

# Active Floodplain Mapping: *Defining the “River Space”*

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## GRB EMP : Ganga River Basin Environment Management Plan

*by*

Indian Institutes of Technology



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## Preface

In exercise of the powers conferred by sub-sections (1) and (3) of Section 3 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government has constituted National Ganga River Basin Authority (NGRBA) as a planning, financing, monitoring and coordinating authority for strengthening the collective efforts of the Central and State Government for effective abatement of pollution and conservation of the river Ganga. One of the important functions of the NGRBA is to prepare and implement a Ganga River Basin: Environment Management Plan (GRB EMP).

A Consortium of 7 Indian Institute of Technology (IIT) has been given the responsibility of preparing Ganga River Basin: Environment Management Plan (GRB EMP) by the Ministry of Environment and Forests (MoEF), GOI, New Delhi. Memorandum of Agreement (MoA) has been signed between 7 IITs (Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and MoEF for this purpose on July 6, 2010.

This report is one of the many reports prepared by IITs to describe the strategy, information, methodology, analysis and suggestions and recommendations in developing Ganga River Basin: Environment Management Plan (GRB EMP). The overall Frame Work for documentation of GRB EMP and Indexing of Reports is presented on the inside cover page.

There are two aspects to the development of GRB EMP. Dedicated people spent hours discussing concerns, issues and potential solutions to problems. This dedication leads to the preparation of reports that hope to articulate the outcome of the dialog in a way that is useful. Many people contributed to the preparation of this report directly or indirectly. This report is therefore truly a collective effort that reflects the cooperation of many, particularly those who are members of the IIT Team. Lists of persons who are members of the concerned thematic groups and those who have taken lead in preparing this report are given on the reverse side.

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## 1. Introduction

A river must have 'adequate space' to perform its myriad function. The river 'valley' and 'active floodplain' define that space for the river albeit with different functionality. It is important that the functionality of the river valley and floodplains are recognized and documented properly for a sustainable river management. For example, a river with a complete floodplain is not just considered as the one in equilibrium but also in good health. Floodplains support a wide variety of rich life forms ranging from riparian vegetation to different species of organism which have a direct influence on soil fertility. Thus, these areas are good for agriculture due to its high nutrient content, and that is why, they are frequently occupied by local population at the cost of other ecosystems. Another important aspect of preserving river's active floodplain is that it reduces the risk to life and property due to annual flooding. It is therefore critical that the active floodplain of the river is mapped accurately as this will have an important bearing on the restoration of the naturalness of the river.

An obvious question is, what is active floodplain of the river, and how to define this? A river floods when it crosses the bank-full stage. Active floodplain is defined as an area on either side of a stream/river which is regularly flooded on a periodic basis. A typical hydrological criterion to designate an active floodplain in a given reach is the 2.33 year return period of the flood. A river valley is a wider and more extensive area which is primarily defined on the basis of a topographic low across the river. The course of the river may not be necessarily symmetric to its valley.

This report presents a first order assessment of the active floodplain of the main Ganga channel based on satellite data which needs to be validated through field checks. Identification of the valley margin of the river and the present and suggested usage of the valley as well as floodplains will be done subsequently.

## 2. Data used and Methodology

The following data and criteria are used for mapping the active floodplain:

**i) *Landsat 4-5 TM with 30 m resolution and 7 bands.***

It was observed that the 7 band combination for Landsat provides a distinct tone for high moisture content area. Figure 1a shows Landsat (2003) imagery of Kanpur area on which the active floodplain has been mapped. Figure 1b shows the Landsat (2010) data for the same area when a large flooding occurred in this region and this validates the geomorphic delineation of the active floodplain.

**ii) *IRS P6 AWIFS data with 56 m resolution and 4 bands.***

For the AWIFS data, the band combination of 432 was found suitable for interpretation. Further, the AWIFS data was processed to generate a Tasseled cap and NDWI imagery. In NDWI the formula that was used was  $(NIR - Green)/(NIR + Green)$  while for tasseled cap the default coefficients were used as in ERDAS. Both

these images have a distinct tone for high moisture area. Figures 2a and 2b show the various ways as to how the AWIFS data was used for interpretation. Figures 3a is the grey scale image of AWIFS data which prominently show the water related features. Figure 3b shows the actual floodplain extent on the AWIFS data after collating all the information from the different imageries. Further, the plotting was corroborated by the flood inundation maps of the Dartmouth Observatory (<http://www.dartmouth.edu/~floods/hydrography>). Figure 3c shows a clipped window from this map for the Kanpur area.



Figure 1: (a) LANDSAT 2003 data showing the meander scroll and the stretch of Ganga upstream of Kanpur. The active floodplain of the river is shown with a dashed line. Note that the right bank of the river does not have any active floodplain whereas the left bank has a wide floodplain. (b) LANDSAT data of the Kanpur area during the flood of 2010.

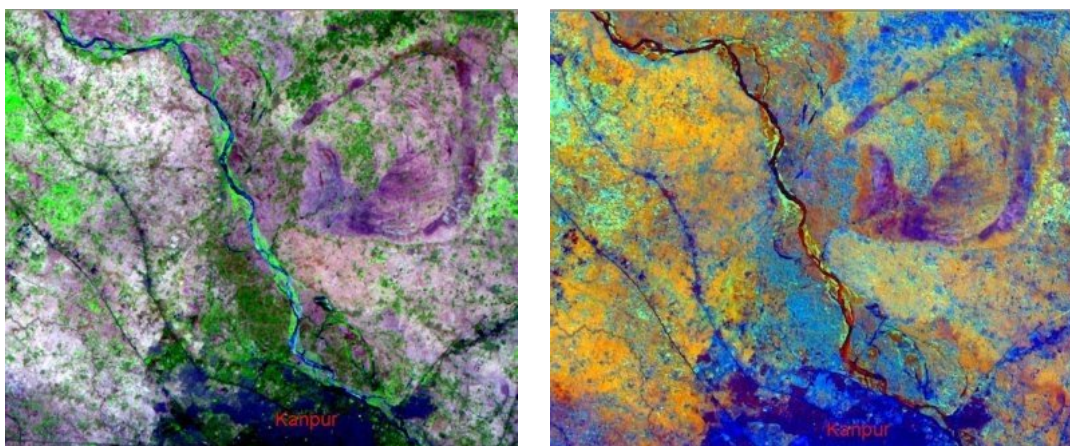


Figure 2: (a) AWIFS data for floodplain mapping; an FCC using 432 bands on RGB provided the best results, (b) Tasseled cap of the same area.

### iii) Google Earth

The Google Earth images are very useful in identifying and delineating features because of its high resolution. Figure 3d shows a snapshot of the Kanpur area for the year 2010.



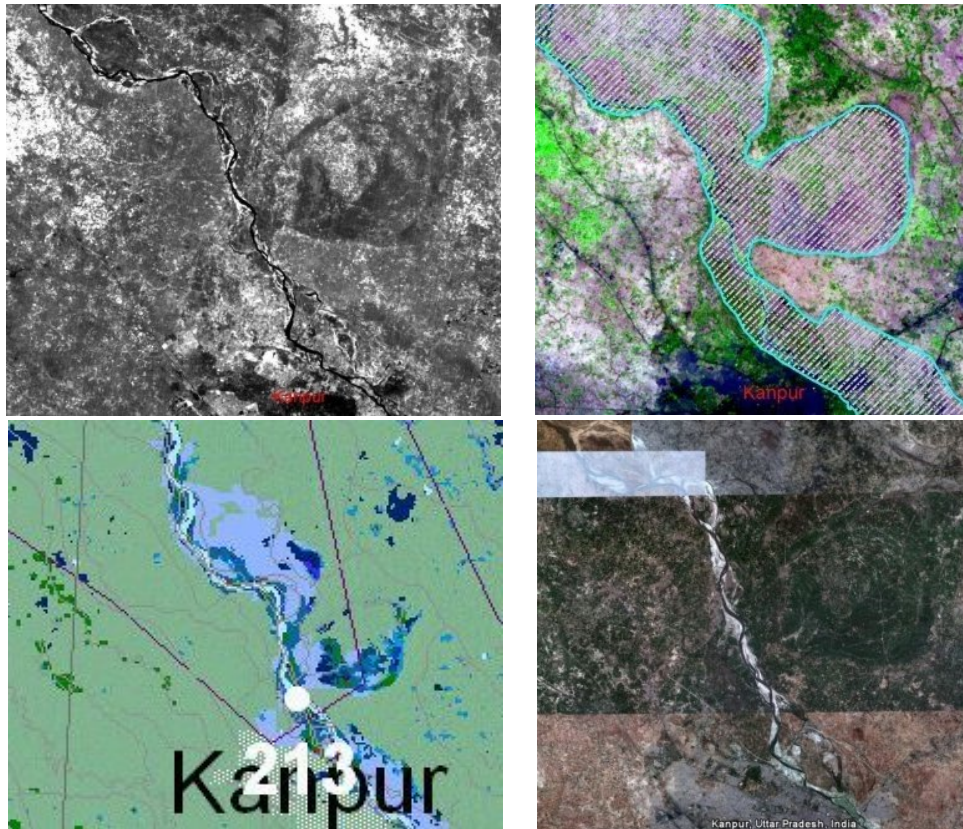


Figure 3: (a) NDWI (Normalized difference water index) map, (b) Actual floodplain mapping after integrating all the data, (c) MODIS data from the Dartmouth Flood observatory site for the Kanpur area, (d) Google Earth imagery of Kanpur

For mapping of geomorphic unit for a small window LISS IV data was used wherever available along with the LANDSAT data.

### 3. Result and Discussions

#### 3.1 Basin scale mapping

Figure 4 shows the active floodplain for the river Ganga from Haridwar to Farakka. The active floodplain from Haridwar to Farakka does not show any uniformity. At some sites, the floodplain is broad and at some other site it is narrow. In some cases, there is total absence of floodplain on one bank.

Based on distribution of active floodplain, the Ganga River can be divided into four distinct reaches between Haridwar and Farakka (the reaches upstream of Haridwar have not been mapped yet):

- (a) Haridwar to Narora: As soon as Ganga leaves the mountainous part and enters the plains downstream of Haridwar, the floodplain is quite wide (~28km). Around Bijnore (latitude 29°22' N and longitude 78°8' E) the floodplain width narrows down to ~ 10km. Further downstream, it becomes even narrower and at Narora barrage (Latitude 28°13' N and longitude 78°23' E) it is only about 5 km wide.

- (b) Narora to Kanpur: Downstream of Narora barrage the floodplain starts widening and at the confluence with Ramganga it attains a maximum width of ~28km. Further down the floodplain starts narrowing again and at upstream of Kanpur maximum width is ~15 km and downstream of Kanpur it is ~9 km.
- (c) Kanpur to Buxar: The floodplain starts narrowing down downstream of Kanpur to a minimum of about 1 km. As the river approaches Allahabad, the flood plain starts widening again and at Allahabad (Latitude 25°28' N and longitude 81°52' E) it is about 7.5 km. This width is more or less maintained with little variation till Buxar (latitude 25°33' N and longitude 83°59' E) after which the floodplain becomes very wide.
- (d) Buxar to Farakka: Downstream of Buxar the floodplain reaches the maximum width in the whole of the basin and just downstream of Munger (latitude 25°23' N and longitude 86°28' E) the width is about 42km and at Farakka (latitude 24°48' N and longitude 87°55' E) about 26km.

### 3.2 Detailed mapping for Kachla Bridge and Kanpur

Geomorphic units are the building blocks of river systems. They have a distinct morphology, bounding surface and sedimentological associations. These units tend to occur at distinct locations where particular sets of flow energy conditions create and modify their forms. Detailed mapping of major geomorphic units has also been initiated and some initial results for the stretch of Ganga in and around Kachla bridge (latitude 27°56' N and longitude 78°52' E) and Kanpur (latitude 26°25' N and longitude 80°20' E) are presented.

Two geomorphic units are mapped, instream and floodplain. The different elements that were distinguished are shown in the Figure 5 for Kachla bridge and Figure 6 for Kanpur.

- (a) In-stream geomorphic unit: The most common instream geomorphic units are accumulation of deposits referred to as bars. They are produced as rivers rework their bed material. Flow strength, material type and availability along with vegetation determine the type of depositional feature that will be formed. The different elements that were identified include (a) Mid channel bars, (b) Point bars, and (c) Lateral bars.
- (b) Floodplain geomorphic unit: These units reflect river history and channel stability indicating the relationship among a range of floodplain formation and reworking processes. Two major elements that were identified include (a) Meander scroll, and (b) Flood channel.

## 4. Ongoing Work

Similar mapping work for the remaining part of the main Ganga River and other major tributaries is in progress. These maps will provide the basic framework for the River style Framework which may be used for the assessment of geomorphic condition of the river.

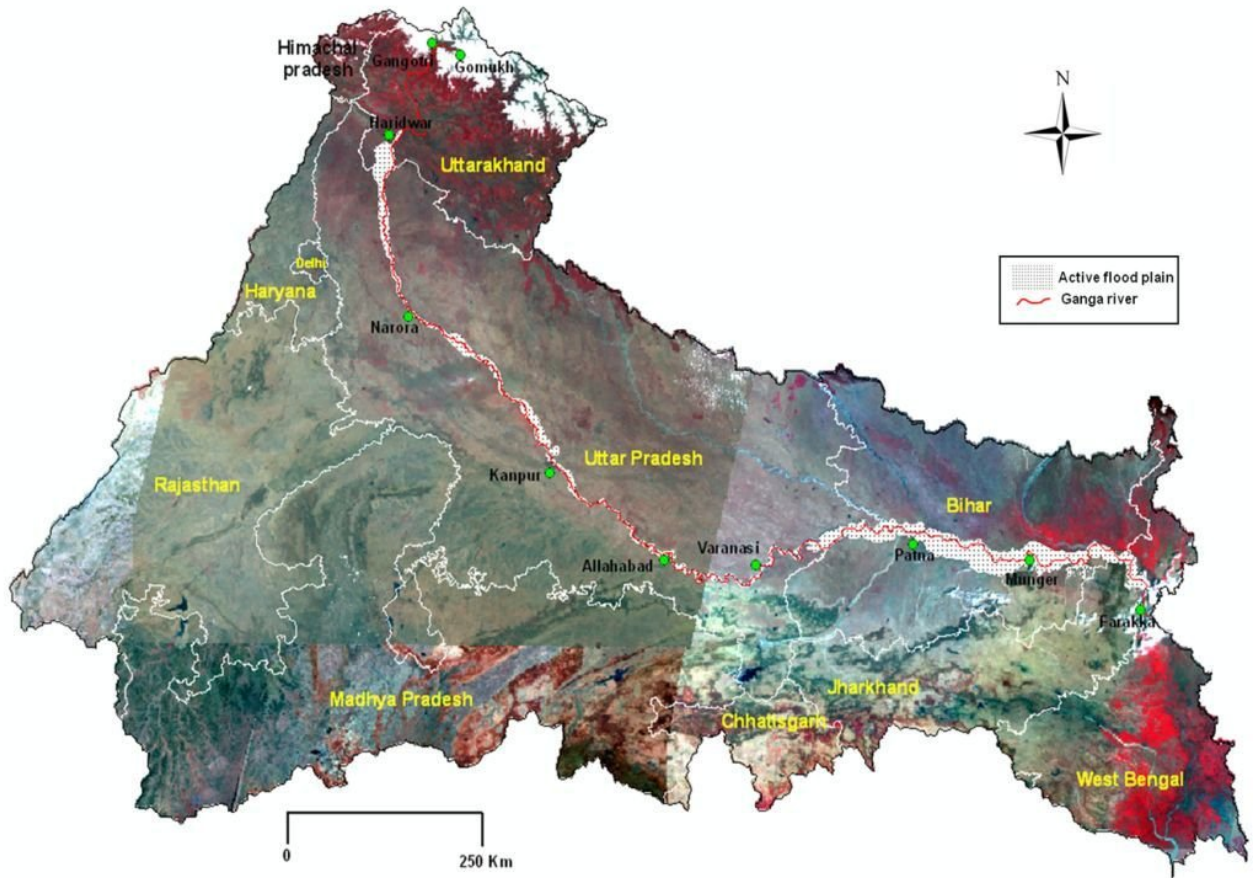


Figure 4: Ganga Basin boundary map showing the major states, the river Ganga and the active floodplain associated with it on AWIFS



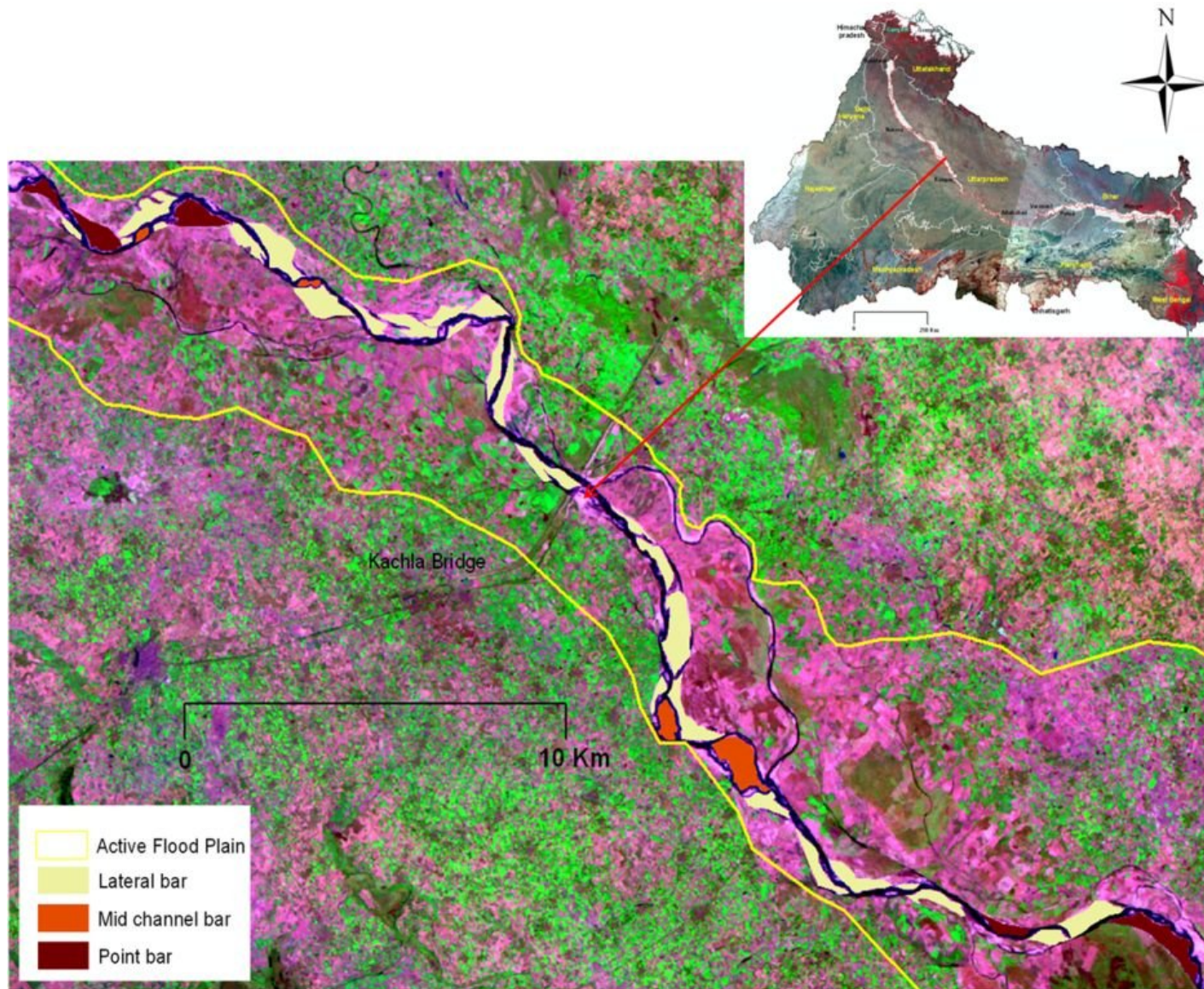


Figure 5: Enlarged view of the stretch of Ganga around Kachla Bridge plotted on Landsat 2010 data



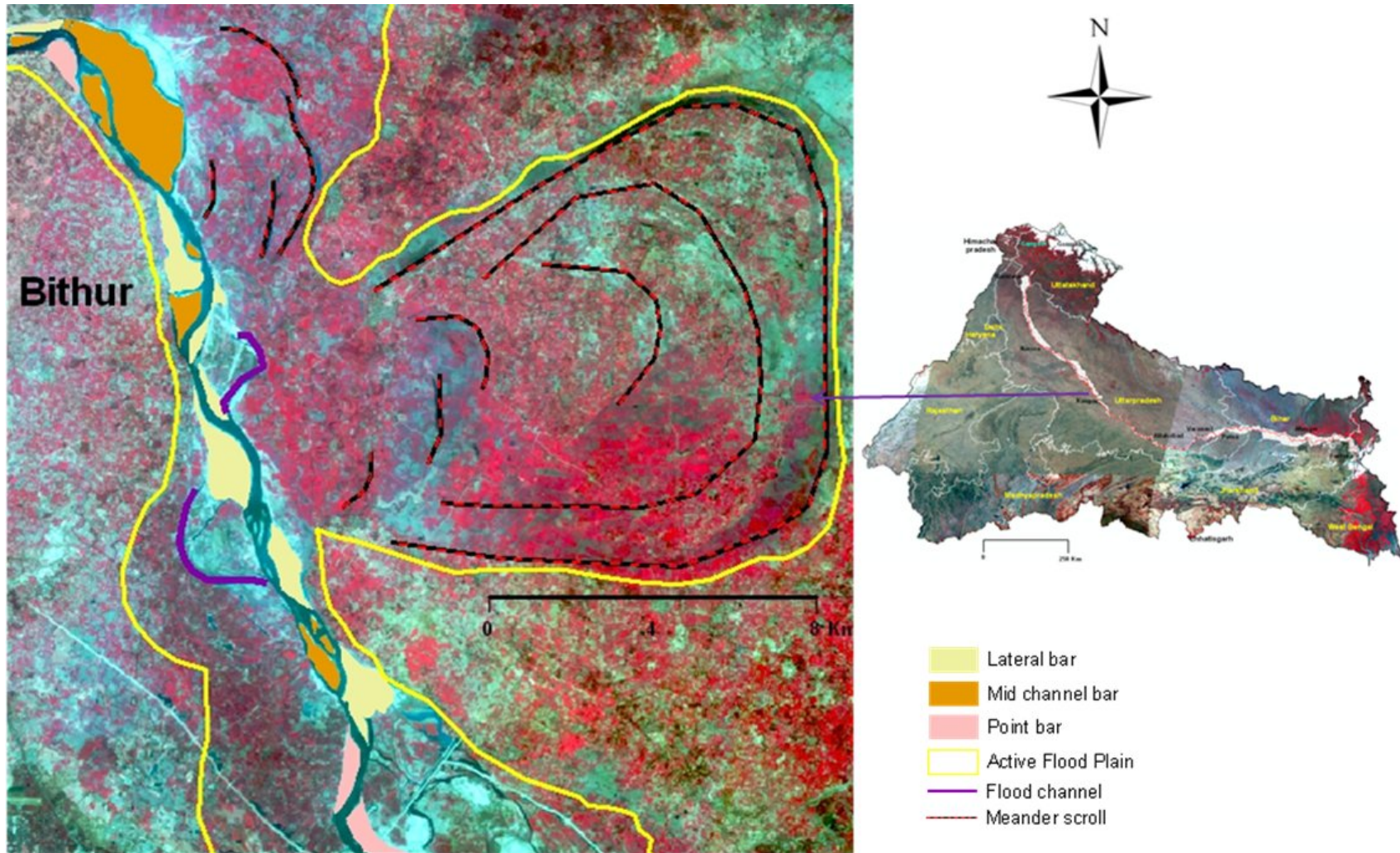


Figure 6: Enlarged view of the stretch of Ganga around Kanpur with the major geomorphic elements plotted on LISS IV 2007 data.