alluvial

[3] Jensen, J.R. (2005). Digital Image Processing: a Remote Sensing Perspective (3rd ed.). Prentice Hall.

[4] Pal, S.K., and Das, A. (1992) Quaternary Geology and Geomorphology in parts

[5] http://www.malda.gov.in/

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Table 1: Satellite specifications parameter and toposheet details:

MATERIALS USED	DESCRIPTION OF THE DATA
REMOTE SENSING IMAGE	PATH:-107
IRS-P6 LISS III	ROW:-54
	DATE:-9TH, December,2005
PROJECTION INFORMATION	
a). PROJECTION	GEOGRAPHIC(LAT/LONG)
b). SPHEROID	CLARKE 1866
c). DATUM	CLARKE 1866
RESOLUTION INFORMATION	
a). SPATIAL RESOLUTION	23.5m
b). SPECTRAL RESOLUTION	4 Spectral Wavelength
c). RADIOMETRIC RESOLUTION	8 bit
d).TEMPORAL RESOLUTION	21 DAYS
SOI TOPOSHEET NO.	78C/3
SCALE	1:50,000

Table 2: Lithology of each geomorphic unit:

GEOMORPHOLOGY AND CODE	CODE AND LITHOLOGY OF SOIL
FLOOD PLAIN(FP)	11(Sand & Silt dominated)
1.Channel Bar(CB)	11(Sand dominated)
2.Point Bar(PB)	11(Sand dominated)
3.Oxbow Lake(OL)	13(Sand & Clay alt bands)
4.Backswamp(BS)	12(Clay dominated)
5.Natural Levee(NL)	11(Silt dominated)
6.Palaeochannel(PC)	11(Sand dominated)
7.Cut-Off Meander(CM)	13(Sand & Clay alt. bands)
ALLUVIAL PLAIN YOUNGER(APY)	13(Sand-Silt-Clay alt. beds)
1.Channel Bar(CB)	11(Sand dominated)
2.Cut-Off Meander	13(Sand & Clay alt. bands)
3.Oxbow Lake(OL)	13(Sand & Clay alt bands)
4.Backswamp(BS)	12(Clay dominated)
5. Natural Levee(NL)	11(Silt dominated)
6.Palaeochannel(PC)	11(Sand dominated)
ALLUVIAL PLAIN OLDER(APO)	12(Clay dominated)
1.Alluvial Plain Older-Ferricrete(APO)	1201(Clay dominated with Iron)

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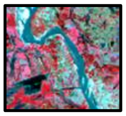
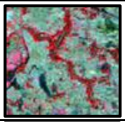
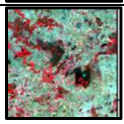
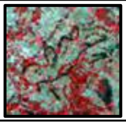
Table 3: The table represents different geomorphic feature based on FCC.

Geomorphic feature	Tone	Texture
Meander Scar	Whitish tone	Moderately Smooth
Palaeochannel	Bright red tone	Smooth
Channel Bar	White tone within river channel	Very smooth
Point Bar	White tone at the convex side of the river channel	Very smooth
Ox-bow lake	Shades of blue and bright red somewhere (water on surface)	Smooth
Serpentine Lake	Moderately bright (water on surface)	Moderately smooth
Back swamp	Dark tone with bright red tone somewhere	Smooth
Natural Levee	Bright red tone	Coarser

Table 4: Identifications of various geomorphic features

Sl No.	Geomorphic Feature	Description	Figure
1	Point bar	Sand bar formed at the convex side of meandering river by lateral accretion of sediments.	
2	Channel bar	Sand bar formed in the braided river course due to vertical accretion of the sediments.	
3	Natural levee	Natural embankments formed by deposition of alluvium on river bank due to flooding.	
4	Back swamp	Depressions formed adjacent to natural levees in the flood plains of major streams or rivers.	
5	Oxbow lake	A lunate shaped lake located in an abandoned meandering channel.	
6	Palaeochannel	An earlier river course filled with channel fills or channel lag sediments, which is cut-off from the main river.	

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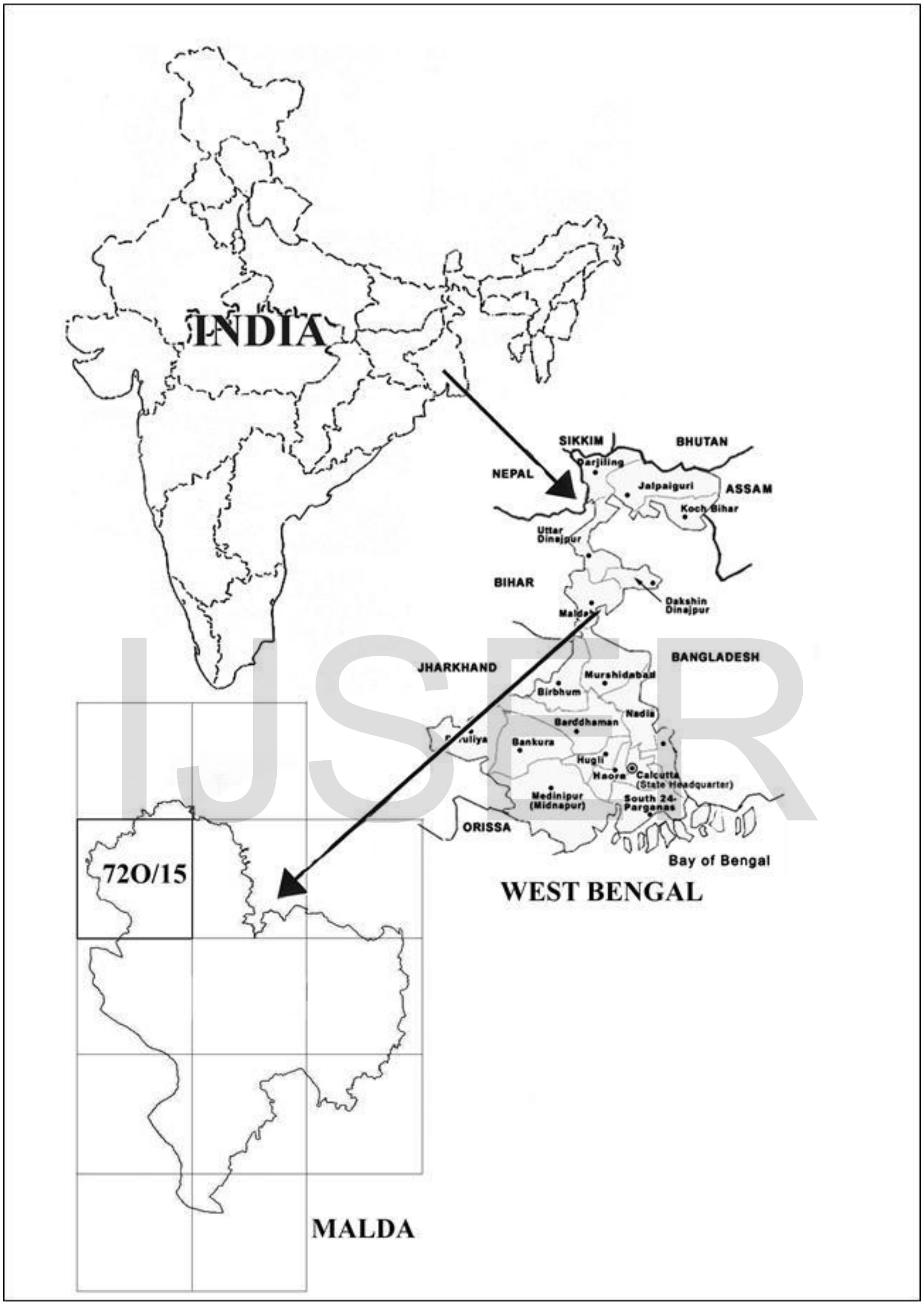

Fig. 1: Location map of the study area

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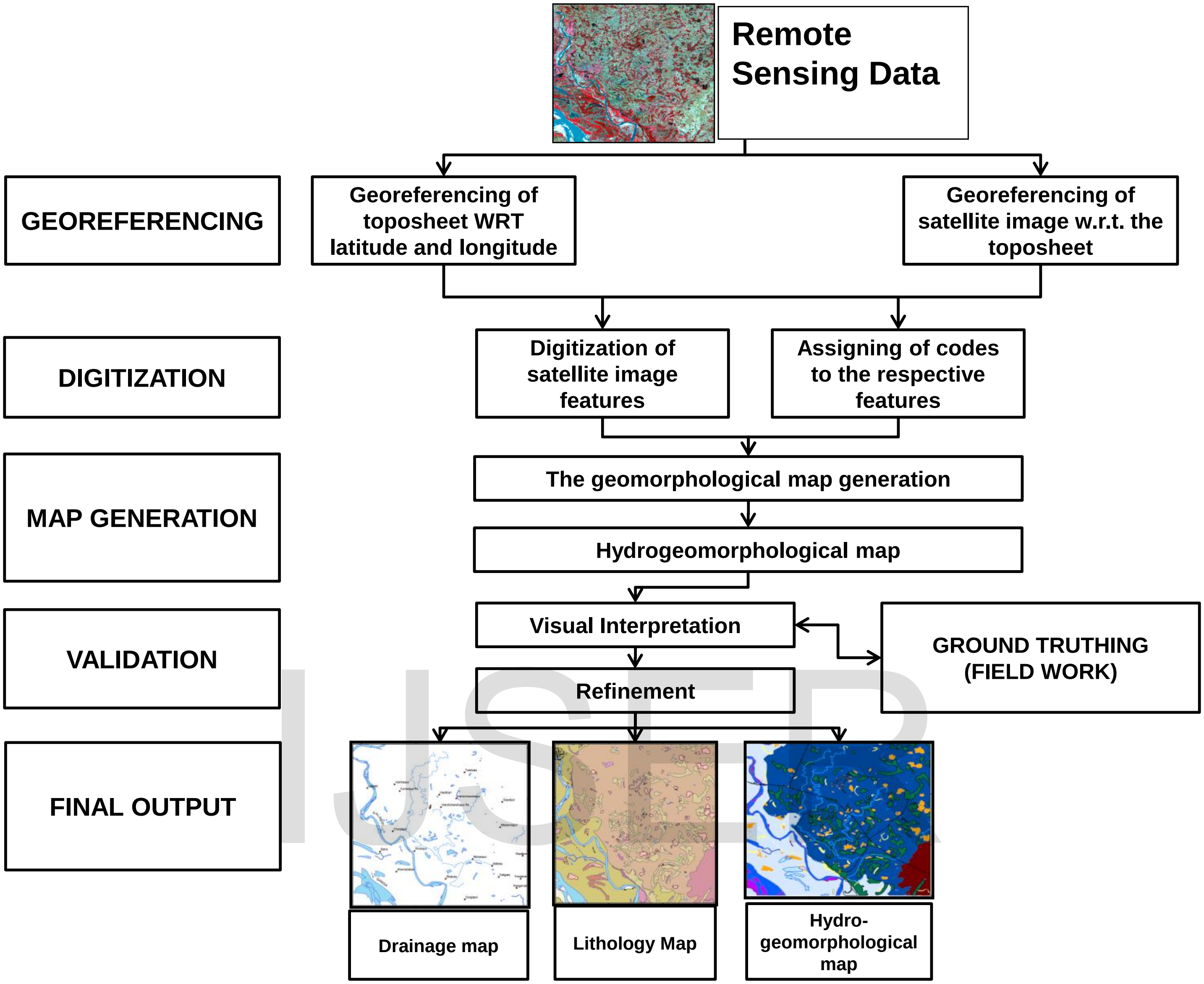

Fig.2: Workflow of the present study

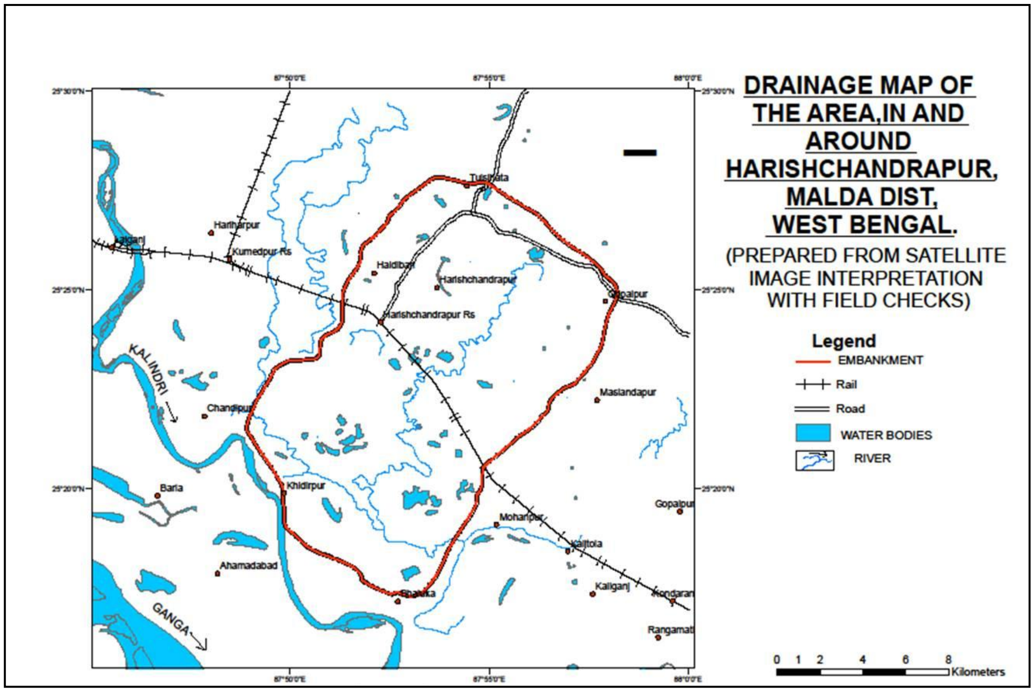

Fig. 3: Drainage map of the study area

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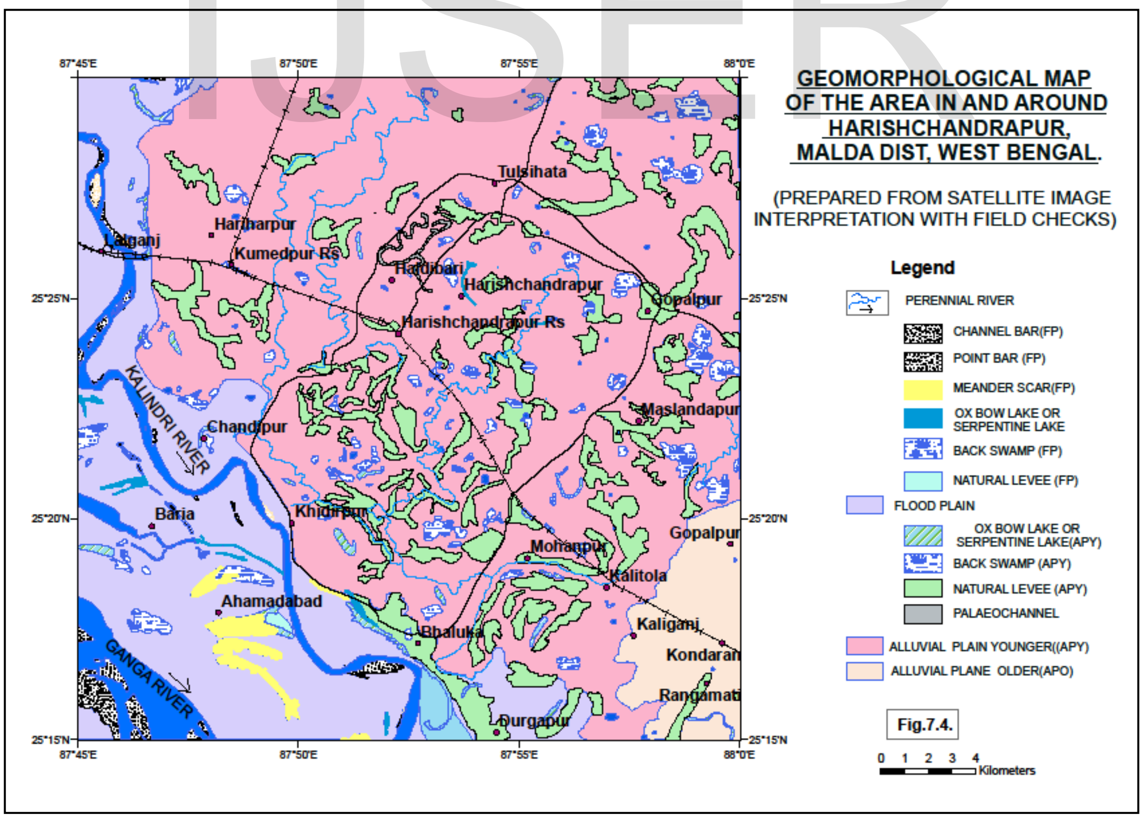

Fig. 4: Geomorphological map of the study area

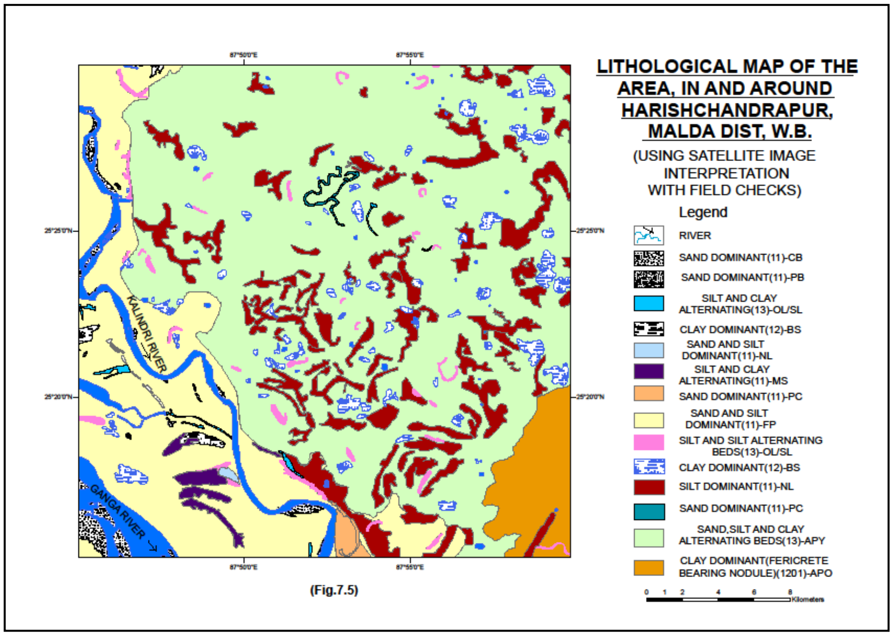

Fig. 5: Lithological map of the study area

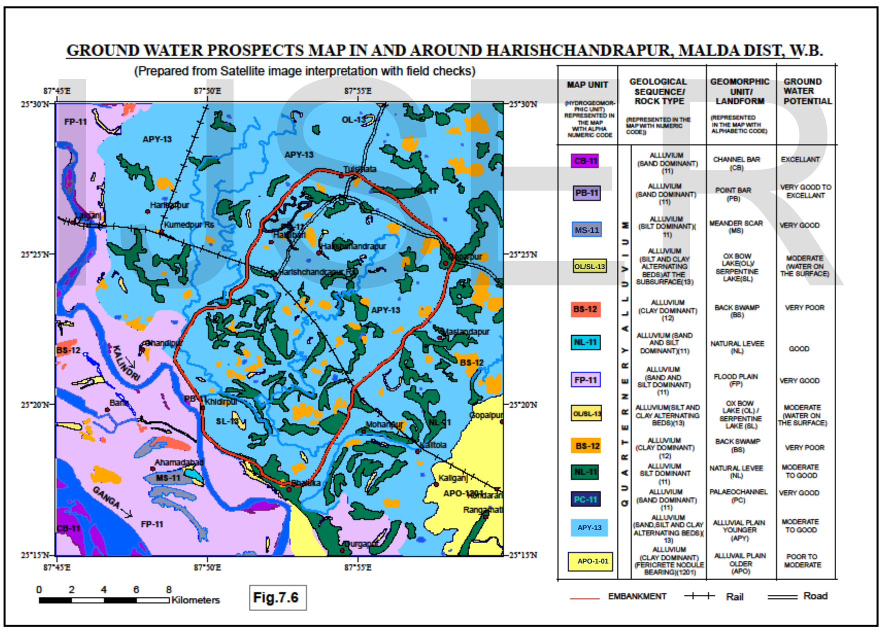

Fig. 6: Hydrogeomorphological map for Ground water prospect

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