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On

Morphological Study of River Mahanadi using Remote Sensing Technique

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Preface

Morphology of rivers is a field of science which deals with the change of river plan form and cross sections due to sedimentation and erosion. In this field, dynamics of flow and sediment transport are the principal elements. The morphological studies, therefore, play an important role in sustainable river management & restoration structures as well as for mitigating flood risk and geomorphic hazards. From a scientific and rational approach to different river problems and proper planning and design of water resources projects, an understanding of the morphology and behaviour of the river is a pre-requisite.

The morphological studies on various Indian rivers using remote sensing techniques are an important requirement for the Central Water Commission (CWC), Government of India and other State Water Resources Departments. The use of remotely-sensed data in natural resource mapping and as a source of input data for environmental process modeling has been popular in recent years. With the availability of remotely-sensed data from different sensors of various platforms with a wide range of spatiotemporal, radiometric and spectral resolutions has made remote sensing as, perhaps, the best sources of data for large scale applications and study.

The Department of Civil Engineering and the School of Water Resources, Indian Institute of Kharagpur were engaged as consultants for preparation of Morphological Studies of the rivers Mahanadi, Mahananda and Hooghly using Remote Sensing Techniques by the CWC. The team focused on the morphological structures, erosion/deposition pattern, cross section profiles, water level information and sand mining areas. Various tables and diagrams are generated based on primary and secondary data with field observed photographs to authenticate the contents of the morphological report.

The present report provides a detailed database of information generated on the Mahanadi through the consultancy work, as mentioned above.

Acknowledgement

The authors duly acknowledge the support from Prof. Partha Pratim Chakrabarti, Director, Indian Institute of Technology Kharagpur. The project team is immensely thankful to the offices of CWC Berhampore, Patna and Bhubaneswar, SOI Kolkata, Bhubaneswar, Dehradun, NRSC Hyderabad and IMD for their help in data sharing.

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CHAPTER 1

INTRODUCTION

1. Overview

Water flowing over the land surface is the leading agent of land space alteration. Water flowing downhill inherently contains the energy and the rate of energy is power, which power erodes the surface and makes its own path to follow. Those paths with flowing water are known as a stream or river. River morphology or fluvial geomorphology is used to describe the shapes of river channels and how they change in shape and direction over time. It is dynamic and constantly changing in both space and time.

It is clear that rivers play an important role in landform evolution; the force of water is deeply connected to the dislodging of soil and rock particles and their conveyance. Where the power of water becomes less, it is forced to deposit the particles on its way. When the sediment load being transported by a river is less than sediment transporting capacity of the river and the excess sediment needed to satisfy the capacity of the river will be scoured from the erodible riverbed. Degradation results in channel incision and milder slopes, often this phenomenon is observed downstream of a dam constructed on a river. When the sediment transporting capacity of a river at a point becomes less than the sediment load being carried, as a result of reducing the velocity due to an increase in cross-section or reduction in the slope of the river, the excess sediment gets deposited on the river bed. As a result the riverbed raises, the phenomenon is termed as aggradation. Channel aggradation may also occur in a river reach if due to geological reasons (say, increase of erosion of the catchment) the sediment load being conveyed to the river increases than that can be carried by the river in equilibrium. As a result the river bed rises and forces the channel to carve out its path in a braided fashion. For braided rivers, there is a tendency for a stream to widen and become very shallow with bars subjected to rapid changes in morphology. At high flows braided streams have a low sinuosity and often appear to be straight at low flows, numerous small channels weave through the exposed bars. A river that winds a course not in a straight line, but in a sinusoidal pattern is called a meandering river. It is the continued action of the secondary flow developed on the river bends that cause further erosion on the outer bank and deposition on the inner bank. The meandering action increases the length of the stream or river and tends to reduce the slope. Channel meandering is a result of an ongoing bed and bank deformation of the flow in a self-formed alluvial channel, thus the meander sinuosity increases with the passage of

time. The increase in sinuosity of a meandering river is associated with riverbank retreat. Riverbank retreat or bank erosion is inseparably connected to lateral river migration or river bank shifting.

Sinuosity is the only plan-form parameter used in the initial delineation of the stream. Sinuosity describes how the stream has adjusted its slope in relation to the slope of its valley and is quantitatively described as the ratio of stream length to valley length and also as the ratio of a valley slope to channel slope. The stream and valley lengths are measured from two common points in a direction that is parallel with the line of the valley. The shape of the river in a plan is very important in many design problems concerning the location of bridges, etc. In general, the plan forms of alluvial rivers can be classified as (i) Braided, (ii) Straight and (iii) Meandering. In streams having highly variable discharge and easily erodible banks, sediment gets deposited to form bars and islands that are exposed during periods of low discharge. In such a stream the water flows in a braided pattern around the islands and bars, dividing and reuniting as it flows downstream. Where they do occur, the channel is usually controlled by a linear zone of weakness in the underlying rock, like a fault or joint system. Even in straight channel segments, water flows in a sinuous fashion, with the deepest part of the channel changing from near one bank to near the other. Velocity is highest in the zone overlying the deepest part of the stream. The velocity structure of a stream, and especially in streams flowing over low gradients with easily eroded banks, straight channels will eventually erode into meandering channels. Erosion will take place on the outer parts of the meander bends where the velocity of the stream is highest. Sediment deposition will occur along the inner meander bends where the velocity is low. Such deposition of sediment results in exposed bars, called point bars. Because meandering streams are continually eroding on the outer meander bends and depositing sediment along the inner meander bends.

Remote sensing and GIS techniques help to analyze and visualize those morphological characteristics and changes in the river. It also helps to understand the effect of morphological changes in natural and man-made features on the earth's surface.

1.1. Objectives

The specific objectives of works, as mandated by the Central Water Commission, are as follows:

a) Compile complete river drainage map in GIS by integrating available secondary maps in WRIS of CWC. Collect additional required information on major flood protection structures, existing water resources projects, important cities/ towns, CWC H.O. Sites, airport, island, etc. and to be integrated with final river drainage maps.

b) The Study shifts of river courses and also changes in its plan form from the base year (say 1970) till 2010, by collecting 4 sets of satellite imageries at 10 year interval in addition to one set of Survey of India toposheets for the base year on a scale of 1:50,000. In case toposheets are available for the older period, say 1950, the base year may be shifted accordingly.

c) Compile changes in land use/land cover and study of its impact on river morphology.

d) Channel evolution analysis to describe the status of the river channel. The analysis of the channel dimension, pattern, and longitudinal profile identifying distinct river reaches i.e., channel in the upper reaches, a channel in a flood plain with bank erosion, etc. This segregation of the reaches is to be determined by using channel evolution analysis.

e) Work out the rate of bank erosion/deposition in term of erosion length & erosion area w.r.t. base year at 50 km interval.

f) Assess the present condition of critical reaches of the main channel of the river may be assessed by conducting ground reconnaissance. Field reconnaissance trips may be taken, if required.

g) Evaluate the impacts of major hydraulic structures on the morphological behavior of the river's course and its impacts on river morphology.

h) Evaluate braiding pattern of rivers by using plan-form index (PFI) criteria along with its threshold classifications.

i) Compile information (if any) on flood affected areas in the vicinity of river course prepared by NRSC using Multi-temporal satellite data of IRS WiFS (188m) & Radarsat Scan SAR Wide & Narrow (100 m & 50 m).

j) Plot probability curve (exceedance probability vs. flow rate) and show flow rates corresponding to return period of 1.5 years and 2 years for different CWC H.O. Locations. The observed flows need to be normalized before using for analysis.

k) Relate the morphological changes in the river on the basis of available peak discharges of different years in the time domain considered in this study. Study impact of changes in annual rainfall in the basin on river morphology.

l) Identify critical and other vulnerable reaches, locations. Analysis of respective rate of the river course, shifting and based on it, future prediction of river course behaviors.

m) Suggest suitable river training works for restoration of critical reaches of depending on site conditions

n) Possible location of river sand mining areas in the river reaches.

CHAPTER 2

REVIEW OF LITERATURE

2. Overview

There are several direct and indirect methods of monitoring the river bank erosion/ deposition, river course shifting and flood delineation. The direct method is taking measurements from the field in terms of linear rates of erosion/deposition, volumes of erosion and channel cross section. The indirect method involves as analyzing the archival sources at various time scales with the sediment records. The archival sources can be conventional survey maps, aerial photos or satellite images. In present days, satellite remote sensing and GIS methods/models took the key role in river morphological/engineering studies and geospatial database creation for various analyses. Multi-temporal high-resolution satellite data are used to analyze the river configuration, shifting of courses, the formation of new channels/oxbow lakes, bank erosion/deposition, and drainage-congested areas and also for mapping the database in various scales according to purpose. The remote sensing information also used in river morphological application studies, like flood control, monitoring work, vulnerable reaches identification, river bank protection planning, river bank beatification, drainage improvement planning etc.

The Mahanadi River arcuate delta system has been formed in a tectonic downwarp of the Gondwana Graben believed to be a failed arm of the triple junction on the Eastern Indian coast passive margin (Jagannathan et al, 1983). Subsurface sediments of the Mahanadi Basin range in age from the old era to Recent. Sediment deposition in the Mahanadi River deltaic environments is principally monsoon-dominated (Delta Development Plan, 1986). Because of the low volumetric capacity of the Mahanadi River and high flushing velocity, the suspended load during the monsoon enters into the Bay of Bengal probably as a friction dominated plane, jet depending on the volume of fluvial discharge and the hydrodynamic conditions of the inner shelf (Ray, 1988; Ray and Mohanti, 1989).

2.1 Application of remote sensing and GIS for river shifting analysis

No study is available on river shifting, erosion and deposition, LULC change, soil loss estimation, and possible sand mining area identification based on different resolution satellite data using remote sensing and GIS techniques in the whole Mahanadi river. Some researchers carried out on the cause and process of the changing nature of morphological features during the last few decades. A medium

number of researchers studied river shifting analysis, erosion-deposition, LULC change using geospatial techniques in different river basins of India. The monitoring the river course changes using IRS 1A and IB LISS-II satellite images for the periods of 1991-1993 on the Ravi river, Amritsar and Gurdaspur Districts of Punjab is available in Thomas and Sharma (1998). The results show that drastic changes in the river course of 20 years due to human activities. Goswami et al. (1999) analyzed bank erosion of various changes in the channel of the Subansiri river by different index (e.g., sinuosity) in Assam. The bank line of the river is divided by 10 equal segments for the periods 1920–1970, 1970–1990 and 1920–1990. Lahiri and Sinha (2012) identified syntectonic evidence of changes in the morphodynamics for 90 years using platform index in the Brahmaputra River. In this research, the planform characteristics of the Brahmaputra river depends on subsurface configuration and channel slope from upstream to downstream reaches.

Sinha and Ghosh (2012) analyzed temporal dynamic changes of Lower Ganga Plains using satellite images for habitat dynamics. The results show that the Farakka barrage has moved towards the east, but channel shifting downstream of the Farakka barrage has been erratic. Laha and Bandyopadhyay studied the morphometric change of the Ganga River, upstream of Farakka Barrage up to Rajmahal based on sinuosity and braideness index for the periods of 1955, 1977, 1990, 2001, 2003, 2005 and 2010 using multi-resolution satellite images. This research work mainly focuses prediction on the river's future trend and identification of vulnerable areas. Sarkar et al. (2012) analyzed channel pattern changes and shifting of bank line based on a normalized difference water index (NDWI) using IRS 1A LISS-I, and IRS-P6 LISS-III satellite images for the periods of 1990-2008. This analysis included not only river morphology, stable and unstable reaches of the river banks and changes in the main channel. The results provide a guideline of drainage development programmes and erosion control schemes in the northeastern region of the country. Identification of riverbank erosion and change detection analysis of the Pravara River flowing into the northern part of Ahemadnagar district into Akole using remote sensing data is available in Aher et al. (2012). Mallick (2013) identified bank line shifting and fluvial-geomorphological changes using remote sensing techniques in the part of the moribund deltaic region of district Nadia. The objective of the study is to identify the different pattern of fluvio geomorphic features on the flood plain by GIS platform. The analysis indicates the anthropogenic cause has a greater influence on morphological changes.

Gogoi and Goswami (2013) performed shifting of the bankline due to erosion in the Subansiri river using the satellite imagery (IRS LISS-III of 1995 and Landsat 5 TM of 2010) of 1995 and 2010. It is one of the principal tributaries of the Brahmaputra river. It contributes as much as 11% of the total

flow of the river Brahmaputra. The Lower Subansiri has flood and drainage congestion problems. The results show erosion is dominant in the upper, middle a lower channel. Laha (2015) studied fluvio-geomorphological analysis of the Bhagirathi-Hooghly River reach from 5 km north of the confluence of Ajay River for 5 km south of the Jalangi River using satellite images. This analysis shows that north-south flowing river is characterized by acute meandering (e.g., cut-off meanders, ox-bow lakes, meander scars, abandoned channels). Mongaldip et al. (2015) analyzed bank erosion and shifting based on cross-section data in the Hooghly river at Sundalpurchar and Gosainchar Mouza, Ranaghat-I Block, Nadia. This research mainly focuses on the formation of a mid-channel bar named Mangaldwip. Maurya and Yadav (2016) identified the historical changes in the Ramganga river course using remote sensing and GIS techniques from 1972-2013 for river management and planning framework. The delineation of river course changes by Landsat MSS, TM, ETM+ and LISS-III images from 1972, 1989, 2000, 2005 and 2013. The result shows the shifting trend is the south-west direction in different places. Rai et al. (2018) studied quantitative and qualitative assessment of the floodplain region of the lower Kosi river basin based on morphometric analysis using remote sensing data from the GIS platform. The Landsat data of 2005, 2010 and 2015 are utilized to assess the changes in the dynamic of river basin for watershed prioritization by GIS environment. Moreover, the morphometric parameters can be assessed nature of bedrock, infiltration capability and surface runoff for channel development.

2.2 Impact of land use/land cover change on river morphology

According to Shirira and Yanda (2002), management of riparian ecosystems would be of particular importance in mitigating the effects of land-use/cover change on the southern slopes of Mount Kilimanjaro, north-eastern Tanzania. Establishment of riparian buffer vegetation using appropriate plant species will increase infiltration and water storage in the catchment and reduce sediment loading in the river. The changing proportions of these land-use types within a basin can have dramatic effects on discharge and response to storms, either increasing total yield in a flashier manner or decreasing and smoothing the hydrography in the Hilly Red Soil Region of Southern China (Zheng et al., 2008). Wang et al. (2012) developed an integrated erosion model for land use information and the effects of land use changes on soil erosion in the Lushi basin, China. Land use affects soil erosion through altering soil loss and influencing sediment delivery, which indicates the relative minor land use changes had a significant effect on regional soil erosion rates and sediment transport to rivers. Prokop and Sarkar (2012) employed to delineate three study areas along river courses on alluvial fans based on a hydrologic and geomorphic approach using topographic maps and satellite images combined for land use transformation in the Sikkimese-Bhutanese Himalayan piedmont over last 150 years. The effect of

land use changes on soil erosion is also assessed after the transformation of forest to farmland. Mahapatra et al. (2014) analyzed long-term morphological changes of Narmada estuary based on LULC change using multi-date maps and satellite images spread over a 37-year period. It is a significant change in the LULC and morphological feature for the evolution of river mouth geomorphology. The result shows that continue increasing human activities, like salt pans, industrial and settlements during past three to four decades.

Hazarika et al. (2015) show in an active floodplain that change in the land-use occurred due to the river dynamics of upper Brahmaputra plains. Importance of river dynamics of land-use is a major concern as it directly influences livelihood of the floodplain dwellers. The study shows that increased in settlement and agricultural land, but grassland is decreased. Thus, erosion and deposition area in the river basin affected by agricultural land. Zope and Jothiprakash (2016) performed, the impact of land use–land cover (LULC) change on urban flooding using the HEC-GeoHMS and HEC-HMS models for periods 1966, 2001 and 2009 in the Oshiwara River Basin in Mumbai. The flood plain and hazard maps for various flow condition have been developed by using the hydrological model. Moreover, the developed output can help to prepare flood mitigation and early evacuation management planning framework. Debnath et al. (2017) described the channel migration of the Khowai river of Tripura directly affects the land use, which has a direct impact on the floodplain dwellers. River reveals the endangered condition of the nearby settlements and infrastructures due to high bank erosion. The output results very much helpful for upcoming future mitigate the hazards and minimize human intervention to the natural flow of the river. Finally, remote sensing & GIS technology provides a detailed assessment of spatial and temporal changes in the river under changing climatic condition.

CHAPTER 3

STUDY AREA AND DATA USED

3.Overview

The Mahanadi is the major peninsular river of India, rising in the hills of southeastern Madhya Pradesh state. This river drainage area is around of 141599 sq. km. It originates from the Farsiya village of Dhamtari district of Chhattisgarh. The total length of the river from origin to its outfall into the Bay of Bengal is 851 km. The Mahanadi river basin (Figure 1) extends over the states of Chhattisgarh and Odisha and the minor part of Jharkhand, Maharashtra, and Madhya Pradesh. The location of the Mahanadi river is within latitude 19°8’ - 23°32’N and longitude 80°28’ - 86°43’E. The river is demarcated by the east-central India hills on the north, by the Eastern Ghats on the south and east and by the Maikala Range on the west. The Seonath, the Hasdeo and the Mand join Mahanadi from left, whereas the Ong, the Tel and the Jonk join it from the right. Six other small streams between the Mahanadi and the Rushikulya draining directly into the Chilka Lake also forms the part of the basin. The catchment of rivers comprises of a drainage system with stream order up to six.

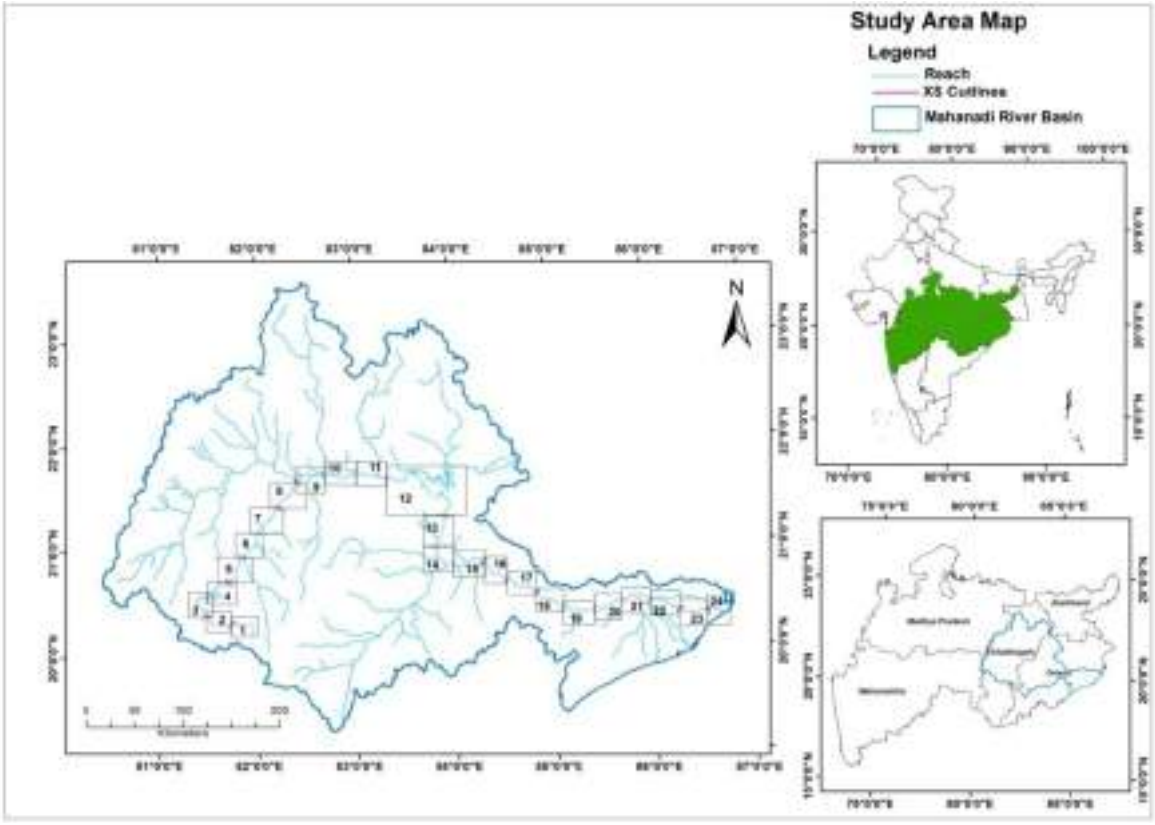


Figure 1: Mahanadi river drainage basin map, States covered, and reaches studied (numbered)

For the purpose of this study, the Mahanadi river is divided into 24 reaches, starting from the Sondhur Dam (Reach 1). Each reach distance is around 34 kms, approximately.

3.1. Soil

The texture of the soil, which is classified into 4 types, namely fine, medium, coarse and rocky textures (Figure 2). 41.95 % of the area comes under fine textured soil followed by covering 51.27 % area under medium textured soil. Dhenkanal has old alluvium generally having higher content of clay. The soils are of sandy in nature found in Puri districts and are poorer in plant nutrients. In Cuttack, soils vary from clays to clay loams, the latter being found to a larger extent. The soil information indicates that main soil types found in the basin are red and yellow soils, mixed red and black soils, laterite soils, and deltaic soils.

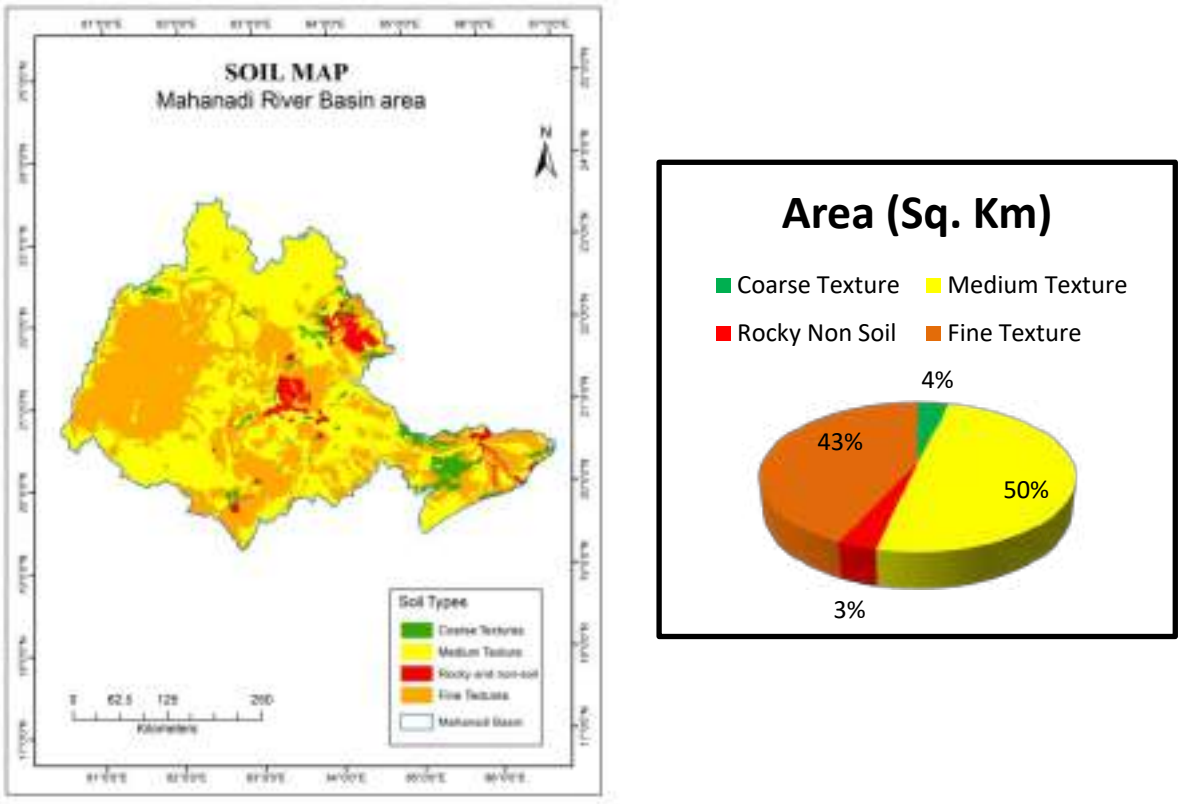


Figure 2: Soil map and statistics

3.2. Geology

The gneisses form a very widespread type of rocks in Orissa. Some well defined areas of Sambalpur, Purl and Cuttack districts consist of the Gondwanas. Also a large exposure of the upper Gondwana

rocks occurs Mahanadi basin just west of the Delta. The Eastern fairly in the Ghats through which the Mahanadi passes in Orissa state consist of rock types as khondalites, charnockites, leptynites, quartzites and minor basic granulites, gneisses, migmatites, anorthosites, granites and minor basic Intrusives of Pecambrian age. The sedimentary rocks in the drainage basin are chiefly conglomerates, sandstones, quartzites, shales and limestones. Geology maps shown in figure 3.

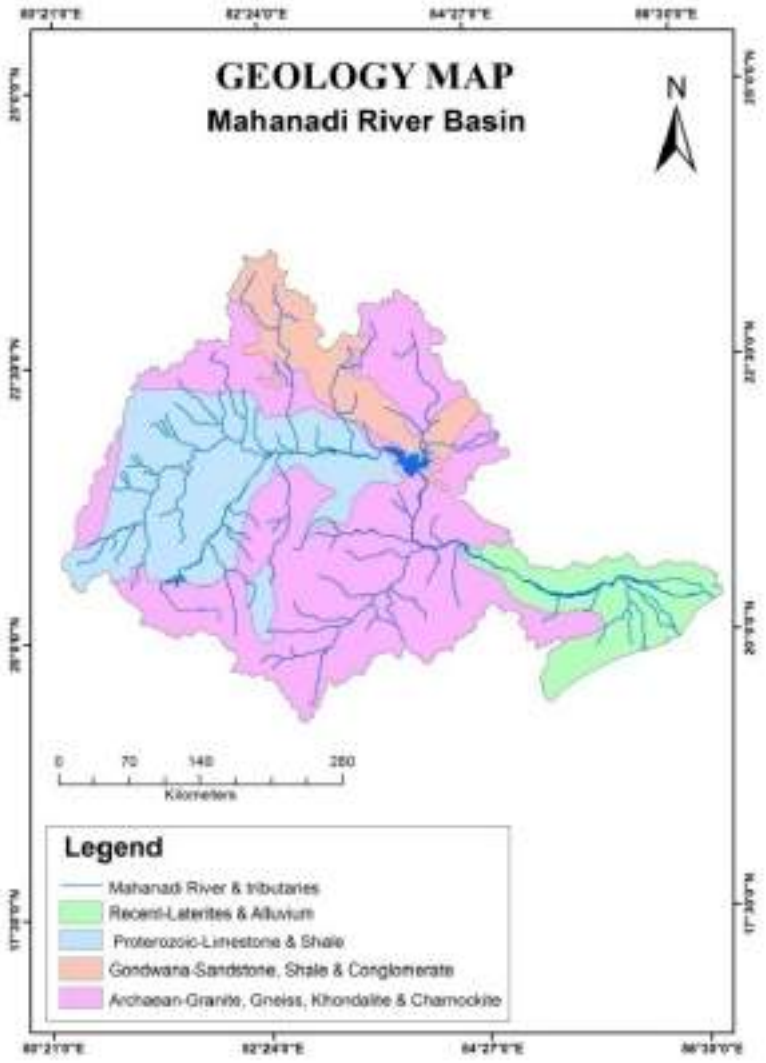


Figure 3: Geology map of Mahanadi Basin area

3.4. Rainfall

The average annual variations in the basin based on daily rainfall data (0.25 X 0.25) for the period 1960-2010, collected from IMD, is shown in following Figure 4. Major part of the basin area receives rainfall from 1000-2000 mm. More than 90% of the total annual rainfall occur during the monsoon.

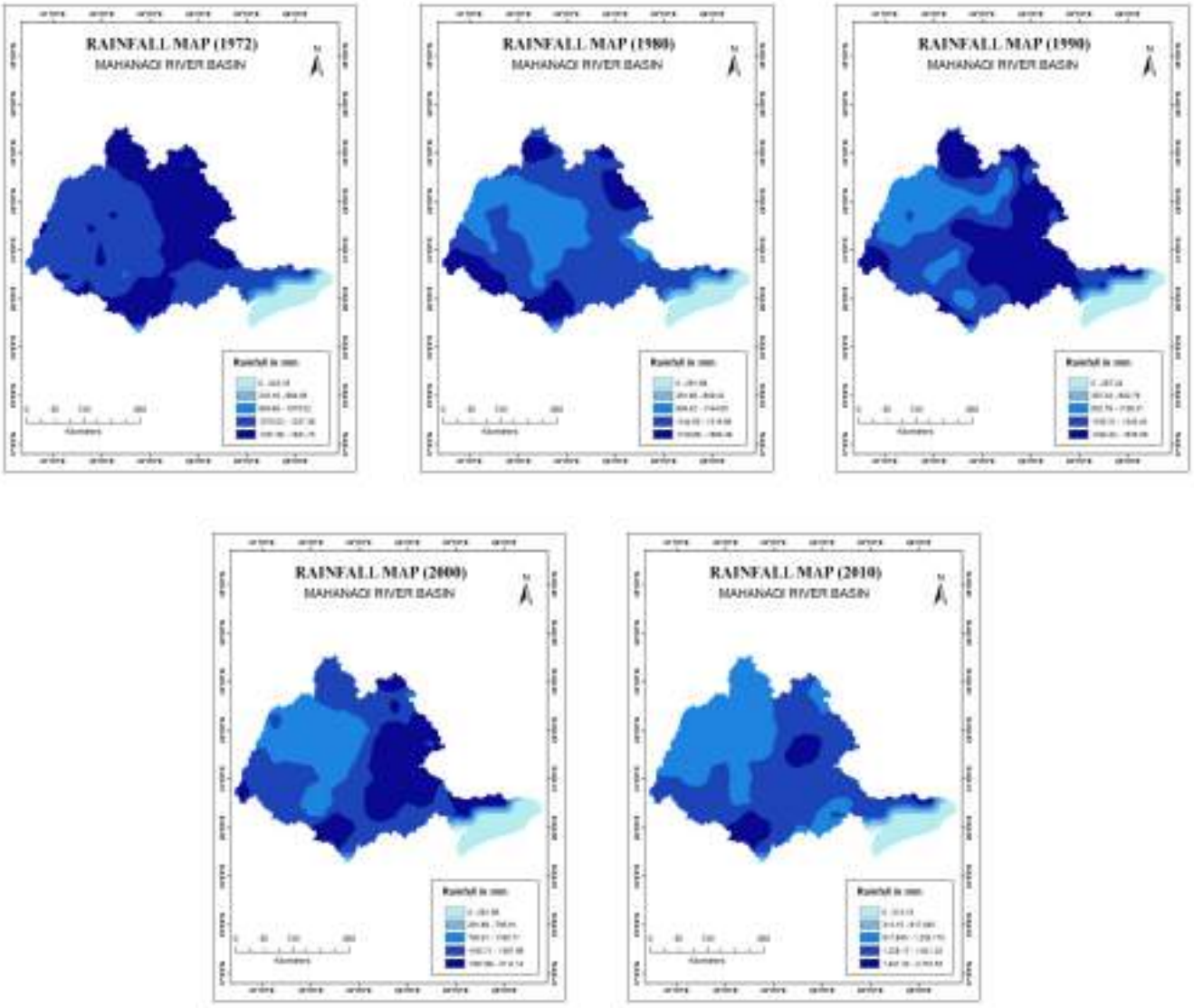


Figure 4: Rainfall map of the Mahanadi River Basin

3.5 Data Used

Table 1:- Data information

Toposheets				
Data	**Data sources**	**Year**	**Scale**	**Remarks**
Toposheets for Mahanadi river Basin	SOI, Dehradun	1970 onwards	1: 50,000	Available data have not covered the whole study area

Remote Sensing Data for study shifting of the river				
Data	**Data sources**	**Year**	**Resolution**	**Remarks**
Landsat MSS	USGS	1972 and 1980	60 m	Only main river
IRS LISS-I	NRSC, Hyderabad	1990	72.5 m	Only main river
IRS LISS-II	NRSC, Hyderabad	2000	36.25 m	Only main river
IRS LISS-III	NRSC, Hyderabad.	2010	23.50 m	Only main river

Remote Sensing Data for land use/land cover mapping				
Data	**Data sources**	**Year**	**Resolution**	**Remarks**
Landsat MSS	USGS	1972 and 1980	60 m	Full basin
Landsat TM	USGS	1990 and 2000	30 m	Full basin
Bhuvan Land Use and Land Cover	Bhuvan	2010	1: 250,000	Full basin

Hydrometeorological Data					
Name of the station	Data Types	Data Sources	Year	-	-
Tikarapara	Rainfall	IMD	1970-2010	-	-
	Hydrological Data	CWC	1972-2015	-	-
Basantpur	Rainfall	IMD	1970-2010	-	-
	Hydrological Data	CWC	1971-2015	-	-
Seorinarayan	Rainfall	IMD	1970-2010	-	-
	Hydrological Data	CWC	1985-2015	-	-
Rajim	Rainfall	IMD	1970-2010	-	-
	Hydrological Data	CWC	1971-2015	-	-

CHAPTER 4

METHODOLOGY

4. Overview

The present study, Survey of India toposheets and satellite data has been used to delineate the course of the Mahanadi River. Satellite data for the year 1990, 2000 and 2010 have been collected from NRSC, Hyderabad and Satellite data for the year 1972 and 1980 have been collected from USGS website (https://earthexplorer.usgs.gov). All the digital maps were georeferenced with the same projection and then the shifting course of the river, erosion-deposition of river banks, etc. have been studied in GIS environment by using the ArcGIS software. The data of IRS satellite of LISS-I, LISS-II, and LISS-III sensors for different dates pertaining to the years 1990, 2000 and 2010 were obtained from the NRSC. Collected data were processed and analyzed using the ERDAS software. Image mosaic, and color balancing were performed to join individual scans to generate the full basin of the river course in which Mahanadi basin area was extracted. Bank lines of the year 1972, 1980, 1990, 2000 and 2010 were digitized from satellite imageries by on-screen digitization methods in ArcGIS.

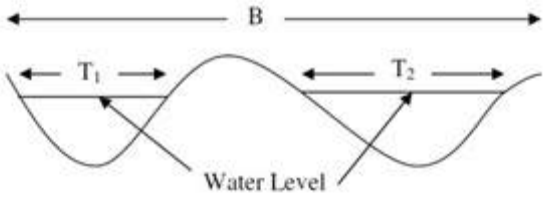
On-screen visualization of Google Earth helps to generate GIS layer including riverbank line, major hydraulic structures, embankment, railway bridges, airport, city, town, important monuments. Rainfall Map of 1972, 1980, 1990, 2000 and 2010 are generated using collected data from the India Meteorological Department. Soil map and Geology map have been digitized form available Soil map and Geology map. Land Use/Land Cover (LU/LC) map of 1972, 1980, 1990 and 2000 was prepared using satellite imageries. The Landsat MSS satellite image was used for 1972 and 1980. LISS I and LISS-II satellite imageries were used for 1990 and 2000 respectively. The river was divided into 24 reaches approximately by 34 km distance to prepare the detailed study (Figure 5).

Digital Elevation Model (DEM) of 2000 was collected from USGS Earth Explorer and Google earth was used to prepare the DEM of 2010. Longitudinal profiles for each reach were drawn using that DEM. The slope was calculated for each reach. Channel evolution analysis was done comparing two DEMs of 2000 and 2010.Overlay operation performed to calculate the shifting of the river bank, measure shifting distances, and erosion and deposition areas in specific locations. The area considered as erosion where the bank goes to the inner side of the river respected to the previous year and the area considered as deposition where the bank goes to the outer side of the river. Critical zones are extracted based on the maximum erosion of a particular location. We have identified a possible sand mining area based on maximum deposition year by year in river reaches.

4.1. Plan form index (PFI) describes the river property as its braiding, meandering or straight. PFI was calculated from the following equation.

$$Plan\ Form\ Index\ (PFI) = \frac{\frac{T}{B} \times 100}{N}$$

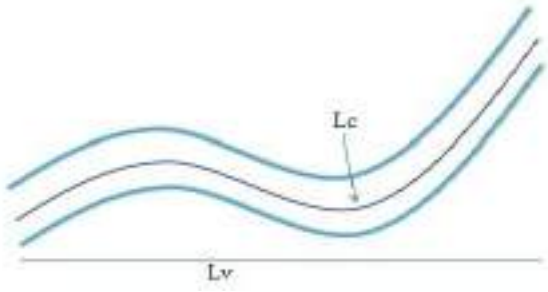
Where, $T=T_1 + T_2$= Flow top width, B= Overall flow width, N= Number of braided channels



4.2. Sinuosity index (SI) is computed by using the length of the channel and length of the valley. It is the ratio between those two lengths.

$$Sinuosity = \frac{L_c}{L_v}$$

Where, L_c = Length of the channel, L_v = Length of the valley



Hydrologic data like discharge, gauge, stage, water depth, etc. have been collected from CWC, Bhubaneswar. Plot probability curve generated based on the relation between exceedance probability and discharge relation. Recurrence interval has been calculated.

4.3. Soil loss: is an important factor for morphological study. Land use/ Land cover change, Soil type, rainfall, surface slope, etc. are influencing the total soil loss and sediment in the river. Soil loss has been estimated using RUSLE method. The RUSLE method is expressed as:

$$A = R \times K \times LS \times C \times P$$

where A is the computed spatial average of soil loss over a period selected for R, usually on yearly basis R is the rainfall-runoff erosivity factor; K is the soil erodibility factor; LS is the slope length steepness factor (dimensionless); C is the cover management factor (dimensionless, ranging between 0

and 1.5); and P is the erosion control (conservation support) practices factor (dimensionless, ranging between 0 and 1).

The critical zone has been identified, considering the long-term effects of erosion, LULC change, shifting which is the most affected and changed zone in total length. In any reach, most eroded zones are considered as a critical zone. Identification of possible sand mining area also has been identified in the whole river basin.

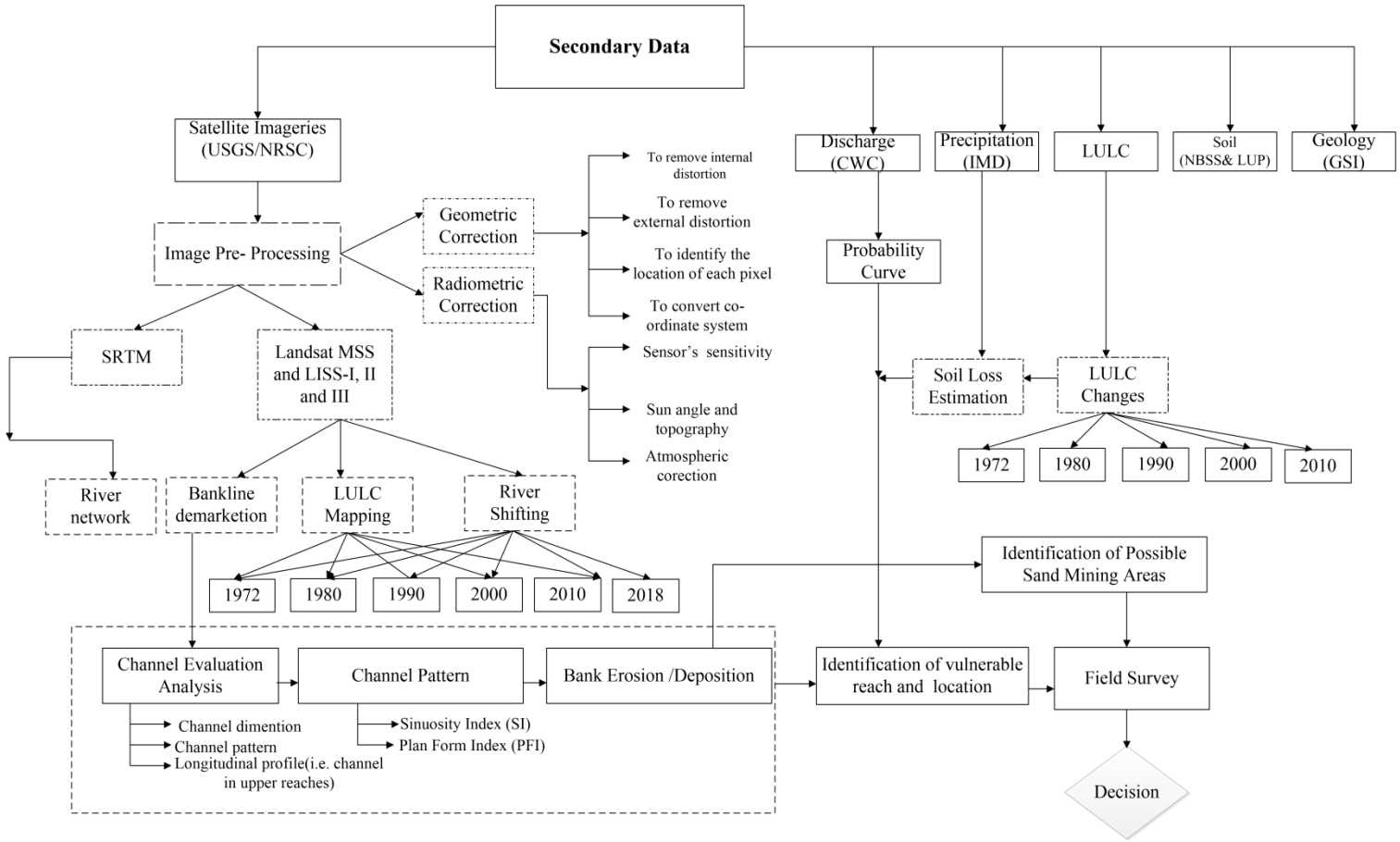


Figure 5: Overall methodology of Morphological study

CHAPTER 5

ANALYSIS AND RESULTS

5.1. River drainage map in GIS by integrating available secondary maps:

The drainage map was prepared by using remote sensing and GIS technique. The position of city, town, local place, major hydraulic structure, Railway Bridge, the airport was identified from Google Earth. One map was prepared by incorporation of those things with the Mahanadi River basin area and the slope of the area (Figure 6).

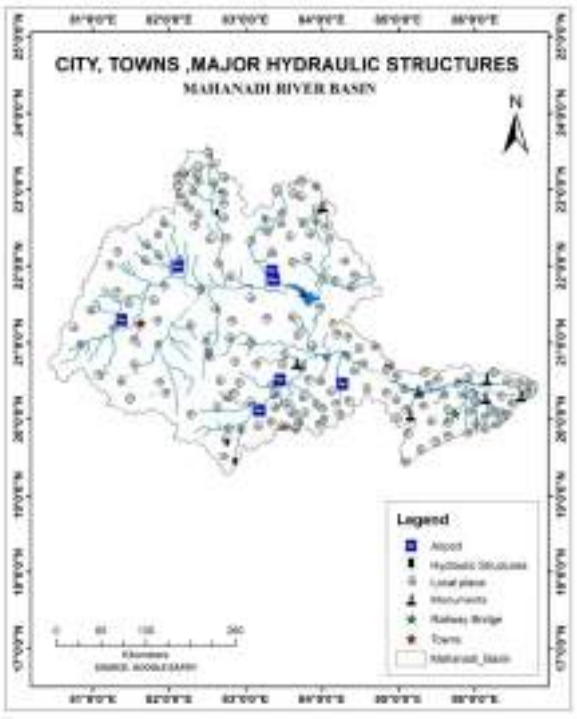
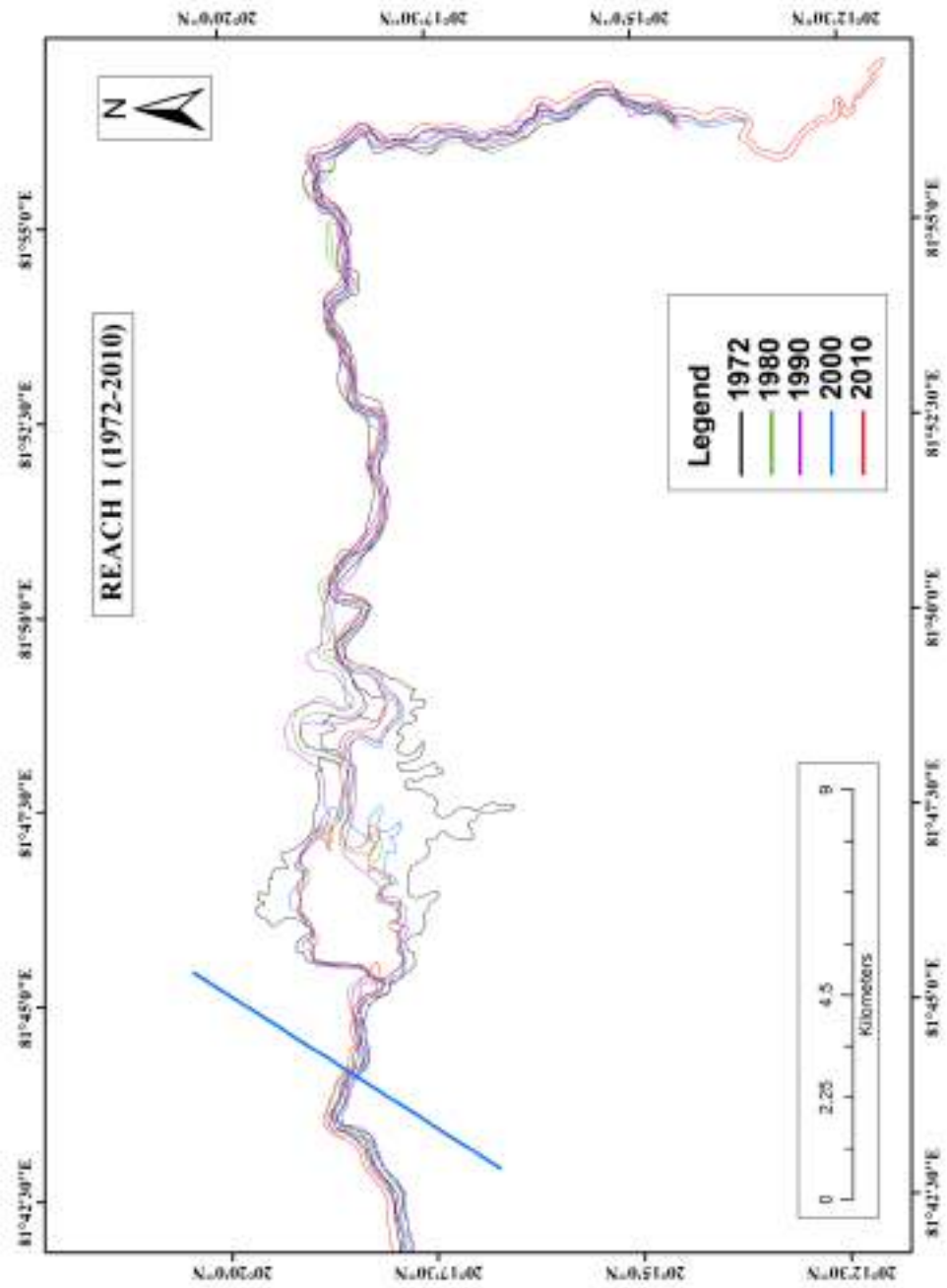


Figure 6: Compile complete river drainage map in GIS by integrating available secondary maps

5.2. Shifting of River Bank

For Mahanadi River, shifting is not occurring severely within the different reaches (Annexure 1). Some specific places, due to erosion and deposition some amount bank shifting is shown (Table 2 to

3). Superimposed layers of Mahanadi river for different years from 1972 to 2010 are shown in the following pages (Figure 7.1 – Figure 7.24). In reach 13, 15, 16, 21, 22, 23 and 24 some amount shifting was noticed (Figure 8.1 – Figure 8.12).



Figur7.1: Map of Superimposed Courses of Reach 1 during 1972-2010

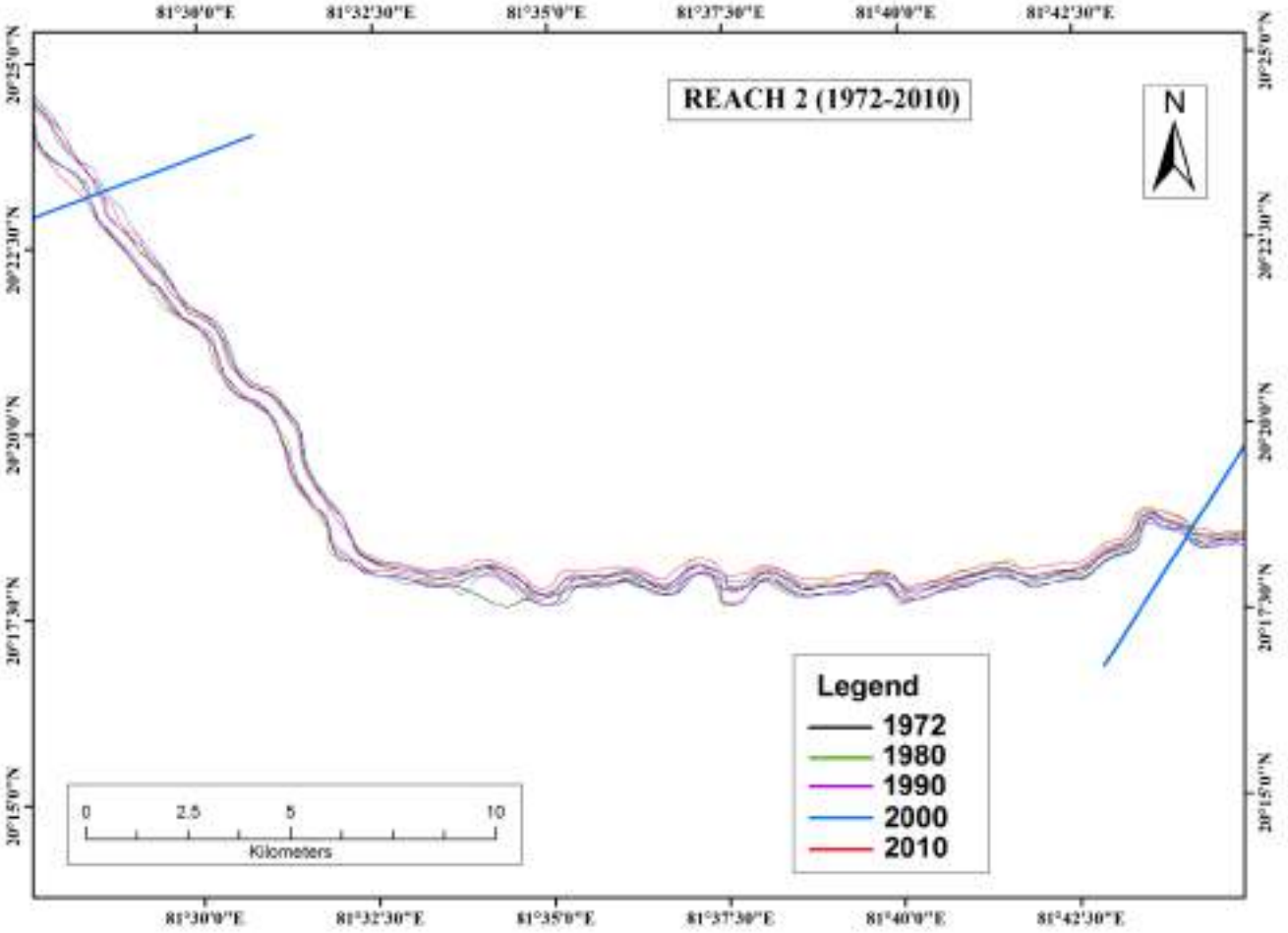


Figure 7.2: Map of Superimposed Courses of Reach 2 during 1972-2010

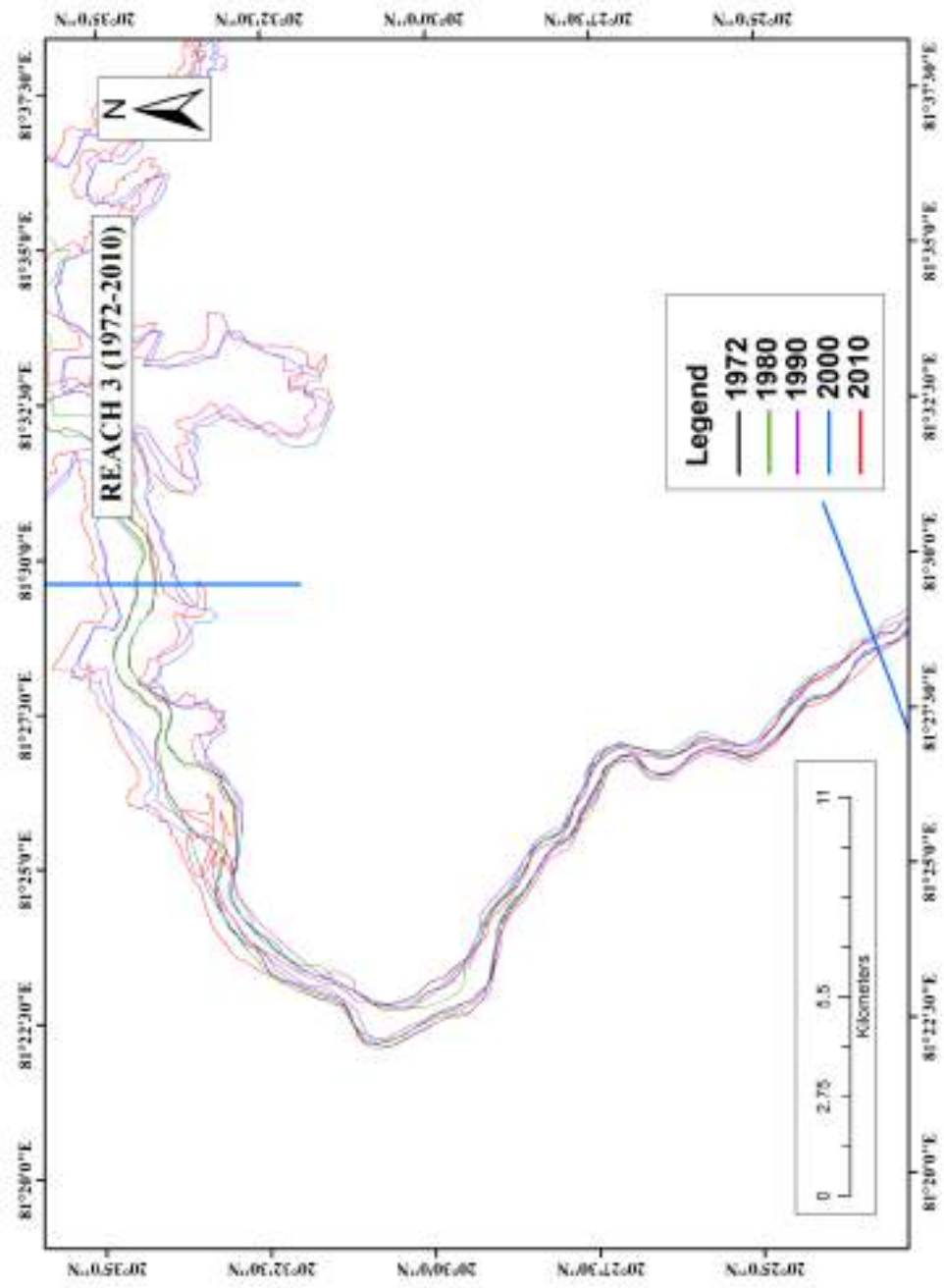


Figure 7.3: Map of Superimposed Courses of Reach 3 during 1972-2010

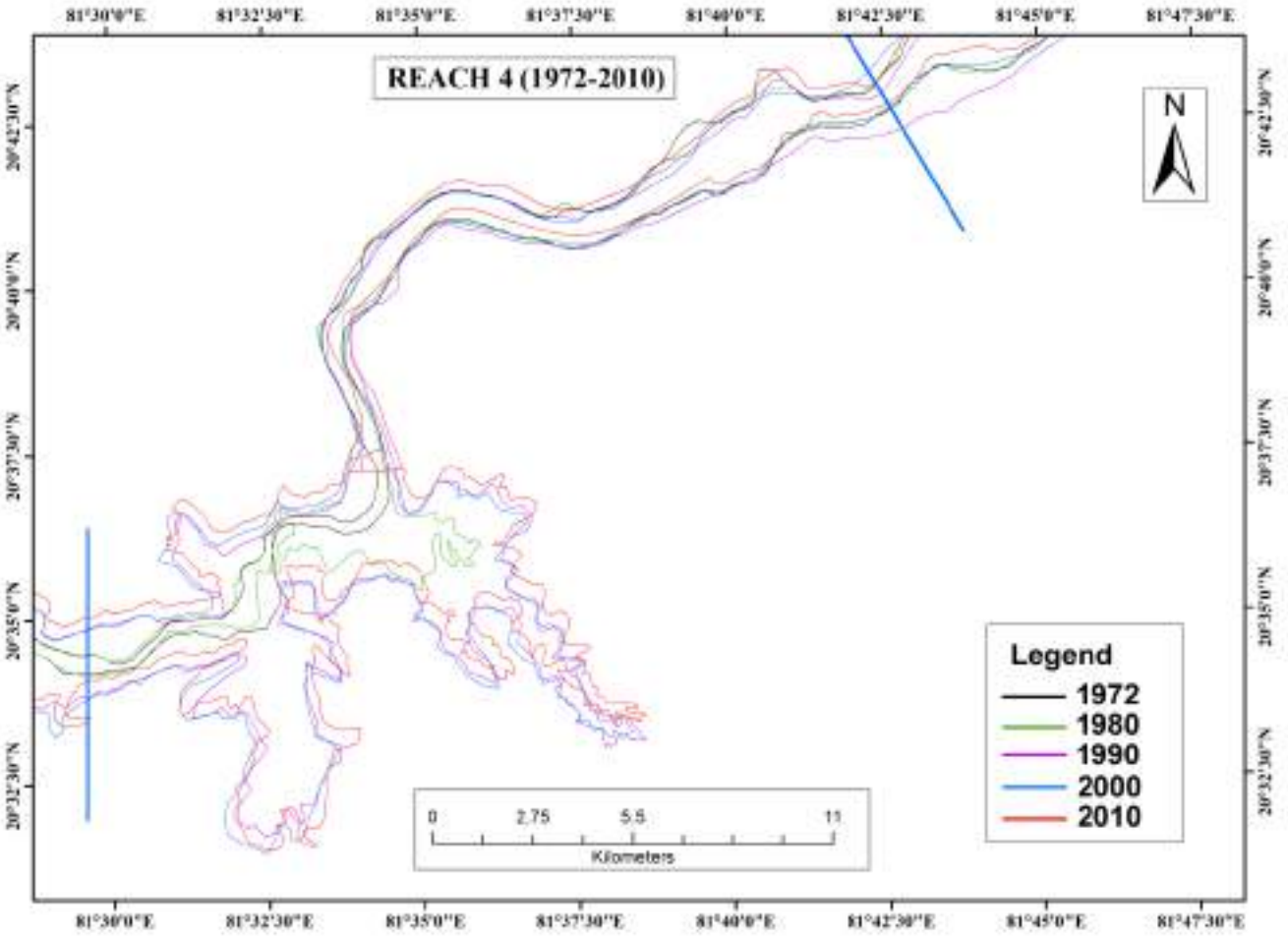


Figure 7.4: Map of Superimposed Courses of Reach 4 during 1972-2010

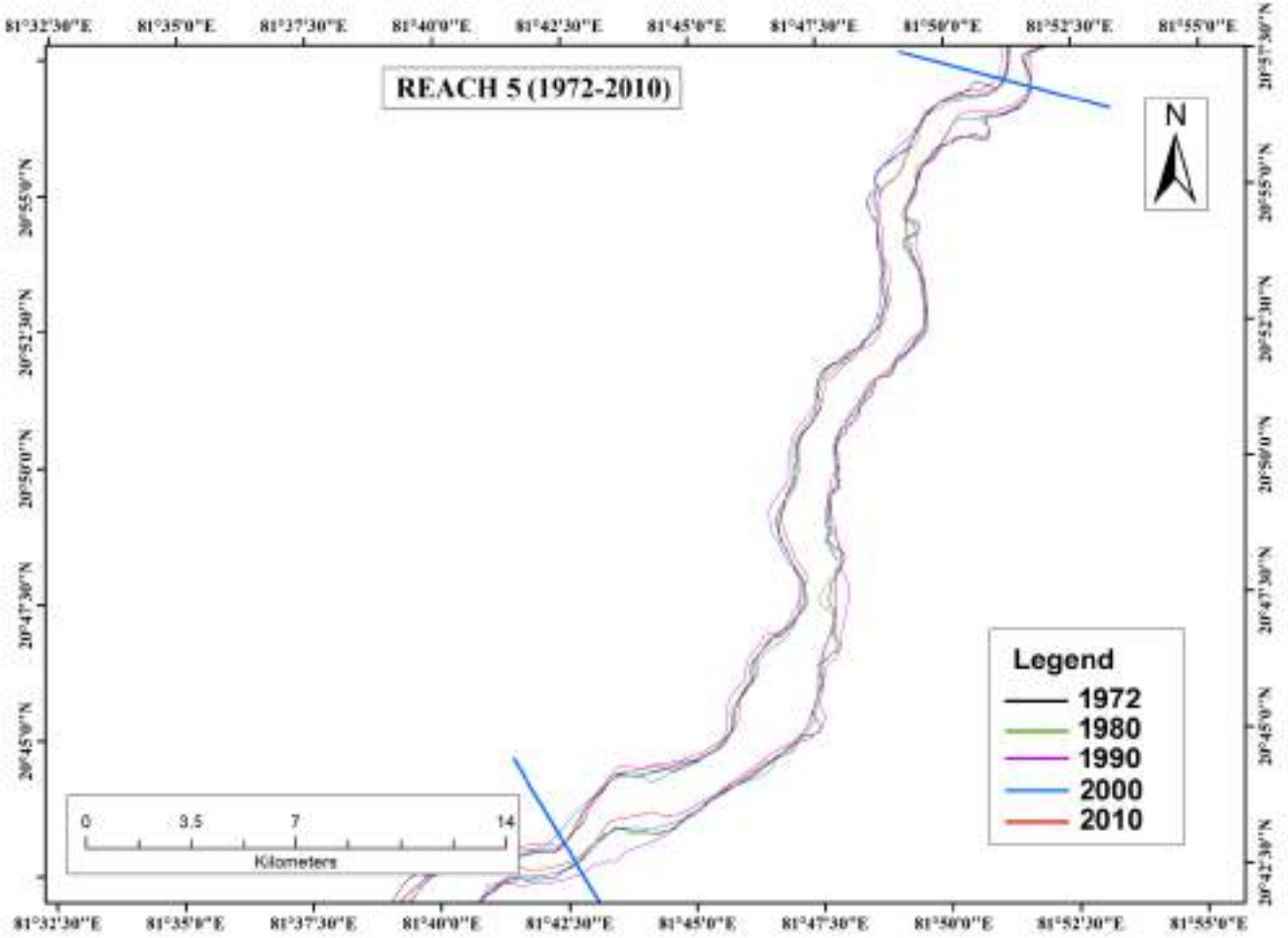


Figure 7.5: Map of Superimposed Courses of Reach 5 during 1972-2010

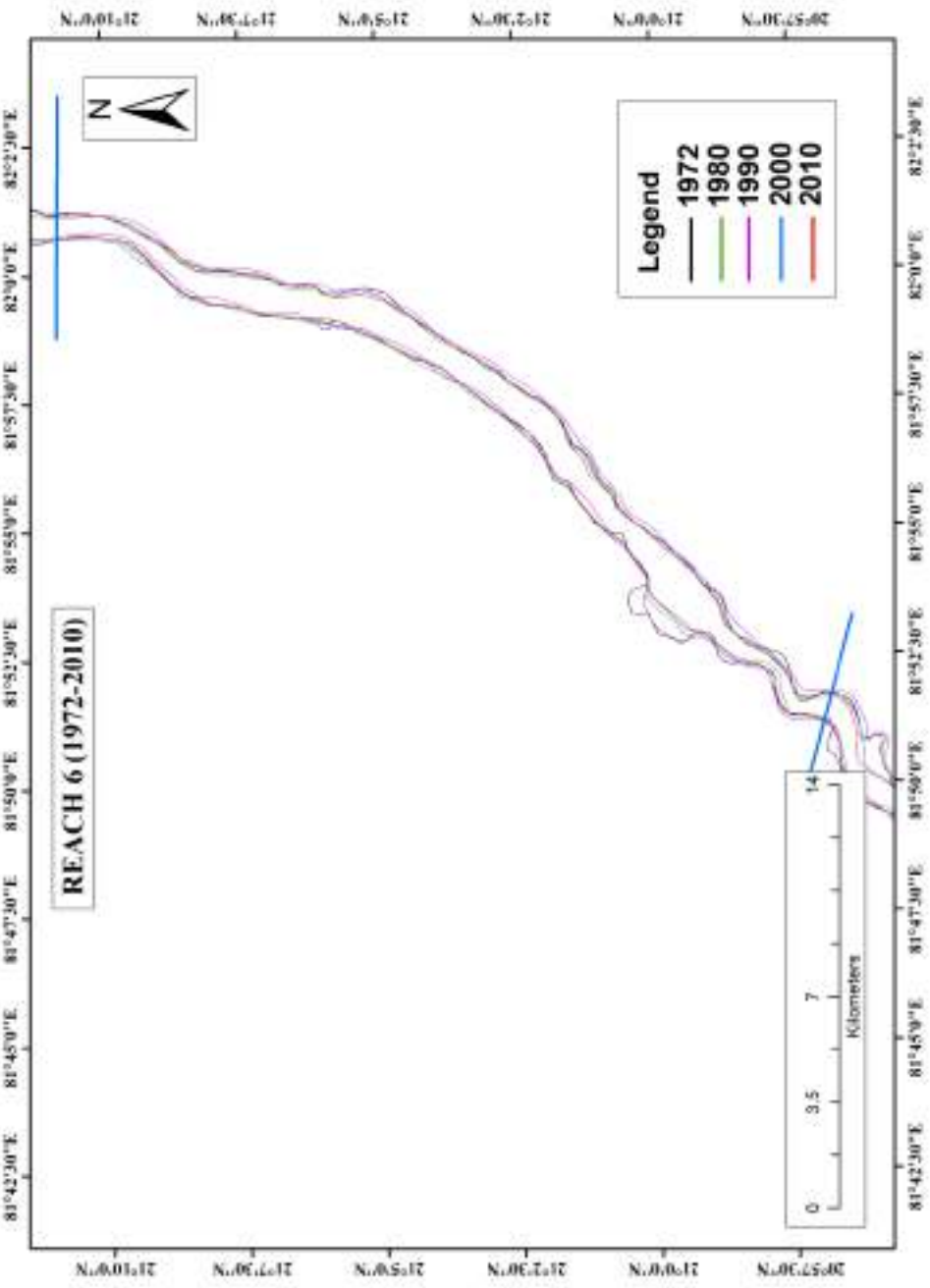


Figure 7.6: Map of Superimposed Courses of Reach 6 during 1972-2010

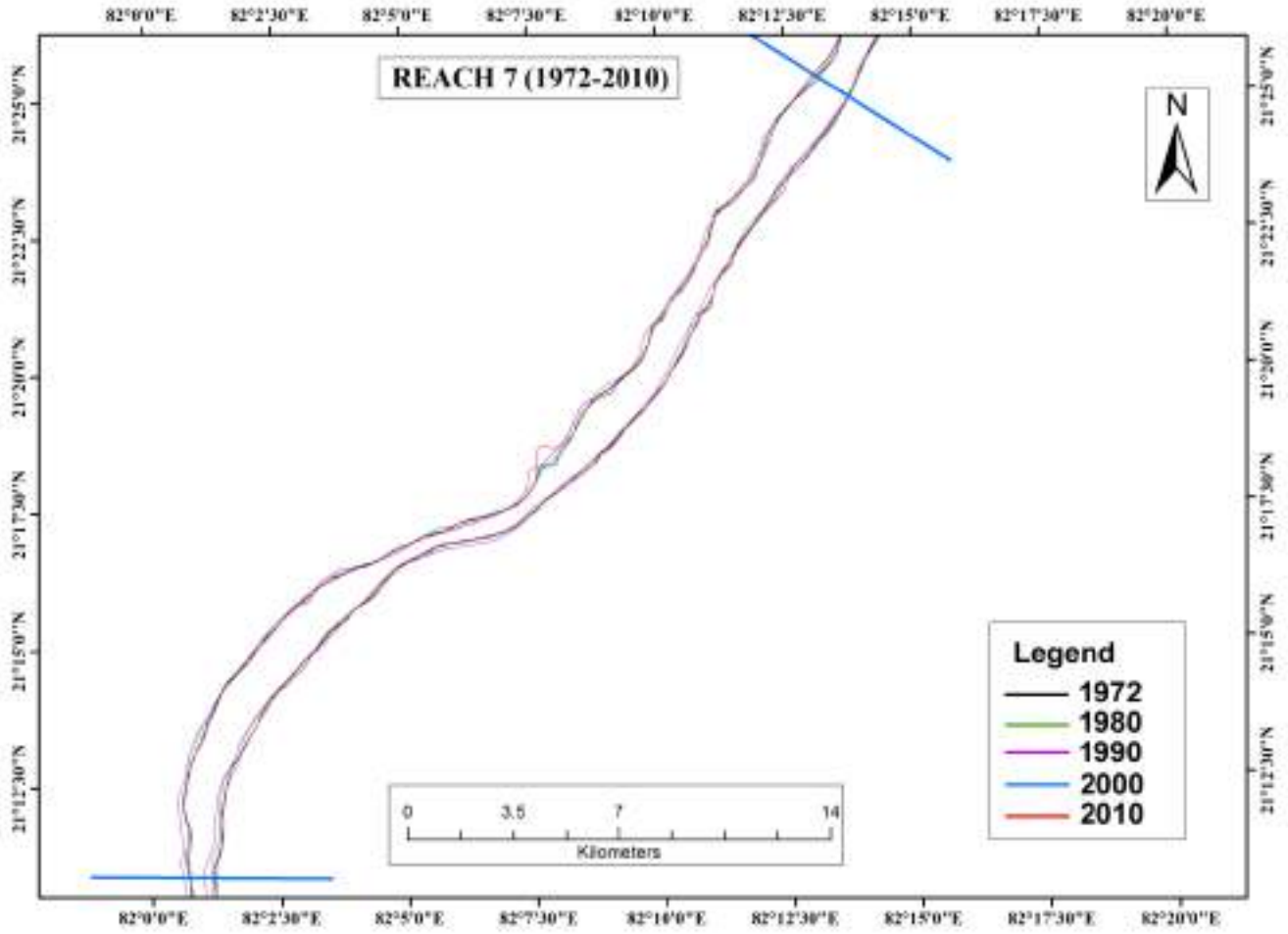


Figure 7.7: Map of Superimposed Courses of Reach 7 during 1972-2010

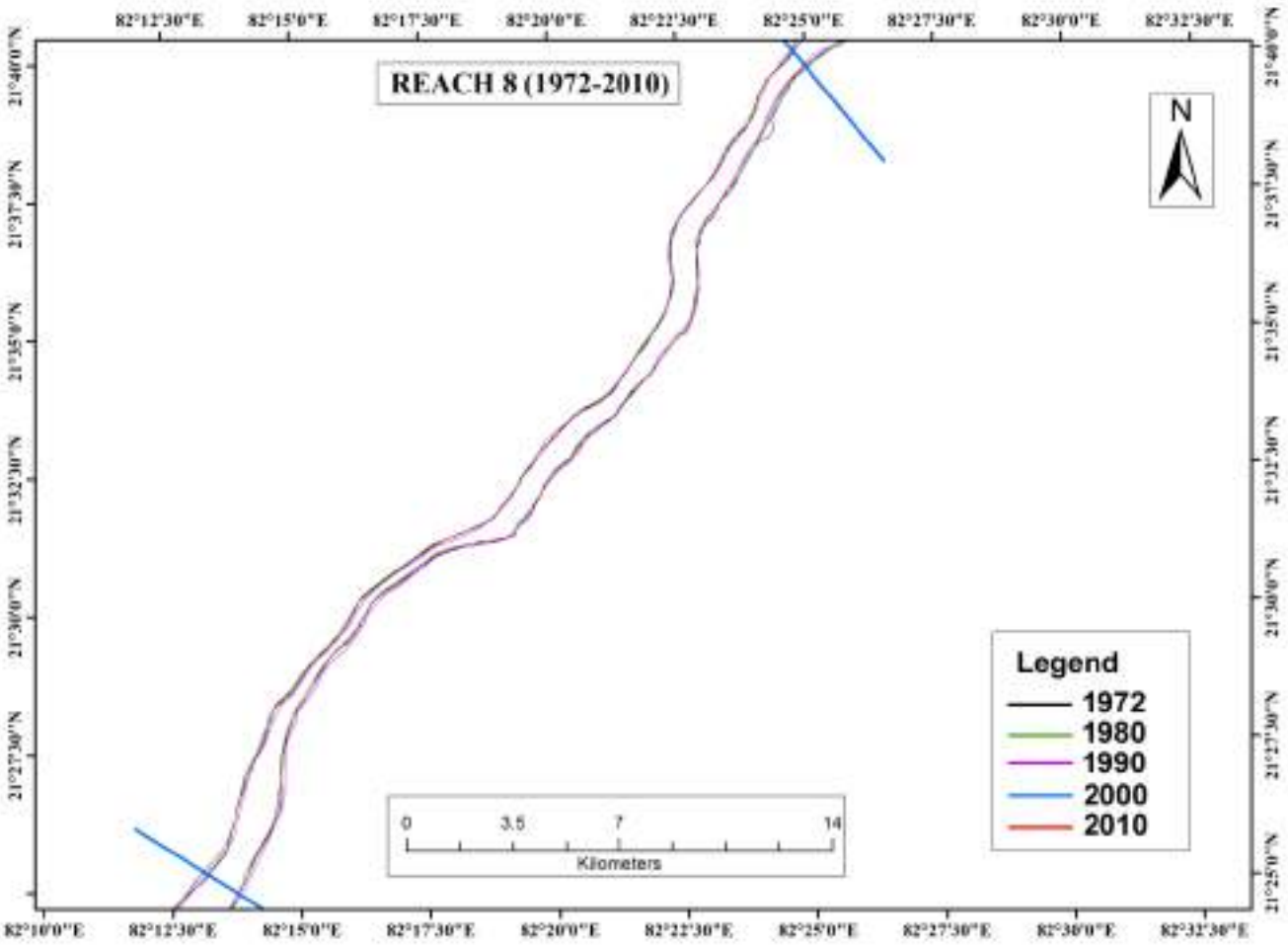


Figure 7.8: Map of Superimposed Courses of Reach 8 during 1972-2010

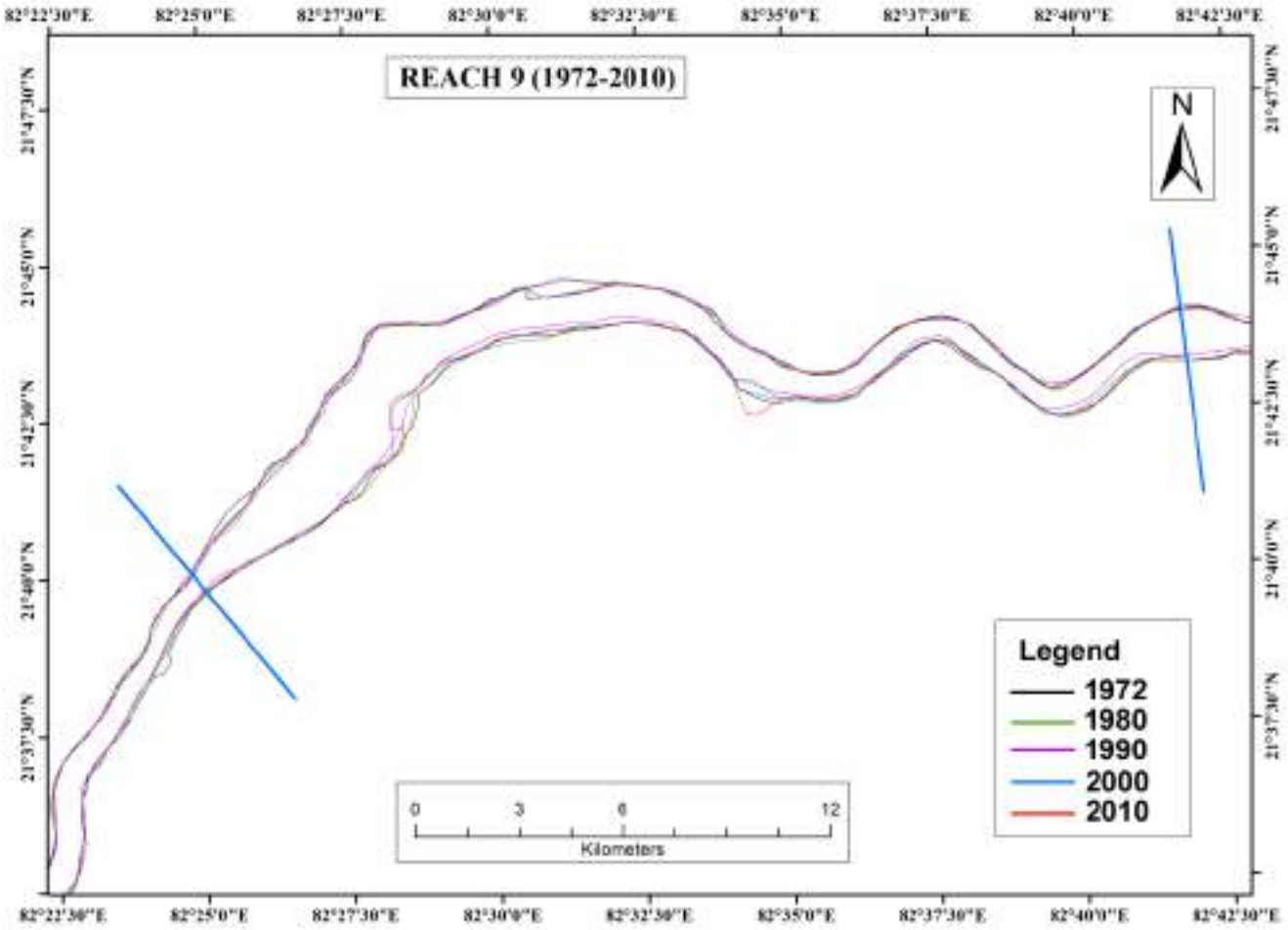


Figure 7.9: Map of Superimposed Courses of Reach 9 during 1972-2010

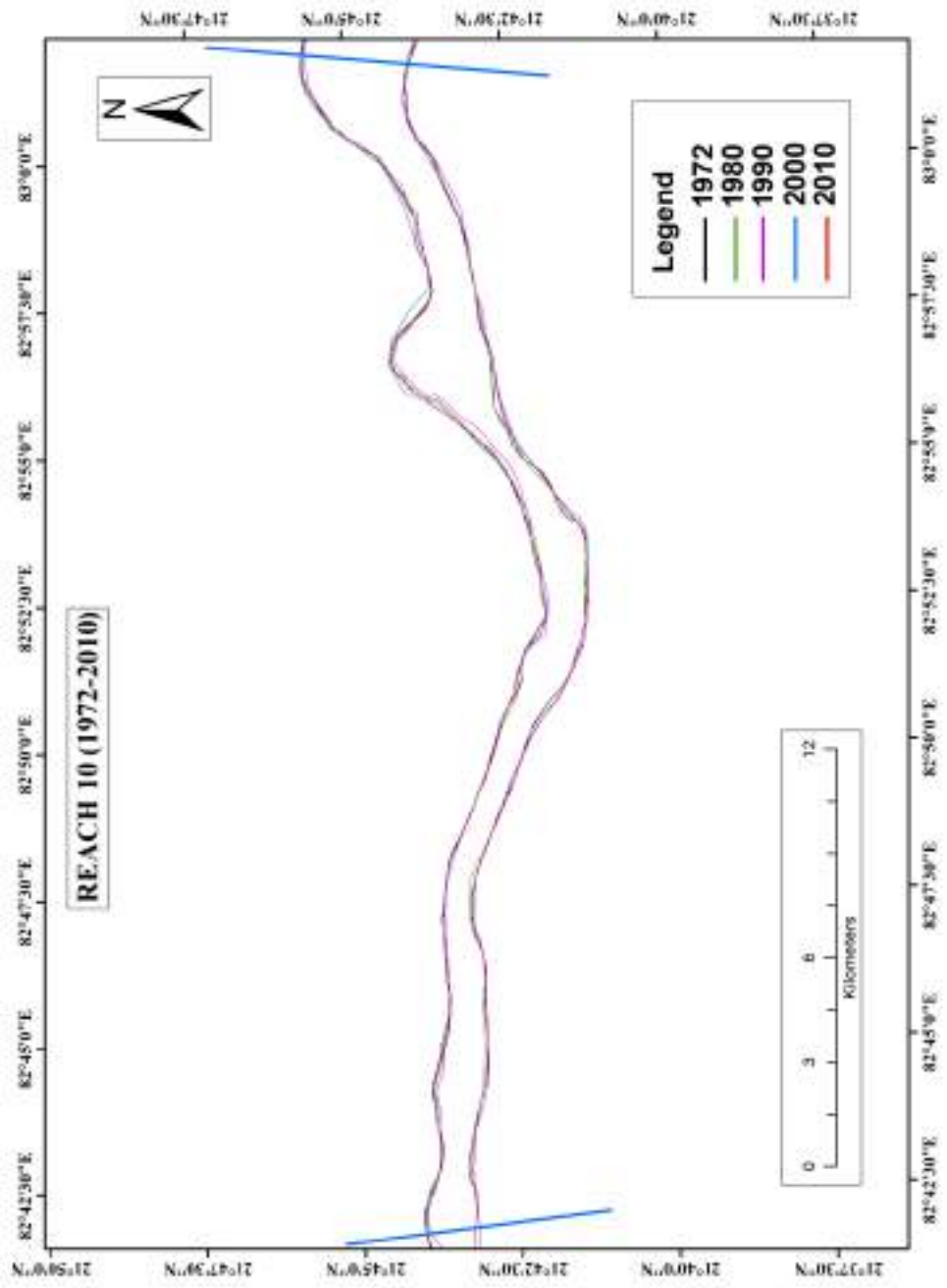


Figure 7.10: Map of Superimposed Courses of Reach 10 during 1972-2010

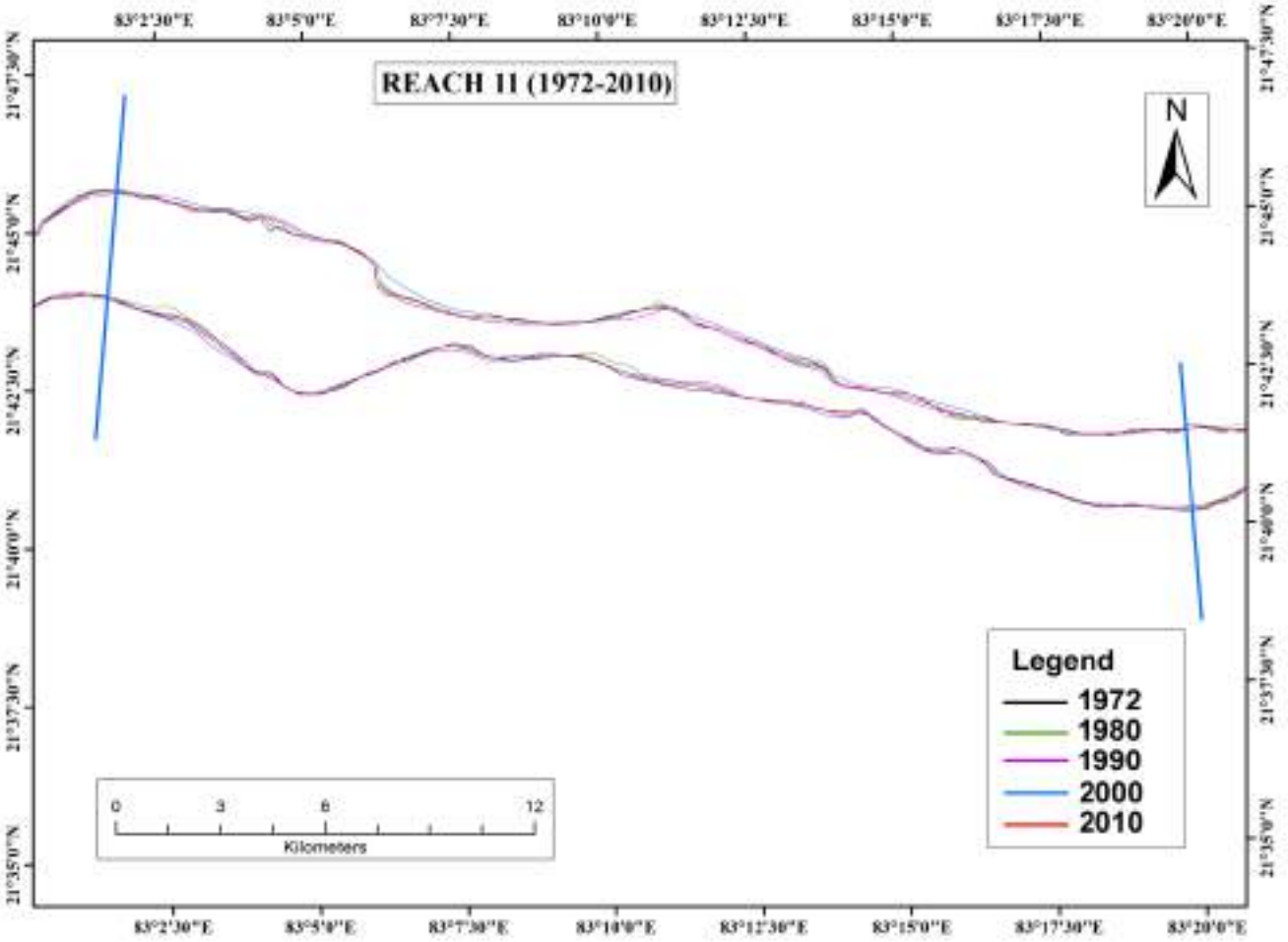


Figure 7.11: Map of Superimposed Courses of Reach 11 during 1972-2010

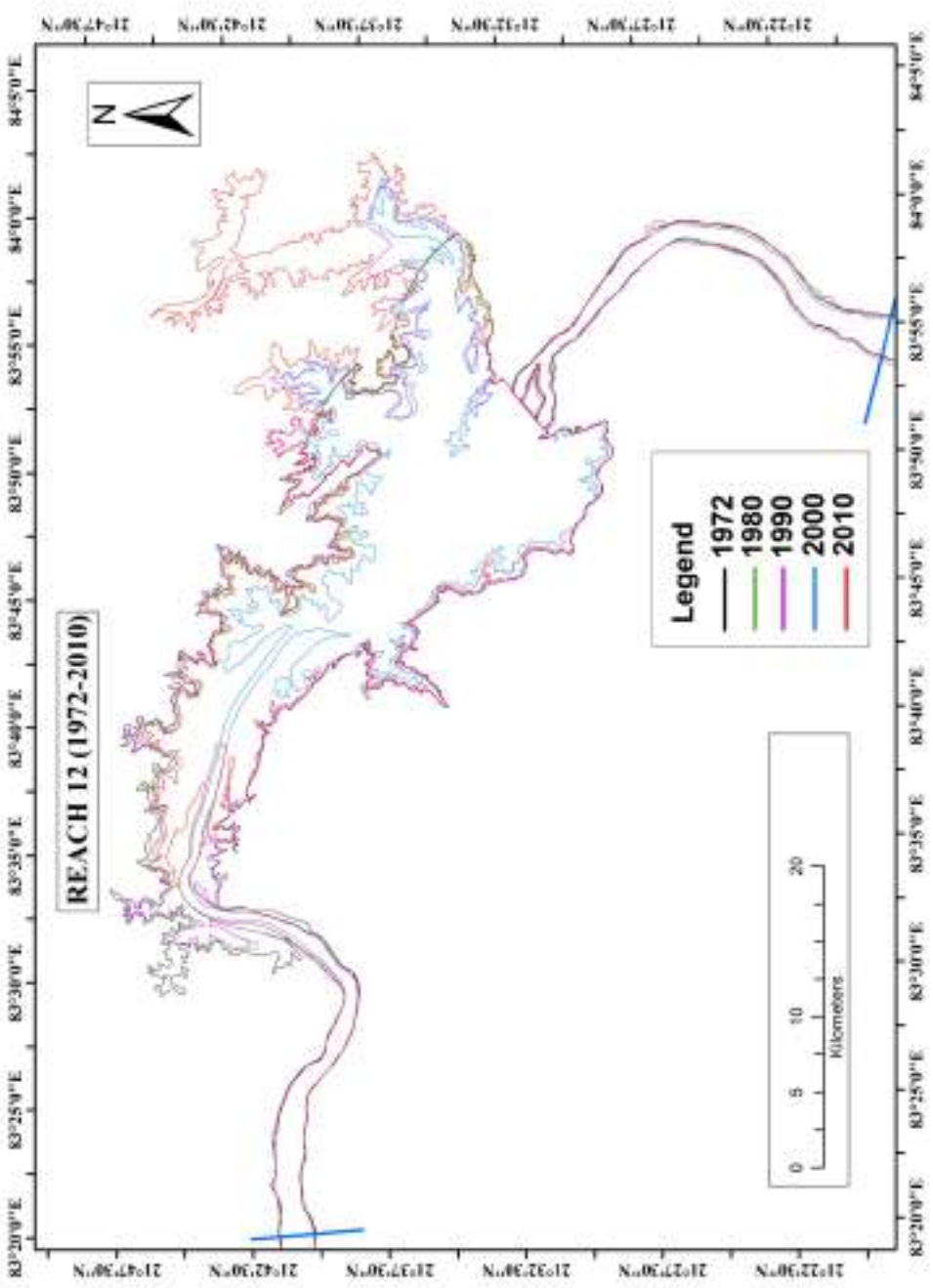


Figure 7.12: Map of Superimposed Courses of Reach 12 during 1972-2010

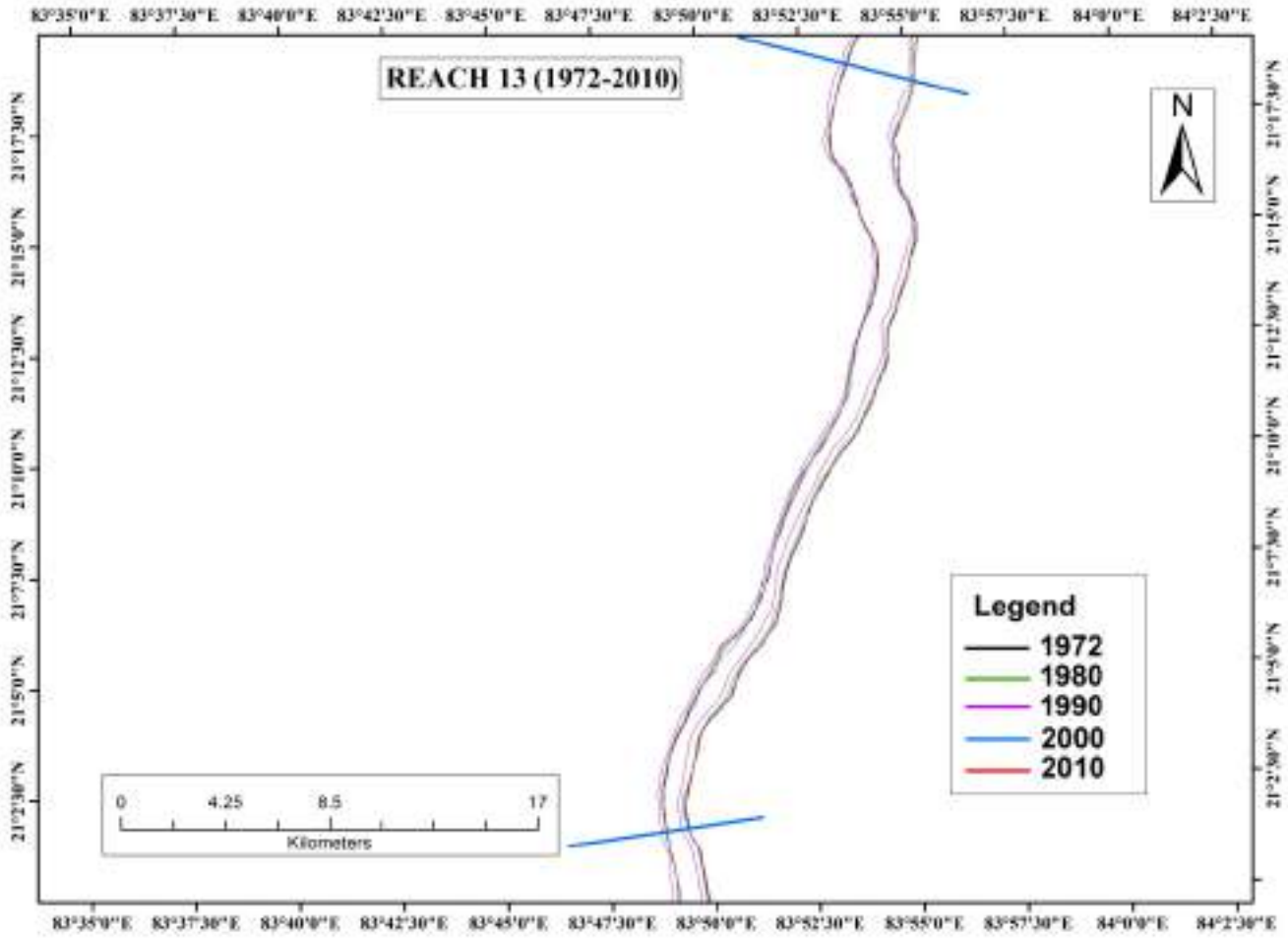


Figure 7.13: Map of Superimposed Courses of Reach 13 during 1972-2010

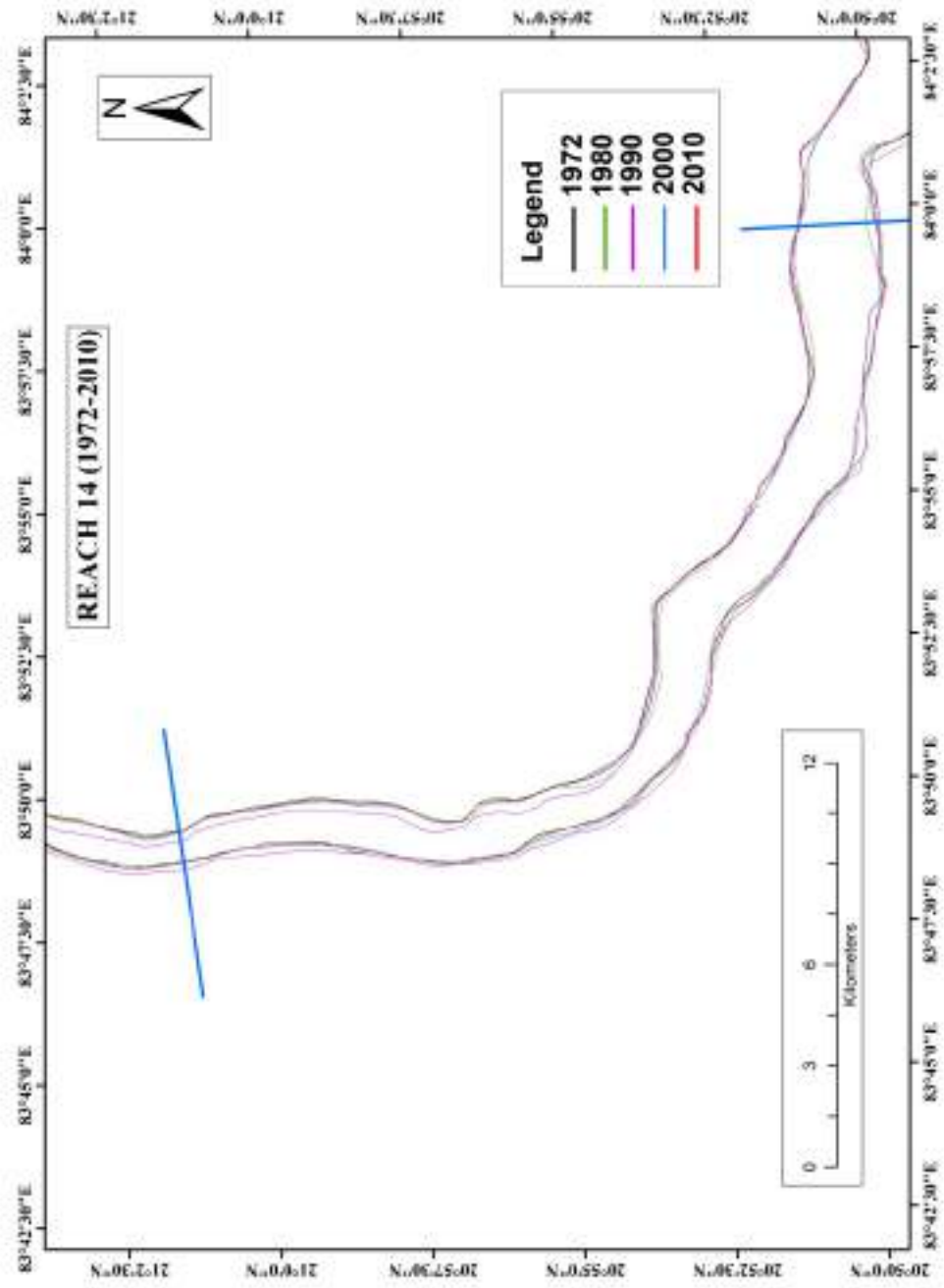


Figure 7.14: Map of Superimposed Courses of Reach 14 during 1972-2010

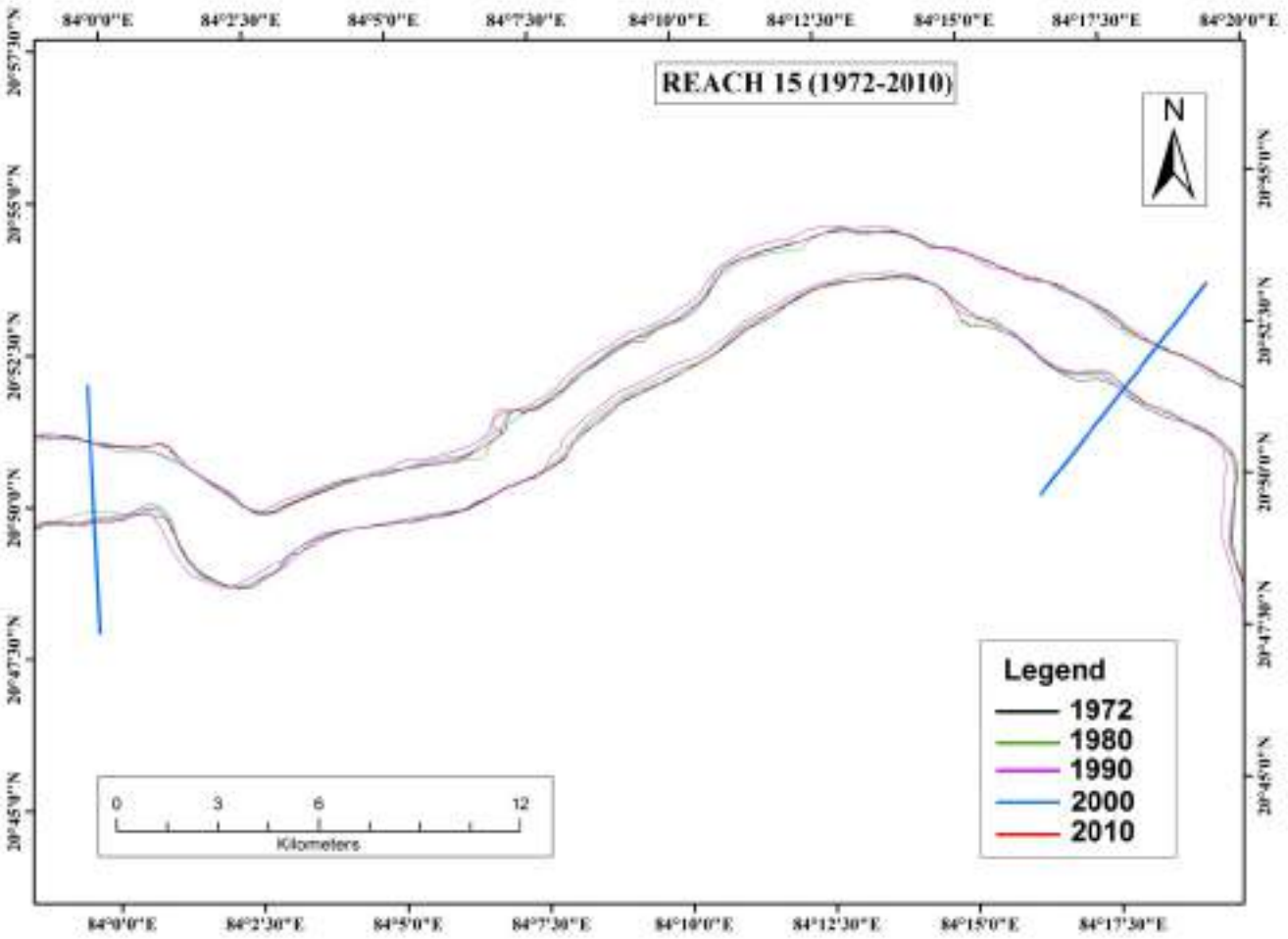


Figure 7.15: Map of Superimposed Courses of Reach 15 during 1972-2010

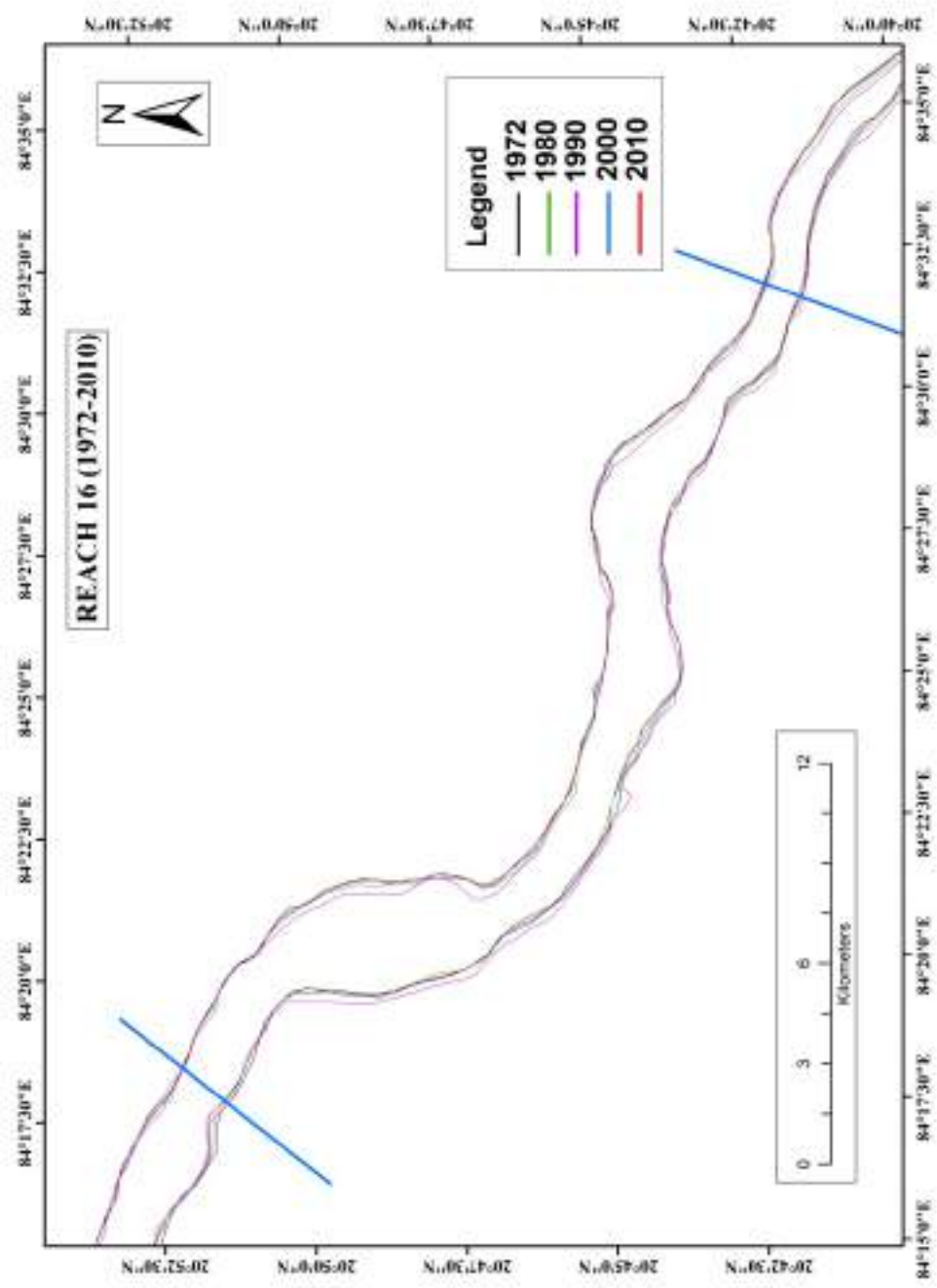


Figure 7.16: Map of Superimposed Courses of Reach 16 during 1972-2010

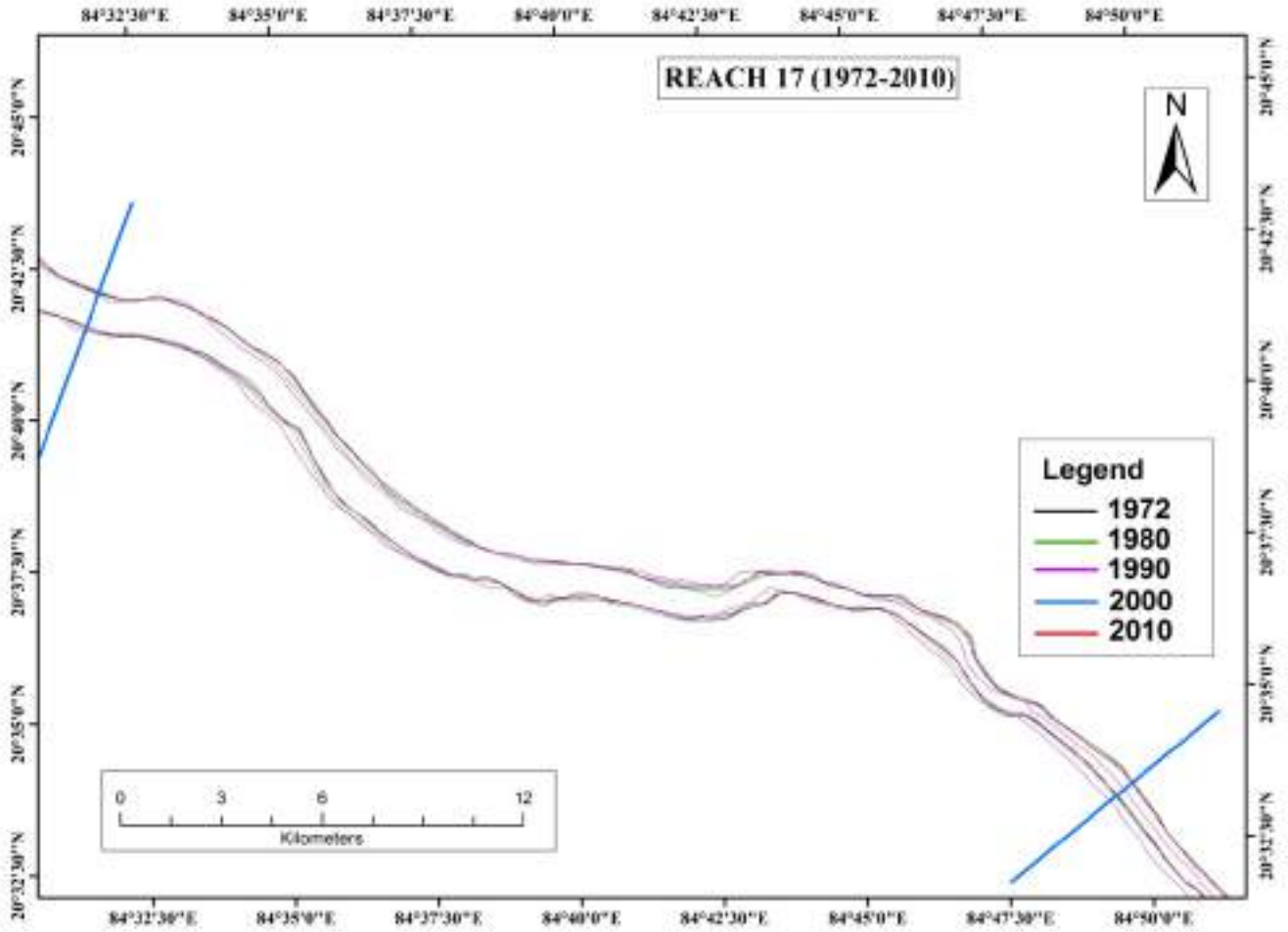


Figure 7.17: Map of Superimposed Courses of Reach 17 during 1972-2010

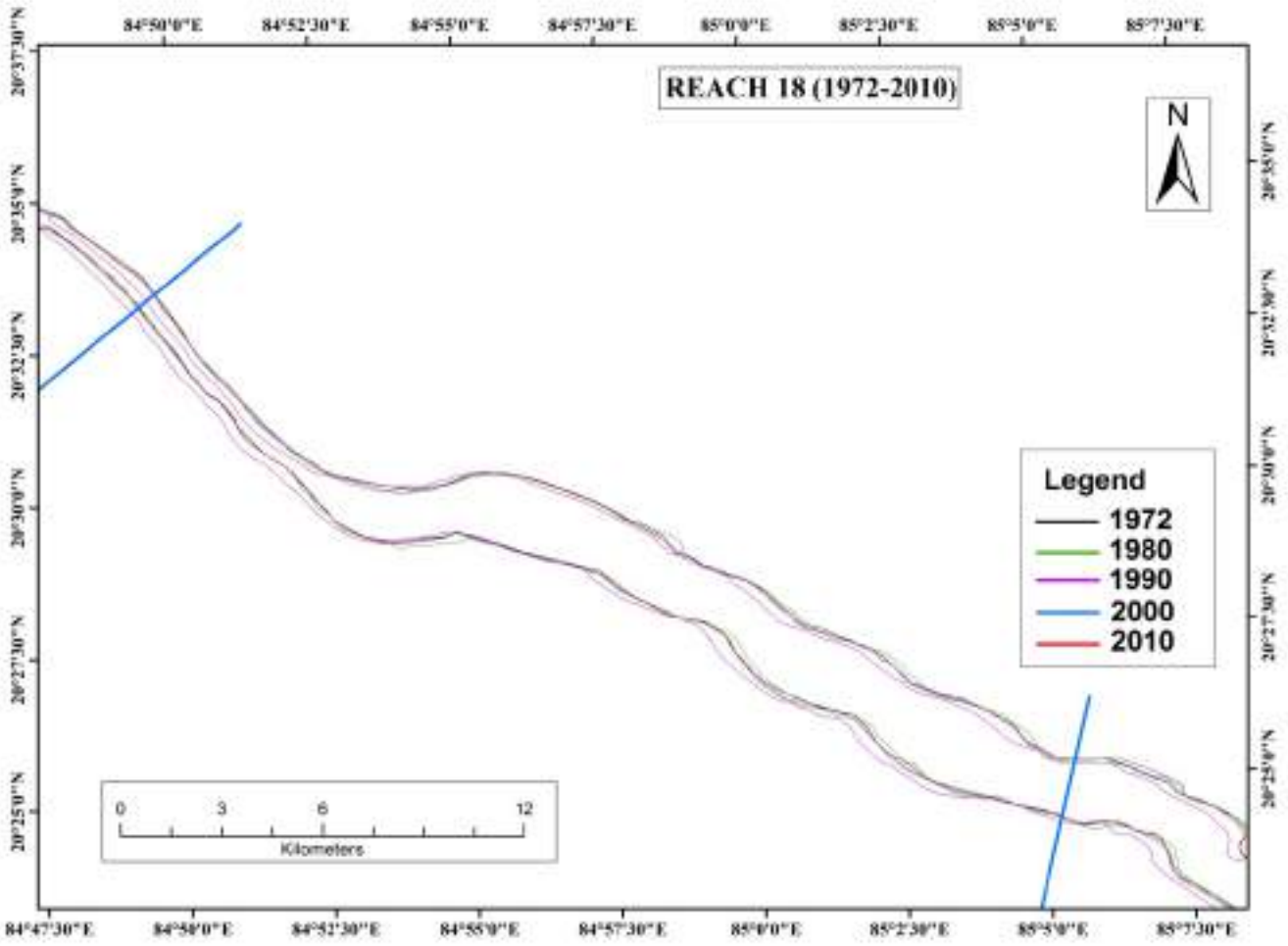


Figure 7.18: Map of Superimposed Courses of Reach 18 during 1972-2010

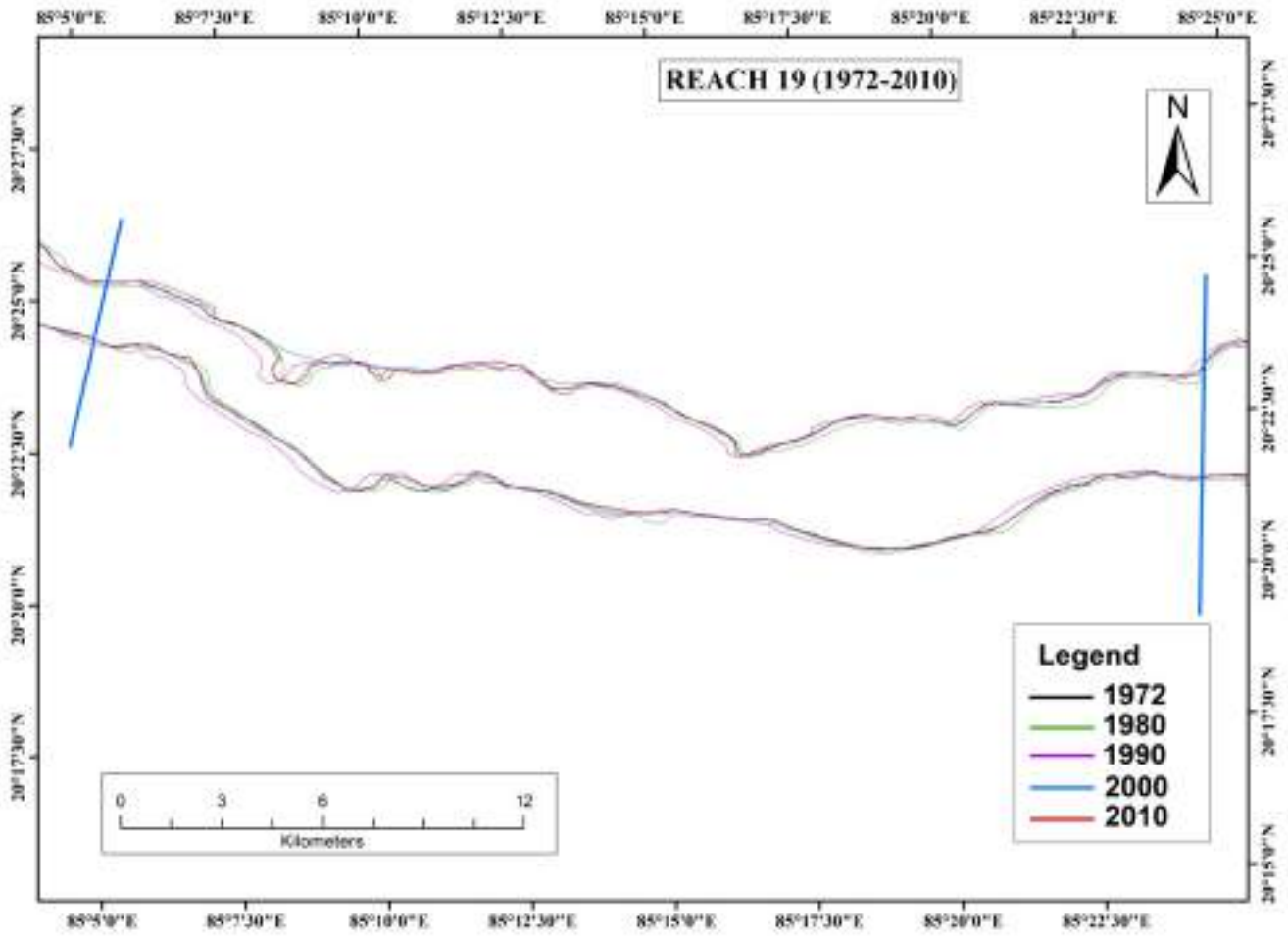


Figure 7.19: Map of Superimposed Courses of Reach 19 during 1972-2010

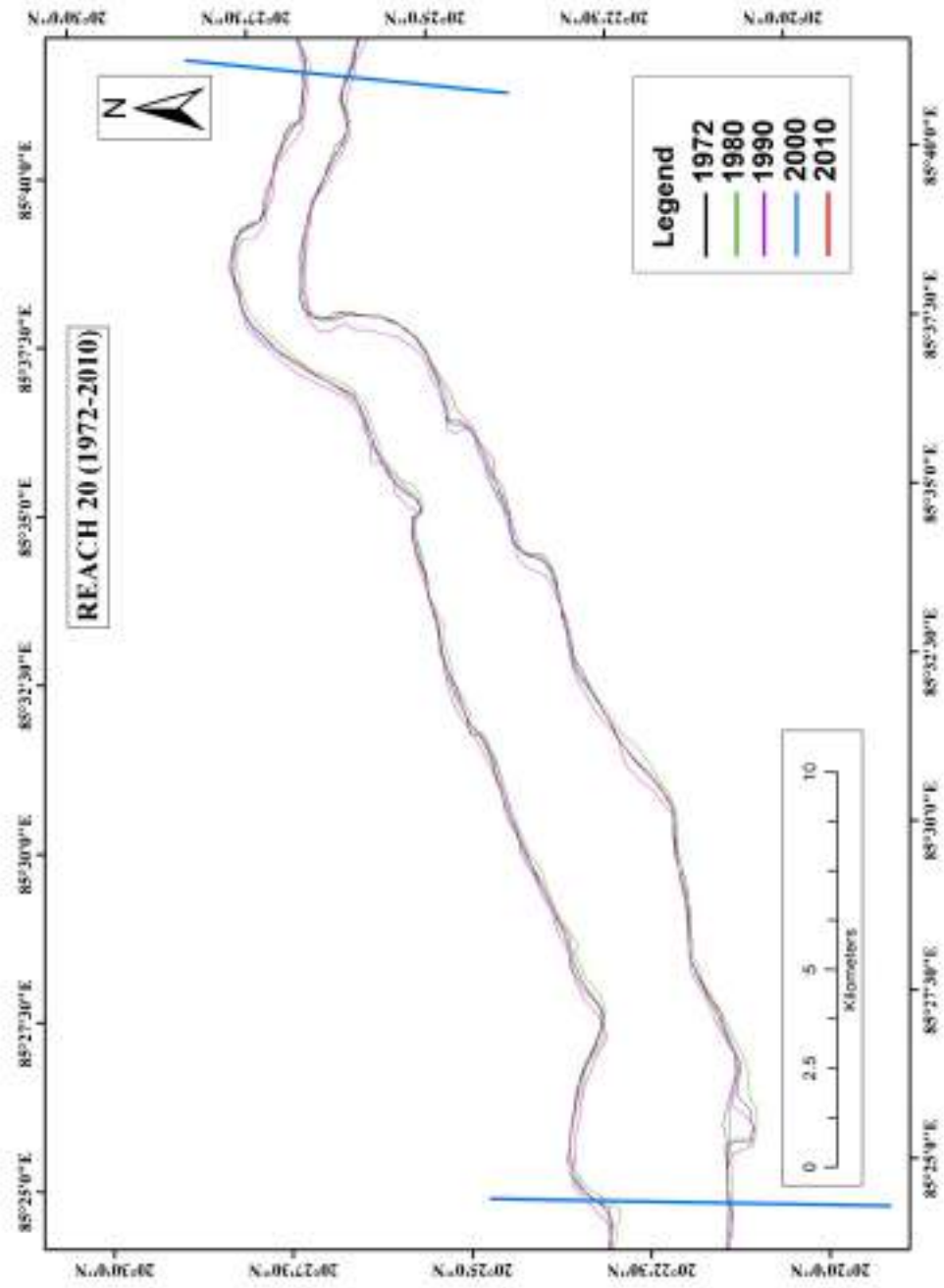


Figure 7.20: Map of Superimposed Courses of Reach 20 during 1972-2010

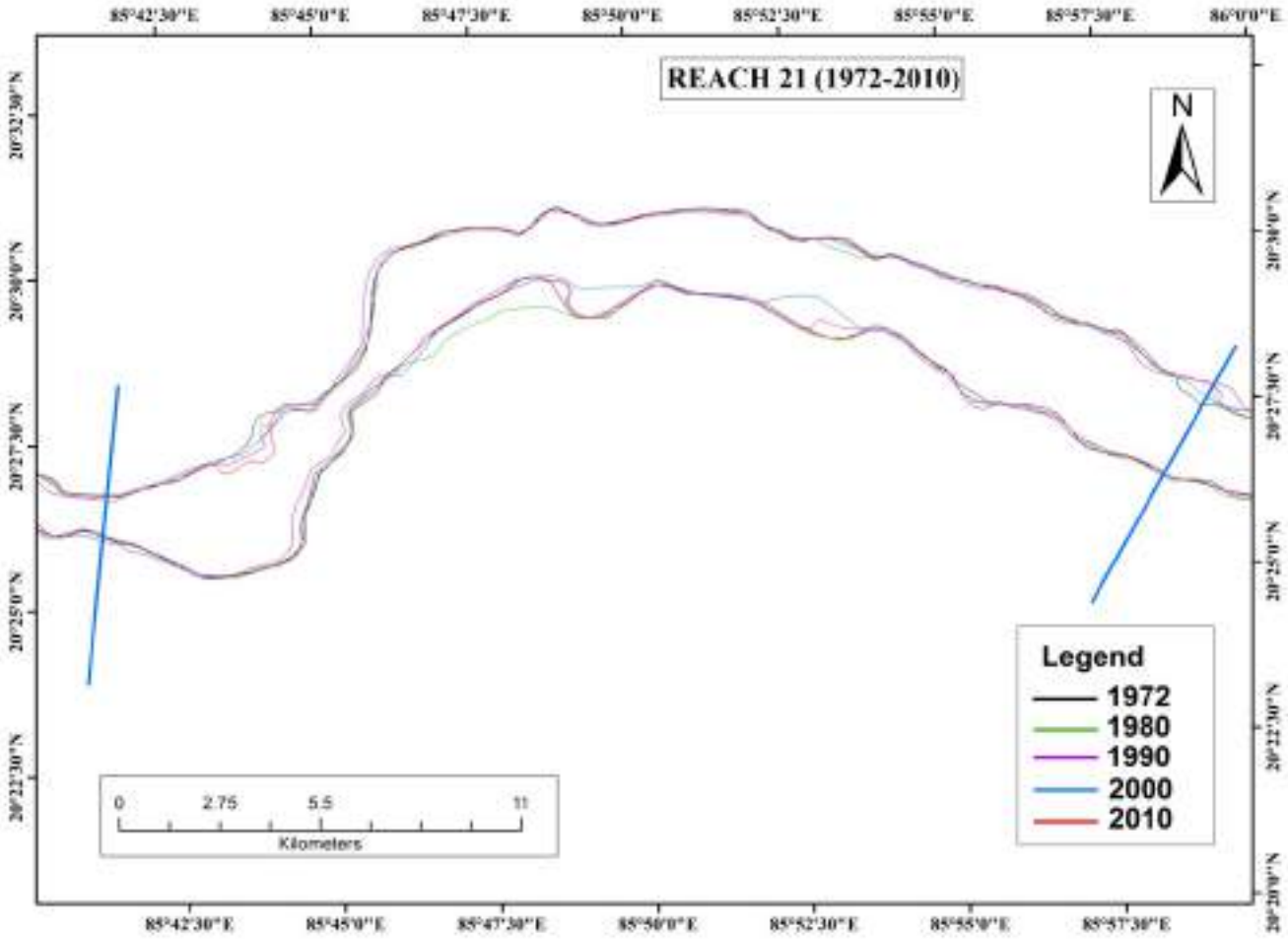


Figure 7.21: Map of Superimposed Courses of Reach 21 during 1972-2010

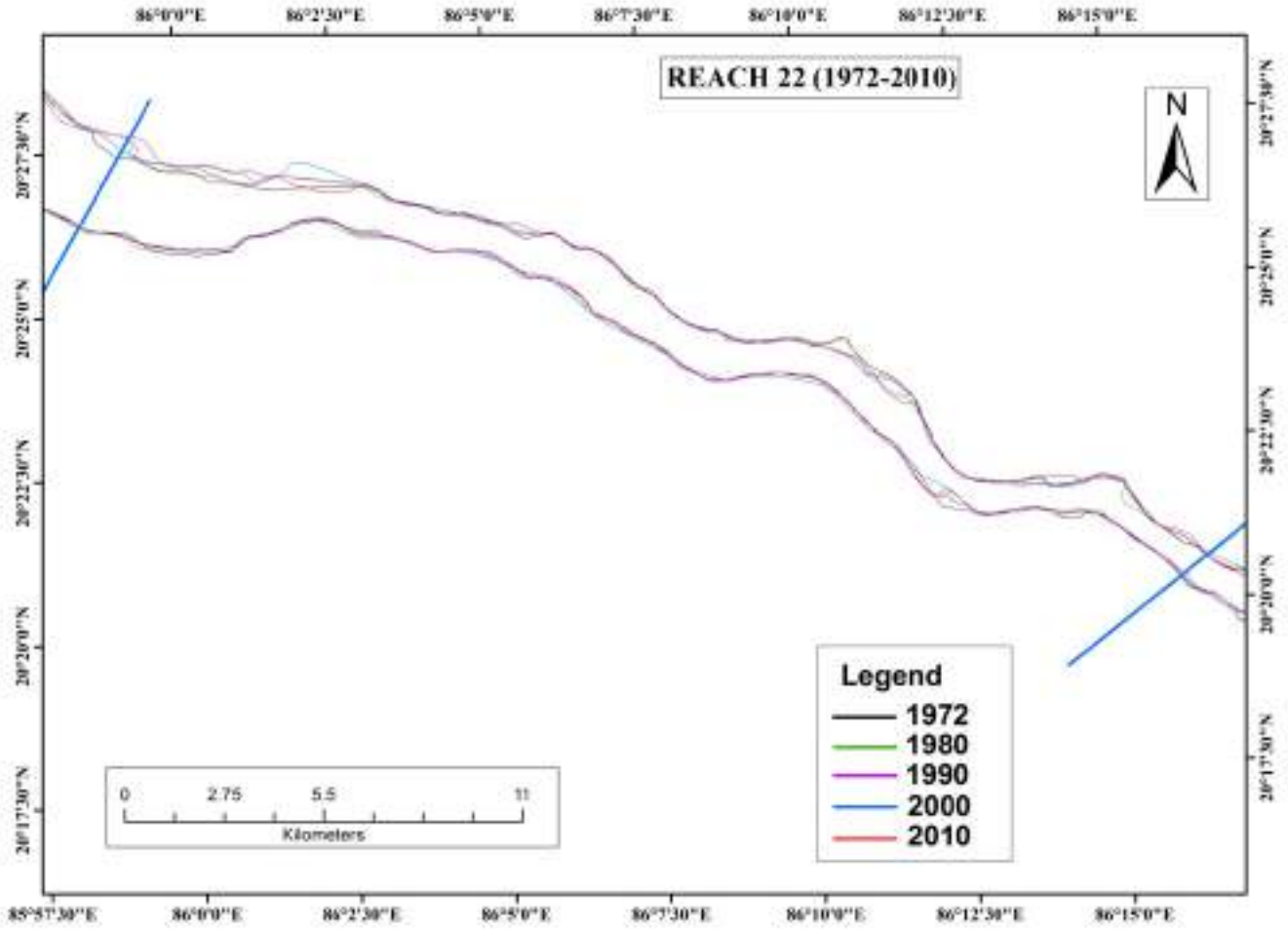


Figure 7.22: Map of Superimposed Courses of Reach 22 during 1972-2010

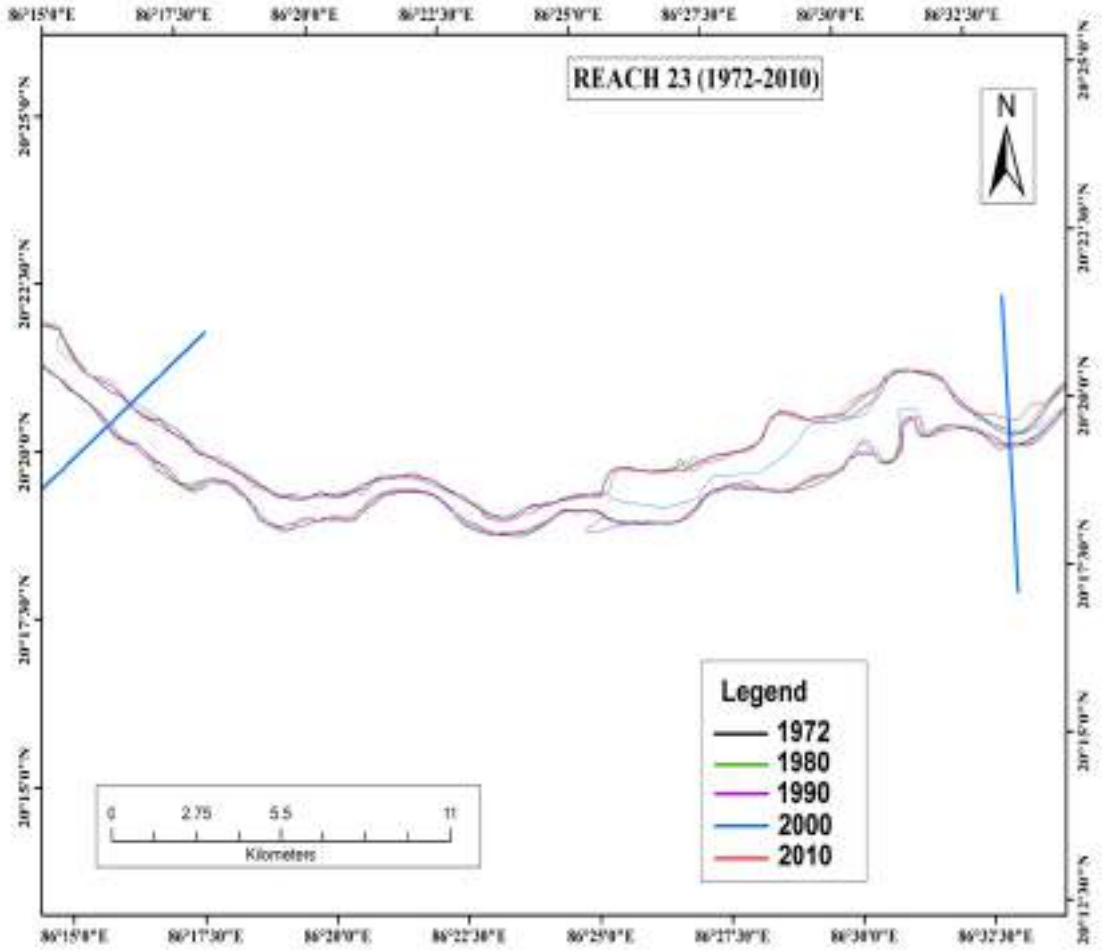


Figure 7.23: Map of Superimposed Courses of Reach 23 during 1972-2010

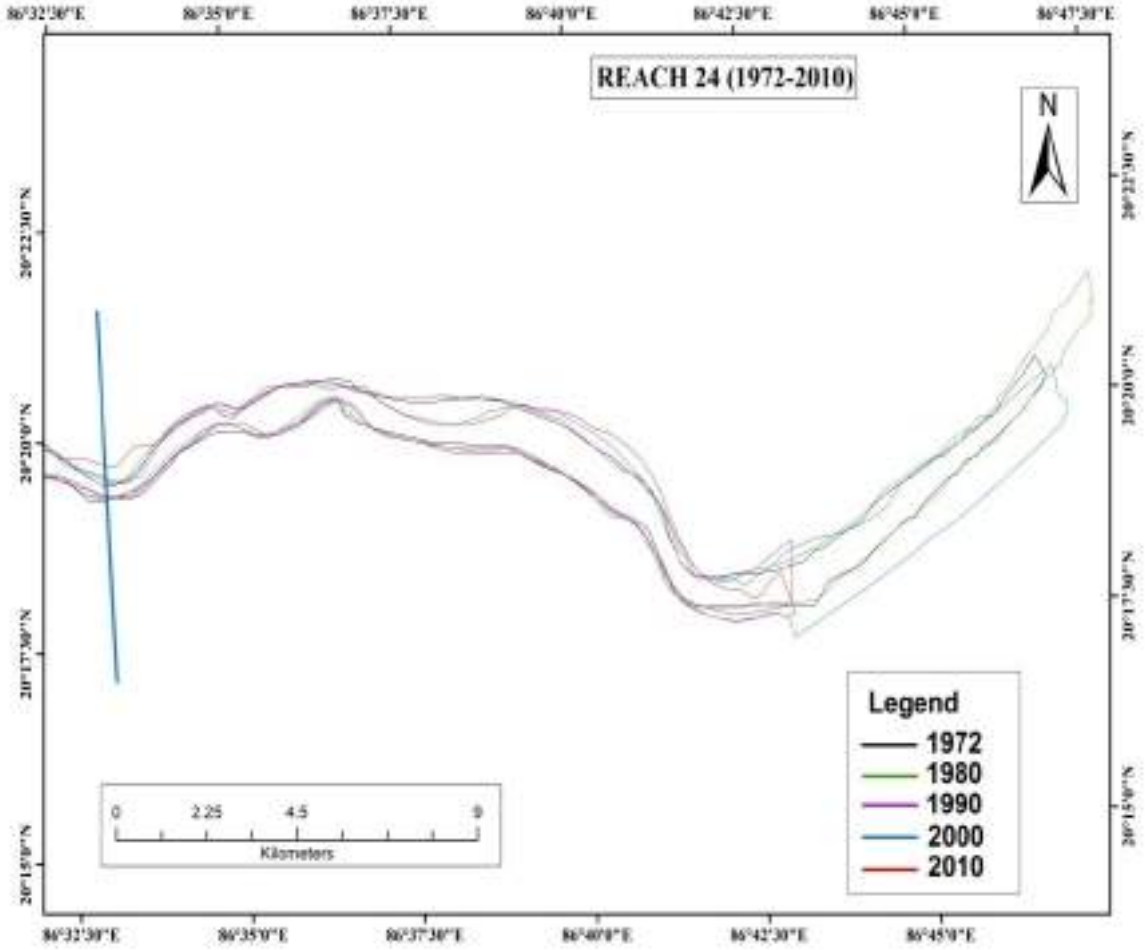


Figure 7.24: Map of Superimposed Courses of Reach 24 during 1972-2010

Table 2 : Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
0	1	81°57'2.197"E 20°12'18.325"N	-92.14	-213.91	13.3618	-207.81	-47.90	71.1218	-699.90	302.48	-466.31	522.40	202.55	110.25
2	1		-250.55	-287.16	19.2995	-232.13	-299.88	53.4126	-129.59	249.15	-24.05	-422.99	-379.11	102.7
4	1		-33.68	218.73	46.0653	88.28	-315.59	77.9886	-546.93	205.58	-476.74	-121.87	-52.95	88.0208
6	1		-7.80	14.31	57.1677	93.43	-83.48	66.8606	-159.67	159.10	-108.34	-555.89	-145.22	90.8238
8	1		-68.62	-153.65	666.248	17.56	-213.32	605.933	-94.96	-73.35	-53.08	-150.07	-129.15	621.27
10	1		-179.48	-330.69	234.667	-86.18	-394.25	435.925	-661.77	-253.28	-663.45	-187.68	-185.50	185.453
12	1		-9.05	50.68	516.604	7.15	-126.21	540.234	-326.22	-35.44	-259.07	-566.74	-280.92	578.773
14	1		-80.74	-190.53	137.061	-178.68	-129.13	218.416	-759.29	146.50	-821.76	-280.16	-237.31	318.605
16	1		181.21	124.00	503.542	29.04	-272.46	699.862	-797.02	104.29	-736.10	-1074.87	-146.05	576.794
18	1		-102.79	-99.97	280.745	-194.24	-229.72	483.888	-735.86	10.69	-873.05	-741.33	-294.68	519.088
20	1		230.06	214.91	489.283	88.39	230.84	511.612	-617.23	202.07	-723.47	-830.28	-223.33	533.094
22	1		-12.60	106.56	637.027	-129.51	235.76	613.924	-459.88	121.04	-968.35	-820.91	-370.79	590.672
24	1		-13.87	41.31	544.419	-119.74	123.10	118.963	-92.99	-74.71	-435.61	-619.92	-521.98	574.453
26	1		319.38	-31.35	-108.689	279.07	-304.91	-320.777	159.66	-34.27	-8.63	-660.17	-597.22	-378.001
28	1		198.80	87.30	88.1183	-45.15	-262.61	162.951	-244.03	-18.11	-848.74	-1017.88	-207.60	577.205
30	1		154.06	-111.94	317.353	107.94	-365.50	368.832	-729.26	-145.72	-928.22	-781.42	-766.28	344.043

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
32	1		-28.20	-92.37	-308.801	-64.11	-389.97	-	-687.78	104.28	-619.29	-555.44	-788.74	-
34	1	81°45'23.684"E 20°18'15.773"N	45.62	-58.65	-156.339	83.35	-472.44	-132.731	-437.60	-24.11	-795.31	-574.10	-775.52	-61.582
36	2		8.42	-14.02	404.323	66.39	-104.65	105.491	-397.15	-16.95	-367.28	-385.34	-183.29	175.148
38	2		111.06	-51.90	250.843	-35.47	-144.98	142.488	-764.64	-15.27	-796.21	-1005.19	-160.01	119.21
40	2		128.58	5.08	227.672	109.89	-120.42	253.392	-352.64	-34.62	-613.42	-766.90	-116.14	176.854
42	2		26.44	-43.66	215.319	-38.37	-134.93	88.8811	-624.01	-43.34	-704.29	-223.96	-121.97	147.335
44	2		62.88	-108.22	164.058	-117.88	-170.48	224.794	-482.95	-147.97	-557.34	-629.77	-101.94	221.506
46	2		124.66	136.46	136.487	79.21	-164.61	106.234	-700.46	-44.25	-843.25	-587.02	-173.57	149.511
48	2		17.68	50.92	393.176	70.74	-192.46	175.593	-709.54	57.17	-599.39	-735.39	-199.04	207.785
50	2		-86.61	-71.43	180.784	-155.28	-179.77	173.979	-799.74	19.05	-481.55	-686.04	-155.67	151.061
52	2		-13.11	-102.49	125.817	117.92	-193.96	120.926	-502.15	70.83	-395.22	-598.64	-122.05	136.779
54	2		20.67	-58.84	113.123	31.86	-179.93	74.7458	-625.19	18.11	-691.35	-440.48	-132.33	239.232
56	2		-10.42	57.38	76.2638	-79.67	-194.18	153.4	-745.91	199.82	-743.62	-750.67	-107.08	22.6728
58	2		37.95	87.74	95.6746	-2.29	-162.03	96.708	-550.18	53.83	-599.70	-793.64	-181.66	100.215
60	2		290.94	89.66	83.134	165.47	-105.49	115.593	-671.20	160.95	-542.62	-489.66	-162.08	43.1933
62	2		88.48	-61.55	77.0543	142.08	-109.00	51.05	-531.03	97.37	-585.22	-574.16	-165.97	76.56

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
64	2		88.76	-54.42	103.669	96.25	-194.85	90.6517	-648.18	90.71	-647.59	-554.05	-149.41	125.411
66	2		40.61	173.20	-102.52	-11.80	-119.52	-103.594	-352.66	92.55	-287.32	-581.57	-157.33	-234.361
68	2	81°27'56.133"E 20°24'10.306"	-20.88	59.46	-85.9976	38.53	-184.75	-84.4119	-441.37	170.35	-508.34	-313.28	-170.04	-132.012
70	3		25.77	39.39	-167.611	97.15	-181.86	-128.538	-687.95	92.63	-506.85	-476.02	-498.02	-199.273
72	3		20.81	-124.55	-83.4387	53.66	-475.67	-103.185	-566.49	-31.64	-360.91	-483.63	-516.83	-229.971
74	3		89.90	238.67	-133.515	22.45	-581.39	-158.664	-596.05	-20.25	-522.07	-608.21	-499.06	-109.193
76	3		-53.95	305.68	-70.2651	95.14	-701.13	-109.212	-289.39	-60.34	-134.82	-506.90	-558.40	-203.018
78	3		3.50	212.43	-166.031	23.02	-575.77	-140.514	-458.45	-79.97	-493.99	-194.46	-128.80	-153.848
80	3		18.21	39.23	-187.227	148.41	-467.43	-85.401	-490.17	-146.81	-426.09	-362.79	-387.38	-77.852
82	3		7.25	-175.46	-128.552	-38.41	-612.70	-422.188	-752.32	-38.00	-599.50	-360.87	-488.12	-117.717
84	3		161.89	156.47	-275.939	2.24	-175.34	-514.901	-452.42	-147.99	-545.57	-553.34	-533.40	-296.239
86	3		-62.35	28.69	-	81.25	-92.87	-	-295.84	-192.46	-572.08	-417.57	-427.76	-999
88	3		24.01	-230.14	-	61.82	-293.46	-	-503.68	-190.00	-454.66	-470.33	-455.75	-999
90	3		-93.11	19.51	-	23.76	-204.23	-	146.81	-170.45	369.40	-585.05	-209.38	-999
92	3		-51.99	-77.54	-	-42.06	-191.38	-	151.46	-228.82	152.09	-66.30	390.82	-999
94	3		124.95	-6.15	-25.8353	4.10	-247.61	-39.2852	534.19	-43.02	548.80	-38.34	357.11	-71.9457

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
96	3		8.61	-112.03	-198.679	-29.98	-218.56	-602.881	811.48	75.35	563.93	315.01	362.95	-677.164
98	3		7.47	30.82	-108.297	34.04	-352.09	-97.9042	432.13	68.27	838.24	805.81	417.60	-161.685
100	3		66.08	-91.02	1214.22	120.93	-292.48	1121.48	280.14	-44.68	764.53	598.98	373.01	178.832
102	3	81°27'40.598"E 20°33'55.028"	37.75	70.23	148.985	23.01	-203.23	180.204	808.74	-154.03	627.14	338.11	471.61	136.417
104	4		48.52	347.37	604.524	37.11	89.91	622.984	204.14	25.38	432.54	800.27	517.32	388.076
106	4		93.89	235.01	1003.26	186.23	-361.13	1120.8	943.75	26.50	581.42	212.41	388.99	305.415
108	4		-142.79	116.79	1200.38	638.78	-296.05	1208.13	913.89	77.93	521.36	961.59	408.46	129.13
110	4		30.60	117.78	150.602	395.10	-109.69	83.9781	72.74	39.05	386.44	848.20	123.10	320.293
112	4		-4.96	52.59	543.407	38.68	-602.13	674.861	-50.88	154.95	443.52	144.38	530.53	371.436
114	4		85.22	63.73	-	77.73	-216.92	-	-343.84	75.26	443.76	143.31	603.63	49.0811
116	4		69.06	-110.62	-	116.45	-305.87	-	360.51	-269.68	317.83	605.41	264.30	92.0806
118	4		54.78	166.43	-	-42.28	-125.31	-	315.46	-227.93	308.20	370.49	400.54	359.834
120	4		18.96	77.83	-	70.09	-303.92	-	334.57	-140.49	469.23	489.57	305.73	173.981
122	4		44.45	120.86	-	72.87	-473.73	-	-746.20	20.14	550.30	266.58	81.81	299.344
124	4		34.14	72.23	-	74.57	-168.77	-	247.80	73.77	606.44	318.67	-110.42	91.5501
126	4		-126.69	-69.20	-	-3.72	-212.28	-	270.08	263.64	407.68	-390.36	-298.20	245.194

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center r Line	Right Bank	Left Bank	Center Line	Right Bank
128	4		-61.95	-139.40	-	-75.22	-410.75	-	103.76	247.57	583.71	-568.52	70.74	239.029
130	4		-154.59	203.89	-	-55.44	-66.41	-	197.80	398.50	277.23	-7.31	423.35	925.375
132	4		-22.81	330.69	-	-17.62	-210.06	-	326.15	237.94	-298.58	0.11	420.44	357.601
134	4		-33.89	-122.21	-	21.41	-125.54	-	-508.41	135.66	268.53	300.44	281.95	550.176
136	4	81°33'32.774"E 20°34'55.688"	-83.24	-77.04	-	-33.25	-252.77	-	-430.65	115.09	223.27	578.91	220.78	487.495
138	5		-93.42	-178.86	594.155	-55.14	-304.65	1322.99	-398.65	413.54	225.33	-115.15	236.32	371.03
140	5		-73.19	-98.96	1719.37	-97.35	-211.58	563.984	171.89	494.07	319.56	107.91	198.57	279.169
142	5		-59.34	40.78	1291.73	-1.17	56.88	263.656	-651.32	53.97	264.62	380.37	179.40	476.283
144	5		7.91	144.39	-	30.37	42.66	-	-235.45	166.99	330.49	-328.14	101.34	604.879
146	5		46.10	238.74	-	246.22	-86.26	-	-1228.62	92.44	199.48	-172.05	184.20	550.262
148	5		41.68	-105.73	-	110.59	209.66	-	-302.10	60.90	262.67	-1062.38	123.65	532.612
150	5		62.75	310.02	-	104.70	265.10	-	-409.61	25.72	374.08	289.70	77.73	186.762
152	5		23.88	395.94	-	76.78	163.15	-	-271.73	111.08	306.61	510.41	78.85	447.804
154	5		68.06	328.20	-	242.29	237.36	-	-699.24	129.27	401.20	-214.34	72.18	238.1
156	5		629.38	79.66	-	250.78	69.41	-	-365.58	248.27	337.37	-430.22	-139.98	230.969
158	5		-62.91	-95.21	-	28.48		-	-456.88			319.43		602.502

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
160	5		83.08	-95.21	-	102.42	-118.05	-	-456.88	341.74	370.44	319.43	-79.99	588.697
162	5		13.64	-203.32	-	125.37	-83.53	-	-879.62	218.21	167.66	228.72	108.76	278.069
164	5		13.08	-176.81	-	222.22	-8.40	-	-889.19	38.89	256.83	467.12	-295.77	781.18
166	5		4.04	106.09	-	68.03	-161.65	-	-530.49	97.13	180.32	132.94	-87.49	289.299
168	5		15.42	265.95	-	136.68	-178.41	-	404.66	36.68	-116.87	164.07	-50.46	233.79
170	5	81°36'30.112"E 20°36'22.98"N	12.28	53.20	-	73.37	-100.20	-	137.78	153.59	-194.17	521.81	104.74	265.344
172	6		29.47	19.37	-	47.93	-210.52	-	406.00	4.13	-136.00	-585.58	128.34	441.031
174	6		9.00	-165.07	-	199.36	100.43	-	63.17	69.18	-61.05	23.69	147.09	487.94
176	6		-64.76	-199.10	418.815	190.43	82.75	380.065	189.21	200.65	-202.71	469.22	-79.26	149.399
178	6		8.56	-244.72	281.796	-26.00	-72.32	400.762	450.76	114.28	-136.90	329.03	55.31	257.138
180	6		-8.21	-203.29	-287.01	101.32	-28.92	-164.007	4.30	-232.56	-75.04	412.60	-61.95	-271.294
182	6		217.08	267.06	-336.101	231.75	68.54	-118.571	194.07	-215.69	-102.64	269.74	188.44	-143.768
184	6		45.39	609.59	-425.101	55.26	71.78	-309.199	104.68	-429.47	-220.85	-179.39	-47.80	-404.037
186	6		35.54	336.74	-332.176	24.31	-64.16	-242.381	674.72	-338.79	-121.18	440.10	-47.15	-334.951
188	6		-94.26	37.51	-432.381	-139.44	114.77	-49.8681	277.52	-276.44	-45.88	-200.99	54.10	-94.5473
190	6		-32.90	-194.95	-251.261	-227.98	22.76	-434.337	399.98	-174.18	-105.02	-526.68	-27.92	-341.129

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
192	6		-32.90	117.76	-333.333	-227.98	-48.74	-153.091	285.25	-107.96	-26.95	-598.98	157.47	-202.481
194	6		-13.05	83.90	-201.523	103.36	-79.59	-266.48	154.16	-234.61	534.68	315.19	-64.72	-207.367
196	6		8.32	-46.06	-582.348	25.09	-106.44	-159.101	111.29	-551.48	-99.60	747.64	-44.88	-126.227
198	6		-55.87	102.34	-163.297	43.44	100.84	-414.27	397.02	-284.20	-369.50	-398.95	-56.90	-383.212
200	6		-55.33	-15.14	-380.237	-85.68	-87.37	-187.82	493.71	-443.02	-177.83	-286.62	-49.26	-151.674
202	6		-48.35	91.81	-209.211	-177.68	-62.62	-349.22	340.06	-235.64	-192.31	-302.62	62.71	-182.515
204	6	81°47'24.255"E 20°45'31.458"	-82.45	80.75	-348.032	-68.11	-80.64	-103.696	402.04	-112.89	-288.21	246.27	196.45	-103.696
206	7		-8.42	-177.24	-209.221	-144.57	196.51	-303.1	350.58	-104.07	-242.06	282.36	53.34	-22.5791
208	7		-26.49	-32.49	-320.279	-30.42	169.00	-129.768	274.27	-129.12	-267.02	353.67	-27.04	-44.3021
210	7		12.34	155.24	-294.03	20.80	42.68	-154.582	740.96	-119.17	-62.60	292.99	-38.13	-78.4569
212	7		-80.00	162.37	-122.424	40.72	89.36	-158.555	862.95	-43.33	-273.18	90.53	138.44	-143.434
214	7		-13.71	208.86	-297.425	-8.62	-23.27	-228.746	1323.83	-229.05	-366.89	264.69	43.13	-124.783
216	7		21.96	30.66	-397.97	261.56	-32.12	-221.079	446.33	-235.31	-359.66	199.55	42.09	-120.142
218	7		-113.86	-30.94	-235.706	95.79	-31.77	-275.475	335.91	-308.21	-319.09	85.96	-82.65	-86.671
220	7		13.87	-93.31	-1186.46	19.58	53.88	-94.818	403.18	-281.55	-206.52	267.09	-50.33	-123.554
222	7		6.82	-43.18	-234.093	45.55	27.05	-1086.36	423.70	-329.74	-221.98	205.16	-48.32	-183.409

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center r Line	Right Bank	Left Bank	Center Line	Right Bank
224	7		-22.29	83.20	-211.908	18.12	-52.10	-234.255	641.32	-362.99	-226.03	172.48	-39.45	-152.993
226	7		35.43	22.50	-167.743	42.84	-161.24	-123.254	-217.58	-242.10	-300.69	124.67	76.91	-117.979
228	7		27.56	48.70	-173.911	92.42	-46.04	-39.7047	-238.54	-307.52	-257.01	17.68	32.84	-115.286
230	7		25.81	99.50	-125.838	78.56	54.95	-125.87	-185.72	-248.80	-288.51	-34.73	126.19	-88.2928
232	7		-20.86	-48.86	-141.04	30.93	55.70	-161.925	-132.77	62.01	-220.22	9.99	-77.90	-161.925
234	7		-15.35	-44.66	-189.981	47.43	-53.24	-134.694	612.11	22.78	-176.03	-119.68	17.68	-58.3721
236			-39.43	67.43	-223.381	69.24	-114.98	-216.736	305.30	298.83	-214.27	-45.31	26.75	-89.912
238	7	81°58'7.162"E 21°2'57.528"N	-9.13	41.37	-183.79	39.07	-112.53	-176.046	249.11	90.82	-231.95	82.82	45.78	-114.527
240	8		-22.17	-69.42	-153.109	18.84	-87.84	-112.439	507.49	36.44	-281.77	14.66	41.83	-52.3556
242	8		-85.23	-37.46	-260.005	1.36	26.33	-179.036	270.21	120.65	-199.74	5.93	-50.65	-94.6264
244	8		-82.61	-82.61	122.525	31.67	19.54	87.2339	204.20	40.65	-301.07	-64.19	42.28	70.9845
246	8		-3.89	-174.53	196.415	44.45	64.40	312.254	309.79	-279.40	-279.46	42.48	-164.54	89.5797
248	8		-40.38	-137.80	215.474	46.76	-13.12	136.869	275.23	-249.98	-308.94	13.44	-63.37	88.6545
250	8		-56.27	-95.17	157.456	198.87	19.00	249.77	329.02	-261.69	-266.21	227.08	107.91	133.972
252	8		-46.08	-137.96	201.967	37.08	57.18	97.2558	281.04	-340.24	-246.10	19.30	25.37	83.1555
254	8		-24.93	-119.79	190.577	111.00	-72.37	227.466	541.32	-324.70	-368.77	-63.42	135.34	52.9944

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
256	8		-21.10	143.72	174.508	142.80	-49.06	206.029	245.95	-83.95	-354.36	27.81	206.88	117.057
258	8		-39.27	155.18	96.7101	63.97	25.83	157.556	441.92	-123.30	-322.00	29.21	-29.01	70.5836
260	8		-84.85	190.71	222.64	115.44	-33.59	251.662	288.01	-106.55	-327.87	92.75	43.41	77.7772
262	8		-72.48	130.22	203.85	6.06	-56.29	174.422	303.23	-279.01	-347.56	71.39	-183.60	110.788
264	8		-42.90	-142.50	189.151	25.51	-215.34	237.365	347.70	227.36	-302.52	150.79	29.89	63.4752
266	8		-9.29	-41.25	190.167	18.80	-74.92	308.022	444.83	94.81	-284.45	18.70	-112.64	58.4014
268	8		-38.48	41.22	60.091	42.54	-114.15	136.478	274.31	38.86	-303.73	-15.80	66.75	140.693
270	8		17.41	81.12	84.1204	29.37	-41.97	322.137	371.52	-62.39	-277.07	12.16	-38.14	68.9743
272	8	82°10'25.262"E 21°20'14.715"	-21.10	-109.38	185.822	19.08	-45.83	318.584	237.14	-267.55	-337.28	37.52	94.63	82.8596
274	9		-30.89	22.25	203.534	-95.14	166.90	293.068	344.42	-180.97	-291.54	149.32	58.84	91.8972
276	9		-7.02	46.91	186.864	-58.74	52.26	185.625	401.57	-74.69	-253.96	78.42	165.45	122.827
278	9		-25.64	108.45	82.2323	37.29	-319.93	158.493	250.93	-37.11	-277.84	11.86	80.66	117.427
280	9		-107.18	103.13	120.676	-133.36	-305.87	206.287	302.18	-339.33	-307.91	101.20	45.96	53.4777
282	9		-409.07	64.75	125.714	-383.20	-44.55	206.043	185.45	-372.35	-226.87	104.04	28.27	80.3022
284	9		-23.07	165.91	146.041	35.86	-37.77	206.192	357.73	-499.38	-256.11	80.19	120.11	83.0938
286	9		-30.29	-156.98	25.5149	-4.16	-289.44	251.799	200.41	-361.89	-343.37	-122.90	-51.54	76.4412

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
288	9		24.40	-112.40	216.677	-6.57	-12.94	313.774	314.64	-423.19	-341.97	-33.78	-80.74	97.3301
290	9		34.53	-260.32	106.229	-78.50	-42.34	140.786	254.06	-141.45	-253.95	17.35	-51.37	96.6337
292	9		-90.27	-41.14	101.733	-68.68	135.25	179.882	289.46	120.14	-237.21	-50.64	-73.78	86.7298
294	9		-68.29	135.06	133.177	-88.46	-161.64	169.894	383.38	79.83	-370.92	9.45	-78.01	65.0734
296	9		71.40	-41.83	184.66	33.83	-89.78	165.309	333.18	-70.81	-324.11	8.95	-34.86	71.3062
298	9		123.66	112.17	132.611	31.24	66.75	121.987	272.56	-29.46	-498.72	40.89	-23.27	65.7672
300	9		215.19	16.79	40.2028	98.99	-28.13	112.014	324.87	-22.19	-315.95	-27.11	-21.42	83.5338
302	10		24.12	50.71	165.099	89.79	184.95	279.449	332.95	-75.66	-291.82	-5.55	-112.62	100.826
304	10		318.07	21.08	54.0575	342.36	10.64	212.786	290.36	-367.63	-613.95	-23.34	-43.77	206.79
306	10	82°22'55.684"E 21°36'49.635"	43.52	242.45	179.532	89.17	38.94	110.508	211.61	-171.51	-206.68	3.80	-75.20	52.543
308	10		29.75	75.49	-214.089	51.01	-45.77	-80.2696	300.83	-370.30	-59.51	3.46	-68.38	-87.8041
310	10		65.38	-115.81	-200.6	53.89	-92.83	-144.563	225.63	-273.07	-62.32	36.37	36.17	-173.802
312	10		40.46	-120.94	-87.9311	-22.26	79.28	-67.056	301.52	-215.19	-48.42	64.79	-36.22	-83.0168
314	10		17.40	-113.41	-188.752	-141.66	-47.69	-213.829	338.69	-93.61	-272.72	44.11	32.51	-71.1752
316	10		75.94	-349.02	-769.589	-136.58	193.05	-218.134	374.24	-14.56	-219.71	56.93	-210.06	-88.3441
318	10		14.67	-18.25	-178.191	-76.71	-66.89	-645.957	273.06	-114.18	-72.29	50.49	43.37	-65.5839

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
320	10		-9.23	-328.76	-195.576	-13.29	13.70	-176.48	297.35	-227.35	-28.92	-46.14	94.91	-67.3674
322	10		33.09	156.88	-154.515	-35.90	29.51	-75.8483	410.21	-112.80	-178.11	20.39	-151.44	-117.732
324	10		-22.63	282.94	-201.196	-3.76	-254.30	-154.515	348.83	279.62	-269.18	-12.17	-160.95	-100.004
326	10		-105.71	-211.60	117.111	-178.40	30.64	120.092	317.48	51.37	-41.83	4.11	70.42	82.4797
328	10		64.27	-147.33	121.649	-13.41	61.75	87.2747	360.95	25.89	-87.76	81.55	-196.81	63.537
330	10		-17.32	159.78	-104.502	81.25	397.63	-110.37	390.81	39.68	-114.61	29.08	134.52	-65.656
332	10		53.74	66.02	-119.758	-68.49	211.85	-115.364	380.49	-38.97	-75.27	-73.03	133.79	-166.058
334	10		124.67	179.17	-137.752	-221.60	-134.81	-133.446	278.11	-118.32	-86.49	57.16	-46.67	-101.944
336	10		19.40	221.96	152.236	55.86	52.64	192.454	288.05	-136.15	-30.86	-5.51	108.07	52.6317
338	10		-197.39	68.64	48.5142	-146.76	237.20	160.367	270.89	-138.89	-18.19	38.41	-74.96	78.2684
340	10	82°40'54.077"E 21°43'4.436"N	-153.44	85.46	122.528	-41.00	174.03	168.484	315.78	71.98	-107.31	-10.19	-118.17	66.0866
342	11		-63.23	13.88	216.261	60.12	180.49	85.2494	274.78	-54.07	-99.88	59.61	62.09	132.628
344	11		-41.49	68.95	105.314	-76.00	-627.37	121.257	273.07	92.55	-37.69	33.61	-127.47	79.4011
346	11		-81.78	185.74	145.913	138.96	-998.94	233.278	252.62	314.87	-148.62	93.21	-84.58	69.7132
348	11		14.51	248.43	171.275	46.00	-273.83	207.631	225.47	337.83	-178.78	78.44	-54.53	178.08
350	11		-13.52	74.86	125.998	27.18	12.98	303.219	249.63	411.67	-231.06	73.73	65.43	113.537

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
352	11		11.75	-82.72	48.5795	37.86	134.52	142.367	223.48	282.59	-26.39	42.03	50.72	86.6635
354	11		0.95	-51.63	134.5	12.60	20.05	89.2064	220.21	206.62	-89.21	38.58	30.47	105.596
356	11		10.06	-106.13	211.166	13.55	189.62	154.451	187.73	208.99	-59.51	-48.97	-87.07	21.2888
358	11		-61.74	-175.40	101.059	-10.64	29.45	148.165	305.07	248.80	-45.02	-34.91	-82.71	90.9067
360	11		-20.93	-144.64	147.184	93.89	131.61	89.3646	242.28	328.32	-29.60	62.72	-51.72	110.812
362	11		16.79	-140.58	219.945	41.52	-47.69	189.384	134.95	239.57	-47.01	36.50	-168.88	72.6744
364	11		-30.84	-210.79	124.293	-0.63	272.53	168.179	592.20	213.93	-257.35	-13.33	-128.35	97.1162
366	11		-43.90	-112.21	196.709	59.60	-19.72	216.271	277.89	222.47	-234.80	45.38	-58.60	66.5346
368	11		-5.92	-67.95	124.636	-75.92	-112.99	224.117	92.15	242.39	-66.14	-66.98	89.24	68.6796
370	11		-6.76	-148.42	91.9068	-0.82	-77.86	203.603	33.81	189.48	-83.64	102.79	74.05	142.405
372	11		-58.82	-97.97	143.752	-40.11	150.89	161.08	35.75	216.59	-142.46	16.17	90.29	126.786
374	11	83°1'51.15"E 21°43'53.15"N	-128.13	-215.61	147.314	-220.76	248.21	125.837	53.53	246.43	-20.99	80.02	169.88	69.2731
376	12		-136.86	57.51	190.058	-54.55	172.64	143.752	28.36	222.94	-216.12	-75.31	99.41	135.645
378	12		-79.17	87.24	173.854	-19.16	140.29	286.76	124.91	96.22	-131.17	-69.44	106.46	90.2733
380	12		-56.35	-38.38	160.956	-35.86	12.99	166.31	85.17	425.86	-147.17	41.28	-98.04	70.1965
382	12		-66.79	-22.12	88.1939	-102.79	27.73	201.815	110.77	193.43	-47.49	22.70	30.51	78.7129

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
384	12		-84.29	-68.10	133.159	-73.31	94.97	266.813	62.51	192.59	-94.46	48.26	38.22	79.7571
386	12		-26.66	-274.94	183.886	-36.44	48.78	133.159	-268.84	294.51	-63.24	-51.20	104.09	117.486
388	12		-1.44	-126.44	136.082	21.56	-55.37	274.253	-51.18	184.23	-36.71	50.93	150.56	124.908
390	12		-30.91	-103.56	-121.731	-53.80	133.49	-309.945	-18.45	263.60	-44.36	49.32	186.66	-115.228
392	12		-19.60	-81.48	190.531	57.80	120.68	98.9489	-12.14	109.65	-76.41	34.71	172.89	98.0544
394	12		85.27	269.74	289.88	13.65	124.60	111.366	44.92	258.94	-120.08	62.67	-229.30	127.256
396	12		-26.27	-95.95	131.104	38.24	174.16	95.1034	34.57	74.82	-101.34	-47.62	-336.096	130.094
398	12		17.61	136.31	215.053	21.59	143.77	107.8	12.20	181.91	-48.35	74.14	-525.214	62.0299
400	12		-7.89	-114.87	136.707	42.16	50.82	82.2741	119.76	211.89	-11.13	-13.64	-463.926	61.3686
402	12		-39.29	165.84	-139.622	-57.19	186.50	-76.5666	-36.07	451.04	-53.43	12.06	-145.78	-96.9496
404	12		-39.88	-63.03	-198.629	14.38	101.32	-125.111	-16.84	281.38	-44.09	42.56	-144.475	-123.789
406	12		57.13	142.57	-212.499	-22.02	78.75	-118.855	97.76	137.91	-43.33	-24.09	-298.296	-108.994
408	12	83°22'57.452"E 21°40'33.908"	-10.82	98.26	-249.09	-130.46	-53.89	-106.214	-39.27	329.05	74.90	80.51	317.362	-147.487
410	13		24.36	153.77	-190.332	-42.15	-152.86	-152.542	-68.38	181.27	228.18	-56.58	200.4009	-124.704
412	13		0.76	72.10	-170.623	-65.20	67.32	-151.685	24.71	161.70	196.30	22.83	300.40	-29.4439
414	13		-14.20	-103.42	185.788	-154.31	140.37	184.712	-36.71	232.37	215.38	54.04	441.13	83.6668

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
416	13		-48.01	145.04	125.63	-169.35	53.07	173.103	43.84	49.07	446.91	-92.02	524.02	170.263
418	13		-66.98	206.25	-158.428	-6.77	163.76	-258.817	-15.95	47.09	248.66	16.37	571.39	-108.255
420	13		5.52	-78.19	-266.134	-12.58	-59.75	-202.788	4.24	-93.75	523.13	25.84	531.08	-206.817
422	13		-22.13	-146.62	-351.549	57.53	-113.25	-106.781	83.75	-228.64	367.12	145.20	390.18	-65.6857
424	13		46.86	-200.05	-171.634	13.93	98.84	-133.443	57.68	-76.55	1262.19	-81.29	200.94	-148.77
426	13		-72.08	-125.95	-220.222	-7.62	268.51	-114.062	-52.25	101.14	479.07	38.97	440.89	-71.6183
428	13		-96.63	-150.96	-1760.08	102.37	53.42	-104.771	25.21	411.43	594.18	15.47	141.94	-134.604
430	13		19.40	-168.60	-940.664	116.94	143.12	-203.281	24.31	585.78	546.69	16.57	155.52	-92.3992
432	13		87.40	-15.10	-197.957	-13.91	-135.66	-687.4	-22.57	636.06	723.19	93.54	133.56	-130.985
434	13		143.74	-35.98	-	-6.50	-284.00	-	-27.62	623.25	492.52	-89.76	-21.44	-1067.89
436	13		16.93	-97.45	-	19.76	68.49	-	47.33	678.49	336.18	50.87	-76.57	-999
438	13		3.62	-80.89	-54.1948	9.16	30.09	-117.599	123.86	714.02	400.91	17.45	115.33	-999
440	13		83.18	-47.57	-204.104	52.04	38.25	-144.6	72.31	769.93	-337.84	-17.64	-15.12	-716.688
442	13	83°37'0.237"E 21°43'8.03"N	-23.51	-130.65	-	21.23	88.99	-	0.72	386.43	-759.89	46.95	33.67	-565.56
444	14		-2.93	-174.57	-	65.02	-68.27	-	-43.91	219.67	-633.01	23.83	57.39	-2685.72
446	14		2.81	-245.71	-	-12.61	216.26	-	-59.88	195.95	-269.59	-39.94	-113.33	-

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
448	14		-1.07	-153.77	-	50.92	92.97	-	-60.66	167.30	-293.44	33.42	-324.33	-
450	14		10.16	-38.83	-103.57	102.13	61.85	-183.314	-112.95	141.54	-252.85	47.97	-79.00	-
452	14		26.24	-121.65	-198.538	56.64	22.84	-110.584	-85.33	124.22	-77.77	91.25	31.24	-2417.04
454	14		54.26	-18.51	-176.705	79.01	31.69	-66.9198	25.80	26.86	-92.62	84.87	-28.29	-1850.71
456	14		136.80	-14.79	-111.78	45.67	15.10	-147.047	-53.39	85.74	-38.15	-27.34	-51.65	-2282.17
458	14		73.33	-265.85	-99.1748	74.28	148.15	-67.3564	-17.51	60.67	-149.64	35.03	-135.62	-1561.49
460	14		47.72	-93.71	-26.9824	101.16	40.42	-61.0773	17.62	-41.26	-116.63	29.92	-101.07	-535.351
462	14		1598.52	-136.45	-22.7604	1574.25	59.35	-220.152	84.06	-103.32	-70.26	18.01	-7.74	-209.115
464	14		445.32	-37.95	-35.9873	37.08	29.84	-139.025	38.40	-160.79	-253.18	-6.36	-41.53	-472.093
466	14		364.44	-169.07	-747.344	168.45	175.23	-123.768	28.44	-273.03	-252.42	-18.05	-65.46	-157.129
468	14		127.98	-17.21	-205.164	300.08	103.50	-50.4967	69.30	-395.42	-353.56	68.48	-181.44	-167.63
470	14		229.72	-148.49	-144.544	362.92	44.66	-120.588	28.40	-426.17	-665.58	82.46	-26.77	-189.419
472	14		327.22	-20.74	-275.279	139.38	111.06	-188.363	-6.19	-449.60	-342.21	32.42	-49.55	-247.071
474	14		112.75	-212.02	-89.3197	102.82	-68.49	-158.245	-83.30	-474.62	-183.55	10.63	-20.01	-355.856
476	14	83°41'47.326"E 21°37'43.349"N	170.56	-870.72	-143.712	112.87	-263.45	-254.473	36.28	-474.02	-110.60	-70.04	-21.25	-883.816
478	15		258.58	-634.16	-263.246	42.14	179.11	-178.031	126.01	-550.67	-337.43	-302.72	-34.23	-280.418

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center r Line	Right Bank	Left Bank	Center Line	Right Bank
480	15		45.50	-183.82	-138.631	23.30	-72.24	-176.195	3.87	-567.96	-190.32	-47.30	38.67	-561.651
482	15		160.96	-167.97	-194.68	-42.45	59.36	-140.436	-13.08	-586.58	-181.82	-133.96	16.24	-1191.71
484	15		83.36	-234.64	-710.362	-40.22	61.29	-180.1	-9.70	-567.96	-260.68	-298.22	-55.99	-805.021
486	15		75.64	55.83	-328.015	-21.58	50.90	-195.911	-40.73	-586.58	-192.69	-1805.11	-22.53	-340.663
488	15		43.18	141.14	-125.622	85.92	-206.93	-166.761	236.07	-600.90	-233.02	-1243.74	56.03	-244.409
490	15		67.16	292.97	-119.288	132.08	-185.33	-97.6219	69.96	-619.32	-253.85	-1232.65	-54.03	-245.03
492	15		208.09	258.75	-102.17	50.76	-66.60	-163.807	1427.31	-611.83	-326.02	-589.70	118.40	-203.099
494	15		9.38	71.63	-67.9679	132.53	-100.54	-138.787	999.75	-515.32	-304.35	-1190.04	-102.84	-302.335
496	15		310.60	25.32	-96.0726	140.05	153.20	-96.9477	1311.99	-501.84	-391.91	-2266.32	-126.72	-286.604
498	15		39.20	251.08	-54.7087	-135.89	205.99	-101.172	347.92	-548.20	-350.13	-592.97	-84.13	-444.765
500	15		73.05	34.67	-130.284	-180.82	-281.76	-220.619	121.93	-636.36	-414.95	-723.31	46.28	-358.284
502	15		-83.03	12.50	-96.5879	-2.14	-178.89	-130.258	60.92	-712.58	-266.65	-337.27	-116.09	-161.917
504	15		57.99	67.87	-124.103	-23.02	319.19	-772.073	62.07	-714.72	-320.01	-1956.39	-74.49	-542.608
506	15		-5.77	191.49	-212.799	-58.15	29.24	-317.988	168.17	-992.15	-393.40	-2099.16	-177.11	-365.6
508	15		0.88	-49.91	-135.476	8.45	-300.63	-87.4022	880.60	-1012.7	-277.02	-2171.68	-160.92	-103.553
510	15	83°46'10.324"E 21°31'58.654"	196.34	79.28	-1576.45	21.45	-132.05	-121.032	602.08	-862.69	-316.36	-1425.79	49.16	-341.501

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center r Line	Right Bank	Left Bank	Center Line	Right Bank
512	16		74.33	97.11	-723.747	66.91	96.32	-153.136	51.02	-726.76	-250.43	-2375.83	-51.45	-406.638
514	16		168.90	49.01	-22.2968	6.42	114.56	-79.7993	62.60	-967.01	-342.82	-1993.57	82.07	-186.939
516	16		472.57	44.51	97.3518	45.86	-54.65	55.3354	82.56	-919.60	-321.53	-788.80	258.98	304.54
518	16		232.46	-12.35	133.191	225.29	-226.59	86.8225	140.91	-808.48	-190.55	-559.26	-139.32	214.547
520	16		388.43	174.18	139.775	31.18	-15.03	97.3163	32.49	-220.46	-398.66	-934.89	-84.21	230.918
522	16		88.73	82.07	109.643	0.00	-34.89	152.94	224.32	210.12	-330.93	-176.83	97.91	147.395
524	16		230.77	44.78	141.685	140.91	-70.16	104.256	6.16	207.61	-374.36	-21.98	81.74	463.668
526	16		70.05	-65.56	-118.456	56.40	-110.77	-96.4174	66.91	459.42	-59.06	-4.76	-168.90	-20.2029
528	16		-3.49	65.80	-149.833	40.26	31.77	-118.448	20.07	-484.35	-115.65	-218.15	73.17	-228.619
530	16		225.29	154.28	-172.18	53.84	-110.64	-208.262	47.65	-596.39	-44.03	-233.15	38.74	-116.7
532	16		1905.70	-134.26	-94.5963	698.62	31.87	-108.491	-63.55	-526.38	-63.32	-653.59	119.89	-57.6738
534	16		3269.20	-45.57	159.695	1779.12	256.13	63.701	-63.85	-550.05	-153.47	-157.63	71.43	31.868
536	16		1668.67	-20.32	112.478	635.15	120.59	180.704	23.02	-613.49	-107.76	-215.45	-195.32	103.611
538	16		732.12	-301.18	105.171	228.52	156.31	132.431	5.47	-572.97	-95.99	-482.59	-55.46	58.4134
540	16		79.55	-42.56	81.5313	70.85	-167.44	109.614	-165.78	-692.64	-75.18	-624.96	-26.05	35.361
542	16		881.43	-73.99	206.087	311.98	-70.39	158.572	127.22	-791.09	-34.21	-1225.21	49.78	43.0454

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center r Line	Right Bank	Left Bank	Center Line	Right Bank
544	16	83°58'13.75"E 21°24'41.623"	412.66	-279.71	90.8717	1149.27	-53.56	112.71	132.54	-200.22	-90.36	-148.02	103.62	72.0869
546	17		79.17	282.80	109.614	960.26	-114.12	103.83	-151.96	-389.15	-47.06	-174.73	220.97	106.001
548	17		174.23	-120.03	73.6636	121.93	-54.87	106.831	59.68	-367.35	-69.28	-392.06	-94.98	110.174
550	17		1046.70	-173.30	85.7552	60.92	73.52	100.621	211.63	-335.56	94.14	-1227.13	-18.83	133.935
552	17		1486.12	-99.87	127.36	1422.18	-103.70	137.372	85.92	-263.06	135.65	-86.44	203.55	52.6704
554	17		779.95	-53.57	120.224	66.85	-22.06	96.7313	23.30	-182.12	106.07	-254.24	83.86	105.505
556	17		197.27	-107.97	180.134	58.37	39.57	37.292	34.03	-190.58	186.49	-165.94	-6.54	82.1969
558	17		264.66	-83.26	51.3925	-14.92	131.82	110.591	-17.67	-199.06	240.34	-148.02	52.58	79.7929
560	17		343.17	230.88	203.032	63.27	93.76	75.0903	-40.22	-152.30	191.98	-230.63	-105.92	76.4247
562	17		162.21	52.72	37.292	22.45	201.73	67.1036	39.13	-58.42	360.35	-405.73	-121.87	65.4707
564	17		144.15	22.21	171.506	0.63	158.04	58.3497	46.47	204.43	201.82	-418.71	-62.33	114.337
566	17		83.95	80.31	17.6714	-21.03	136.65	63.8326	134.83	78.59	160.71	-560.77	-53.92	68.4973
568	17		21.93	55.33	74.6878	-41.62	110.83	52.9632	141.75	-346.30	185.89	-226.99	49.48	113.926
570	17		1.69	65.92	28.1635	-17.52	-183.70	178.262	369.79	-118.78	73.54	-315.41	45.29	98.9556
572	17		2.19	65.07	39.393	4.53	-97.29	103.599	299.76	-166.80	116.87	-454.39	-29.86	97.3712
574	17		-30.52	-18.03	45.7332	-37.44	-132.47	87.6358	162.49	-143.45	85.65	-323.03	-154.56	289.612

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center r Line	Right Bank	Left Bank	Center Line	Right Bank
576	17		58.23	15.00	152.032	-8.35	-199.51	88.764	1035.10	-121.97	174.59	-294.92	-19.72	85.4289
578	17	83°49'46.233"E 21°4'41.784"N	47.72	-67.83	47.6786	-1.55	-81.44	120.599	114.01	-72.94	45.44	-122.65	-79.54	105.535
580	18		36.98	21.03	61.8608	38.02	-30.64	104.864	35.35	65.70	61.53	-86.03	171.01	52.6639
582	18		67.69	-26.42	58.7615	28.03	-55.11	68.1694	74.69	70.14	-447.00	-281.77	-139.72	79.8254
584	18		80.87	-92.34	41.1483	-17.58	-38.66	63.3362	106.20	25.11	-184.99	-263.55	112.82	77.5692
586	18		43.22	-114.16	61.9984	-17.11	-2.77	129.379	83.09	-83.97	-342.18	-283.51	30.52	64.1045
588	18		-32.60	-117.06	43.378	-53.37	-37.25	165.909	55.61	-102.93	-193.86	-133.71	50.45	81.5132
590	18		-91.16	-53.61	79.8254	19.56	-6.61	102.264	101.76	-88.94	-136.16	-141.82	42.20	68.6026
592	18		-60.02	47.23	88.9255	-85.11	-20.00	144.471	50.06	112.01	-32.88	-53.38	-105.57	100.147
594	18		-117.06	55.63	45.9521	-122.92	-7.63	83.0142	12.61	127.69	-117.64	43.89	-17.21	74.7273
596	18		-84.79	42.32	39.6749	-60.52	-146.17	63.3767	-92.62	344.90	75.01	117.62	80.58	93.883
598	18		91.79	131.45	93.0065	-59.25	-47.02	79.865	-22.10	851.69	72.57	81.66	-67.79	115.099
600	18		47.88	44.67	69.193	-44.38	-76.45	81.2027	-53.44	97.15	118.23	-56.06	50.23	97.5468
602	18		49.17	28.89	89.5475	-162.81	-72.94	100.645	-9.72	205.60	254.29	40.51	60.22	74.4535
604	18		19.43	53.65	43.1495	-2.12	10.26	30.1041	-5.94	-224.45	169.35	60.31	-43.64	66.7533
606	18		-68.03	86.90	38.0455	1.98	25.20	60.3612	-20.93	36.87	67.11	30.28	-127.03	71.3161

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
608	18		20.10	78.35	158.541	46.96	-9.97	200.855	-15.07	176.60	56.19	25.00	-92.63	49.2168
610	18		9.55	21.94	82.7568	-25.70	-10.42	138.926	-8.15	-91.33	58.86	-77.28	-11.85	158.158
612	18	83°58'46.773"E 20°49'45.299"	-98.27	90.85	70.5046	-20.78	-209.93	136.463	57.68	-41.83	193.07	14.06	-110.34	197.794
614	19		-84.84	39.63	214.617	-64.29	-151.99	198.144	102.36	139.85	248.11	13.28	14.93	81.5126
616	19		15.82	-168.49	214.348	-109.35	-144.06	81.2554	15.10	71.34	238.75	69.49	-7.79	11.4518
618	19		54.56	46.90	120.952	-46.69	6.34	92.3004	57.78	177.77	325.74	18.32	13.20	69.2748
620	19		7.93	-160.83	28.681	-81.64	174.28	81.3014	0.00	94.32	186.93	63.03	-18.67	127.428
622	19		-12.54	60.59	35.1281	-7.18	-100.65	111.888	-13.33	-41.13	56.56	22.99	-53.34	105.342
624	19		-0.40	-91.53	45.4548	6.58	-107.74	87.6539	-6.82	-28.75	37.42	16.26	8.83	69.5504
626	19		-76.69	58.70	65.561	-67.70	-10.24	133.985	209.64	40.00	56.73	76.06	-118.97	66.9856
628	19		-48.52	137.17	88.2101	-56.28	-94.03	104.964	99.80	-77.64	-127.97	40.45	-26.31	116.261
630	19		15.62	86.95	68.3527	-91.37	68.92	136.333	111.01	39.07	-355.69	72.46	121.53	105.811
632	19		-24.64	-47.73	45.2311	15.86	-97.16	77.5229	145.96	37.16	25.87	86.02	75.01	102.281
634	19		-117.44	-21.08	75.3028	-72.21	-116.69	249.409	134.53	25.40	53.01	55.55	-36.40	114.757
636	19		-45.61	122.69	2.38215	-39.40	221.30	162.947	187.46	69.18	195.66	-97.17	138.91	118.949
638	19		-3.97	-52.66	-96.2278	97.80	97.61	-339.939	220.28	94.13	208.41	71.39	-72.15	-44.3782

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
640	19		19.24	35.63	-39.5297	-13.54	-342.82	-56.2743	164.86	130.90	261.94	55.11	170.60	-52.223
642	19		0.43	-154.97	-43.8937	-82.93	-619.50	-107.86	258.73	50.57	225.96	67.26	207.04	-48.2892
644	19		105.87	105.87	194.365	90.06	-255.40	116.099	181.70	25.16	315.00	144.78	33.02	92.0457
646	19	84°19'39.519"E 20°49'44.935"N	6.29	101.52	80.3584	-86.91	198.80	100.435	81.39	139.18	241.43	-44.71	-156.64	40.4702
648	20		-11.42	-78.87	183.086	-86.76	241.13	73.9239	-1.38	212.38	305.78	-290.31	-178.26	97.1304
650	20		70.98	15.93	60.694	35.79	175.16	95.3314	232.54	22.07	173.13	-38.57	384.98	65.7086
652	20		1.70	252.71	42.4348	-12.07	171.94	62.9191	139.25	-120.77	103.53	-15.09	303.37	57.684
654	20		102.82	97.73	23.5298	40.39	-5.30	170.836	-50.44	94.98	163.54	81.27	81.70	242.269
656	20		-31.66	-182.07	37.5569	-138.29	-53.03	427.665	74.91	76.36	166.85	39.37	18.44	107.139
658	20		19.55	191.75	51.992	9.62	-266.40	143.119	204.28	205.16	127.12	8.37	202.41	98.2778
660	20		52.22	-20.87	32.4609	-49.16	-114.35	89.024	98.35	147.00	163.20	30.26	320.74	136.654
662	20		-13.60	90.86	429.416	-49.43	148.54	174.857	135.91	306.19	171.08	-20.17	387.56	109.745
664	20		9.90	129.05	104.134	101.56	215.57	109.679	164.81	395.56	188.57	-84.70	222.97	88.9611
666	20		87.28	84.72	45.1768	27.77	97.30	140.612	116.09	368.84	316.02	21.86	28.23	111.471
668	20		-152.20	184.90	119.972	-472.74	-57.58	67.2464	133.19	76.31	-182.51	130.71	-101.01	104.619
670	20		-53.68	-192.80	74.9449	20.89	-328.43	127.152	121.33	152.17	-271.37	111.26	-427.12	140.086

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
672	20		61.99	-260.20	97.898	34.35	-343.74	60.9893	169.09	166.15	-90.38	-48.83	-249.30	113.739
674	20		102.51	-190.17	88.1051	74.36	-226.73	140.61	245.59	210.84	-419.58	-115.25	-90.34	97.2563
676	20		25.82	102.73	63.3192	132.71	43.49	59.3509	239.66	382.91	-111.78	52.32	55.28	101.785
678	20		226.72	-48.94	77.9647	257.60	-270.00	188.59	208.00	228.80	-253.75	38.31	351.72	104.067
680	20	84°37'6.311"E 20°37'40.325"N	673.01	50.09	70.2276	563.18	-109.54	245.766	96.06	272.54	346.71	123.42	118.78	87.9668
682	21		48.23	201.71	52.3487	69.90	28.10	147.276	137.21	303.97	444.58	35.12	-279.57	236.652
684	21		35.56	327.49	77.1897	53.48	99.81	174.767	209.78	288.37	-518.07	-31.89	-46.32	109.468
686	21		75.79	281.56	58.0208	75.60	177.69	28.7937	220.36	273.53	-266.63	-107.15	-90.77	72.957
688	21		60.25	130.42	112.342	48.70	141.07	115.282	26.41	293.57	-99.33	-31.42	-212.43	127.554
690	21		140.08	217.34	311.237	59.92	-87.85	131.403	185.88	275.21	-127.99	-134.73	-67.44	64.398
692	21		104.43	61.75	88.6875	55.86	368.74	136.71	43.75	232.19	-104.86	42.38	-313.46	73.7239
694	21		90.36	29.41	100.479	-7.75	-206.69	60.4971	74.94	328.44	-138.34	-30.53	65.74	101.06
696	21		37.35	201.76	64.1197	15.64	-108.68	74.444	60.81	340.13	-61.21	-123.49	97.31	123.714
698	21		41.16	169.77	85.6365	28.99	135.48	88.3005	-73.69	293.24	-32.03	-41.14	-49.70	135.383
700	21		44.18	332.41	84.4317	14.56	-9.27	141.794	-11.99	363.56	-133.95	-62.14	-114.30	92.7893
702	21		37.18	323.63	38.3272	5.16	-121.65	101.152	-23.27	317.83	-181.46	22.39	-211.01	128.774

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
704	21		9.25	54.70	54.5275	-26.09	-61.55	79.0671	-146.76	364.11	-177.82	-34.87	-250.00	165.44
706	21		-0.43	-45.73	76.2291	-70.25	-175.56	102.015	-4.11	450.64	-158.66	-14.55	-63.85	125.649
708	21		63.18	-303.68	39.7374	-8.02	142.39	112.342	-51.61	314.72	-100.76	-45.44	-39.60	162.573
710	21		28.60	-47.91	40.6255	-40.40	-71.43	236.595	20.53	194.55	-118.76	38.65	11.15	108.416
712	21		11.89	177.99	46.016	-4.37	-53.89	144.071	260.61	312.80	-110.55	16.16	47.34	69.486
714	21	84°57'17.699"E 20°28'32.628"	11.49	250.12	59.0289	-56.02	-127.13	96.492	222.01	295.93	-162.66	13.52	129.25	92.2672
716	22		33.57	-378.64	109.989	-68.91	102.05	142.443	-191.74	335.02	-178.32	-0.43	-260.69	174.119
718	22		82.61	-806.92	94.2315	-22.91	-232.35	147.833	-177.62	201.52	-92.90	52.16	-353.85	149.031
720	22		26.53	-451.76	136.969	20.10	-343.65	192.561	-3.79	278.22	-88.67	-34.99	-38.27	106.64
722	22		74.80	295.32	129.114	-47.22	-68.00	164.459	-35.95	291.66	159.09	18.11	-8.24	75.0993
724	22		-50.12	109.51	92.1971	-37.65	89.25	182.848	-14.38	226.64	-170.19	43.57	70.42	111.226
726	22		50.32	-59.27	96.6564	-97.30	-26.23	132.048	-265.92	256.74	78.73	-11.30	-196.30	153.086
728	22		50.87	310.77	77.7271	-81.38	-157.90	190.704	-269.18	241.37	-101.10	46.89	-35.08	91.8351
730	22		-37.67	347.68	50.2584	-54.46	167.13	103.02	-336.00	284.03	108.15	24.42	-74.71	152.072
732	22		26.33	132.22	65.0036	-74.16	118.20	107.335	-160.26	467.81	200.57	-28.70	-31.81	87.0222
734	22		0.22	-28.63	-108.692	-59.54	-93.44	-189.152	-111.42	352.23	-130.62	-64.46	-19.34	-84.5751

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
736	22		44.53	677.87	112.456	-77.47	-34.75	68.1243	-134.86	284.58	174.92	266.47	-110.35	144.745
738	22		55.06	474.93	79.4175	-91.25	-215.72	203.374	-37.49	205.62	71.58	113.78	-385.02	115.625
740	22		53.24	387.95	169.751	-68.09	-301.38	230.19	72.91	216.29	-106.96	-16.73	-290.52	78.8201
742	22		19.06	537.93	62.666	15.08	-239.81	114.459	89.45	144.37	-232.77	18.77	-30.40	89.2139
744	22		129.67	153.62	77.076	52.19	-56.91	109.595	-78.12	333.93	-130.90	12.75	105.34	77.7272
746	22		72.39	260.51	69.7968	-47.02	105.64	158.449	83.15	171.77	-233.17	3.70	68.08	114.845
748	22	85°20'7.28"E 20°20'34.805"N	-95.81	208.94	69.5825	-99.55	18.80	125.701	34.63	335.30	-329.25	-16.26	-111.99	86.3063
750	23		11.19	317.83	37.2568	26.51	61.62	143.986	290.09	253.50	-49.76	27.19	-60.41	73.8464
752	23		50.78	275.33	34.084	-18.27	-33.16	121.531	151.24	154.78	-126.06	-37.38	-215.77	78.4692
754	23		53.57	86.40	43.4165	-197.10	-59.98	103.372	223.63	380.38	-131.24	22.85	-48.38	105.725
756	23		-70.49	162.30	53.0895	-67.87	-162.06	82.427	238.29	118.68	-219.89	40.20	-83.42	121.982
758	23		46.66	-415.98	104.674	-58.06	51.95	371.295	203.52	290.63	-42.68	46.67	-35.57	93.1254
760	23		3.12	-417.98	80.7081	62.94	43.09	110.043	142.95	167.25	-40.46	-27.06	81.76	49.1189
762	23		103.28	-553.70	73.3695	-146.88	-95.94	216.519	173.12	215.28	-67.28	61.17	28.13	136.546
764	23		65.69	-550.48	114.748	-105.17	-96.25	150.932	8.80	287.07	-50.92	48.15	24.16	146.172
766	23		19.70	-516.31	66.9563	-106.14	-57.01	150.264	-268.73	296.83	-67.19	5.97	173.90	99.9557

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
768	23		45.91	-443.73	65.0762	13.97	60.10	134.193	-45.73	70.60	-40.60	13.60	-52.99	166.591
770	23		34.04	-121.27	64.5332	-57.17	110.55	240.083	-104.25	282.36	-48.82	12.98	90.09	128.748
772	23		219.64	-486.25	35.4826	-67.38	78.10	155.186	49.29	181.84	-73.25	107.25	44.42	172.64
774	23		92.29	-416.25	79.6824	-17.04	84.54	111.563	28.61	115.19	-88.14	53.96	38.19	81.1802
776	23		102.98	-613.24	48.7437	-29.83	-53.17	105.294	253.69	405.78	-207.57	51.89	47.32	163.388
778	23		78.67	-474.51	69.7623	-123.82	-136.55	88.4912	-3.59	286.92	-135.56	-20.68	-38.83	93.2574
780	23		37.08	-377.18	168.565	14.16	105.31	80.0019	-24.20	88.94	-74.82	-28.15	-173.85	63.6976
782	23	85°40'35.356"E 20°26'8.512"N	93.85	-574.49	52.284	-9.60	44.43	107.388	24.24	167.23	-537.59	3.96	-72.14	111.236
784	24		41.49	-453.38	160.865	23.33	56.40	84.1724	188.20	132.46	-263.71	7.91	-49.84	104.083
786	24		765.34	-628.61	51.2087	-12.68	14.71	93.1628	255.90	153.45	212.26	-52.82	-152.06	73.3295
788	24		102.10	-717.55	93.9358	20.67	57.10	72.5796	234.76	104.57	302.20	15.92	49.77	142.782
790	24		56.57	-869.26	109.916	-34.89	93.17	200.431	156.74	338.87	55.28	37.86	-83.82	159.327
792	24		-32.67	-643.66	69.831	317.69	96.21	159.327	88.31	32.40	-13.78	16.60	43.10	83.3992
794	24		65.10	-546.94	115.016	-60.79	-54.56	381.176	-6.99	136.44	27.63	19.86	480.35	91.4195
796	24		83.73	-611.91	91.4535	-62.73	35.30	573.166	-79.49	323.20	67.19	4.46	461.40	717.117
798	24		265.19	-668.17	96.7785	-151.10	-98.74	172.464	15.11	457.11	-29.85	-5.07	320.16	130.576

Table 2 (continued)**:** Shift in the course of the Mahanadi River of years 1972, 1980, 1990 and 2000 w.r.t. year 2010

Distance (km)	Reach No.	Lat/Long	1972 (m)			1980 (m)			1990 (m)			2000 (m)		
			Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank	Left Bank	Center Line	Right Bank
800	24		42.19	-746.37	100.986	10.44	-212.67	171.304	-3.72	192.48	126.08	-23.65	173.76	101.432
802	24		-125.32	-546.35	108.407	-15.05	101.47	134.16	-138.48	215.49	-48.56	44.96	118.54	322.538
804	24		-99.16	-648.67	107.004	190.39	-125.33	133.621	96.53	440.68	97.79	20.48	52.25	157.089
806	24		333.38	-197.23	126.499	-84.32	193.54	110.277	15.13	986.57	-160.74	-42.39	-111.62	119.684
808	24		19.38	-725.69	39.5327	-179.73	329.74	149.843	246.82	643.20	136.74	8.58	-105.35	117.013
810	24		301.05	-711.00	44.1706	-238.53	134.47	117.789	176.92	435.41	-177.57	4.86	-76.68	77.2798
812	24		166.08	-735.48	54.3277	234.64	-205.13	122.814	233.26	363.71	26.34	32.65	116.80	130.506
814	24		142.28	-651.08	91.6495	31.27	251.15	199.484	306.33	316.93	-52.55	-88.66	-156.36	59.6051
816	24	86°0'11.068"E 20°25'58.551"N	346.68	-543.59	131.593	160.30	-	138.131	318.97	323.32	125.67	11.06	-60.24	99.6754

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank(m)			
0	1		0	0	0	Lakhanpuri	Minimum	-
2	1		0	0	0	Lakhanpuri	Minimum	-
4	1	81°57'2.197"E 20°12'18.325"N	+55.16	+5.30	+63.93	Ratewa	Minimum	-
6	1		+51.07	-7.76	+39.27	Panderwahi	Minimum	-
8	1		+207.48	+109.44	+57.80	Ghoghopuri	-	Maximum
10	1		+440.38	+164.85	+51.81	Rawansinghi	-	Maximum
12	1		+68.52	+12.97	+261.50	Sirsida	-	Maximum
14	1		-74.23	-163.76	+165.24	Chhipalipara	-	Maximum
16	1		+33.34	-52.94	-59.88	Prem Nagar	-	Maximum
18	1		+135.23	+97.19	+11.23	Bhejari Rawan	-	Maximum
20	1		+285.32	+132.42	+27.55	Sahnikhar	-	Maximum
22	1		+130.73	+49.92	+99.74	Bhumka Ryt	-	Maximum
24	1		+91.73	-13.31	-344.27	Birgudi	-	Maximum
26	1		+438.23	+343.21	+176.49	Junwani	-	Maximum
28	1		+221.37	+13.35	-31.34	Banora Mal	Minimum	-
30	1		+106.54	+61.57	-4.40	Kekradongri	-	Maximum
32	1		+69.29	+95.08	+32.60	Kormud	-	Maximum
34	1	81°45'23.684"E 20°18'15.773"N	+4.87	+7.23	+26.37	Sarwandi	Minimum	-
36	2		+35.84	+8.27	-19.08	Dudhawa	Minimum	-
38	2		+36.64	+16.20	-25.00	Deodongar	Minimum	-
40	2		+13.73	+12.20	-41.18	Dhanora	Minimum	-
42	2		+87.99	+52.23	-4.29	Bhiraud	-	Maximum
44	2		+44.75	+25.74	+89.23	Malgaon	Minimum	-
46	2		-36.56	-62.99	-15.63	Daldali	Minimum	-
48	2		+6.57	+14.70	-56.36	Sarona	Minimum	-
50	2		+26.85	+17.12	-43.67	Mudpar	Minimum	-

Table 3 (continued)**:** Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
52	2		+22.92	+27.74	+20.22	Manikpur	Minimum	-
56	2		-34.13	-23.01	+6.16	Budeli	Minimum	-
58	2		+26.06	-9.64	+10.01	Puriyara	Minimum	-
60	2		+366.55	+235.32	+35.83	Satlor	Minimum	-
62	2		-20.41	-34.05	-18.54	Bagod	Minimum	-
64	2		+40.56	+34.28	-30.07	Bagod	Minimum	-
66	2		-12.64	+8.49	-54.79	Salhe-Tola	Minimum	-
68	2	81°27'56.133"E 20°24'10.306"	-5.34	+21.67	-65.93	Rampur	Minimum	-
70	3		-48.99	+6.98	-72.18	Nara	-	Maximum
72	3		+6.95	+43.35	-271.14	Mudpur	-	Maximum
74	3		+23.07	+166.49	+16.70	Shahawada	-	Maximum
76	3		-48.90	-22.91	+10.79	Tarasgaon	Minimum	-
78	3		+33.13	+14.86	-30.98	Badatola	Minimum	-
80	3		-27.86	+3.98	-93.48	Bhaisa Katta	Minimum	-
82	3		-38.79	+44.74	-59.13	Araud	Minimum	-
84	3		-302.67	-136.99	-79.76	Tahkapar	-	Maximum
86	3		-50.02	+11.09	-69.61	Khartha	-	Maximum
88	3		-49.46	+10.97	-73.08	Nawagaon	-	Maximum
90	3		+20.22	+50.96	-13.02	Ratesara	Minimum	-
92	3		-101.78	-62.97	-103.09	Bhiraund	-	Maximum
94	3		+30.94	+53.78	-26.10	Telguda	Minimum	-
96	3		+53.10	+46.99	+68.90	Bhelai	-	Maximum
98	3		-166.99	-129.72	-65.00	Kochwahi	-	Maximum
100	3		-96.31	-50.32	-374.20	Bhaismundi	-	Maximum
102	3	81°27'40.598"E 20°33'55.028"	-373.11	-341.75	-575.82	Muskera	-	Maximum
104	4		-477.02	+192.18	-174.64	Tirra	-	Maximum

Table 3 (continued)**:** Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
106	4		-870.76	-409.47	-1351.77	Tumabujurg	-	Maximum
108	4		-296.60	+310.16	-562.37	Satiyara	-	Maximum
110	4		-939.91	-179.10	-874.75	Tumakhurd	-	Maximum
112	4		-147.71	+341.25	-641.91	Chapgaon	-	Maximum
114	4		-486.86	+9.51	-125.51	Batrel	-	Maximum
116	4		-840.45	-209.45	-349.07	Khirgitola	-	Maximum
118	4		-922.25	-515.81	-55.27	Gangred	-	Maximum
120	4		+24.11	+65.67	-62.37	Maradeo	-	Maximum
122	4		+44.49	+45.71	+53.88	Mudpar	Minimum	-
124	4		+76.81	+32.15	-29.20	Rudri	Minimum	-
126	4		+25.58	+43.03	-22.22	Koliyari	Minimum	-
128	4		+46.50	+35.11	-40.65	Amethi	Minimum	-
130	4		+43.38	+10.50	-85.88	Kalartarai	-	Maximum
132	4		+123.07	+9.70	+39.15	Kharenga	Minimum	-
134	4		+464.22	+226.40	-99.46	Sarangpuri	-	Maximum
136	4	81°33'32.774"E 20°34'55.688"	-19.94	+18.48	+35.87	Deopur	Minimum	-
138	5		+10.14	+59.24	-6.03	Jhiriya	Minimum	-
140	5		+34.35	+53.31	-74.76	Donar	-	Maximum
142	5		-85.30	-48.73	+247.27	Deori	-	Maximum
144	5		-81.67	-33.83	-34.48	Sargi	Minimum	-
146	5		+66.72	-27.46	+36.96	Seoni Khurd	Minimum	-
148	5		+73.66	+36.27	-143.11	Dabha	-	Maximum
150	5		+97.22	+108.17	-34.27	Paraswani	-	Maximum
152	5		-10.72	-68.77	+15.84	Mandraud	Minimum	-
154	5		-190.61	-61.66	+162.92	Giroud	-	Maximum
156	5		+97.03	-20.83	+193.29	Parkhanda	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
158	5		+67.98	+67.67	+19.17	Belodi	-	Maximum
160	5		+235.54	+80.22	+45.72	Sirsida	-	Maximum
162	5		-38.40	-26.35	+79.33	Bhaismundi	Minimum	-
164	5		+142.88	+34.99	+30.64	Charbhatha	Minimum	-
166	5		+142.63	+153.46	-151.53	Nari	-	Maximum
168	5		+697.33	+309.28	+67.05	Nahardih	-	Maximum
170	5	81º36’30.112”E 20º36’22.98”N	+103.91	-30.91	+254.47	Dhuma	-	Maximum
172	6		+262.86	+33.25	+153.77	Chandsur	-	Maximum
174	6		+35.51	+16.93	-65.27	Dulna	Minimum	-
176	6		-72.12	-91.24	+110.95	Tarri	-	Maximum
178	6		+183.97	-234.48	+39.38	Nawapara Ngar	-	Maximum
180	6		+764.46	+80.19	+48.39	Pitaiband	-	Maximum
182	6		+73.43	-7.78	-23.36	Rampur	Minimum	-
184	6		-39.31	+22.95	-27.89	Rawad	Minimum	-
186	6		+87.19	-102.76	+245.97	Champaran	-	Maximum
188	6		-326.74	-164.61	+20.37	Hanpa Jhar	-	Maximum
190	6		+30.67	+27.80	-48.14	Pokhara	Minimum	-
192	6		+82.43	+60.15	-29.90	Tila	-	Maximum
194	6		+177.03	+71.11	+8.61	Pahanda	-	Maximum
196	6		+6.70	+31.00	-41.40	Chingrod	Minimum	-
198	6		+24.06	+12.77	-12.76	Bamhani	Minimum	-
200	6		+27.72	+16.11	-77.12	Bancharouda	Minimum	-
202	6		-5.99	+119.36	-238.23	Goinda	-	Maximum
204	6	81°47'24.255"E 20°45'31.458"	+45.86	+66.78	-104.35	Nisda	-	Maximum
206	7		+65.30	+27.66	-10.47	Paragaon-1	Minimum	-
208	7		+7.67	-5.34	+6.38	Barbaspur	Minimum	-

Table 3 (continued)**:** Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
210	7		+46.99	+38.63	-16.35	Karhidih	Minimum	-
212	7		+81.27	+39.47	+16.69	Badgaon	Minimum	-
214	7		+51.45	-21.33	+94.37	Gullu	-	Maximum
216	7		-67.17	-86.35	+63.59	Achholi	-	Maximum
218	7		+33.42	+38.46	-7.09	Samoda	Minimum	-
220	7		-37.67	-2.69	-42.08	Kusmund	Minimum	-
222	7		-192.19	-89.41	-34.17	Kusmund	-	Maximum
224	7		-10.23	-9.14	-4.49	Kagdehi	Minimum	-
226	7		-4.31	+38.80	-58.20	Karmandi	Minimum	-
228	7		-45.72	-6.52	-31.33	Mohkam	Minimum	-
230	7		-190.13	-82.58	-67.22	Kurd-1	-	Maximum
232	7		+28.75	+4.40	-20.48	Mahmela	Minimum	-
234	7		-18.64	19.62	-35.85	Sirpur	Minimum	-
236	7		-26.57	-5.72	+11.69	Junwani	Minimum	-
238	7	81°58'7.162"E 21°2'57.528"N	+17.97	+53.12	-59.52	Gidhpuri	-	Maximum
240	8		+21.58	+85.38	-137.99	Bijridish	-	Maximum
242	8		-3.23	-35.23	+54.90	Khapri	Minimum	-
244	8		-170.29	-17.69	-53.51	Bamhini	-	Maximum
246	8		+84.25	+84.65	-109.78	Charoda	-	Maximum
248	8		+8.48	+10.34	-8.87	Baldakachhar	Minimum	-
250	8		-63.16	-17.19	-19.87	Semariya	Minimum	-
252	8		+7.53	+55.66	-105.11	Amethi	-	Maximum
254	8		+33.74	+13.28	+11.72	Khaira	Minimum	-
256	8		+19.85	-8.36	+37.11	Ghirghol	Minimum	-
258	8		-8.24	-3.52	+7.18	Dhamni	Minimum	-
260	8		+16.56	+22.23	+26.84	Pairaguda	Minimum	-

Table 3 (continued)**:** Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
262	8		-19.57	-4.58	-12.75	Parsada	Minimum	-
264	8		-43.51	+14.31	-69.09	Pahanda	Minimum	-
266	8		+26.01	+5.92	+4.94	Borsi	Minimum	-
268	8		+12.85	+8.16	-10.04	Amaldiha	Minimum	-
270	8		+62.18	+52.42	-65.30	Nawapara	-	Maximum
272	8	82°10'25.262"E 21°20'14.715"	+48.33	+60.58	-63.59	Kharwa	-	Maximum
274	9		+38.73	+29.38	-22.01	Parsapali	Minimum	-
276	9		+54.30	-1.50	+257.84	Dongridih	-	Maximum
278	9		+47.10	+48.26	-39.79	Mohtara	-	Maximum
280	9		+99.65	+54.20	+65.58	Lata	-	Maximum
282	9		+49.36	+46.74	+51.10	Sonaidih	-	Maximum
284	9		+47.55	+77.05	-77.64	Sunsunia	-	Maximum
286	9		-137.04	-295.50	+282.87	Bhadara	-	Maximum
288	9		-108.97	-195.19	+711.65	Chhechhar	-	Maximum
290	9		+113.37	+30.20	+44.94	Khargahni	-	Maximum
292	9		+6.48	+10.06	-17.20	Malda	Minimum	-
294	9		+20.73	-23.00	+55.49	Khorsi	Minimum	-
296	9		-15.53	+22.30	-16.91	Deori	Minimum	-
298	9		-99.42	-63.28	+47.33	Tharhidih	-	Maximum
300	10		-77.29	+17.80	-448.32	Laxmaneshwar College	-	Maximum
302	10		-97.80	-50.96	-30.93	Sheorinarayan	-	Maximum
304	10		-18.30	-52.14	+40.88	Tusma	-	Maximum
306	10	82°22'55.684"E 21°36'49.635"N	-19.95	-49.47	+79.89	Puleni	-	Maximum
308	10		-30.03	-32.71	+42.79	Pahanda	Minimum	-
310	10		+28.54	+12.88	-17.94	Singhul	Minimum	-
312	10		-6.77	-50.50	+93.69	Madkedi	-	Maximum

Table 3 (continued)**:** Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
314	10		-49.71	-9.37	+8.26	Deoraha	Minimum	-
316	10		-45.73	-53.43	+80.31	Mirchid	-	Maximum
318	10		-51.28	+31.30	-25.40	Deori	Minimum	-
320	10		+98.51	+37.13	-7.12	Belmudi	Minimum	-
322	10		+45.86	+43.56	-37.39	Deoraha	-	Maximum
324	10		-44.54	+17.97	-8.81	Chicholi	Minimum	-
326	10		-44.12	-12.70	-17.23	Guwali	Minimum	-
328	10		+13.86	+6.79	-15.21	Chikanidih	Minimum	-
330	10		-28.74	+15.96	-48.79	Karhi	Minimum	-
332	10		-132.82	-85.49	-36.35	Sarmandi	-	Maximum
334	10		+47.09	+34.38	-33.05	Deorimath	Minimum	-
336	10		-56.95	+94.23	-278.46	Lakhuridih	-	Maximum
338	10		+26.07	+43.06	-77.41	Jitpur	-	Maximum
340	10	82°40'54.077"E 21°43'4.436"N	-61.14	+24.83	-181.34	Parsada	-	Maximum
342	11		-188.03	-100.29	-67.56	pandripali	-	Maximum
344	11		-37.82	-23.67	+2.41	Mirouni	Minimum	-
346	11		-141.45	-72.28	-30.98	Pasid	-	Maximum
348	11		-137.85	-12.37	-83.23	Malda	-	Maximum
350	11		-100.41	-182.59	+18.55	Dahida	-	Maximum
352	11		-142.31	+25.72	+53.62	Manjarkud	-	Maximum
354	11		+60.15	+170.20	-74.16	Jaspur	-	Maximum
356	11		-231.94	-53.76	-91.69	Nawapara	-	Maximum
358	11		+23.73	-246.81	+92.01	Sakrali	-	Maximum
360	11		-130.38	+73.20	-52.69	Jsara	-	Maximum
362	11		-81.91	+40.36	-138.44	Saradih	-	Maximum
364	11		-77.37	-33.24	-7.13	Phaliamuda	Minimum	-

Table 3 (continued)**:** Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
366	11		-39.66	-141.29	+80.22	Kosmanda	-	Maximum
368	11		+53.76	-67.45	+52.51	Mauhapali	-	Maximum
370	11		-39.39	-63.39	+80.77	Bajari	-	Maximum
372	11		-27.25	-40.55	-79.69	Timarlaga	-	Maximum
374	11	83°1'51.15"E 21°43'53.15"N	-54.93	+58.32	-173.40	Chandrapur	-	Maximum
376	12		+38.48	+41.38	-52.06	Chandali	-	Maximum
378	12		-143.88	-63.74	-22.13	Kalma	-	Maximum
380	12		-77.08	-13.02	-77.43	Balpur	-	Maximum
382	12		-47.21	-26.82	+21.19	Balpur	Minimum	-
384	12		-91.60	-78.88	+81.14	Budbuda	-	Maximum
386	12		-20.38	+18.84	-60.70	Chandagarh	Minimum	-
388	12		+194.32	+54.48	-50.79	Lipti	-	Maximum
390	12		-147.61	-60.29	-4.66	Padigaon	-	Maximum
392	12		-262.43	-118.32	+11.58	Randidih	-	Maximum
394	12		-131.02	-38.36	-68.45	Korra	-	Maximum
396	12		+42.73	+12.96	-58.75	Jaipur	-	Maximum
398	12		+45.64	+37.49	+19.02	Tora	Minimum	-
400	12		-57.78	-27.61	-27.48	Chikhili	Minimum	-
402	12		-105.39	-44.00	-23.05	Bharatpur	-	Maximum
404	12		+160.66	+234.66	-249.71	Mohadi	-	Maximum
406	12		+80.33	+237.43	-432.99	Kiritmal	-	Maximum
408	12		-257.37	-97.90	-308.78	Arjunda	-	Maximum
410	13		-62.14	-106.08	-302.64	Badmal	-	Maximum
412	13		-80.66	+215.29	-467.12	Dhulunda	-	Maximum
414	13		-201.29	+216.50	-284.58	Amapali	-	Maximum
416	13		-97.67	-749.37	-225.82	Luhabaga	-	Maximum

Table (continued)**:** Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
418	13		-473.83	-587.69	-95.51	Pujharipali	-	Maximum
420	13		+192.68	-324.51	-67.46	Jharupali	-	Maximum
422	13		+191.74	+73.15	-120.17	Panchpudugia	-	Maximum
424	13		-175.70	+49.85	-122.12	Katarbaga	-	Maximum
426	13		+209.79	+94.63	-41.00	Jamgaon	-	Maximum
428	13		-207.26	-188.69	-93.02	Govindpur	-	Maximum
430	13		-298.72	-509.82	+87.50	Kadamdihi	-	Maximum
432	13		-379.47	-927.29	-172.11	Kurumkel	-	Maximum
434	13		-348.30	-970.69	-119.01	Sagarpali	-	Maximum
436	13		-406.79	-917.66	-196.84	Bachmunda	-	Maximum
438	13		-497.86	-925.24	-113.19	Sunari	-	Maximum
440	13		-484.15	-752.97	-203.63	Pandari	-	Maximum
442	13		-678.12	-1059.23	-268.27	Patrapali	-	Maximum
444	14		-122.32	-1201.17	-137.40	Kutripali	-	Maximum
446	14		-500.71	-970.74	-96.44	Hirakud Reservoir	-	Maximum
448	14		-541.47	-914.74	-41.48	Hirakud Reservoir	-	Maximum
450	14		-1905.69	-1157.80	+214.84	Hirakud Reservoir	-	Maximum
452	14		-1666.03	-1247.90	-218.40	Hirakud Reservoir	-	Maximum
454	14		-2195.94	-1211.88	-166.09	Hirakud Reservoir	-	Maximum
456	14		-3680.60	-1440.18	-211.79	Hirakud Reservoir	-	Maximum
458	14		-528.53	-1254.66	-201.44	ITI Hirakud	-	Maximum
460	14		-232.17	-248.85	+221.53	Hirakud	-	Maximum
462	14		+14.90	-54.25	-39.56	Burla NAC College	Minimum	-
464	14		-121.85	-52.44	+44.90	Mcl Park Burla	-	Maximum
466	14		+277.79	-36.29	+63.11	Hirakud Raiway Station	-	Maximum
468	14		+56.39	+118.06	+7.01	Samaleswari College	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
470	14		+190.16	+37.37	+26.89	Potapali	Minimum	-
472	14		+25.46	+27.17	+137.51	Sambalpur	Minimum	-
474	14		-124.76	+14.92	+15.51	Chaurpur	Minimum	-
476	14		-69.14	+21.35	-97.23	Khadual	-	Maximum
478	15		-79.02	+26.79	-120.98	Gunderpur	-	Maximum
480	15		-24.52	+18.52	-19.52	Jayghant	Minimum	-
482	15		-154.69	-81.01	-35.29	Chakuli	-	Maximum
484	15		-152.91	-16.76	-92.42	Sankhala	-	Maximum
486	15		+238.85	-56.86	-140.71	Radhiapali	-	Maximum
488	15		+64.79	+155.95	-71.62	Haldi	-	Maximum
490	15		-21.10	-61.18	-61.74	Mahada	-	Maximum
492	15		-5.73	+44.89	-57.63	Huma	-	Maximum
494	15		-192.20	-50.21	-90.49	Tabada	-	Maximum
496	15		+252.90	+192.07	-109.96	Tabada	-	Maximum
498	15		+161.71	+177.71	-193.65	PWD Bungalow	-	Maximum
500	15		+73.85	+0.41	+85.24	Deogaon	-	Maximum
502	15		+78.86	-23.89	-26.66	Deshbhatil	Minimum	-
504	15		-42.87	+82.57	-92.65	Manpur	-	Maximum
506	15		+55.86	+37.28	-13.83	Dhatukpali	Minimum	-
508	15		+22.91	+32.42	-59.54	Kapasira	Minimum	-
510	15		+52.52	+86.47	-57.33	Salepali	-	Maximum
512	16		+87.04	+50.48	-29.02	Budhijharan Jungle	-	Maximum
514	16		-9.09	+112.61	-219.92	Keshripali	-	Maximum
516	16		-16.62	+48.10	-91.88	Tihikipali	-	Maximum
518	16		-188.46	-11.37	-123.79	Arigaon	-	Maximum
520	16		+14.47	+212.00	-215.49	Manigaon	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
522	16		-10.15	+50.96	-103.52	Sindurpur	-	Maximum
524	16		+35.39	+8.64	+26.03	Devala	Minimum	-
526	16		+26.24	+25.75	-37.11	Chadaipank	Minimum	-
528	16		+60.01	+43.54	-26.78	Kutmenda Jungle	-	Maximum
530	16		+63.10	+59.76	-72.75	Kalipur	-	Maximum
532	16		+72.21	+9.42	+62.47	Badali	-	Maximum
534	16		-2.70	+49.54	-120.32	Seledi	-	Maximum
536	16		+41.54	+109.82	-81.89	Gariapali	-	Maximum
538	16		-59.93	-34.80	+11.60	Kapasira	Minimum	-
540	16		-101.17	-78.37	+37.33	Barigaon	-	Maximum
542	16		-56.97	-37.54	-8.30	Manamal	-	Maximum
544	16		-7.69	+237.86	-380.60	Babupali	-	Maximum
546	17		-147.65	+233.91	-582.10	Pansiali	-	Maximum
548	17		-183.52	-25.89	-169.19	Nuagaon	-	Maximum
550	17		+159.75	+126.01	-91.75	Sonepur	-	Maximum
552	17		-29.24	+59.72	-174.20	Mundoghat	-	Maximum
554	17		-170.03	-13.64	-186.23	Patrapali	-	Maximum
556	17		-118.53	+21.47	-192.11	Parbatipur	-	Maximum
558	17		+92.85	-42.81	+97.31	Paligaon	-	Maximum
560	17		+12.86	-26.44	+35.59	Chaunriapadar	Minimum	-
562	17		-99.10	-79.16	+80.21	Kamalpur	-	Maximum
564	17		-72.38	-89.46	-39.24	Kamalpur	-	Maximum
566	17		-52.38	-18.54	+7.24	Buroghat	Minimum	-
568	17		-63.98	+14.07	-89.91	Tikirapada	-	Maximum
570	17		-109.33	-50.26	-38.19	Taterkila	-	Maximum
572	17		-126.01	-40.42	-72.82	Bagbar	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
574	17		+6.40	-55.31	-47.79	Jatesingha	-	Maximum
576	17		-94.76	-96.61	-84.12	Jatesingha	-	Maximum
578	17		-122.75	-47.73	-79.73	Ektal	-	Maximum
580	18		-162.61	-97.17	+42.13	Kampara	-	Maximum
582	18		-56.41	-91.68	+84.47	Tebhapadar	-	Maximum
584	18		+60.84	+72.53	-26.77	Rampur	-	Maximum
586	18		-111.07	-74.69	+37.53	Chanditala	-	Maximum
588	18		-45.08	-30.34	+25.81	Duleswar Jungle	Minimum	-
590	18		+30.43	-94.48	+240.54	Balidohali	-	Maximum
592	18		+79.92	+43.79	+56.32	Gobindpur	-	Maximum
594	18		-108.78	-252.75	+282.11	Marjadpur	-	Maximum
596	18		-25.01	-32.21	+69.80	Gambharipadar	Minimum	-
598	18		-34.05	+12.45	-54.60	Baudhgarh	Minimum	-
600	18		-12.61	+209.37	+113.07	Baudh Panchyat college	-	Maximum
602	18		-70.74	+330.83	-54.80	Jogiberini	-	Maximum
604	18		-31.24	-75.45	+76.06	Sarasara	-	Maximum
606	18		-55.42	-154.07	+76.88	Belpunji	-	Maximum
608	18		+39.37	+19.44	-13.59	Pipalkata	Minimum	-
610	18		+36.51	-36.16	+126.04	Mathura	Minimum	-
612	18		+17.52	+92.28	-130.52	Lunahandi	-	Maximum
614	19		+95.85	+20.67	-159.41	Hatagam	-	Maximum
616	19		+4.69	+76.27	-57.55	Makundapur	-	Maximum
618	19		+6.11	-15.68	+33.14	Palaspot	Minimum	-
620	19		+33.77	+69.55	-60.47	Odasinga	-	Maximum
622	19		-72.92	-36.81	-48.45	Baikunthapur	-	Maximum
624	19		-124.89	-126.59	+34.66	Kankala	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
626	19		+8.03	+22.26	-59.46	Odasinga	Minimum	-
628	19		-65.52	-11.89	-22.17	Kharasankulia	Minimum	-
630	19		-18.50	+27.01	-100.83	Nagaon	Minimum	-
632	19		+44.83	+79.31	-115.90	Nagaon	-	Maximum
634	19		+40.10	+70.81	-105.73	Aida	-	Maximum
636	19		-71.01	+84.30	-201.07	Titigaon	-	Maximum
638	19		-20.41	+28.87	-111.40	Surundi	Minimum	-
640	19		-73.94	-14.92	-73.27	Olatha	-	Maximum
642	19		-47.51	+11.71	-74.51	Pataka	-	Maximum
644	19		+50.65	+59.35	-79.01	Kusumakuhuri	-	Maximum
646	19		+45.71	+56.78	-96.62	Kusanga	-	Maximum
648	20		+55.51	-5.64	-72.49	Kumari	-	Maximum
650	20		-10.36	+36.76	-104.67	Kusasingha	Minimum	-
652	20		+58.03	+88.01	-105.27	Daruha	-	Maximum
654	20		-19.50	-23.90	-18.84	Daruha	Minimum	-
656	20		+75.00	+61.28	-50.87	Majhipada	-	Maximum
658	20		+27.03	+49.93	-39.22	Behera Sahi	Minimum	-
660	20		+27.34	+27.45	+37.14	Marada	Minimum	-
662	20		+32.70	+45.61	-61.17	Mhulia	-	Maximum
664	20		+33.56	+17.25	-20.01	Satakosia No-2	Minimum	-
666	20		+49.83	+30.85	+12.32	Kuturi	Minimum	-
668	20		+33.03	+34.73	-20.14	Katranga	Minimum	-
670	20		+36.59	+47.57	-52.23	Satakosia No-1	-	Maximum
672	20		+71.39	+41.01	+10.48	Bahali	-	Maximum
674	20		-42.81	-67.01	-37.75	Malisahi	-	Maximum
676	20		+94.11	+105.59	-119.21	Kamalidha	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
678	20		+7.15	-71.33	+46.54	Kamalidha	-	Maximum
680	20		+19.98	+20.87	+11.02	Zilinda	Minimum	-
682	21		-27.30	-22.27	-84.35	Chhamundia	Minimum	-
684	21		+60.58	+37.47	-25.51	Iswarapur	Minimum	-
686	21		+43.86	+26.30	+8.87	Bentapada	Minimum	-
688	21		+34.46	+61.88	-68.41	Dankarisahi	-	Maximum
690	21		+71.42	+64.36	-125.60	Dankarisahi	-	Maximum
692	21		-136.12	-120.45	-86.10	Kathakhunta	-	Maximum
694	21		+41.30	+79.81	-108.97	Bindhyagiri	-	Maximum
696	21		-18.63	-22.83	-86.94	Belapada	Minimum	-
698	21		-16.35	+36.89	-34.64	Kishoreprasad	Minimum	-
700	21		+13.30	+2.30	+19.10	Paturia	Minimum	-
702	21		-84.99	+31.58	-57.83	Sidhamula	-	Maximum
704	21		+156.67	+11.10	-102.24	Rajakiari	Minimum	-
706	21		+49.94	-41.58	+64.45	Barapurikia,IN	-	Maximum
708	21		-29.28	-88.94	+40.68	Pendaragadia,IN	-	Maximum
710	21		-105.95	-200.95	+120.50	Kanpur	-	Maximum
712	21		-174.14	+252.23	-31.41	Kantilo	-	Maximum
714	22		-155.10	-163.07	-20.62	Balijhari	-	Maximum
716	22		-41.18	+64.33	-55.82	Madhapur	-	Maximum
718	22		-77.64	+80.32	-35.62	Kendupalli	-	Maximum
720	22		-61.23	-25.85	+10.98	M B Temple Badamba	Minimum	-
722	22		-55.50	+124.99	-92.09	Talamarada	-	Maximum
724	22		-1.92	+142.69	-28.67	Karadibandha	Minimum	-
726	22		-237.31	-68.66	-60.25	Badabhuin	-	Maximum
728	22		+161.92	+18.11	-64.60	Kantapada	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
730	22		-85.31	+15.60	-27.58	Gopinathpur	Minimum	-
732	22		-71.91	-7.31	+30.67	Kothapatana	Minimum	-
734	22		-25.85	-53.10	-44.22	Tunapur	-	Maximum
736	22		+126.22	+288.77	+519.88	Rajiba	-	Maximum
738	22		-49.84	-186.64	-93.11	Jajpur	-	Maximum
740	22		-120.96	-107.41	-101.88	Mundali	-	Maximum
742	22		-88.81	-164.32	-31.53	Jaganthapur	-	Maximum
744	22		-41.84	-328.24	+67.43	Durgapur	-	Maximum
746	22		+95.15	-135.85	-120.93	Baunsaput	-	Maximum
748	22		+184.32	-67.85	+55.79	Nandapur	-	Maximum
750	23		-95.41	+49.64	-55.60	Harirajpur	-	Maximum
752	23		-116.95	-71.05	-31.89	Mukundapur	-	Maximum
754	23		-162.31	-38.97	-19.92	Karabara	Minimum	-
756	23		+35.27	+32.21	+49.27	Ghasiput	Minimum	-
758	23		-89.95	-11.84	-7.35	Kuspangi	Minimum	-
760	23		-62.53	+33.64	-113.96	Nuaostia	-	Maximum
762	23		+72.22	+64.92	-179.39	Fulabadi	-	Maximum
764	23		+78.97	+24.80	-36.76	Kandarpur	Minimum	-
766	23		-76.43	-36.57	-95.17	Charigharia	-	Maximum
768	23		-118.61	-109.91	+47.53	Bhogara	-	Maximum
770	23		-153.53	-136.95	+77.44	Dhurukudia	-	Maximum
772	23		+359.94	+267.05	+70.42	Dhurukudia	-	Maximum
774	23		+564.19	+270.78	+69.52	Mundali	-	Maximum
776	23		-51.77	-11.90	-88.63	Talagar	-	Maximum
778	23		-113.25	+61.05	-56.40	Nuashasan	-	Maximum
780	23		-89.06	-41.02	-76.66	NLU Odisha	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
782	23		-61.25	-95.72	-42.93	Lingapada	-	Maximum
784	24		-16.78	-63.24	+120.62	Paikerapur	-	Maximum
786	24		+36.67	-166.44	+571.85	CDA Sector-VI	-	Maximum
788	24		-67.16	-72.14	+61.68	Kayalpada	-	Maximum
790	24		-67.54	-87.03	+120.43	Barabati Fort	-	Maximum
792	24		-31.44	-537.70	+905.09	Odisha Medical	-	Maximum
794	24		-50.34	-74.98	+71.87	BPFTI Odisha	-	Maximum
796	24		-49.46	-80.30	+40.56	Hara Mani Mandap	-	Maximum
798	24		-188.89	-34.80	+32.62	NRRI	Minimum	-
800	24		+304.60	+174.21	-127.17	Bidyadharpur	-	Maximum
802	24		-110.72	-71.41	-90.73	Paschimakachha	-	Maximum
804	24		-130.30	-29.68	-72.62	Nimeisapur	-	Maximum
806	24		-404.03	-264.84	-268.67	Ayatpur	-	Maximum
808	24		-689.42	-355.26	-59.02	Bahugram	-	Maximum
810	24		-50.61	-238.19	-70.71	Barada	-	Maximum
812	24		-432.54	-35.69	+22.12	Kaijanga Forest	Minimum	-
814	24		+16.90	-28.50	+94.98	Murkundi	Minimum	-
816	24		-105.28	-68.77	+133.48	Salipur College	-	Maximum
818	24		+28.20	-8.54	+53.74	Purunahata	Minimum	-
820	24		-19.86	-46.88	-26.81	Jaganathapur	Minimum	-
822	24		-50.49	-120.52	+130.75	Udayapur	-	Maximum
824	24		-5.80	+13.31	-41.91	Nuagaon	Minimum	-
826	24		+42.95	+36.92	-28.17	Brahmankhanda	Minimum	-
828	24		-83.55	-76.04	-31.11	Padmapur	-	Maximum
830	24		-100.49	-148.30	+143.50	Aranga	-	Maximum
832	24		+48.30	+35.93	-44.23	Tarapur	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
834	417		-82.07	-47.11	+108.21	Gokulpur	-	Maximum
836	418		-33.85	-17.73	+23.78	Krushnanandapur	Minimum	-
838	24		-165.25	-112.06	+48.66	Bishanpur	-	Maximum
840	24		-58.65	-95.53	+136.73	Bidyadharpur	-	Maximum
842	24		-62.37	+15.05	+69.07	Kotakana	-	Maximum
844	24		+9.78	-27.70	+52.85	Tentulipada	Minimum	-
846	24		+32.79	+26.55	+10.88	ASD College Tirtol	Minimum	-
848	24		-41.08	-24.08	+20.86	Tartol	Minimum	-
850	24		+26.96	-6.24	+66.54	Nagapura	Minimum	-
852	24		+36.02	+18.60	+52.99	Jogania	Minimum	-
854	24		+24.27	+54.26	-64.42	Teramanpur	-	Maximum
856	24		+133.87	+93.36	-46.14	Kalikud	-	Maximum
858	24		+78.69	+73.06	-99.02	Kaladip	-	Maximum
860	24		-47.18	-90.21	+125.39	Madhapur	-	Maximum
862	24		-30.41	-14.12	+106.58	Jayasankhapur	Minimum	-
864	24		-357.44	-332.26	+165.92	Kothiasahi	-	Maximum
866	24		+208.64	-64.68	+144.69	Mohanangala	-	Maximum
868	24		-78.24	-135.55	+146.47	Baidigadi	-	Maximum
870	24		-245.17	-179.93	+130.18	Talapada	-	Maximum
872	24		+73.18	+40.17	-35.84	Jagati	-	Maximum
874	24		-192.33	-231.53	+199.60	Telengadia	-	Maximum
876	24		+52.29	+67.75	-113.10	Balidia	-	Maximum
878	24		-19.40	+11.68	-44.19	Nuagarh	Minimum	-
880	24		-97.45	+37.28	-193.22	Aganasi	-	Maximum
882	24		-207.21	-87.36	-14.85	Banabiharipur	-	Maximum
884	24		-541.29	-251.20	-29.15	Musadia	-	Maximum

Table 3 (continued): Shift in the course of the Mahanadi River of year 2018 w.r.t. 1972

Distance (km)	Reach No.	Lat/Long	1972 - 2018 (m)			Site Location	Shifting	
			Left Bank (m)	Center Line(m)	Right Bank			
886	24		-262.28	-81.58	-100.46	Jogidhankud	-	Maximum
888	24		+161.05	+148.73	-221.54	Kaudia	-	Maximum
890	24		+76.65	+202.04	-206.49	Kaudia	-	Maximum
892	24		-106.09	-7.81	-96.33	Saralikud	-	Maximum
894	24		+59.81	+87.78	-147.01	Saralikud	-	Maximum
896	24		-244.89	-55.98	-151.96	Hetamundia	-	Maximum
898	24		-81.41	-3.91	-147.27	Hetamundia	-	Maximum

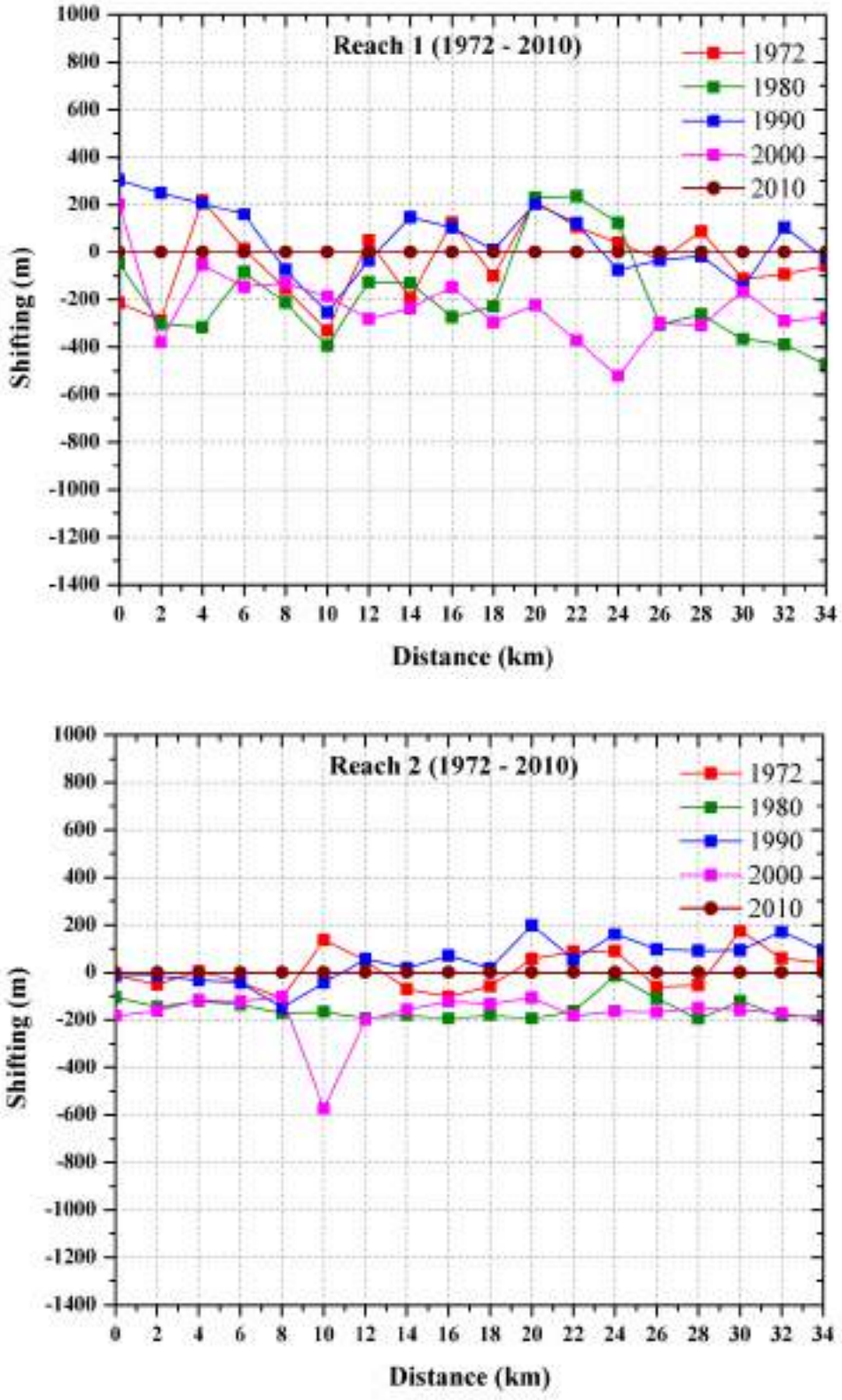


Figure 8.1 : Shifting of the center line of Mahanadi river for reach number 1 and 2

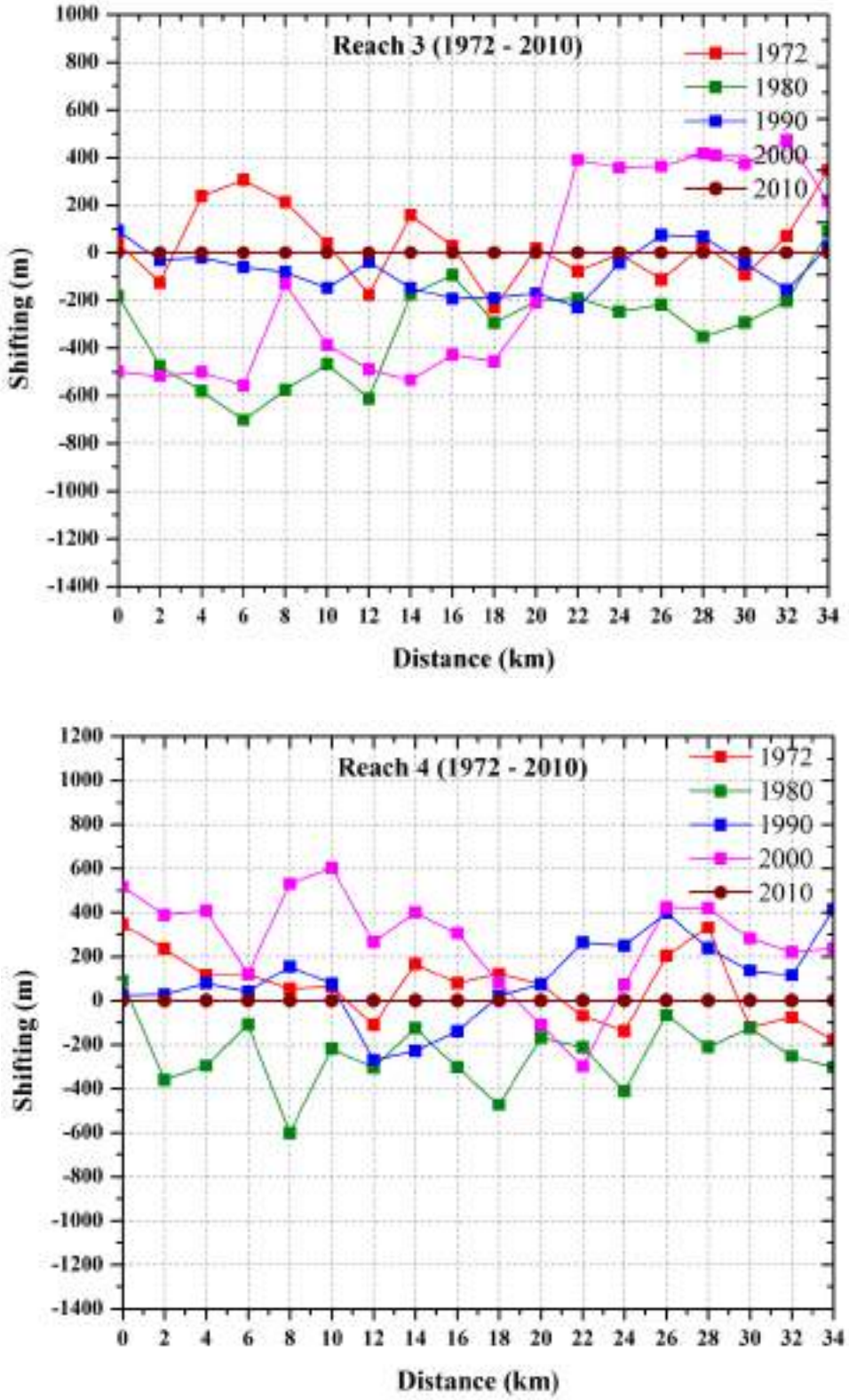


Figure 8.2 : Shifting of the center line of Mahanadi river for reach number 3 and 4

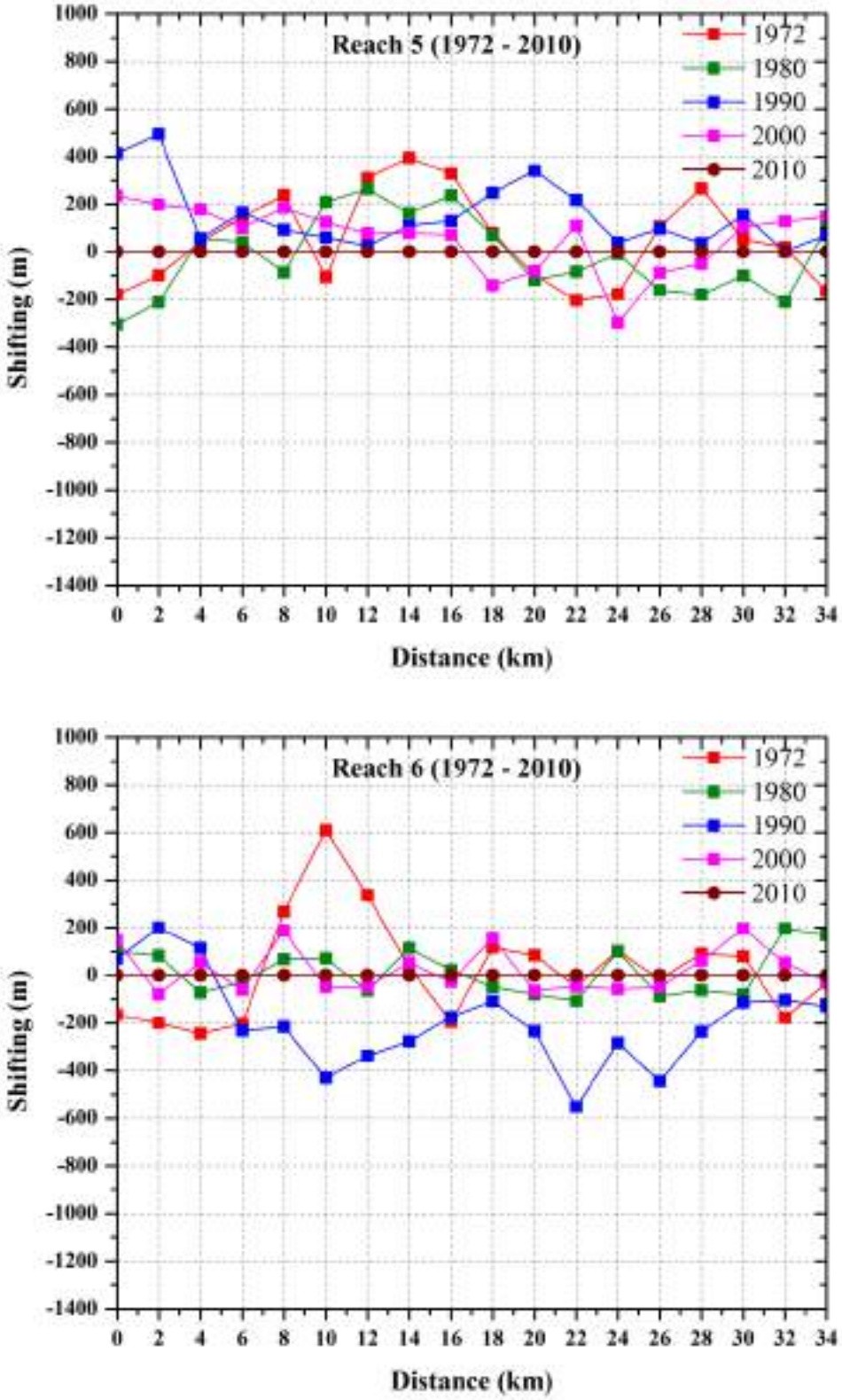


Figure 8.3 : Shifting of the center line of Mahanadi river for reach number 5 and 6

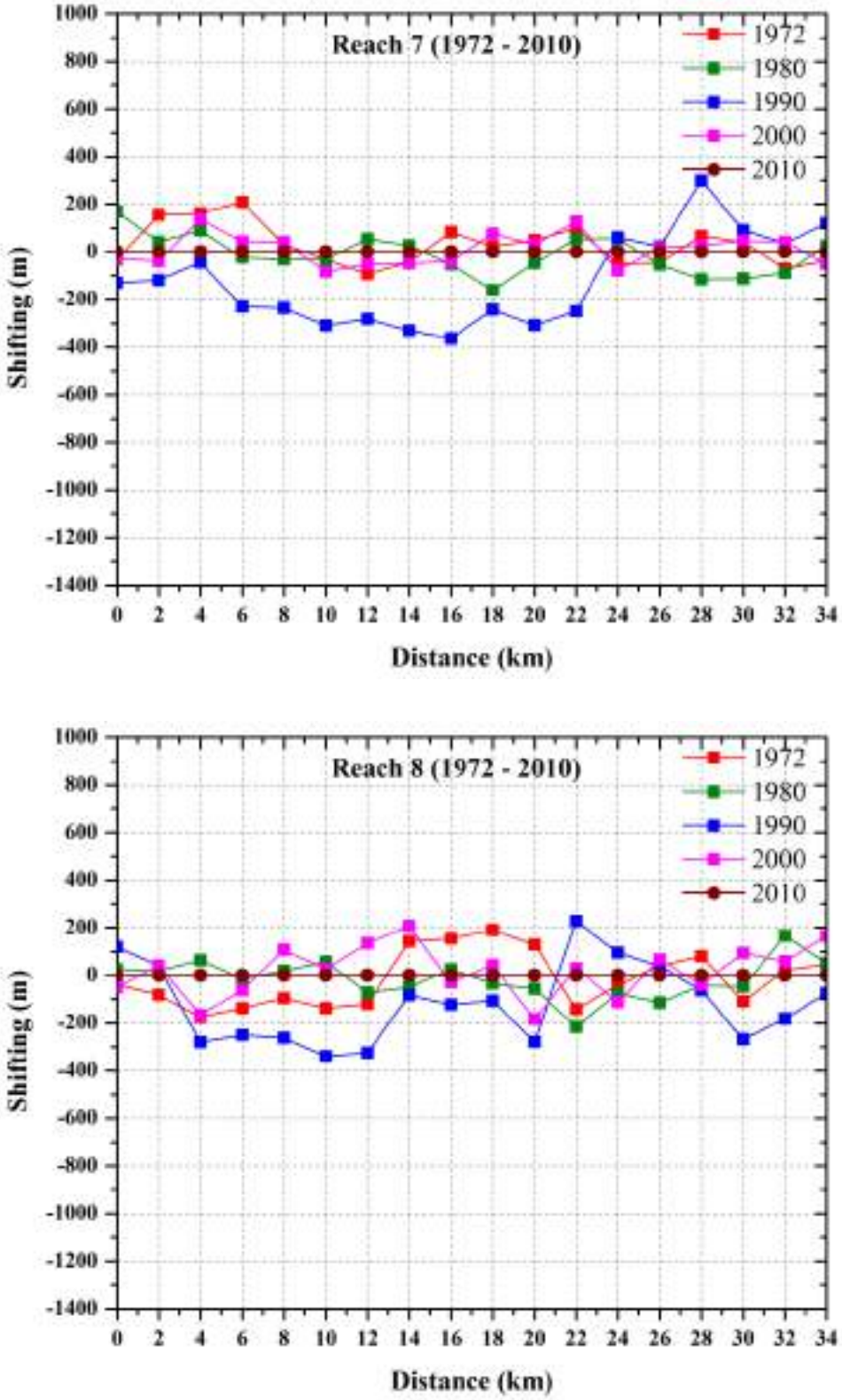


Figure 8.4 : Shifting of the center line of Mahanadi river for reach number 7 and 8

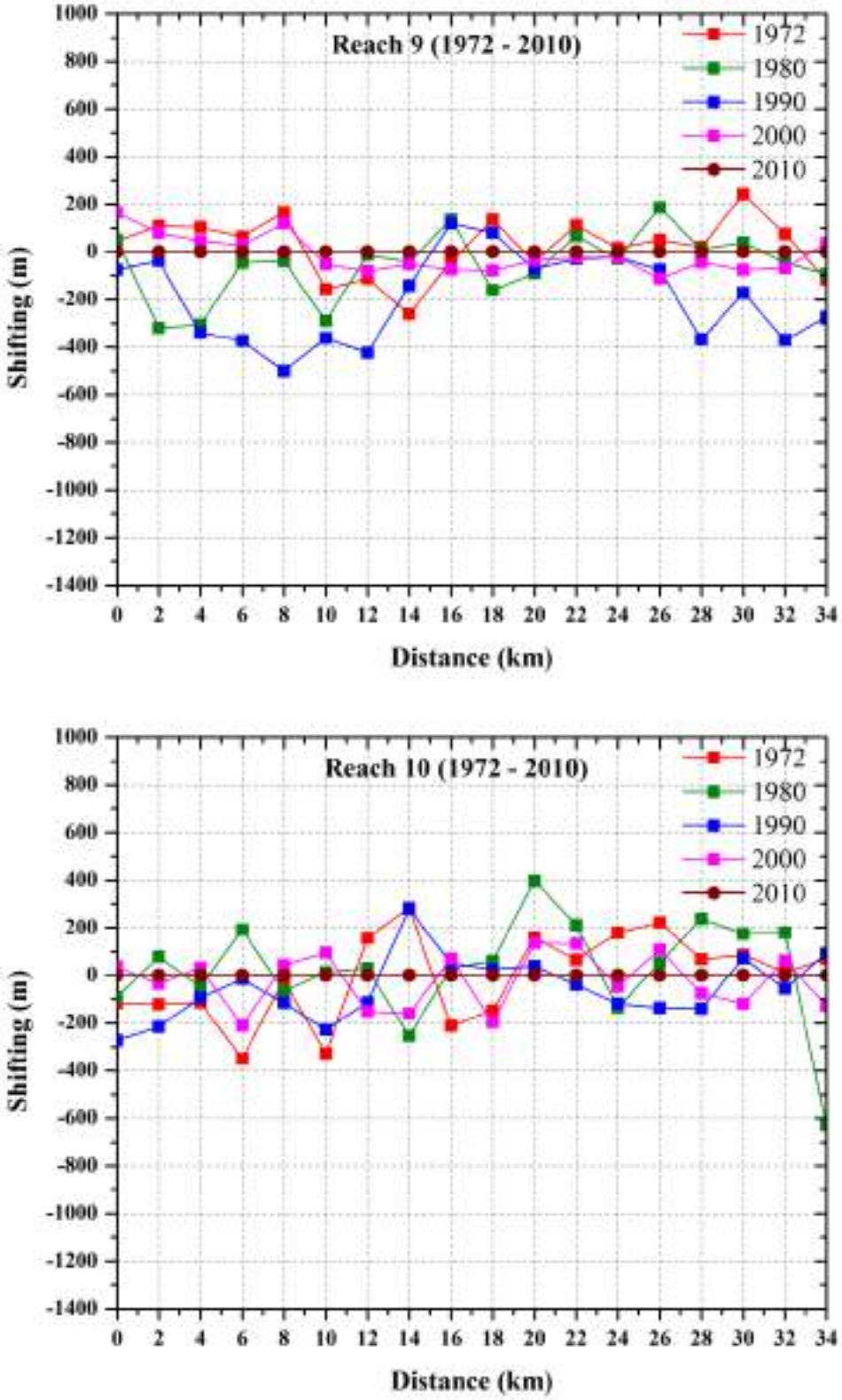


Figure 8.5 : Shifting of the center line of Mahanadi river for reach number 9 and 10

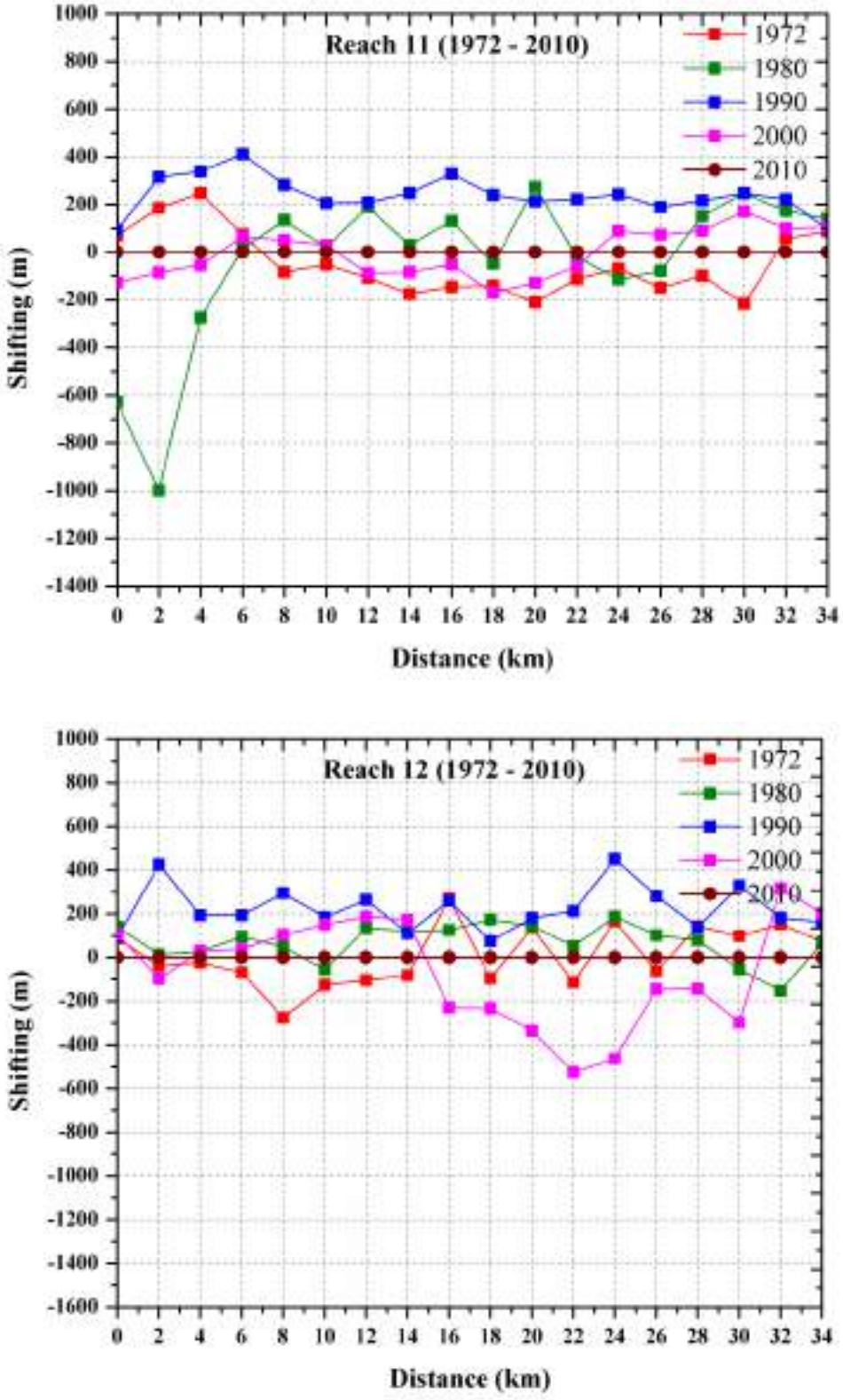


Figure 8.6 : Shifting of the center line of Mahanadi river for reach number 11 and 12

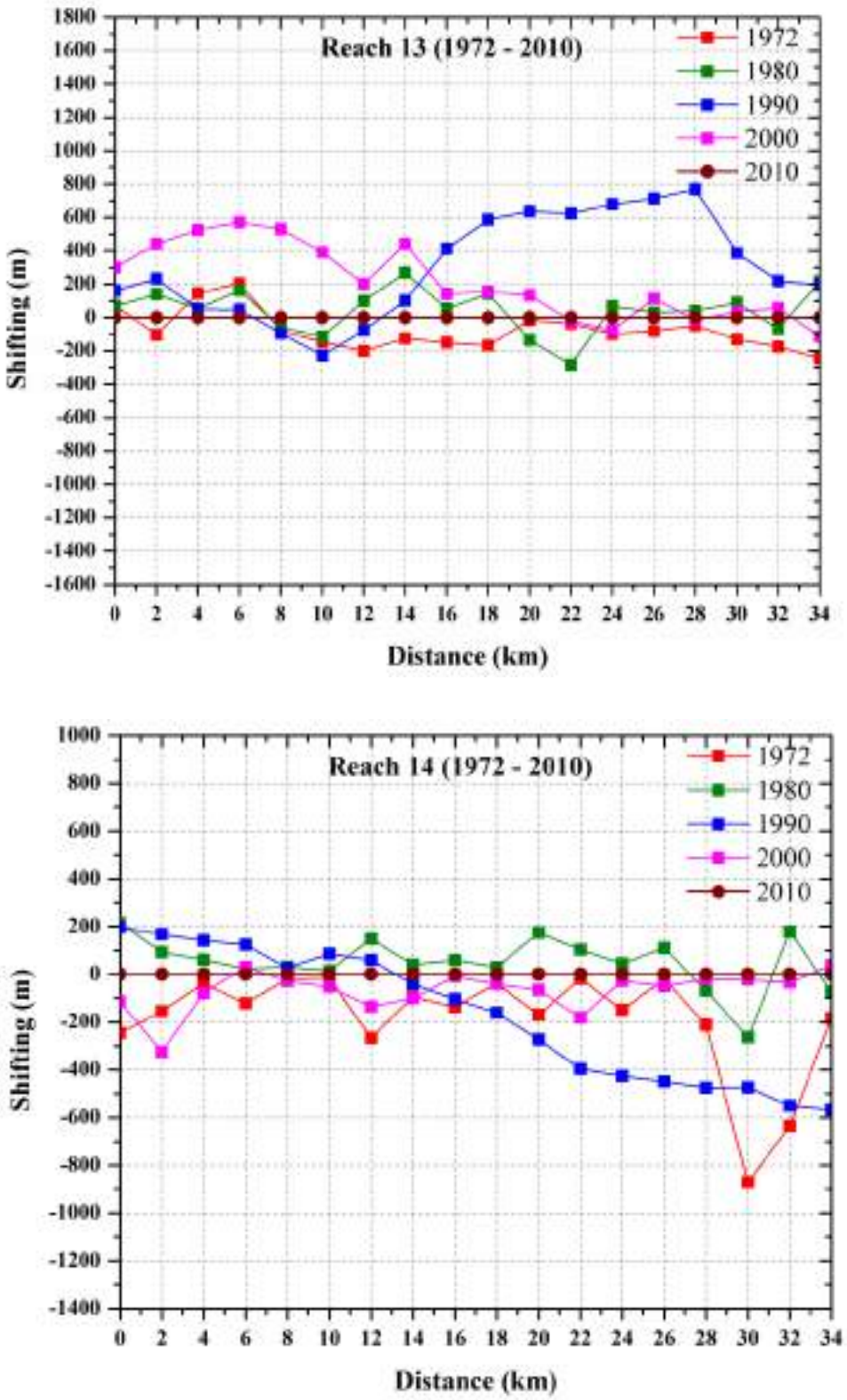


Figure 8.7 : Shifting of the center line of Mahanadi river for reach number 13 and 14

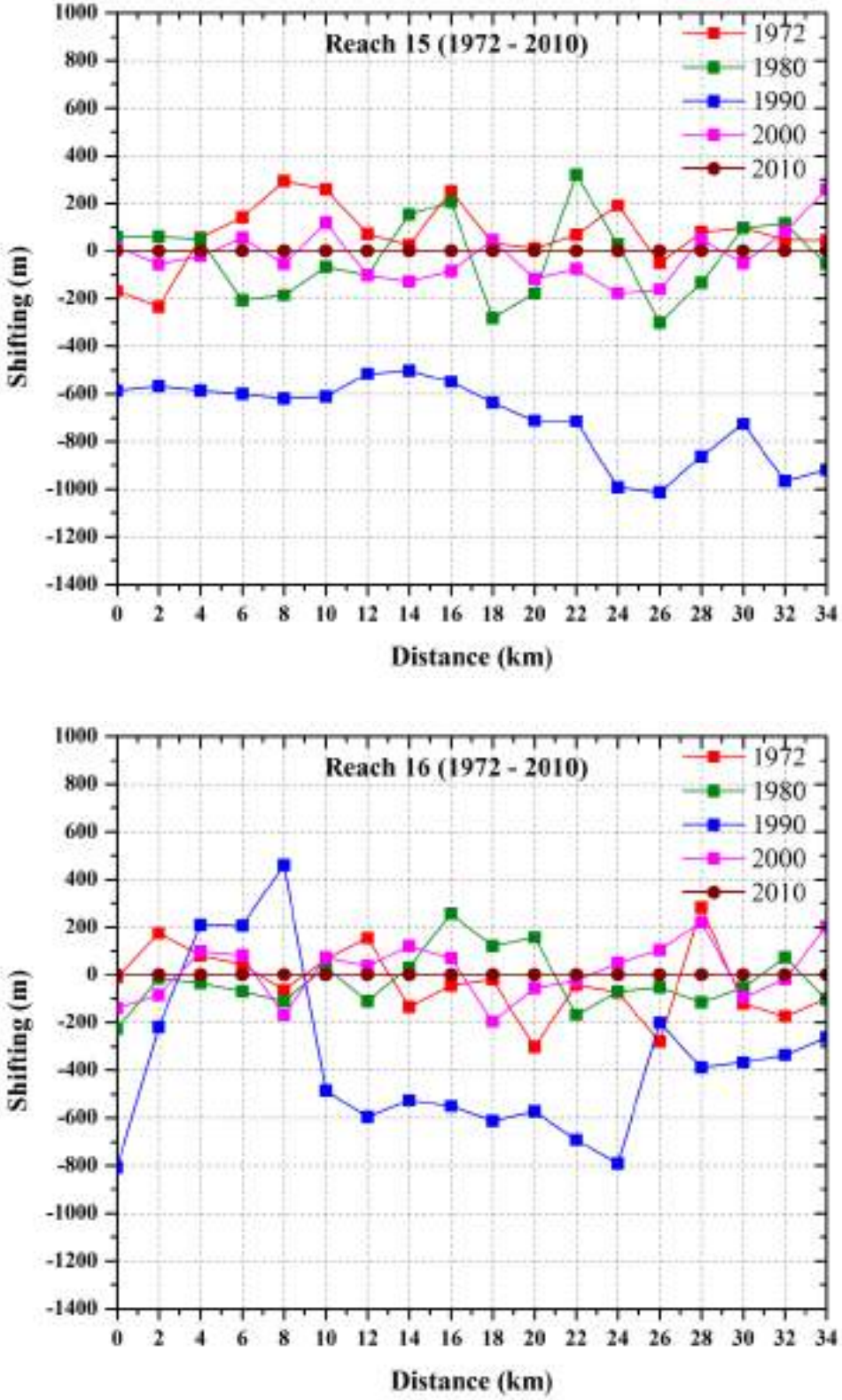


Figure 8.8 : Shifting of the center line of Mahanadi river for reach number 15 and 16

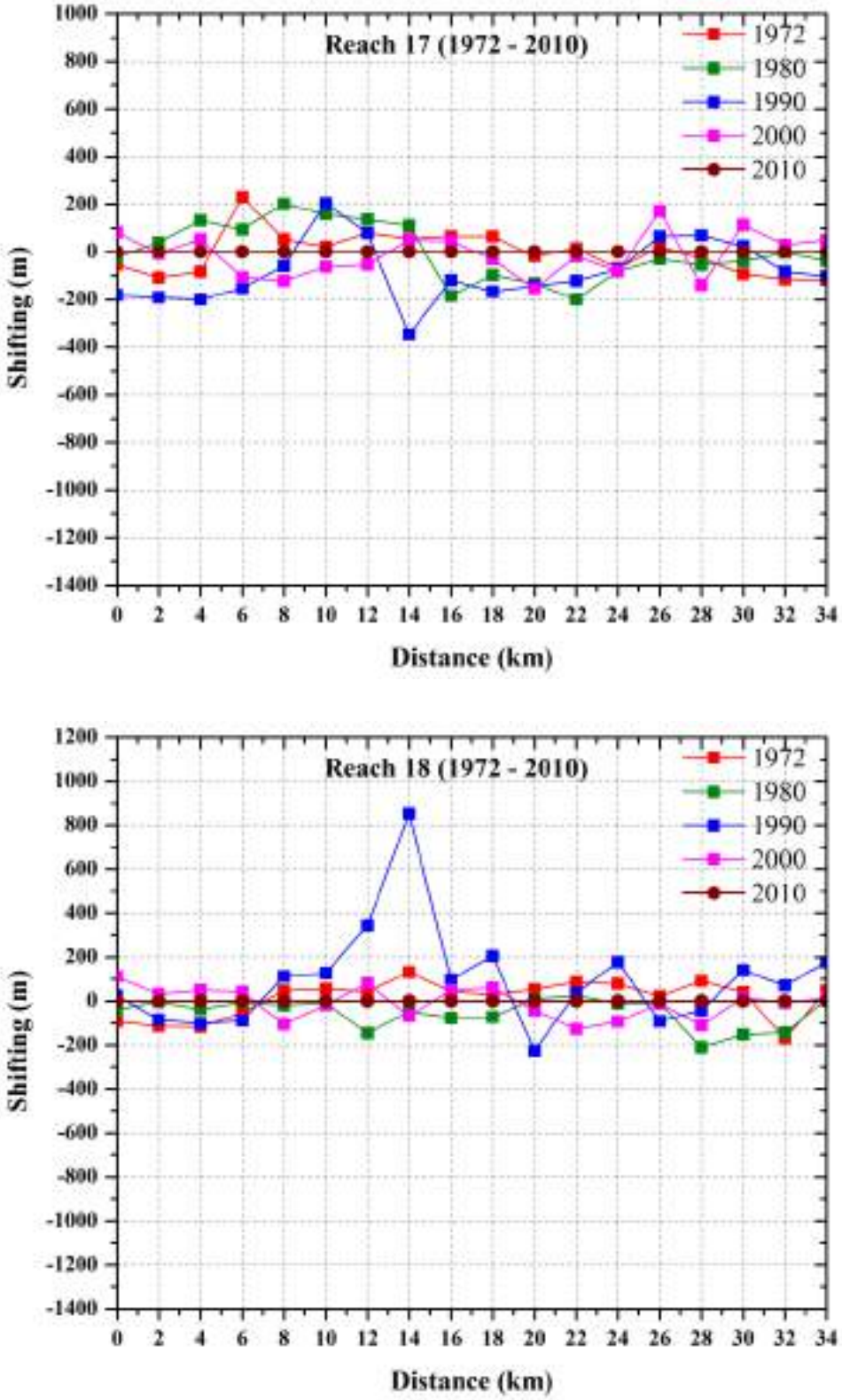


Figure 8.9 : Shifting of the center line of Mahanadi river for reach number 17 and 18

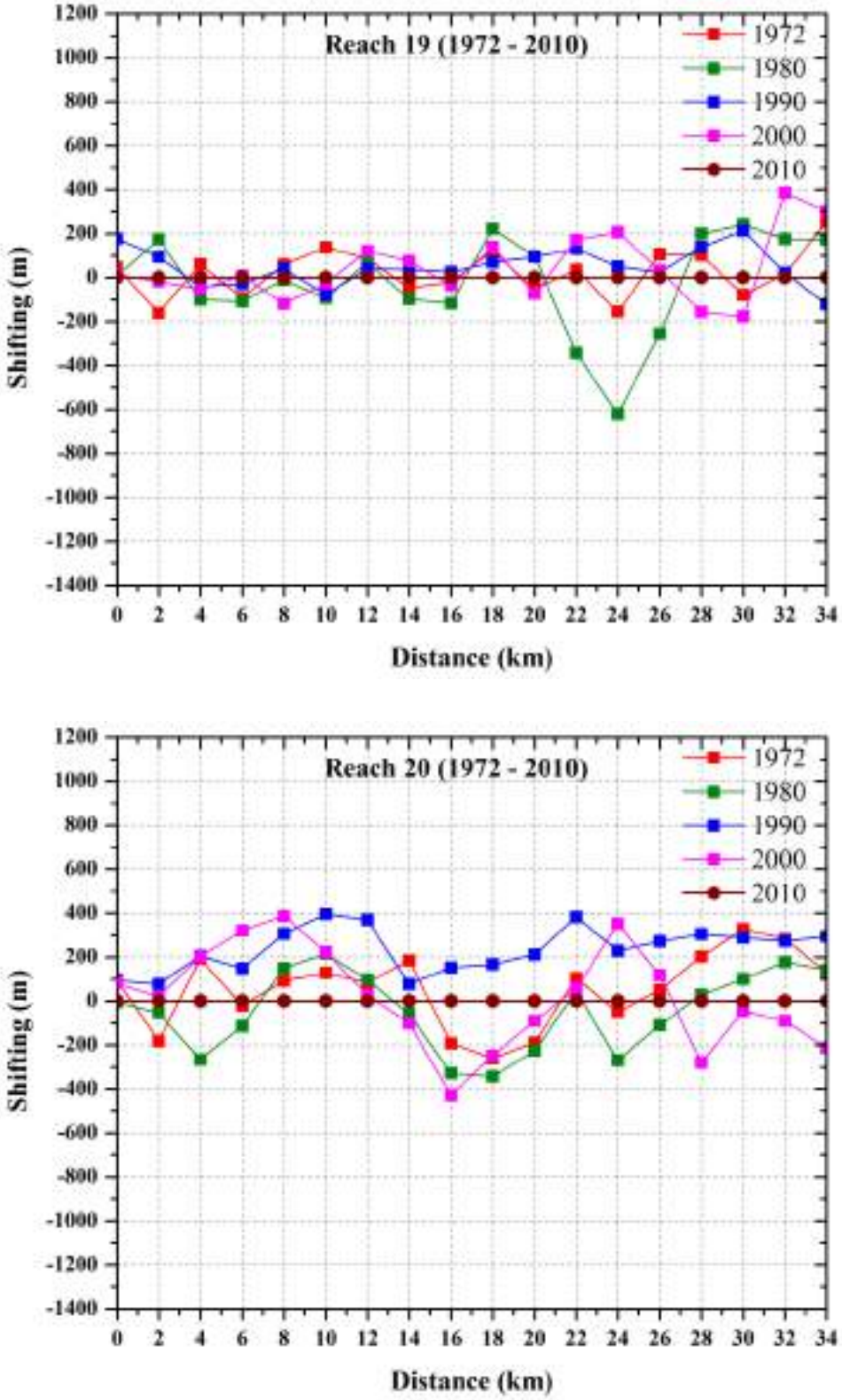


Figure 8.10 : Shifting of the center line of Mahanadi river for reach number 19 and 20

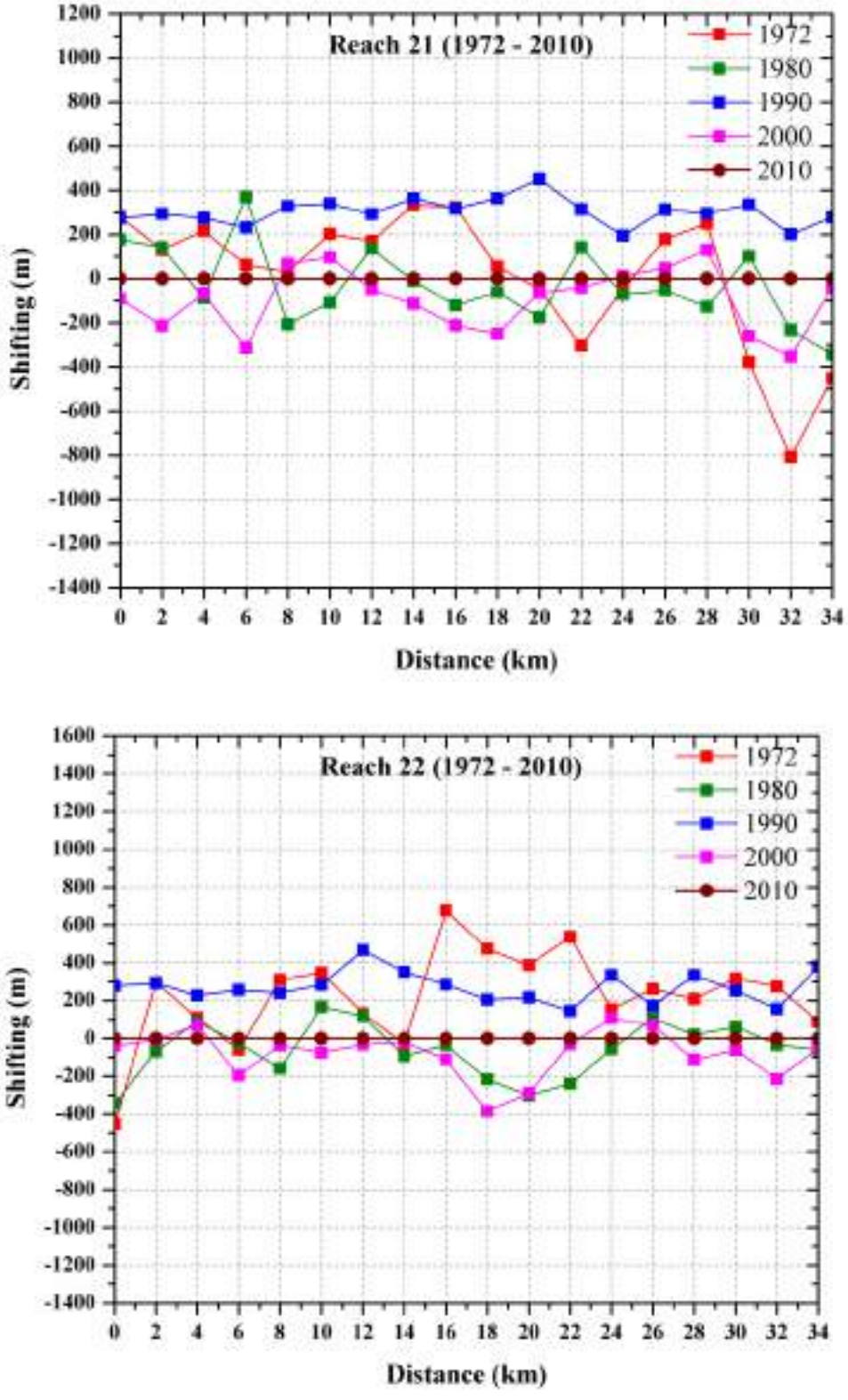


Figure 8.11 : Shifting of the center line of Mahanadi river for reach number 21 and 22

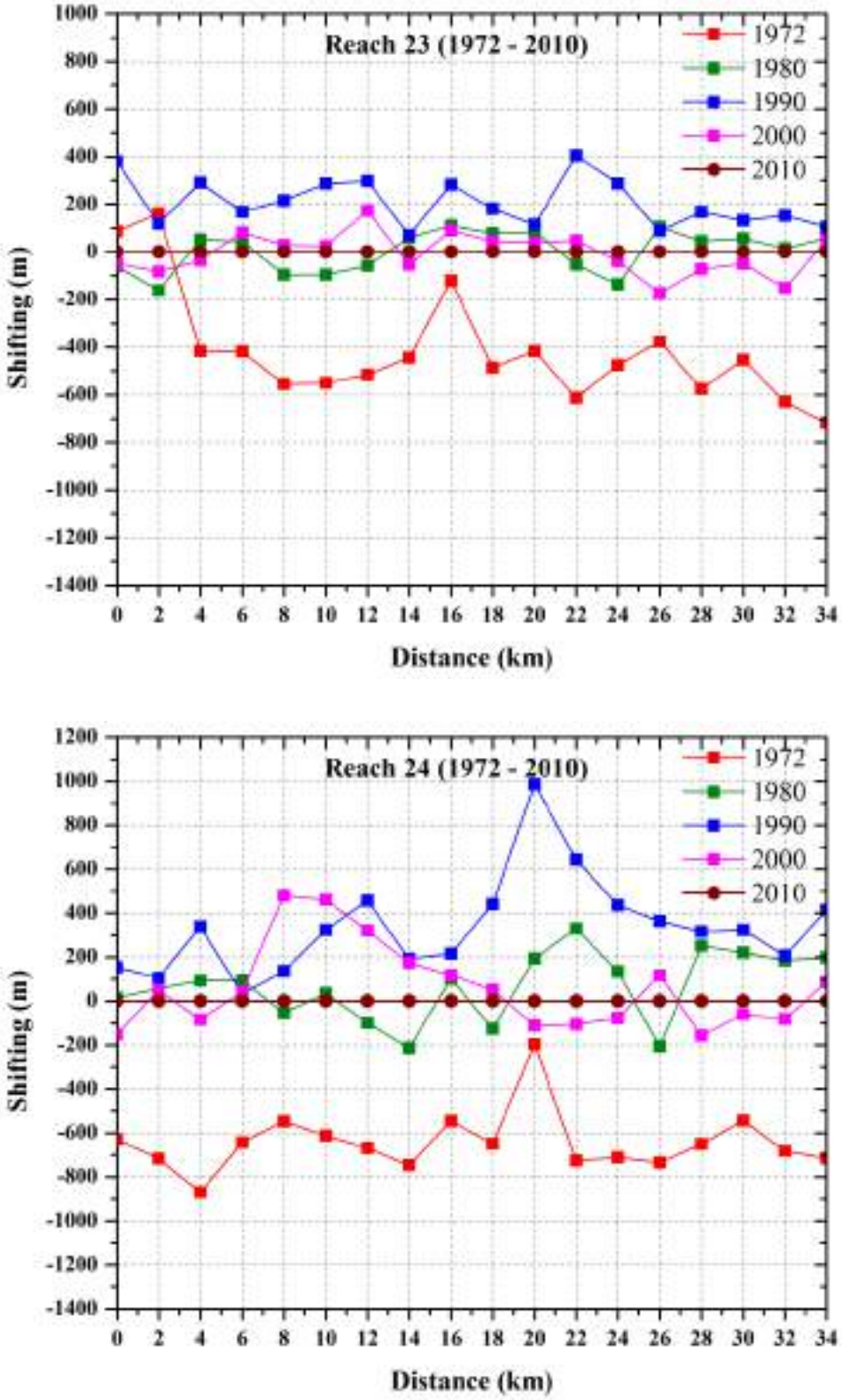


Figure 8.12 : Shifting of the center line of Mahanadi river for reach number 23 and 24

5.3. Identification of bank erosion and deposition:

A river is a dynamic system and tends to adjust its channel roughness, geometry, pattern and profile with time. From source to mouth a river flows with erosion, Transportation and Deposition Process. Two main reasons involved in erosion are hydraulic action and mass failure. The removal of bank material by hydraulic action is closely related to near-bank velocity conditions (Odgaard, 1987; Hasegawa, 1989). River transport the eroded materials. When a river carries high sediment loads, it tends to deposit it wherever the slope is gently leading to the formation of multichannel and development of meanders. A river tries to maintain its course, unless it is disturbed by diastrophic movements, natural calamities like flood, landslides or by human activity. A change in discharge, sediment load size and slopes may disturb the rivers equilibrium state, resulting in aggradations or degradation of the river. This process of aggradation or degradation continues for a long time until a new equilibrium is established. So the river channel is migrated. Lawler (1993) did a review on a measurement of the riverbank erosion and lateral channel changes. Measurement of the area of erosion, deposition, and shifting of riverbank lines is an important objective of fluvial morphology (Pati et al. 2008). Yang (1996) did satellite remote sensing and geographic information system (GIS)-based monitoring of the dynamic environmental change of the active Yellow River Delta, China. The main source of data in this study was a series of time-sequential Landsat images spanning a period of approximately 19 years. A GIS was used to support modernized channel position mapping and measurement. The study demonstrated the efficacy of satellite remote sensing, integrated with a GIS in investigating channel migration.

Satellite Images of the year 1972 to 2018 has been collected from USGS Earth Explorer, which covers the basin area provided by CWC. Banklines of the river were extracted for years 1972 to 2018. The whole river was divided into many reaches. Both the banklines were intersected to identify and estimate the amount of erosion and deposition at different reaches along the main river. The shifting characteristics of the river were evaluated for the identified reaches both on the right as well as left banks of the river courses. The analysis was carried out on a yearly basis and river position was identified and compared to previous years of data to calculate the shifts in the river position. Erosion involves the wearing away of rock and soil found along the river bed and banks. Deposition is the process where the material transported by a river is deposited. Deposition occurs when a river loses energy. The total length of the Mahanadi River is divided into 24 reaches (Figure 9). The total amount of erosion and deposition in the Mahanadi River from 1972 to 2010 was also estimated as shown in Table 4.1 -4.4. Erosion and deposition of the reaches are shown in the Figure 10.1 to 10.2.

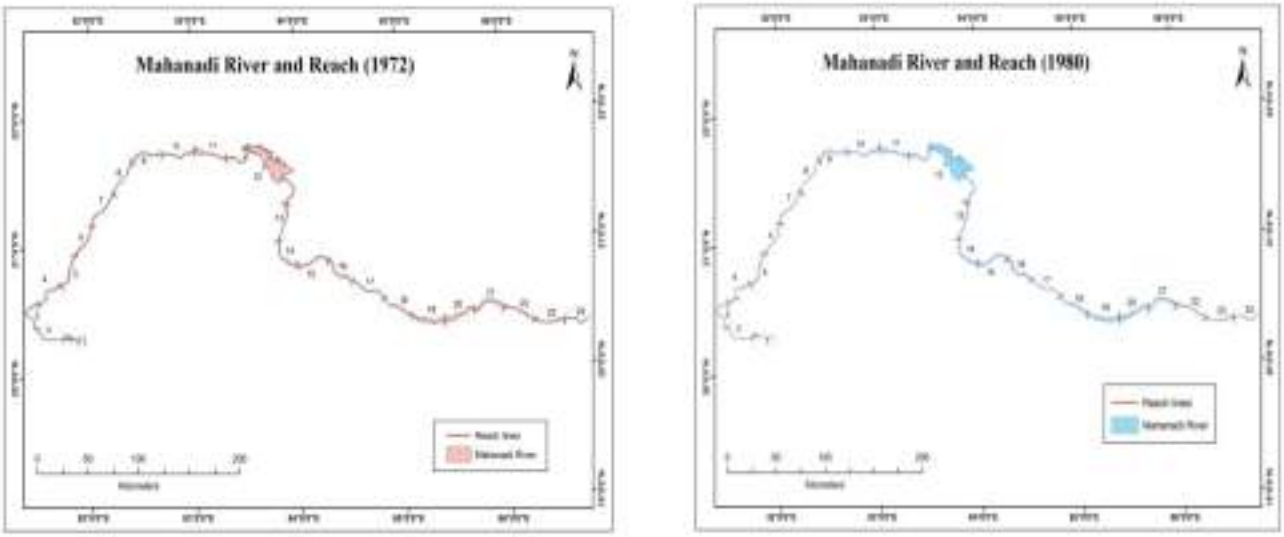


Figure 9: Reaches of the Mahanadi River

Table 4.1: Reach wise bank deposition and erosion statistics

Erosion Deposition (1972-80)				
Reach	Right Bank Deposition area (Ha)	Right Bank Erosion area (Ha)	Left Bank Deposition area (Ha)	Left Bank Erosion area (Ha)
1	393.02	328.27	1137.99	52.48
2	44.85	148.93	135.72	129.30
3	183.40	85.31	27.01	157.59
4	225.15	586.56	130.49	312.84
5	243.51	43.24	239.10	92.56
6	250.84	14.56	189.12	156.73
7	270.48	0.62	16.17	231.73
8	150.24	26.62	25.11	140.80
9	129.69	78.97	148.01	64.91
10	100.98	63.28	95.64	80.06
11	168.52	52.49	93.76	79.25
12	439.00	82.79	207.13	125.61
13	72.62	67.60	204.23	12.28
14	53.80	202.13	292.11	6.69
15	238.10	35.99	147.77	99.17
16	74.34	126.60	227.85	13.16
17	6.51	306.44	261.26	4.44
18	76.48	158.77	144.34	90.99
19	42.67	255.80	320.75	65.85
20	34.37	196.88	318.64	3.17

Table 4.1 (continued): Reach wise bank deposition and erosion statistics

Erosion Deposition (1972-80)				
Reach	Right Bank Deposition area (Ha)	Right Bank Erosion area (Ha)	Left Bank Deposition area (Ha)	Left Bank Erosion area (Ha)
21	43.01	327.96	228.62	74.66
22	93.36	134.34	115.87	138.36
23	154.15	75.69	58.89	127.45
24	64.81	100.47	33.87	156.71

Table 4.2 : Reach wise bank deposition and erosion statistics

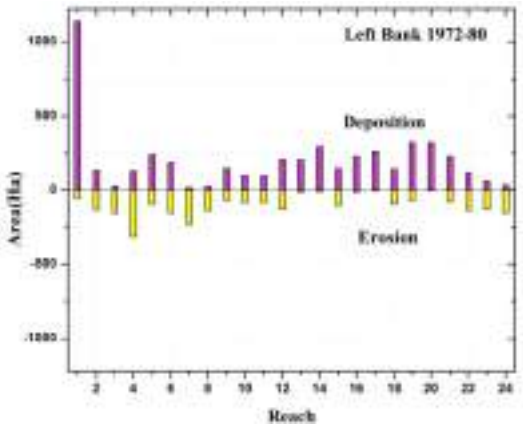
Erosion Deposition (1980-90)				
Reach	Right Bank Deposition area (Ha)	Right Bank Erosion area (Ha)	Left Bank Deposition area (Ha)	Left Bank Erosion area (Ha)
1	121.86	106.63	77.31	153.65
2	103.57	172.07	104.33	81.05
3	44.93	472.50	194.71	404.22
4	0.15	288.66	263.80	165.98
5	0.46	1366.71	398.50	65.86
6	0.00	1036.57	681.45	78.10
7	0.00	1162.97	1094.01	0.00
8	0.00	1008.69	1068.47	0.00
9	31.42	206.14	644.77	3.73
10	3.53	159.45	212.50	35.02
11	0.21	120.53	94.56	10.35
12	39.32	542.60	389.32	48.24
13	4.44	534.33	837.44	4.37
14	14.24	302.43	355.64	130.04
15	276.22	89.17	16.06	446.53
16	24.35	421.04	250.88	81.90
17	114.42	257.16	286.89	118.71
18	62.07	641.60	587.97	51.87
19	314.11	328.08	248.55	370.73
20	458.48	41.05	54.90	424.11
21	546.34	38.70	59.39	149.18
22	18.36	6.68	71.44	96.13
23	19.84	52.87	64.13	6.96
24	23.14	57.28	25.36	30.14

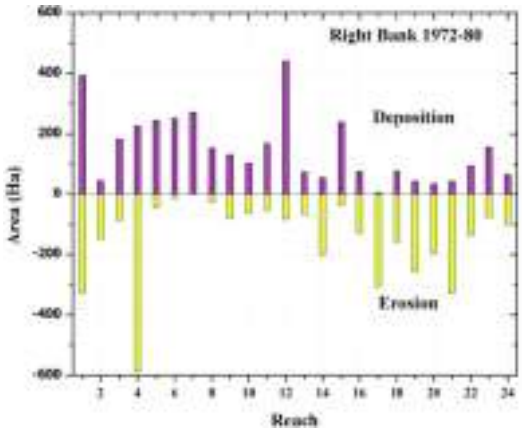
Table 4.3: Reach wise bank deposition and erosion statistics

Erosion Deposition (1990-2000)				
Reach	Right Bank Deposition area (Ha)	Right Bank Erosion area (Ha)	Left Bank Deposition area (Ha)	Left Bank Erosion area (Ha)
1	41.16	64.55	118.15	14.45
2	68.15	134.94	151.34	27.71
3	191.24	226.27	85.38	333.58
4	1436.12	3.54	51.80	316.42
5	373.73	0.00	23.76	463.65
6	868.43	0.00	79.83	613.62
7	918.97	0.00	0.00	927.96
8	894.28	0.00	0.00	960.83
9	366.21	20.54	0.00	757.89
10	75.65	73.81	19.82	339.53
11	53.78	119.57	7.78	376.80
12	350.79	86.98	54.93	493.04
13	436.07	33.27	1.77	765.84
14	359.17	72.74	29.65	437.76
15	131.93	301.80	359.61	70.99
16	329.61	39.56	40.16	356.48
17	383.21	138.12	82.46	451.01
18	568.78	26.14	28.26	531.12
19	339.35	157.19	58.66	376.74
20	111.91	253.22	203.52	126.02
21	343.68	204.71	98.07	194.44
22	91.97	96.91	90.55	168.75
23	123.91	64.83	641.65	88.00
24	16.10	31.18	170.96	100.76

Table 4.4: Reach wise bank deposition and erosion statistics

Erosion Deposition (2000-2010)				
Reach	Right Bank Deposition area (Ha)	Right Bank Erosion area (Ha)	Left Bank Deposition area (Ha)	Left Bank Erosion area (Ha)
1	0.00	1598.19	1483.79	2.05
2	0.00	1819.04	1812.05	0.00
3	4.21	733.75	823.97	247.88
4	331.22	97.60	98.23	408.36
5	300.35	86.67	285.56	148.71
6	131.04	21.67	151.52	25.54
7	67.71	35.79	69.30	86.22
8	123.27	30.49	32.10	79.31
9	78.86	128.25	73.76	61.90
10	92.00	40.67	164.04	42.49
11	113.90	57.07	253.26	16.56
12	208.82	138.64	102.24	424.67
13	124.54	91.67	9.66	152.56
14	90.36	87.21	36.74	99.96
15	38.66	113.79	91.93	102.04
16	88.30	56.00	25.22	86.39
17	101.43	23.41	29.87	104.92
18	65.22	35.07	46.88	34.53
19	131.93	38.10	179.58	134.06
20	44.87	144.81	48.62	97.39
21	103.12	330.19	177.21	70.30
22	158.15	26.51	182.00	112.10
23	94.81	59.59	91.84	631.61
24	28.10	36.72	48.73	133.98





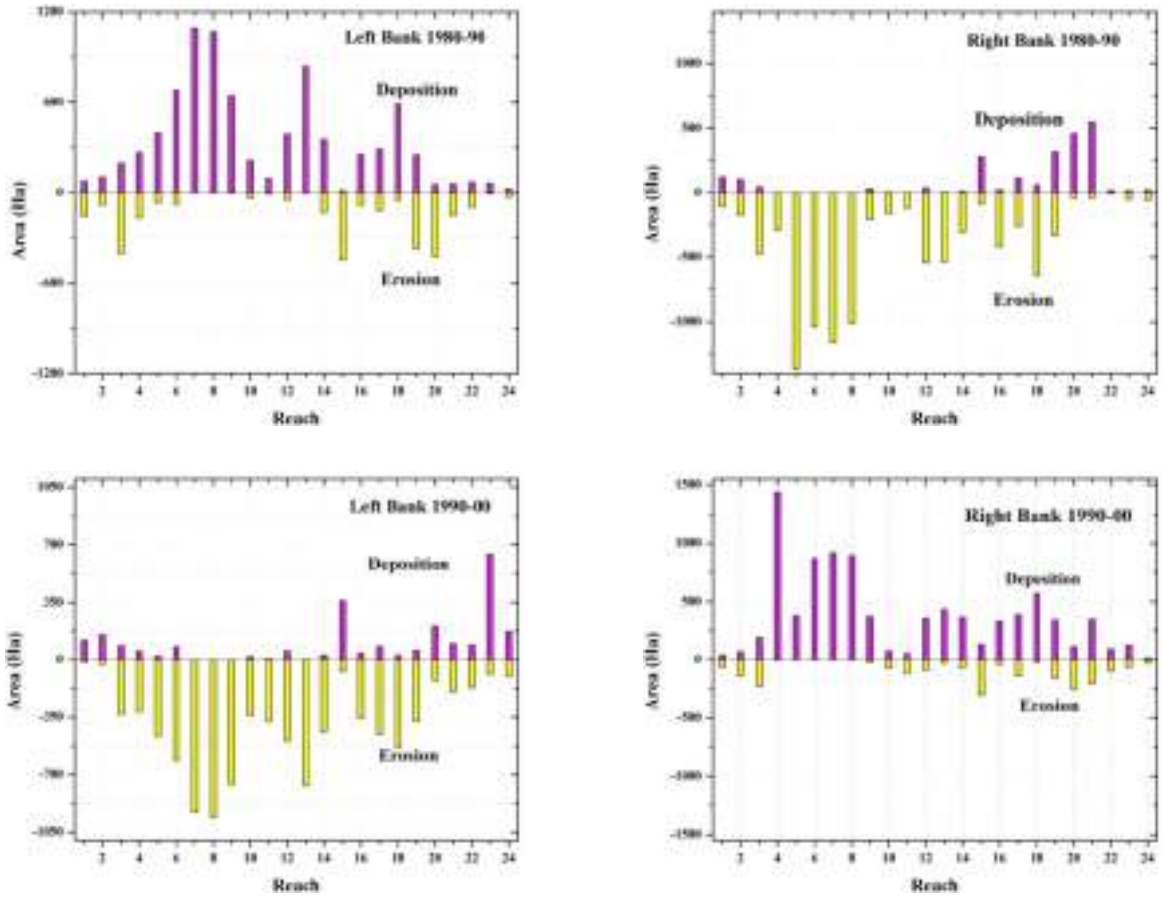


Figure 10.1: Graphical representation of erosion and deposition area of left and right bank of Mahanadi river (1972-2000)

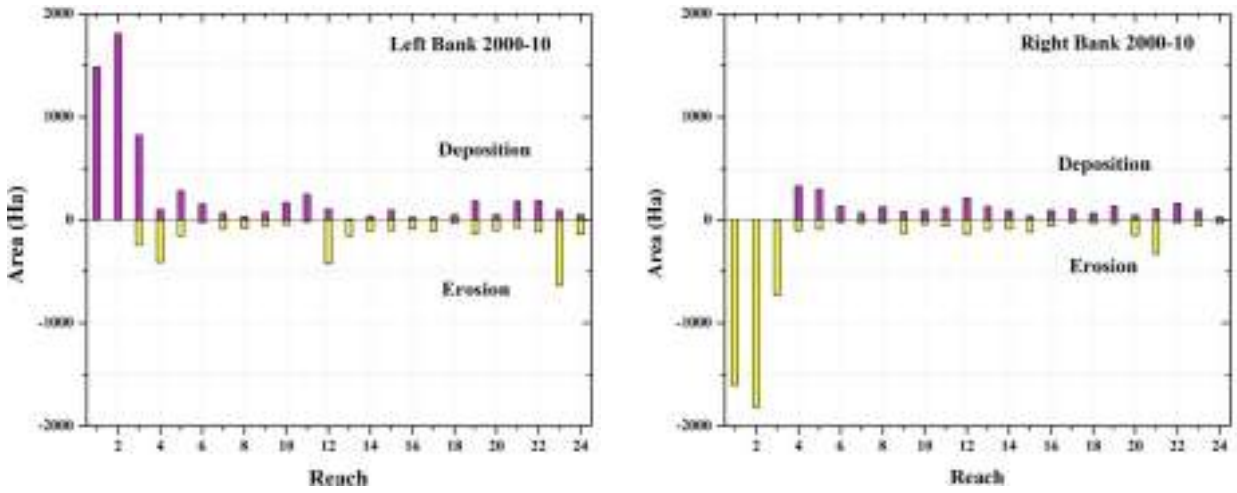


Figure10.2: Graphical representation of erosion and deposition area of left and right bank of Mahanadi river (2000-2010)

5.4. Land Use/Land Cover Change:

Land-use and land-cover changes have been driven by river dynamics along in the Mahanadi River Basin. Impact on river dynamics of land-use is of major concern as it directly influences livelihood of the floodplain dwellers. Change in land-use pattern in association with river dynamics can be effectively used as an indicator for evaluating socioeconomic impact of riverine hazards on human beings. Temporal changes can be identified by the land-use map (Figure 11.1 – 11.5). Land-use of 1972 and 1980 has been done for the Mahanadi River Basin. Many classes were used in the land-use map such as Agricultural land, River, Waterbodies, Sand, Barren land, Vegetation, Build up land (Figure 12.1 - 12.5). Land-use and land-cover map has used to know the present status of the study area. Chiwa (2012) noted Land-use and land cover changes increase impervious ground surfaces, decrease the infiltration rate and increase runoff rate, hence causing low base flow during the dry seasons. The land-use change showed there are an increase in settlement and agriculture and a decrease in the grassland (Table 5). The area affected by erosion–deposition and river migration comprises primarily of the agricultural land. The effect of land use changes on soil erosion is also assessed after all the transformation.

Table 5: Area Statistics of LULC map

LULC Type	1972		1980		1990		2000	
	Area (Sq. Km)	% of Total area	Area (Sq. Km)	% of Total area	Area (Sq. Km)	% of Total area	Area (Sq. Km)	% of Total area
Agricultural Land	113183	70.54	73290.30	52.47	78373.95	53.00	76256.88	51.57
Vegetation	39295.77	24.49	58318.44	41.75	61044.20	41.28	65716.03	44.44
Barren Land	1566.03	0.97	2693.65	1.93	1839.95	1.24	2028.17	1.37
Built up area	1894.48	1.18	2021.43	1.45	2023.04	1.37	2050.25	1.39
Waterbody	1969.14	1.22	1639.41	1.17	2579.50	1.74	2257.93	1.53
River	1993.83	1.24	1054.43	0.75	1677.28	1.13	1480.65	1.00
Sand	561.33	0.35	656.59	0.47	322.21	0.22	338.07	0.23

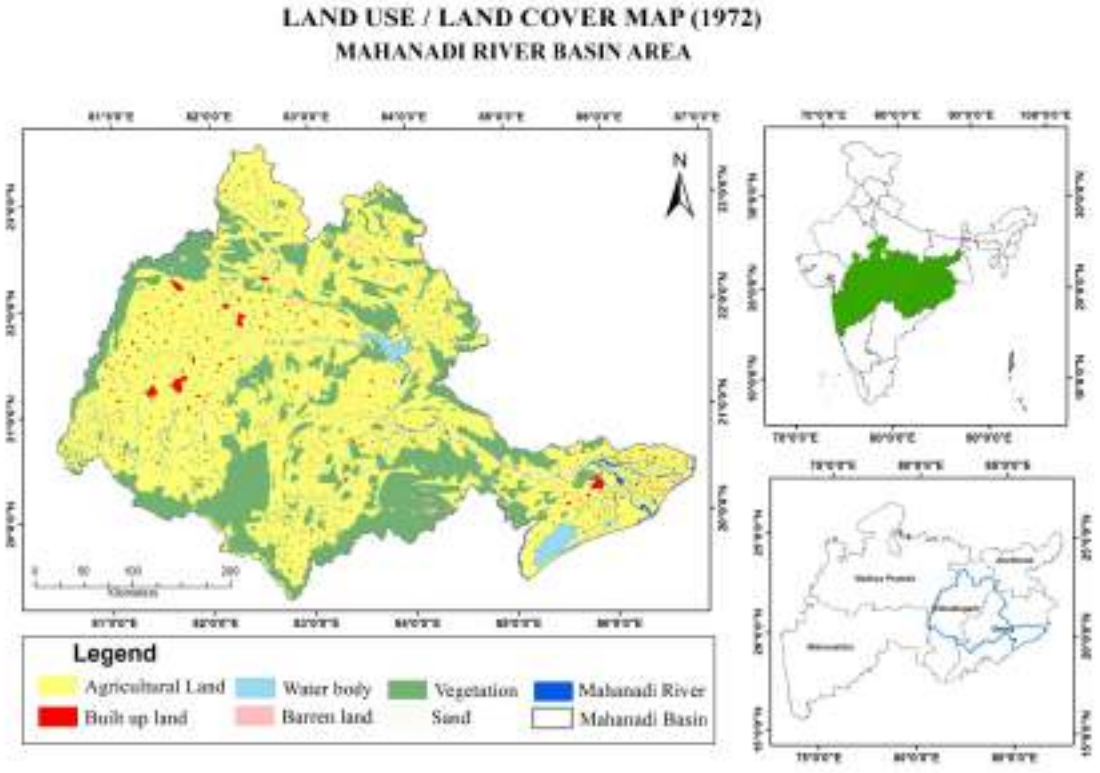


Figure 11.1: Land use and land cover map of Mahanadi river basin (1972)

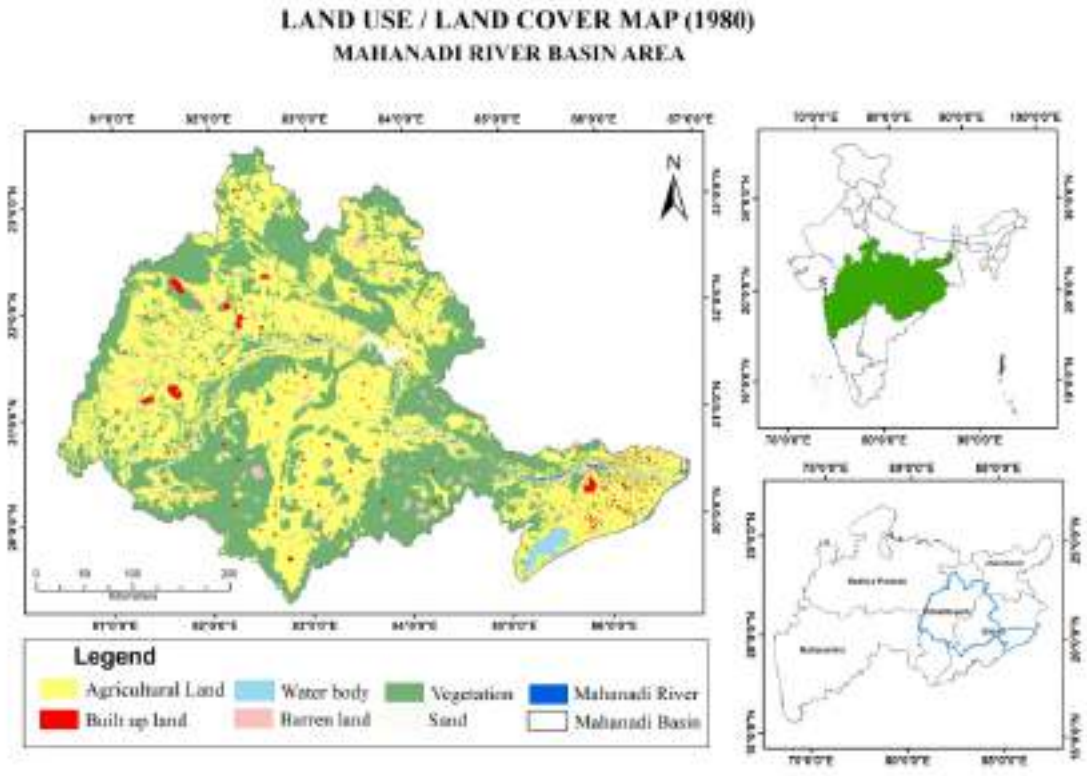


Figure 11.2: Land use and land cover map of Mahanadi river basin (1980)

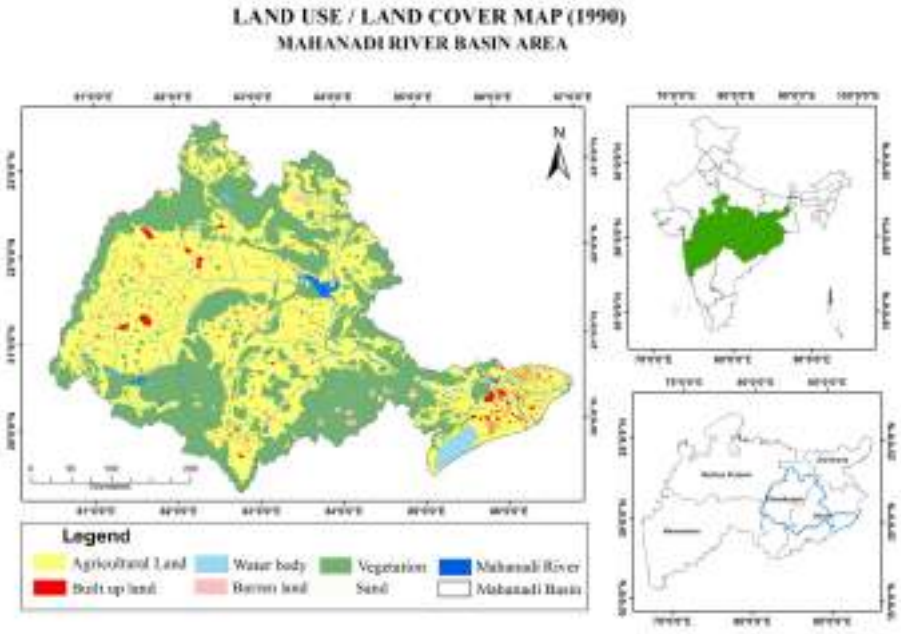


Figure 11.3: Land use and land cover map of Mahanadi river basin (1990)

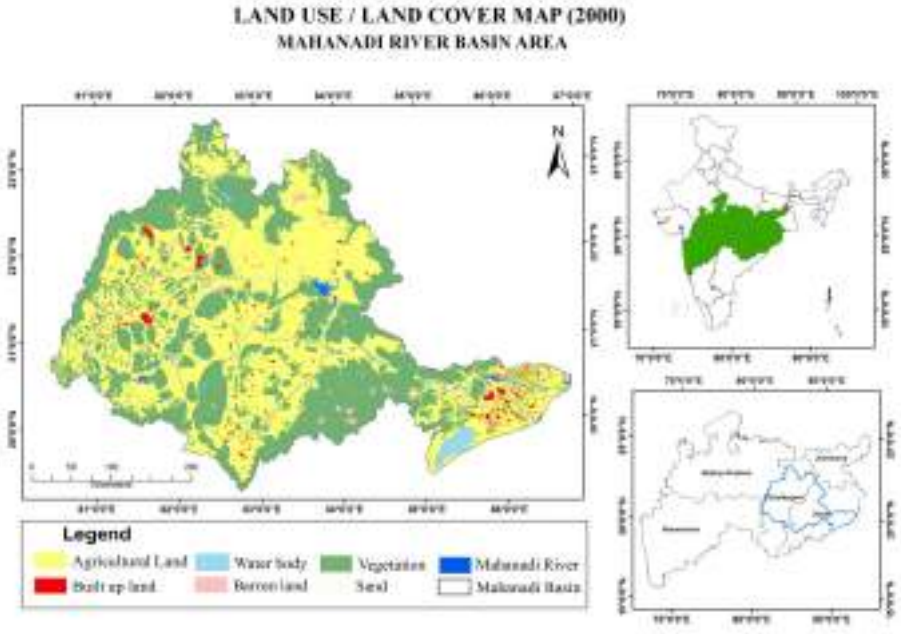


Figure 11.4: Land use and land cover map of Mahanadi river basin (2000)

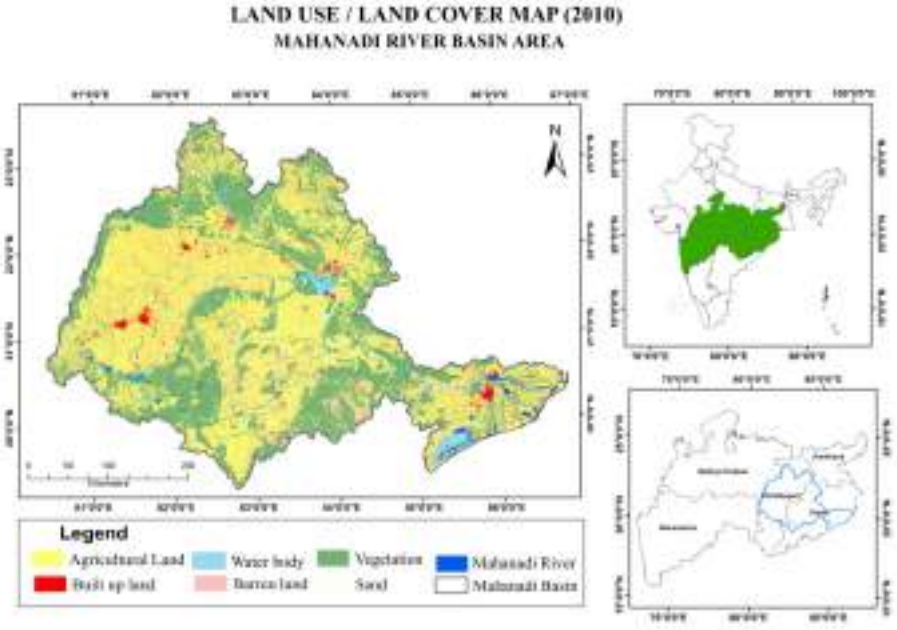


Figure 11.5: Land use and land cover map of Mahanadi river basin (2010)

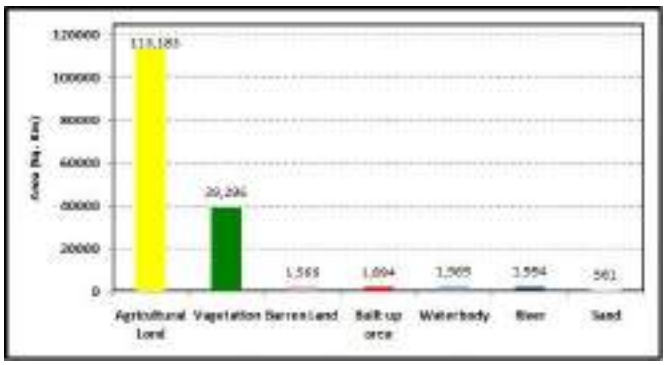


Figure 12.1: Bar graph of the area of Land use/Land cover types (1972)

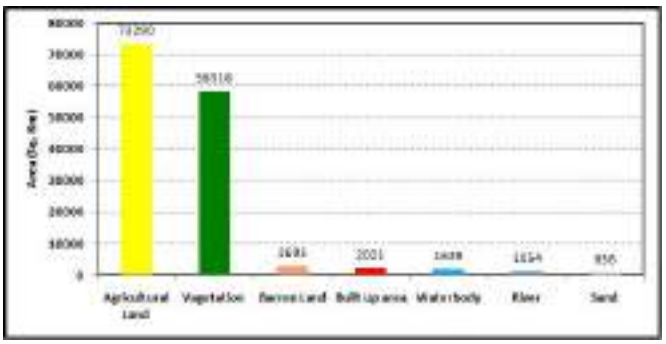


Figure 12.2: Bar graph of the area of Land use/Land cover types (1980)

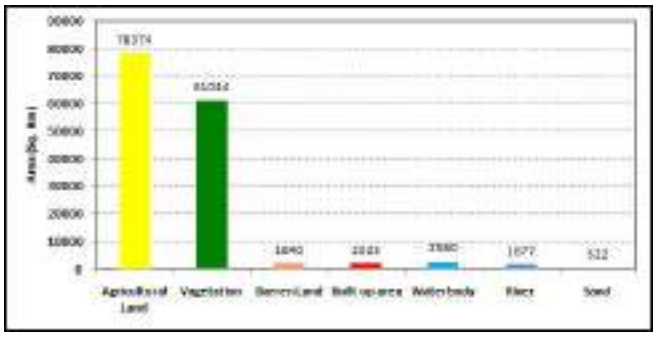


Figure 12.3: Bar graph of the area of Land use/Land cover types (1990)

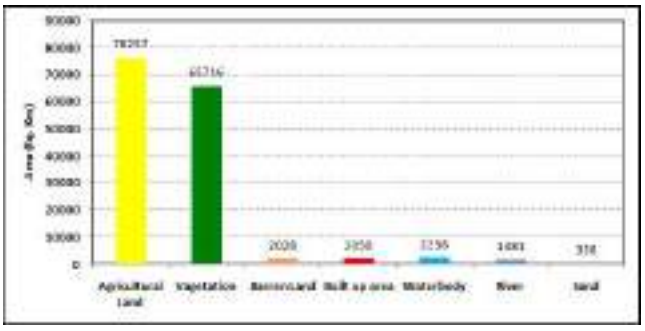


Figure 12.4: Bar graph of the area of Land use/Land cover types (2000)

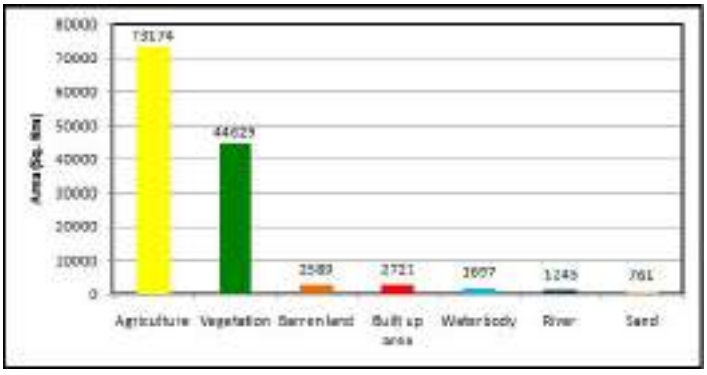


Figure 12.5: Bar graph of the area of Land use/Land cover types (2010)

5.5 Plan Form Index

Shape of river in plan is very important in many design problems concerning the location of bridges, etc. In general, the plan forms of alluvial rivers can be classified as (i) Braided, (ii) Straight and (iii) Meandering. With Plan Form Index (PFI) we can identify types or patterns of channel (Table 6).

PFI are proposed by Sharma (2004)

Highly Braided: PFI < 4

Moderately Braided: 19 > PFI > 4

Low Braided: PFI > 19

Table 6: Plan Form Index

Station	**Plan Form Index (%)**	
	1972	**1980**
Tikarapara	52	36
Basantpur	75	36
Seorinarayan	23	20
Rajim	11	13

5.6 Sinuosity Index

The sinuosity index is the ratio of the length of the channel with a length of meander-belt axis also. That means the sinuosity index can be computed as the ratio of the length of the channel to a length of valley axis (Brice, 1964). According to the Brice, if the sinuosity index of a reach is 1.3 or greater, the reach is considered as meandering, a straight reach has a sinuosity index of 1 and reaches which is having sinuosity indices between 1.05 and 1.3 are defined as sinuous (Table 7.1 – 7.5).

Table 7.1: Sinuosity of Mahanadi River in 1972

Reach	L_c (m)	L_v (m)	Sinuosity = L_c/ L_v
1	32518	22118	1.47
2	34207	27976	1.22
3	35808	20210	1.77
4	33658	26897	1.25
5	33563	29648	1.13
6	31602	29999	1.05
7	35188	33493	1.05
8	34419	33061	1.04
9	34164	29289	1.16
10	36081	33766	1.06
11	32304	31537	1.02
12	103395	71290	1.45
13	33313	332031	0.10
14	32513	26795	1.21
15	35357	31443	1.12
16	32823	29519	1.11
17	36268	33996	1.07
18	32325	31083	1.04
19	34650	33071	1.05
20	32381	29868	1.08
21	34126	29736	1.15
22	33822	32047	1.05
23	30832	28948	1.06
24	27159	23416	1.16

Table 7.2: Sinuosity of Mahanadi River in 1980

Reach No.	L_C	L_V	Sinuosity = $\frac{L_C}{L_V}$
1	34187	22108	1.55
2	35026	28035	1.25
3	34809	20193	1.72
4	33491	26917	1.24
5	33567	29661	1.13
6	31595	29999	1.05
7	35216	33493	1.05
8	34421	33069	1.04
9	34208	29302	1.17
10	36151	33780	1.07
11	32309	31549	1.02
12	104371	71286	1.46
13	33339	32068	1.04
14	32472	26849	1.21
15	35397	31443	1.13
16	32823	29519	1.11
17	36126	33969	1.06
18	32339	31114	1.04
19	34657	33074	1.05
20	32309	29868	1.08

Table 7.2 (continued): Sinuosity of Mahanadi River in 1980

Reach No.	L_C	L_V	Sinuosity = $\frac{L_C}{L_V}$
21	34086	29736	1.15
22	33708	32047	1.05
23	30819	28948	1.06
24	29254	24891	1.18

Table 7.3: Sinuosity of Mahanadi River in 1990

Reach	L_c (m)	L_v (m)	Sinuosity = L_c/ L_v
1	34098	21977	1.55
2	33835	27993	1.21
3	34091	20108	1.70
4	32585	26936	1.21
5	32917	29885	1.10
6	31654	30047	1.05
7	34904	33395	1.05
8	34322	33021	1.04
9	33808	29215	1.16
10	35800	33727	1.06
11	31853	31486	1.01
12	103009	71222	1.45
13	33425	32174	1.04
14	32507	27146	1.20
15	35164	31452	1.12
16	32857	29524	1.11
17	35894	33846	1.06
18	32401	31236	1.04
19	34315	33062	1.04
20	31864	29767	1.07
21	33958	29811	1.14
22	33684	31972	1.05
23	30911	29031	1.06
24	19316	17188	1.12

Table 7.4: Sinuosity of Mahanadi River in 2000

Reach	L_c (m)	L_v (m)	Sinuosity = L_c/ L_v
1	35726.2	22665.4	1.58
2	33616.7	27891	1.21
3	34478.7	19985.6	1.73
4	32451	27023.8	1.20
5	32579.7	29545.5	1.10
6	31403.4	30035	1.05
7	35132.8	33424	1.05
8	34513.3	33089.1	1.04
9	33962.3	29314.8	1.16
10	35777.2	33747.4	1.06

Table 7.4 (continued): Sinuosity of Mahanadi River in 2000

Reach	L_c (m)	L_v (m)	Sinuosity = L_c/ L_v
11	31829.9	31521.2	1.01
12	104824	71206.7	1.47
13	33383	32086.7	1.04
14	32391	26976.5	1.20
15	35104.9	31534.2	1.11
16	32628.8	29514.5	1.11
17	36209.8	33998.3	1.07
18	32217.3	31056.5	1.04
19	34267.1	33046.9	1.04
20	31864	29852.5	1.07
21	33898.3	29789.1	1.14
22	33235.3	31979.2	1.04
23	31087.8	29010.1	1.07
24	27289.4	23787.5	1.15

Table 7.5: Sinuosity of Mahanadi River in 2010

Reach	L_c (m)	L_v (m)	Sinuosity = L_c/ L_v
1	41185	24987.1	1.65
2	33494.4	27757.4	1.21
3	34329	20337	1.69
4	31944.3	26706.8	1.20
5	33125.7	29627.5	1.12
6	31465.1	30002.3	1.05
7	35185.9	33445.2	1.05
8	34506.6	33098.9	1.04
9	34256.7	29333.5	1.17
10	35720.8	33775	1.06
11	31800.7	31551.8	1.01
12	103232	71201.6	1.45
13	33405.2	32083	1.04
14	32209	27024.9	1.19
15	35042.1	31453.9	1.11
16	32546.4	29498.9	1.10
17	35927.1	34006.2	1.06
18	32301.9	31050.6	1.04
19	34237.3	33046.4	1.04
20	31985.5	29875.1	1.07
21	33842.1	29841.3	1.13
22	33161	32003.5	1.04
23	30792.2	28934.3	1.06
24	19219.4	17205.6	1.12

5.7 Radius of Curvature

Radius of curvature is a measure of the "tightness" of an individual meander bend and is negatively correlated with sinuosity. Radius of curvature is measured from the outside of the bankfull channel to the intersection point of two lines that perpendicularly bisect the tangent lines of each curve departure point (Table 8).

Table 8: Reach wise Radius of curvature

Reach No	Radius of curvature (m)				
	1972	**1980**	**1990**	**2000**	**2010**
1	1315, 407, 1211, 792, 716, 410	298,427,1193	1191, 421, 299	529, 399, 384, 953	612, 951, 813, 984
2	240, 1375, 484, 495, 509, 236, 547, 734, 2100	2533	2549	2965	2996
3	1236, 1286, 970, 771, 2385, 966, 1383	1310,946,2284 ,1270	2342, 965, 1302	3980	4690
4	1387, 942, 1003, 3946, 4494,	2218,2317	2347	3581	3788
5	7940, 2903, 4864	10010,3857	3891, 9691	8622	9857
6	2441		-	-	-
7	9751	8374	8823	10196	8791
8	11579	-	-		
9	7964, 2798, 2335, 2009,	8140,2576,188 3	1896, 2605, 8184	9947, 2289	9543
10	7340	4808,	4811	6888	6195
11	-	-	-	-	-
12	4896, 6706	2706,6858	6910, 2704	4979, 6916	5345, 7432
13	-	-	-	-	-
14	20398	21099	20421	19992	17738
15	12488	6808	8058	8849	7813
16	-	5569,4247	4228, 6554	7436	8120
17	6671	9549	9601	8701.96	8618
18	-	-	-	-	-
19	52237	38340	40420	28427	27768
20	-	-	-	-	-
21	13797	12780	11439	13098	12871
22	-	-	-	-	-
23	-	-	-	-	-
24	3934	-	9817	9613	4690

5.8 Longitudinal Profile:

The longitudinal profile characterizes average stream slopes and depths of riffles, pools, runs, glides, rapids and step/pools. It shows how river's gradient change as it flows from its source to mouth. The long profile also shows river's gradient is steep in upstream, but it gradually becomes flat as the river erodes towards its downstream. The plotting of these profiles shows altitude against distance downstream. The resulting form is a curve, more or less regular, the concavity of which increases towards the headwaters area. This is their most obvious and persistent feature regardless of the climatic conditions, the length of the river or the rock cut by the riverbed. (Wheeler, 1979).

According to Gilbert (1877), the slope of the longitudinal profile is inversely proportional to the discharge. Further studies were concerned that the effect that the discharge, the characteristics of the riverbed material, the sediment discharge (suspended or bed load) and the type of rock form of the stream bed profile. The conclusion was that the variation of the discharge (Q), the riverbed material diameter (DMM), and the sediment load (Qs) are the most important in explaining the shape of the profile. All other factors caused in the evolution of the river profile in the different stages. A steady preoccupation was to fend for describing the form of longitudinal profiles. The objective was to define the evolution of the Mahanadi River based on an analysis of the longitudinal profile form and thus estimate their long-term evolutionary tendencies. The evolutionary estimates refer to both prediction and post-diction of profiles.

5.8.1 Detailed longitudinal profile and its analysis:

For the analysis of the detailed longitudinal profile of the Mahanadi River, some techniques have employed. At first, the 30 m resolution SRTM DEM (2000) was downloaded. Then the Profile was extracted from the DEM using the ArcGIS extension 3D analyst. Create 3D line by interpolating height from the selected functional surface (Table 9). After creating the 3D line, make the profile graph of the selected 3D line. From the profile graph, there is the highest and lowest elevation value and also the horizontal distance of the reach of the respective river (Figure 13.1 – 13.12).

Table 9: Station wise slope of Mahanadi River (2008)

Site	Slope
Rajim	0.0006
Seorinarayan	0.0004
Tikrapara	0.0002

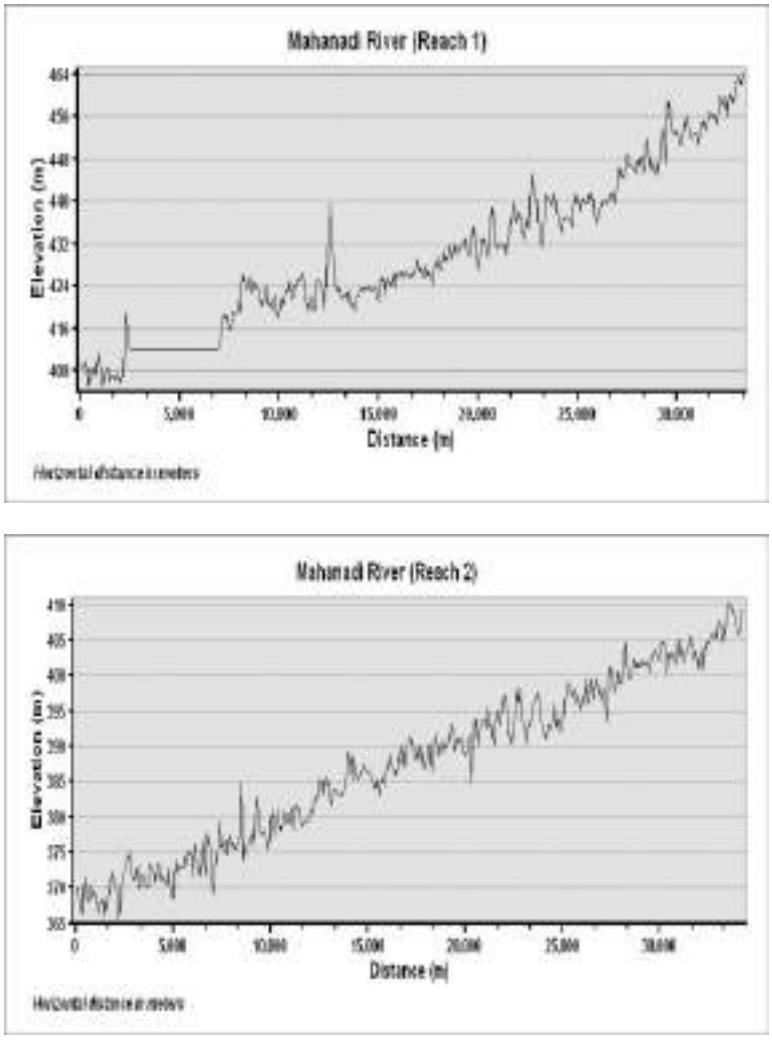
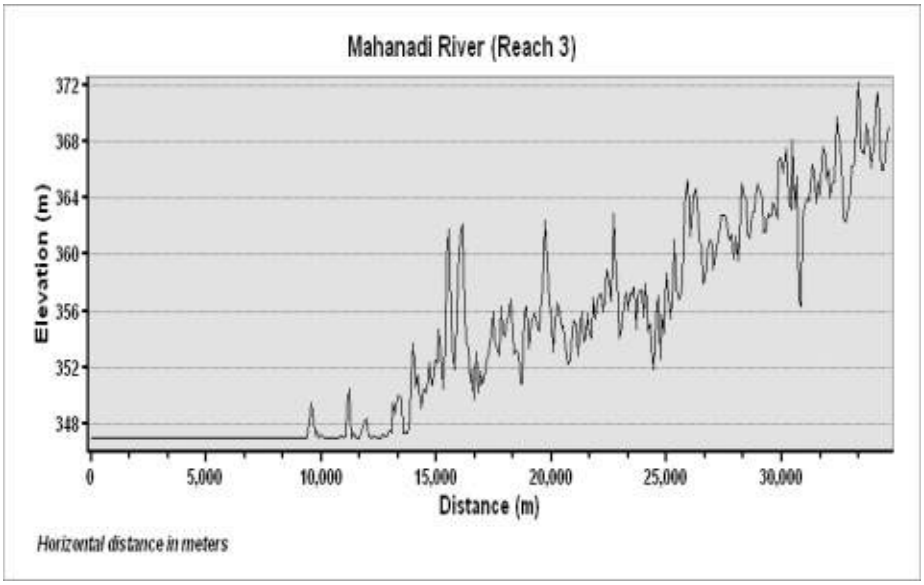


Figure 13.1: Reach wise Longitudinal Profile of Mahanadi River (2000)



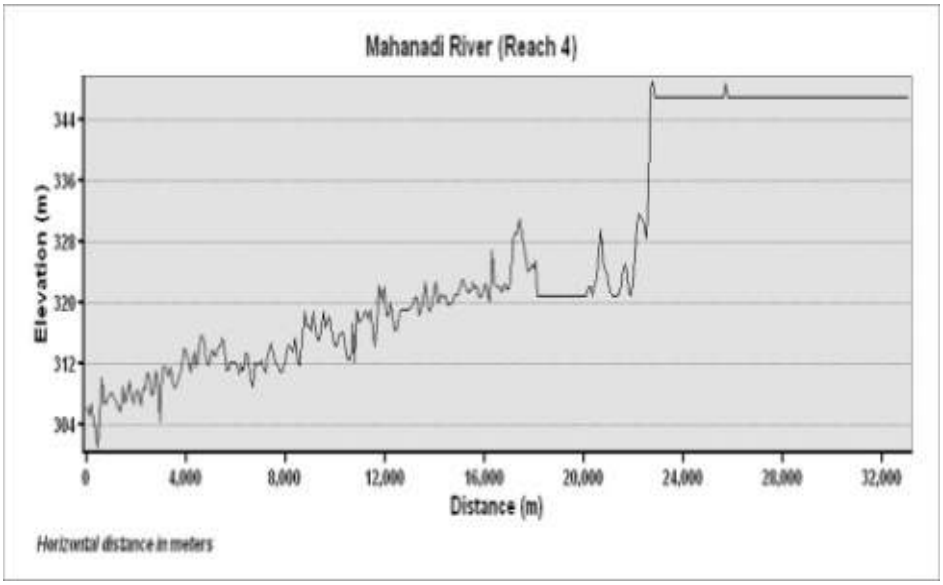


Figure 13.2: Reach wise Longitudinal Profile of Mahanadi River (2000)

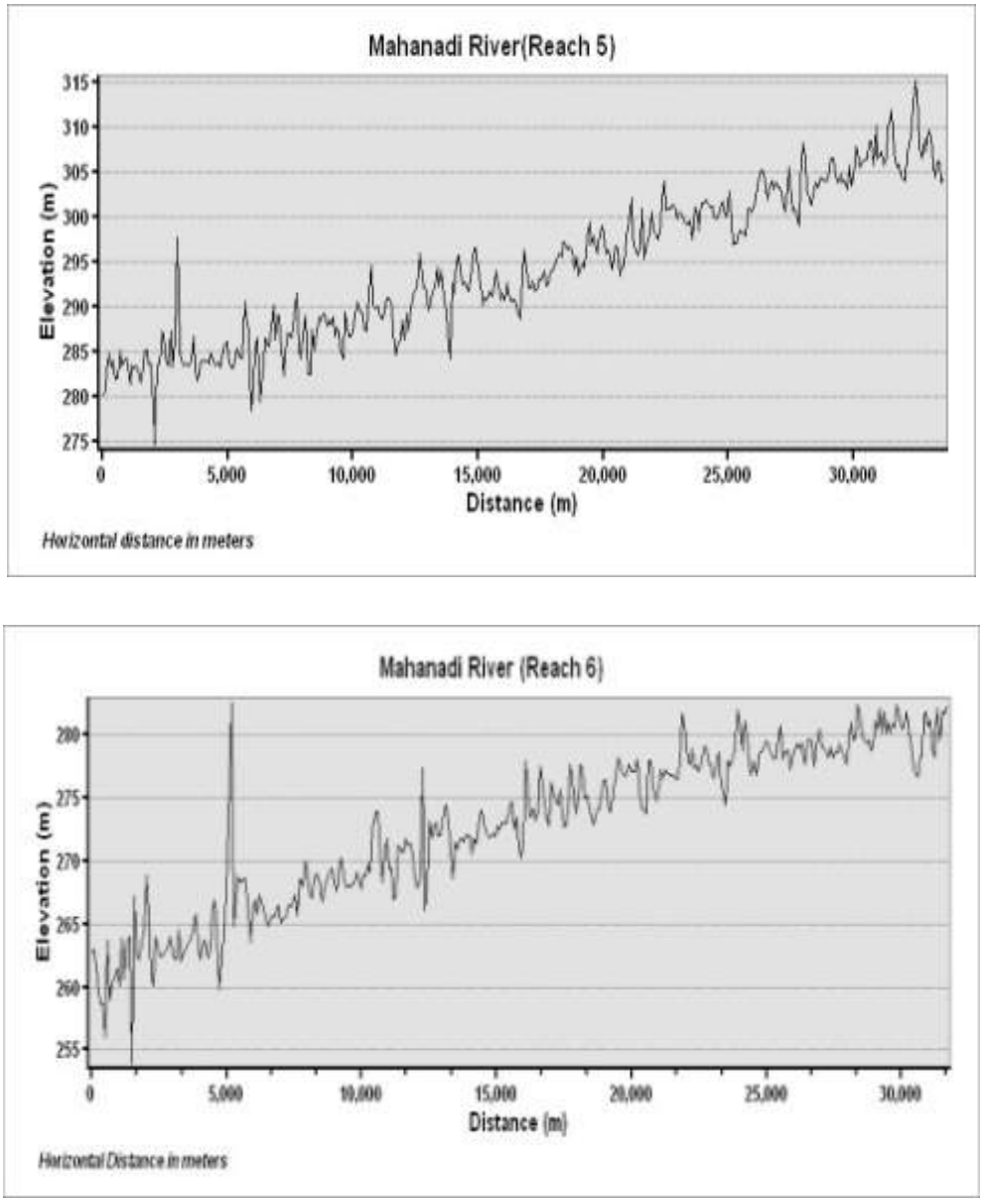
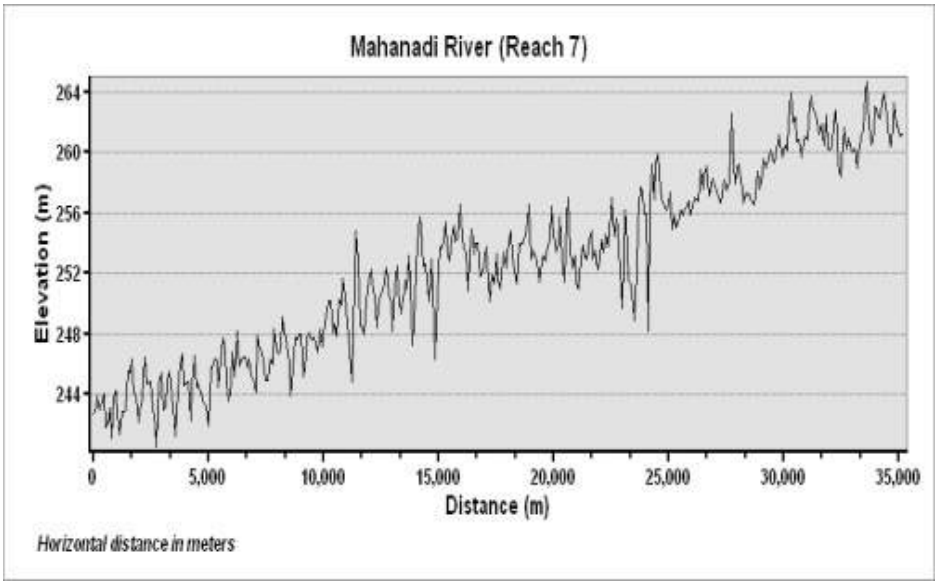


Figure 13.3: Reach wise Longitudinal Profile of Mahanadi River (2000)



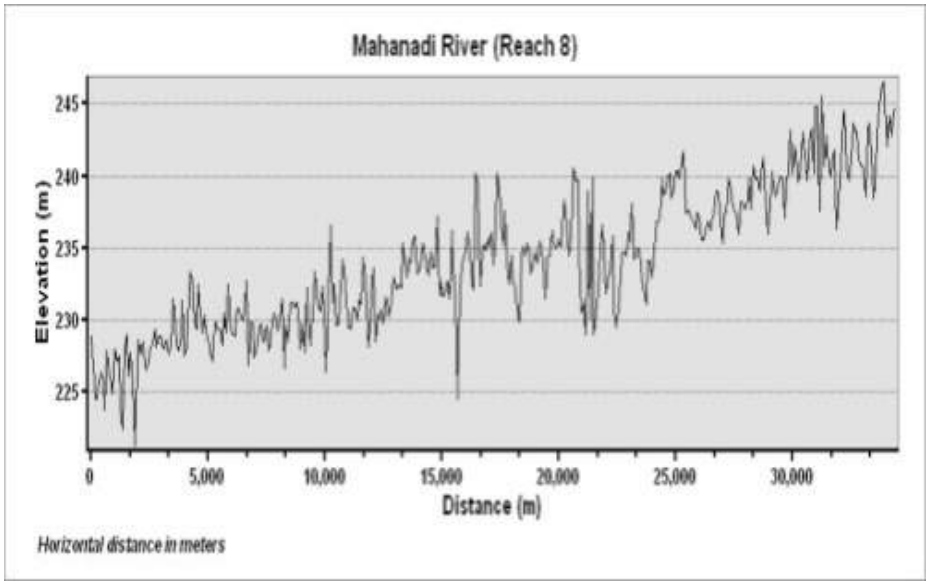
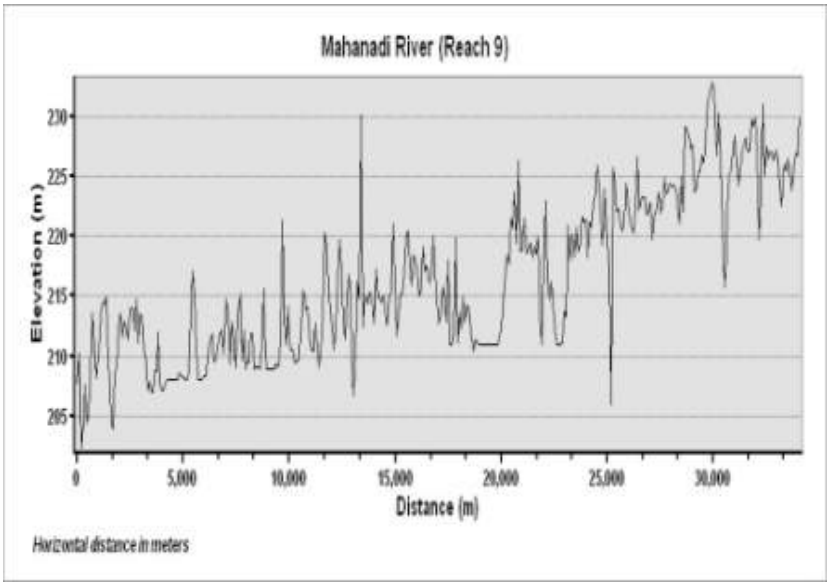


Figure 13.4: Reach wise Longitudinal Profile of Mahanadi River (2000)



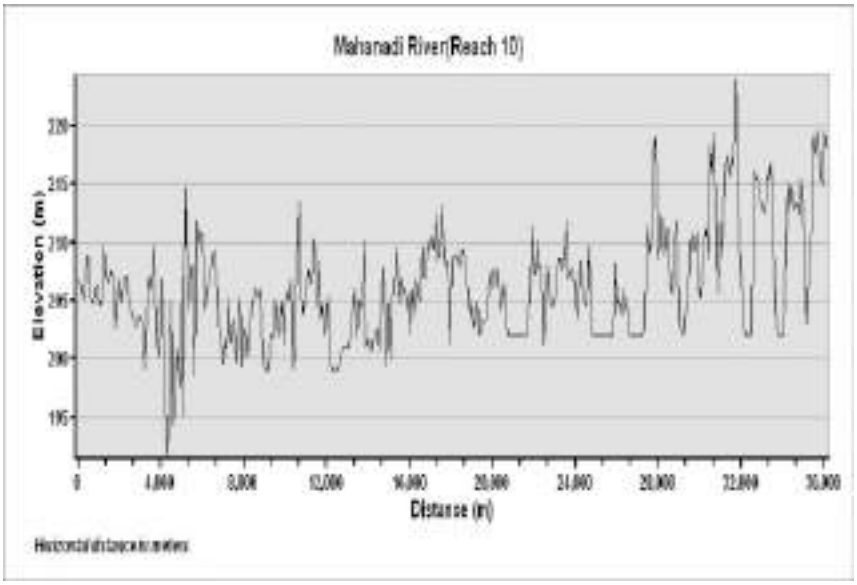
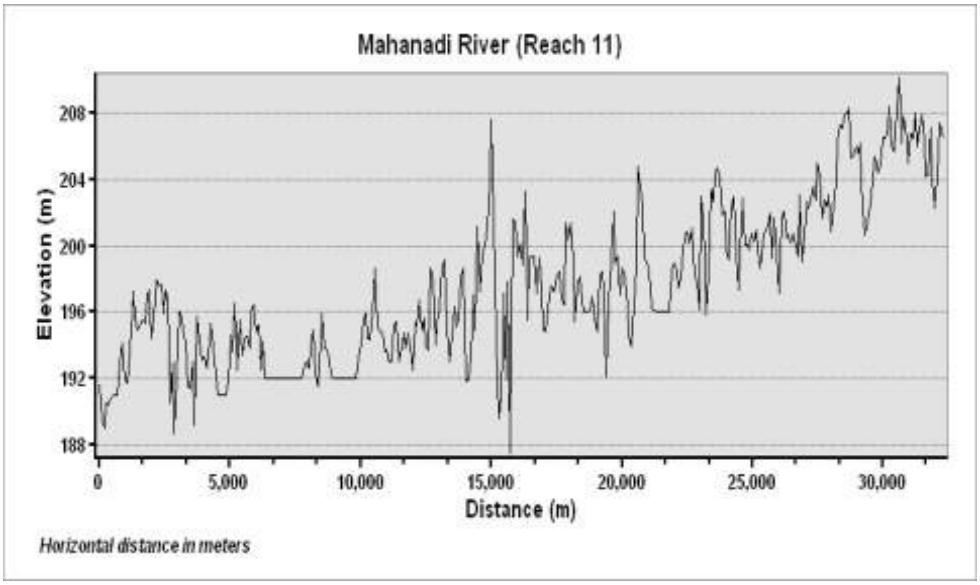


Figure 13.5: Reach wise Longitudinal Profile of Mahanadi River (2000)



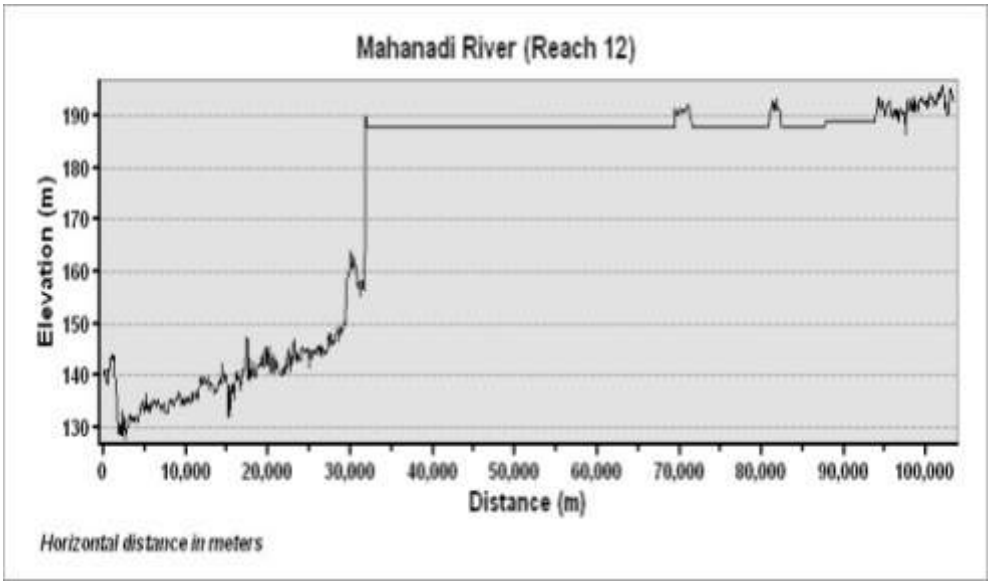
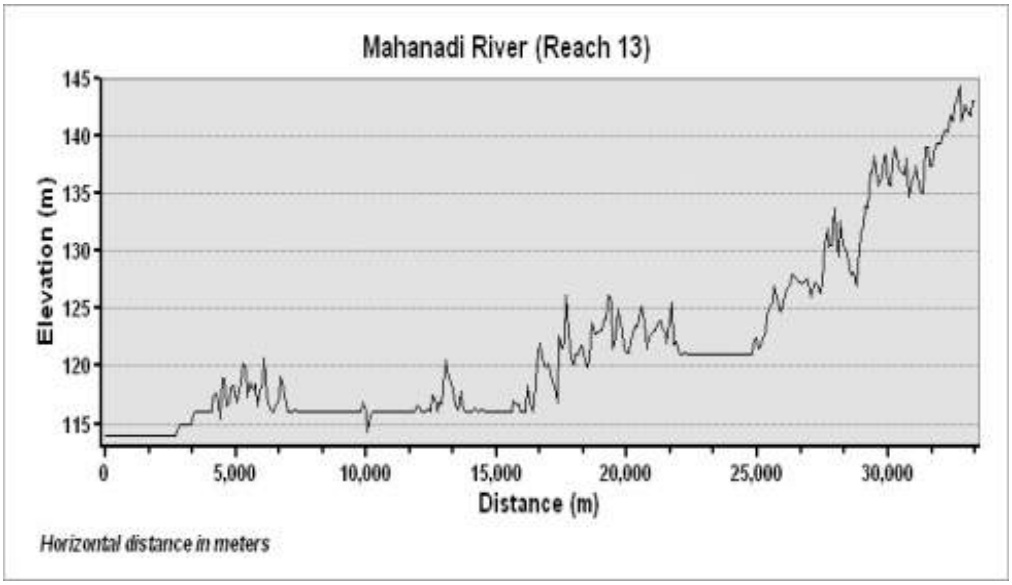


Figure 13.6: Reach wise Longitudinal Profile of Mahanadi River (2000)



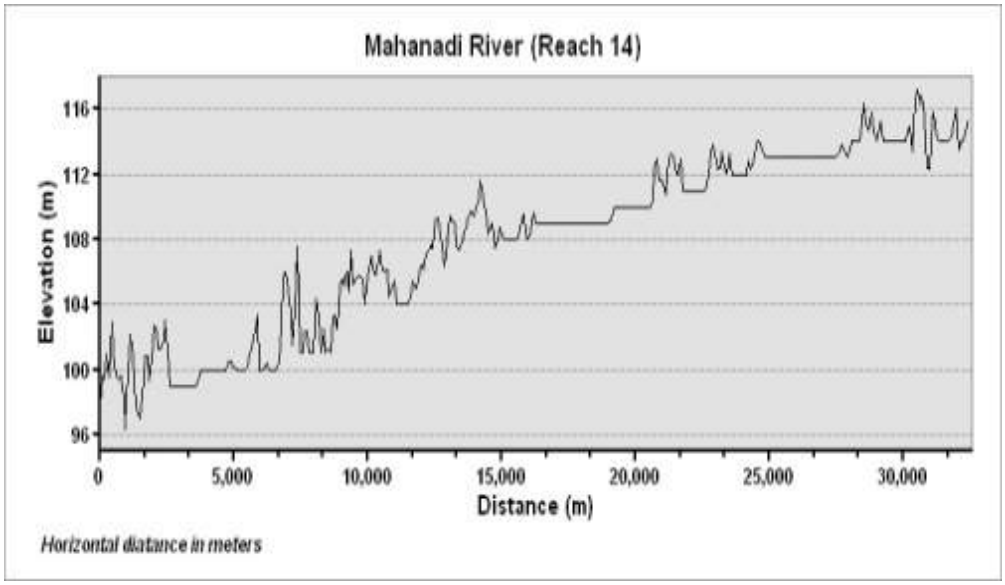
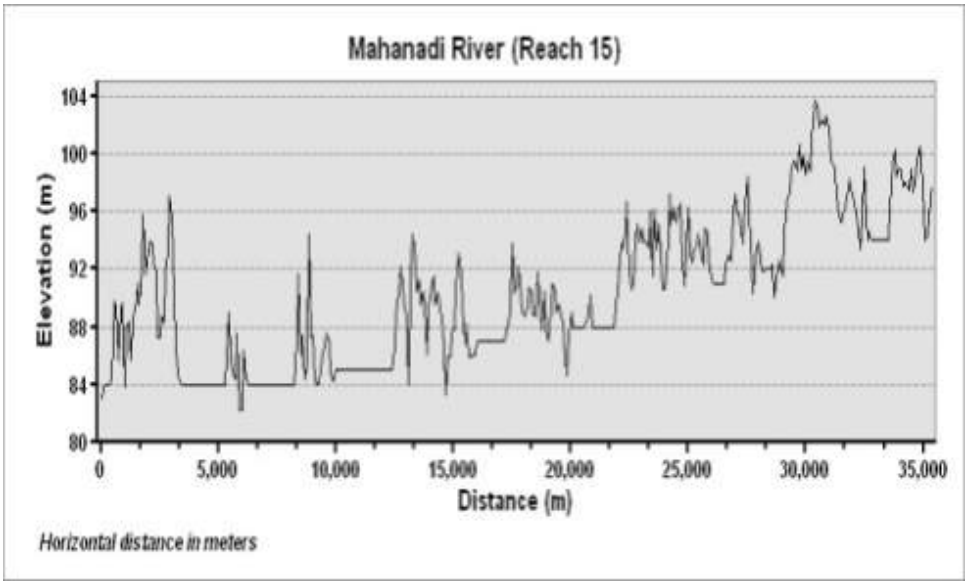


Figure 13.7: Reach wise Longitudinal Profile of Mahanadi River (2000)



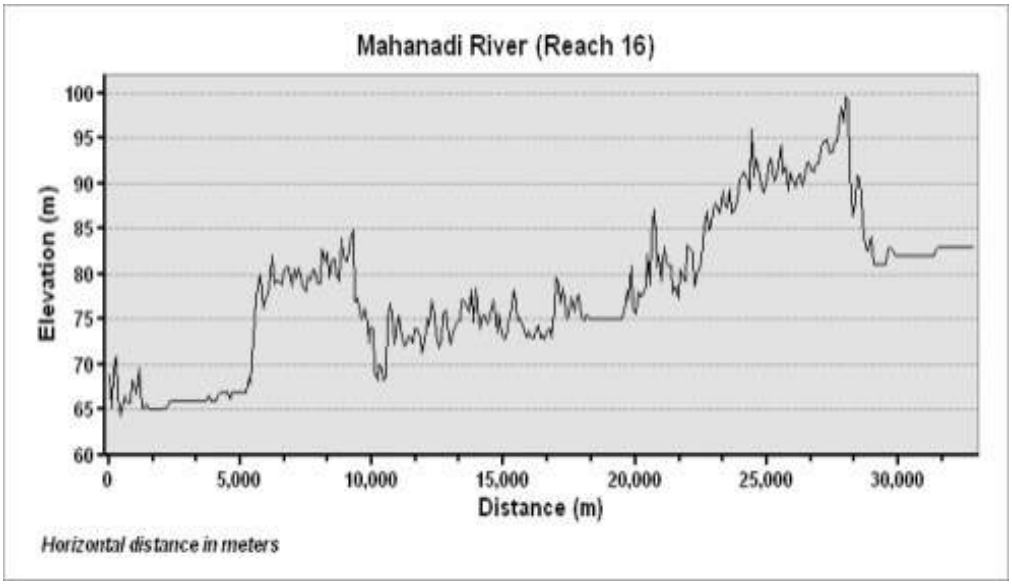
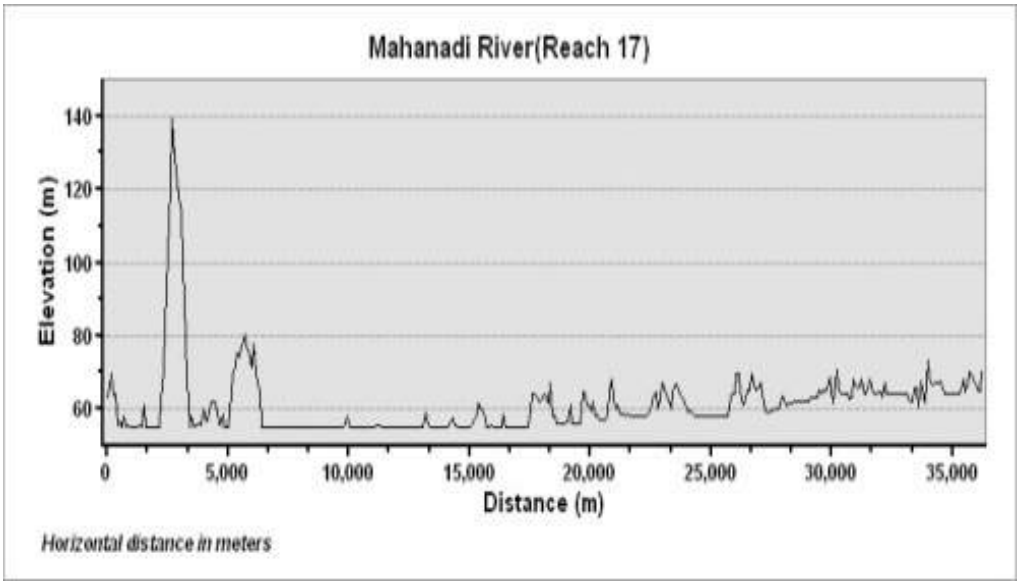


Figure 13.8: Reach wise Longitudinal Profile of Mahanadi River (2000)



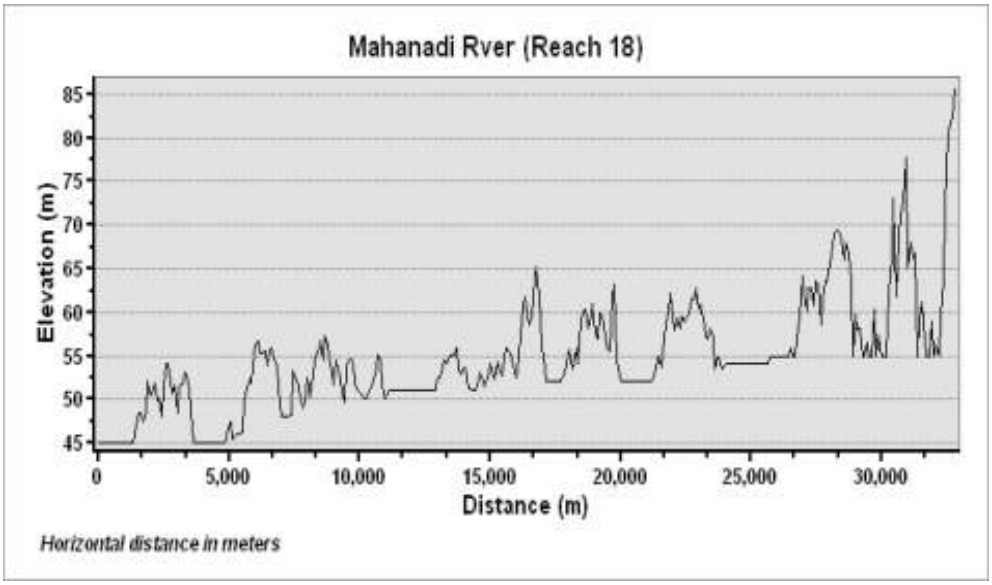
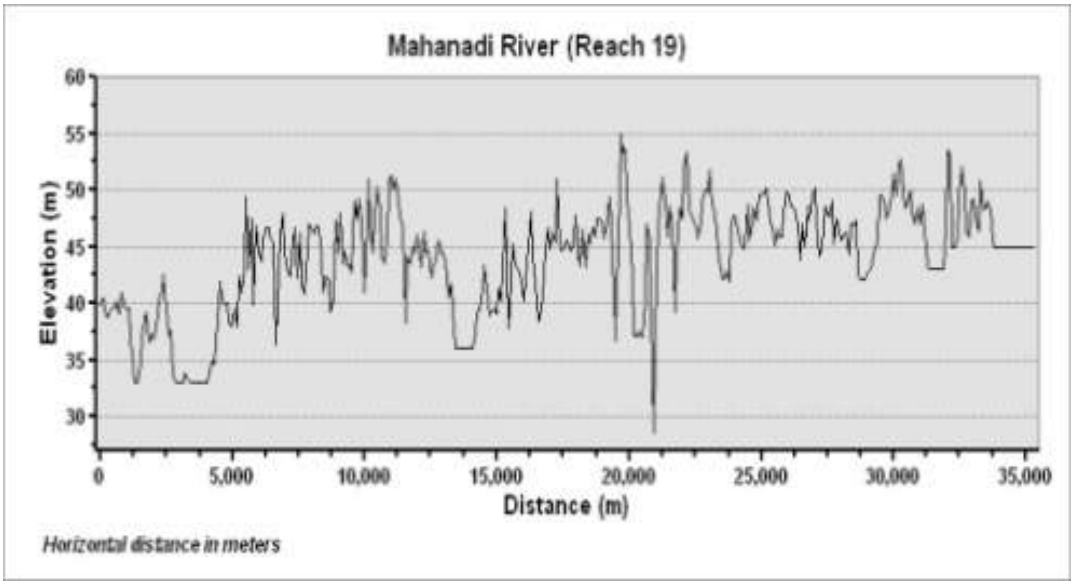


Figure 13.9: Reach wise Longitudinal Profile of Mahanadi River (2000)



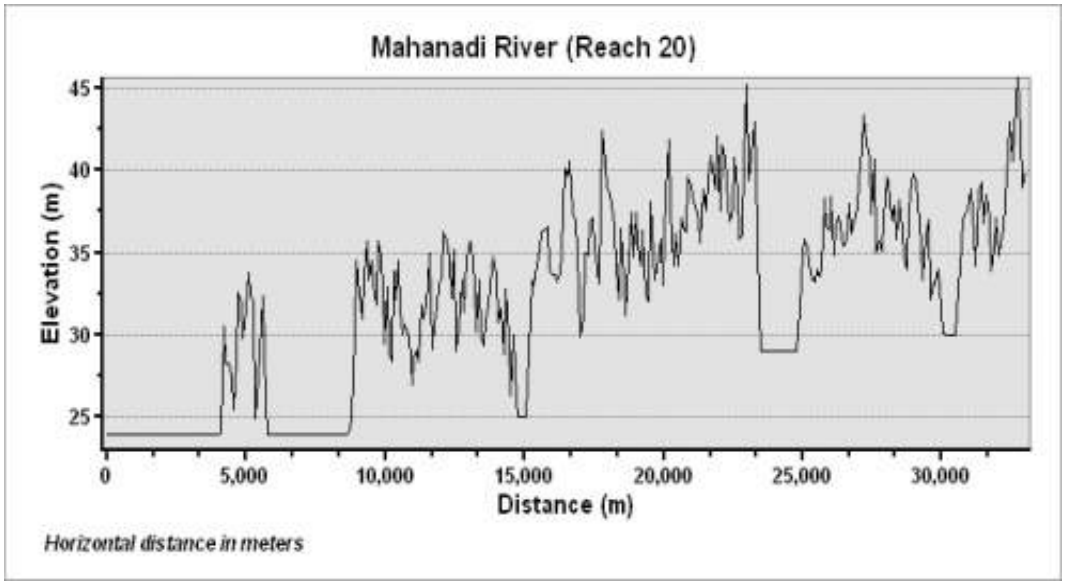


Figure 13.10: Reach wise Longitudinal Profile of Mahanadi River (2000)

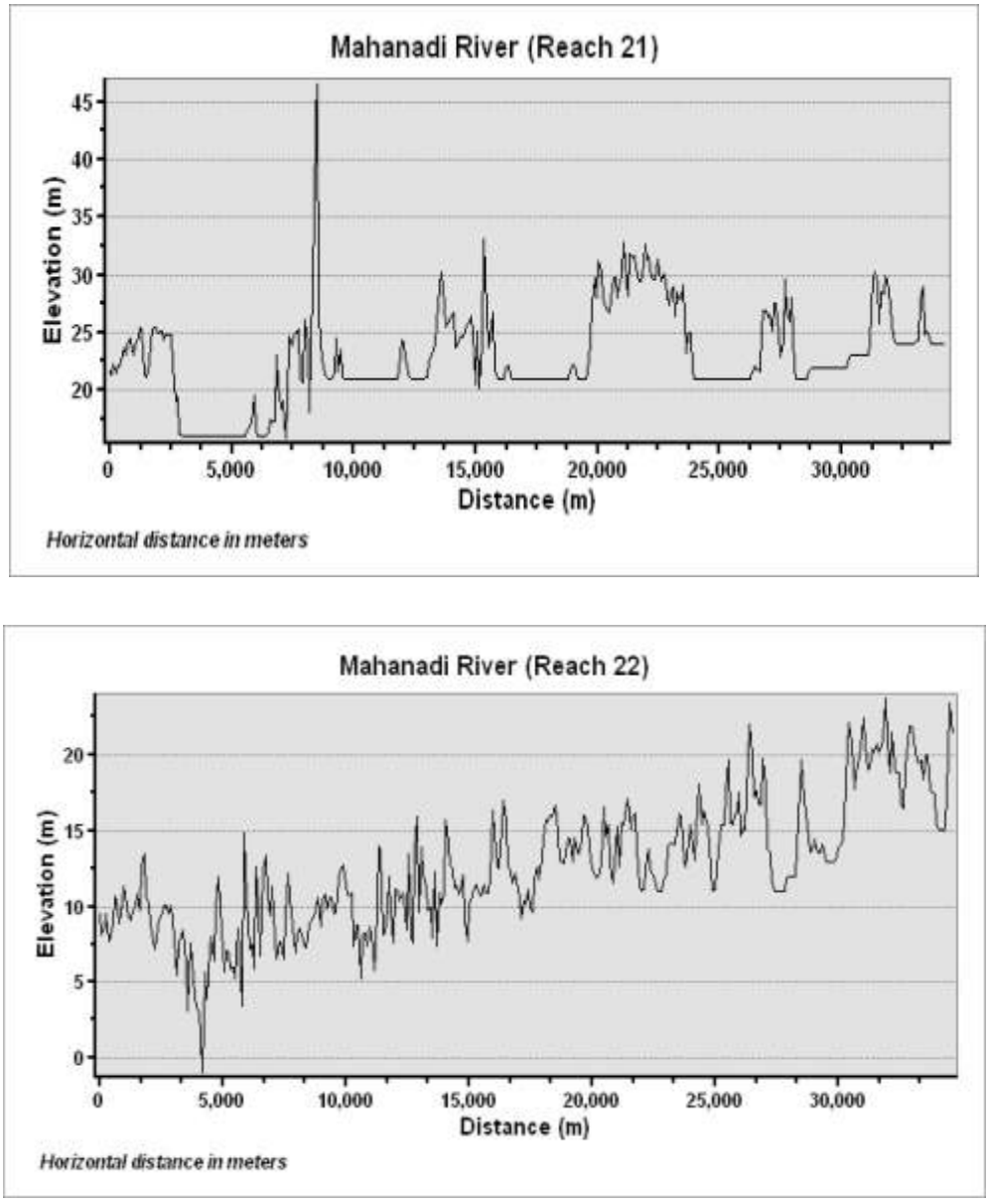
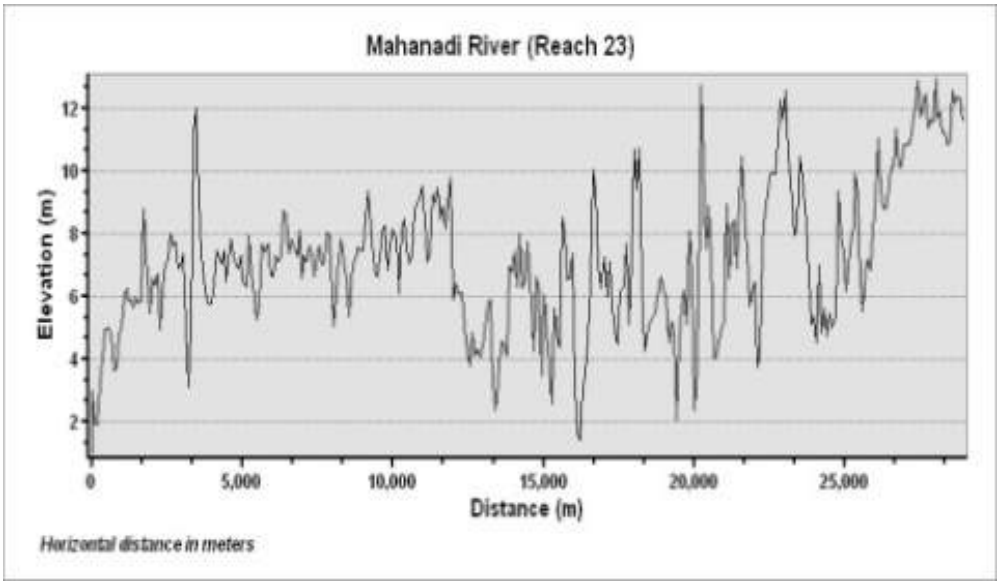


Figure 13.11: Reach wise Longitudinal Profile of Mahanadi River (2000)



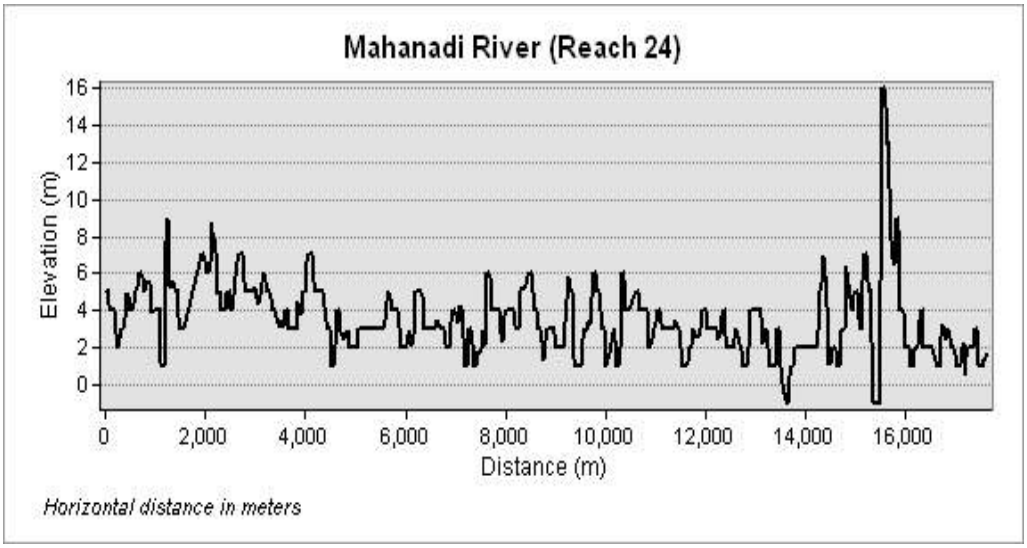


Figure 13.12: Reach wise Longitudinal Profile of Mahanadi River (2000)

5.9 Probability of Exceedence and Recurrence Interval

Peak Discharge data for all the respective year were identified. Then those data were arranged in a descending manner. For the ranking of Discharge data, a serial rank number (r) ranging from 1 to n (number of observations) is assigned. Subsequently, the probability has been determined that should be assigned to each of the Discharge values. If the data are ranked in descending order, the highest value first and the lowest value last, the probability is an estimate of the probability that the corresponding Discharge will be exceeded. When data are ranked from the lowest to the highest value, the probability refers to the probability of non-exceedance. Hence the probabilities are estimates of cumulative probabilities. They are formed by summing the probabilities of occurrence of all events greater than (probability of exceedance) or less than (probability of non-exceedance) some Discharge value. Since these probabilities are unknown the probabilities of exceedance have to be estimated by one or another method. The Weibull, Sevruk and Geiger, and the Gringorten methods are theoretically better sound. We calculate the probability of exceedance for the respective Discharge using Weibull's equation (Table 10.1- 10.4). Probability of exceedance and recurrence interval are shown in the Figure 14 and Figure 15.

Table 10.1: Station wise probability of exceedence and recurrence interval

Date	Peak Discharge (m^3/s)	Probability of Exceedence(Px)=r/(n+1)	Recurrence Interval (RI) =1/Px
Basantpur			
8/30/2003	33087.95	2.33	43.00
8/15/1976	26191.41	4.65	21.50
9/9/2011	23365.90	6.98	14.33
9/20/1980	22500.00	9.30	10.75
8/21/1975	21162.00	11.63	8.60
8/6/2014	19935.00	13.95	7.17
6/28/1986	18512.00	16.28	6.14
8/29/1978	17665.00	18.60	5.38
7/11/1994	17661.00	20.93	4.78
8/22/1992	17201.00	23.26	4.30
9/20/2008	16826.73	25.58	3.91
7/22/2009	16117.48	27.91	3.58
7/10/2001	15685.00	30.23	3.31
7/25/1995	15619.00	32.56	3.07
7/15/1973	15431.00	34.88	2.87
8/18/1974	15388.16	37.21	2.69
8/14/2006	14919.62	39.53	2.53
9/15/1990	14915.00	41.86	2.39
8/8/1977	14631.00	44.19	2.26

Table 10.1 (continued): Station wise probability of exceedence and recurrence interval

Date	Peak Discharge (m^3/s)	Probability of Exceedence(Px)=r/(n+1)	Recurrence Interval (RI) =1/Px
Basantpur			
8/23/1997	14324.00	46.51	2.15
8/24/1991	14236.00	48.84	2.05
8/10/1979	12516.00	51.16	1.95
8/23/1981	12309.00	53.49	1.87
7/1/2007	12200.00	55.81	1.79
8/1/2013	12020.52	58.14	1.72
9/15/2005	11520.71	60.47	1.65
9/13/1985	11094.00	62.79	1.59
8/21/1993	11006.00	65.12	1.54
8/19/1984	10300.00	67.44	1.48
8/31/1982	9624.00	69.77	1.43
9/9/2010	9138.50	72.09	1.39
8/5/2012	8825.12	74.42	1.34
9/15/1998	8789.00	76.74	1.30
9/15/1987	8568.00	79.07	1.26
9/9/1983	8366.30	81.40	1.23
8/24/2004	7890.56	83.72	1.19
8/10/1999	7234.00	86.05	1.16
8/5/1988	6001.00	88.37	1.13
8/3/1996	5983.00	90.70	1.10
7/21/2000	5134.00	93.02	1.08
9/12/2002	3402.19	95.35	1.05

Table 10.2 : Station wise probability of exceedence and recurrence interval

Date	Peak Discharge (m^3/s)	Probability of Exceedence(Px)=r/(n+1)	Recurrence Interval (RI) =1/Px
Rajim			
7/21/1976	9954.13	2.22	45.00
9/19/1980	8457.00	4.44	22.50
8/29/2003	8448.90	6.67	15.00
8/30/1994	8017.00	8.89	11.25
8/16/1978	7668.93	11.11	9.00
7/8/1973	7601.10	13.33	7.50
8/23/1990	7449.00	15.56	6.43
7/9/2001	7132.83	17.78	5.63
9/13/1977	7100.26	20.00	5.00
7/30/1991	6923.00	22.22	4.50
8/31/2006	6789.93	24.44	4.09
8/22/1997	6094.30	26.67	3.75
8/21/1992	6000.00	28.89	3.46

Table 10.2 (continued): Station wise probability of exceedence and recurrence interval

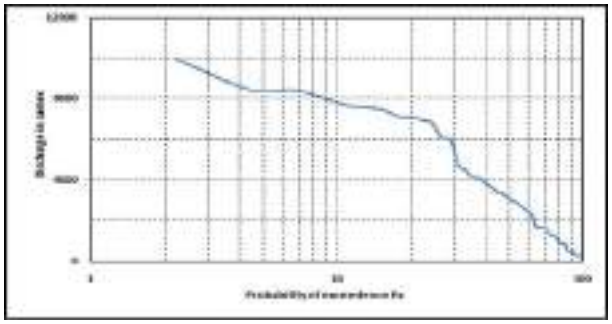
Date	Peak Discharge (m^3/s)	Probability of Exceedence(Px)=r/(n+1)	Recurrence Interval (RI) =1/Px
Rajim			
9/18/2008	4770.89	31.11	3.21
6/24/1986	4498.00	33.33	3.00
6/30/2007	4132.27	35.56	2.81
8/5/2014	4057.60	37.78	2.65
8/2/1996	3823.02	40.00	2.50
9/7/2011	3679.13	42.22	2.37
8/14/1981	3425.00	44.44	2.25
7/24/1995	3340.31	46.67	2.14
9/7/2010	3192.87	48.89	2.05
8/23/2004	3003.24	51.11	1.96
9/14/2005	2907.17	53.33	1.88
9/9/1975	2765.22	55.56	1.80
7/31/2013	2571.67	57.78	1.73
8/4/2012	2404.92	60.00	1.67
8/27/2009	2256.82	62.22	1.61
8/9/1984	1678.94	64.44	1.55
8/7/1985	1649.00	66.67	1.50
8/20/1993	1631.00	68.89	1.45
8/7/1983	1560.00	71.11	1.41
7/8/1972	1334.10	73.33	1.36
8/14/1982	1209.82	75.56	1.32
7/19/2000	1152.30	77.78	1.29
8/31/1999	933.90	80.00	1.25
8/24/2002	838.02	82.22	1.22
8/4/1979	808.00	84.44	1.18
8/10/1971	494.10	86.67	1.15
7/23/1987	486.44	88.89	1.13
9/13/1998	400.00	91.11	1.10
8/1/1988	280.20	93.33	1.07
8/19/1974	271.20	95.56	1.05
8/26/1989	255.60	97.78	1.02

Table 10.3 : Station wise probability of exceedence and recurrence interval

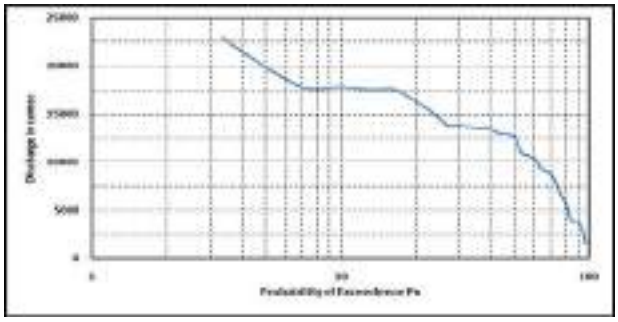
Date	Peak Discharge (m^3/s)	Probability of Exceedence(Px)=r/(n+1)	Recurrence Interval (RI) =1/Px
Seorinarayan			
8/30/2003	22800.00	3.33	30.00
7/25/1995	17967.00	6.67	15.00
9/8/2011	17799.03	10.00	10.00
7/11/1994	17500.00	13.33	7.50
8/6/2014	17489.74	16.67	6.00
8/21/1992	16203.00	20.00	5.00
7/10/2001	15165.71	23.33	4.29
7/1/2007	13868.54	26.67	3.75
8/14/2006	13796.44	30.00	3.33
9/20/2008	13646.39	33.33	3.00
8/23/1997	13470.00	36.67	2.73
9/15/1990	13400.00	40.00	2.50
7/22/2009	12906.61	43.33	2.31
9/15/2005	12831.01	46.67	2.14
8/1/2013	12473.60	50.00	2.00
8/24/1991	10996.00	53.33	1.88
6/28/1986	10705.00	56.67	1.76
8/20/1993	10354.00	60.00	1.67
9/14/1998	9356.00	63.33	1.58
8/6/2012	9017.22	66.67	1.50
7/26/2010	8739.93	70.00	1.43
8/3/1996	7934.00	73.33	1.36
10/2004	6561.23	76.67	1.30
9/1/1999	5788.00	80.00	1.25
7/20/2000	4156.00	83.33	1.20
7/23/1987	3812.51	86.67	1.15
8/4/1988	3608.29	90.00	1.11
9/12/2002	3061.16	93.33	1.07
9/2/1989	1584.00	96.67	1.03

Table 10.4: Station wise probability of exceedence and recurrence interval

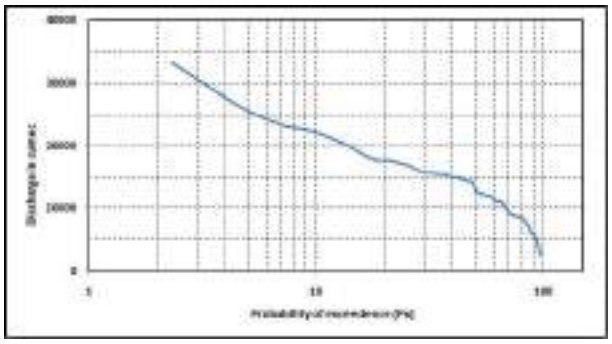
Date	Peak Discharge (m^3/s)	Probability of Exceedence(Px)=r/(n+1)	Recurrence Interval (RI) =1/Px
Tikrapara			
9/21/1980	33800.00	2.33	43.00
7/29/1992	31500.00	4.65	21.50
7/13/1994	31500.00	6.98	14.33
8/30/1982	31050.00	9.30	10.75
8/29/1978	30862.50	11.63	8.60
8/14/1991	30500.00	13.95	7.17
9/10/2011	30400.00	16.28	6.14
9/8/1983	30041.70	18.60	5.38
8/6/2014	29800.00	20.93	4.78
8/31/2006	29000.00	23.26	4.30
9/14/1977	28692.70	25.58	3.91
6/29/1986	27030.00	27.91	3.58
7/19/2001	26700.00	30.23	3.31
8/14/1976	26323.80	32.56	3.07
8/29/2003	25062.00	34.88	2.87
9/13/1998	25000.00	37.21	2.69
8/17/1984	24726.98	39.53	2.53
9/27/1973	23948.72	41.86	2.39
8/7/1985	23921.40	44.19	2.26
7/24/1995	23121.00	46.51	2.15
8/5/1997	23000.00	48.84	2.05
8/23/1975	22735.01	51.16	1.95
9/18/2008	20565.49	53.49	1.87
8/20/1993	20435.00	55.81	1.79
9/5/1990	20067.83	58.14	1.72
7/31/2005	19000.00	60.47	1.65
8/1/2013	18895.00	62.79	1.59
7/22/2009	17750.50	65.12	1.54
8/12/2004	17744.45	67.44	1.48
8/19/1974	17400.00	69.77	1.43
9/24/2007	15789.35	72.09	1.39
8/10/1981	15100.00	74.42	1.34
8/9/1979	14257.07	76.74	1.30
9/20/2010	13575.05	79.07	1.26
8/10/1999	13249.00	81.40	1.23
9/13/2002	12305.64	83.72	1.19
8/22/1996	11930.00	86.05	1.16
8/7/2012	11766.34	88.37	1.13
7/23/1987	10241.00	90.70	1.10
8/9/1988	9593.00	93.02	1.08
8/18/1989	6535.60	95.35	1.05
9/1/2000	4774.76	97.67	1.02



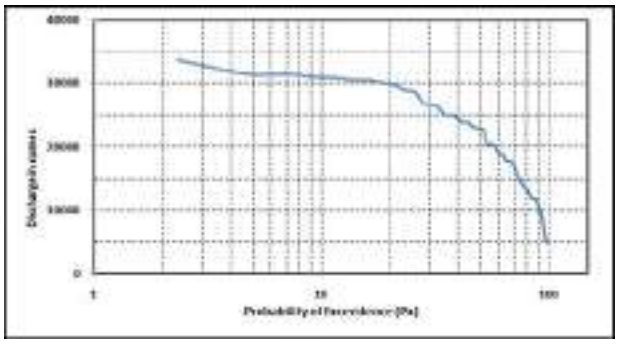
Rajim



Seorinarayan

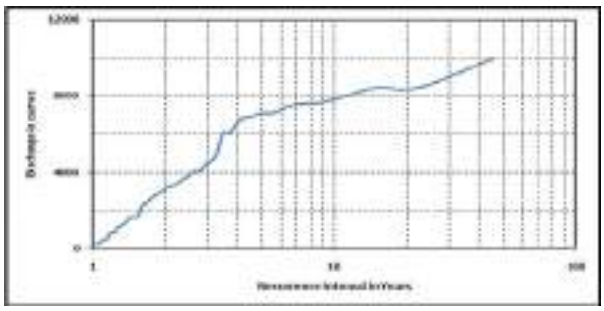


Basantpur

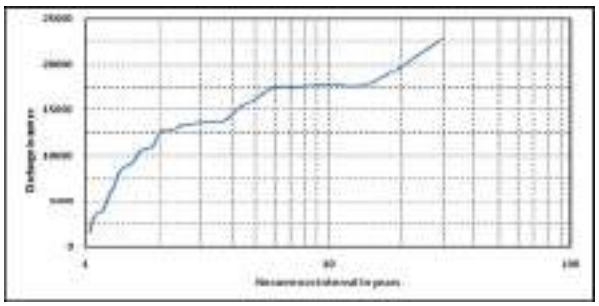


Tikrapara

Figure 14: Graphical representation of the relation between Probability of exceedence & Discharge

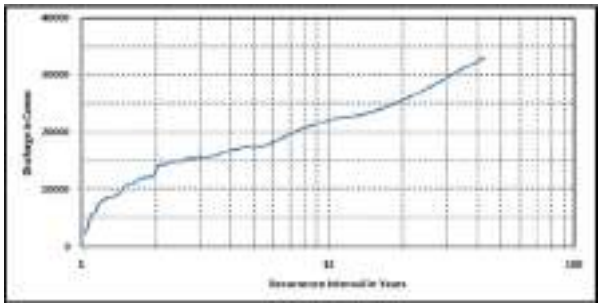


Rajim

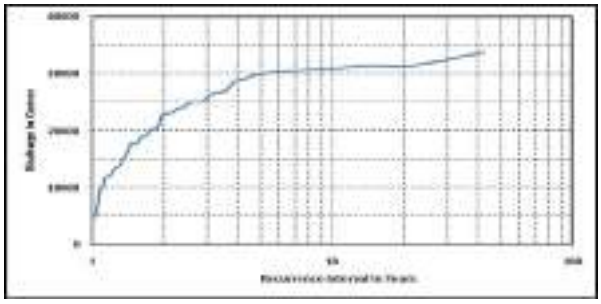


Seorinarayan

Figure 15: Graphical representation of the relation Recurrence interval & Discharge



Basantpur



Tikrapara

Figure 15 (continued): Graphical representation of the relation Recurrence interval & Discharge

5.10 Water Level:-

River stage is an important concept when analyzing how much water is moving in a stream at any given moment. Stage is the water level above some arbitrary point, usually with the zero height being near the river bed, in the river and is commonly measured in feet or meter. In this work we are calculating the annual water level (meter) of Mahanadi river HO stations (Figure 16.1 – 16.4).

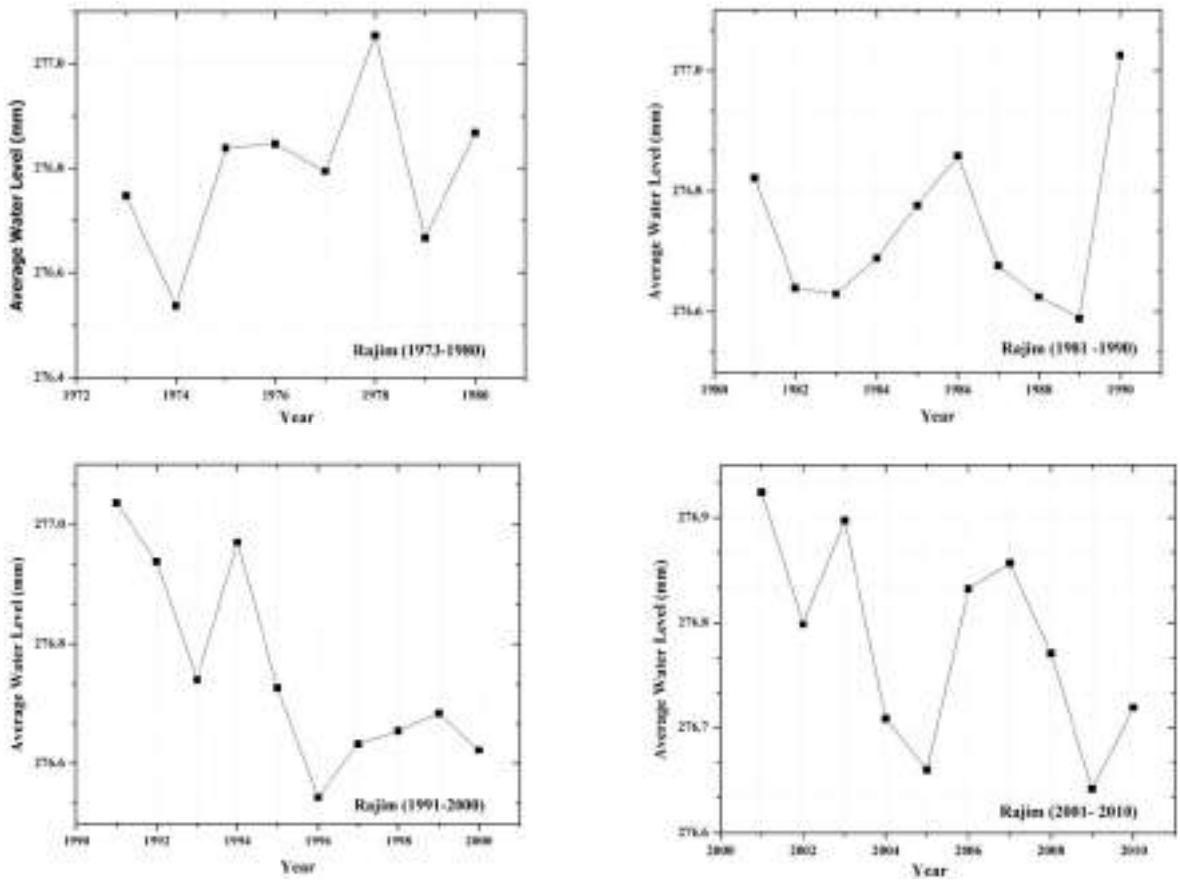


Figure 16.1: Changes in water level in different year for Rajim

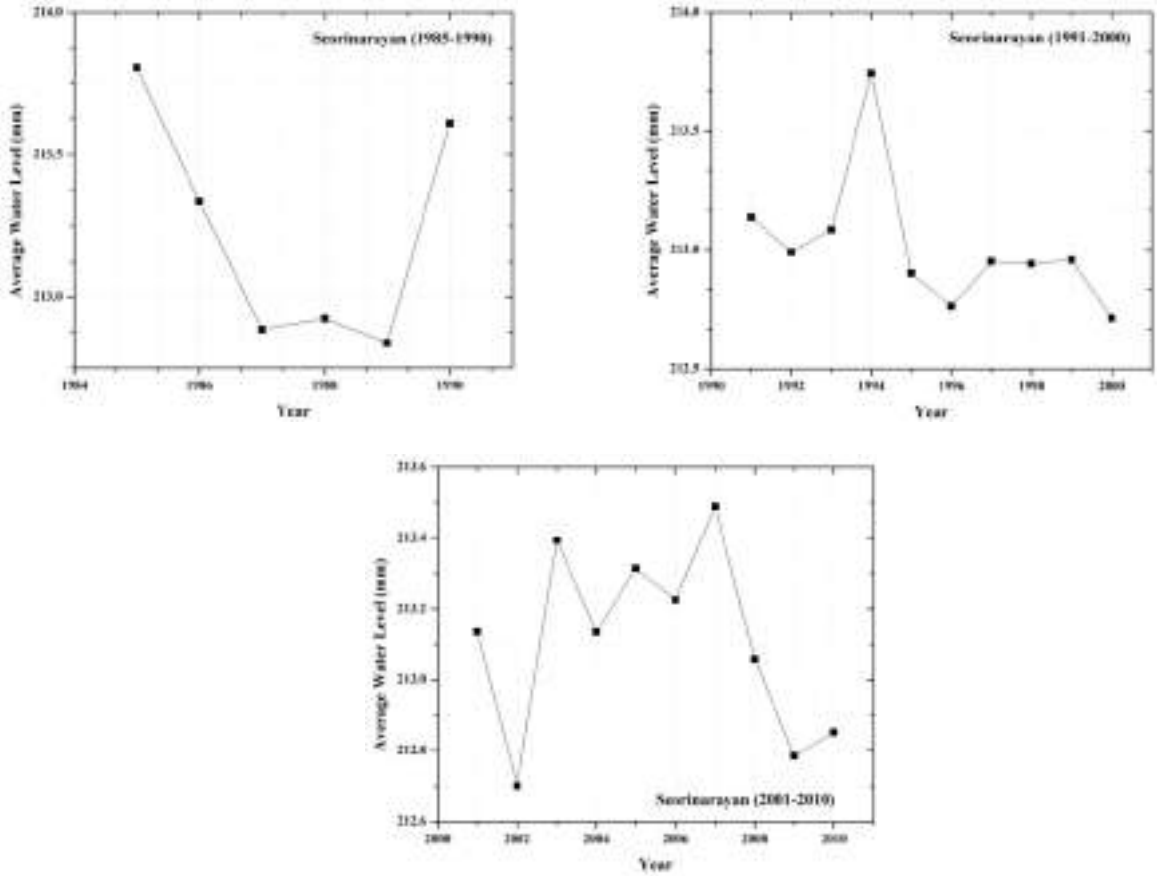


Figure 16.2: Changes in water level in different year for Seorinarayan

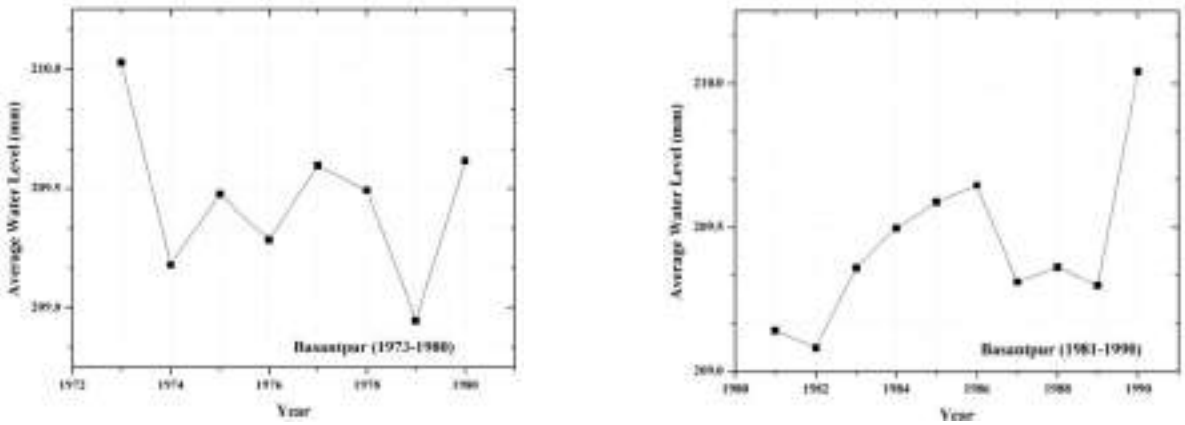


Figure 16.3: Changes in water level in different year for Basantpur

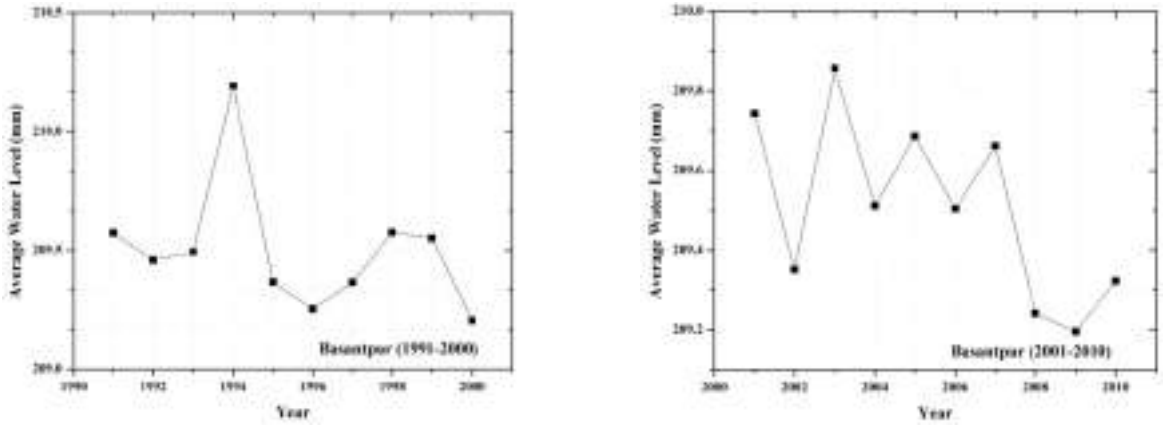


Figure 16.3 (continued): Changes in water level in different year for Basantpur

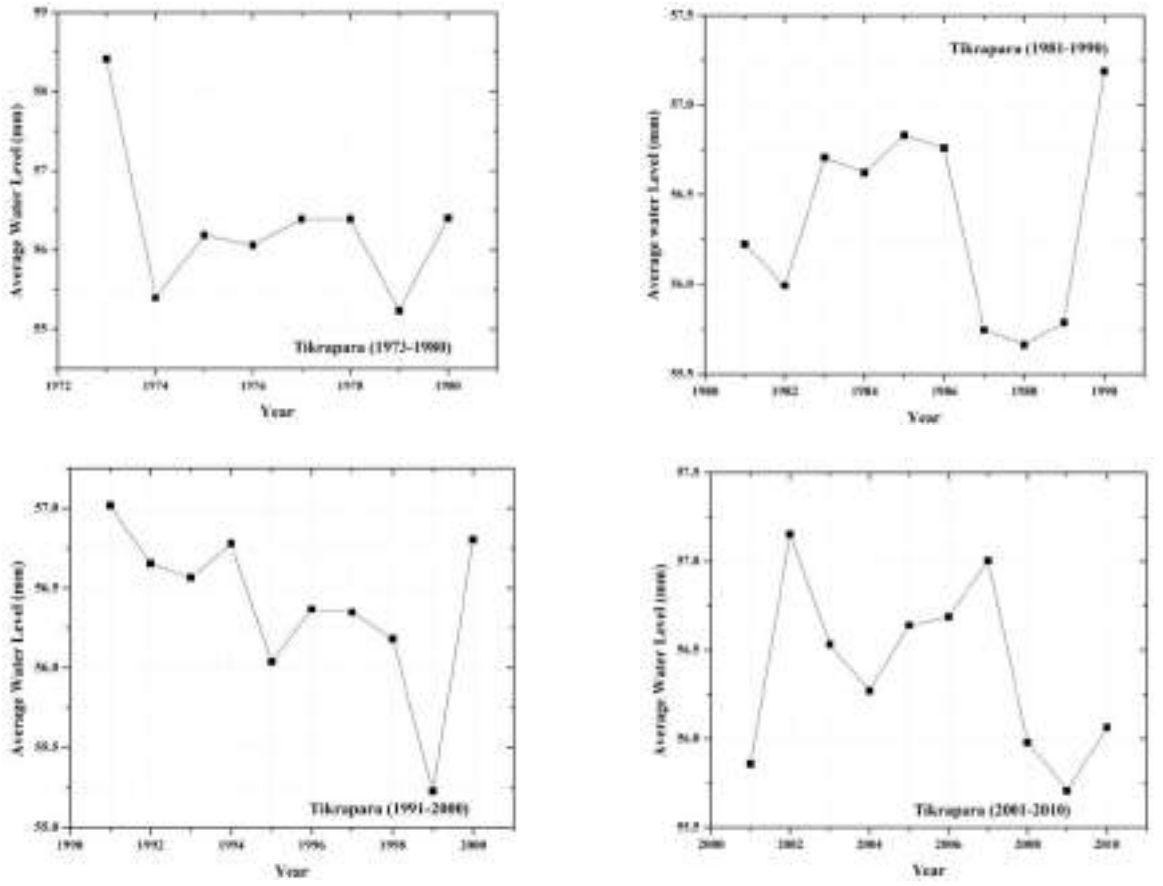


Figure 16.4: Changes in water level in different year for Tikrapara

5.11 Soil loss estimation

Riverbank erosion occurs both naturally and through human impact. Rivers and streams are dynamic systems as they are constantly changing. The natural process of riverbank erosion can produce favorable outcomes such as the formation of productive flood plains and alluvial terraces. In this study, the RUSLE (Revised universal soil loss equation) method is employed along with remote sensing and GIS techniques to estimate the soil loss from the banks of the Mahanadi river within a 2 km buffer. GIS data layers including rainfall passivity (R), soil erodibility (K), slope length and steepness (LS), cover management (C) and conservation practice (P) factors were calculated to calculate their effects on the yearly soil loss in the Mahanadi river riparian region. The river is divided into 24 reaches and each reach is nearby 34 km in length. The soil erosion map is classified into three classes (Low, Moderate, and High). Soil erosion of the Mahanadi river reaches is depicted in (Figure 17.1 – 17.24).

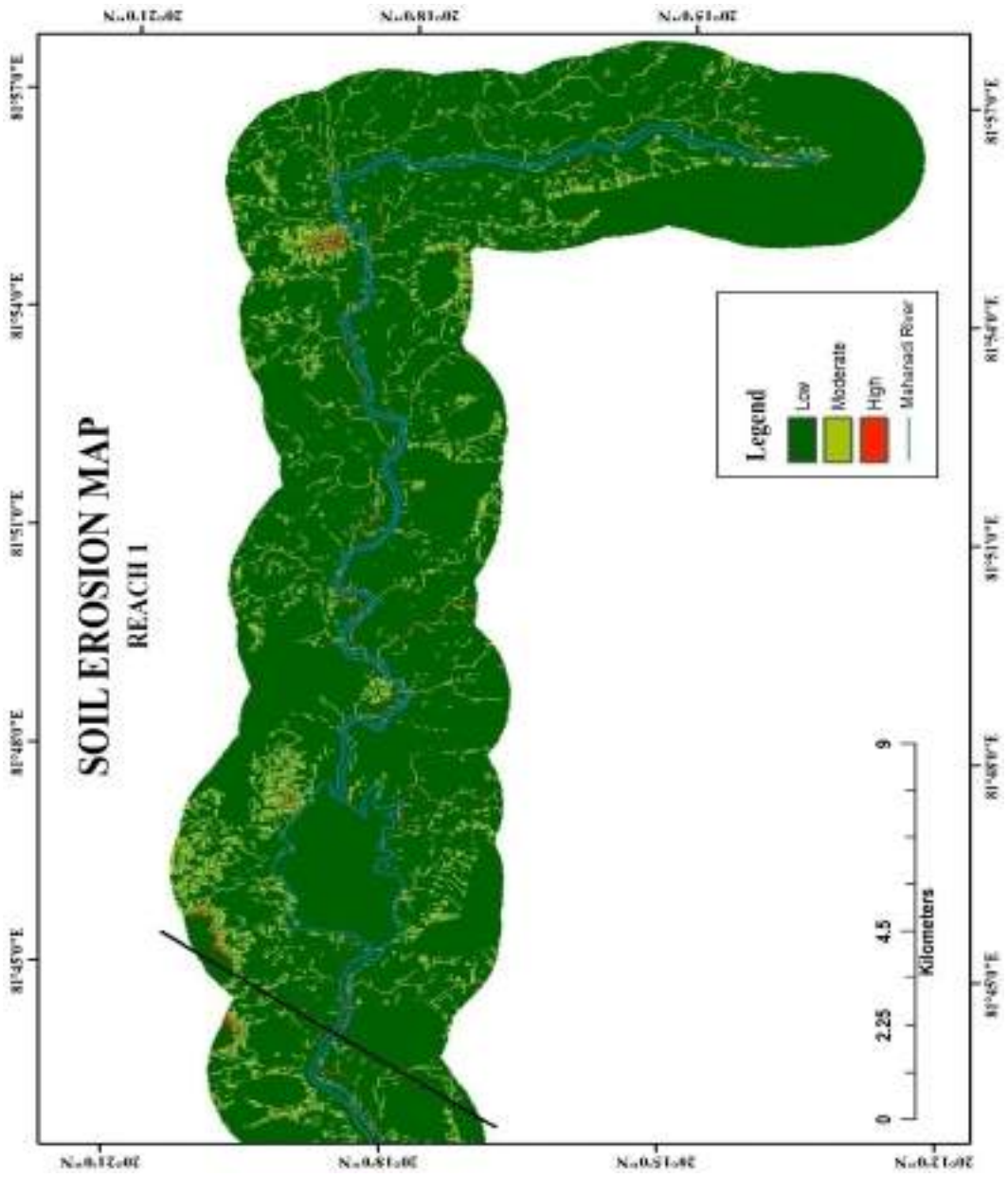


Figure 17.1: Soil Erosion Map 2 km buffer area Mahanadi River

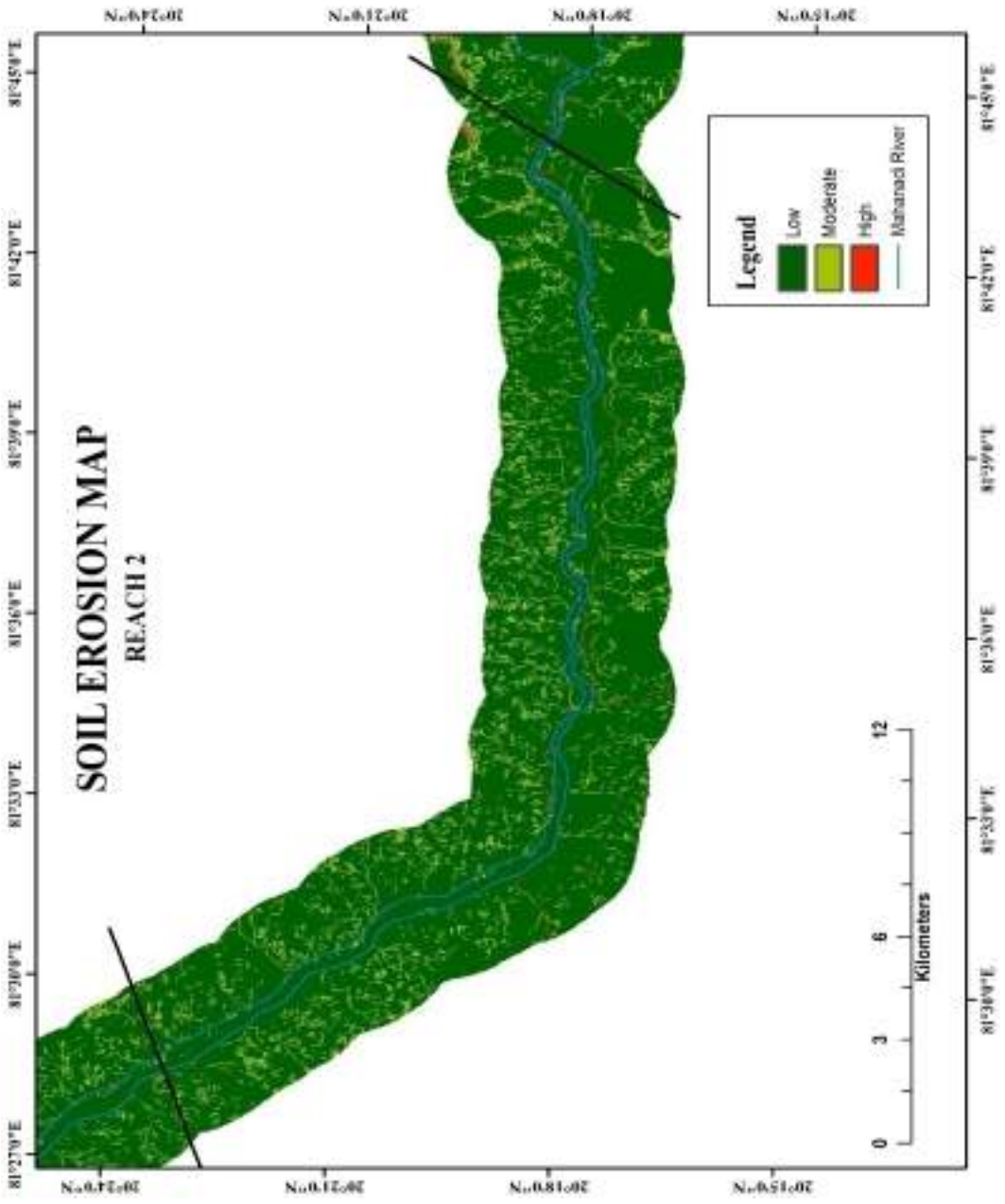


Figure 17.2: Soil Erosion Map 2 km buffer area Mahanadi River

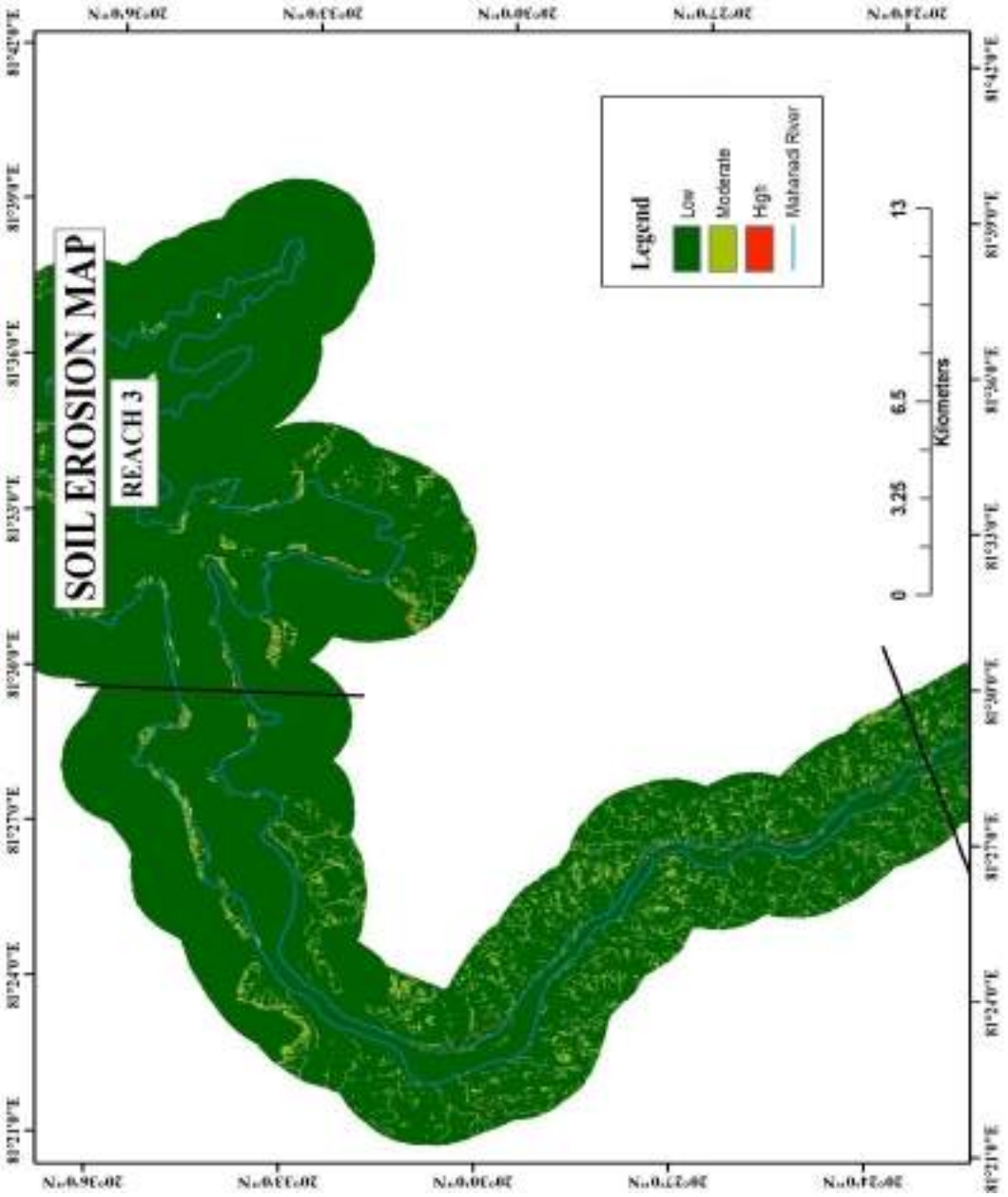


Figure 17.3: Soil Erosion Map 2 km buffer area Mahanadi River

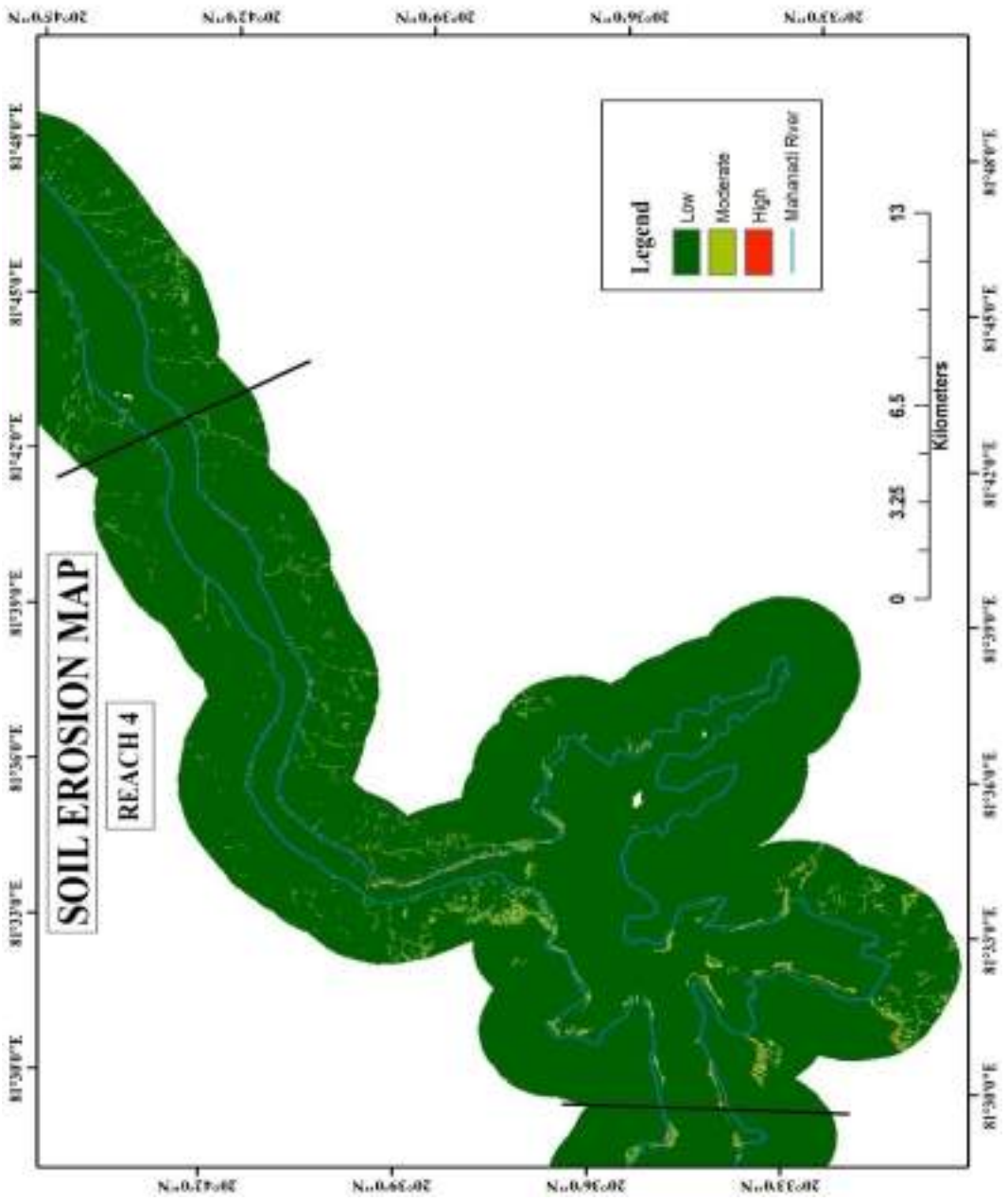


Figure 17.4: Soil Erosion Map 2 km buffer area Mahanadi River

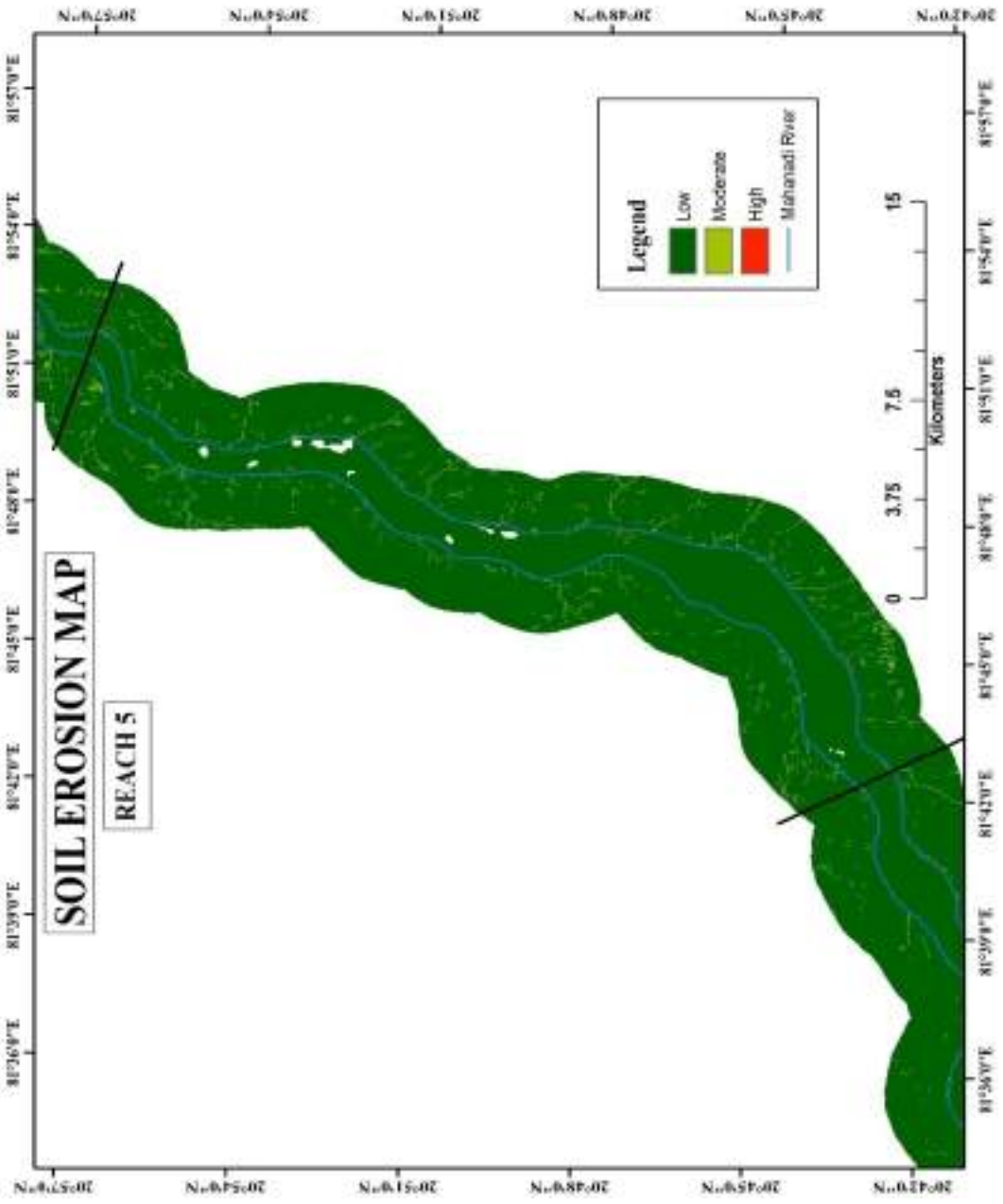


Figure17.5: Soil Erosion Map 2 km buffer area Mahanadi River

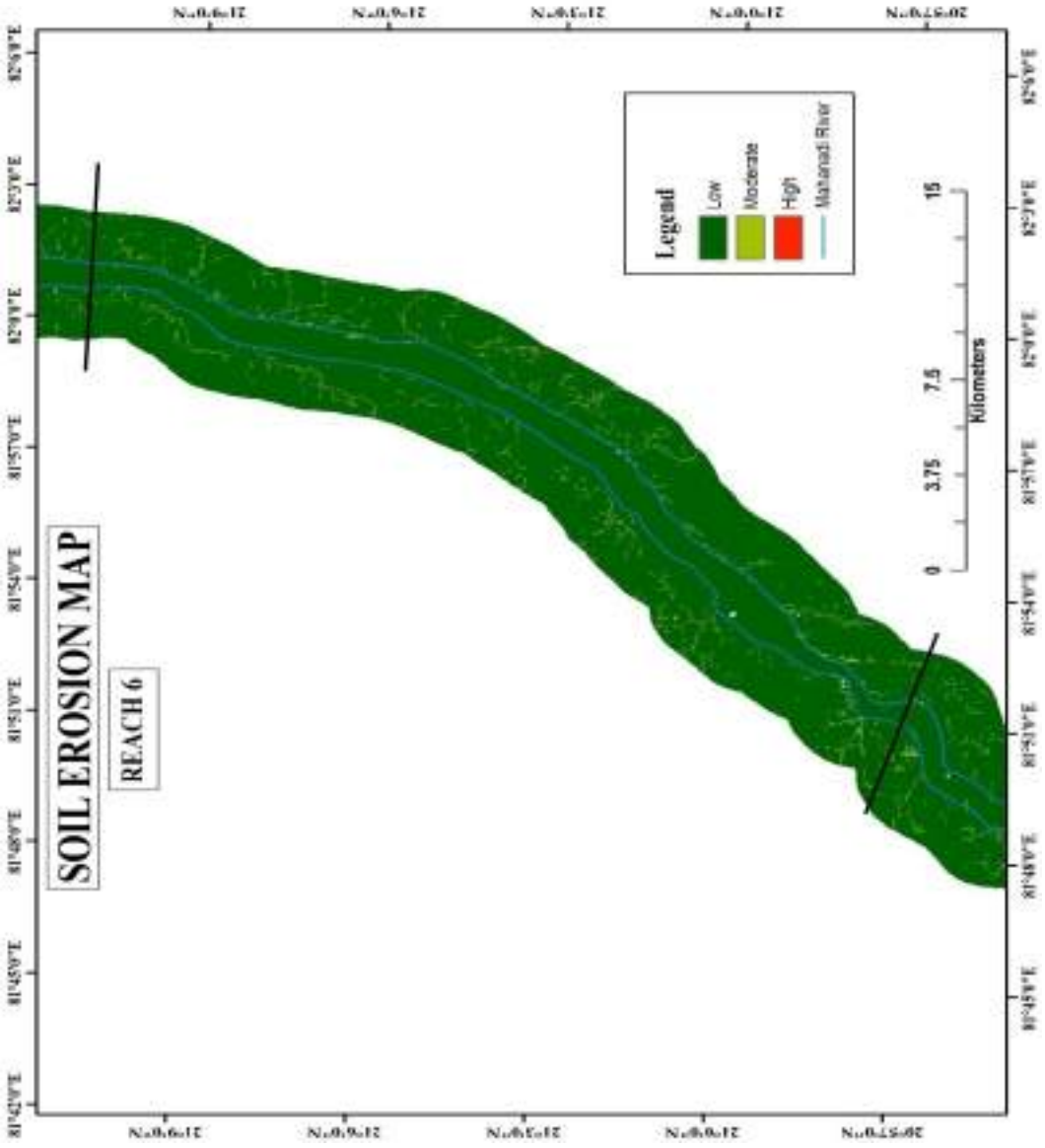


Figure 17.6: Soil Erosion Map 2 km buffer area Mahanadi River

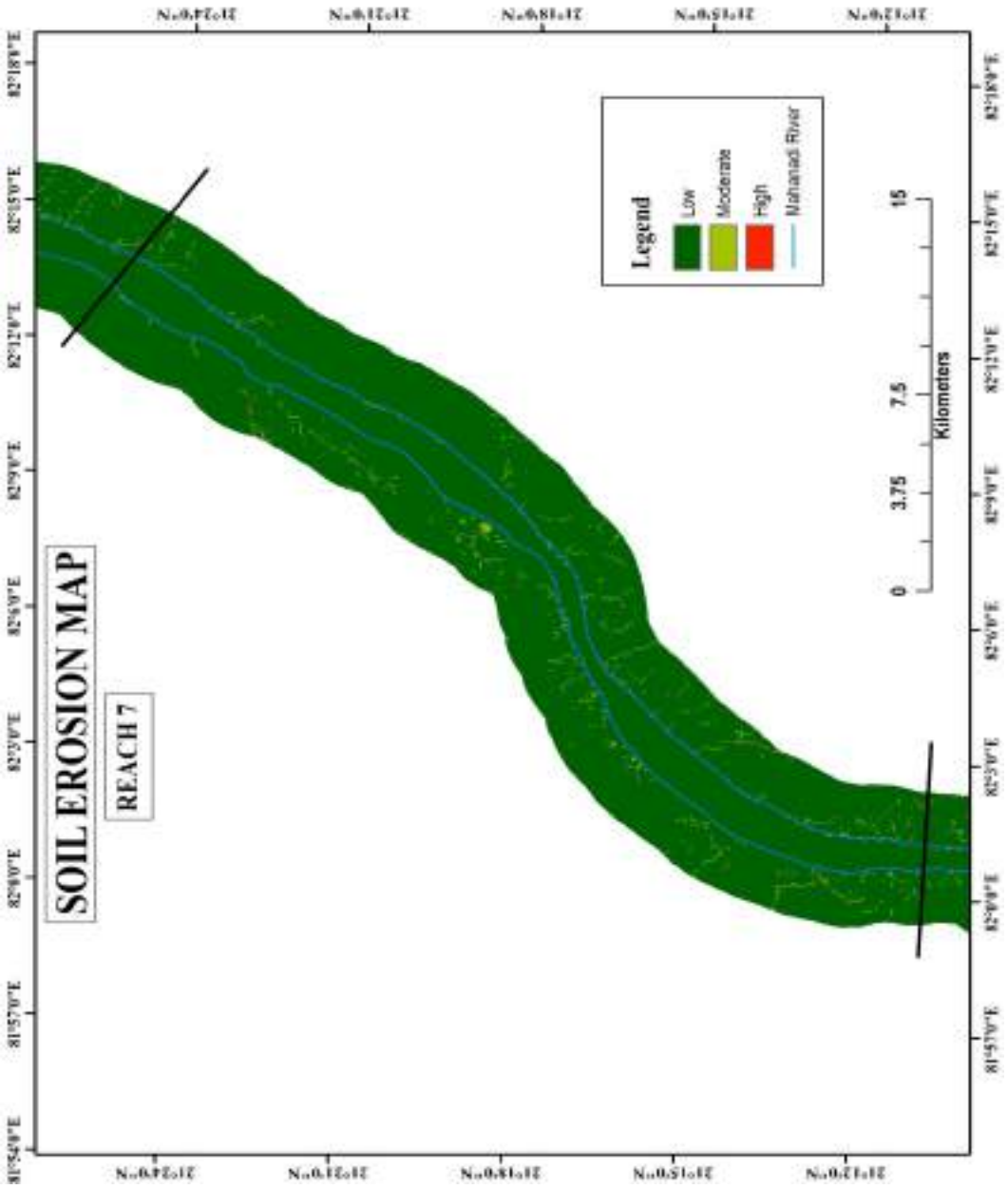


Figure 17.7: Soil Erosion Map 2 km buffer area Mahanadi River

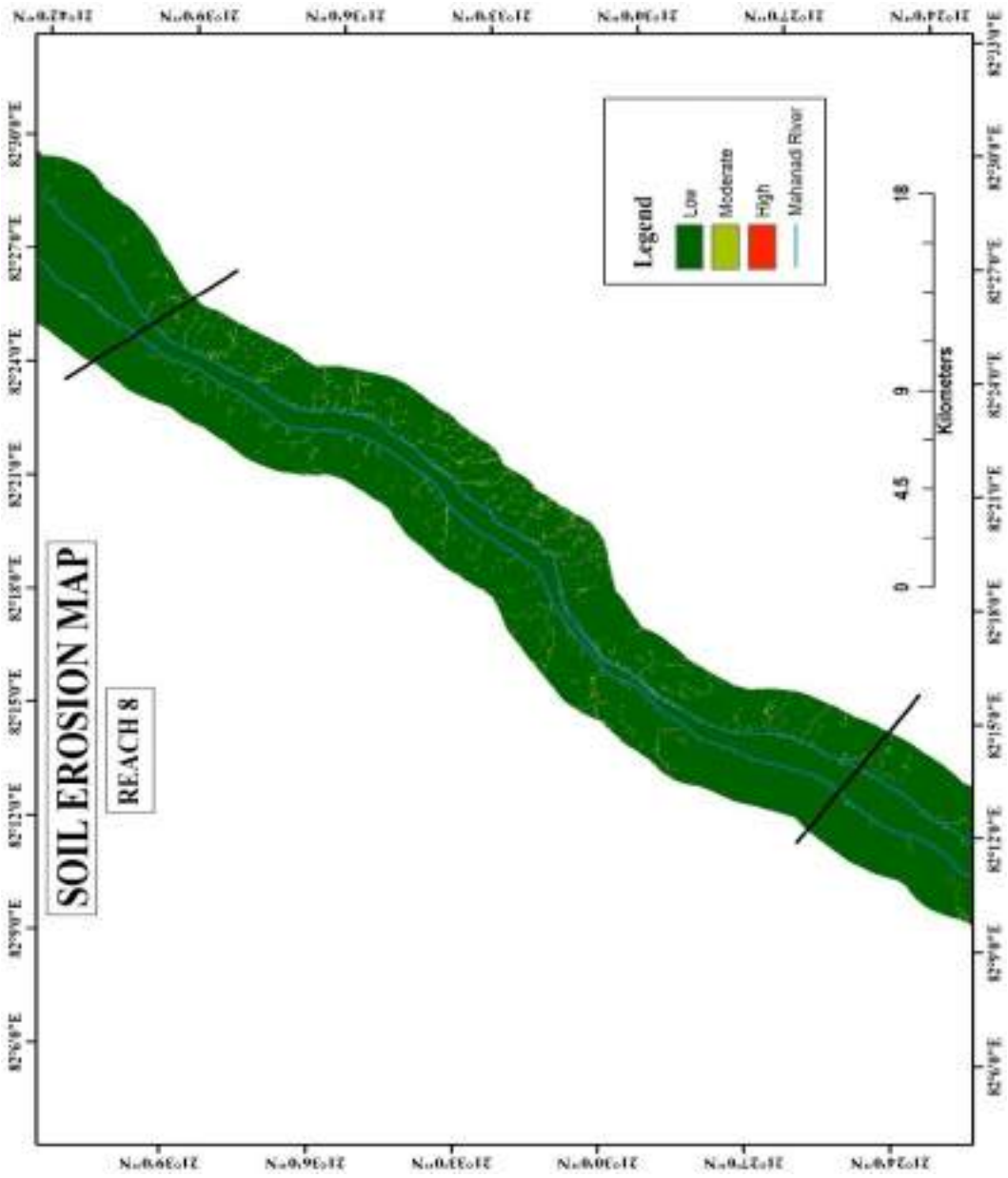


Figure 17.8: Soil Erosion Map 2 km buffer area Mahanadi River

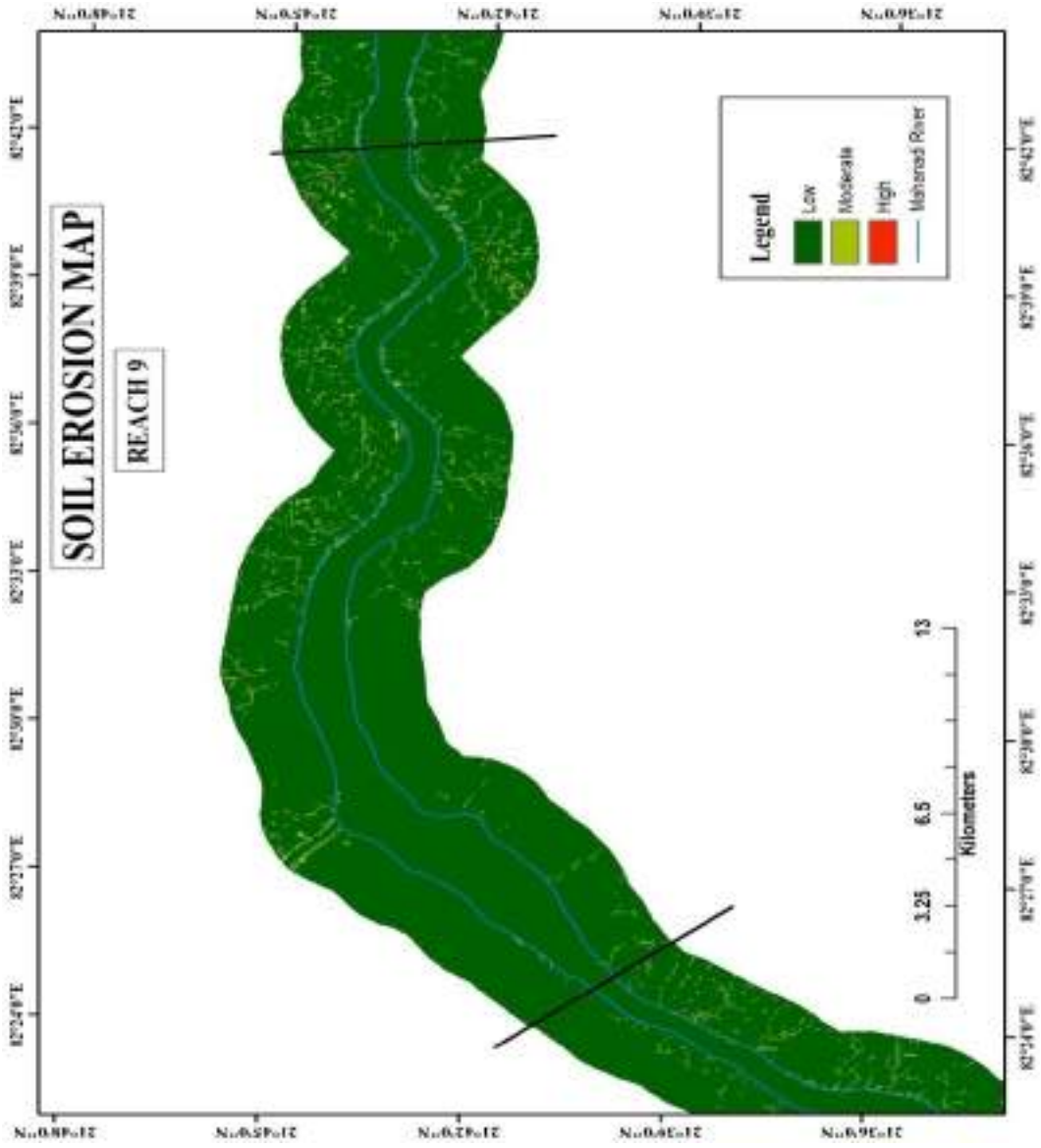


Figure 17.9: Soil Erosion Map 2 km buffer area Mahanadi River

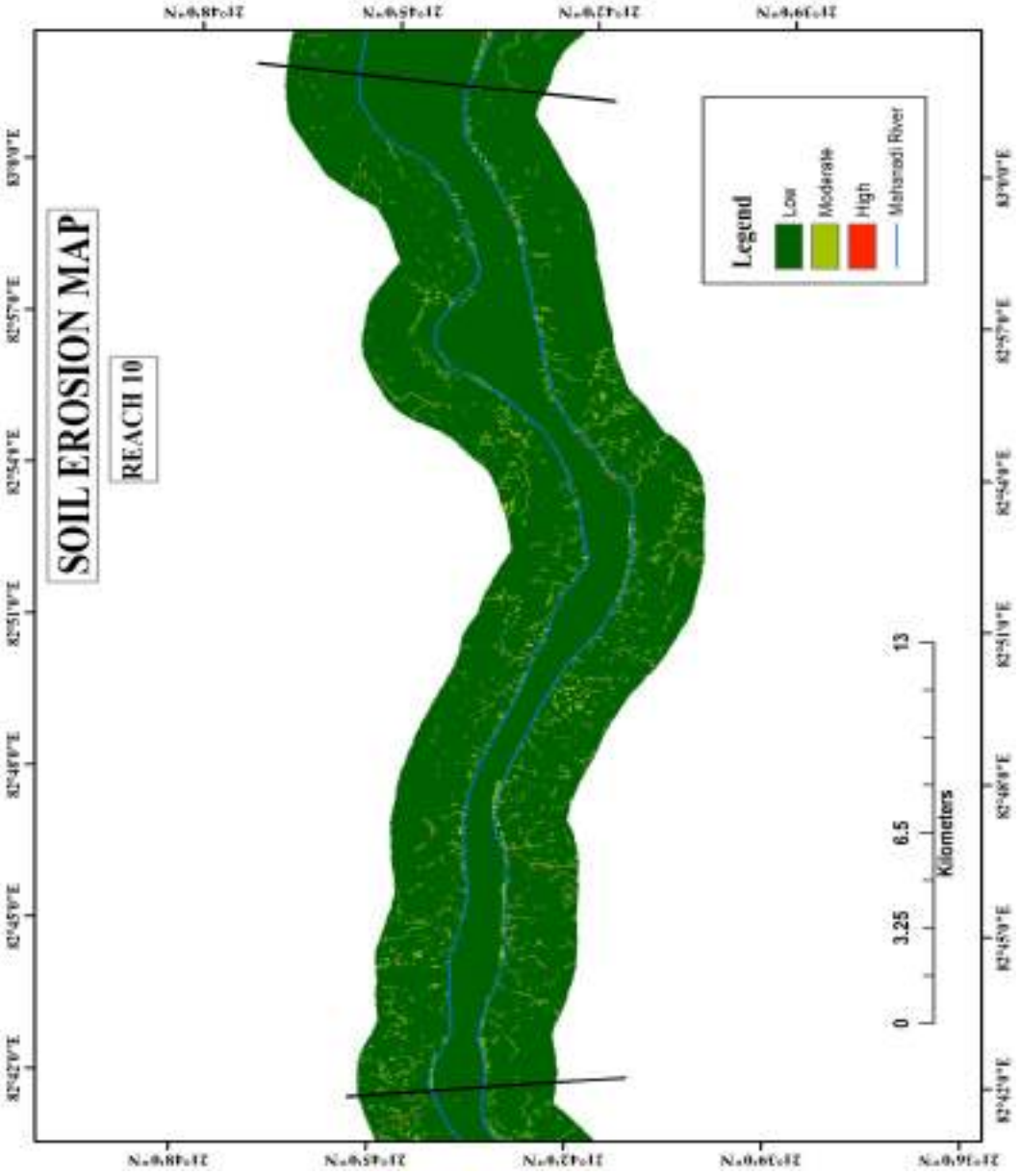


Figure 17.10: Soil Erosion Map 2 km buffer area Mahanadi River

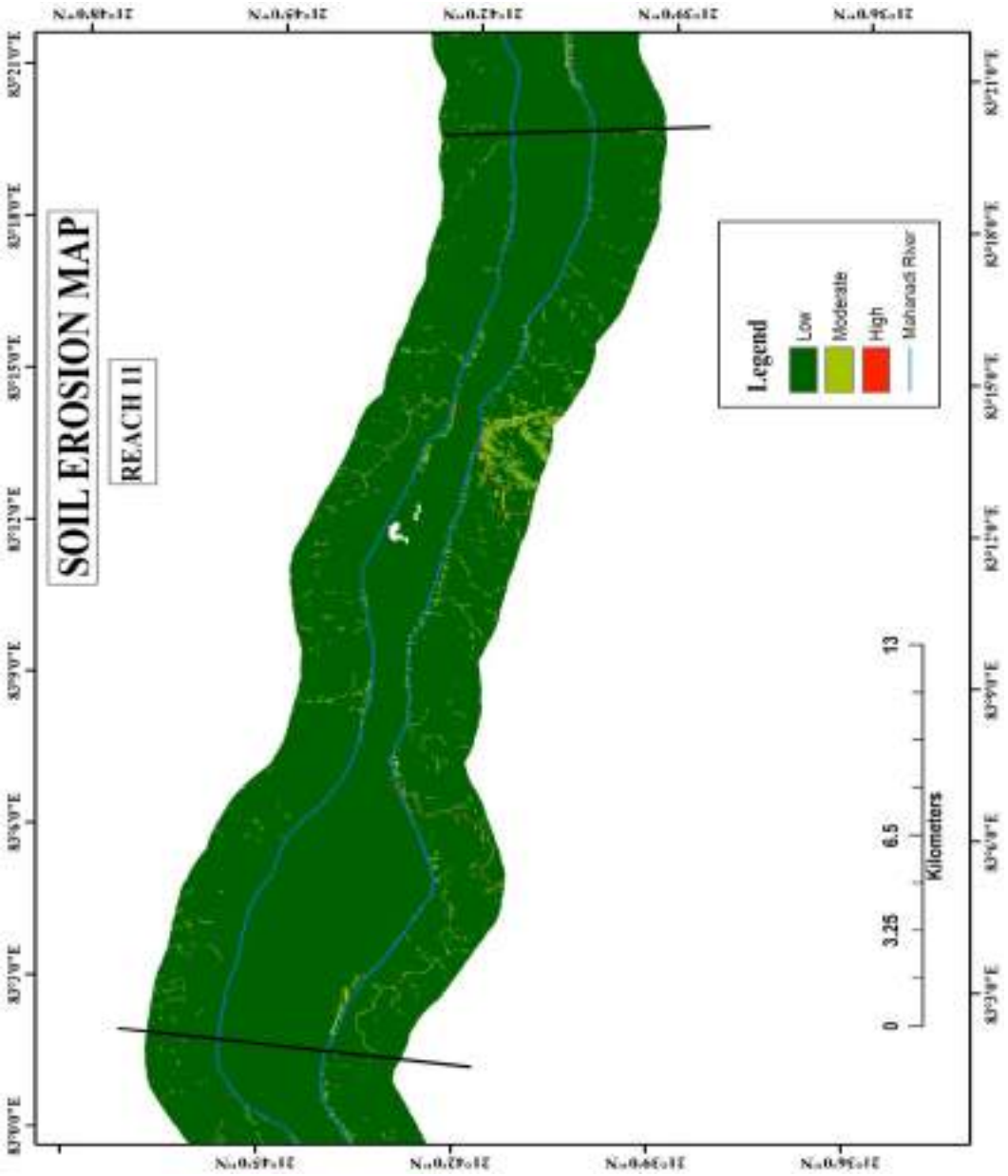


Figure 17.11: Soil Erosion Map 2 km buffer area Mahanadi River

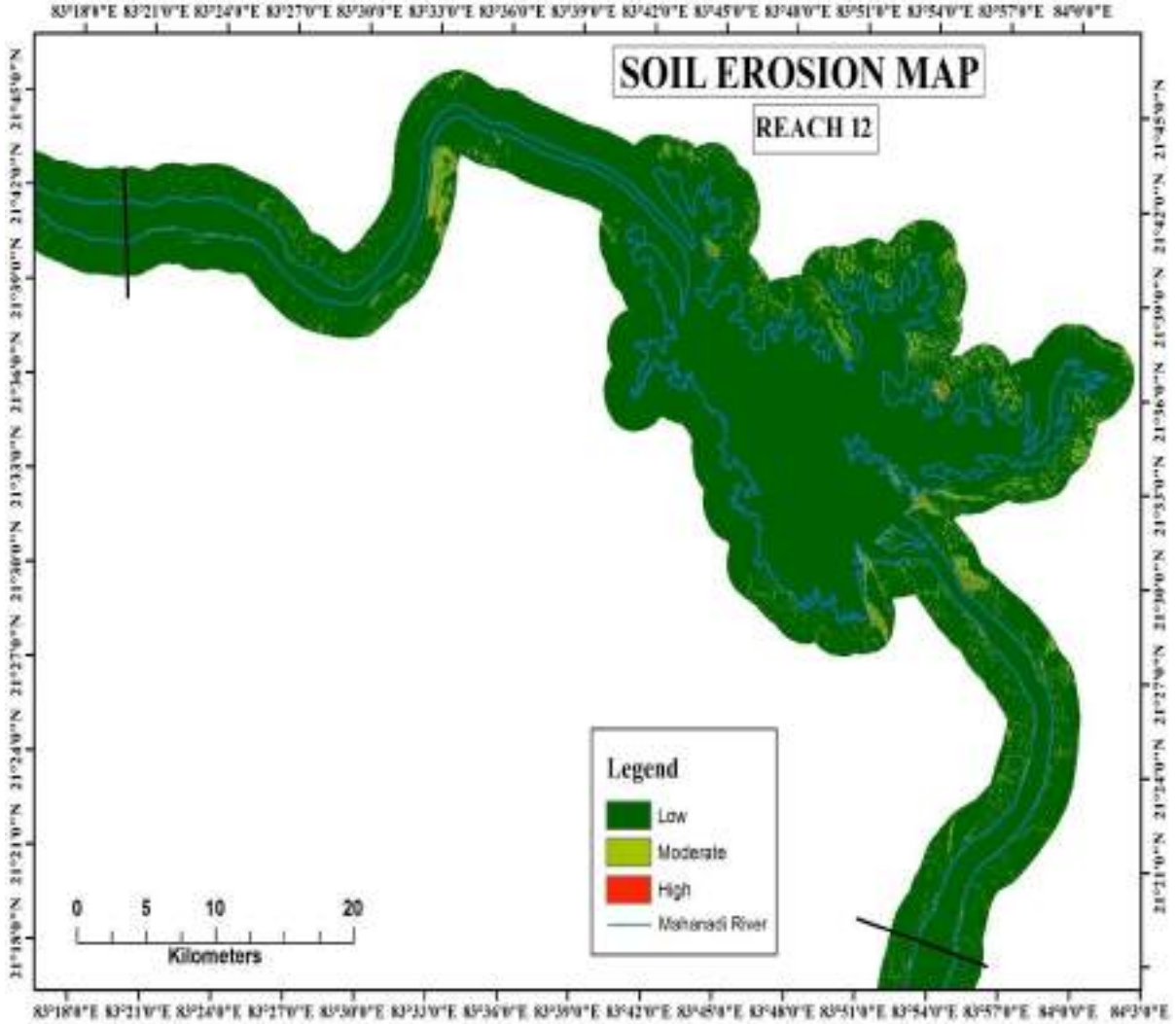


Figure 17.12: Soil Erosion Map 2 km buffer area Mahanadi River

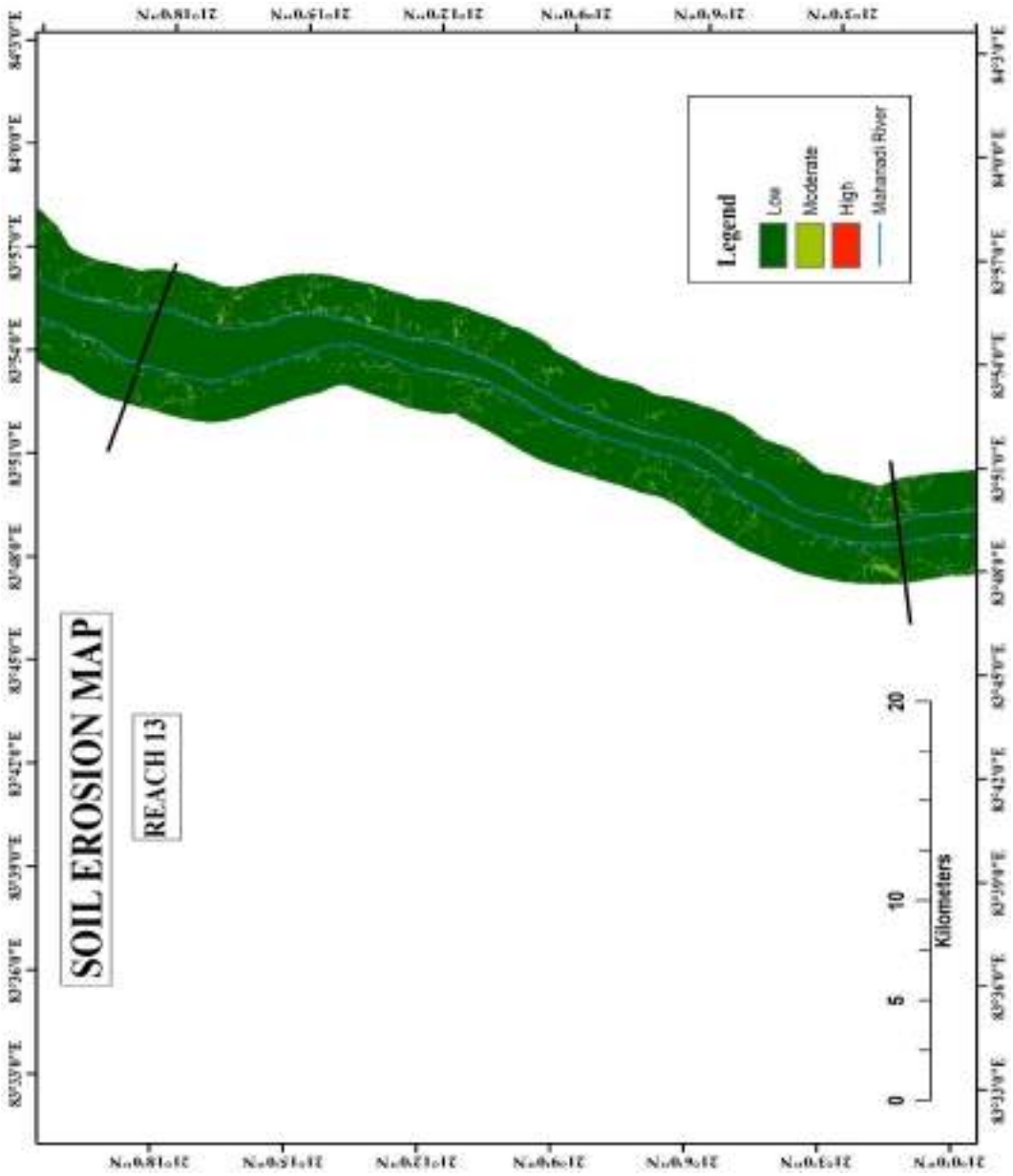


Figure 17.13: Soil Erosion Map 2 km buffer area Mahanadi River

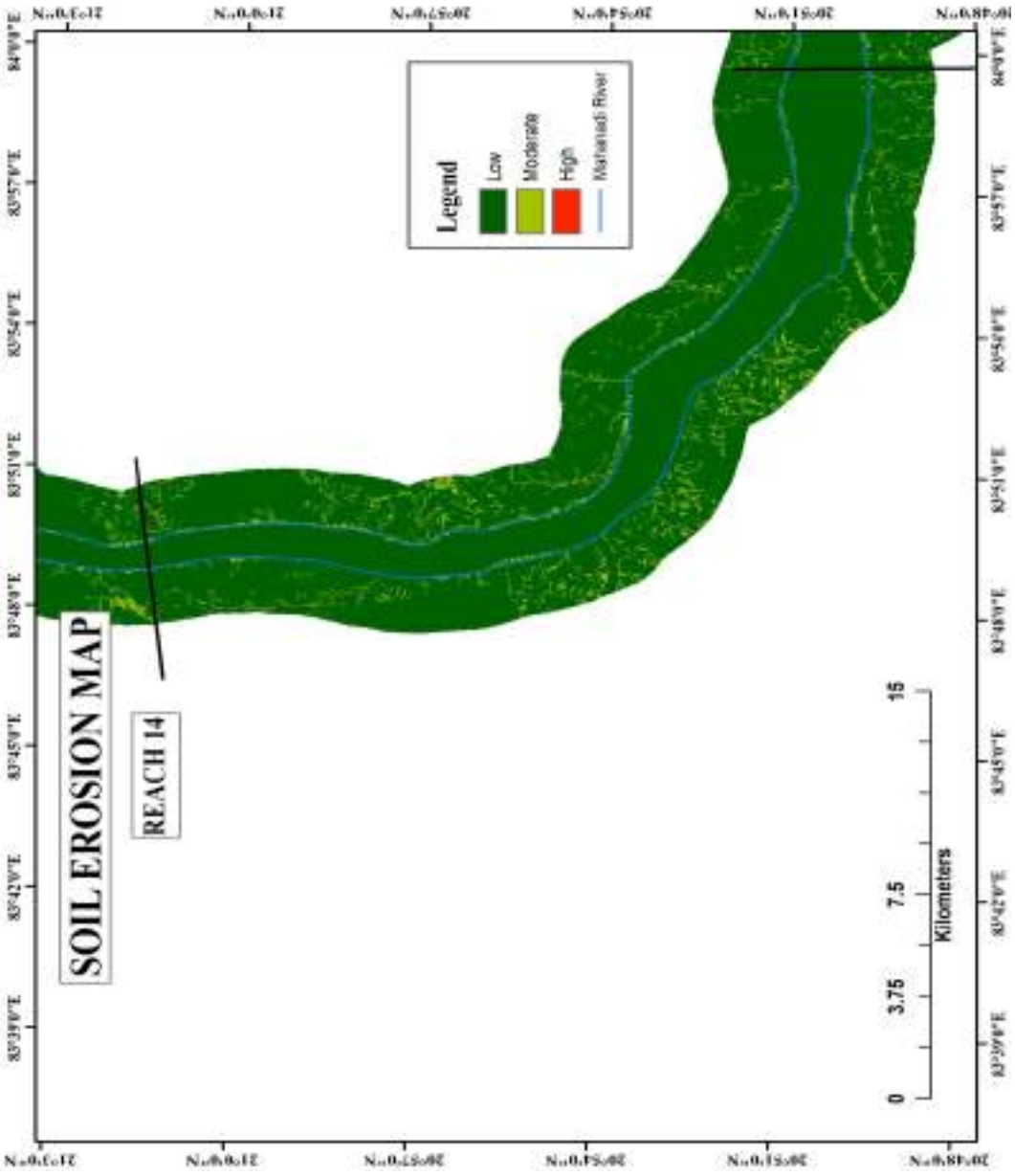


Figure 17.14: Soil Erosion Map 2 km buffer area Mahanadi River

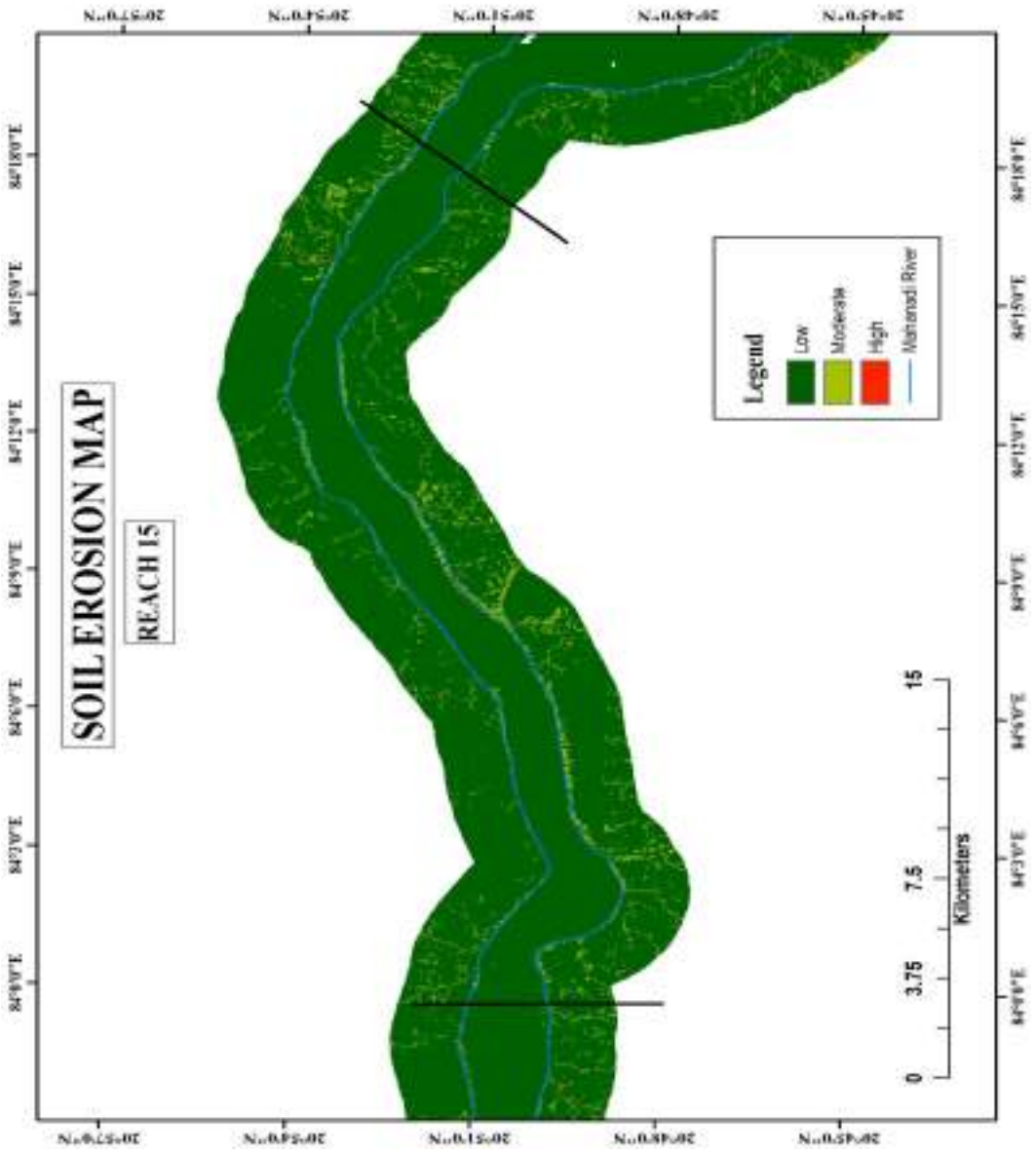


Figure 17.15: Soil Erosion Map 2 km buffer area Mahanadi River

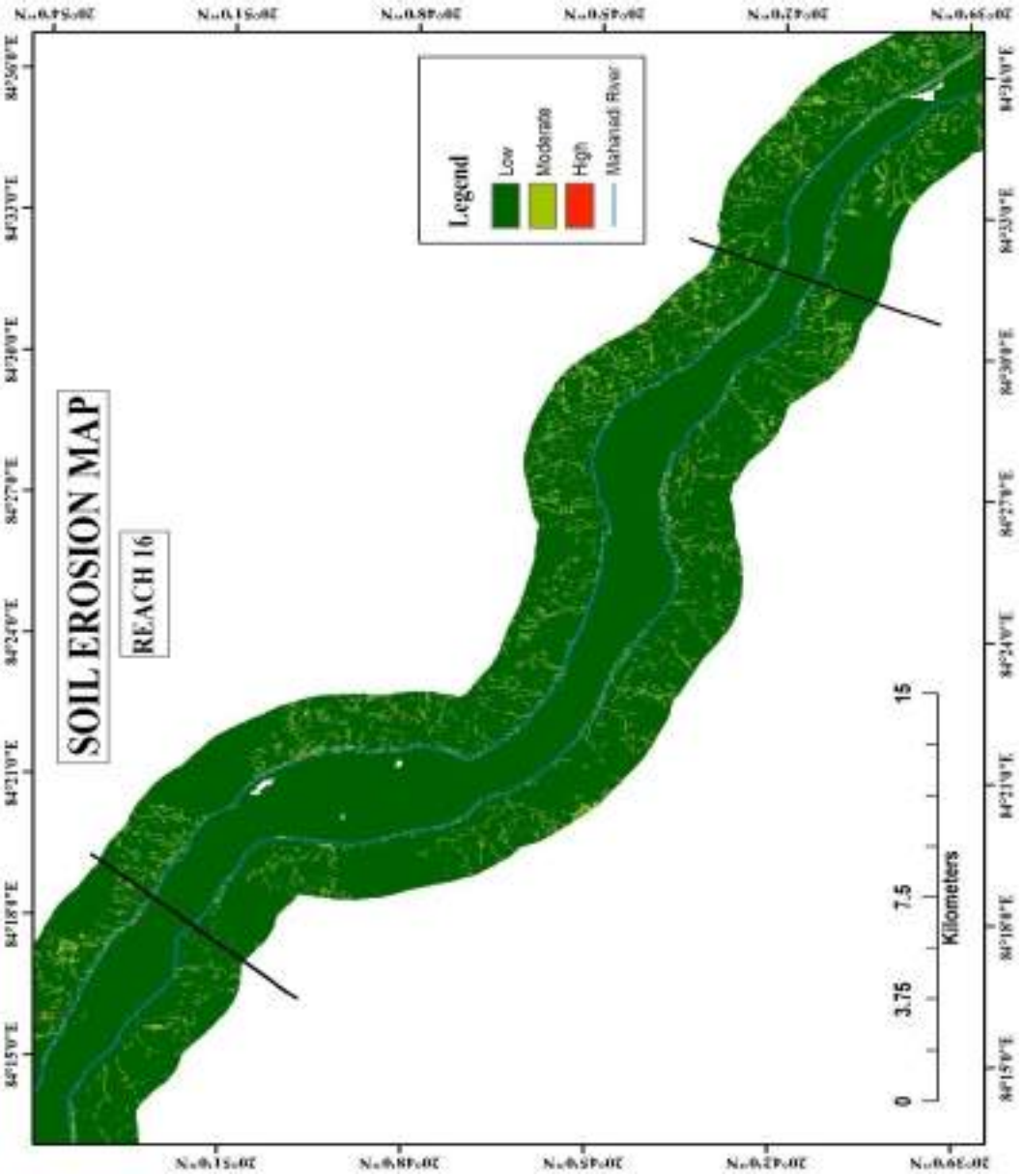


Figure 17.16: Soil Erosion Map 2 km buffer area Mahanadi River

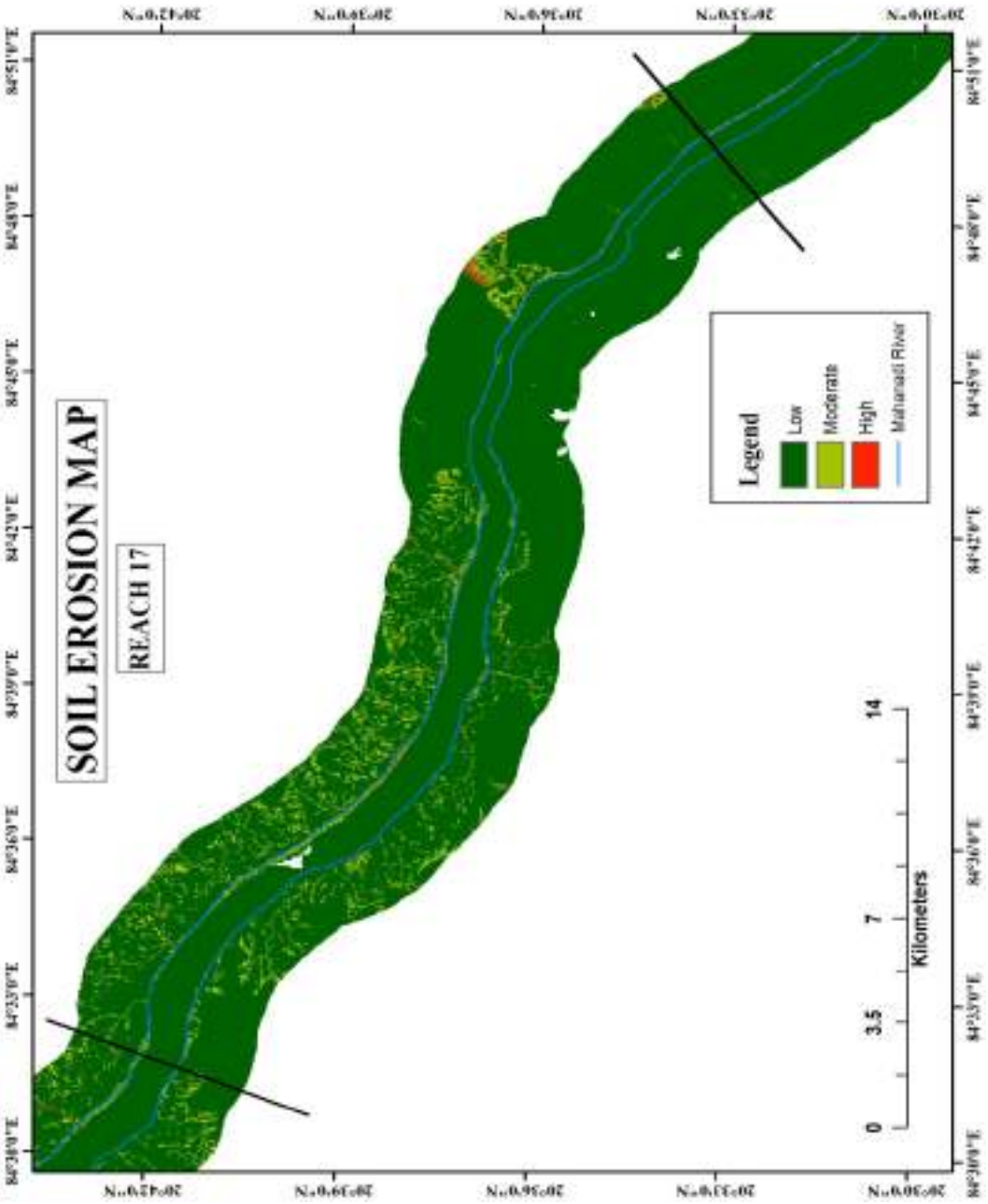


Figure 17.17: Soil Erosion Map 2 km buffer area Mahanadi River

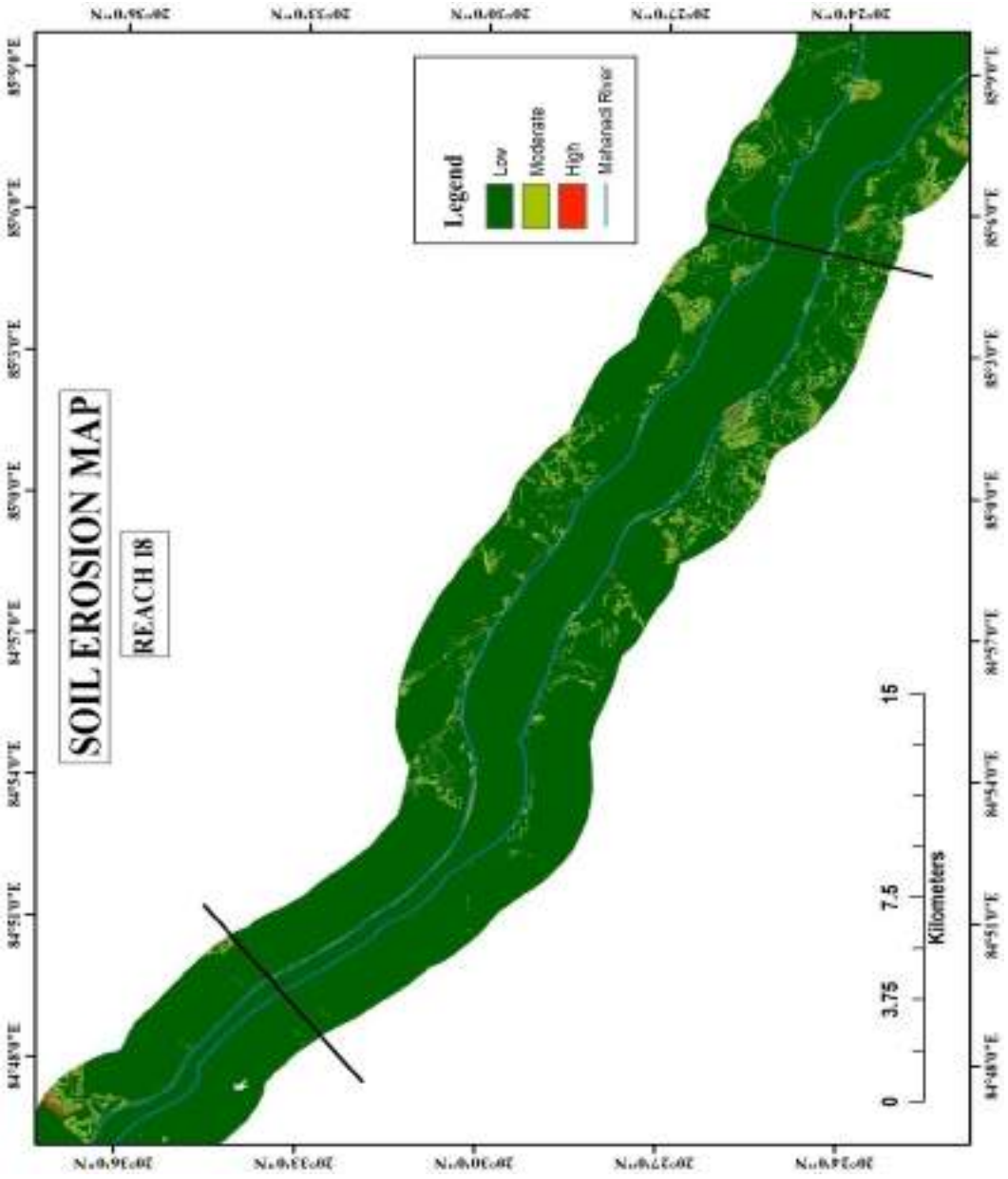


Figure 17.18: Soil Erosion Map 2 km buffer area Mahanadi River

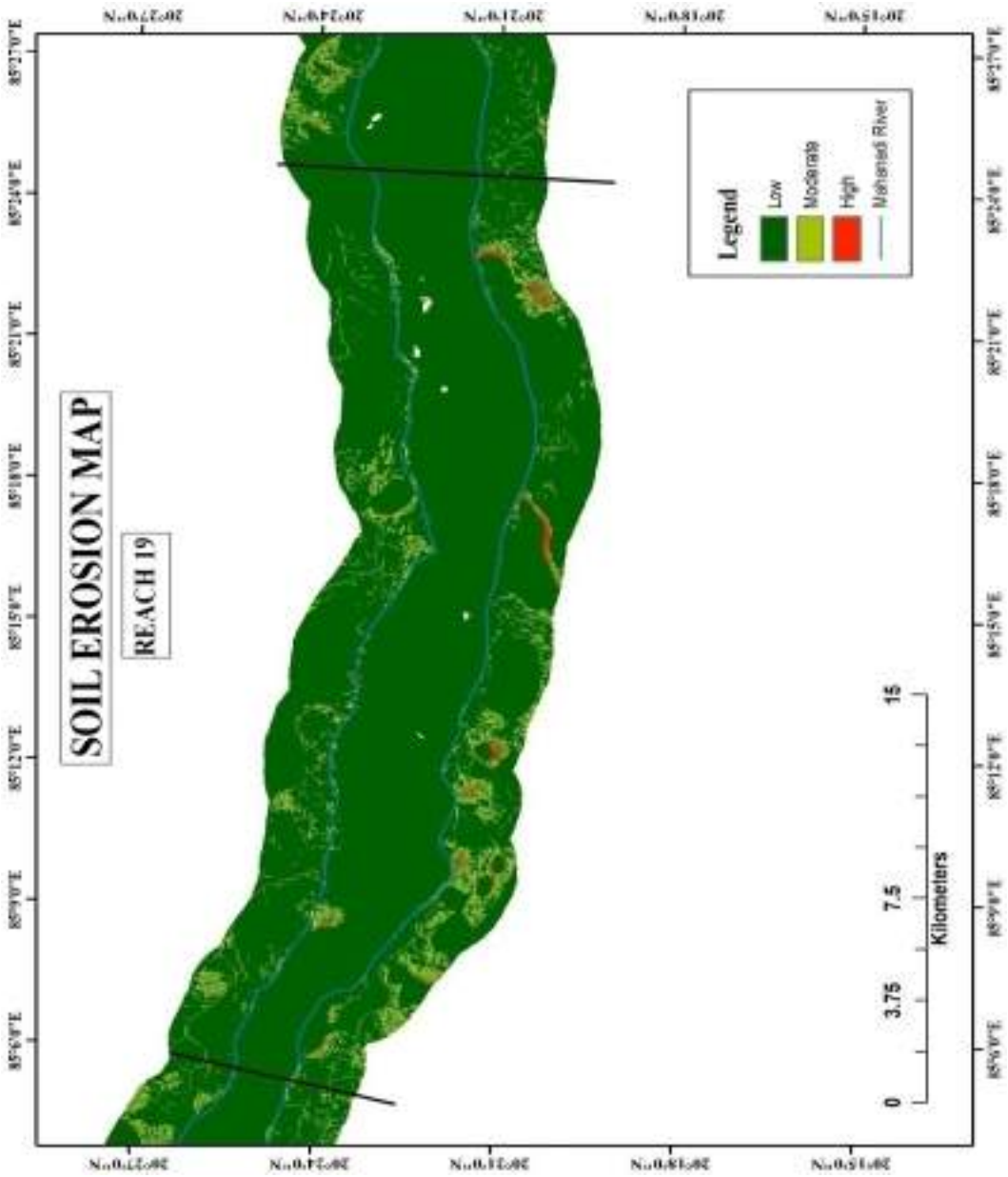


Figure 17.19: Soil Erosion Map 2 km buffer area Mahanadi River

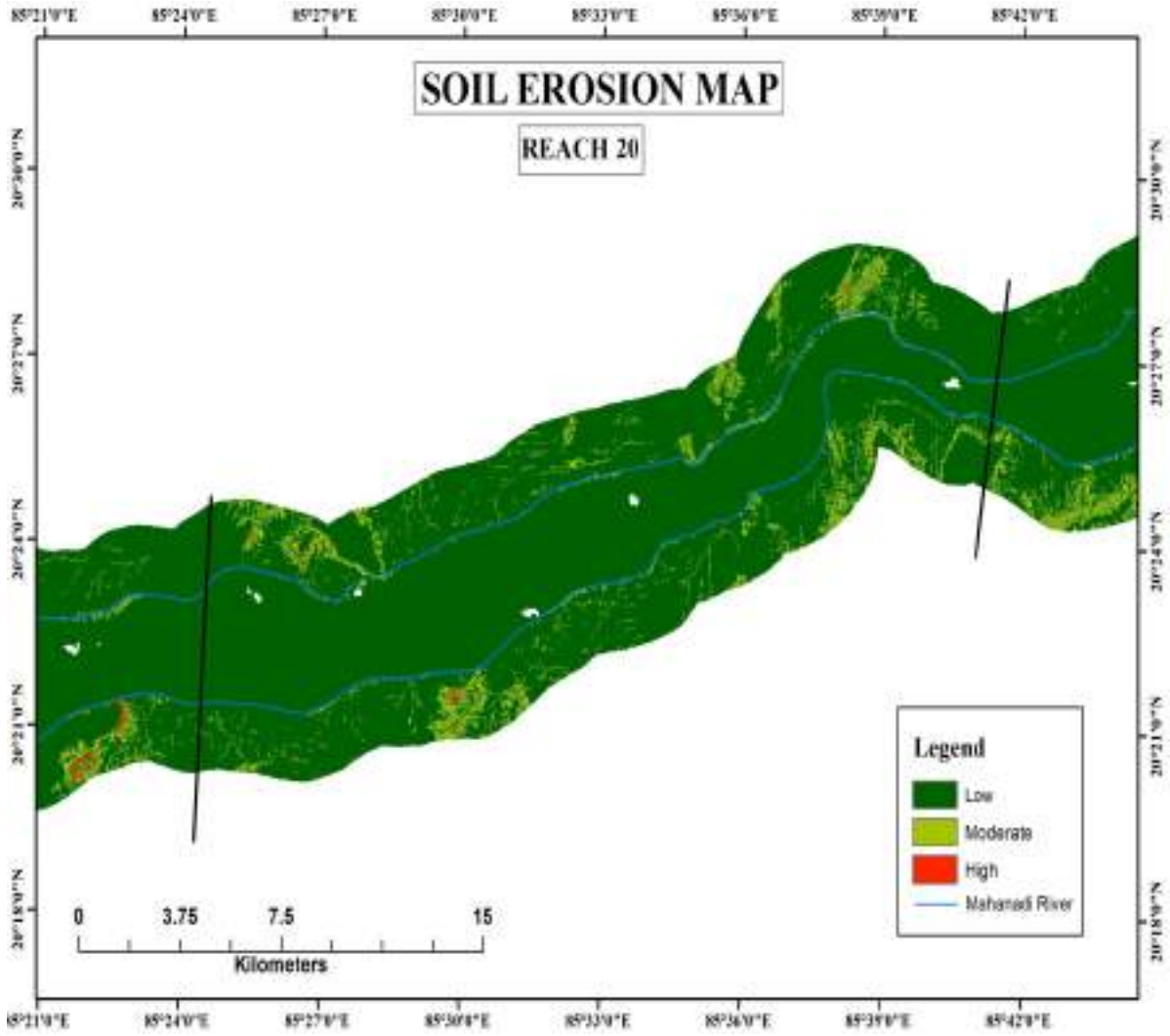


Figure 17.20: Soil Erosion Map 2 km buffer area Mahanadi River

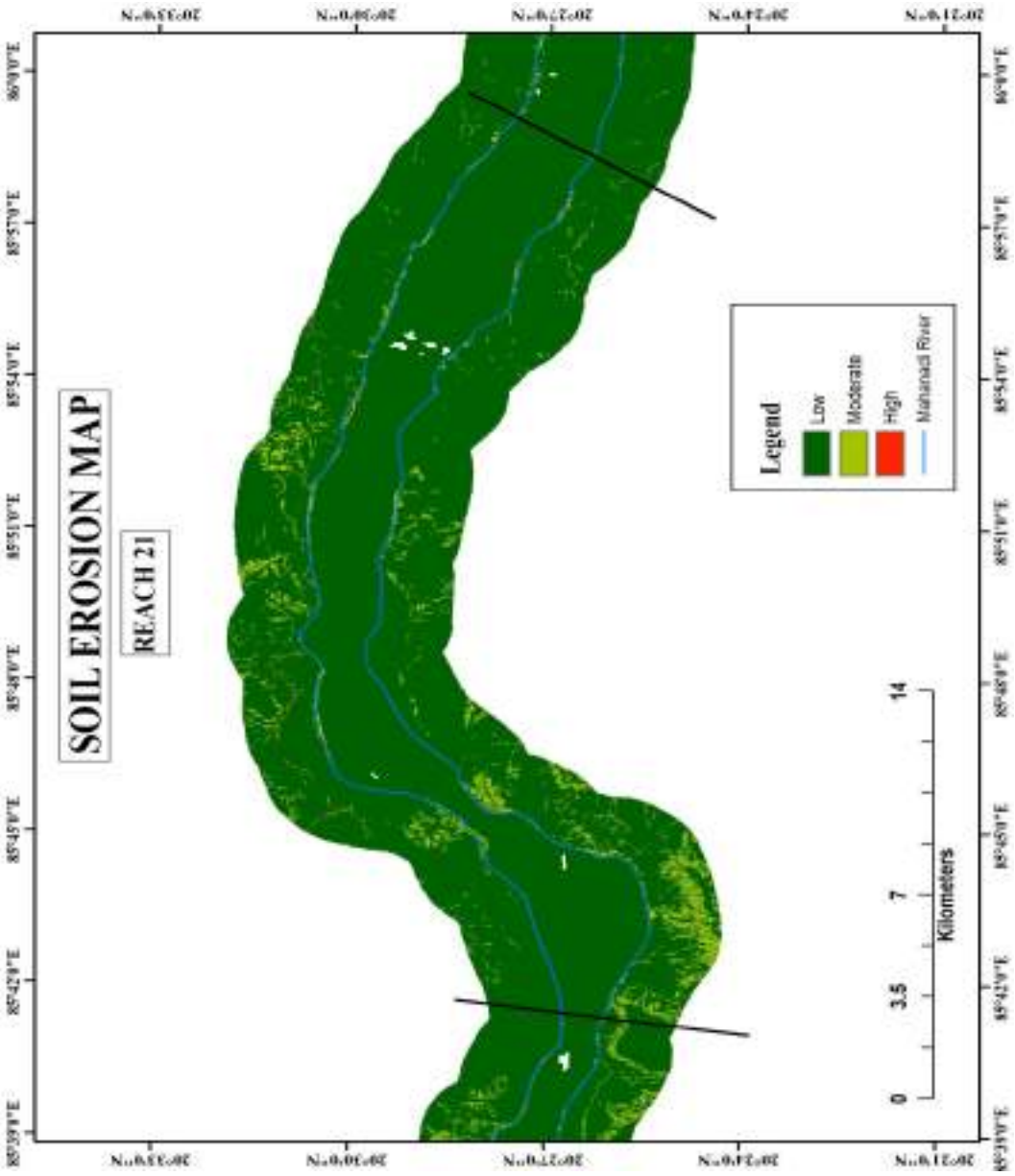


Figure 17.21: Soil Erosion Map 2 km buffer area Mahanadi River

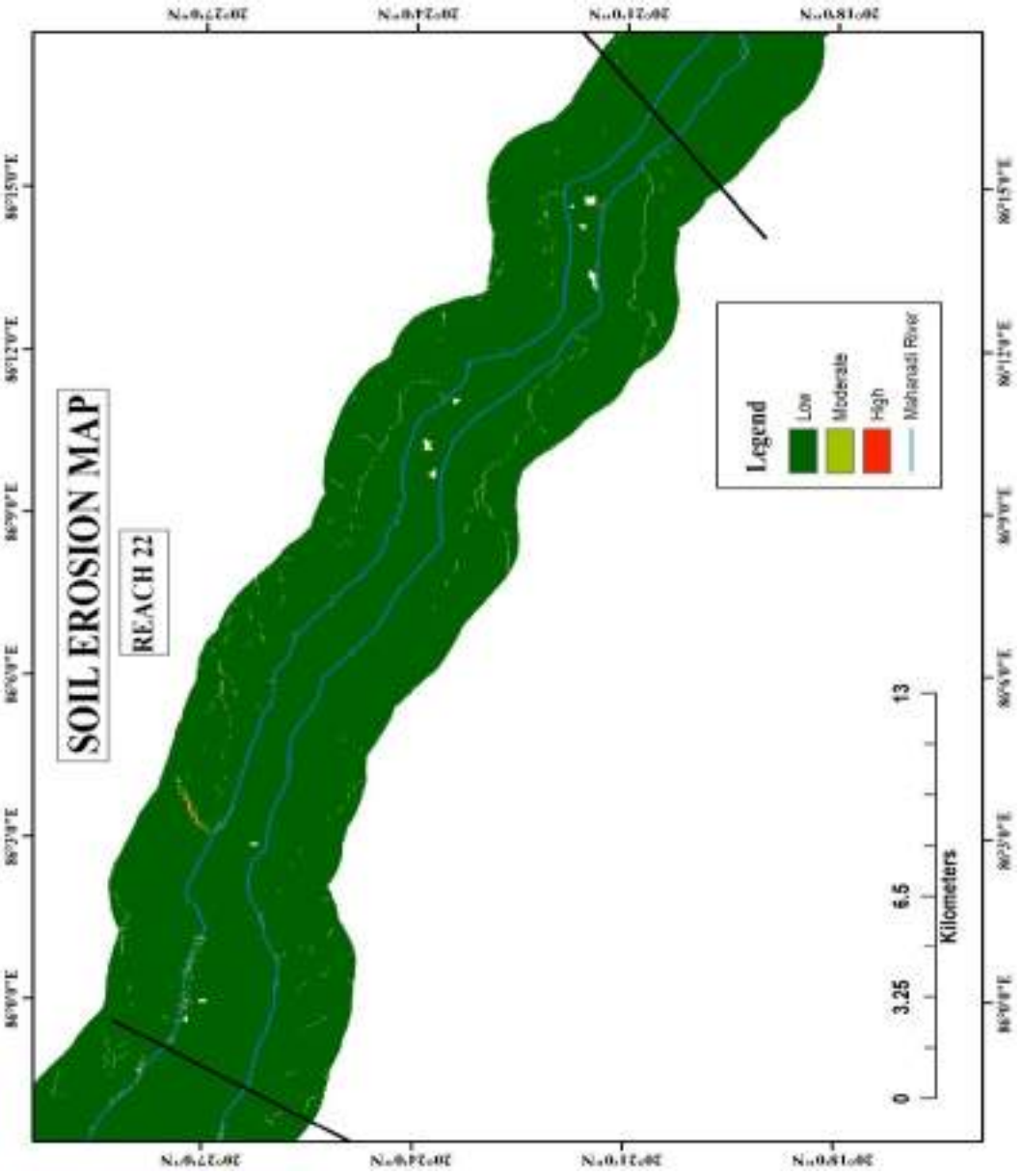


Figure 17.22: Soil Erosion Map 2 km buffer area Mahanadi River

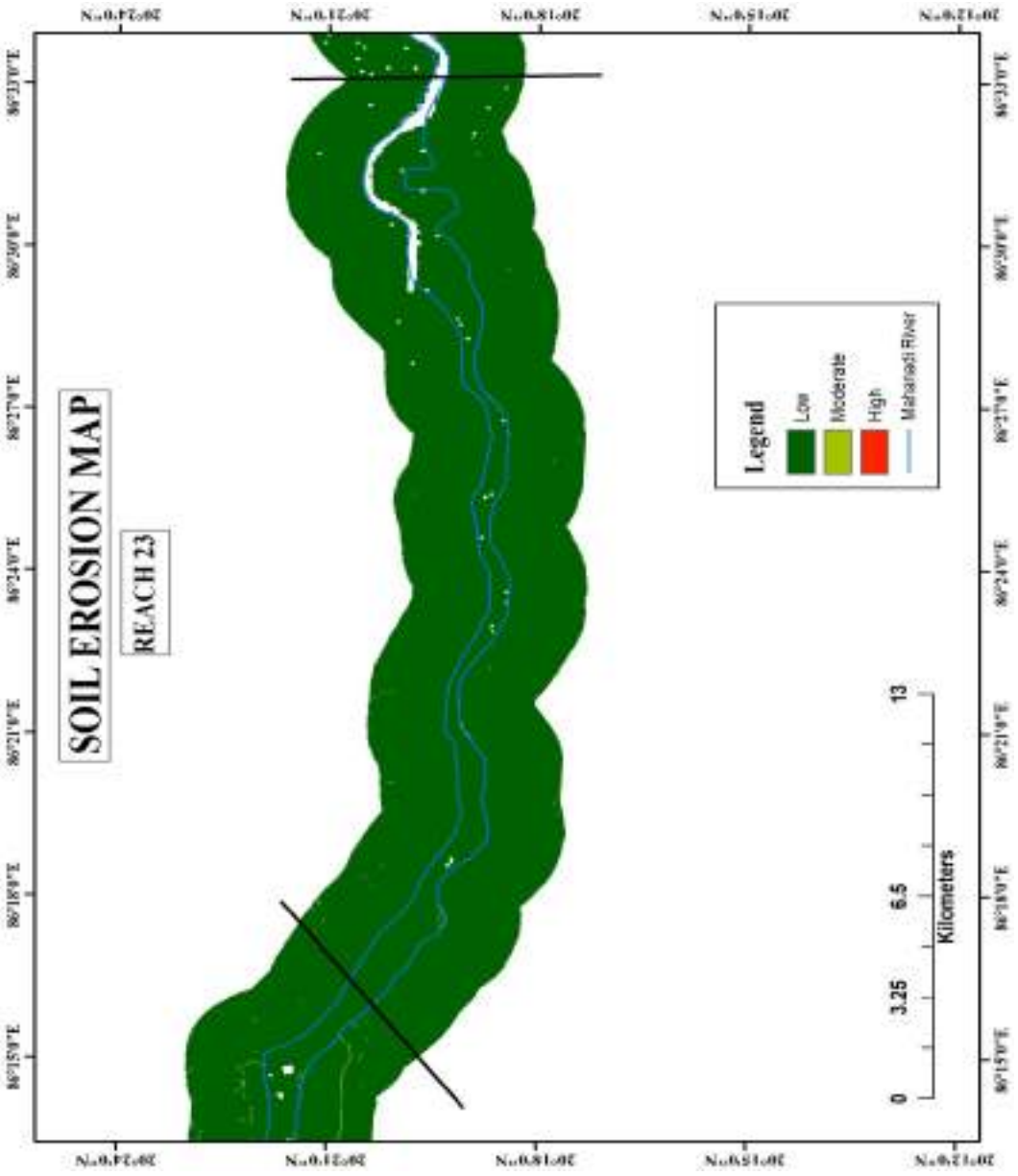


Figure 17.23: Soil Erosion Map 2 km buffer area Mahanadi River

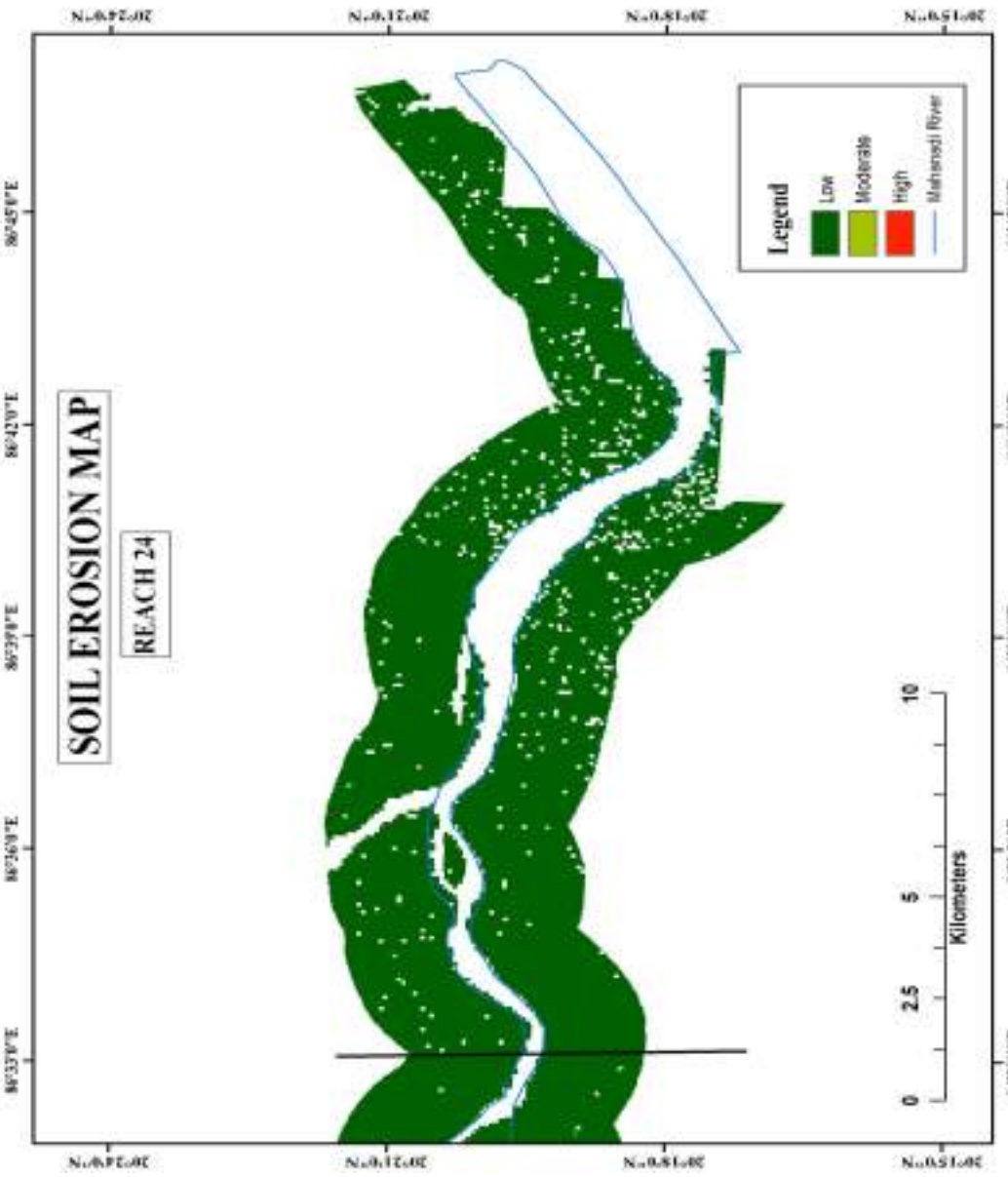


Figure 17.24: Soil Erosion Map 2 km buffer area Mahanadi River

5.12 Critical Reaches

Critical zone is defined as a section within a reach of the river that is undergoing or likely to undergo drastic change in morphology, like migration. It is important for the planning of the natural resource management framework (Table 11). A reach is typically defined as a length of the river as explained in the previous sections and the river Mahanadi is divided into 24 reaches, each of length 34 km (approximately). The objective of this study is to identify the current morphological changes and to predict the potential trends of a critical reaches of the river. Satellite data (Landsat MSS for the years 1972 and 1980, IRS LISS-I for 1990, IRS LISS-II for 2000, IRS LISS-III for 2010, Landsat OLI for 2018) are used to delineate the river course and identify the morphologically critical stretches of the river. Landsat MSS data are downloaded from the website of the United States Geological Survey (USGS). IRS LISS-I, IRS LISS-II, and IRS LISS-III data are collected from the National Remote Sensing Centre, Hyderabad. Identification of critical reaches is based on critical erosion-prone areas using remote sensing and GIS techniques. Erosion prone areas are identified by comparing two different images of the same location at two different times by overlaying the respective bank lines (left and right). Finally, the critical zones are identified under each reach based on maximum erosion-prone areas in the river.

This study has been carried out to identify the erosion-deposition area and shifting in Mahanadi River banks. The morphological changes, including changes in bank lines have been studied. The total length of the river has been divided into 24 reaches. Erosion deposition of the river banks has been studied reach wise. There are a number of places on the left and right bank of Mahanadi River where changes in bank lines have been identified. For Mahanadi river banks, erosion is not so high. There is at least one location in each reach where erosion is high. These locations have been specified as critical zones. In reaches 1,2,3,4 near kagari, kanker, charama, dhamteri erosion is high. The rest of the reaches are not so highly vulnerable to erosion or flooding. Detailed information of reaches is shown in Figure 18.1 to Figure 40.6.

Table 11: Identification of critical site under critical reach in Mahanadi river basin

Critical Reach Number	Critical Site name
1	Ghoghopuri
1	Rawansinghi
1	Chhipalipara
1	Bhejari Rawan
1	Sahnikhar
1	Bhumka Ryt
1	Birgudi
1	Junwani
1	Kekradongri
1	Kormud
2	Bhiraud
3	Nara
3	Mudpur
3	Shahawada
3	Tahkapar
3	Khartha
3	Bhiraund
3	Bhelai
3	Kochwahi
3	Bhaismundi
3	Muskera
4	Tirra
4	Tumabujurg
4	Satiyara
4	Tumakhurd
4	Chapgaon
4	Batrel
4	Khirgitola
4	Gangred
4	Sarangpuri
5	Deori
5	Giroud

Table 11 (continued): Identification of critical site under critical reach in Mahanadi river basin

Critical Reach Number	Critical Site name
5	Parkhanda
5	Sirsida
5	Nari
5	Nahardih
5	Dhuma
6	Chandsur
6	Tarri
6	Nawapara Ngar
6	Pitaiband
6	Champaran
6	Hanpa Jhar
6	Pahanda
6	Goinda
6	Nisda
7	Kusmund
7	Kurd-1
8	Bijridish
8	Charoda
8	Amethi
9	Sunsunia
9	Bhadara
9	Chhechhar
9	Khargahni
9	Tharhidih
9	Laxmaneshwar College
10	Sheorinarayan
10	Sarmandi
10	Lakhuridih
10	Jitpur
10	Parsada
11	pandripali
11	Dahida

Table 11 (continued): Identification of critical site under critical reach in Mahanadi river basin

Critical Reach Number	Critical Site name
11	Manjarkud
11	Jaspur
11	Nawapara
11	Sakrali
11	Jsara
11	Saradih
11	Kosmanda
11	Timarlaga
11	Chandrapur
12	Budbuda
12	Bharatpur
12	Mohadi
12	Kiritmal
12	Chakuli
12	Sankhala
12	Radhiapali
12	Haldi
13	Tabada
13	Tabada
13	PWD Bungalow
13	Salepali
13	Budhijharan Jungle
13	Keshripali
13	Tihikipali
13	Arigaon
13	Manigaon
14	Gariapali
14	Barigaon
14	Babupali
14	Pansiali
14	Nuagaon
14	Sonepur

Table 11 (continued): Identification of critical site under critical reach in Mahanadi river basin

Critical Reach Number	Critical Site name
14	Mundoghat
14	Patrapali
14	Parbatipur
15	Paligaon
15	Jatesingha
15	Ektal
15	Kampara
15	Tebhapadar
15	Balidohali
15	Gobindpur
16	Marjadpur
16	Baudh Panchyat college
16	Jogiberini
16	Sarasara
16	Belpunji
16	Lunahandi
16	Hatagam
16	Kankala
17	Nagaon
17	Aida
17	Titigaon
17	Daruha
18	Kamalidha
18	Dankarisahi
18	Kathakhunta
18	Bindhyagiri
19	Kanpur
19	Kantilo
19	Balijhari
19	Madhapur
19	Kendupalli
19	Talamarada

Table 11 (continued): Identification of critical site under critical reach in Mahanadi river basin

Critical Reach Number	Critical Site name
19	Badabhuin
20	Rajiba
20	Jajpur
20	Mundali
20	Jaganthapur
20	Baunsaput
20	Nandapur
20	Nuaostia
20	Fulabadi
20	Charigharia
21	Bhogara
22	Dhurukudia
22	Dhurukudia
22	Mundali
22	CDA Sector-VI
22	Kayalpada
22	Barabati Fort
22	Odisha Medical
22	Bidyadharpur
22	Paschimakachha
22	Nimeisapur
22	Ayatpur
22	Bahugram
22	Barada
22	Salipur College
22	Udayapur
22	Aranga
22	Tarapur
22	Gokulpur
23	Bishanpur
23	Bidyadharpur
23	Kotakana

Table 11 (continued): Identification of critical site under critical reach in Mahanadi river basin

Critical Reach Number	Critical Site name
23	Kalikud
23	Kaladip
23	Madhapur
23	Kothiasahi
23	Mohanangala
23	Baidigadi
24	Talapada
24	Jagati
24	Telengadia
24	Balidia
24	Aganasi
24	Banabiharipur
24	Musadia
24	Jogidhankud
24	Kaudia
24	Kaudia
24	Saralikud
24	Saralikud
24	Hetamundia
24	Hetamundia

Reach 1

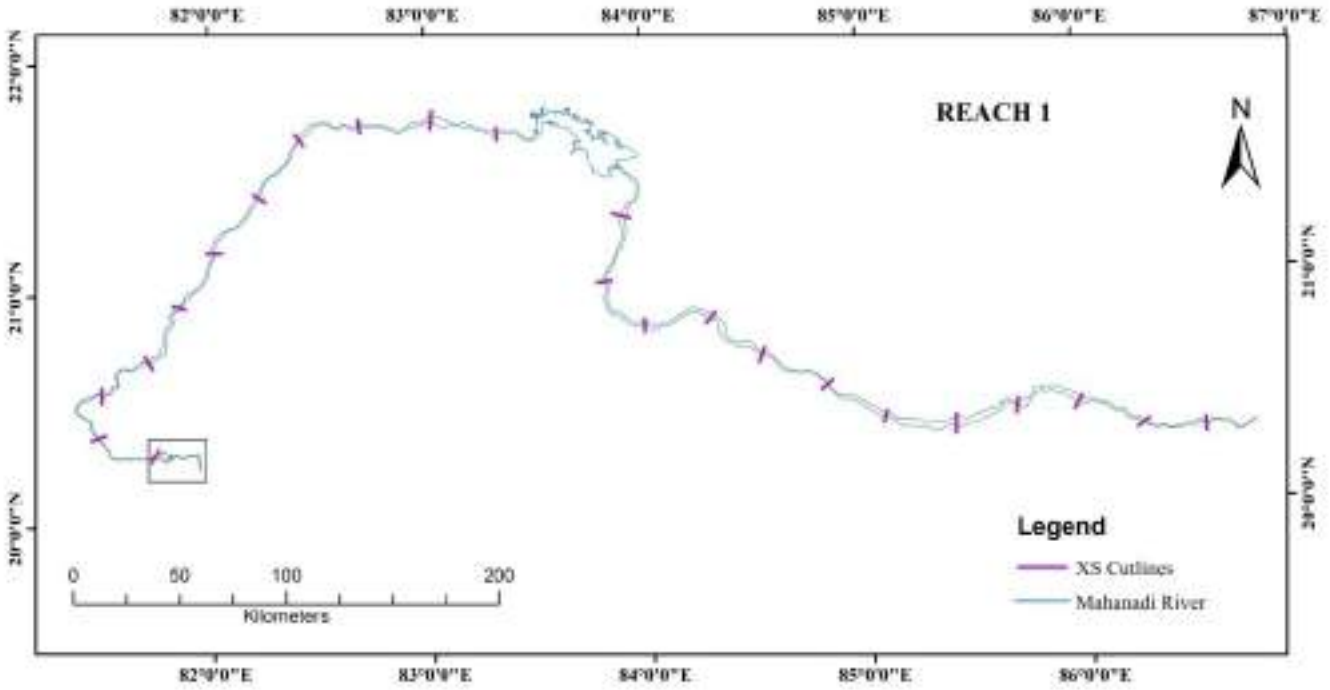


Figure 18.1: Location of reach number 1 in the Mahanadi river

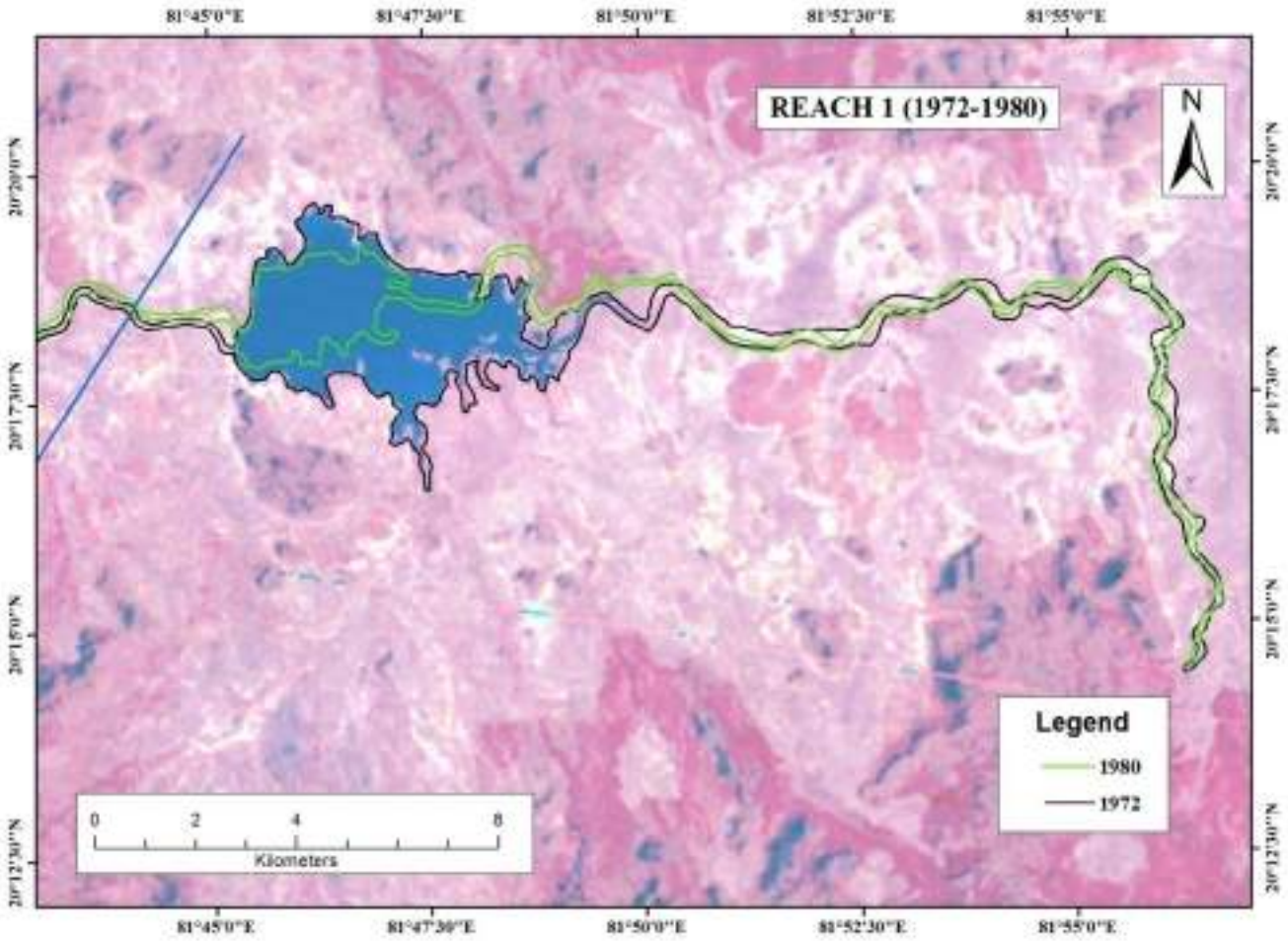


Figure 18.2: Changes in the course of Mahanadi River of Year 1972-1980

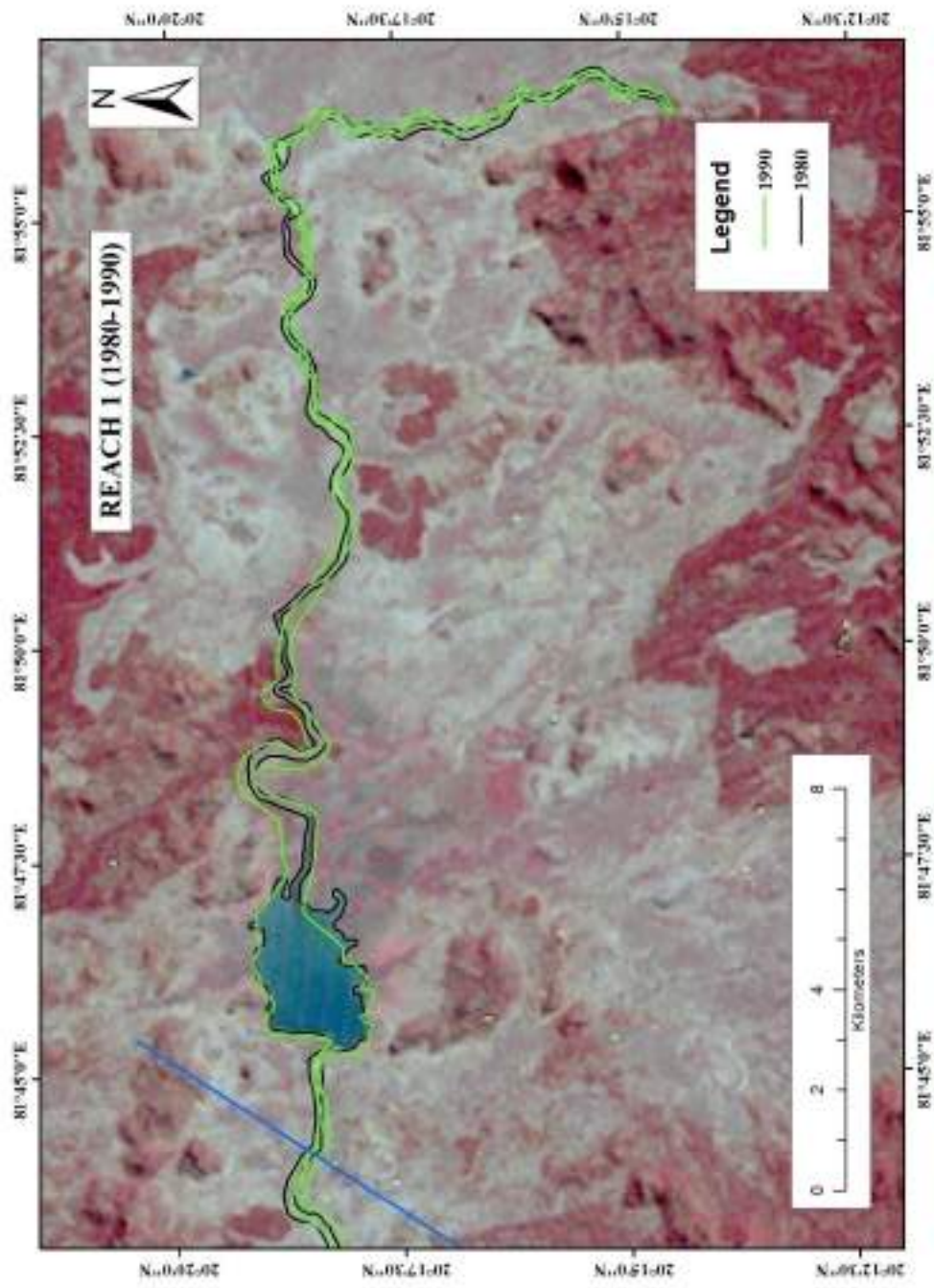


Figure 18.3: Changes in the course of Mahanadi River of Year 1980-1990

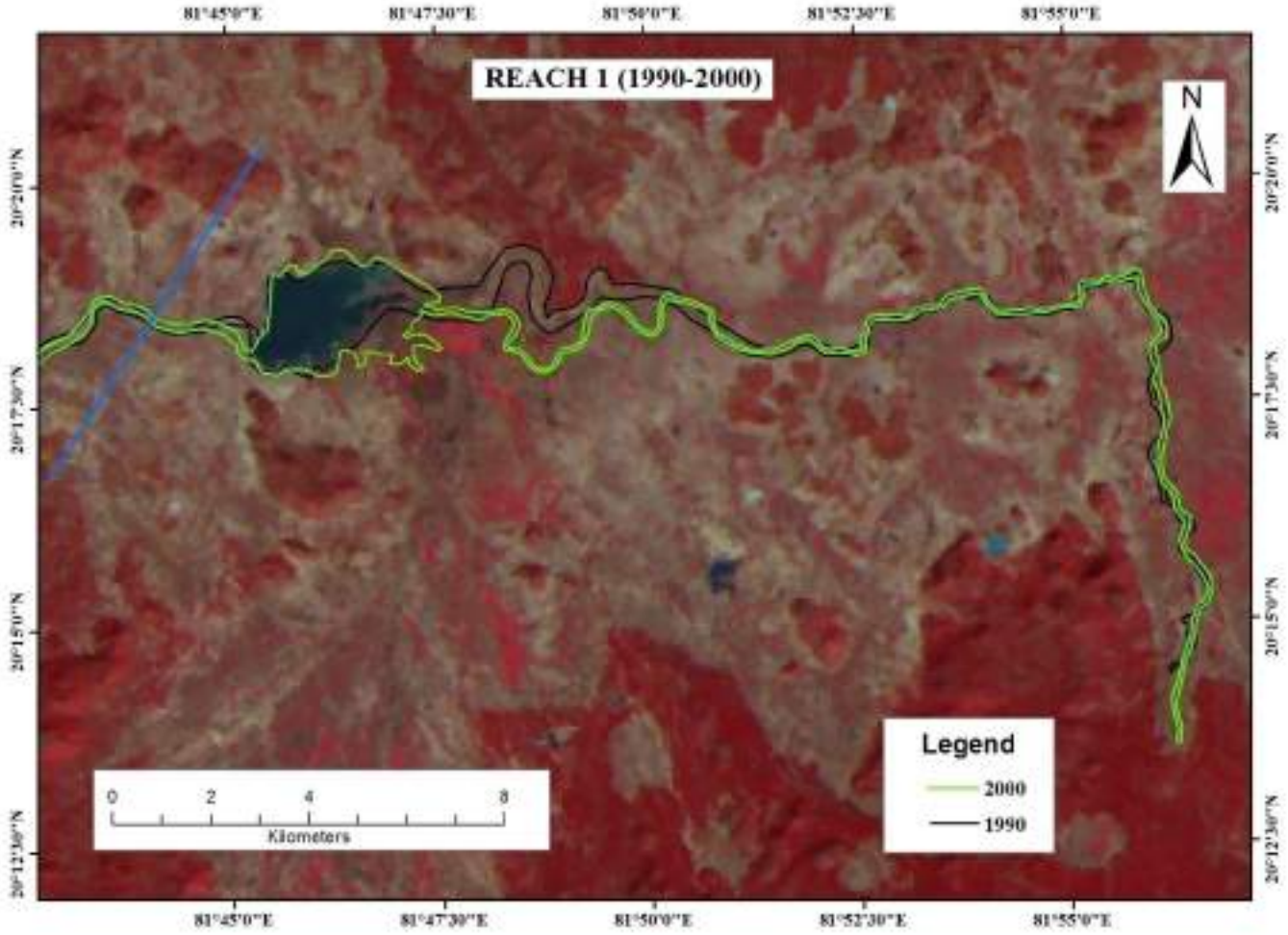


Figure 18.4: Changes in the course of Mahanadi River of Year 1990-2000

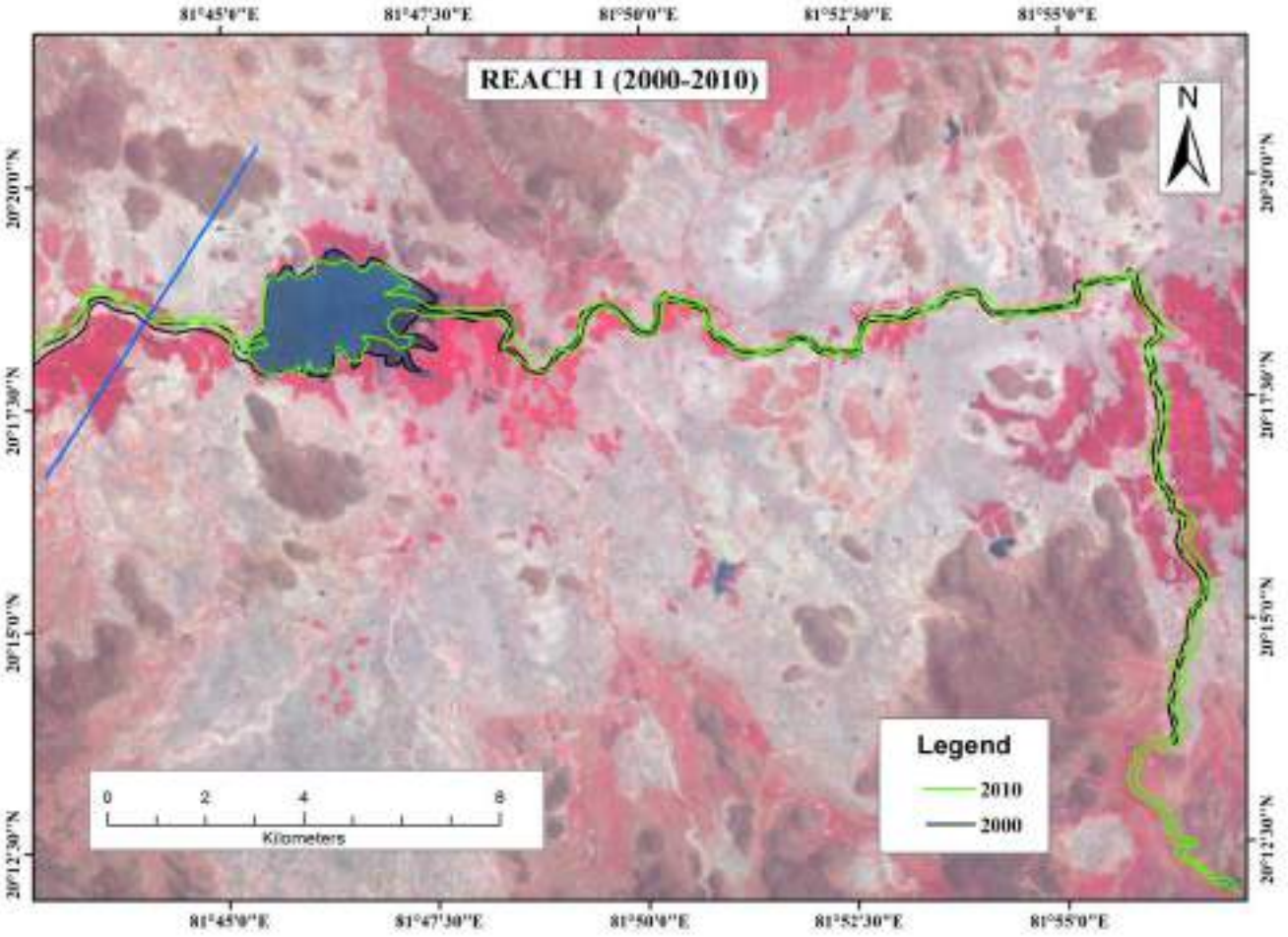


Figure 18.5: Changes in the course of Mahanadi River of Year 2000-2010

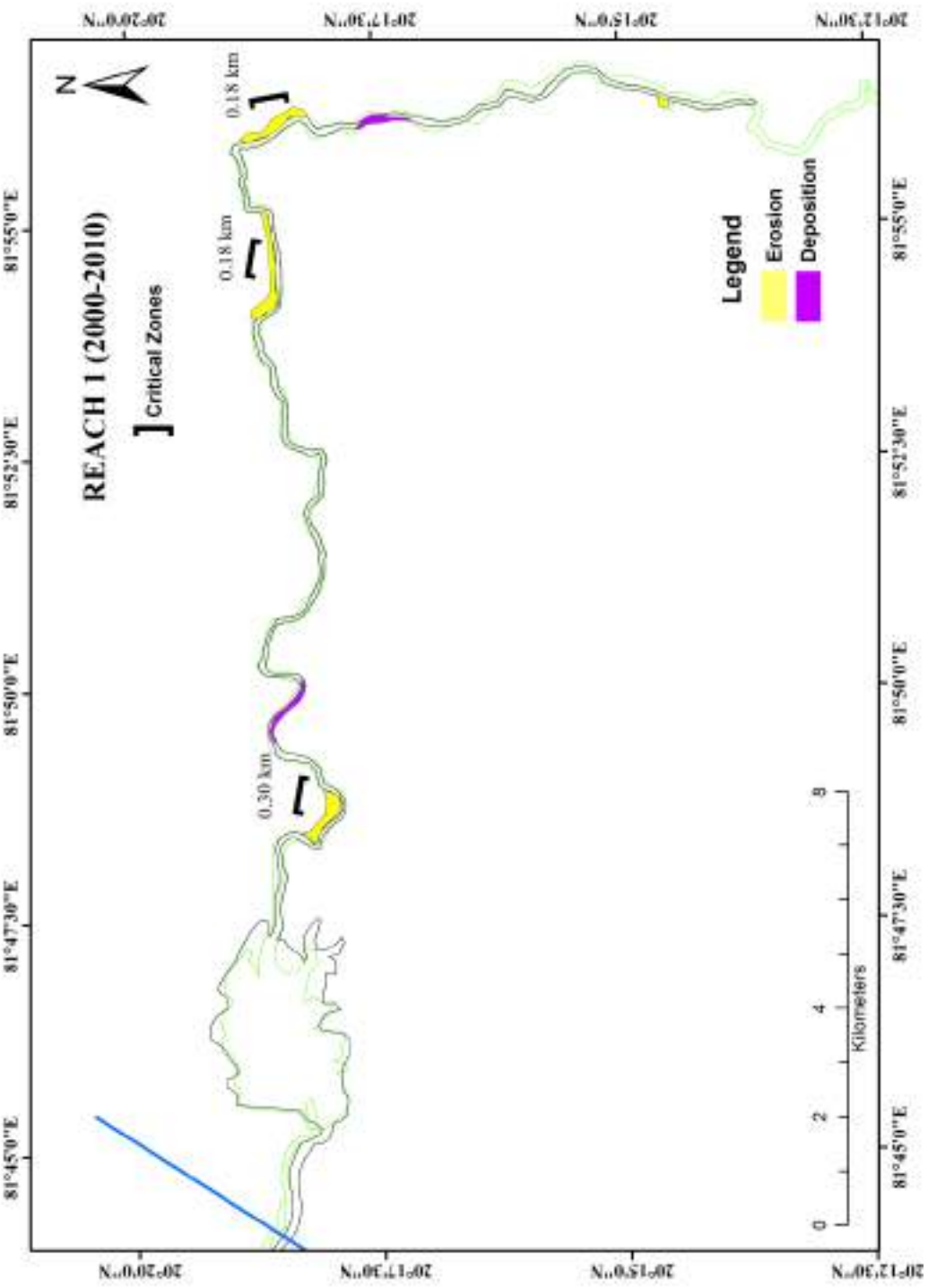


Figure 18.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 2

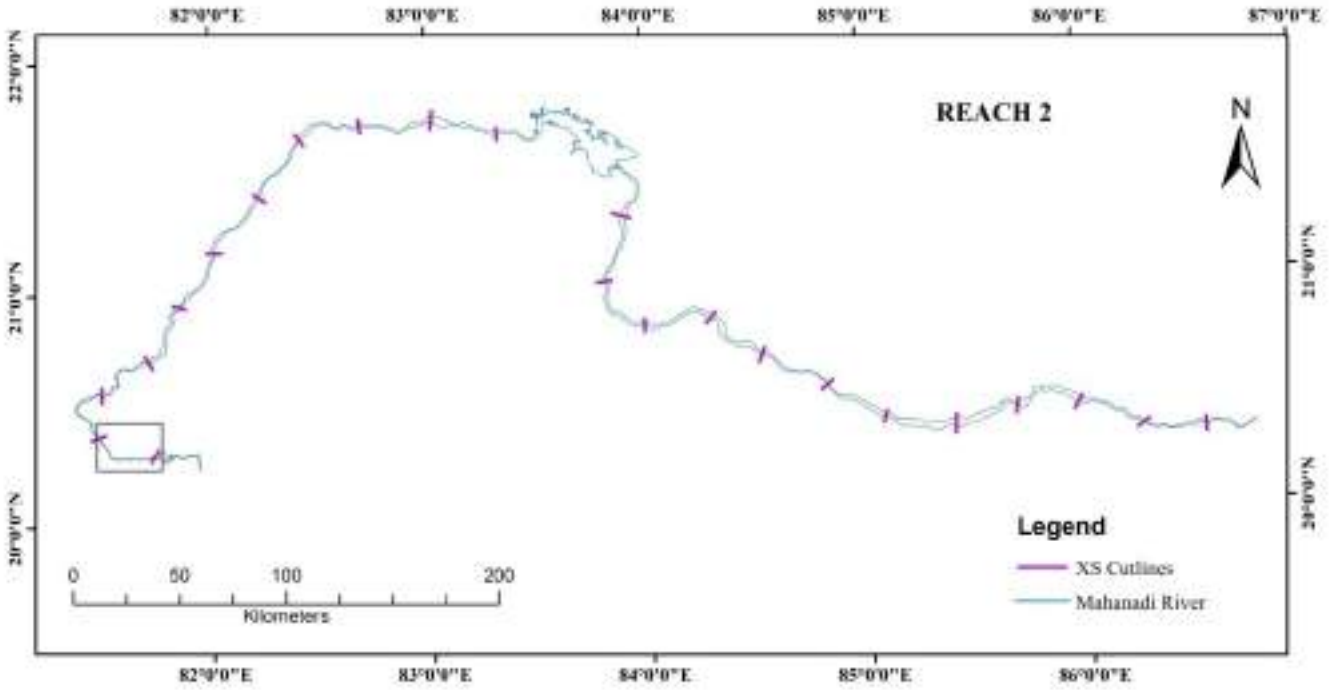


Figure 19.1: Location of reach number 2 in the Mahanadi river

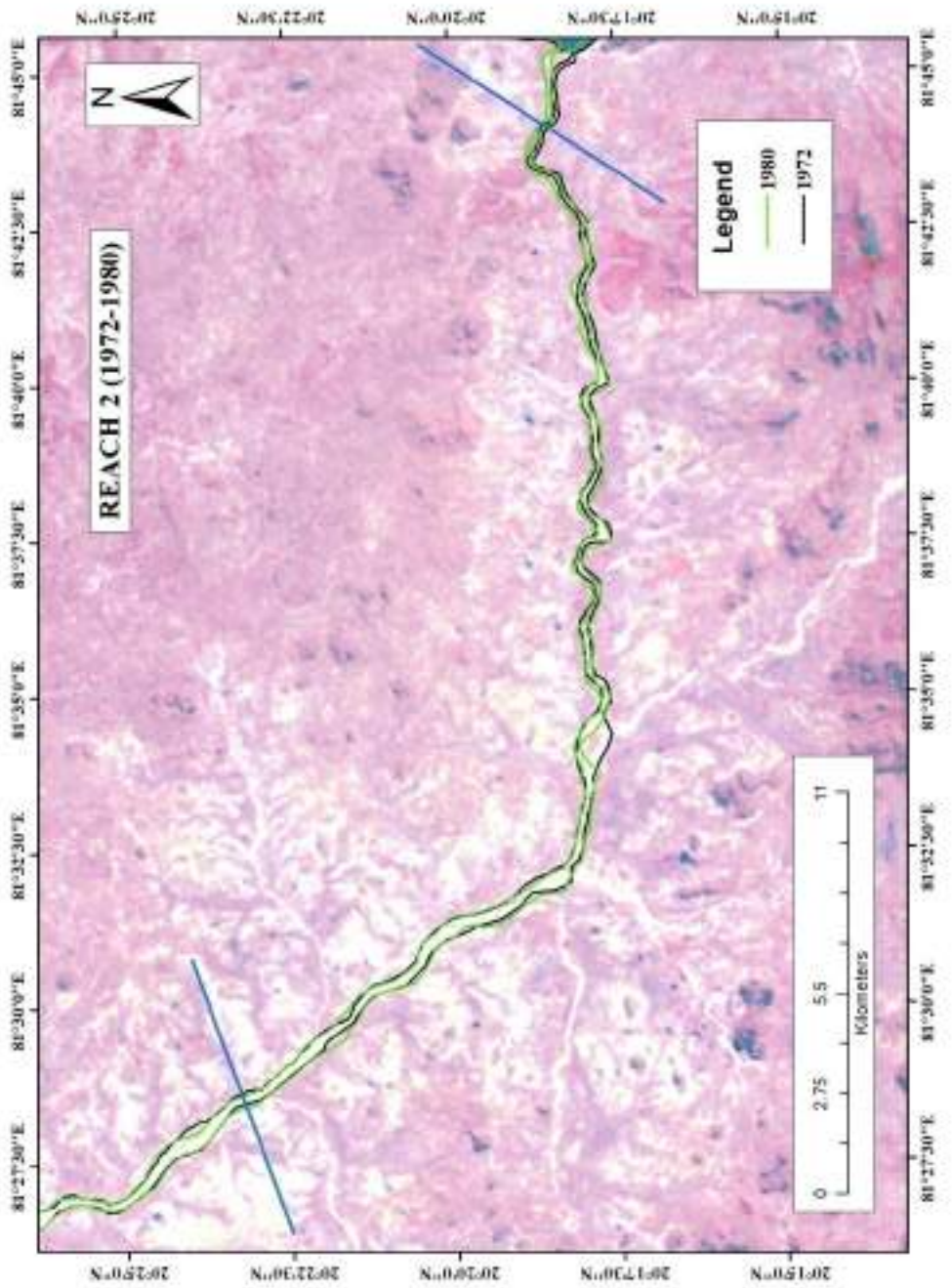


Figure 19.2: Changes in the course of Mahanadi River of Year 1972-1980

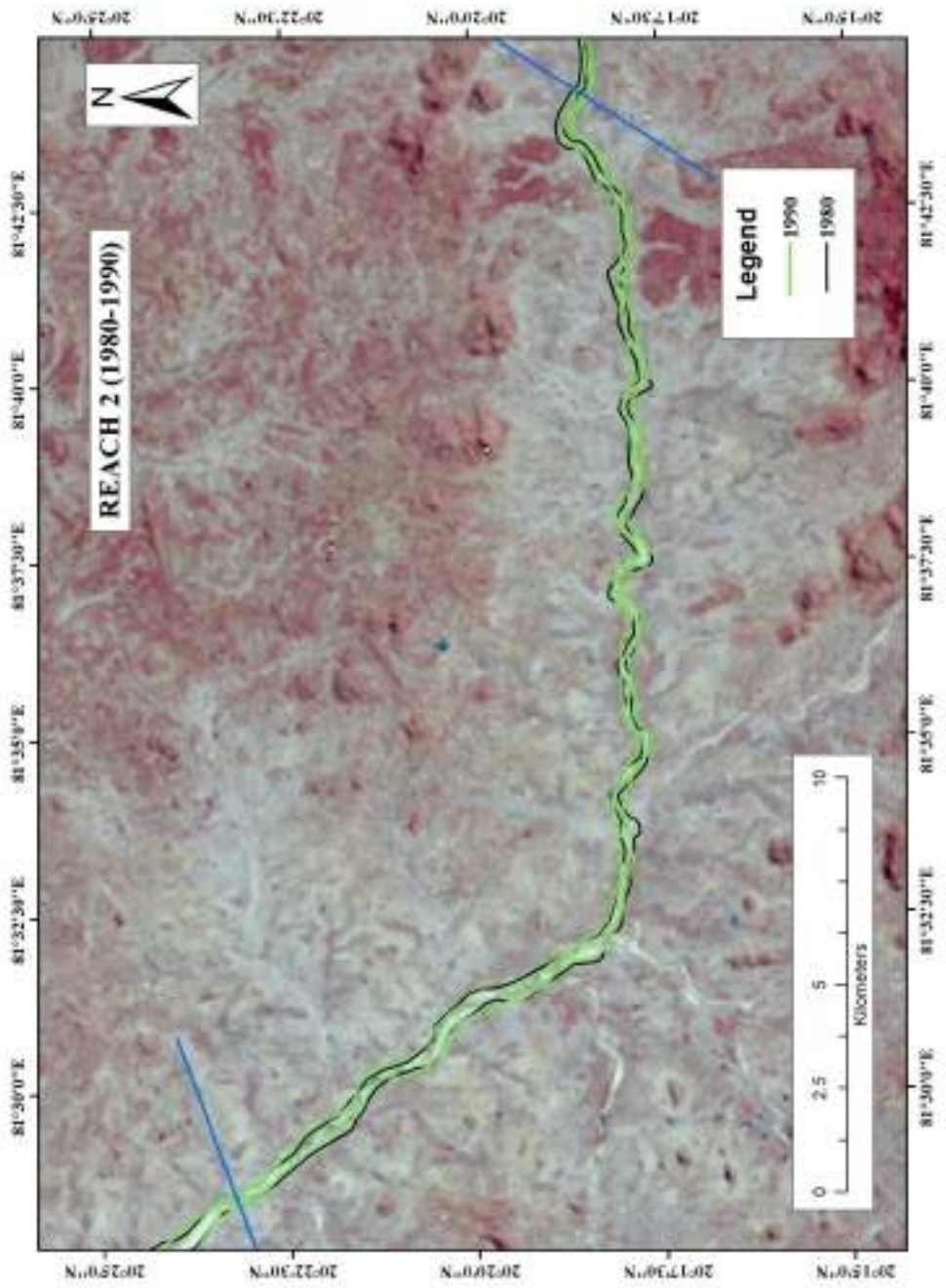


Figure 19.3: Changes in the course of Mahanadi River of Year 1980-1990

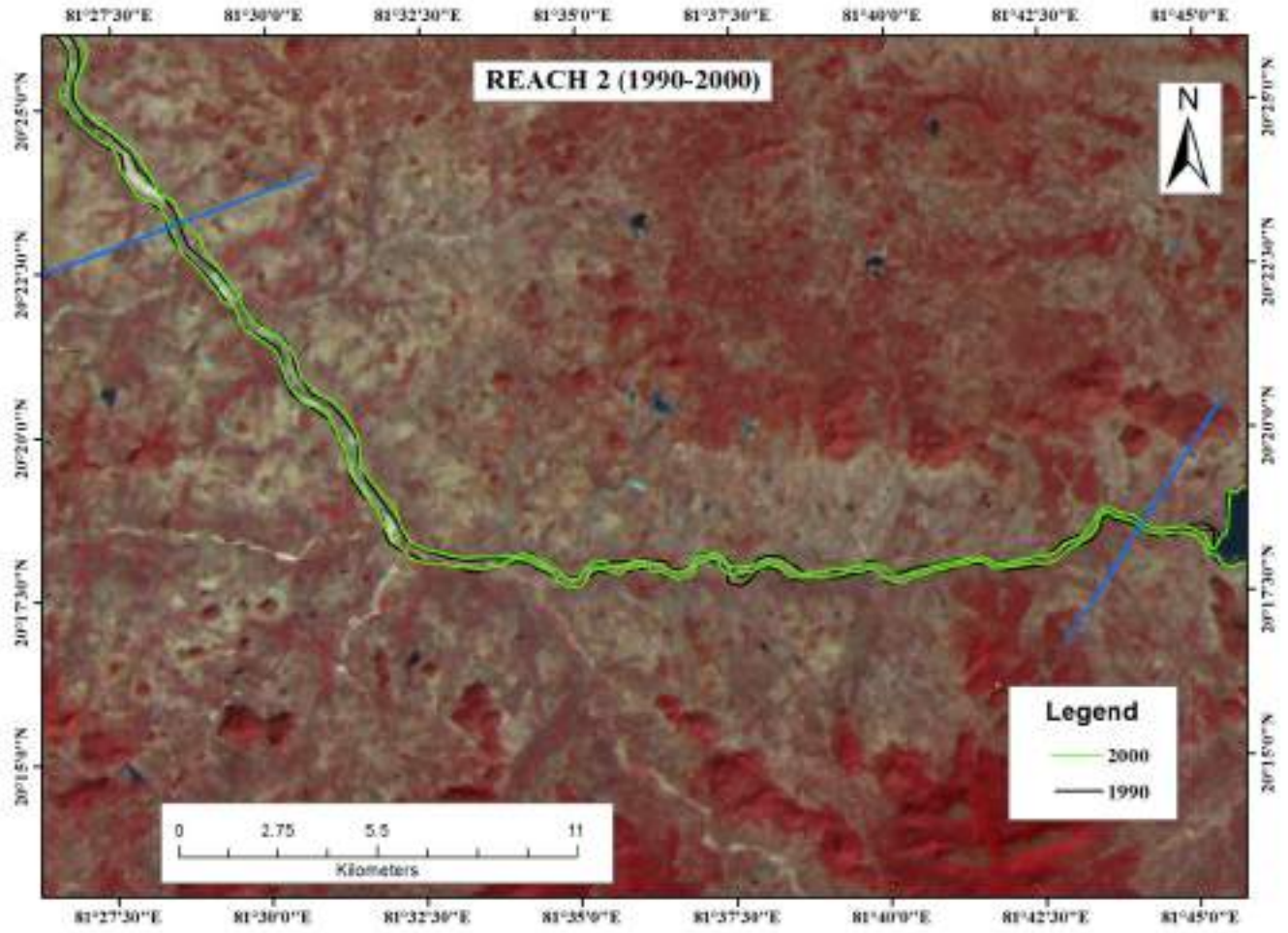


Figure 19.4: Changes in the course of Mahanadi River of Year 1990-2000

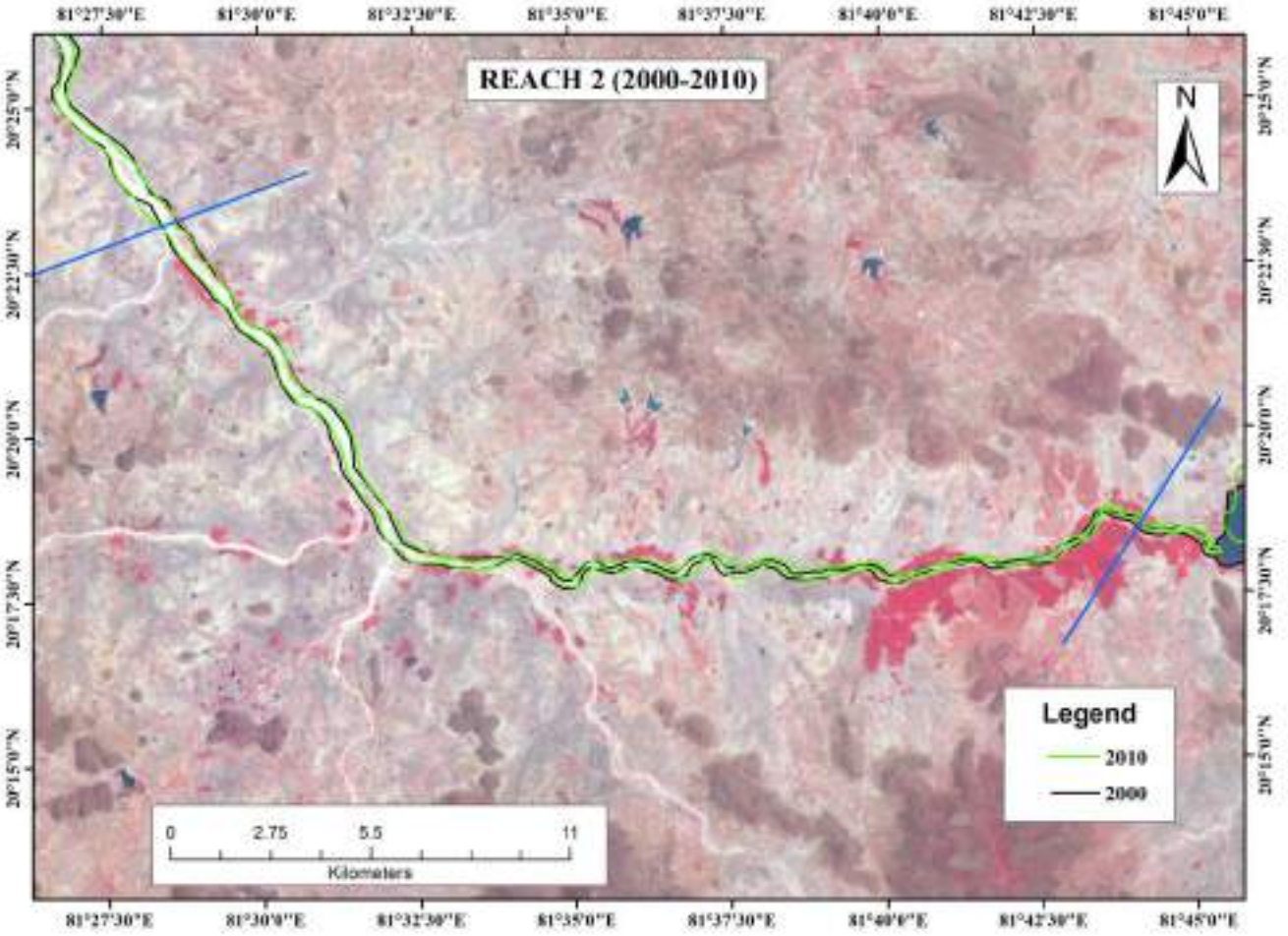


Figure 19.5: Changes in the course of Mahanadi River of Year 2000-2010

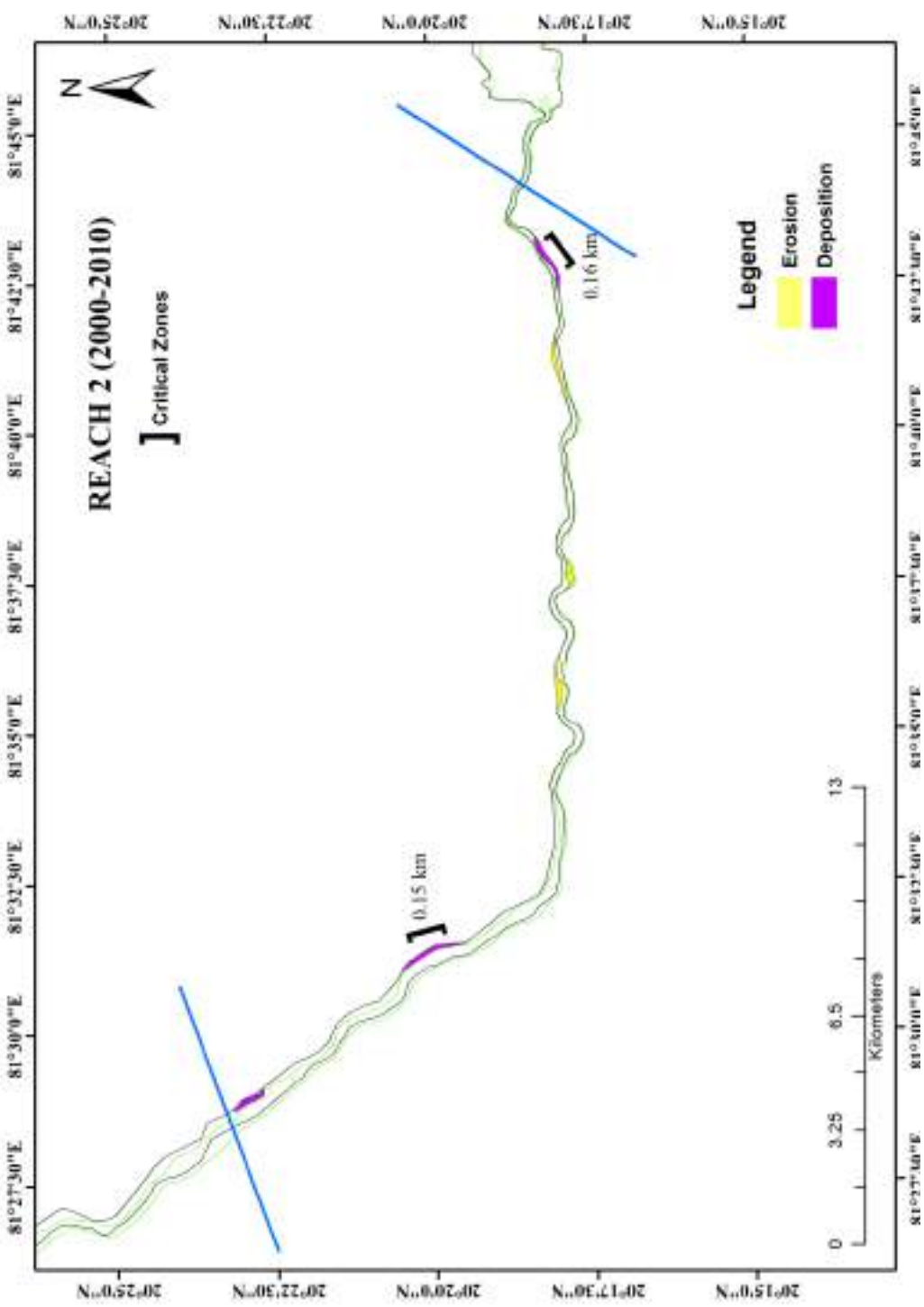


Figure 19.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 3

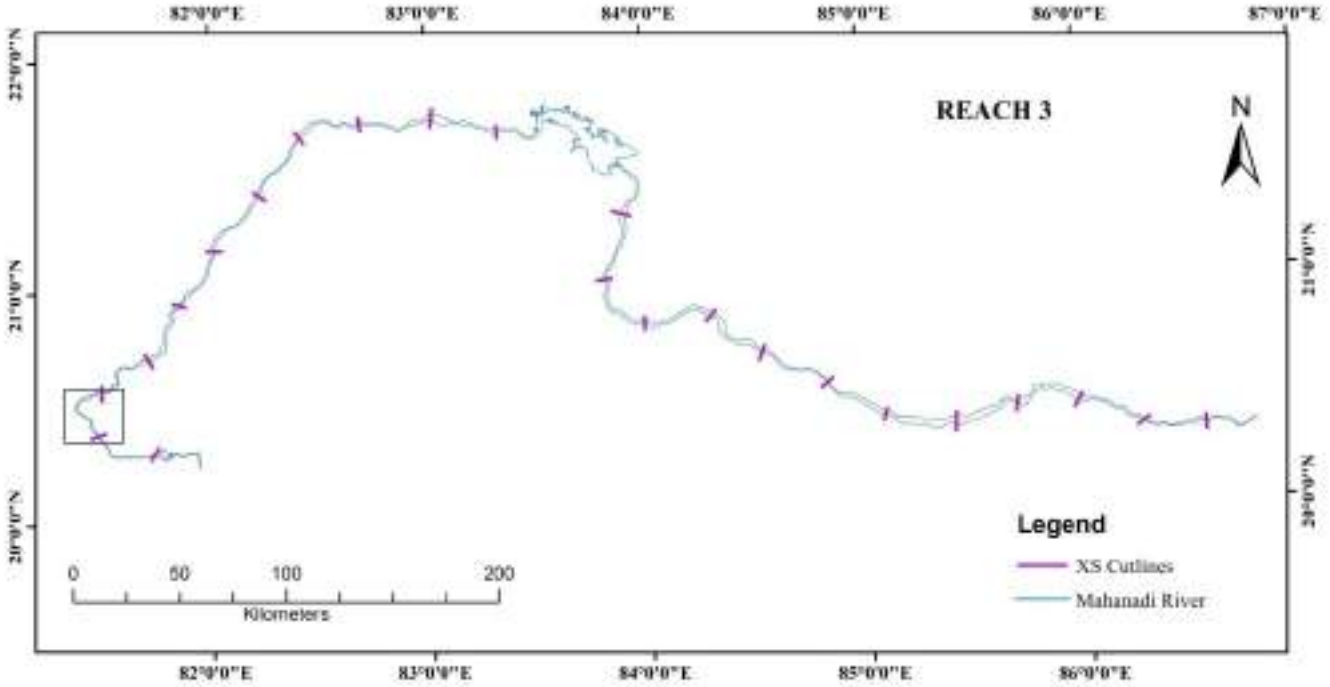


Figure 20.1: Location of reach number 3 in the Mahanadi river

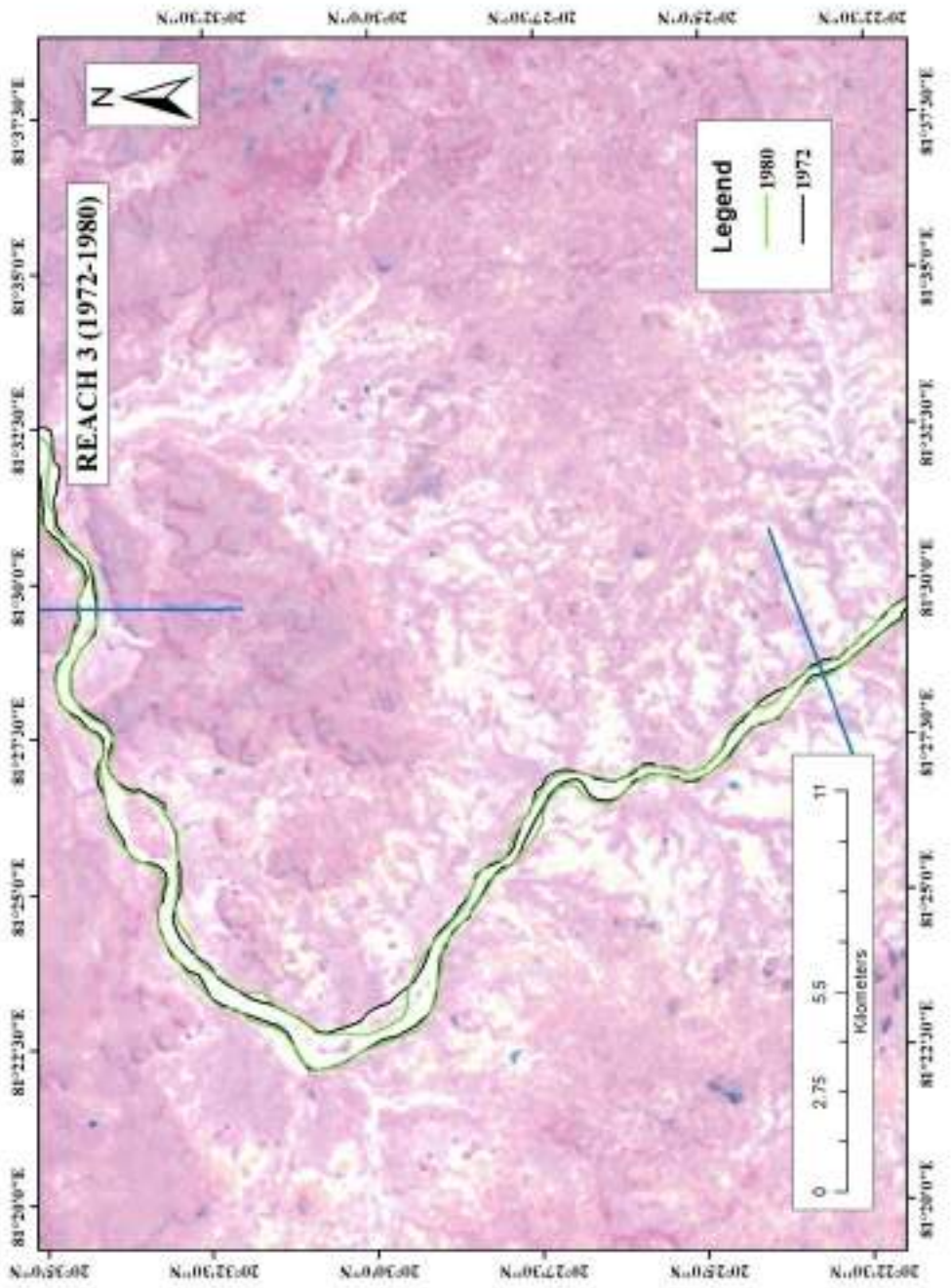


Figure 20.2: Changes in the course of Mahanadi River of Year 1972-1980

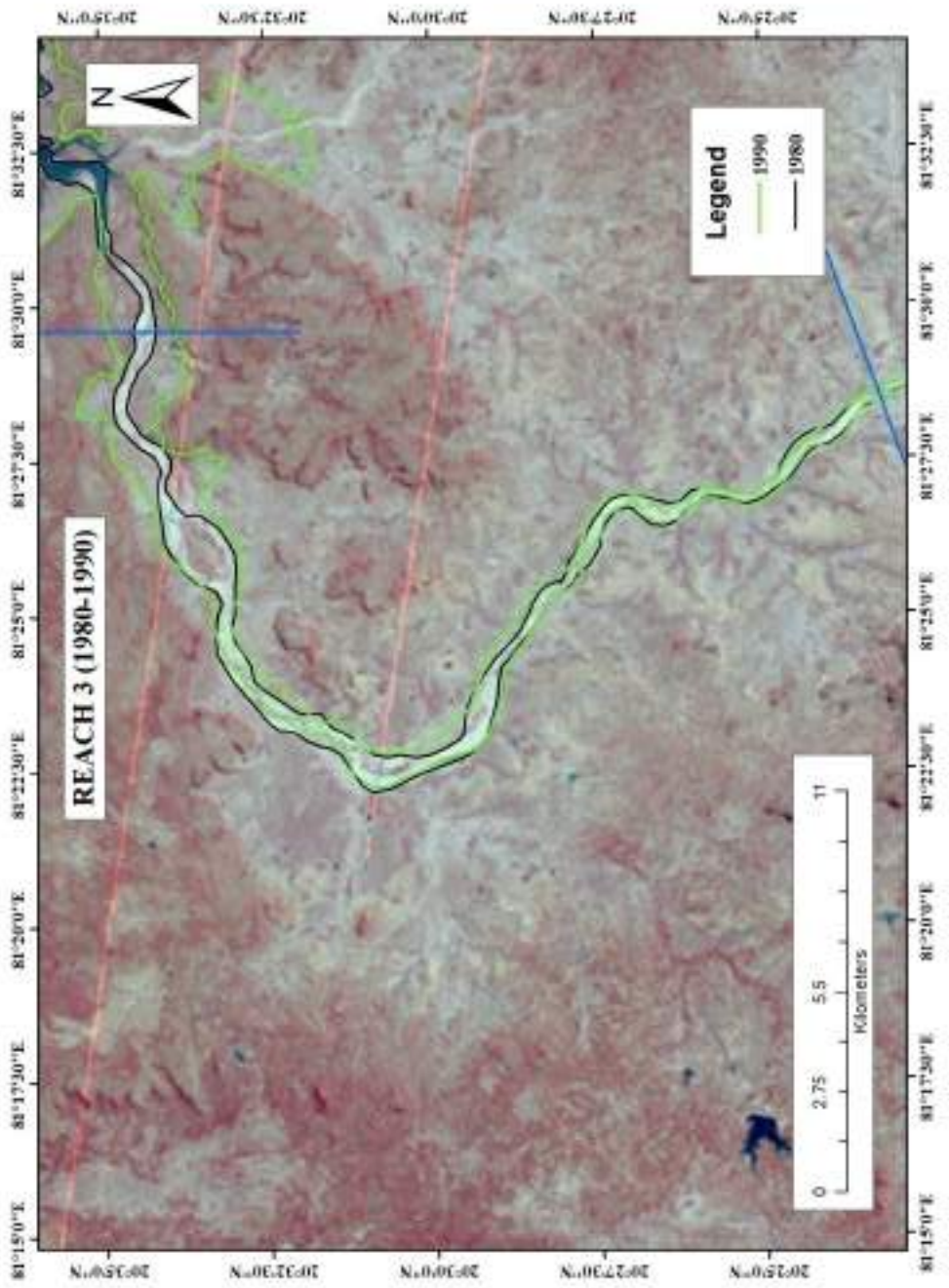


Figure 20.3: Changes in the course of Mahanadi River of Year 1980-1990

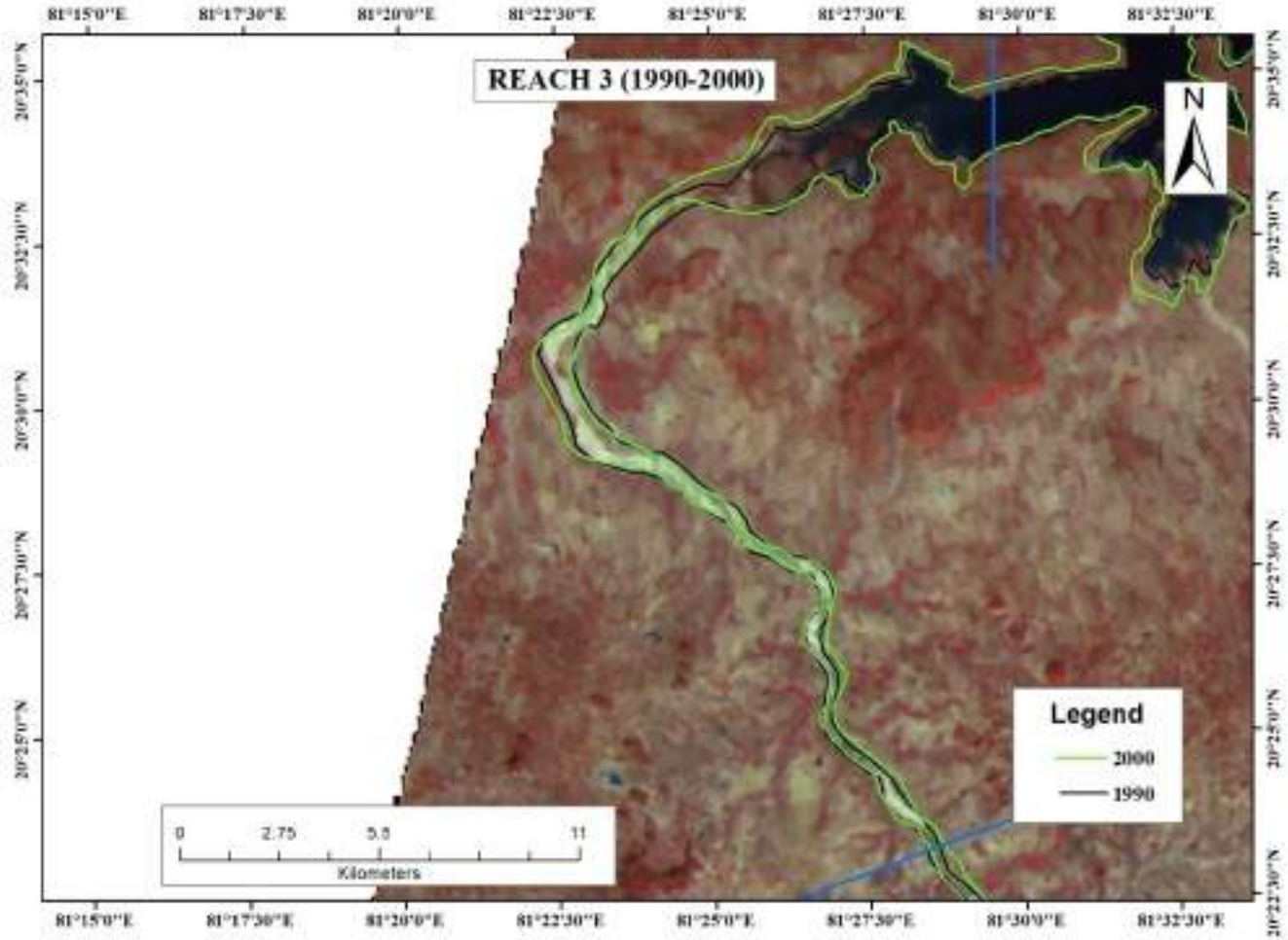


Figure 20.4: Changes in the course of Mahanadi River of Year 1990-2000

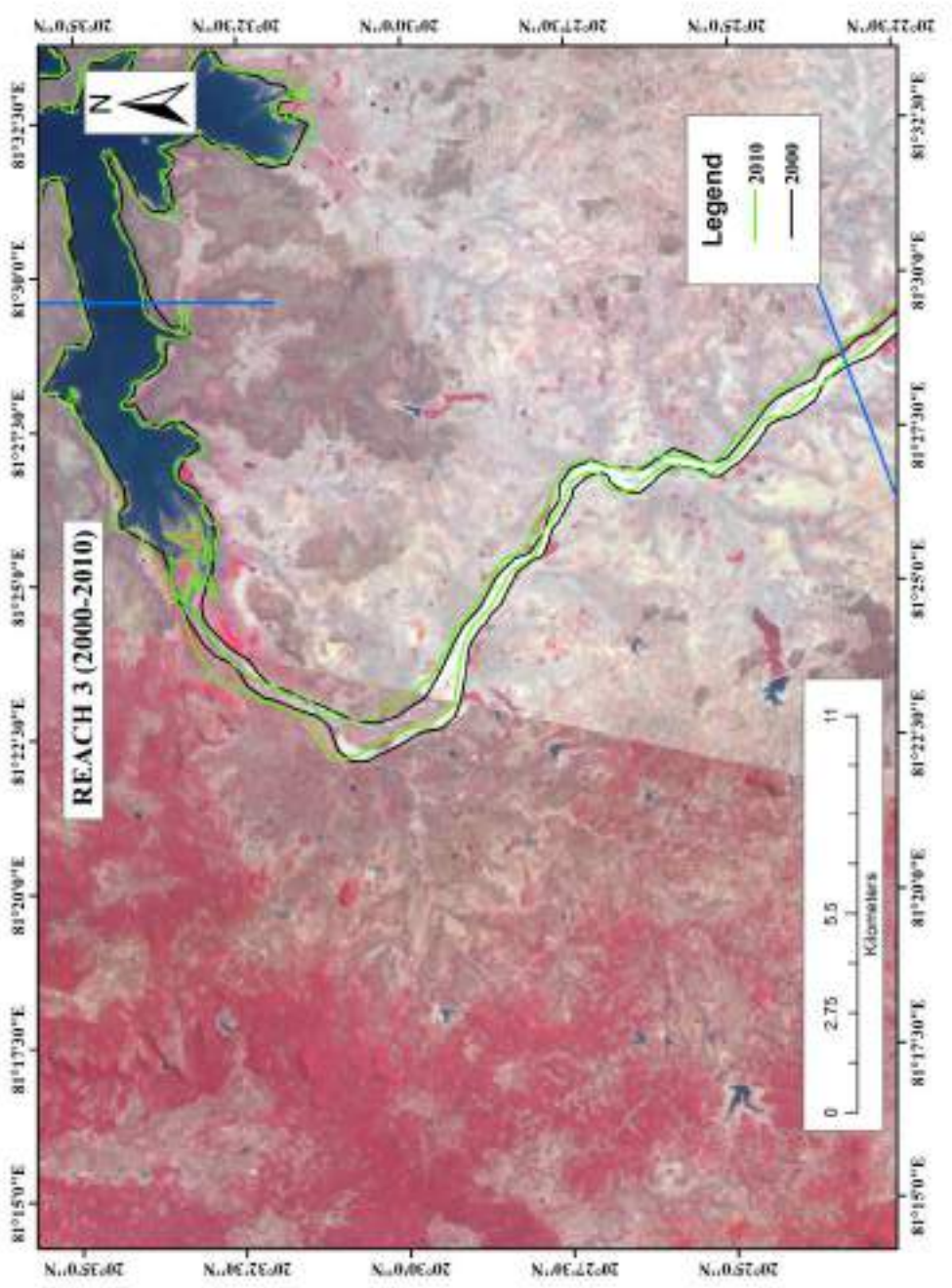


Figure 20.5: Changes in the course of Mahanadi River of Year 2000-2010

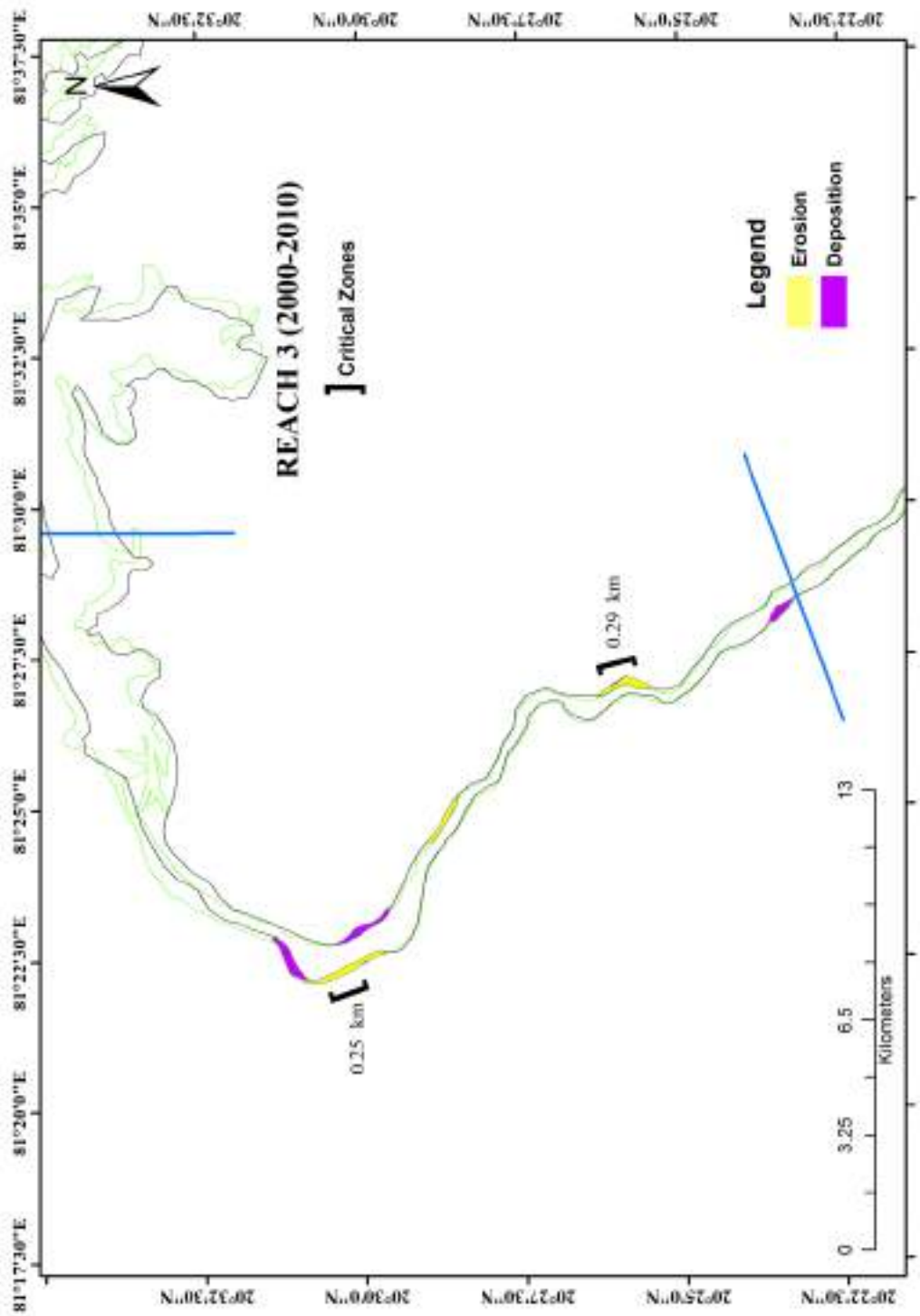


Figure 20.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 4

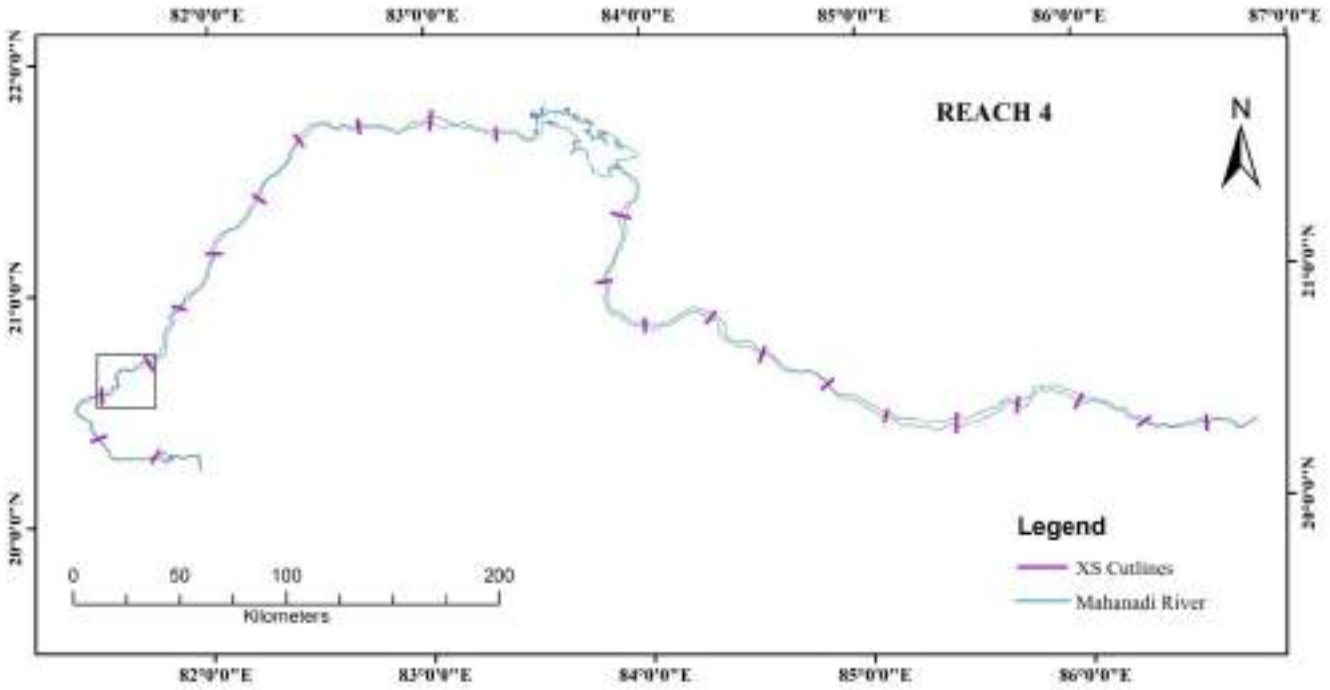


Figure 21.1: Location of reach number 4 in the Mahanadi river

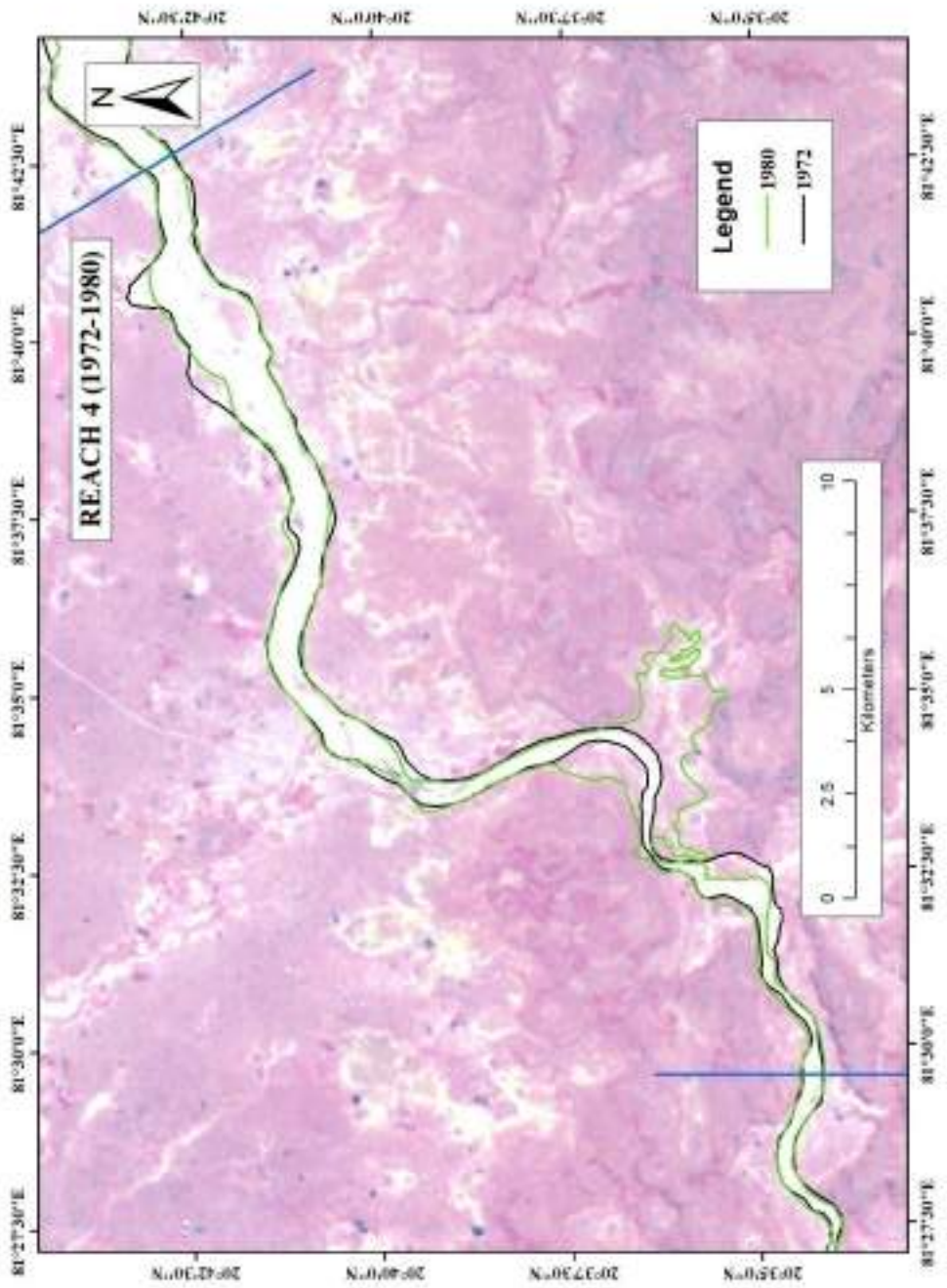


Figure 21.2: Changes in the course of Mahanadi River of Year 1972-1980

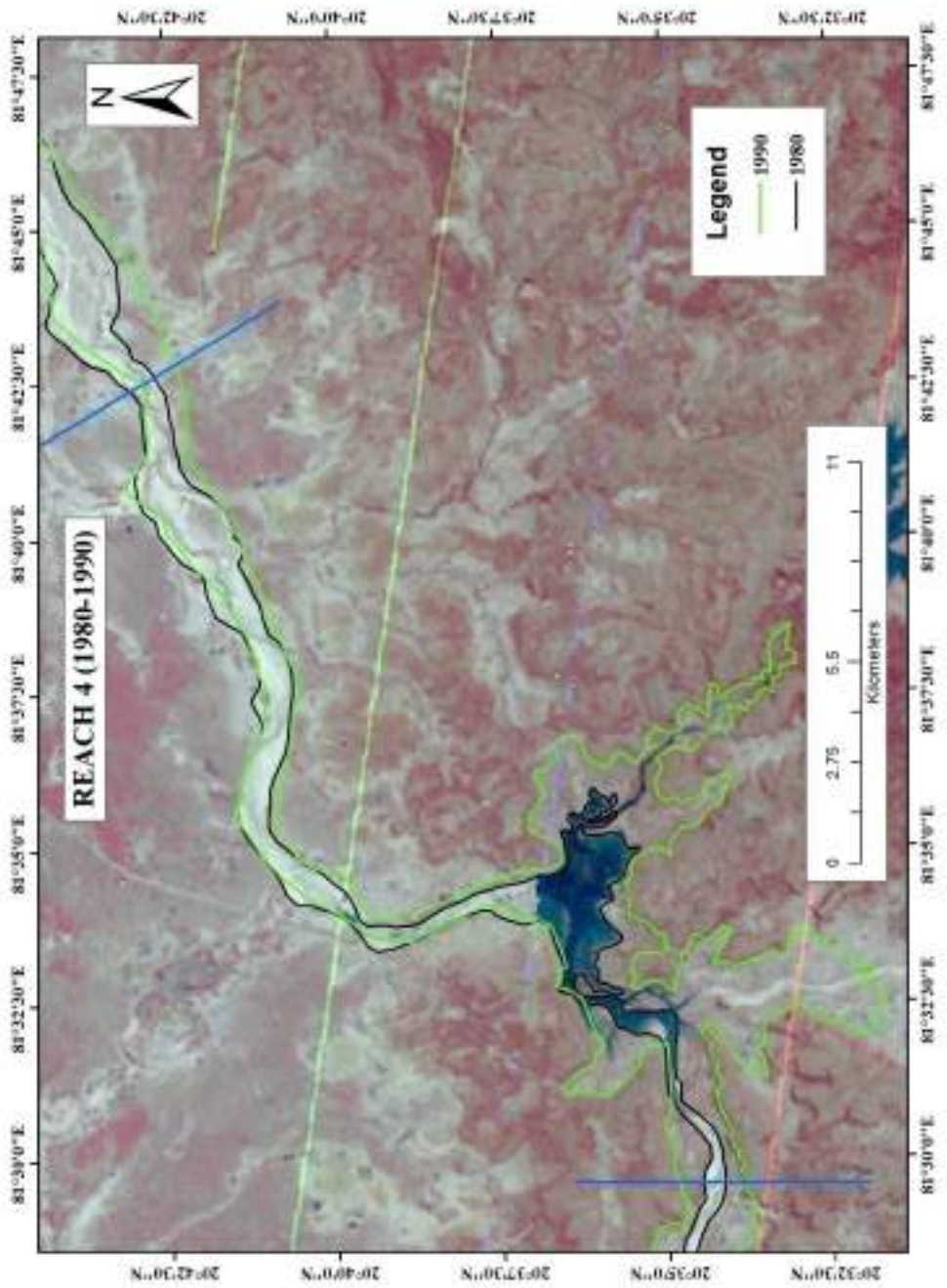


Figure 21.3: Changes in the course of Mahanadi River of Year 1980-1990

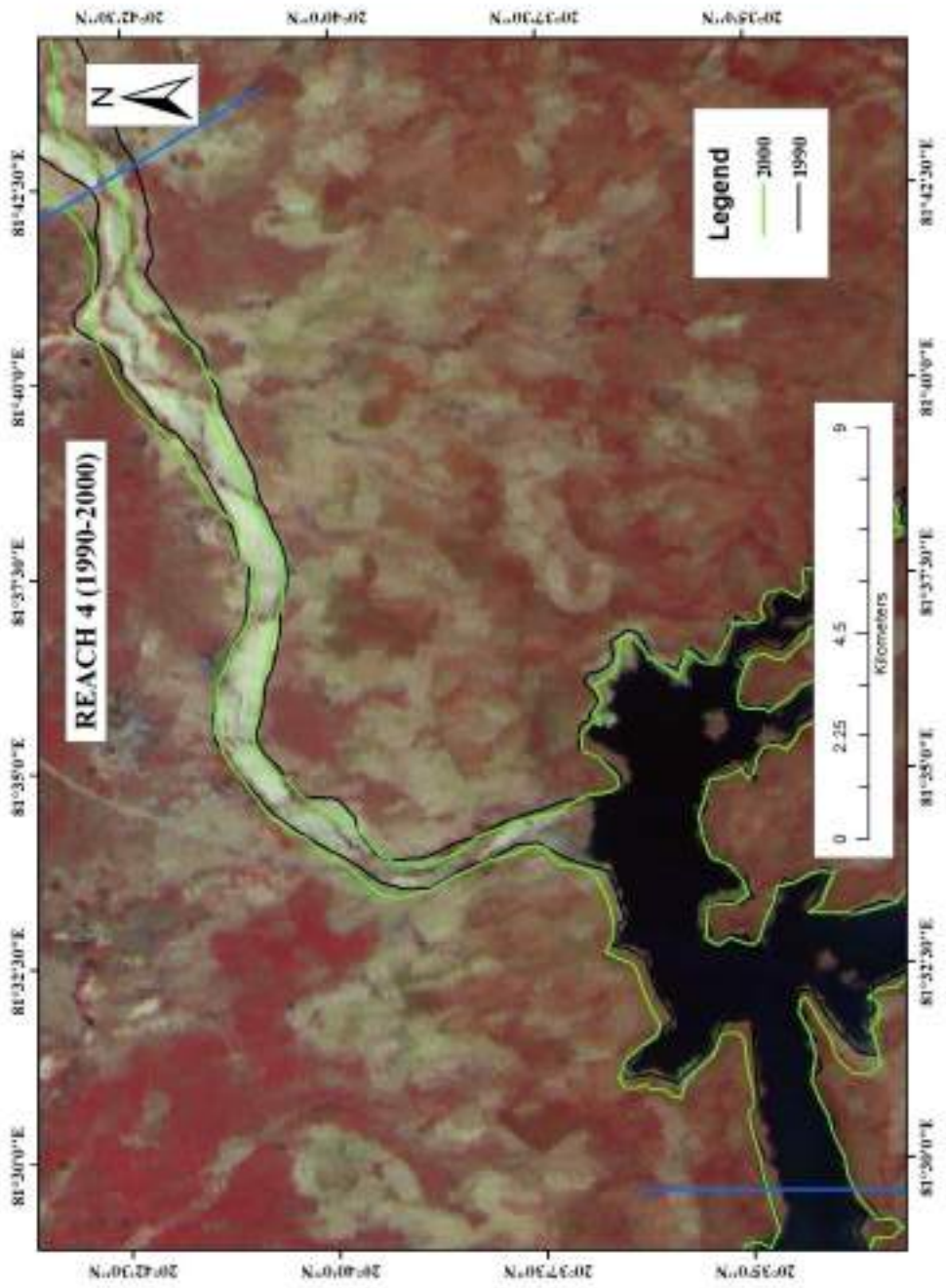


Figure 21.4: Changes in the course of Mahanadi River of Year 1990-2000

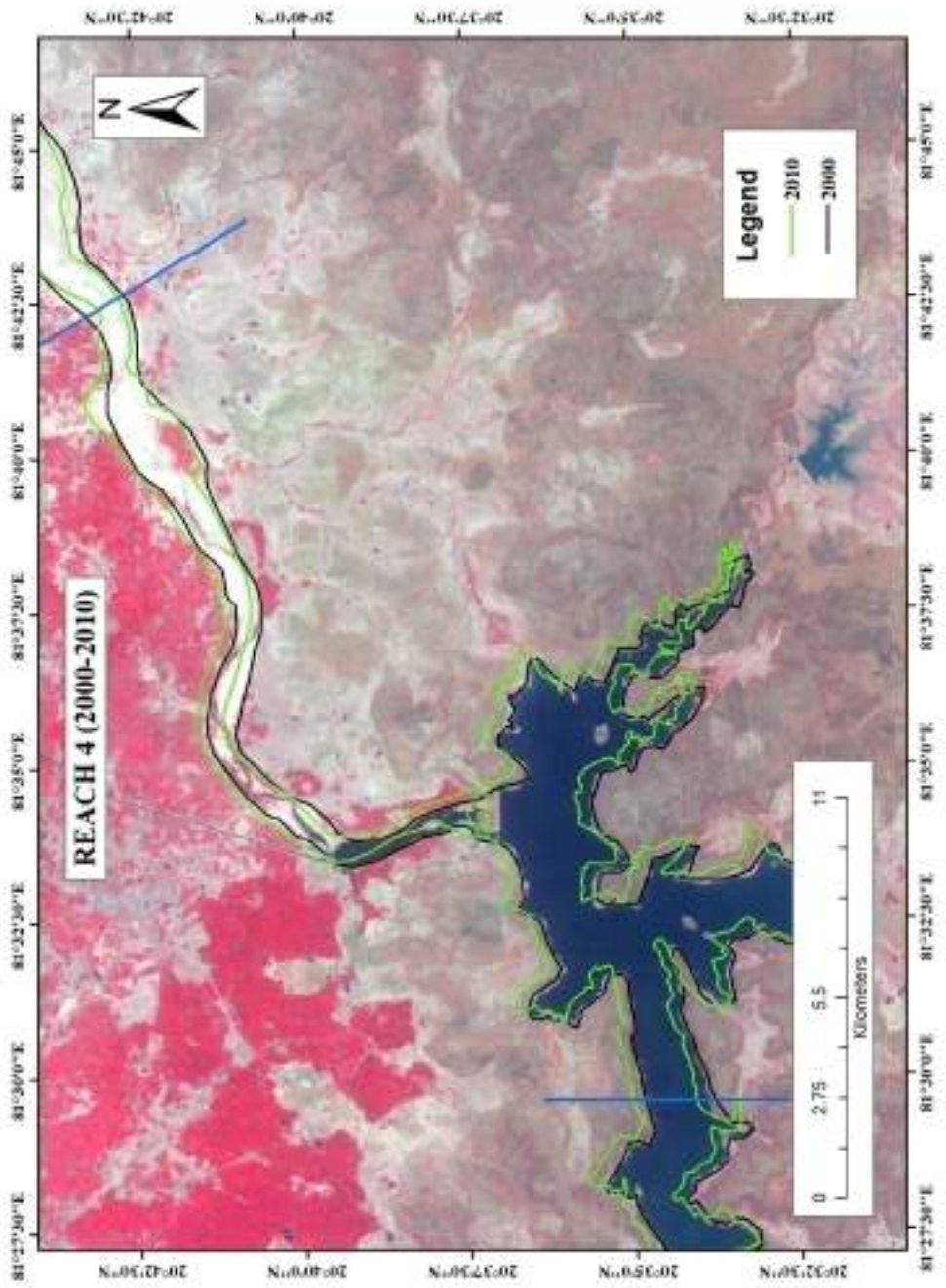


Figure 21.5: Changes in the course of Mahanadi River of Year 2000-2010

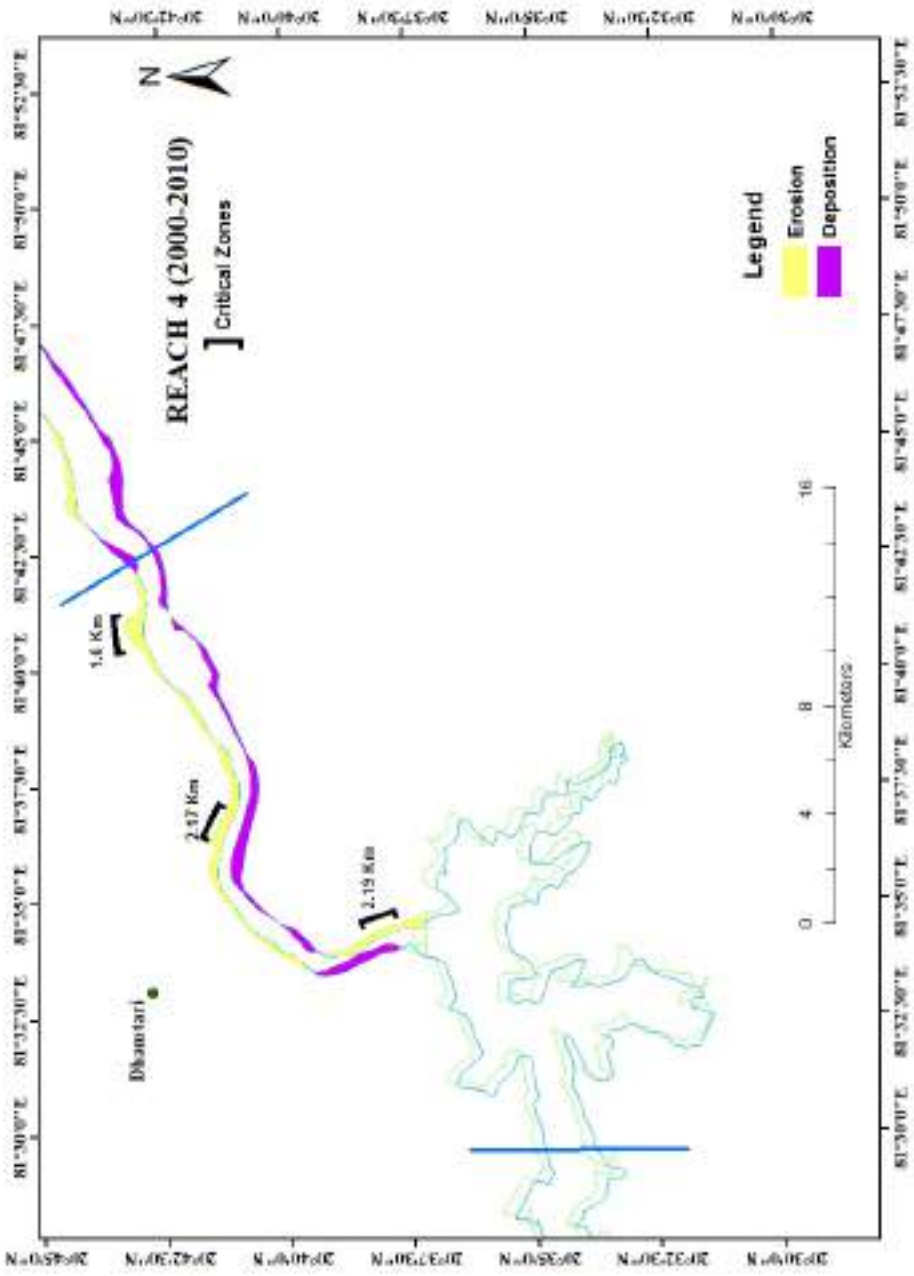


Figure 21.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 5

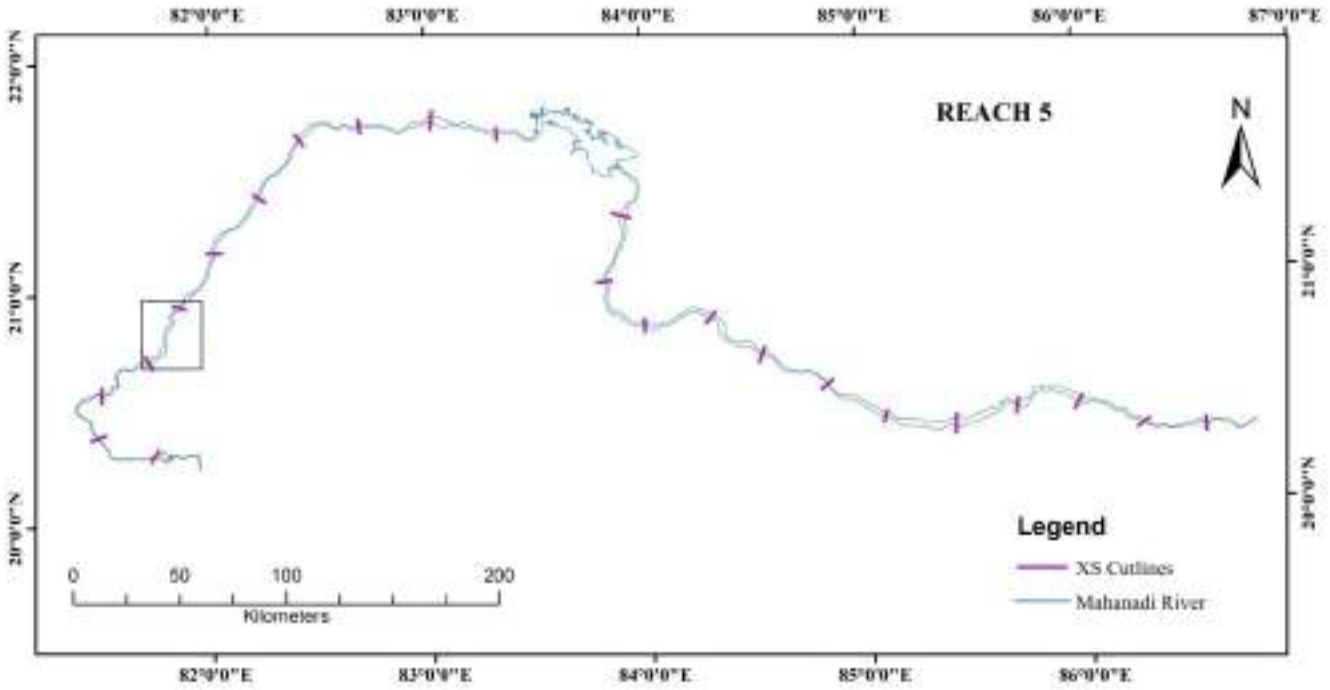


Figure 22.1: Location of reach number 5 in the Mahanadi river

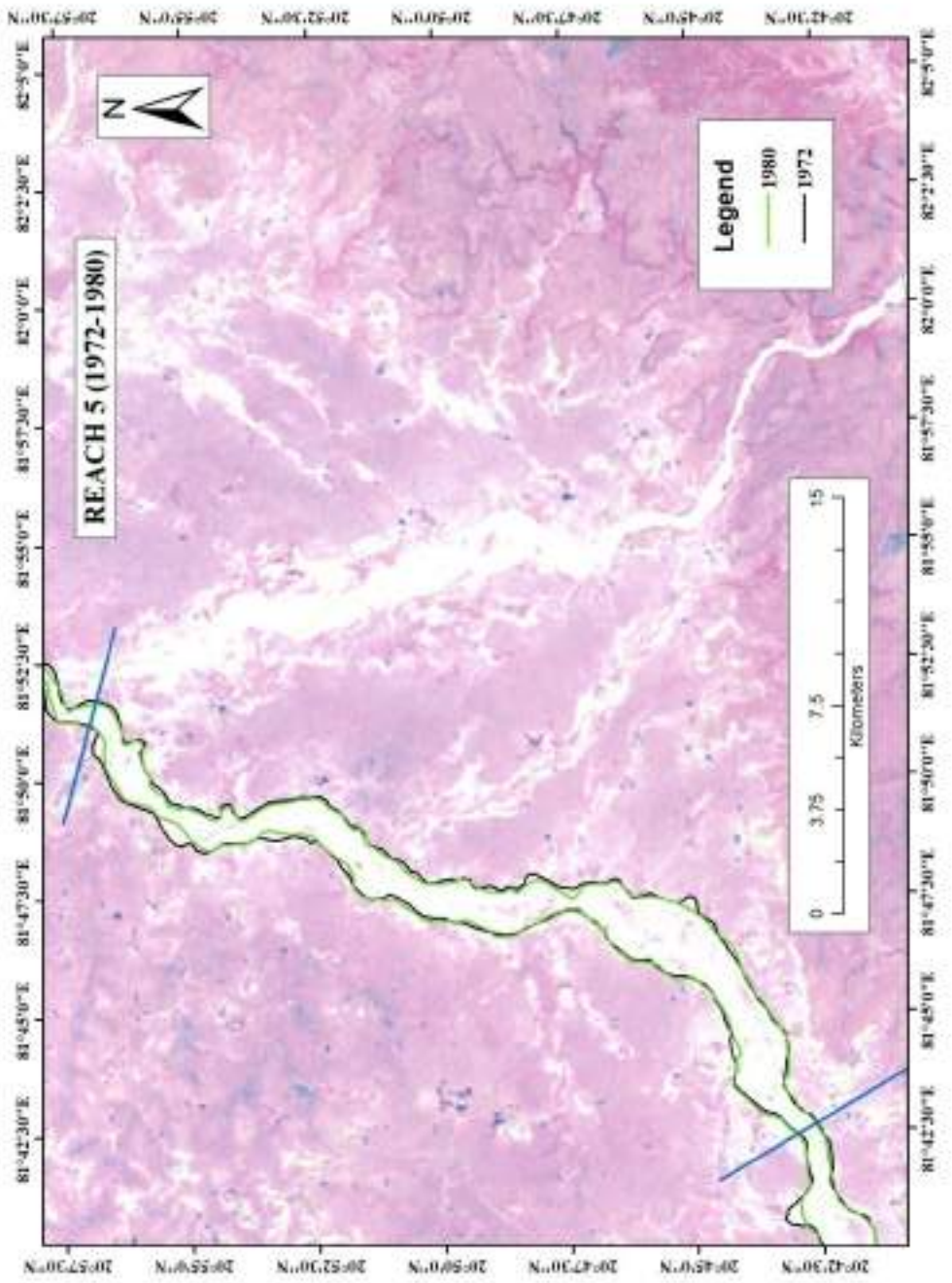


Figure 22.2: Changes in the course of Mahanadi River of Year 1972-1980

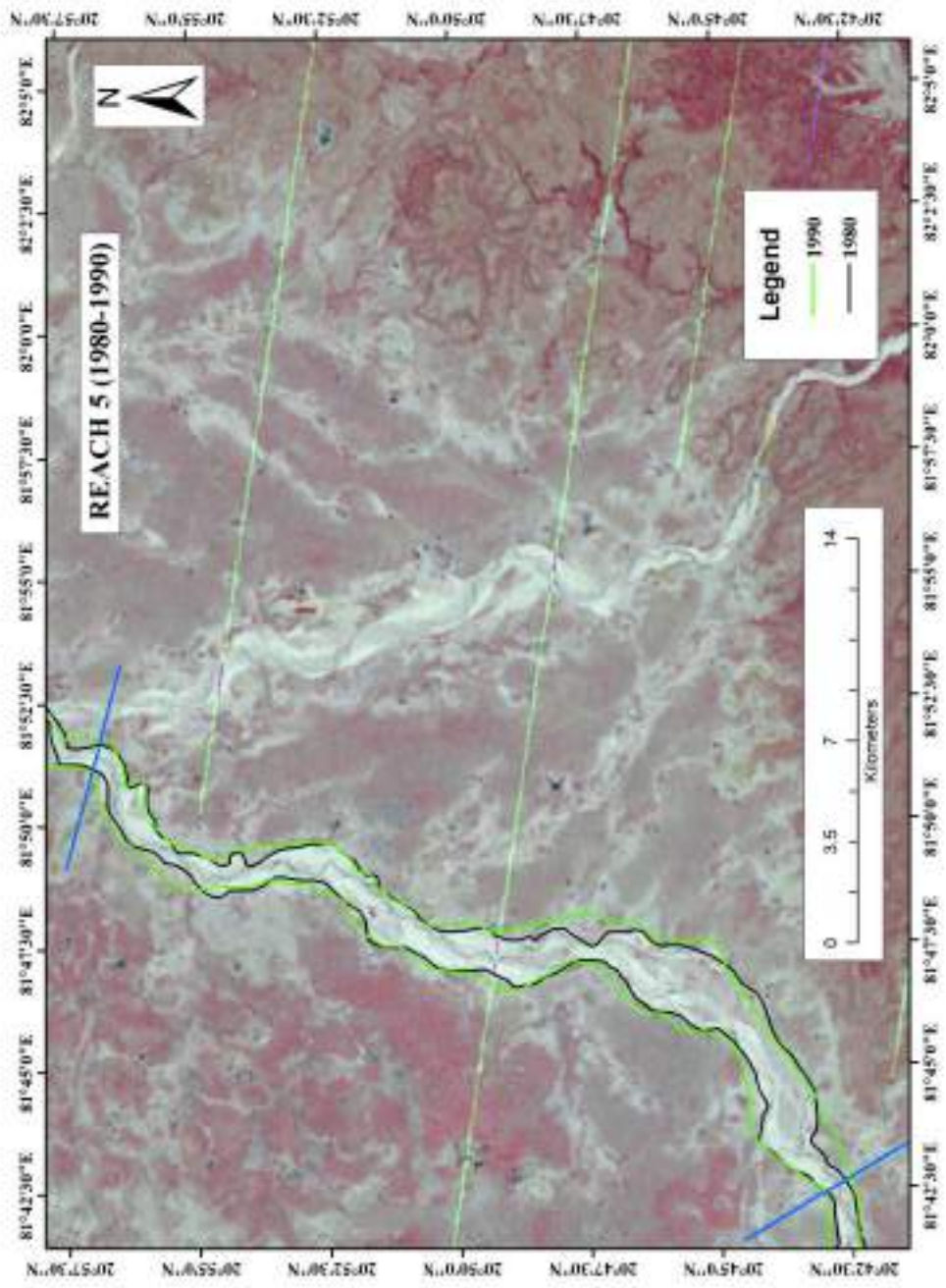


Figure 22.3: Changes in the course of Mahanadi River of Year 1980-1990

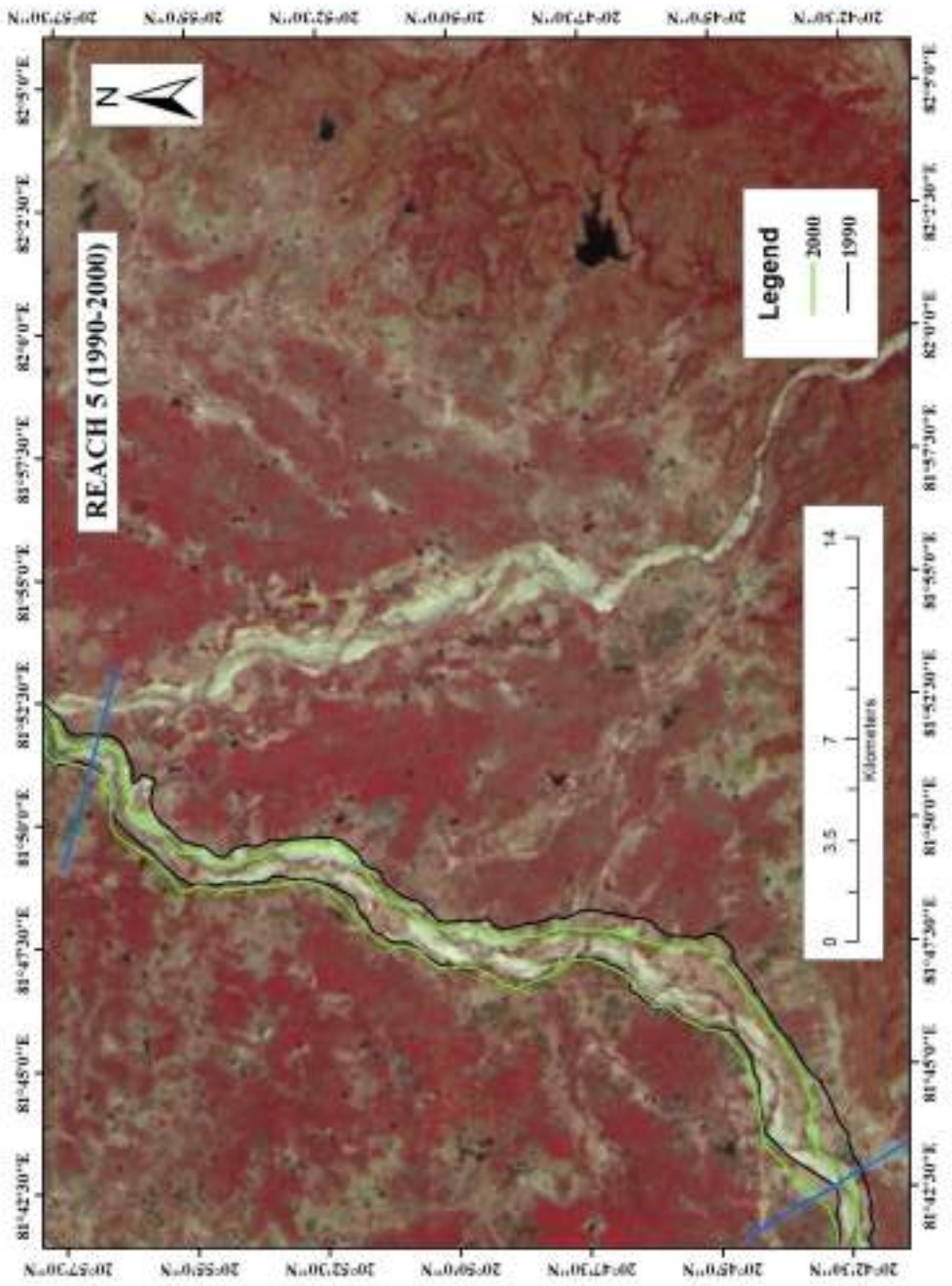


Figure 22.4: Changes in the course of Mahanadi River of Year 1990-2000

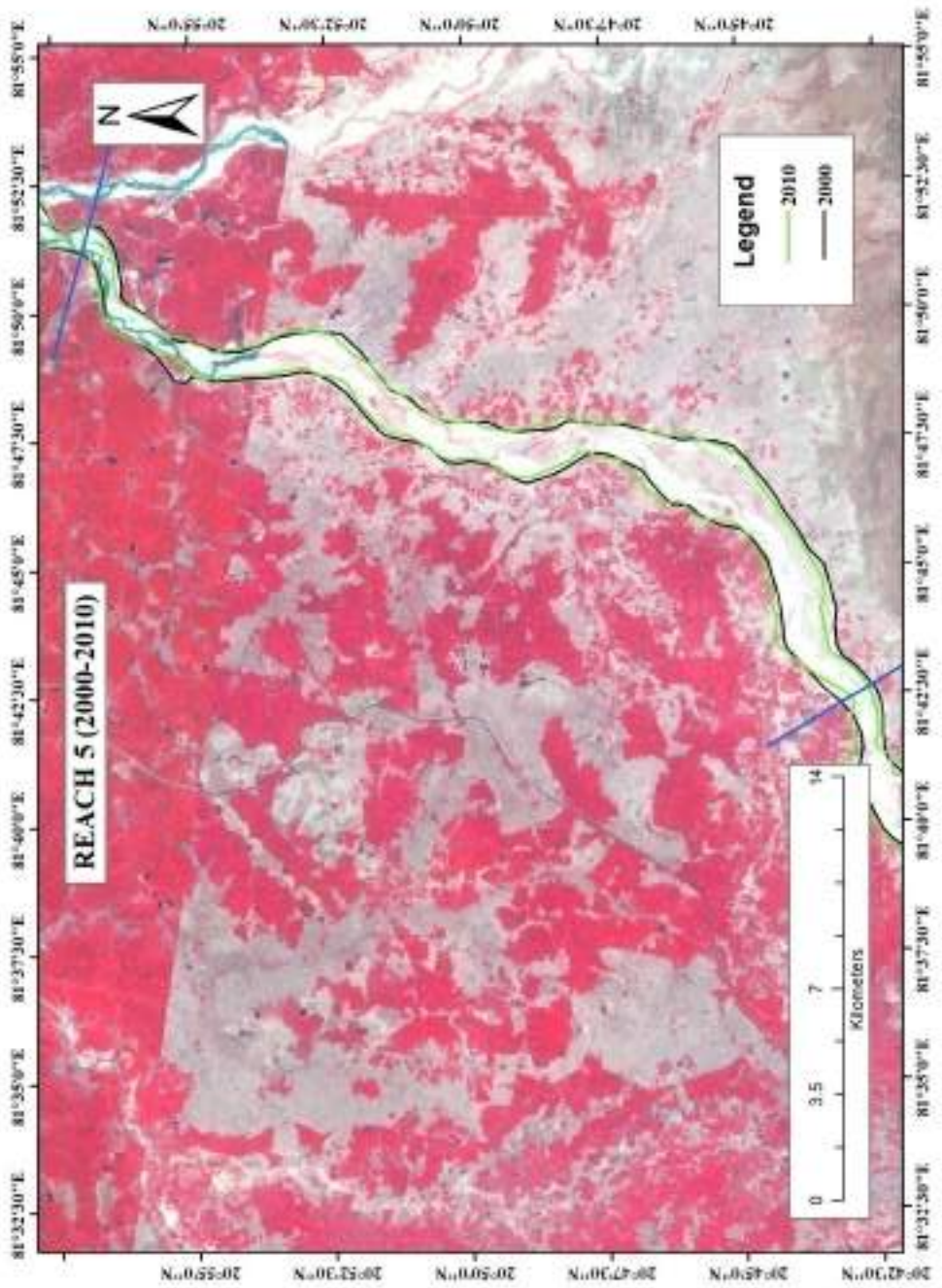


Figure 22.5: Changes in the course of Mahanadi River of Year 2000-2010

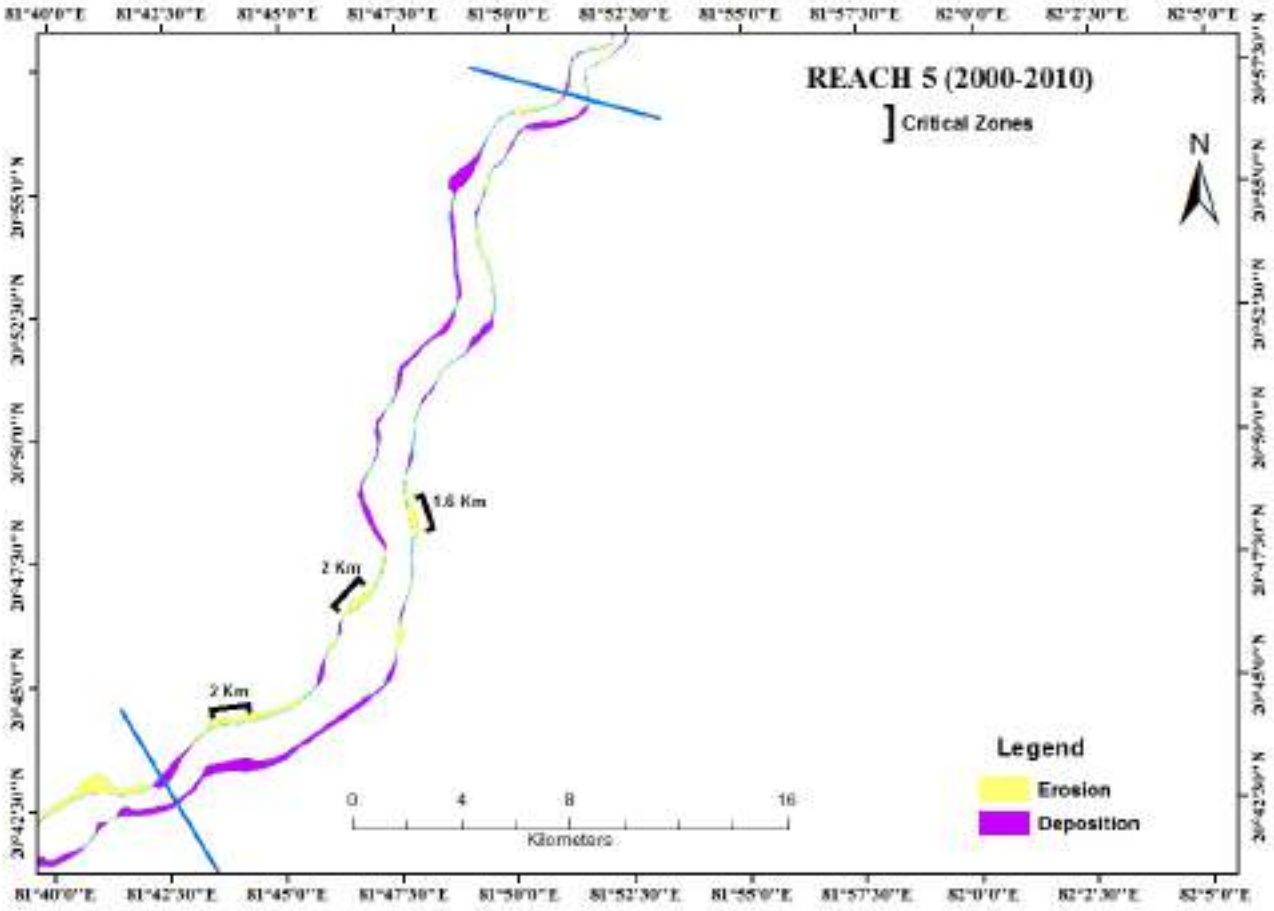


Figure 22.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 6

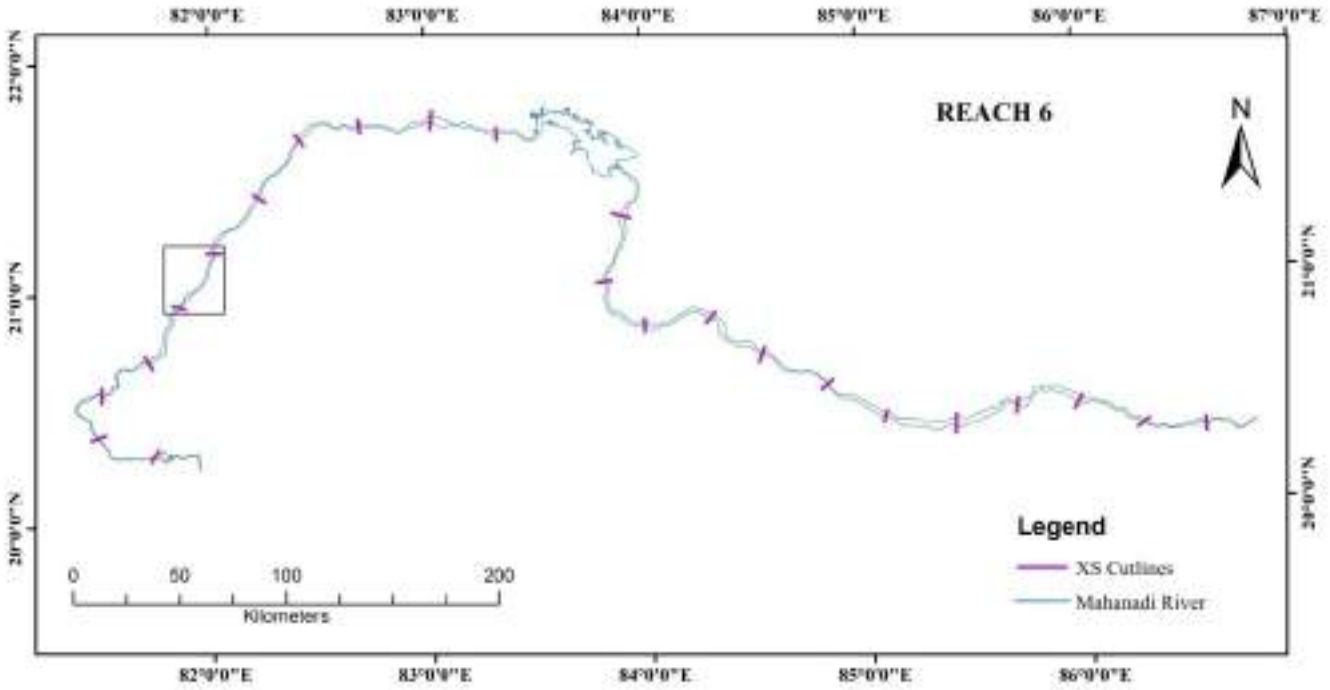


Figure 23.1: Location of reach number 6 in the Mahanadi river

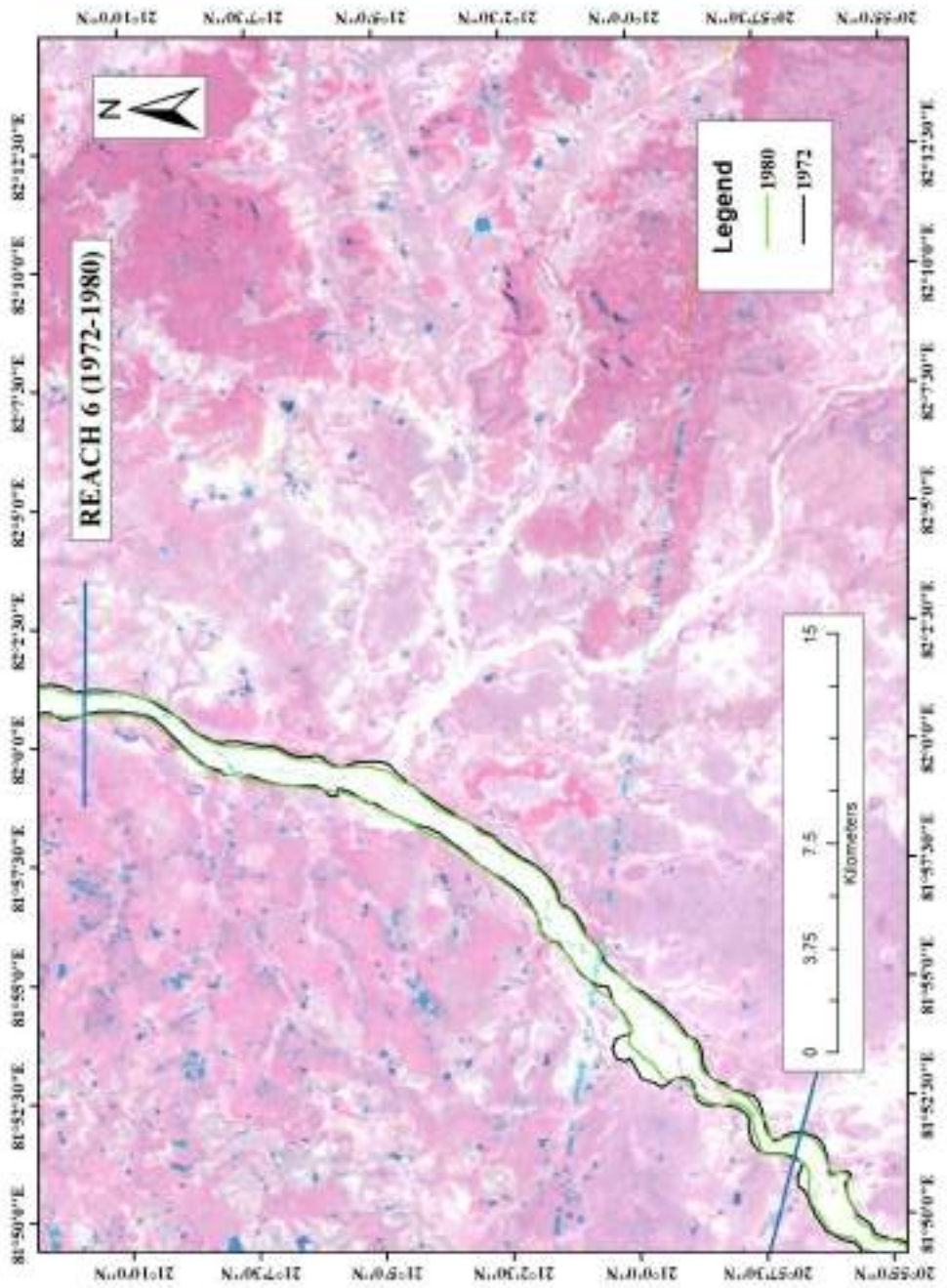


Figure 23.2: Changes in the course of Mahanadi River of Year 1972-1980

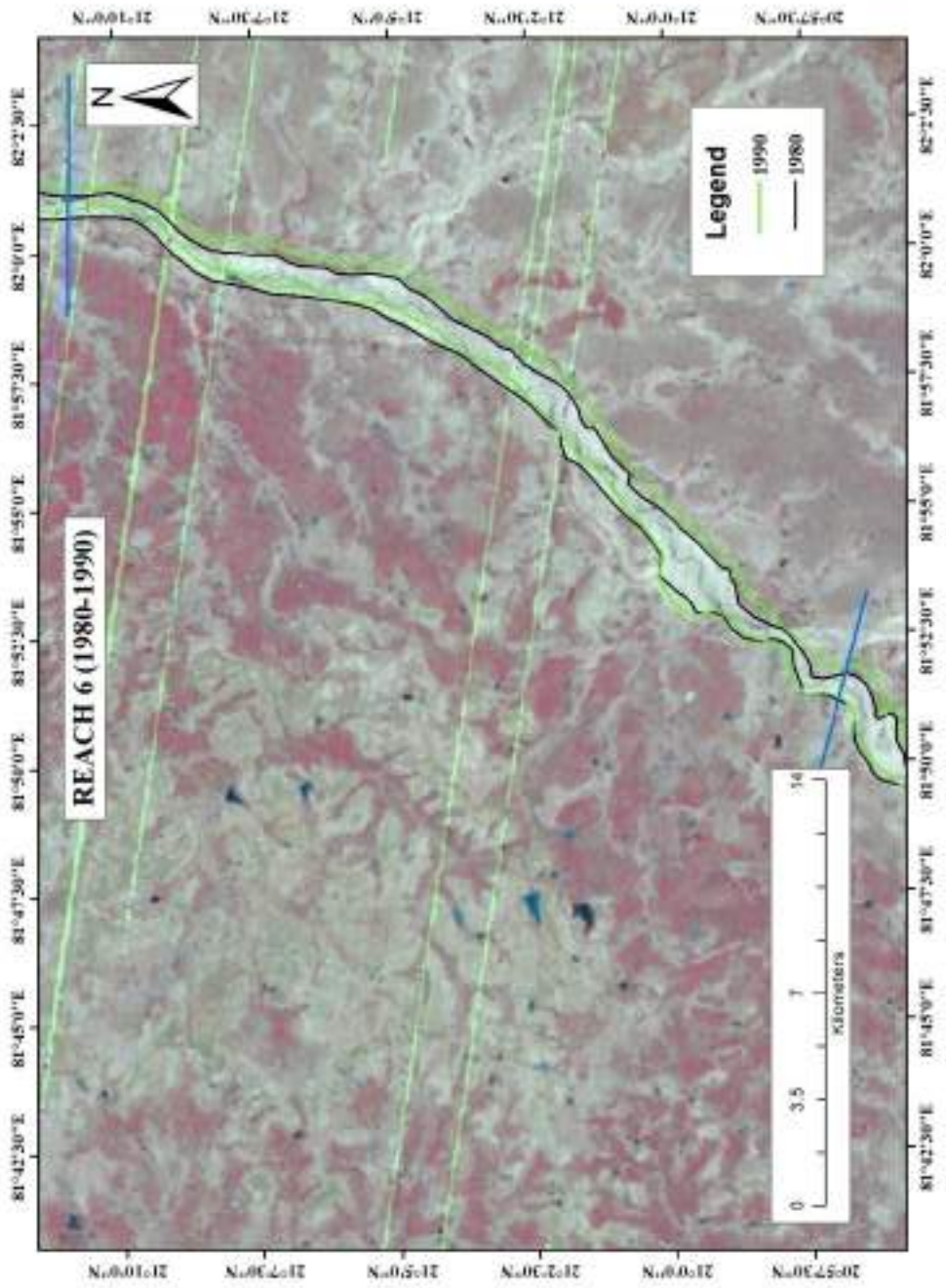


Figure 23.3: Changes in the course of Mahanadi River of Year 1980-1990

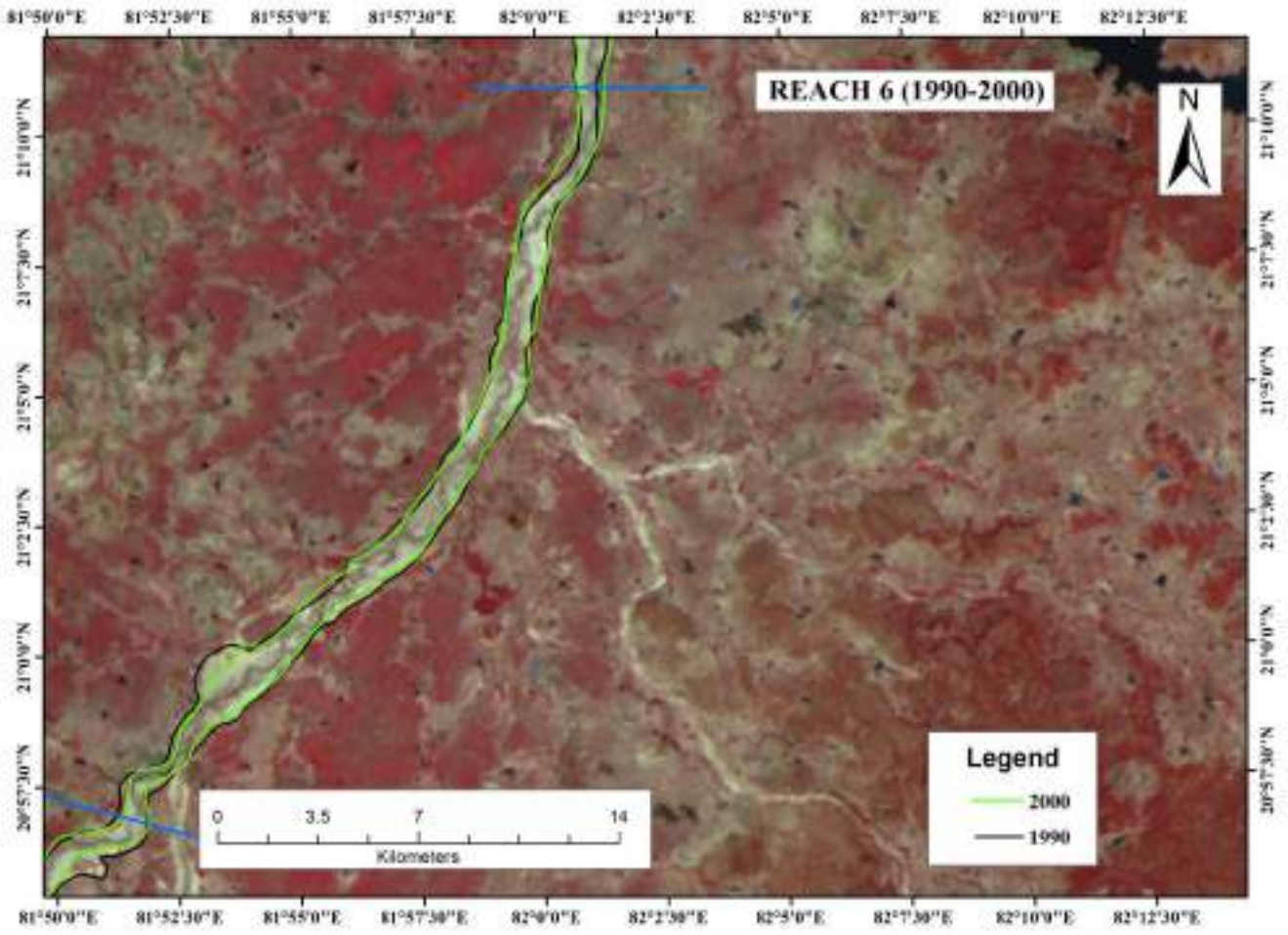


Figure 23.4: Changes in the course of Mahanadi River of Year 1990-2000

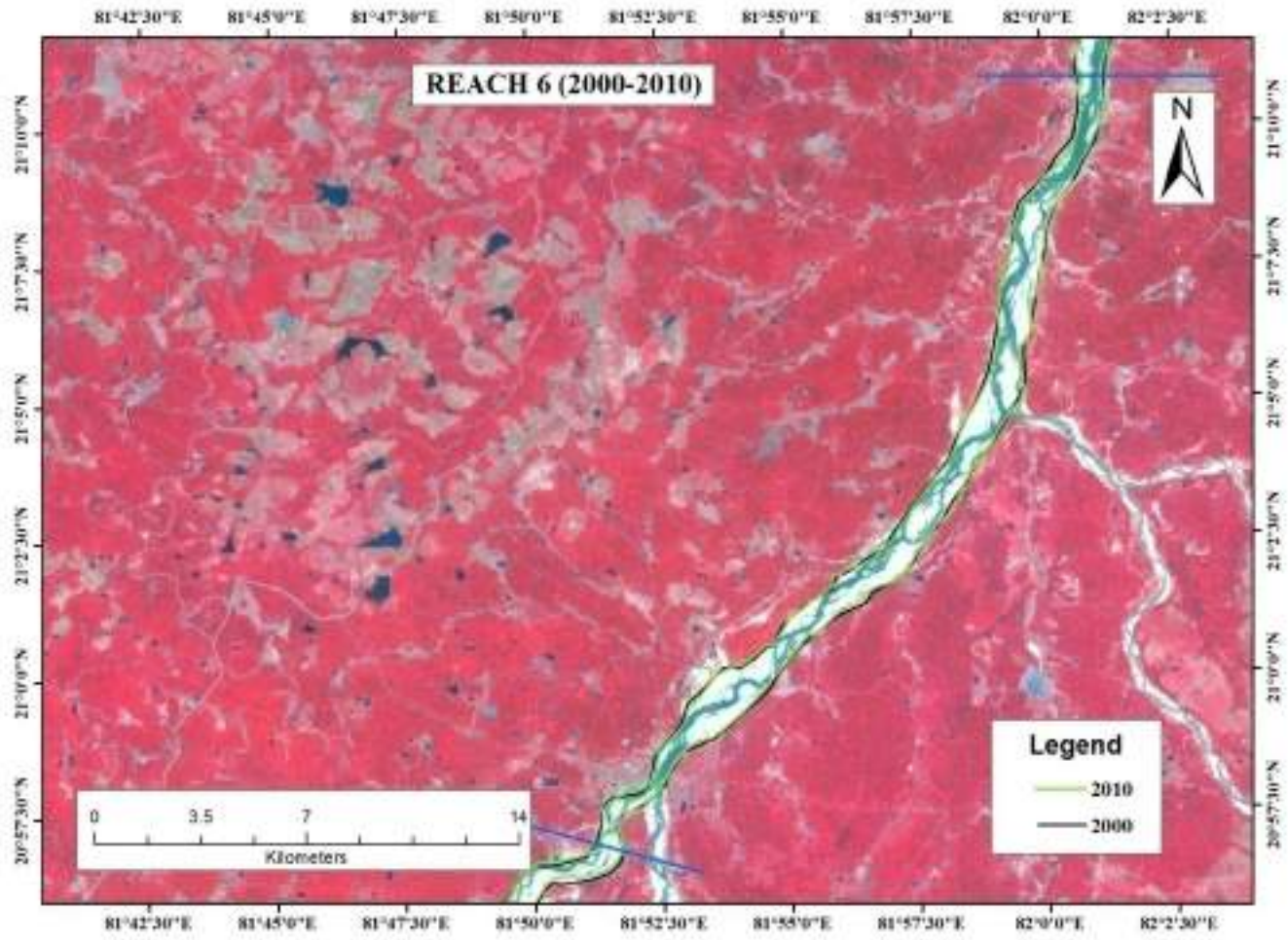


Figure 23.5: Changes in the course of Mahanadi River of Year 2000-2010

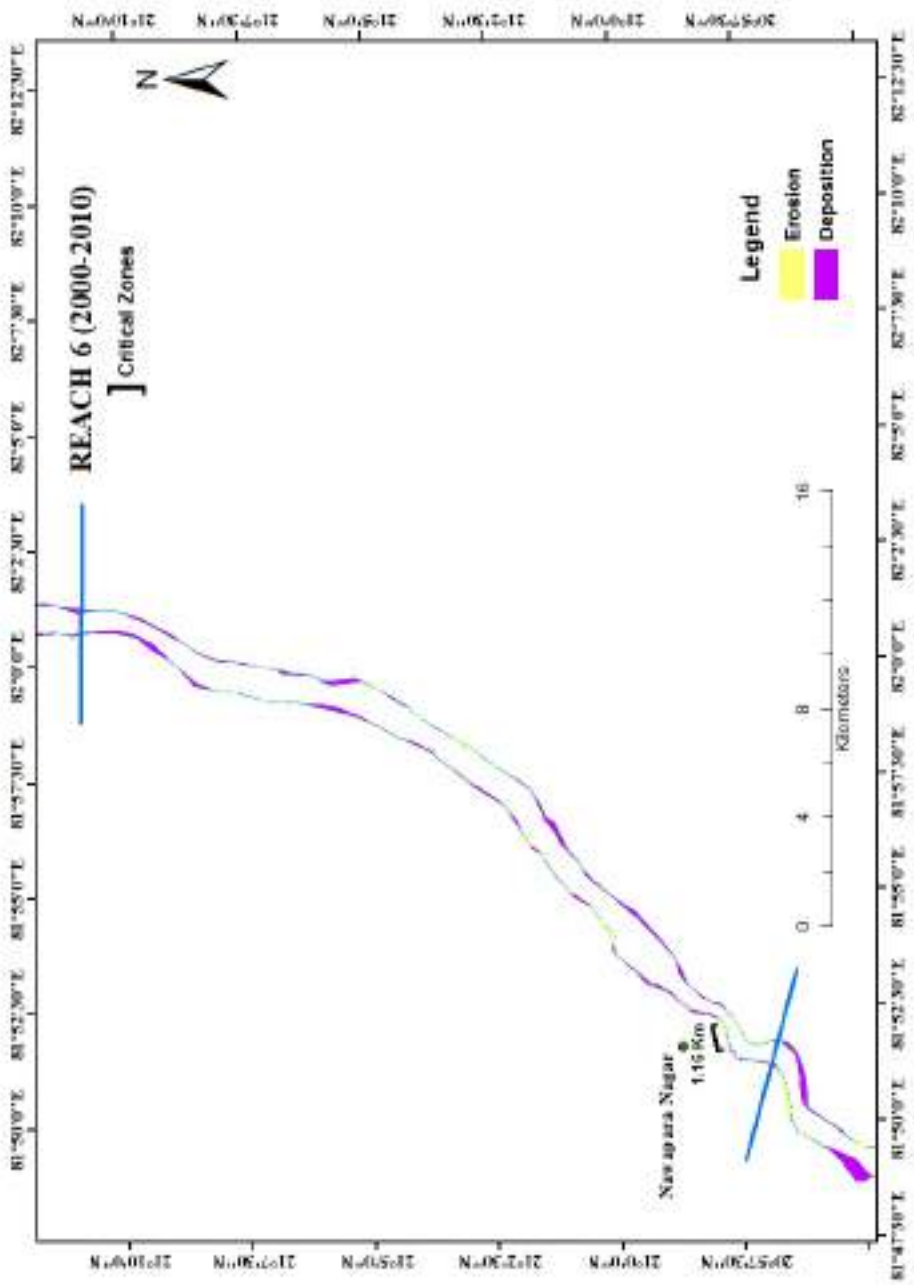


Figure 23.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 7

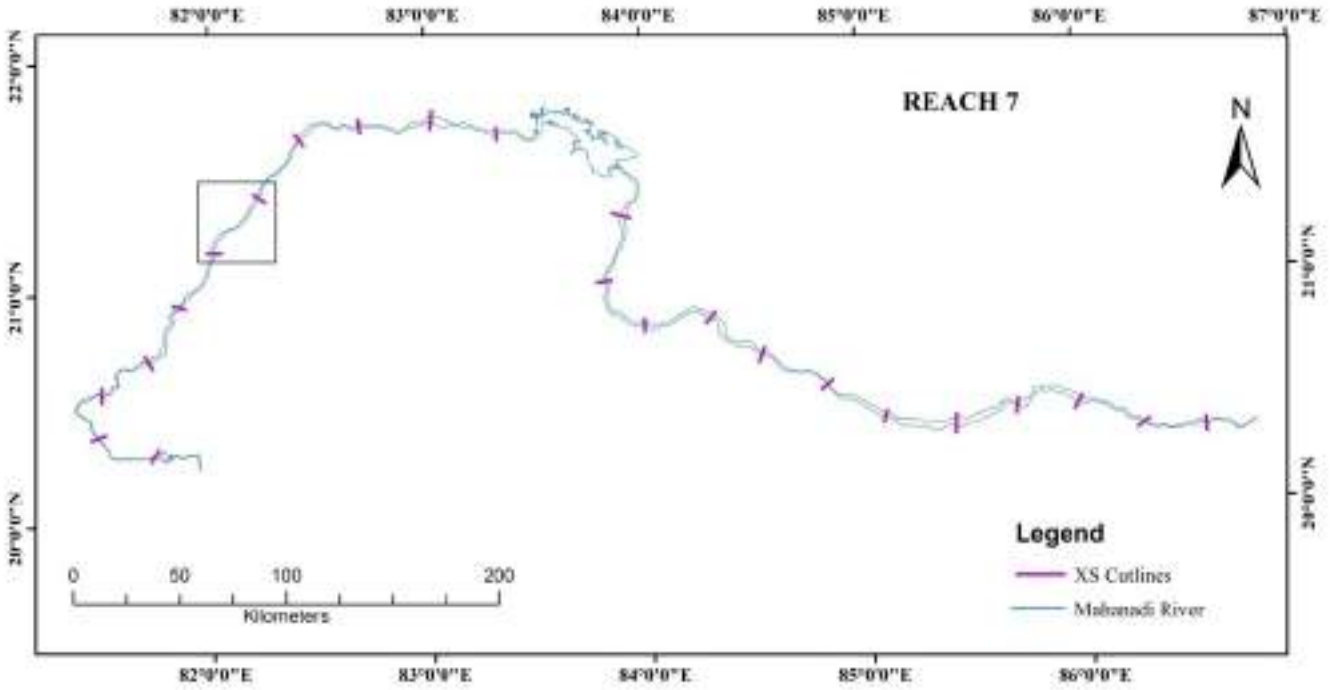


Figure 24.1: Location of reach number 7 in the Mahanadi river

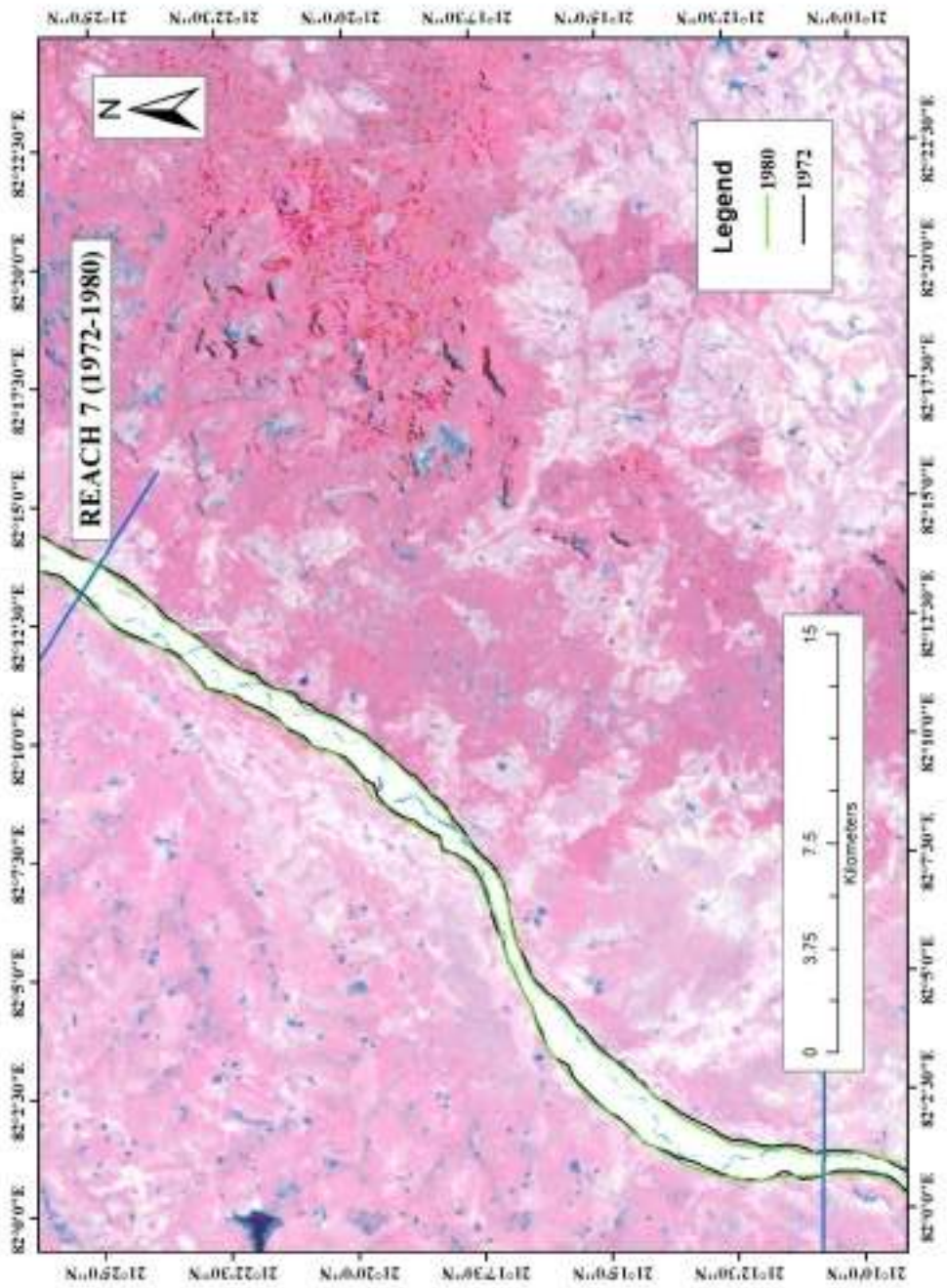


Figure 24.2: Changes in the course of Mahanadi River of Year 1972-1980

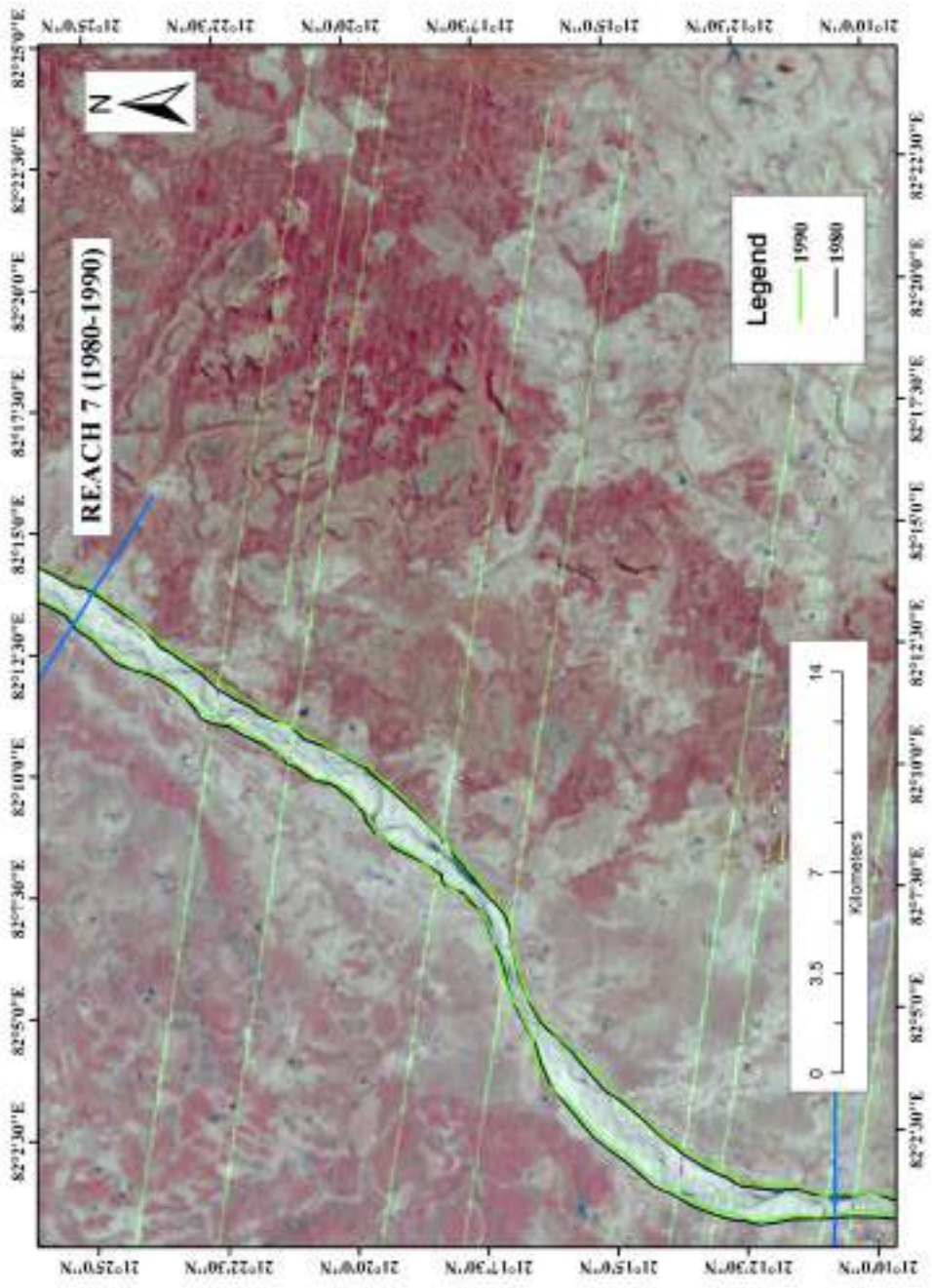


Figure 24.3: Changes in the course of Mahanadi River of Year 1980-1990

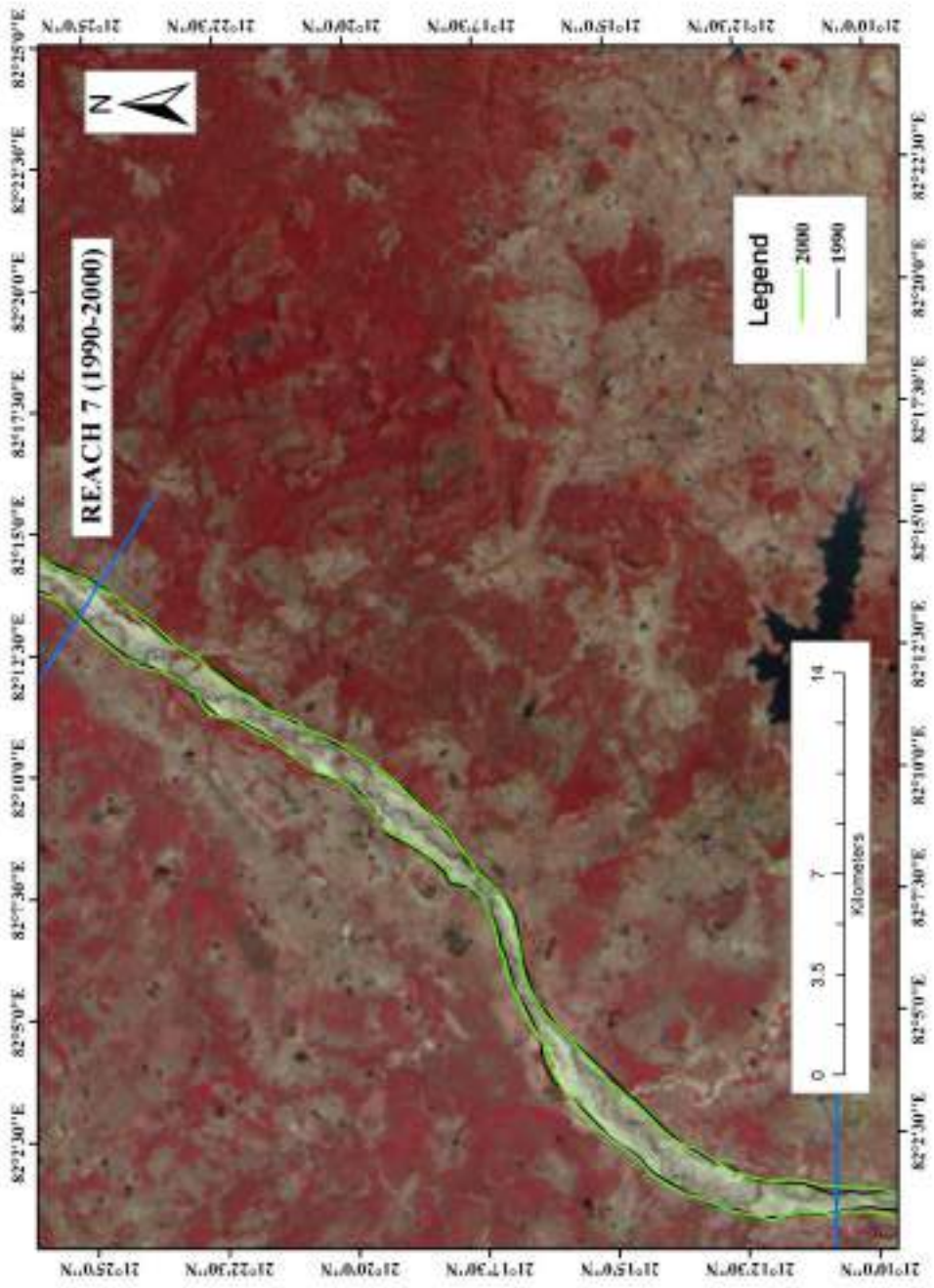


Figure 24.4: Changes in the course of Mahanadi River of Year 1990-2000

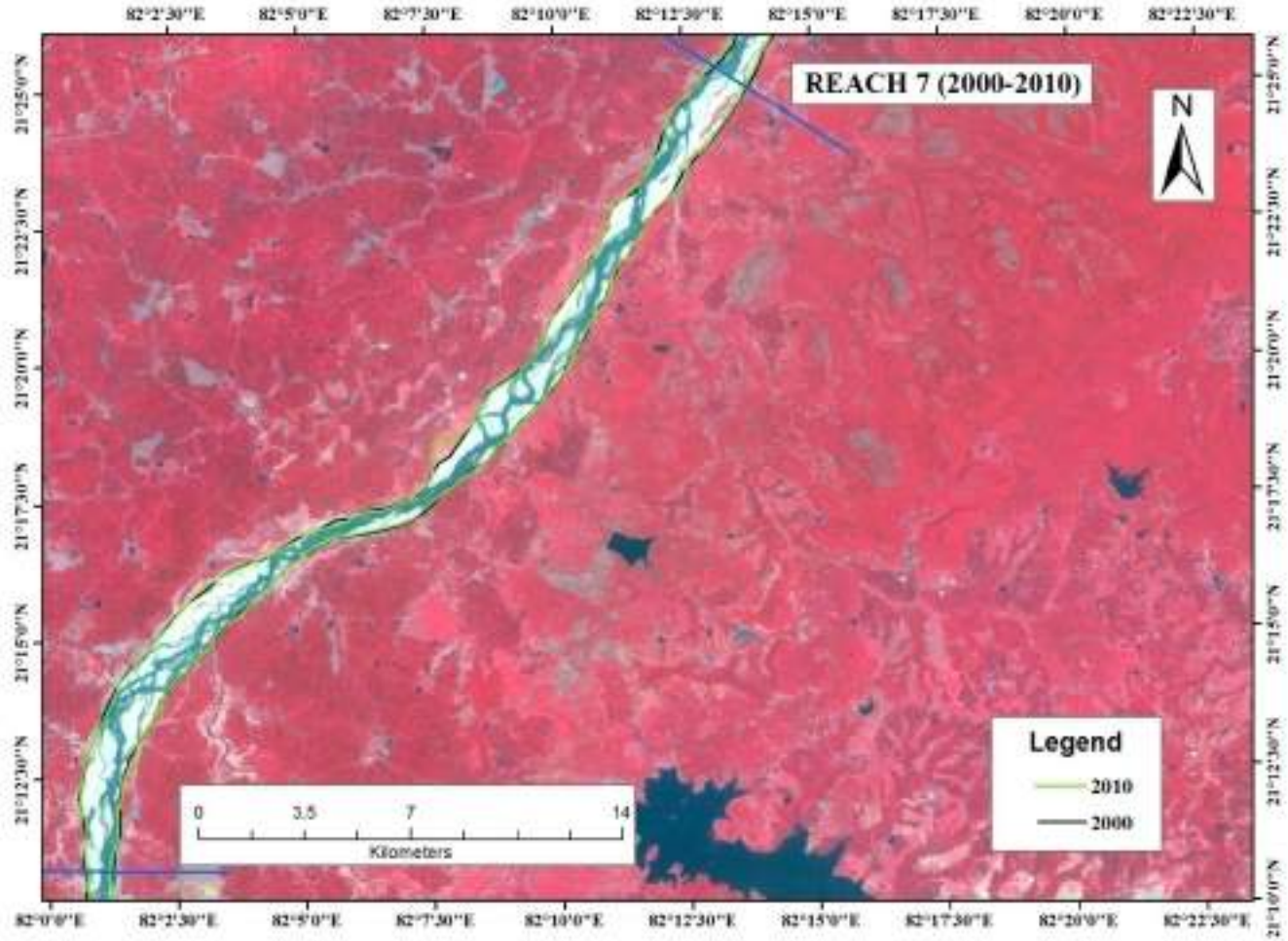


Figure 24.5: Changes in the course of Mahanadi River of Year 2000-2010

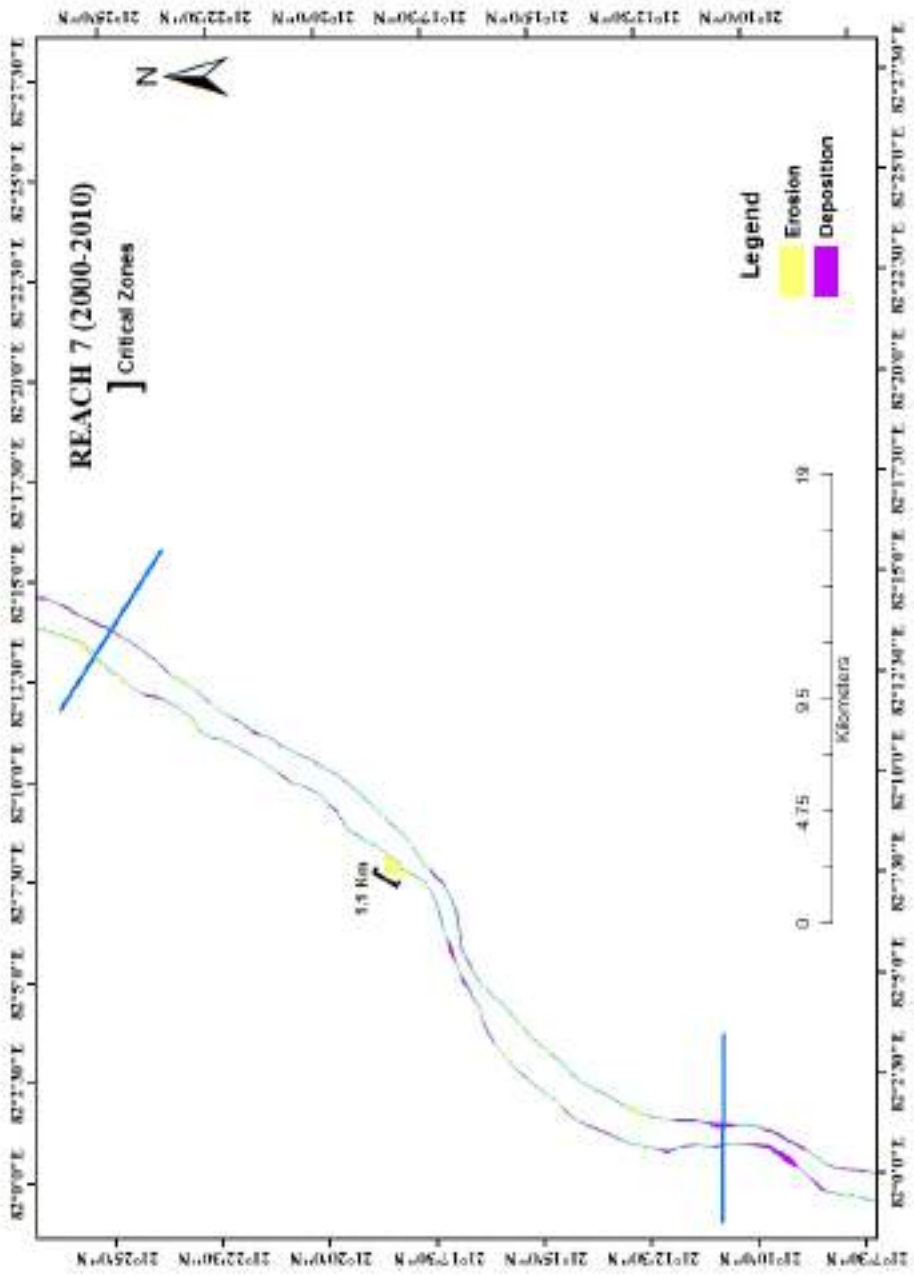


Figure 24.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 8

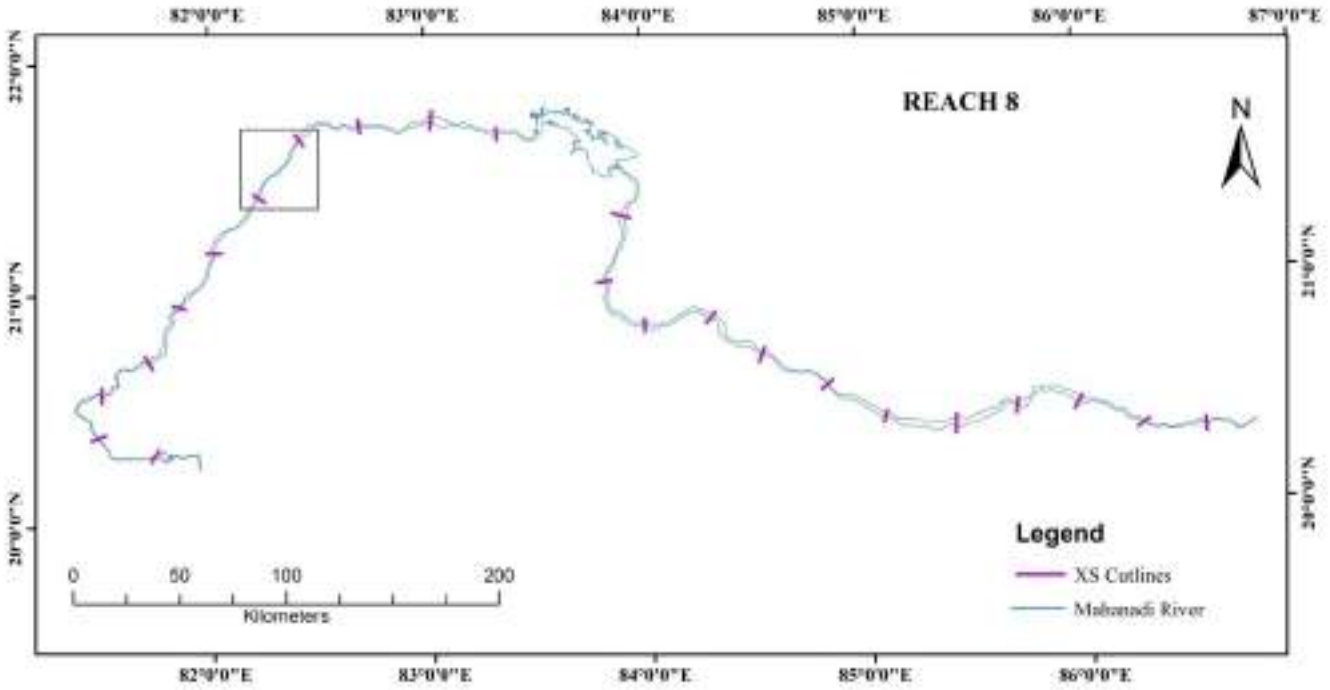


Figure 24.1: Location of reach number 8 in the Mahanadi river

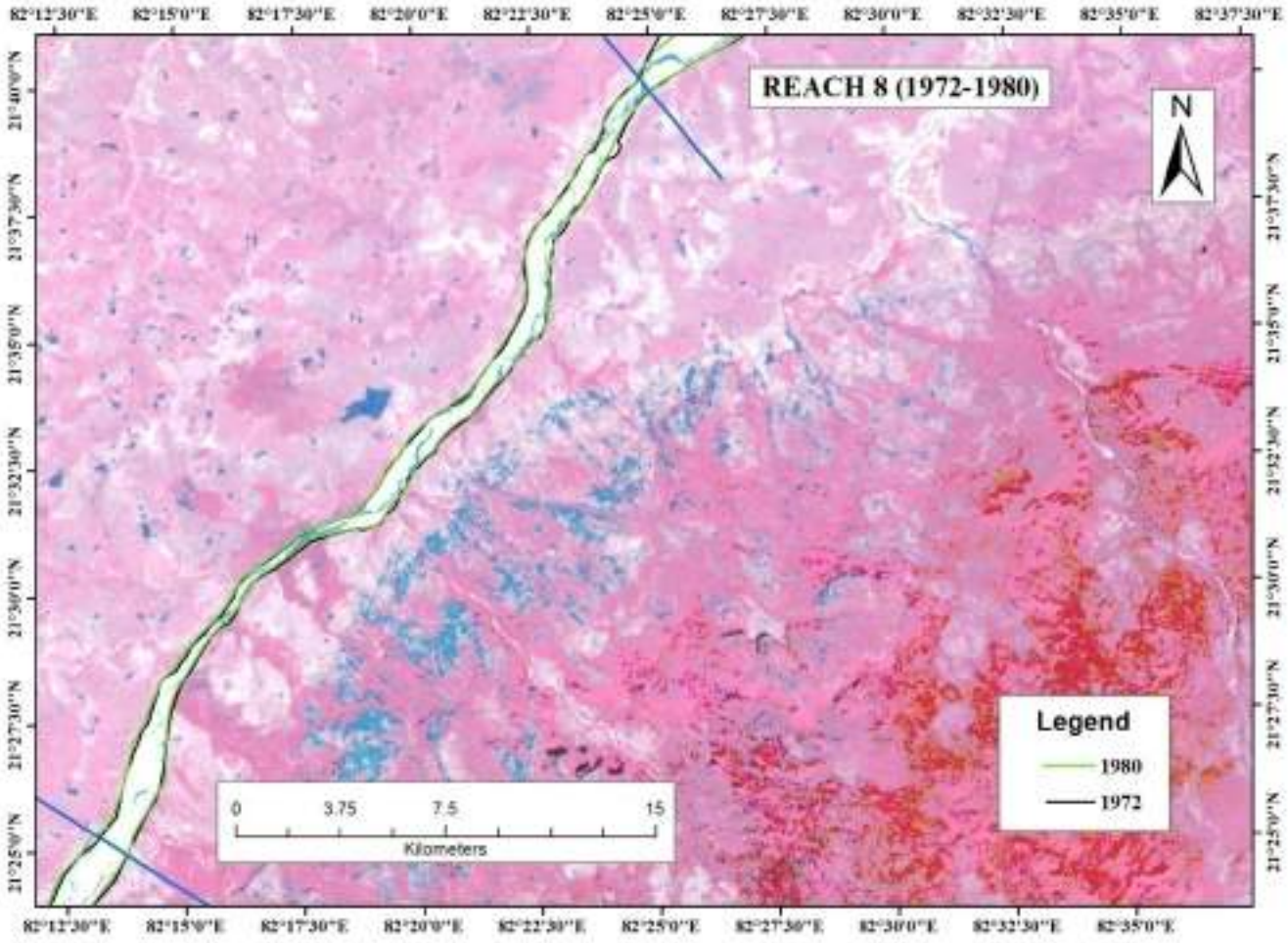


Figure 24.2: Changes in the course of Mahanadi River of Year 1972-1980

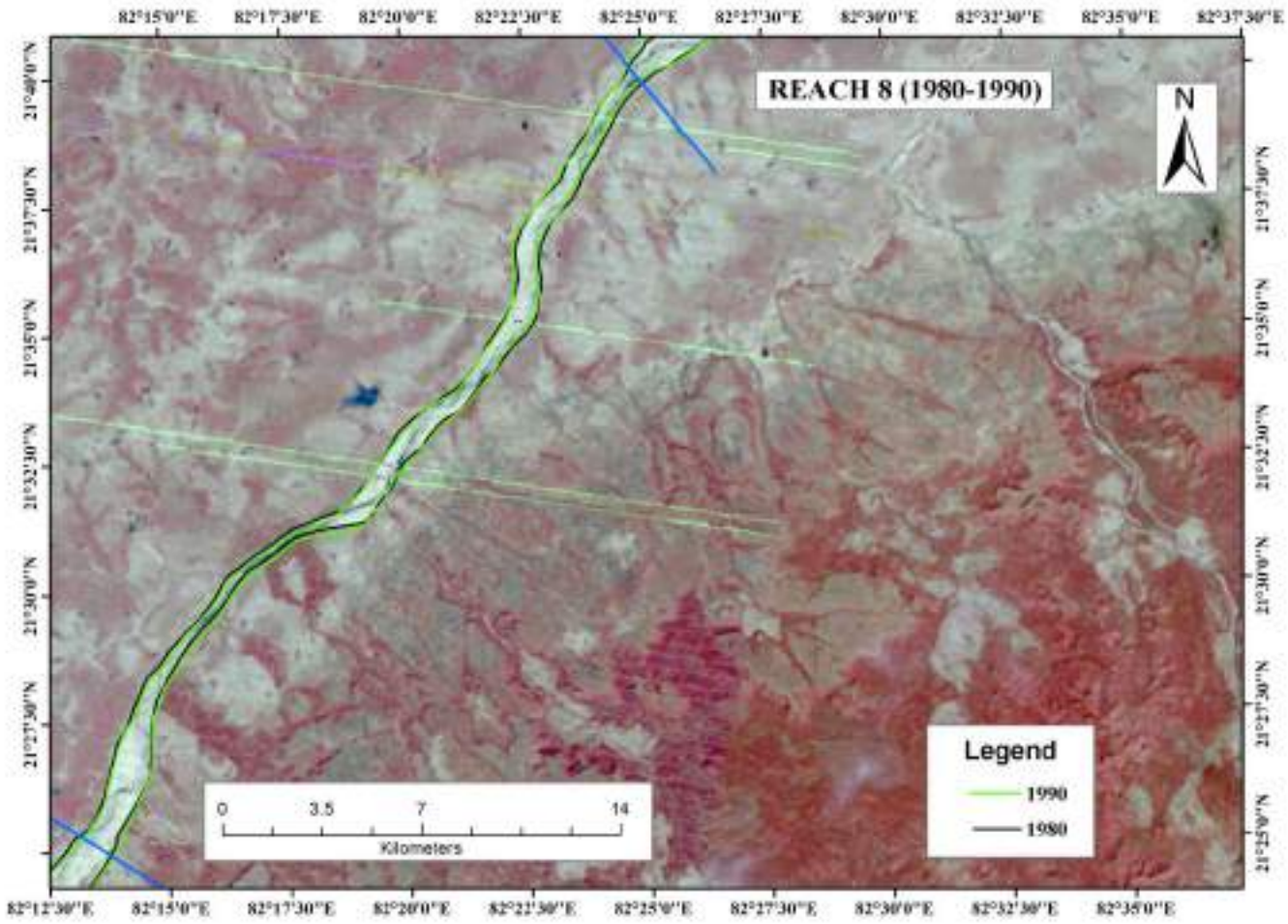


Figure 24.3: Changes in the course of Mahanadi River of Year 1980-1990

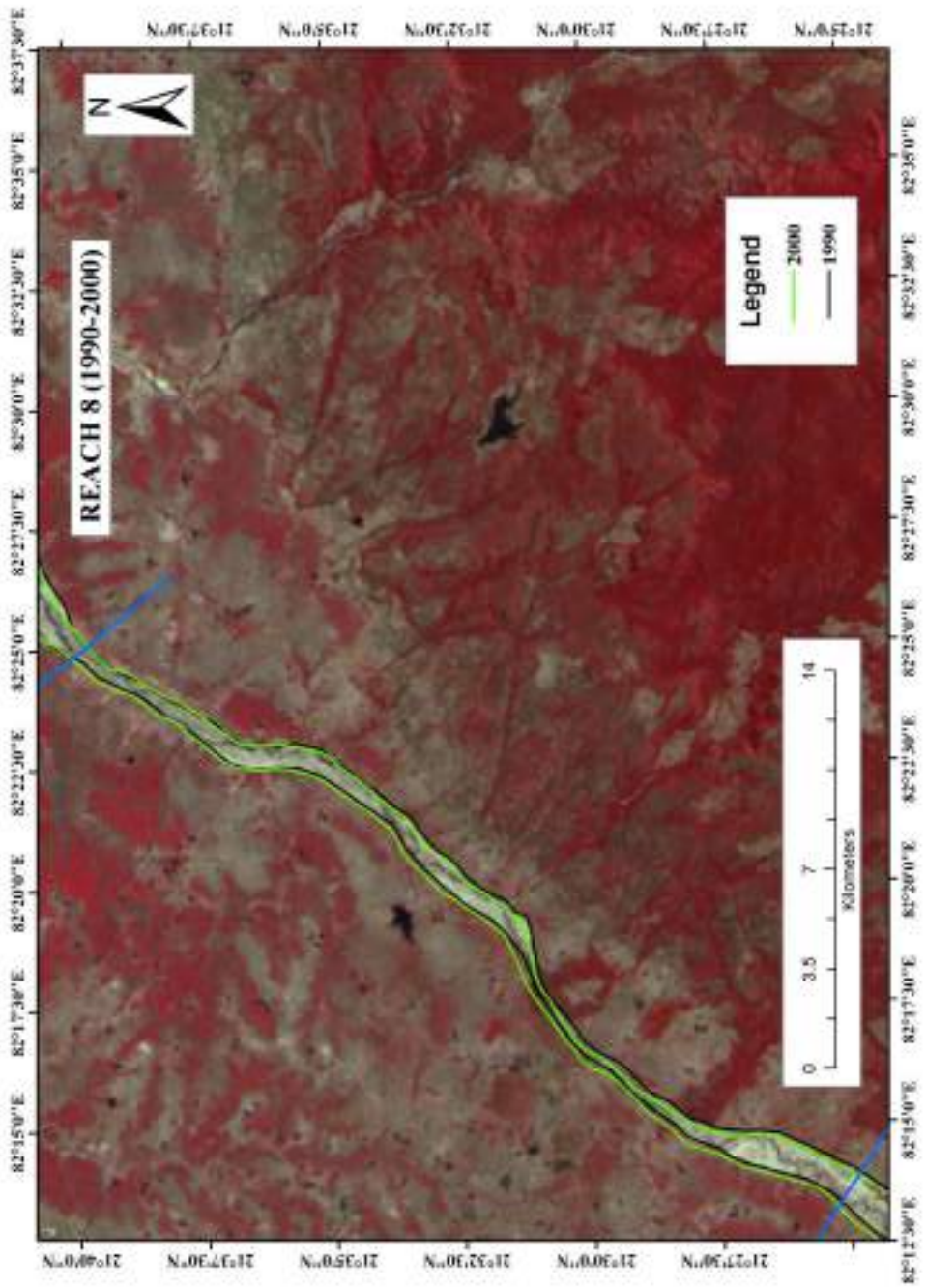


Figure 24.4: Changes in the course of Mahanadi River of Year 1990-2000

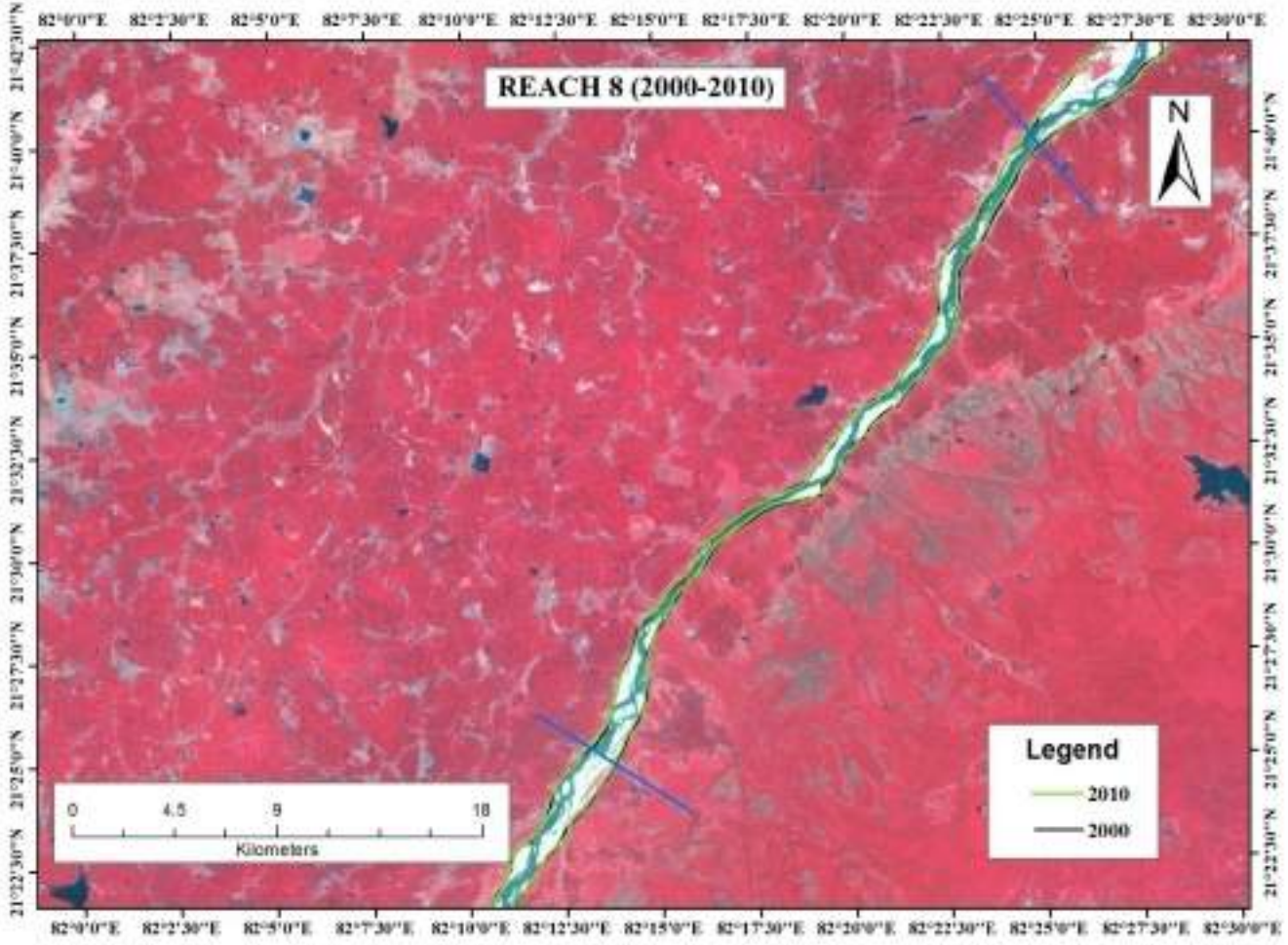


Figure 24.5: Changes in the course of Mahanadi River of Year 2000-2010

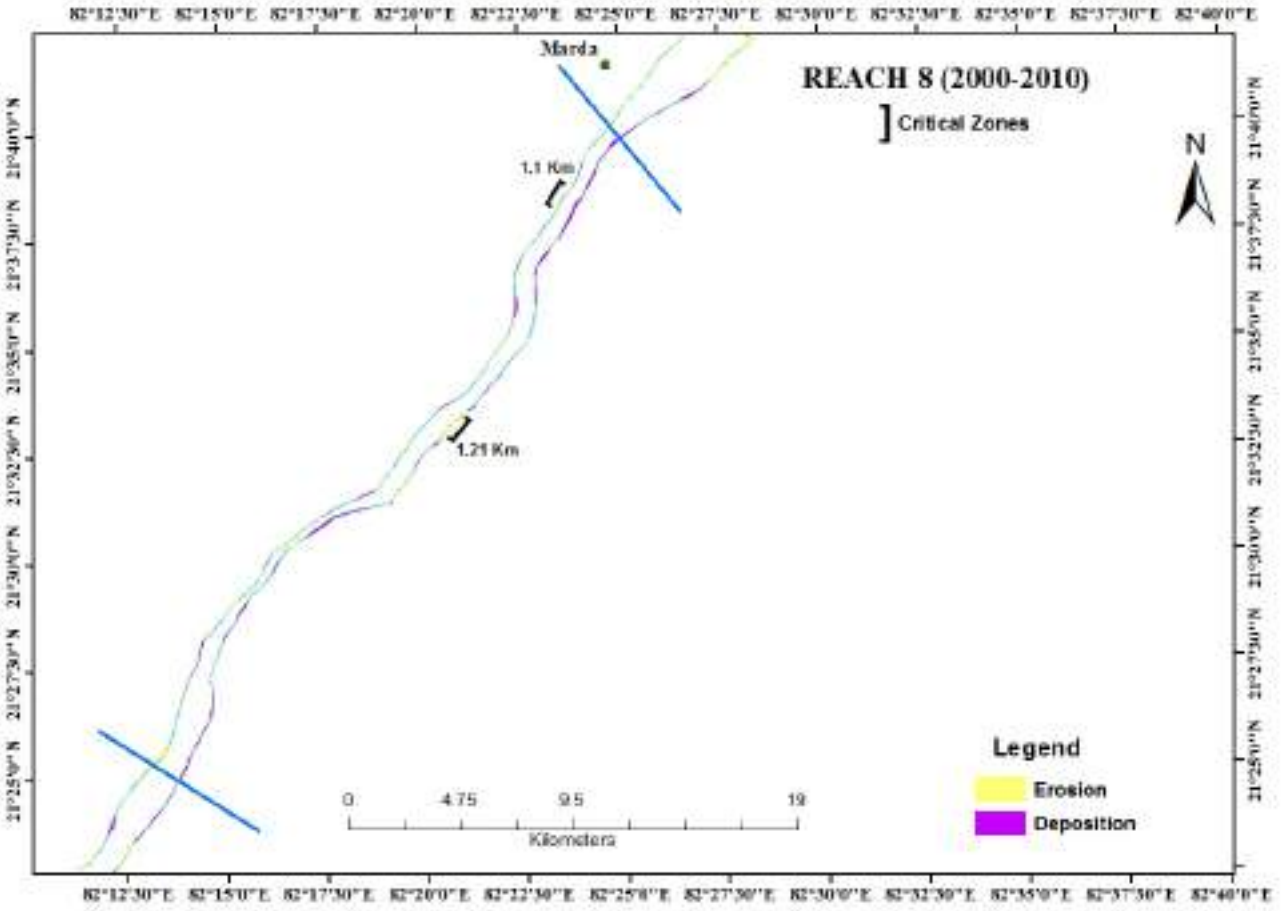


Figure 24.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 9

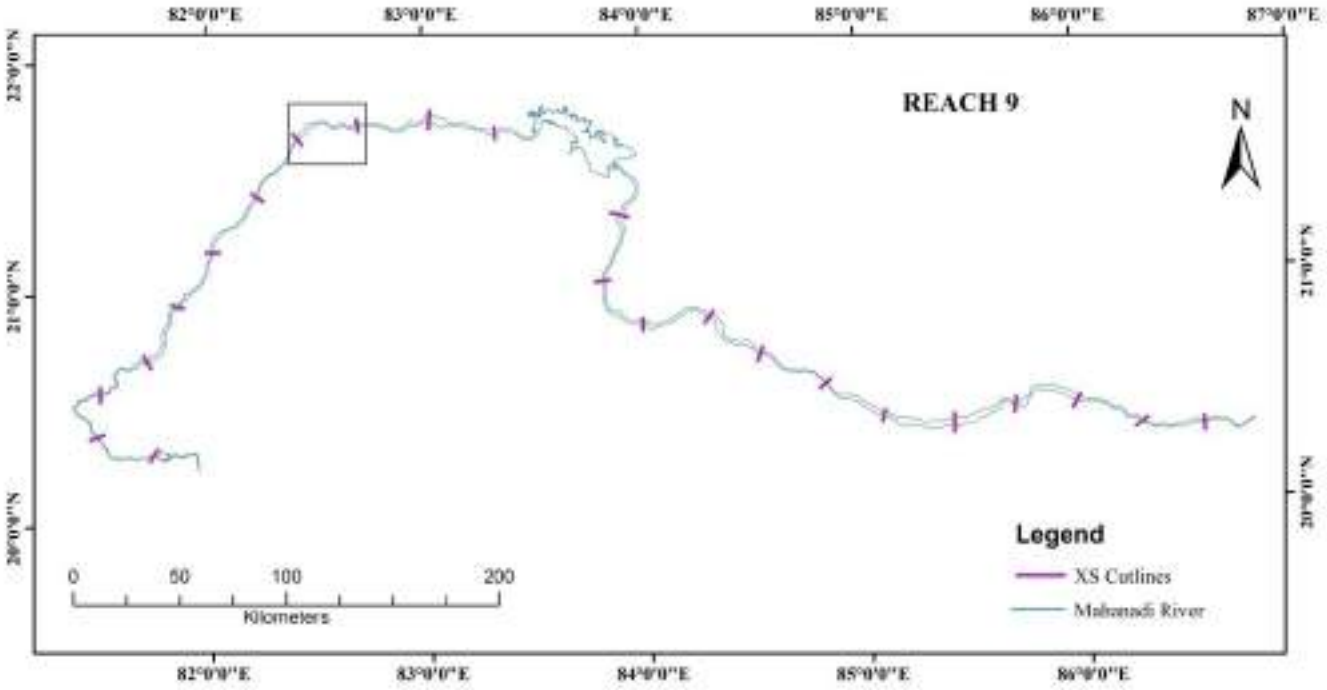


Figure 25.1: Location of reach number 9 in the Mahanadi river

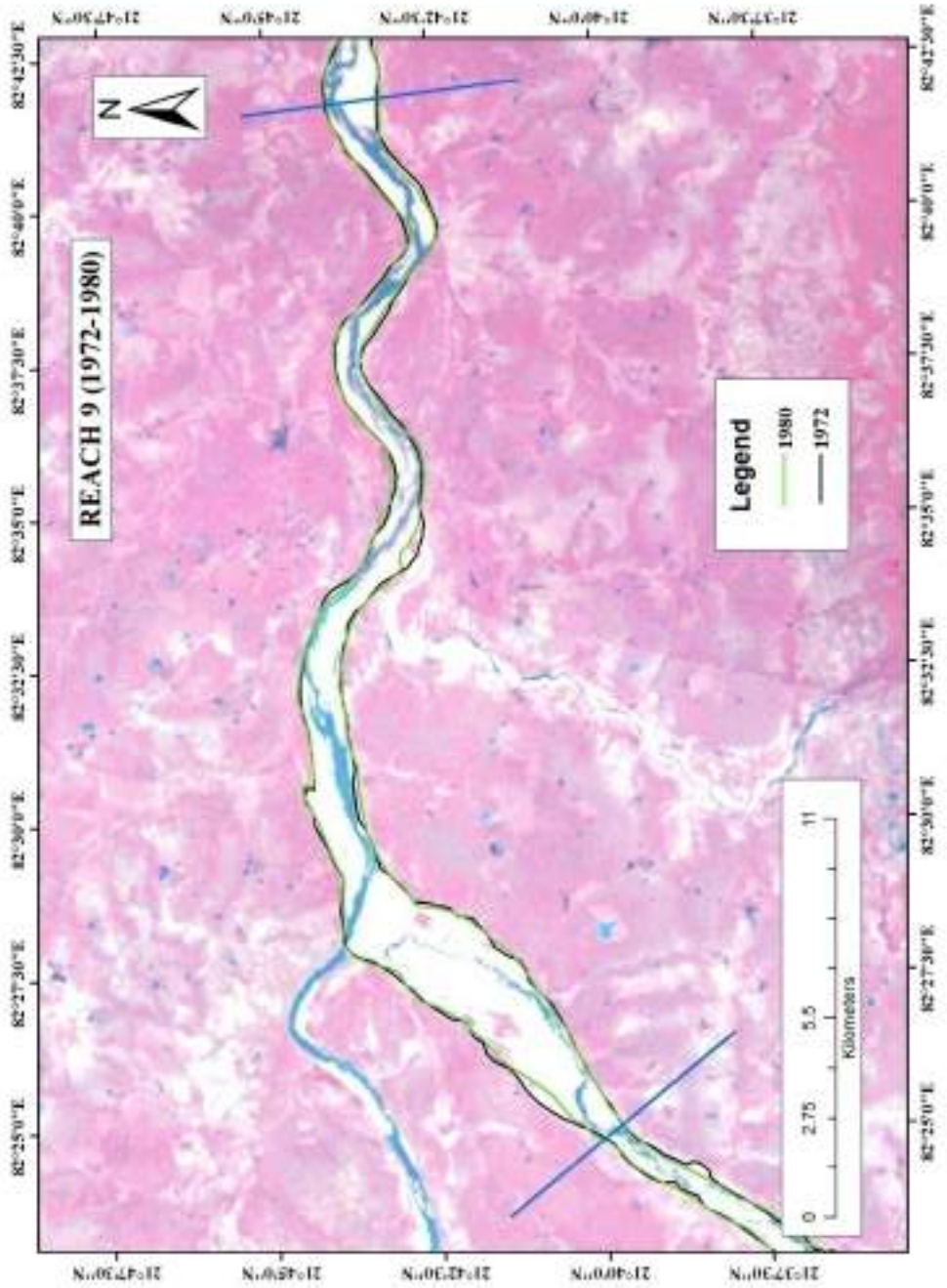


Figure 25.2: Changes in the course of Mahanadi River of Year 1972-1980

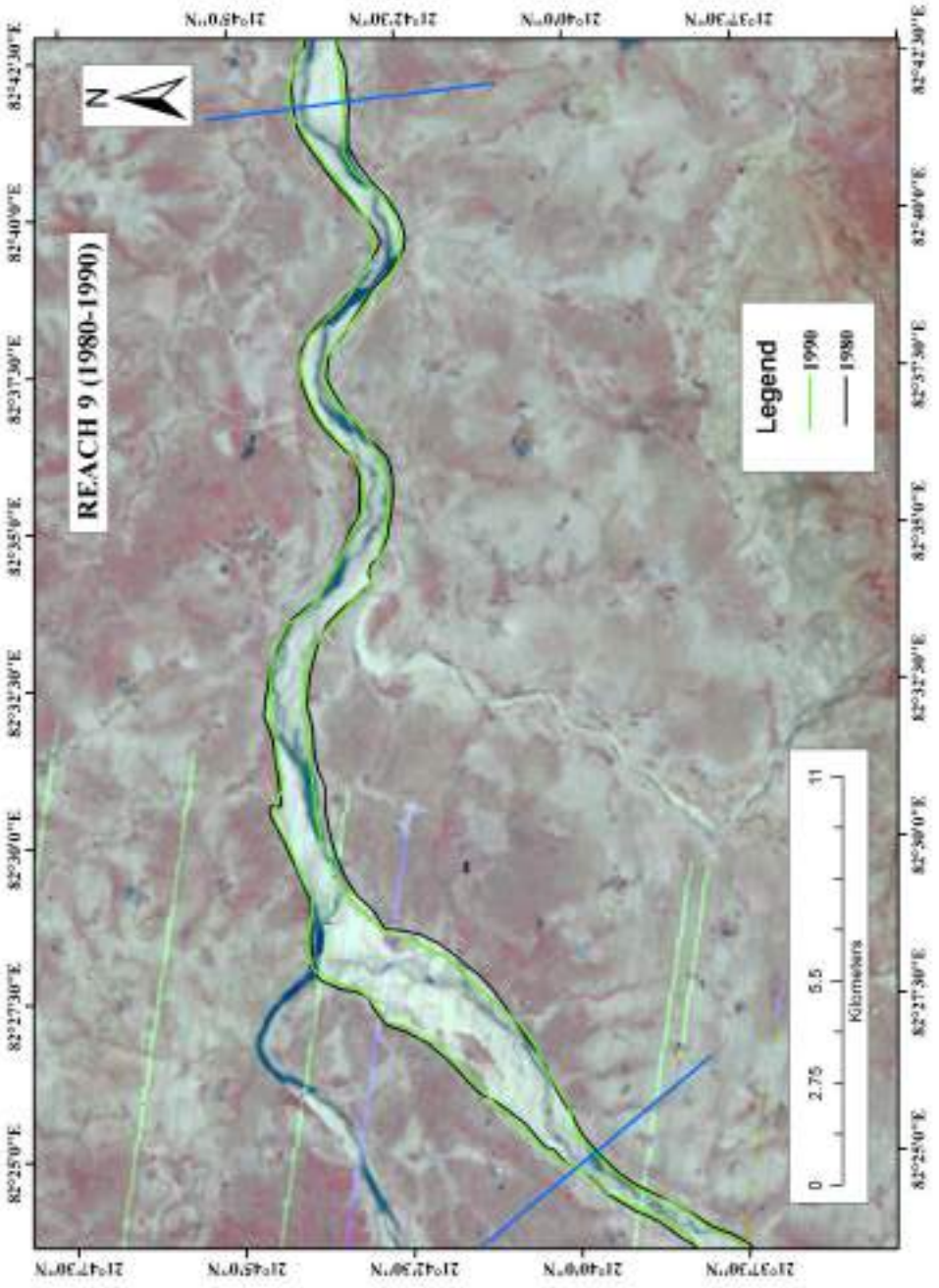


Figure 25.3: Changes in the course of Mahanadi River of Year 1980-1990

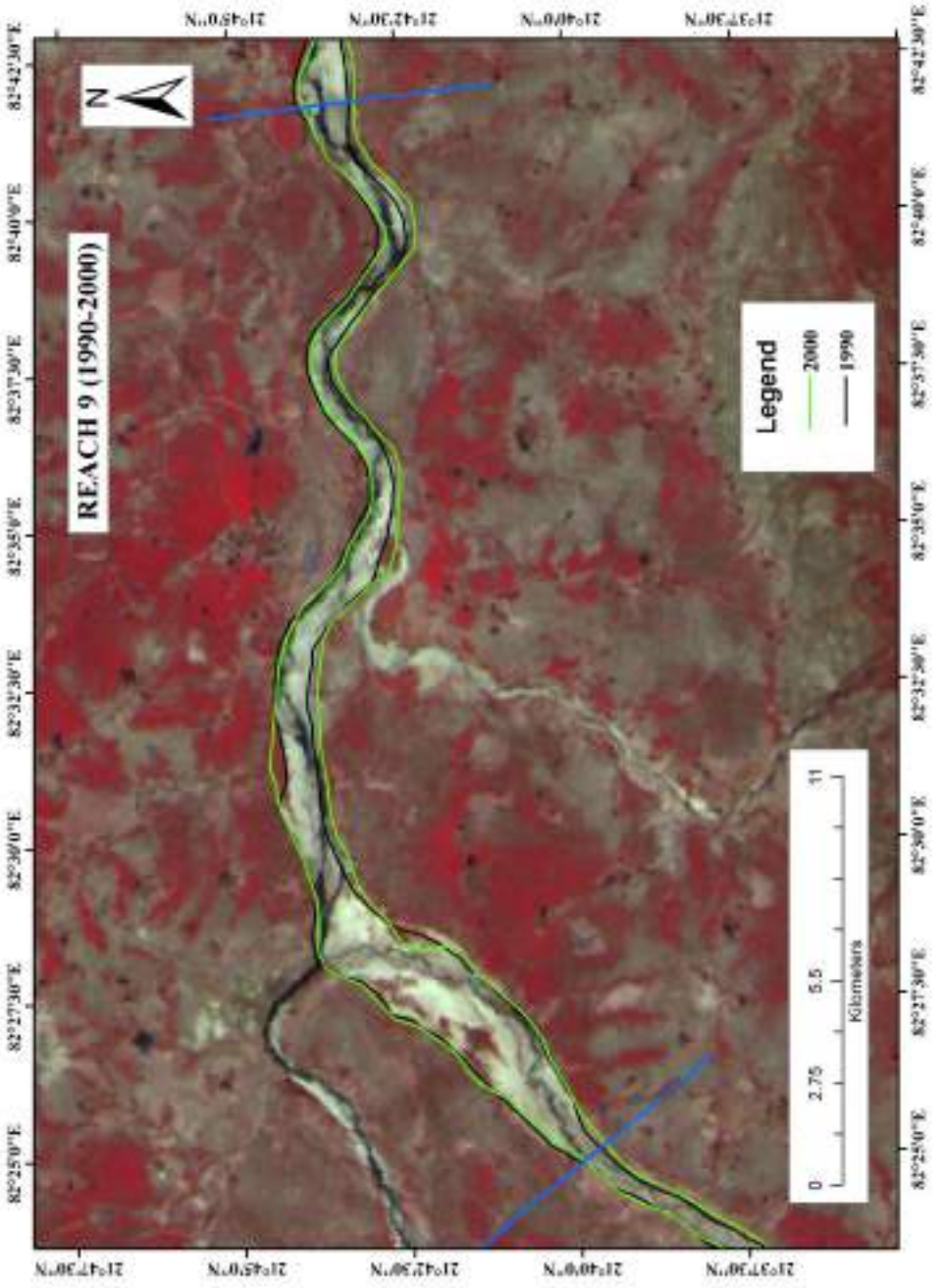


Figure 25.4: Changes in the course of Mahanadi River of Year 1990-2000

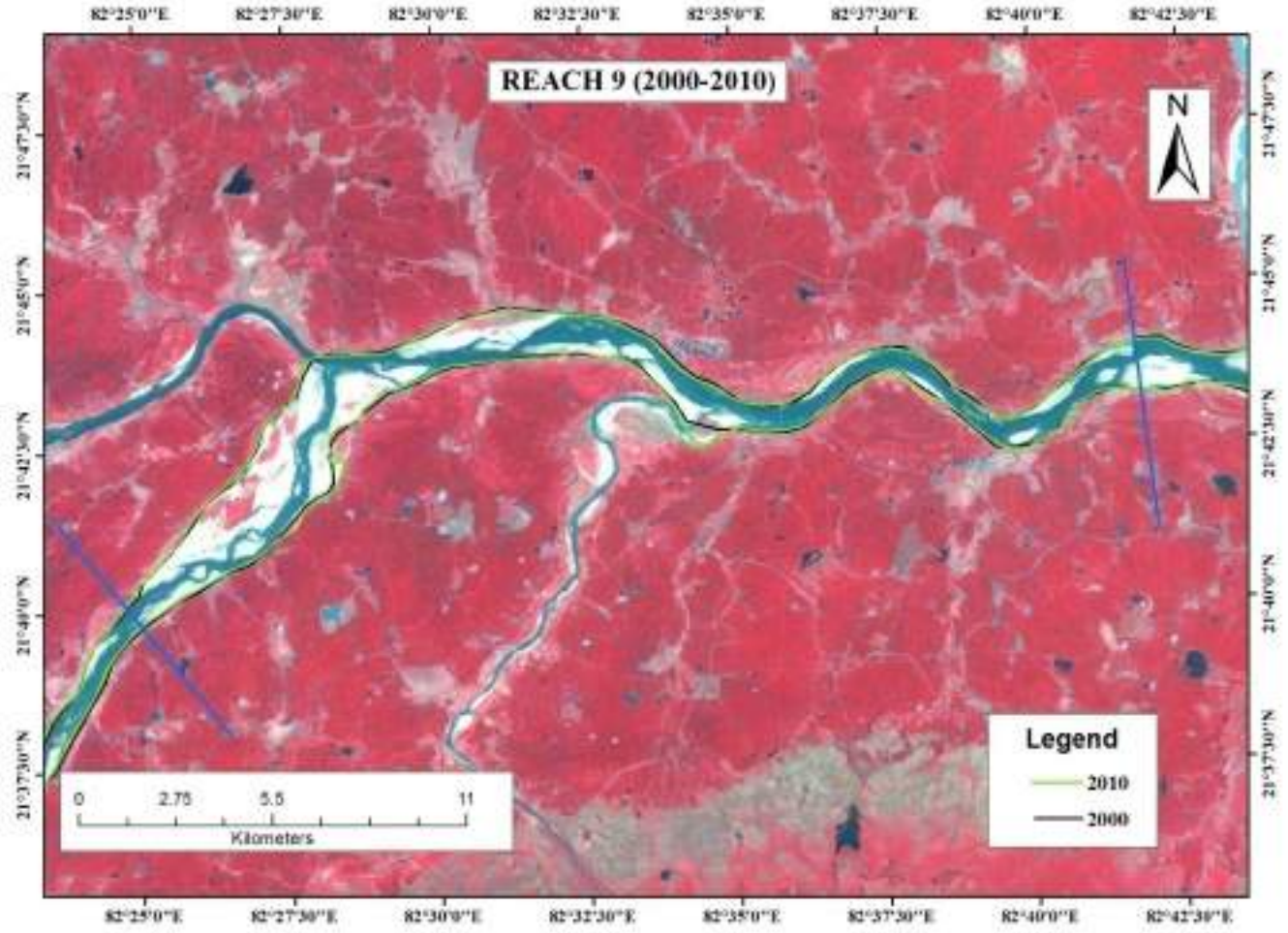


Figure 25.5: Changes in the course of Mahanadi River of Year 2000-2010

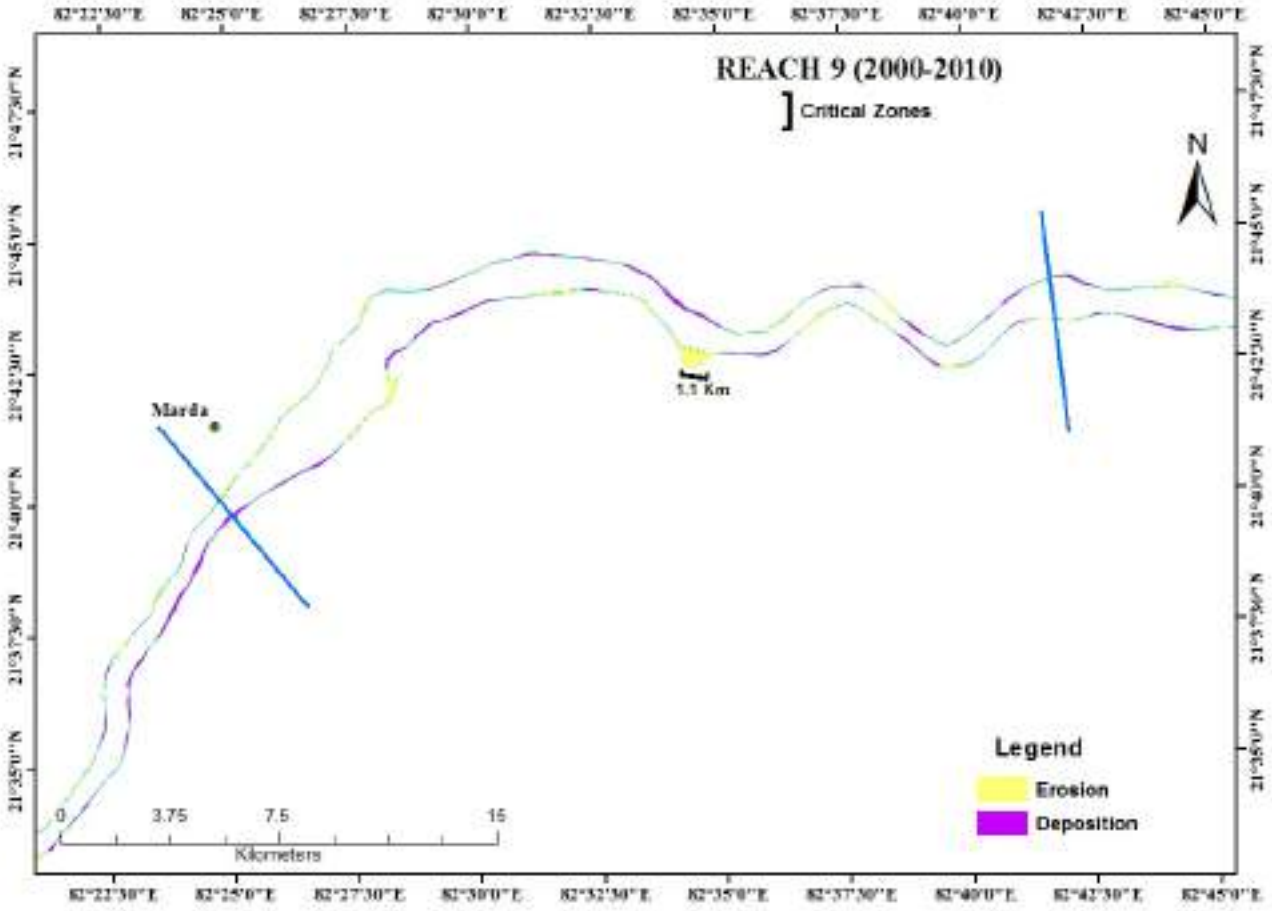


Figure 25.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 10

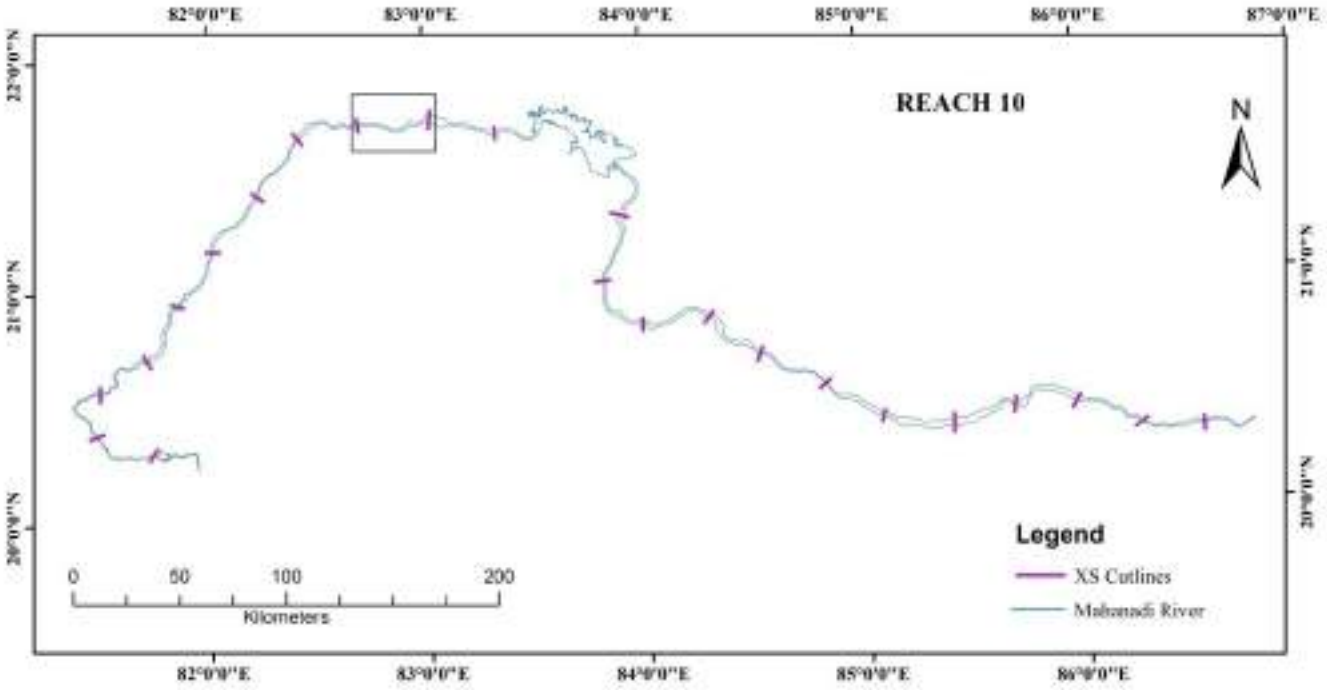


Figure 26.1: Location of reach number 10 in the Mahanadi river

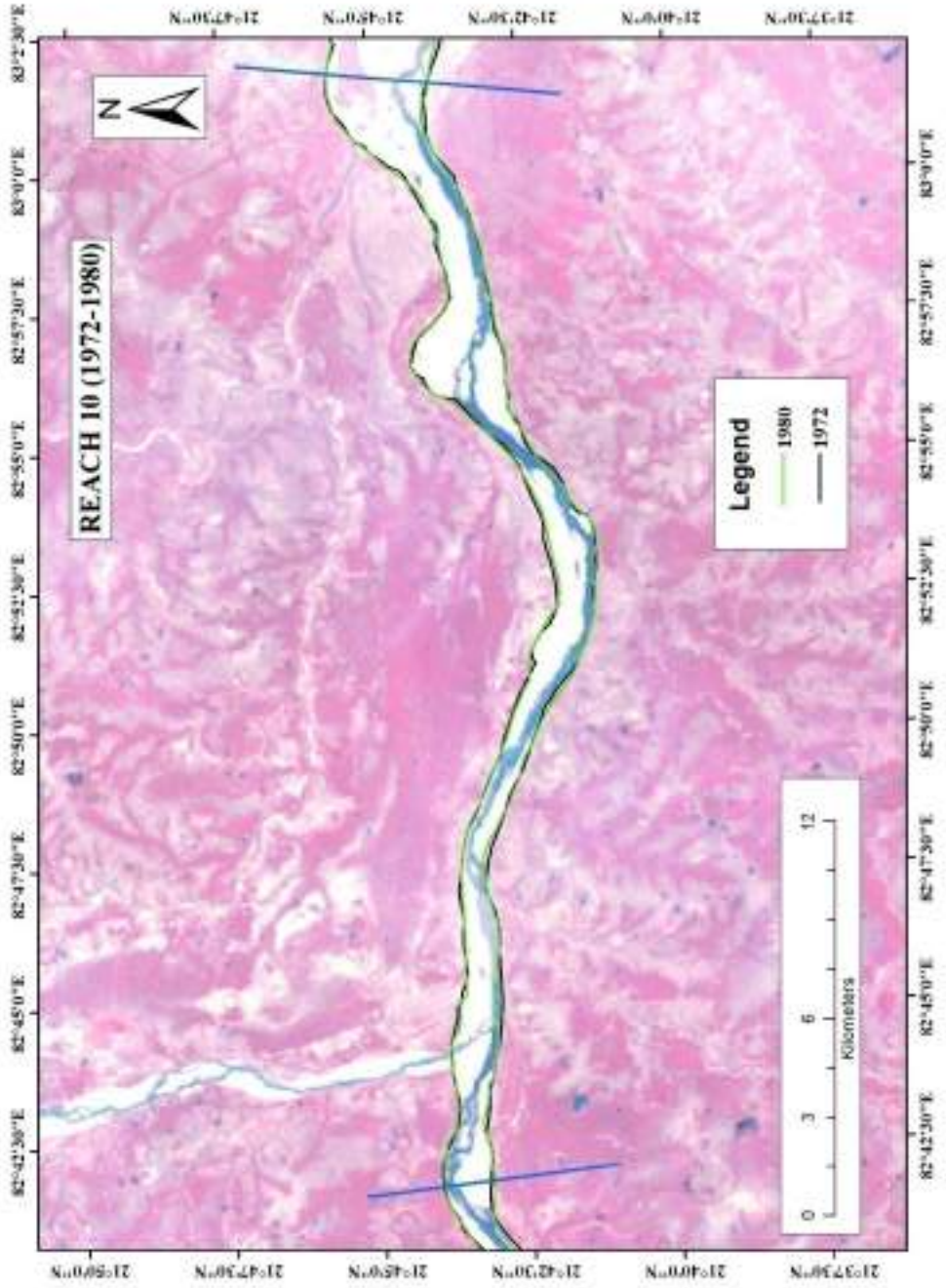


Figure 26.2: Changes in the course of Mahanadi River of Year 1972-1980

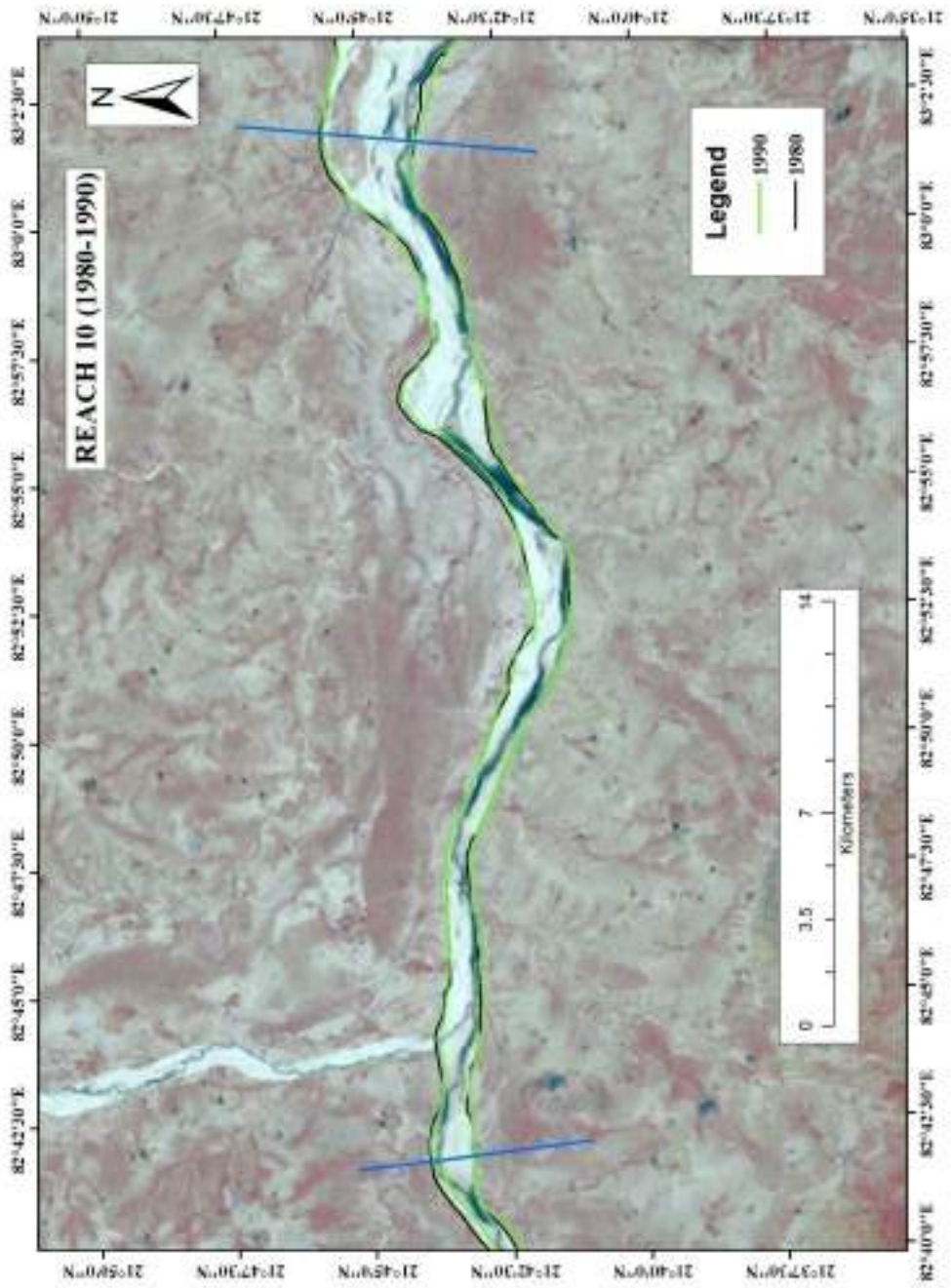


Figure 26.3: Changes in the course of Mahanadi River of Year 1980-1990

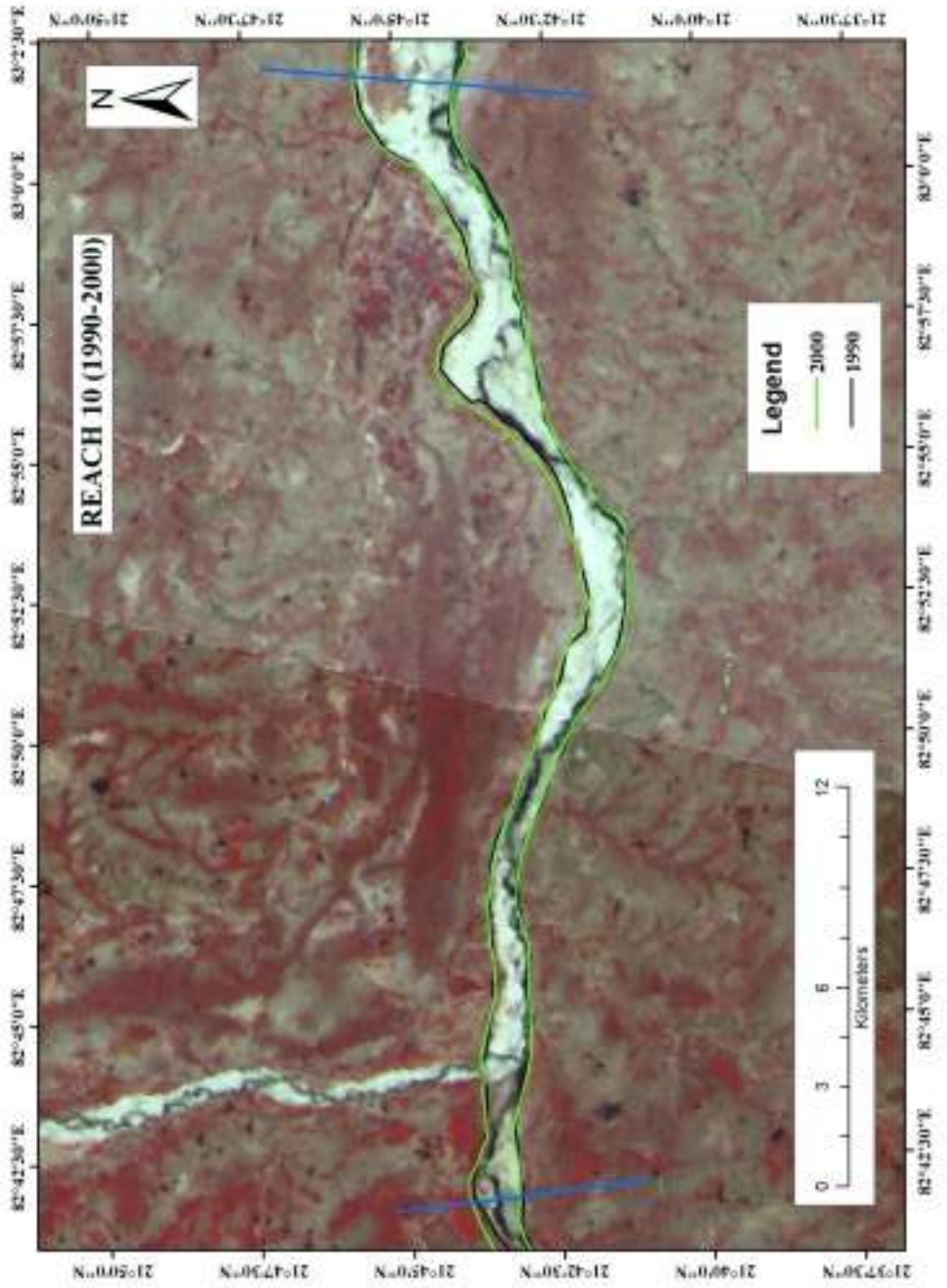


Figure 26.4: Changes in the course of Mahanadi River of Year 1990-2000

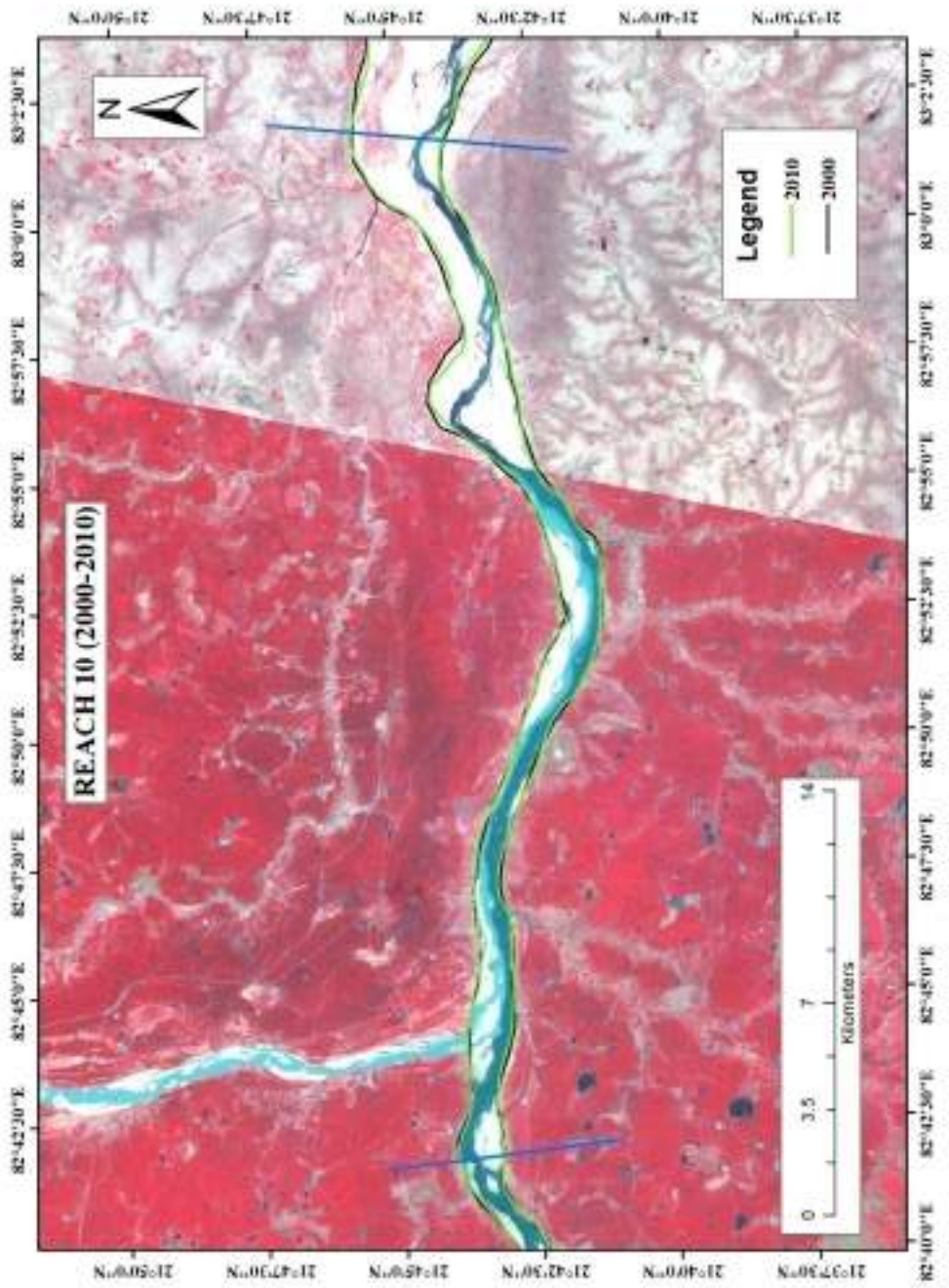


Figure 26.5: Changes in the course of Mahanadi River of Year 2000-2010

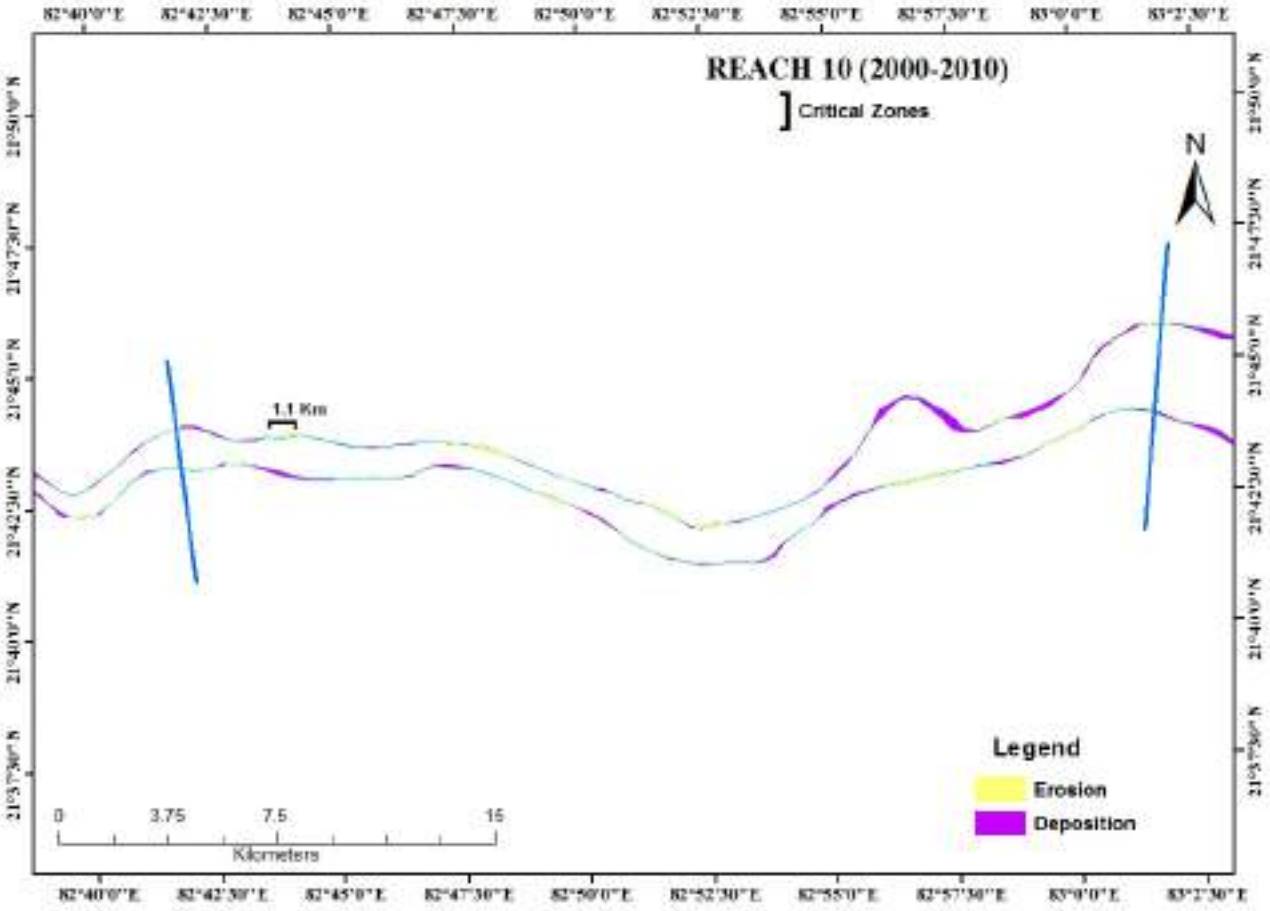


Figure 26.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 11

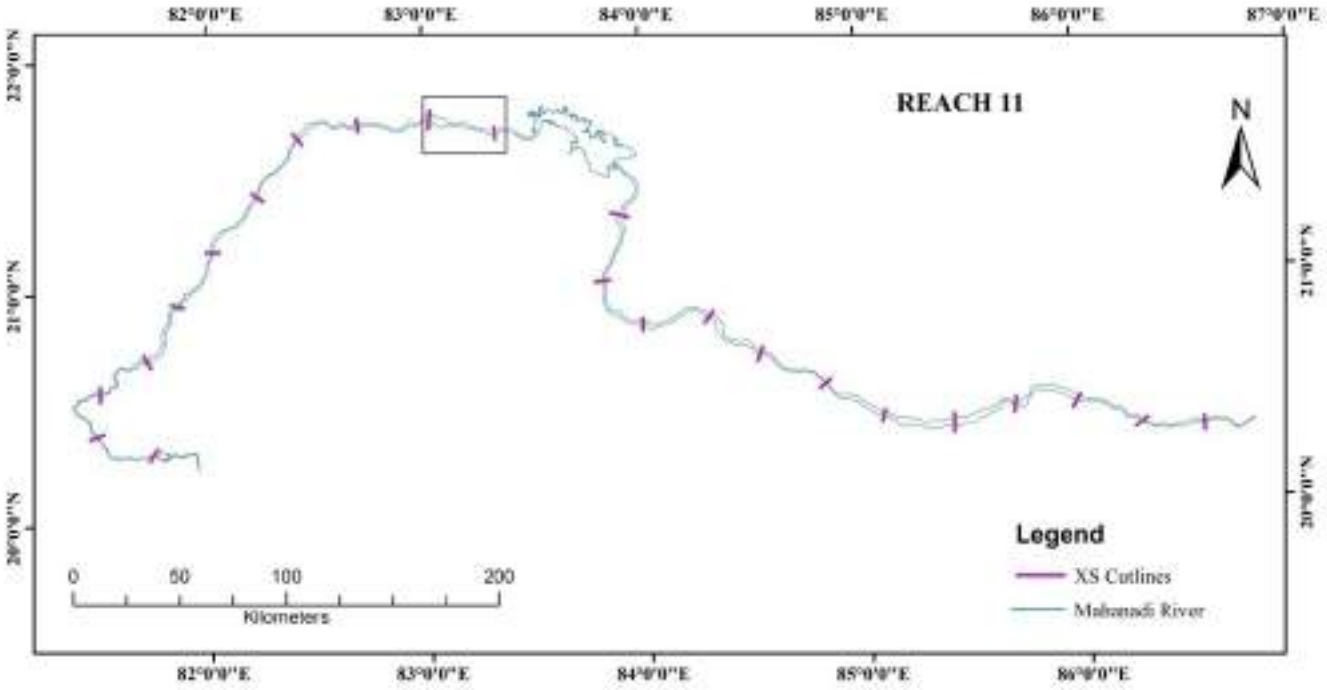


Figure 27.1: Location of reach number 11 in the Mahanadi river

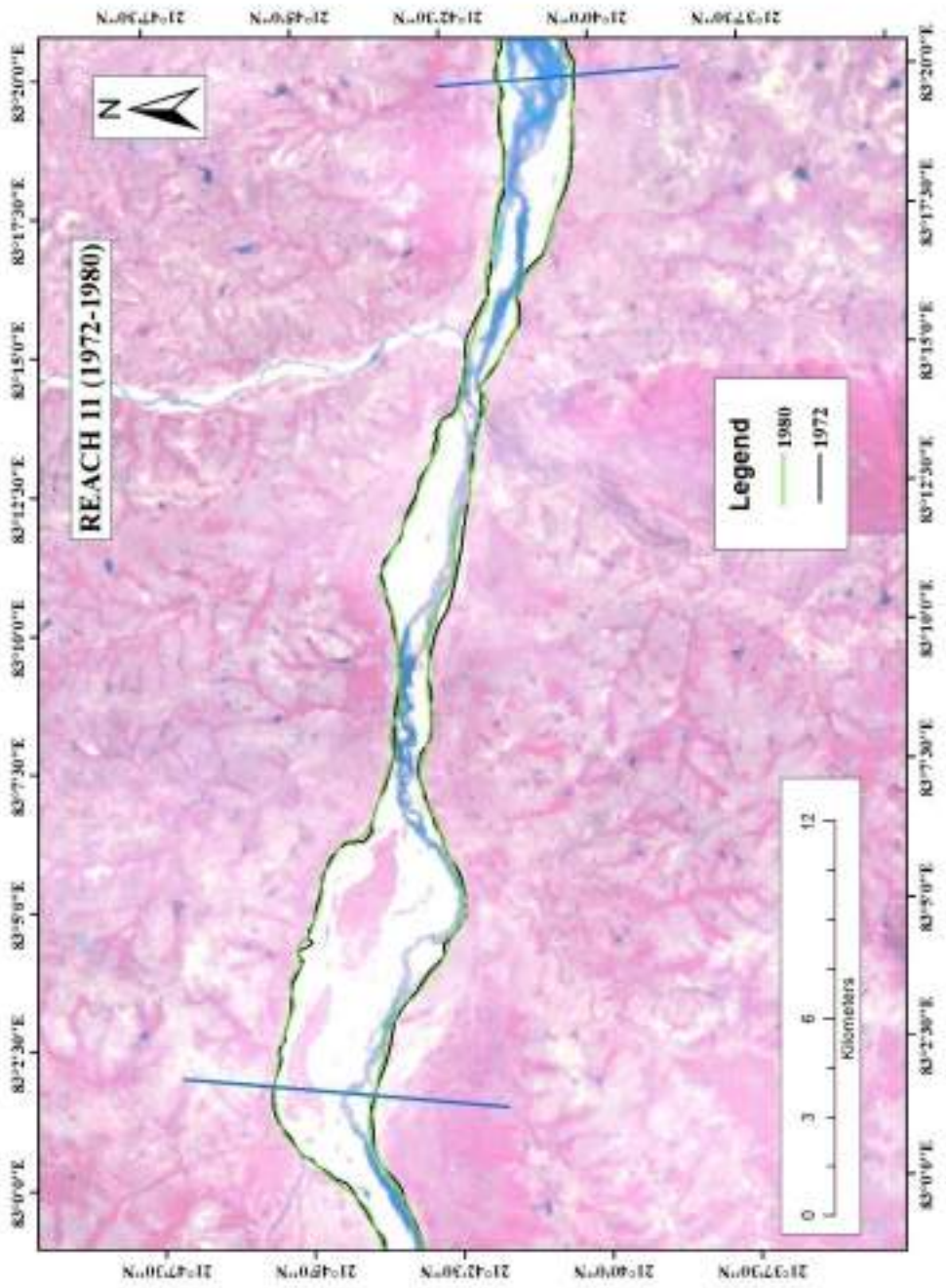


Figure 27.2: Changes in the course of Mahanadi River of Year 1972-1980

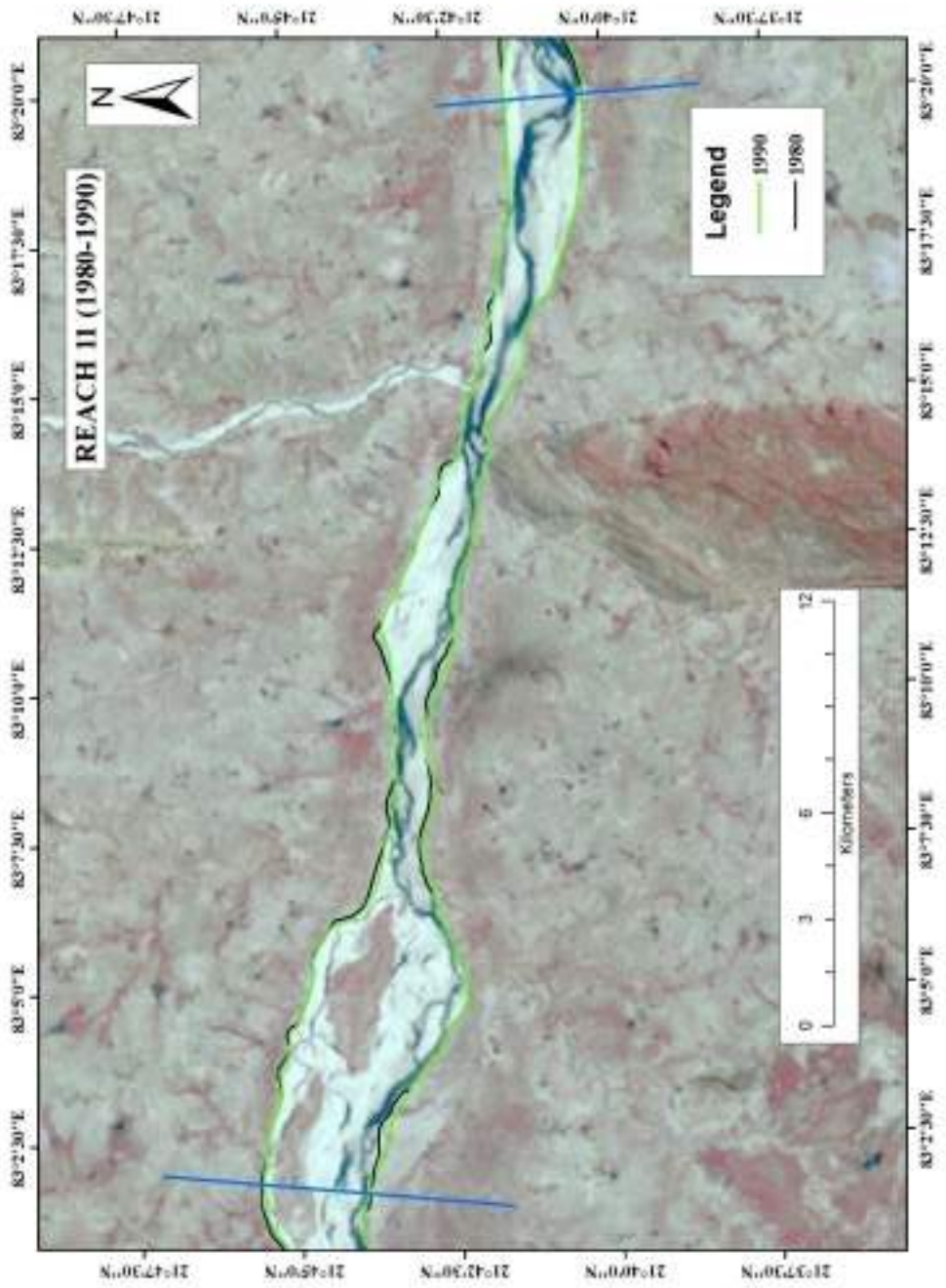


Figure 27.3: Changes in the course of Mahanadi River of Year 1980-1990

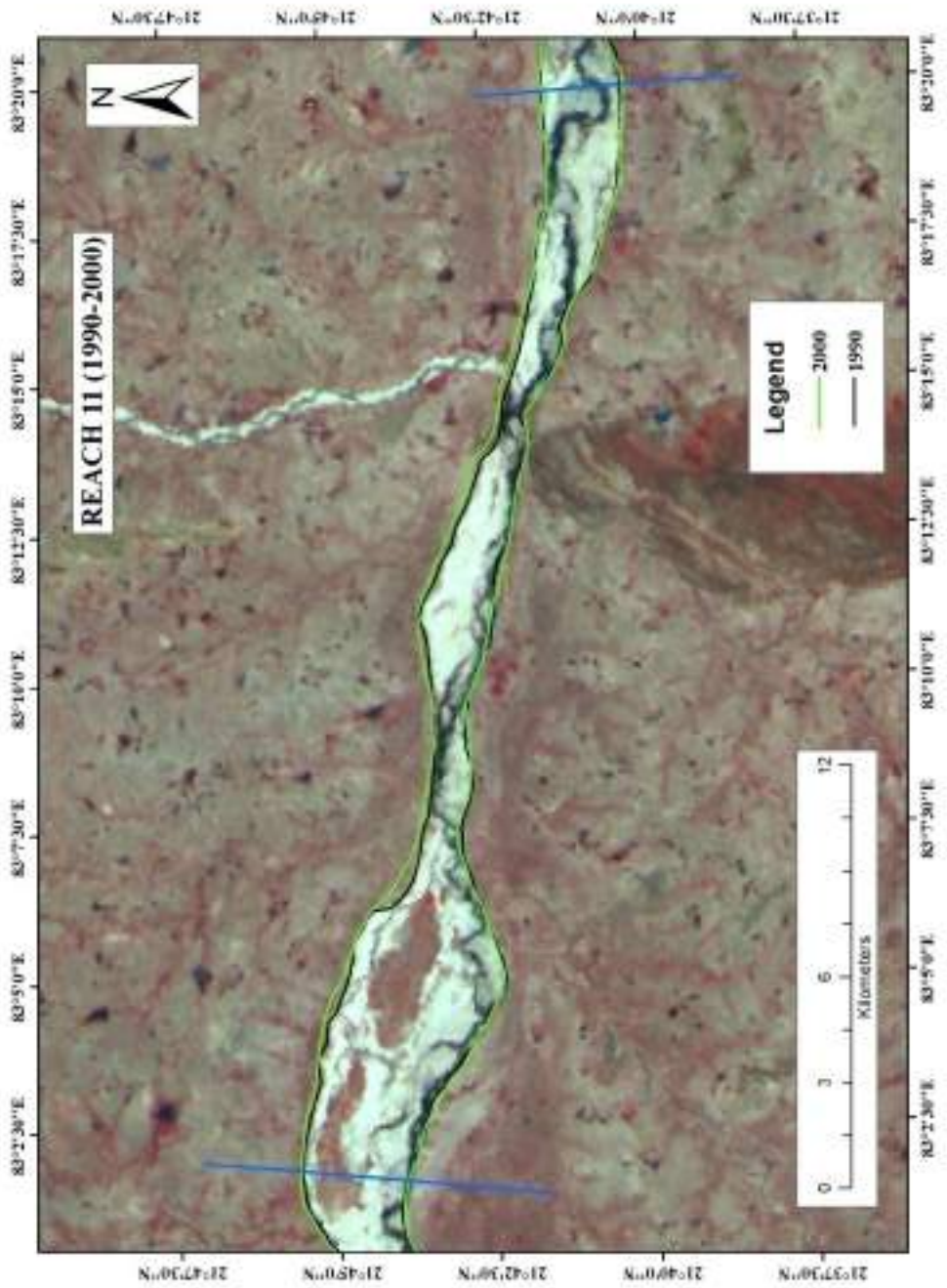


Figure 27.4: Changes in the course of Mahanadi River of Year 1990-2000

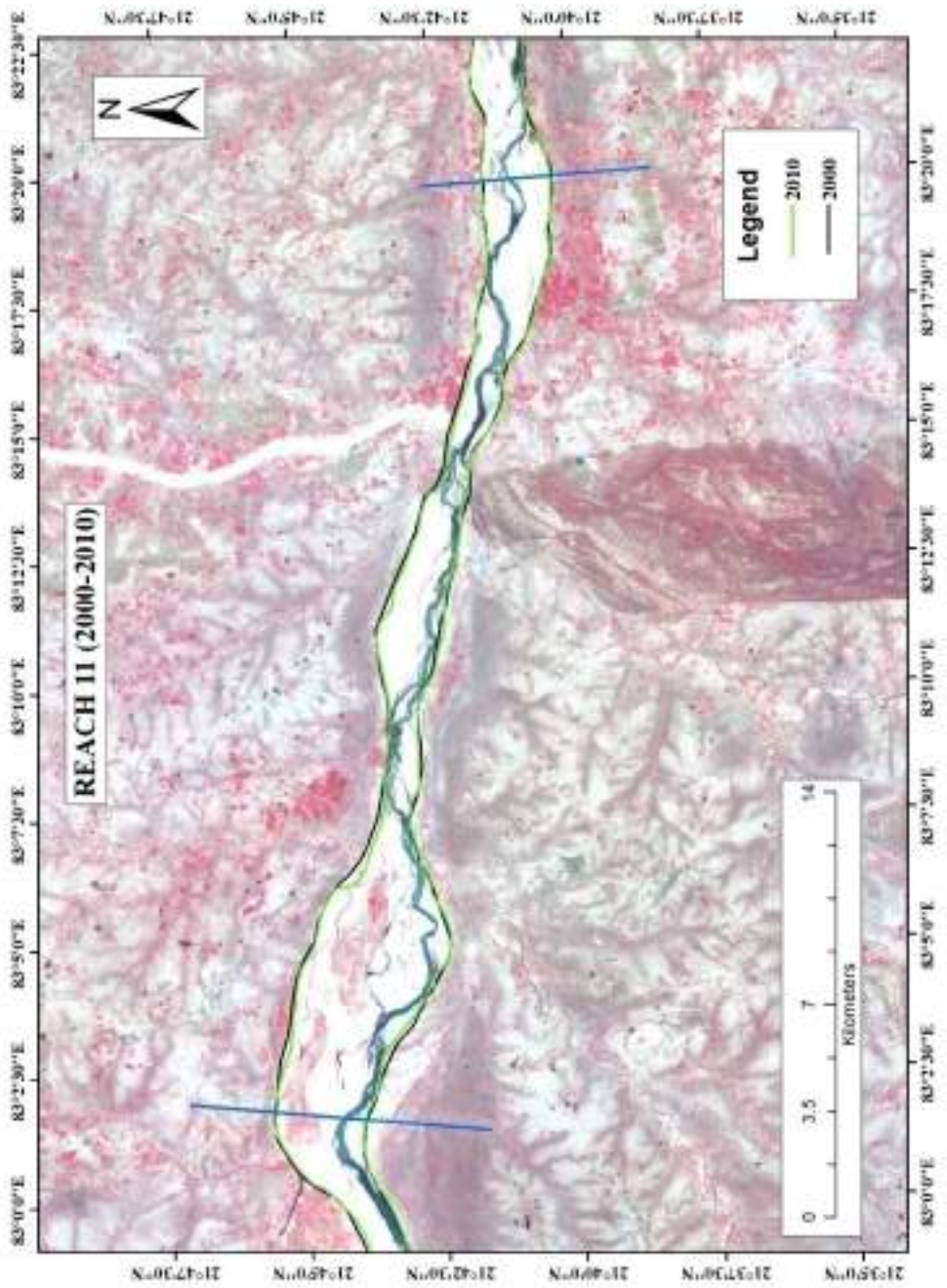


Figure 27.5: Changes in the course of Mahanadi River of Year 2000-2010

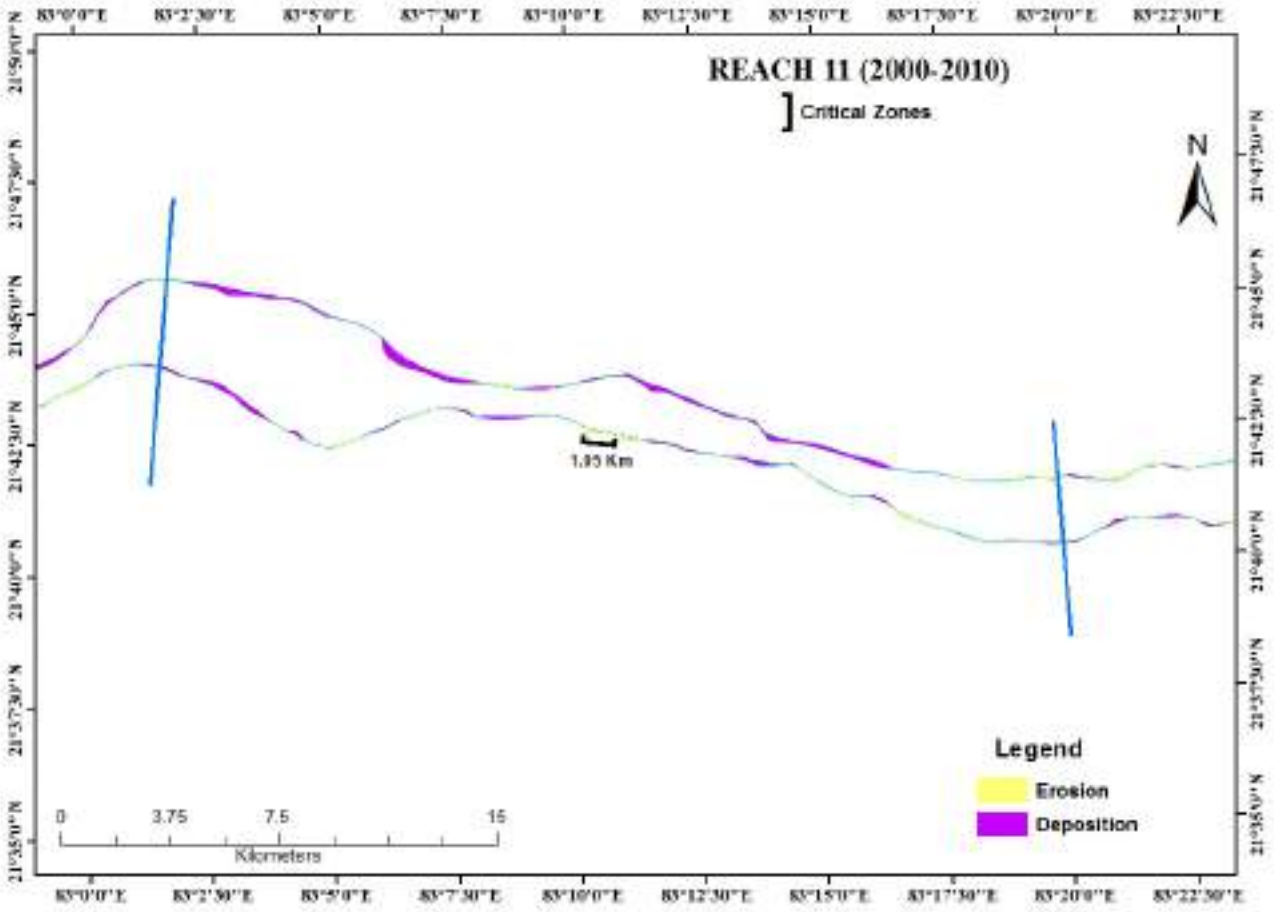


Figure 27.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 12

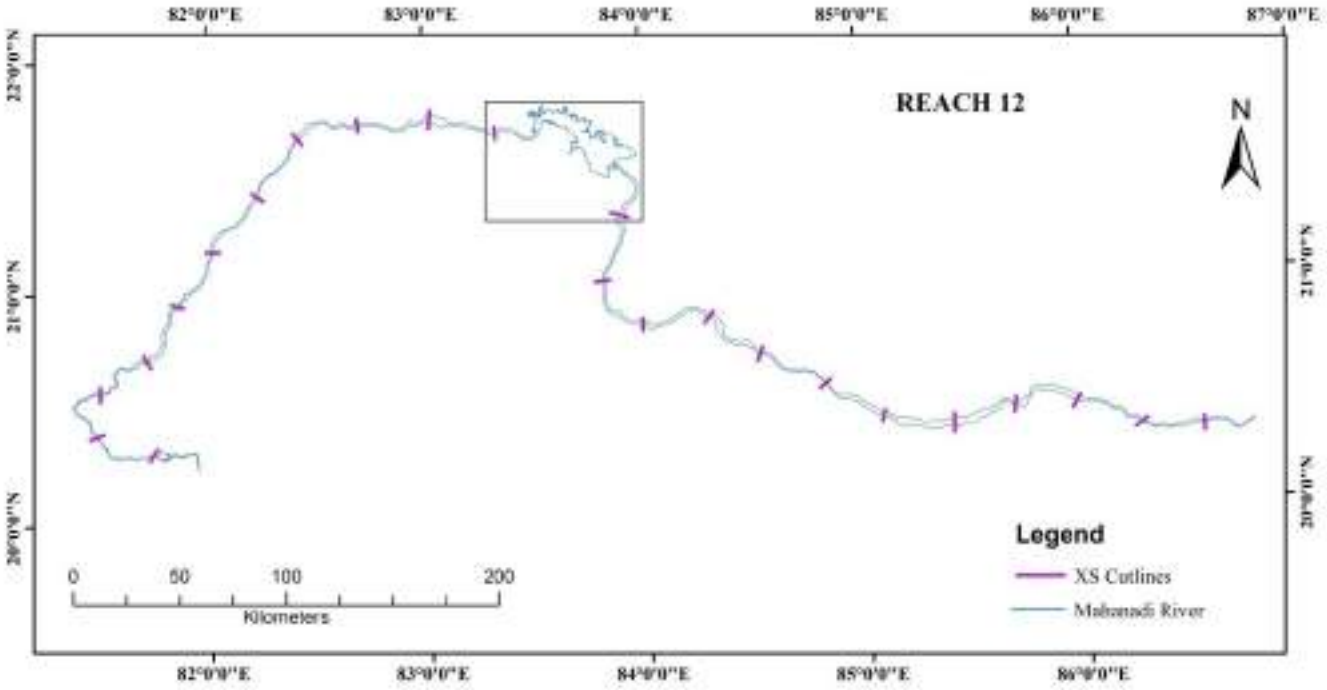


Figure 28.1: Location of reach number 12 in the Mahanadi river

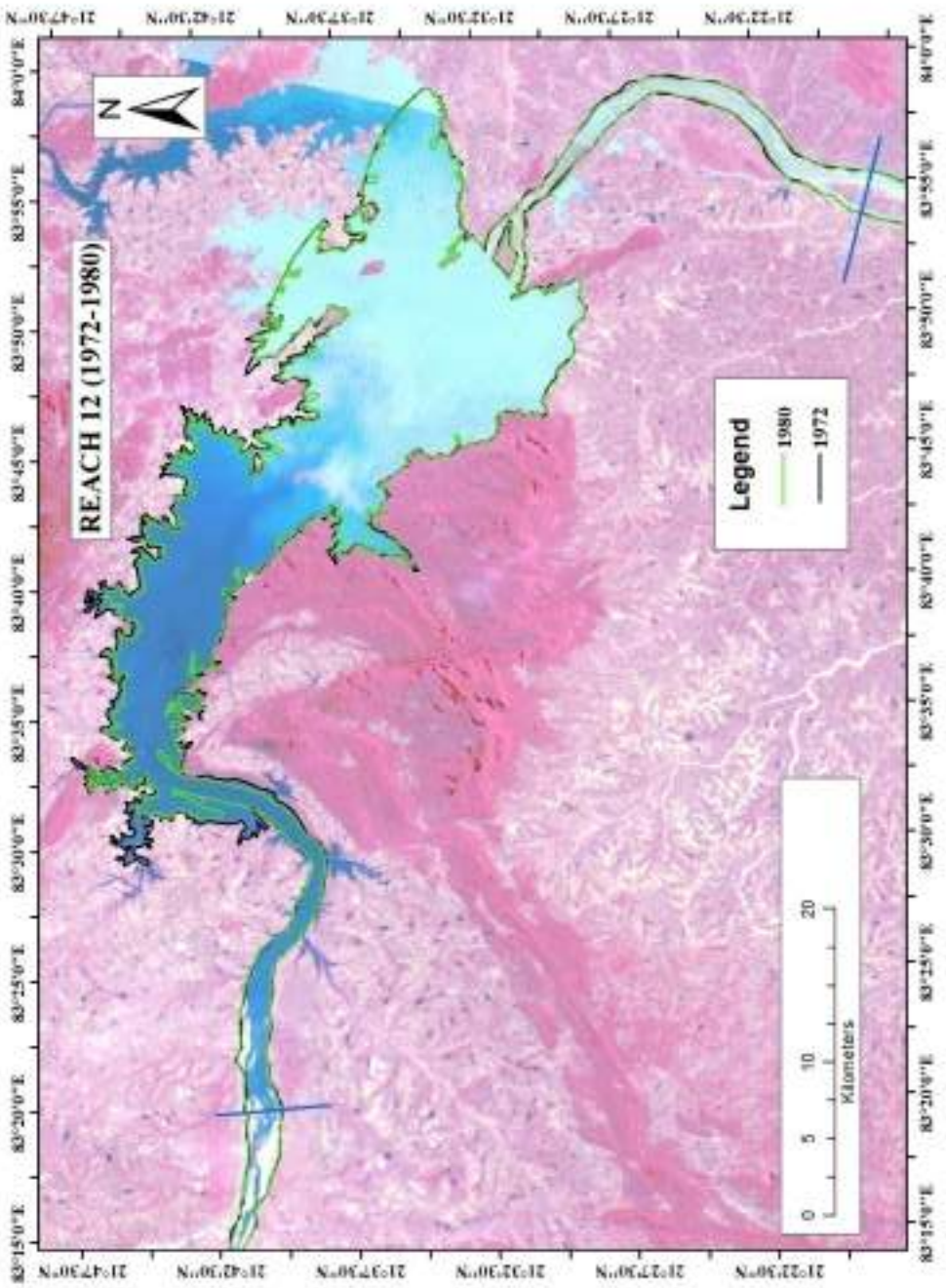


Figure 28.2: Changes in the course of Mahanadi River of Year 1972-1980

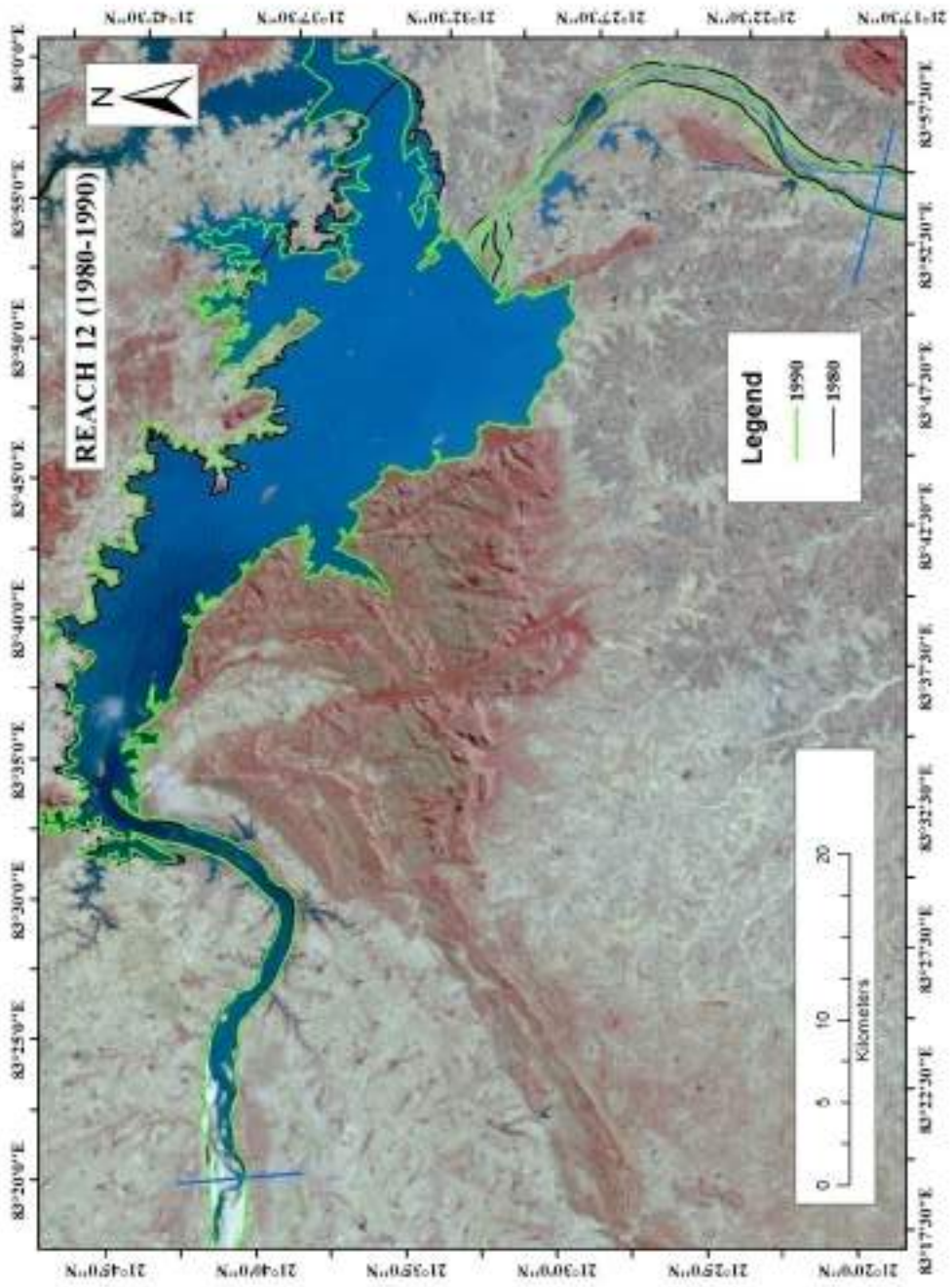


Figure 28.3: Changes in the course of Mahanadi River of Year 1980-1990

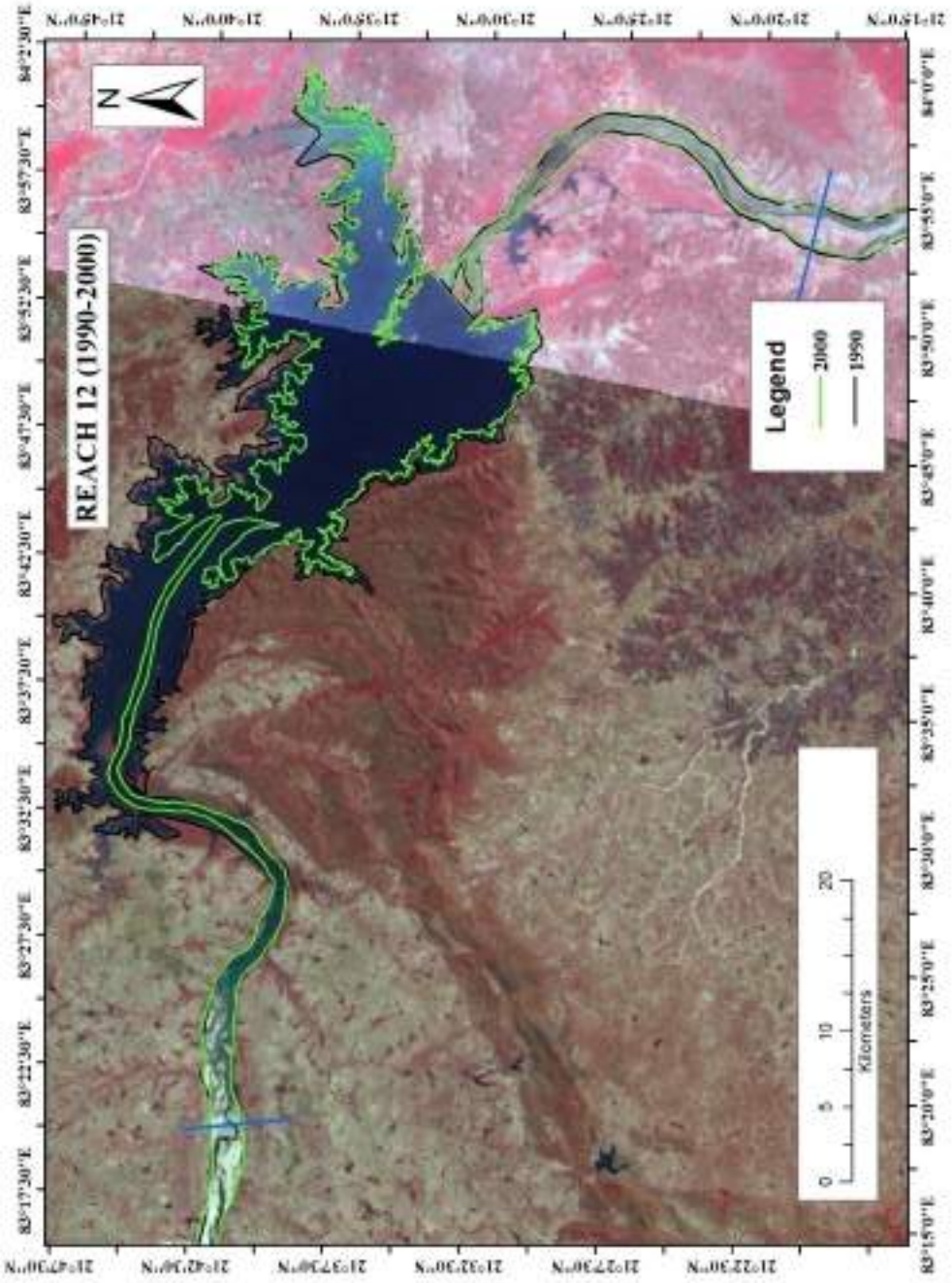


Figure 28.4: Changes in the course of Mahanadi River of Year 1990-2000

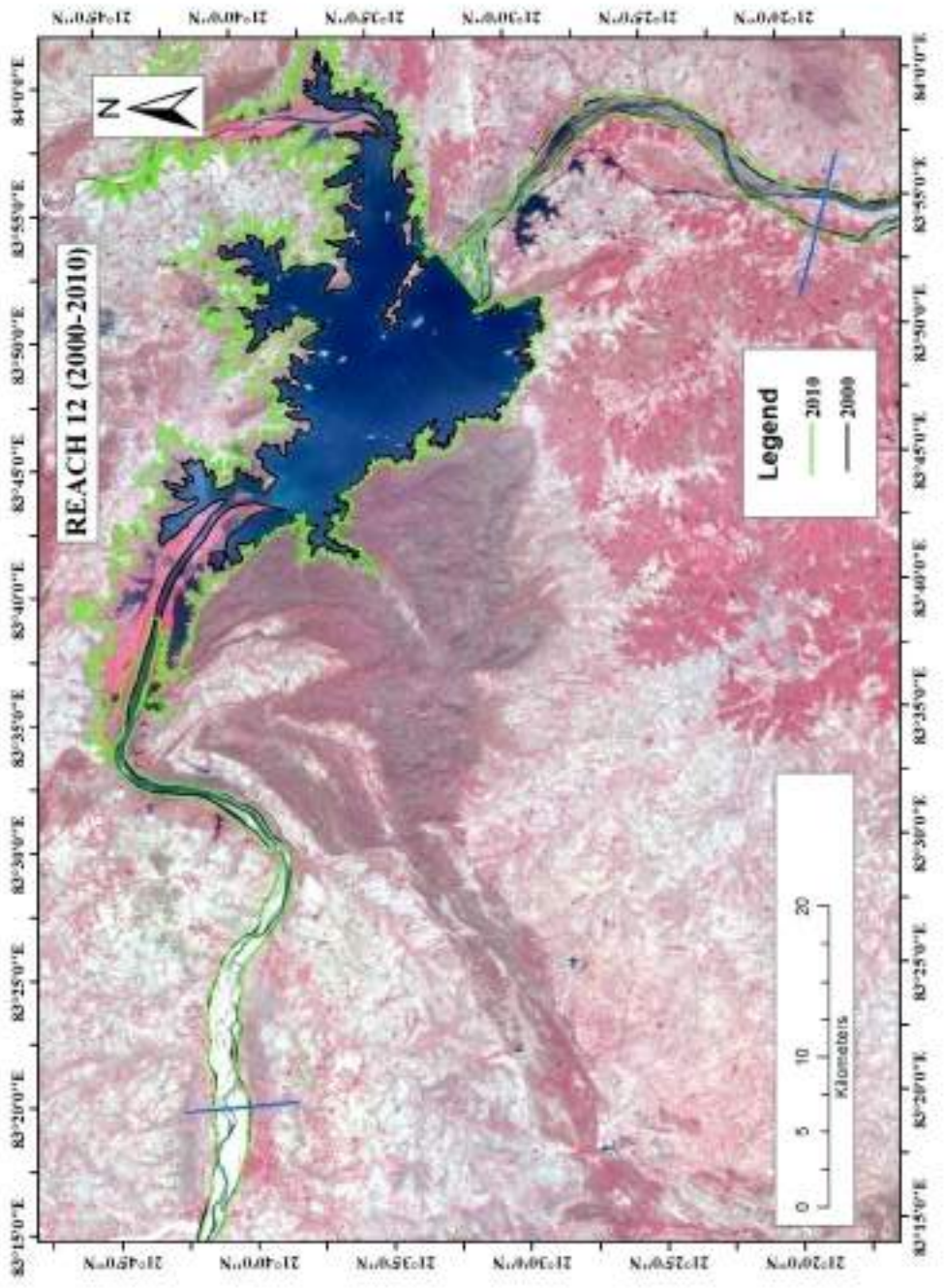


Figure 28.5: Changes in the course of Mahanadi River of Year 2000-2010

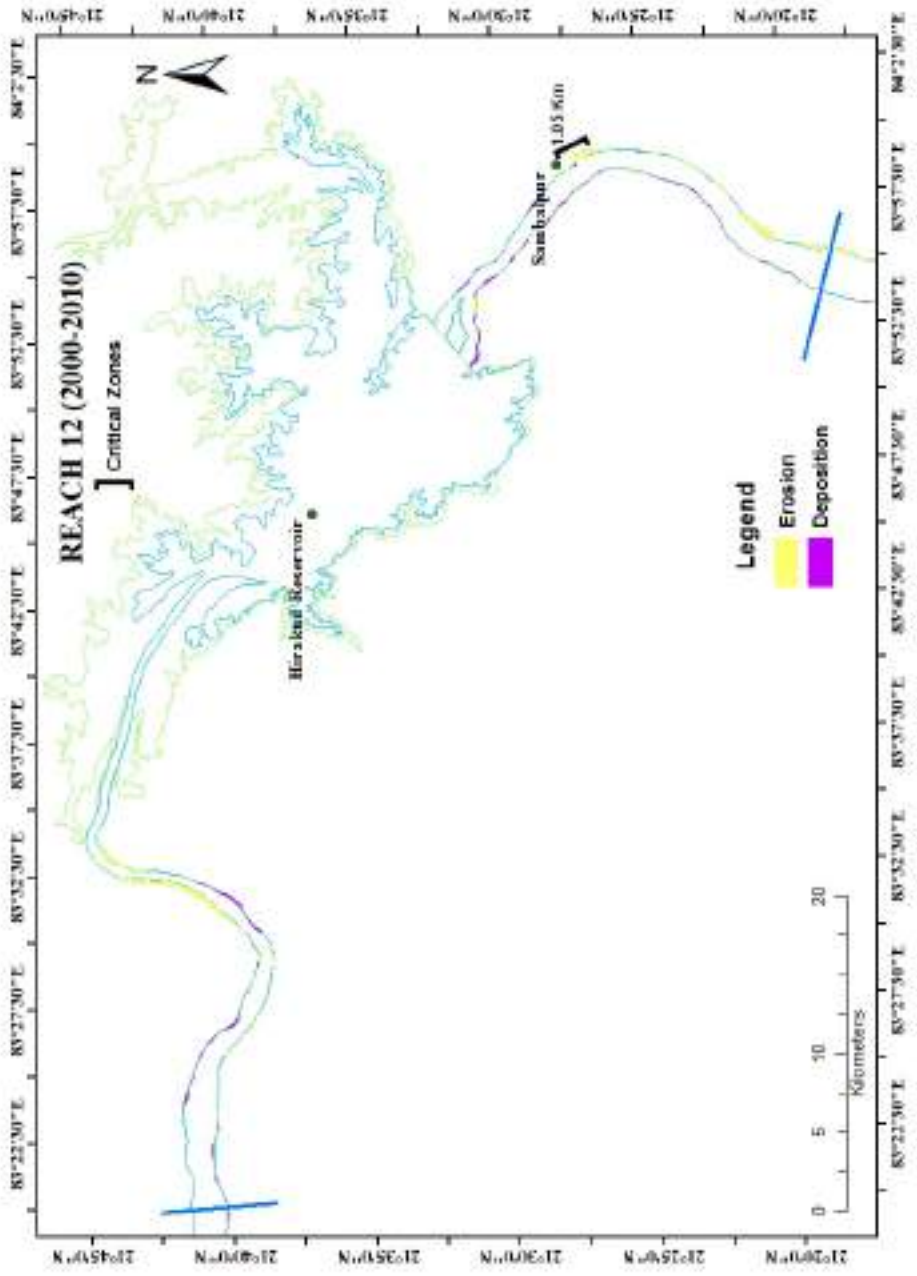


Figure 28.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 13

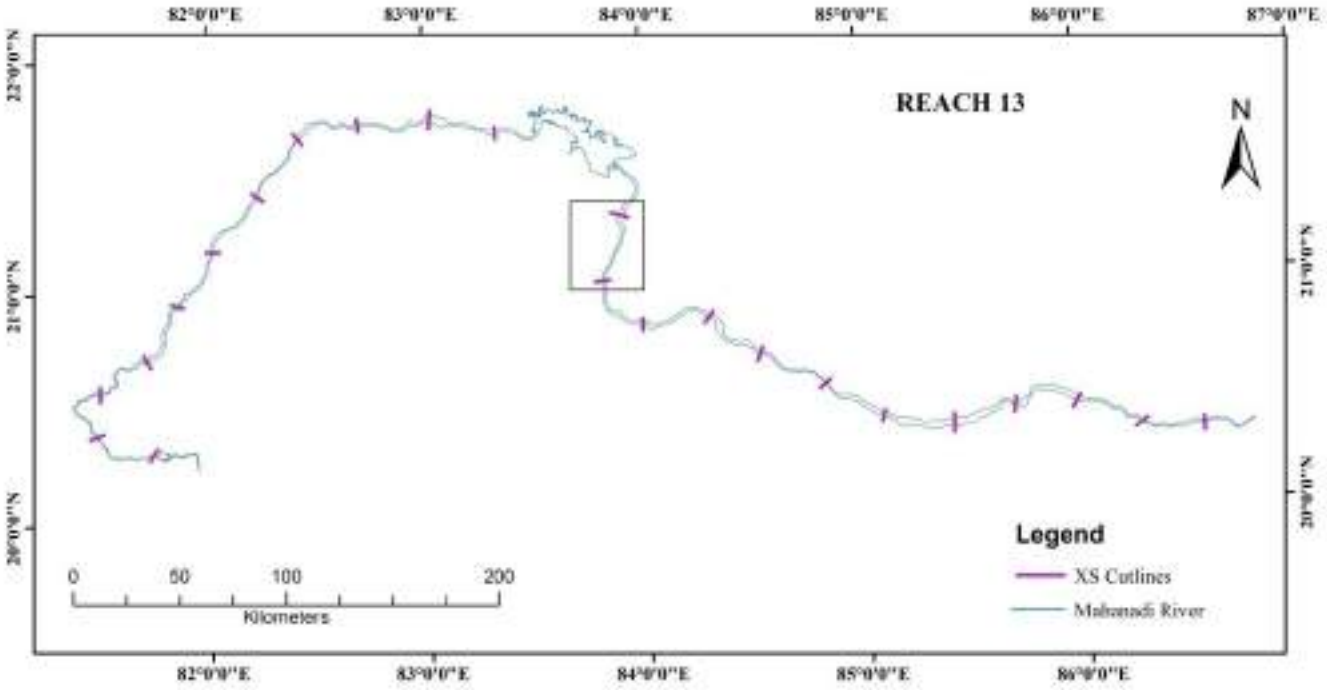


Figure 29.1: Location of reach number 13 in the Mahanadi river

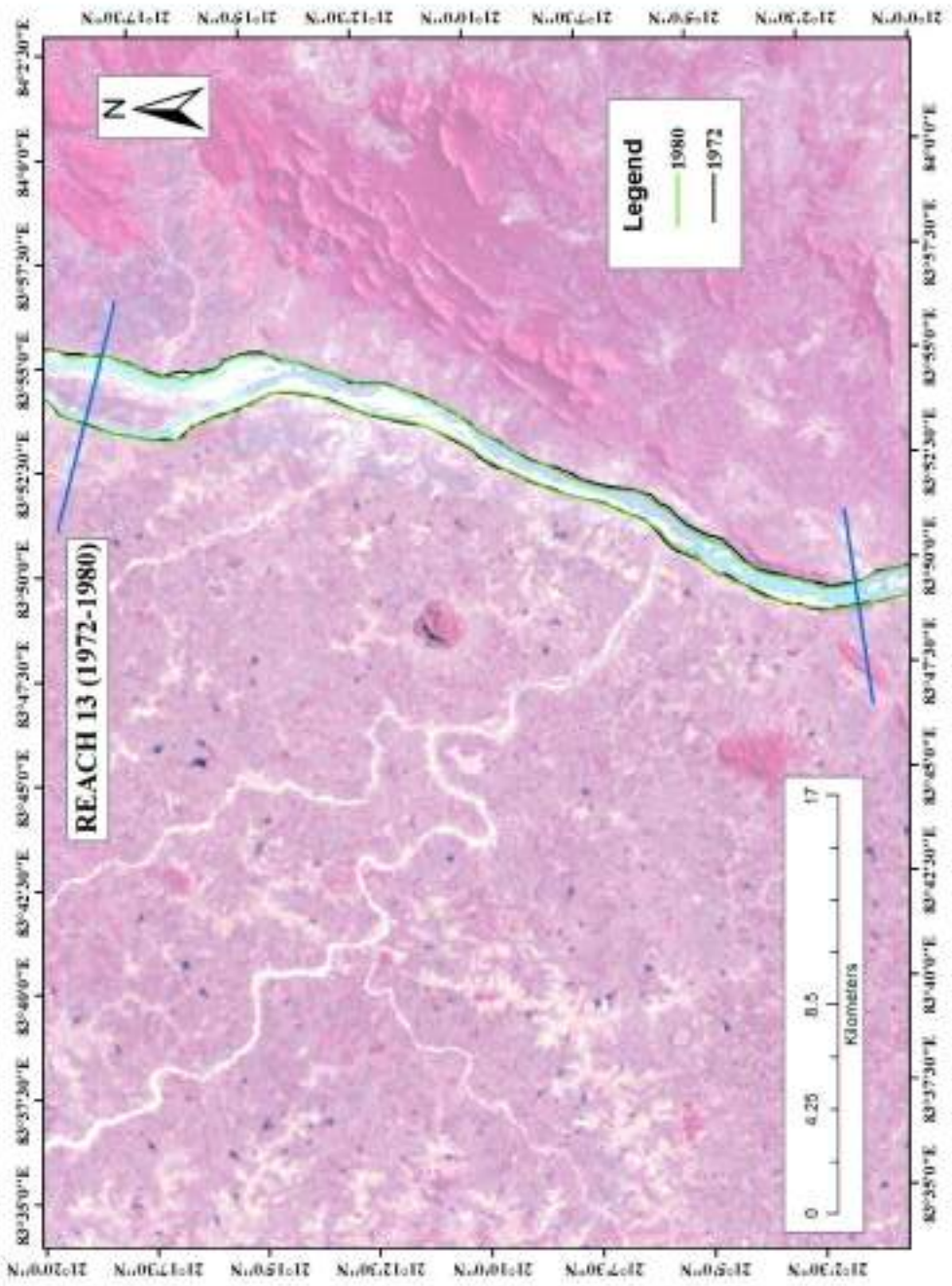


Figure 29.2: Changes in the course of Mahanadi River of Year 1972-1980

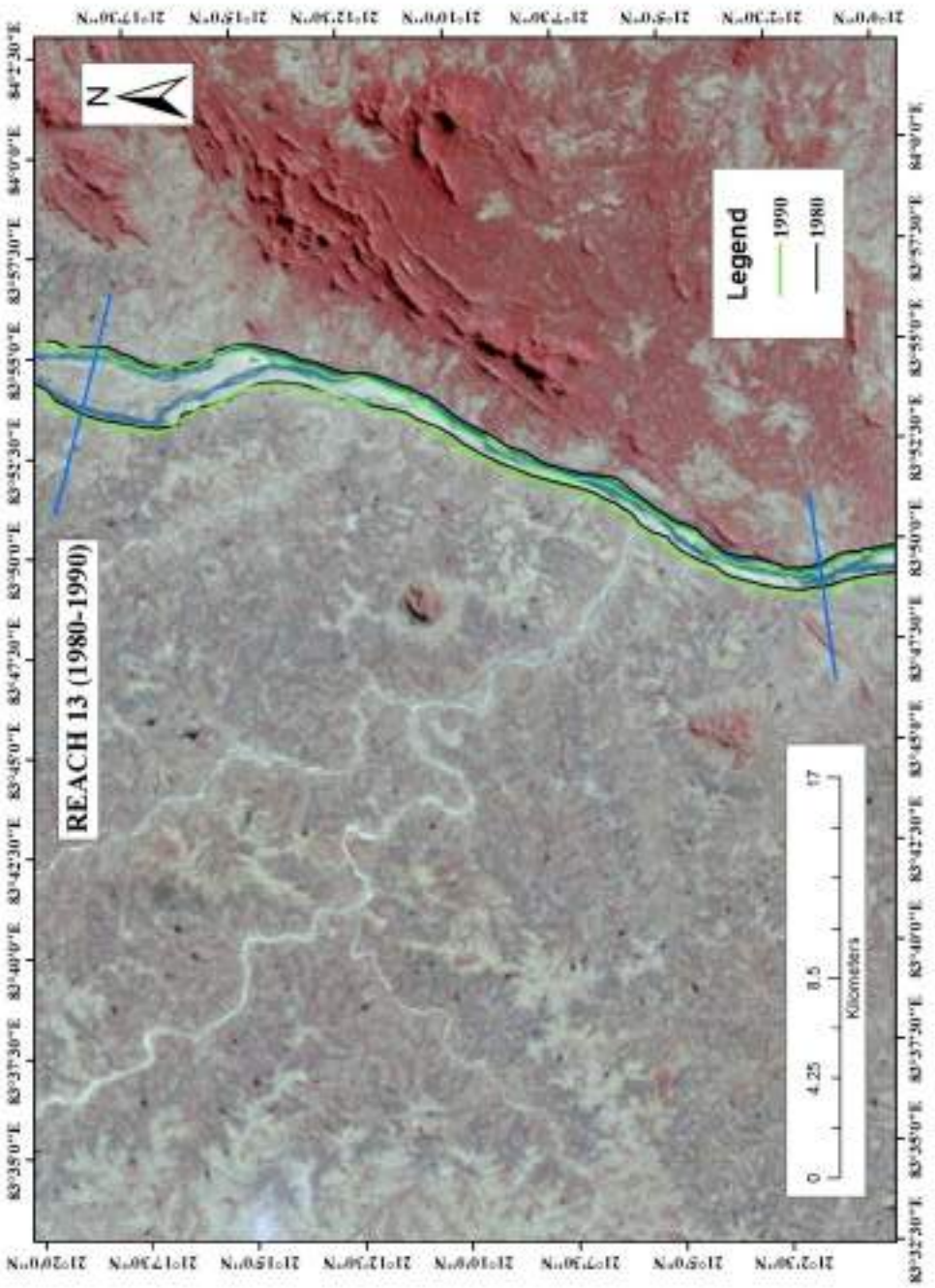


Figure 29.3: Changes in the course of Mahanadi River of Year 1980-1990

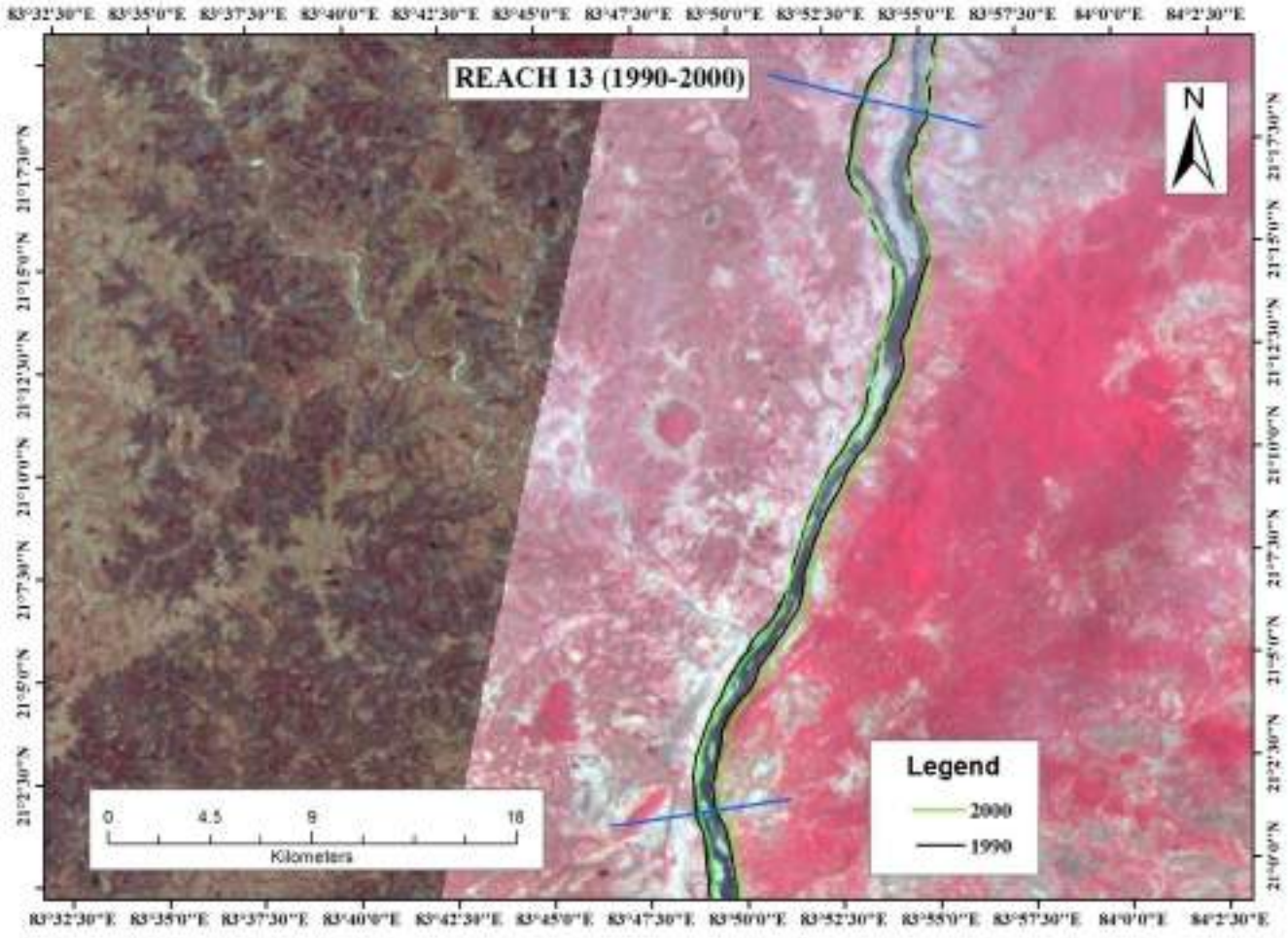


Figure 29.4: Changes in the course of Mahanadi River of Year 1990-2000

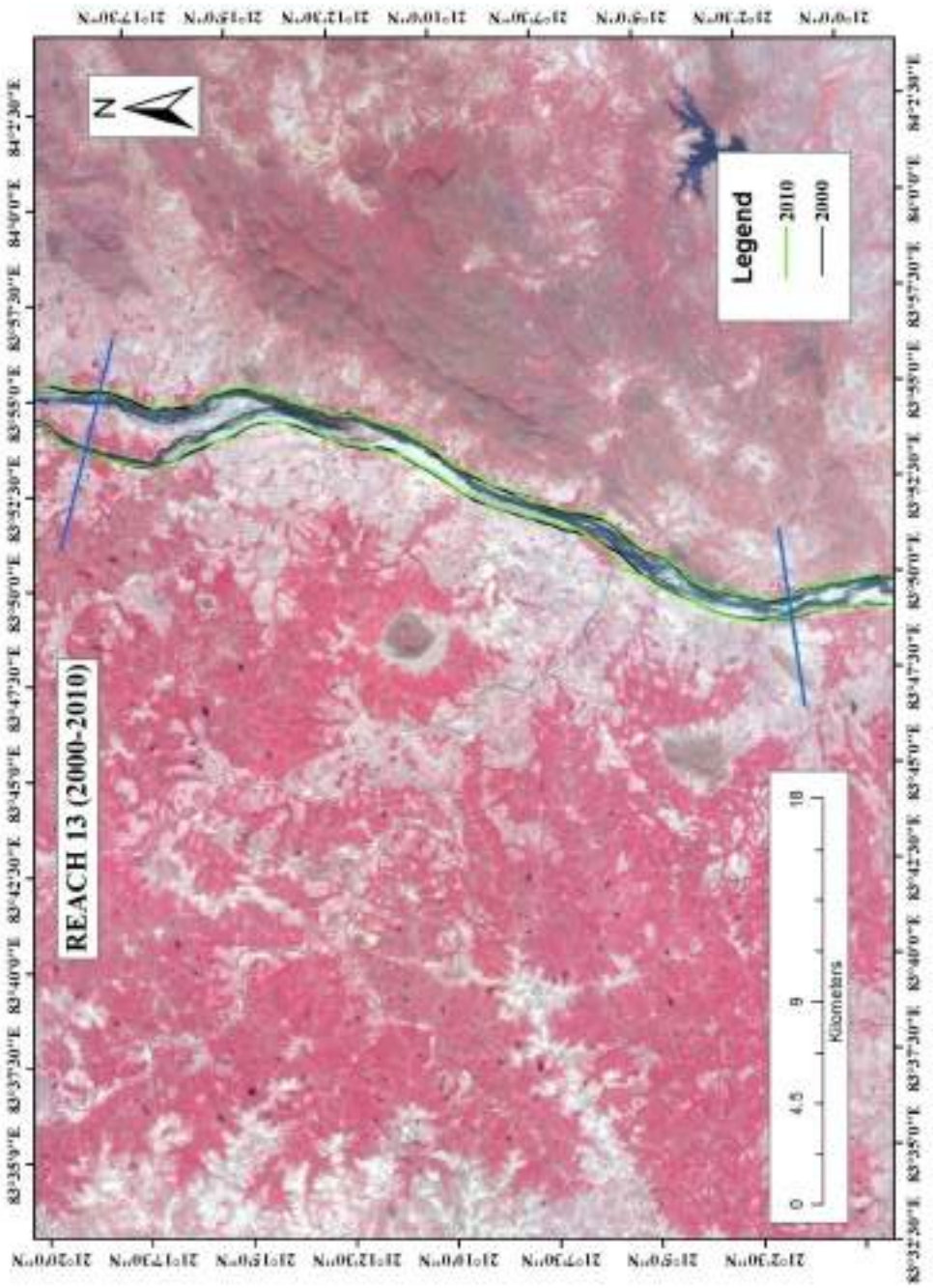


Figure 29.5: Changes in the course of Mahanadi River of Year 2000-2010

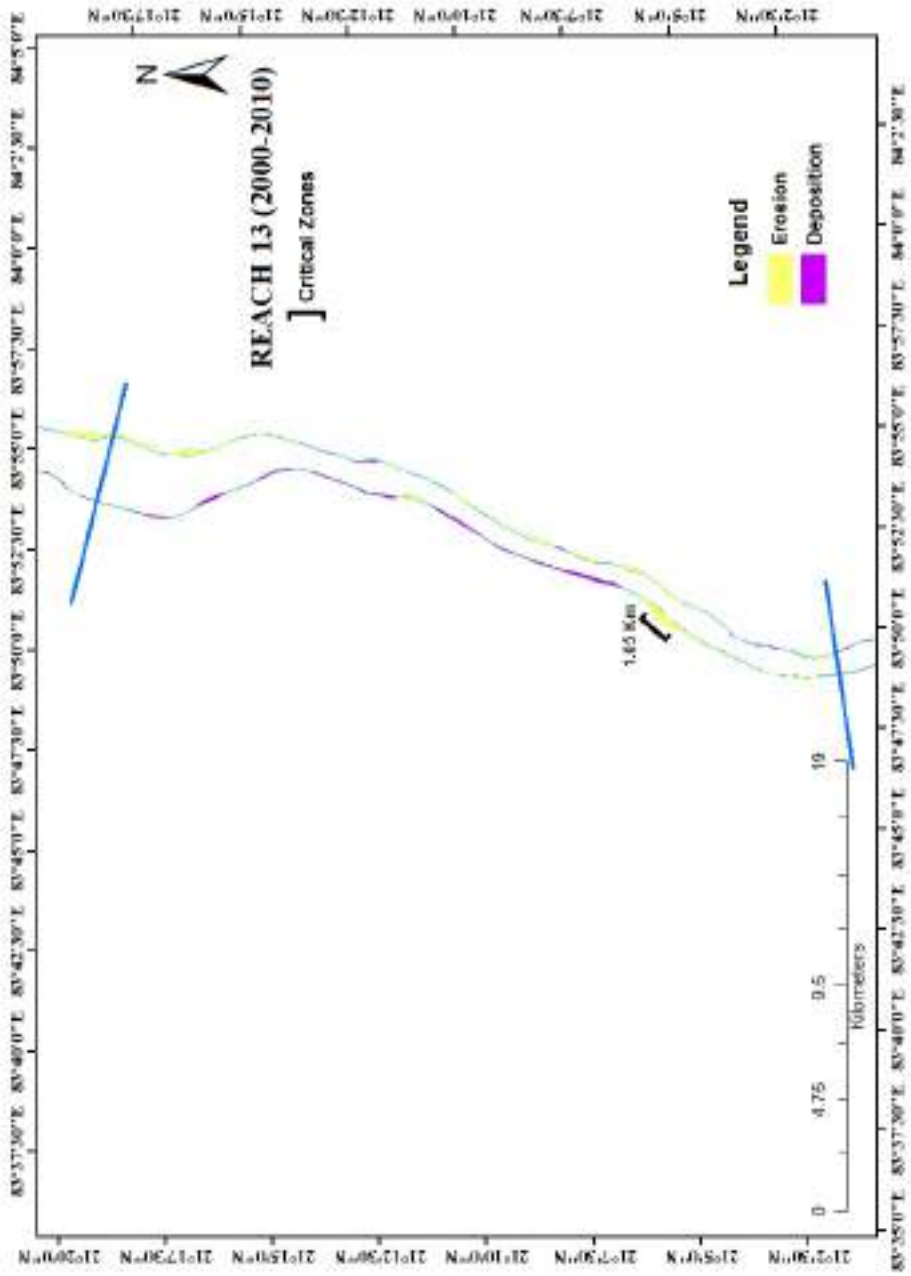


Figure 29.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 14

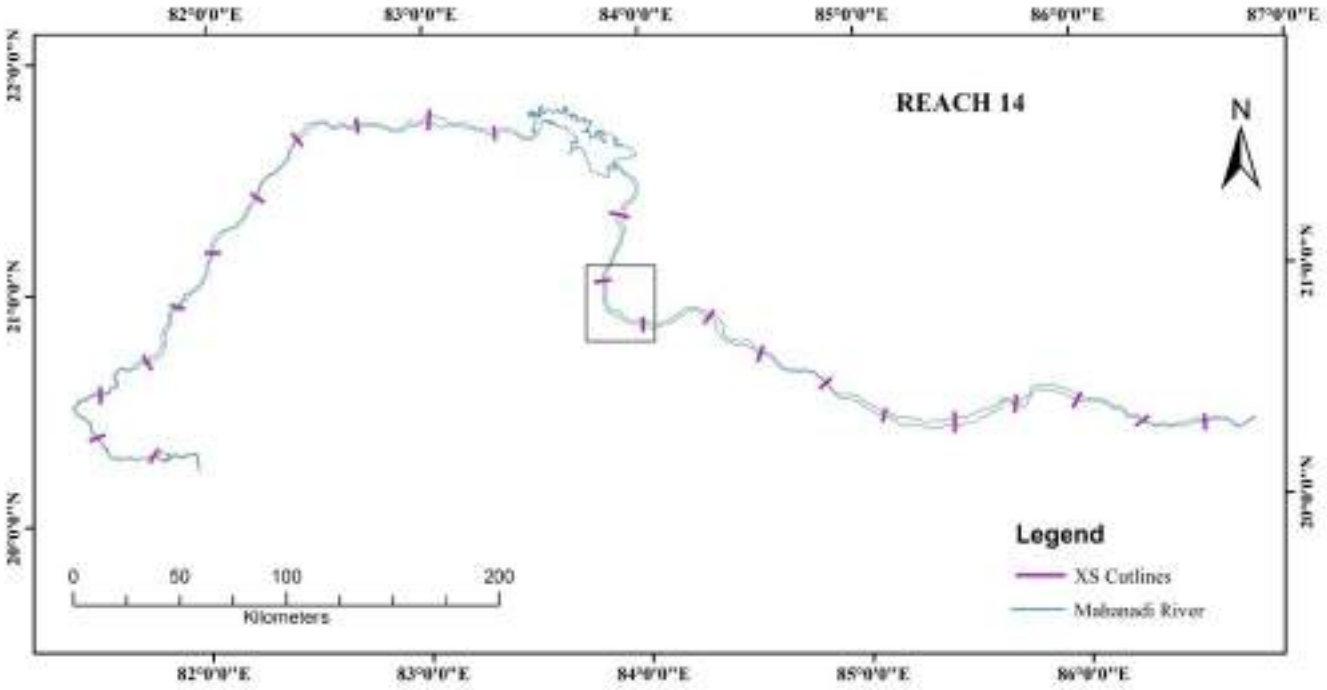


Figure 30.1: Location of reach number 14 in the Mahanadi river

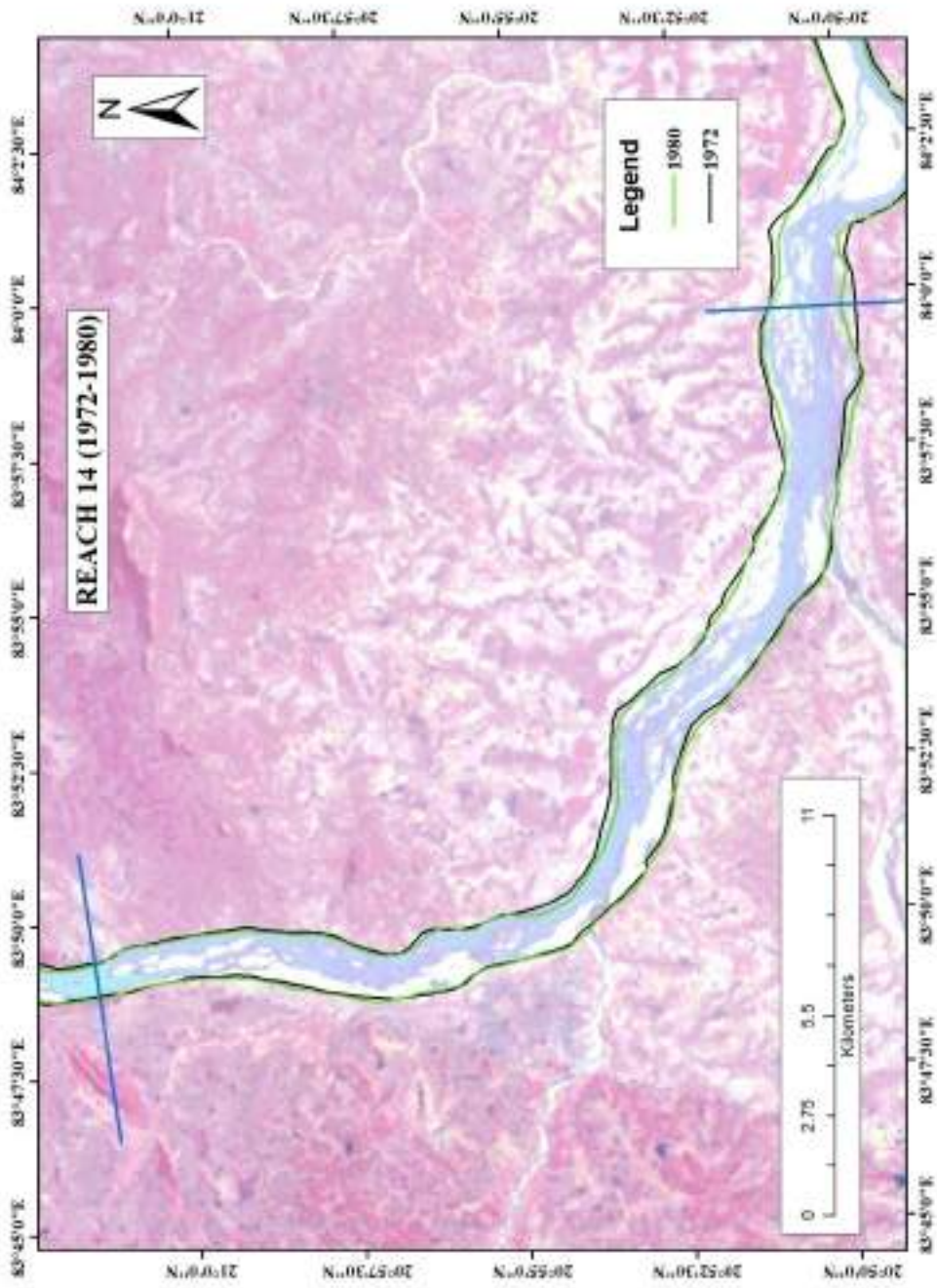


Figure 30.2: Changes in the course of Mahanadi River of Year 1972-1980

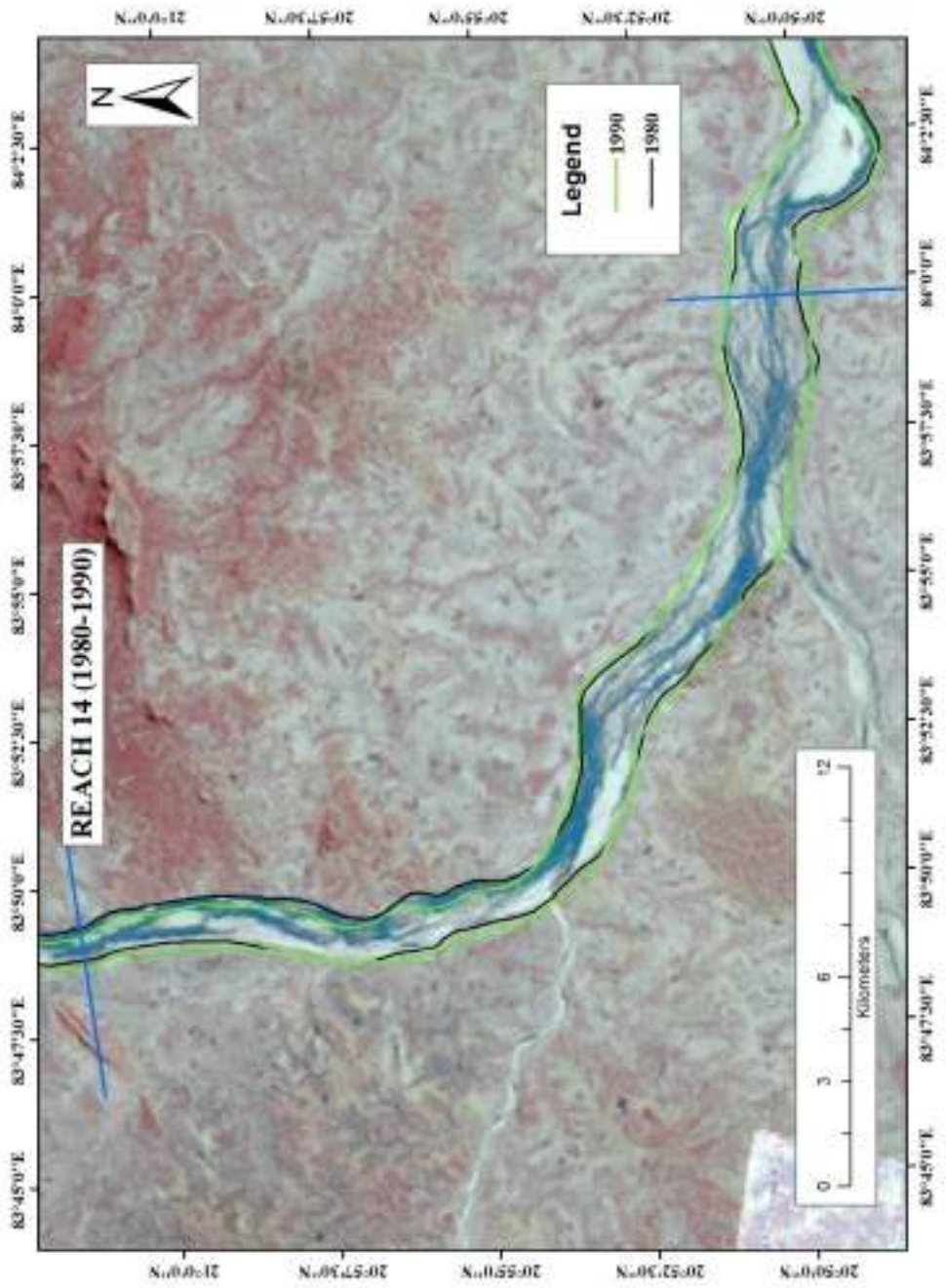


Figure 30.3: Changes in the course of Mahanadi River of Year 1980-1990

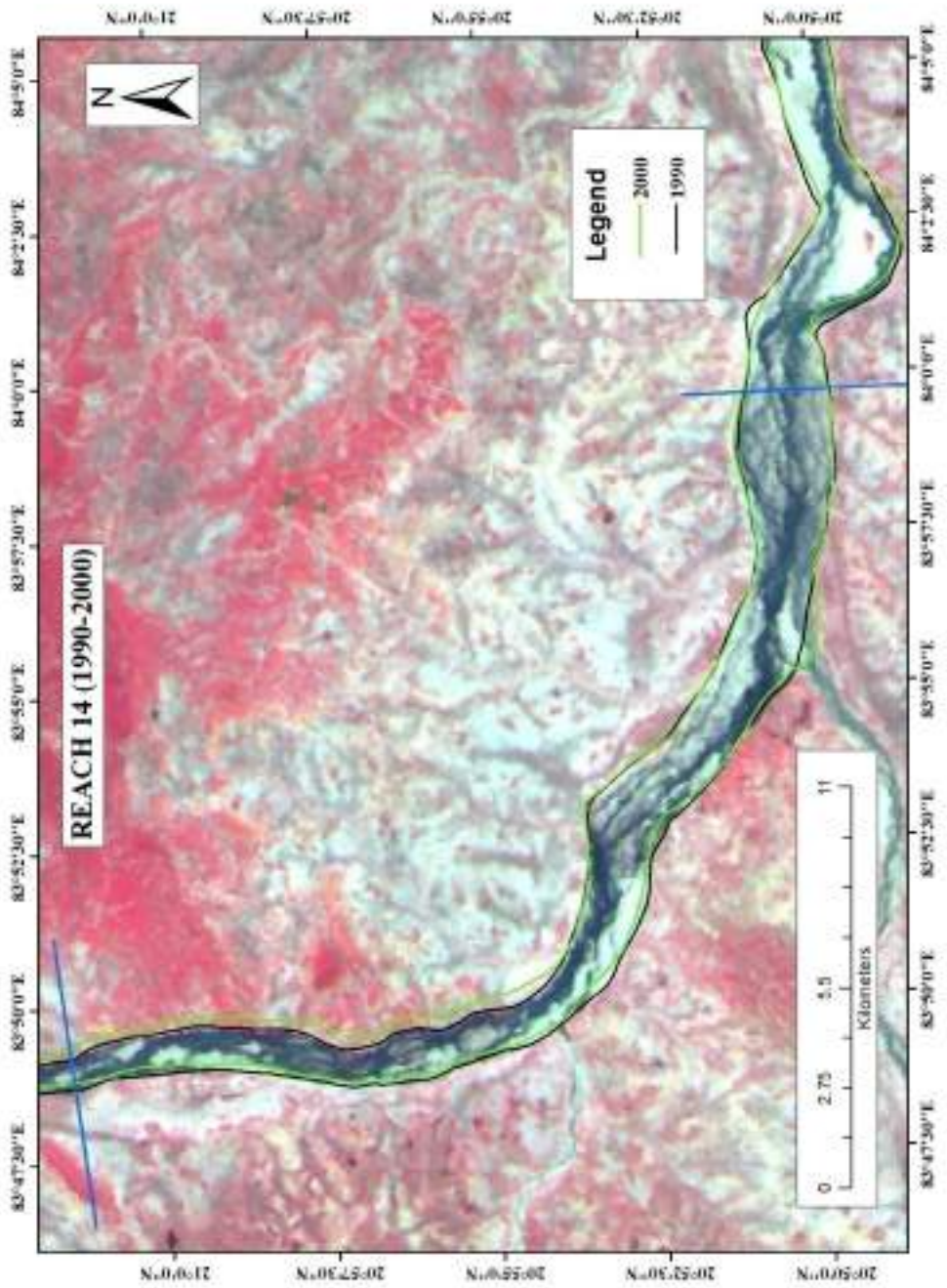


Figure 30.4: Changes in the course of Mahanadi River of Year 1990-2000

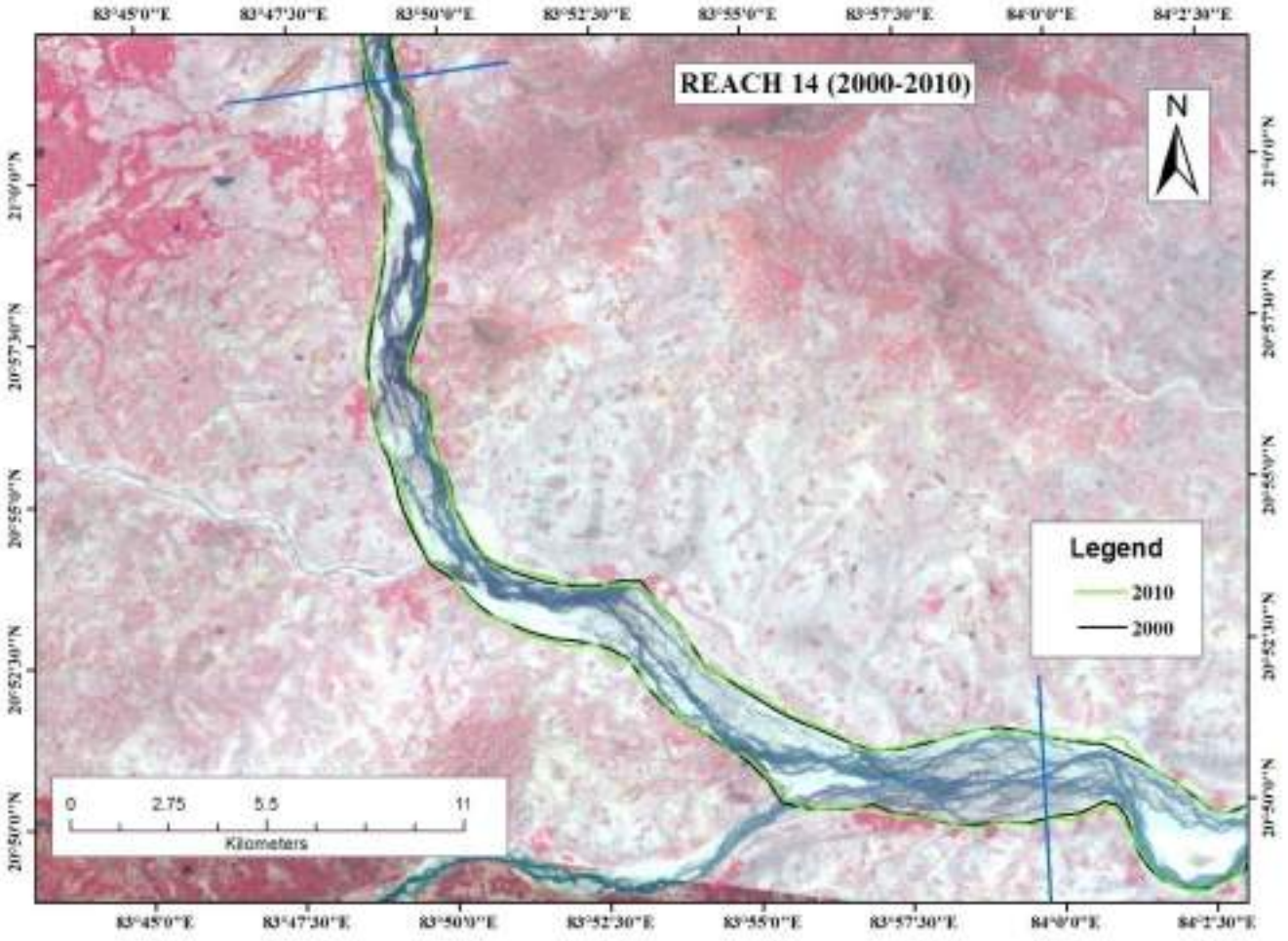


Figure 30.5: Changes in the course of Mahanadi River of Year 2000-2010

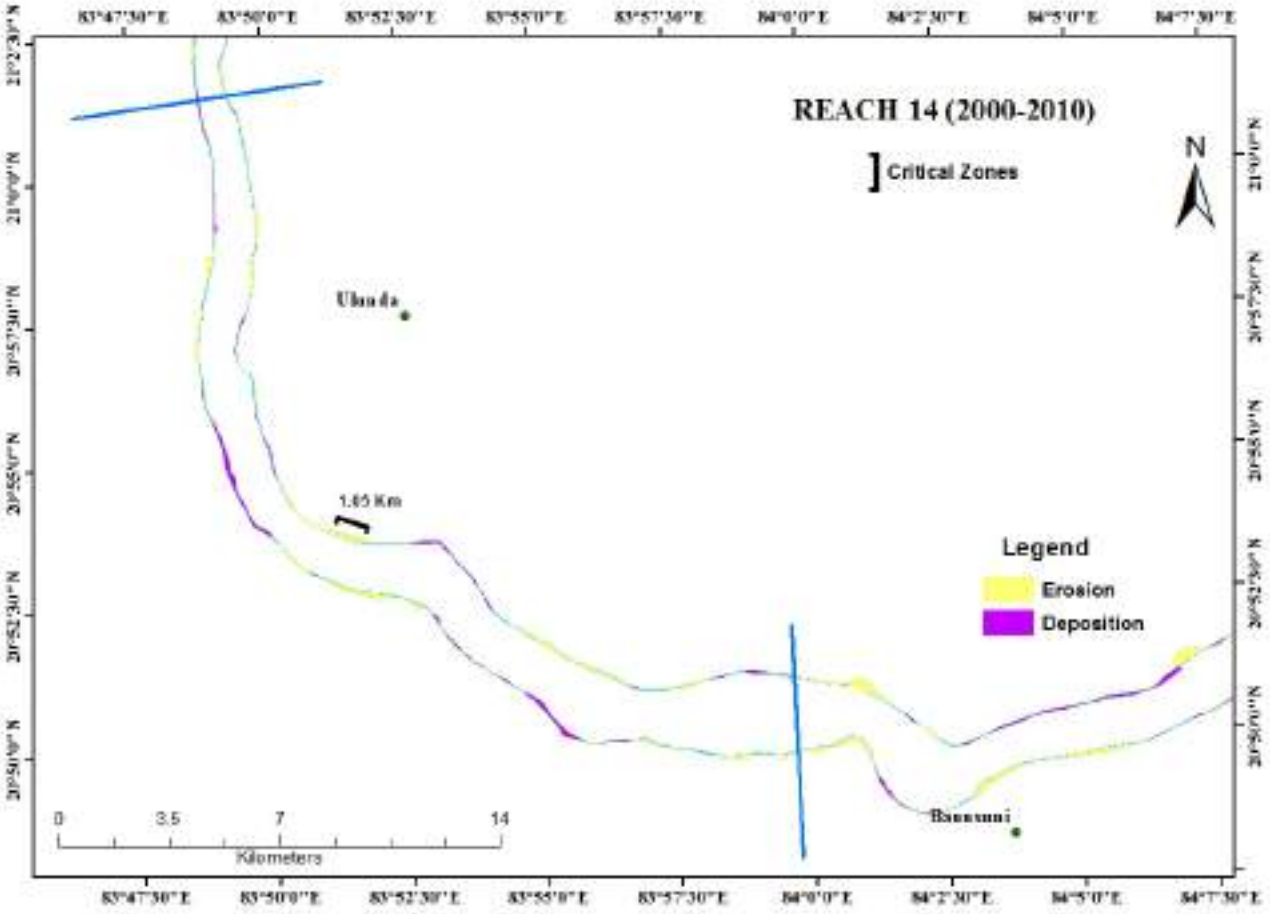


Figure 30.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 15

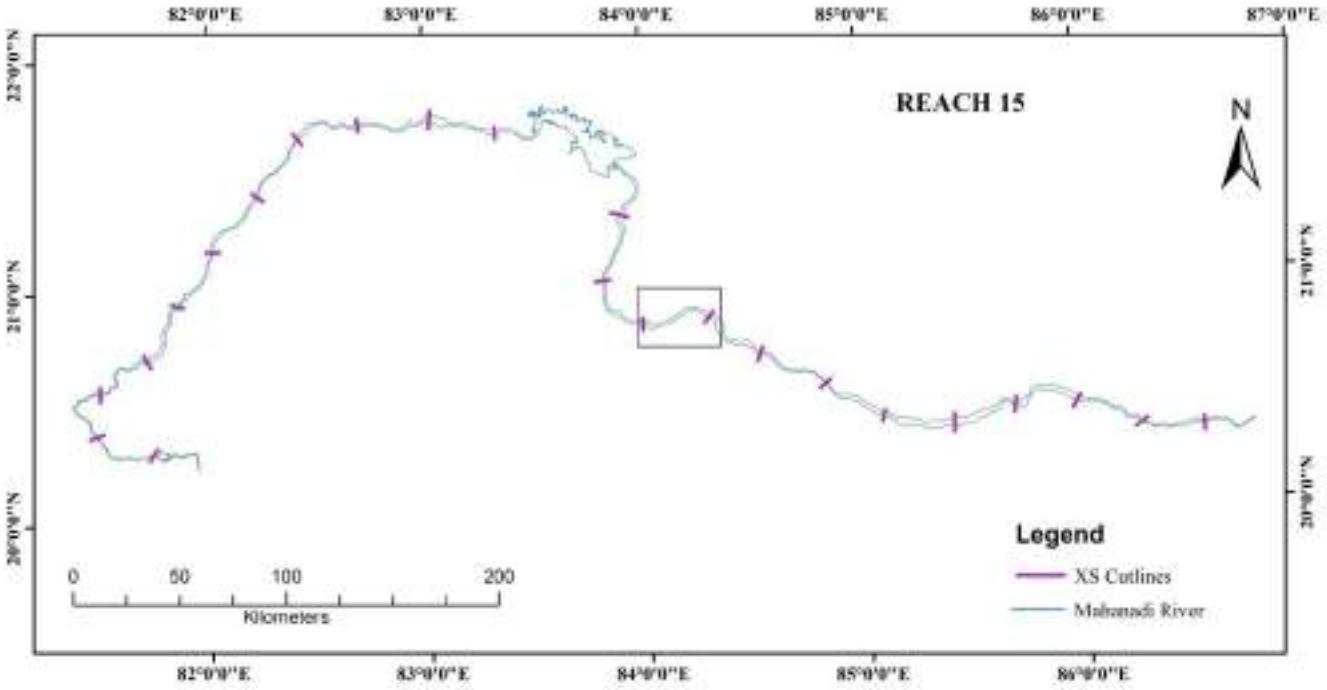


Figure 31.1: Location of reach number 15 in the Mahanadi river

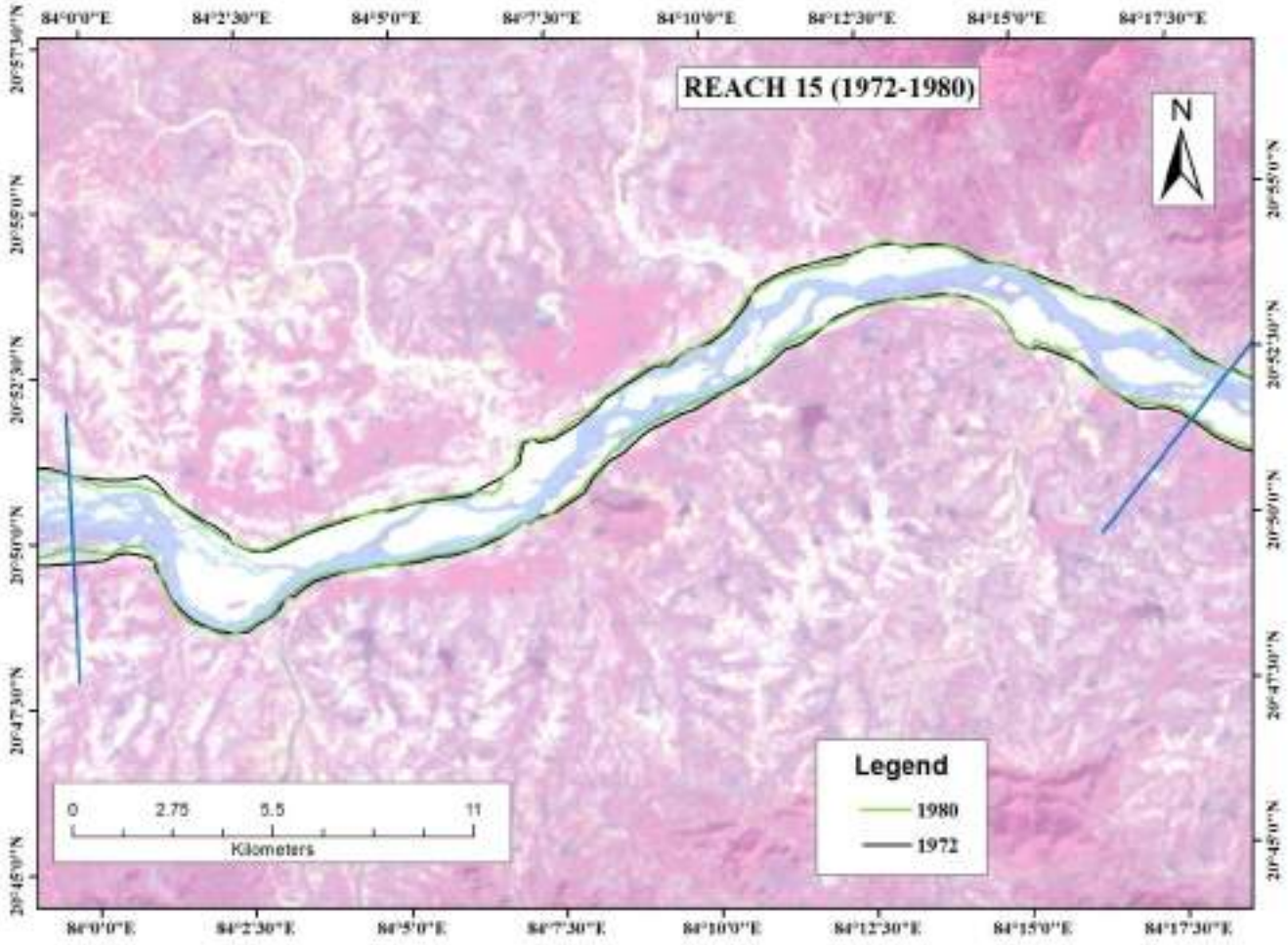


Figure 31.2: Changes in the course of Mahanadi River of Year 1972-1980

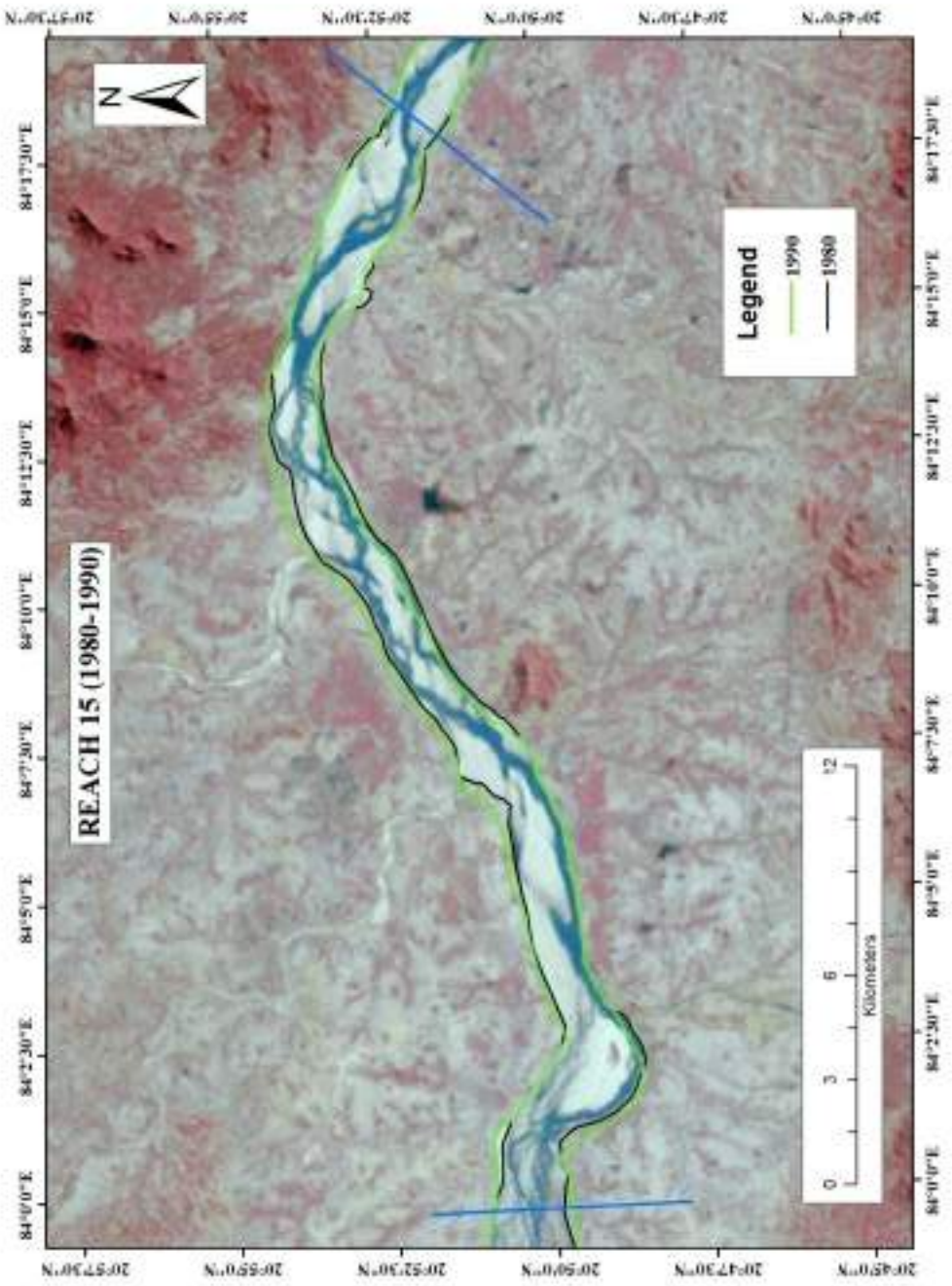


Figure 31.3: Changes in the course of Mahanadi River of Year 1980-1990

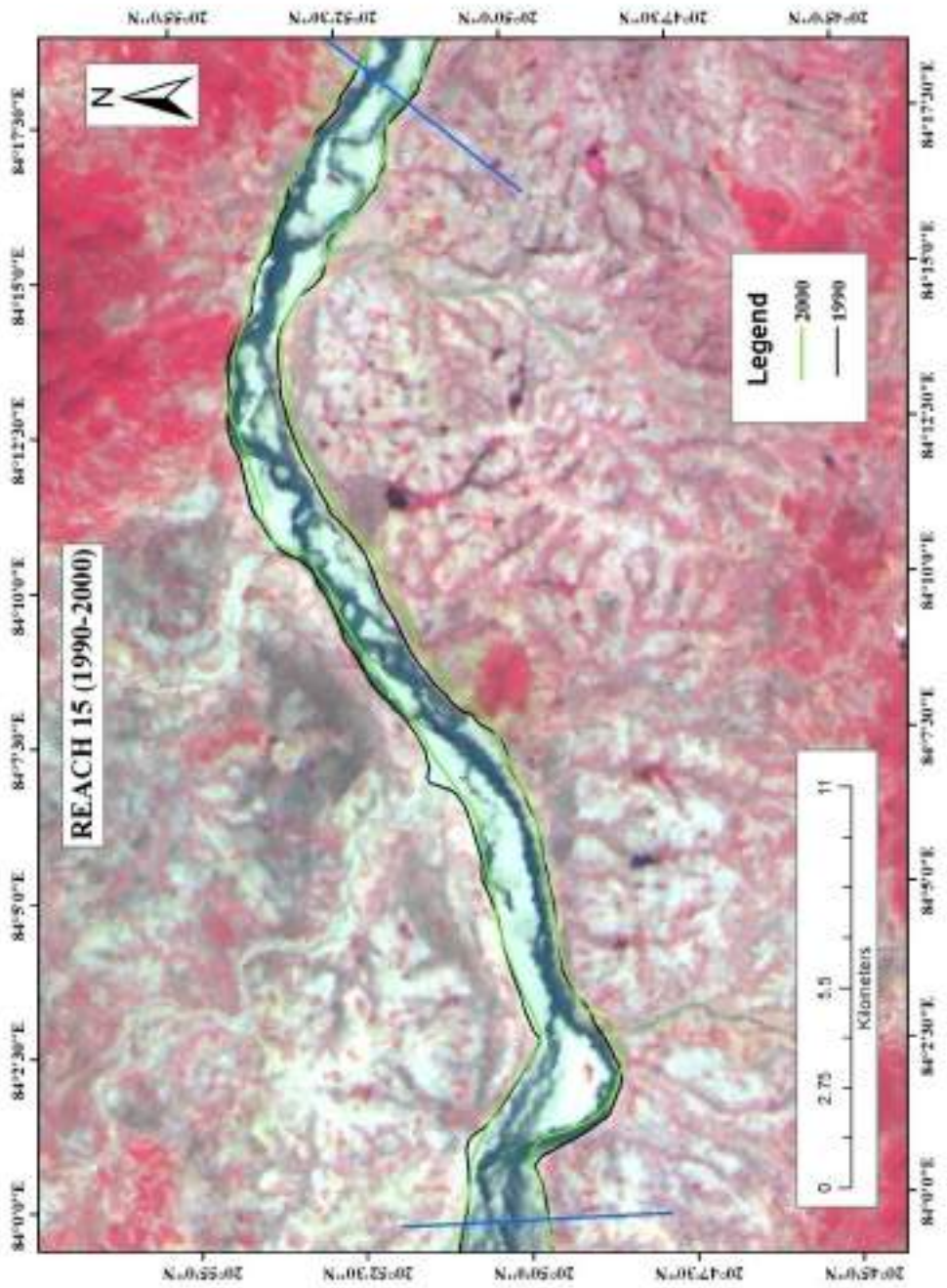


Figure 31.4: Changes in the course of Mahanadi River of Year 1990-2000

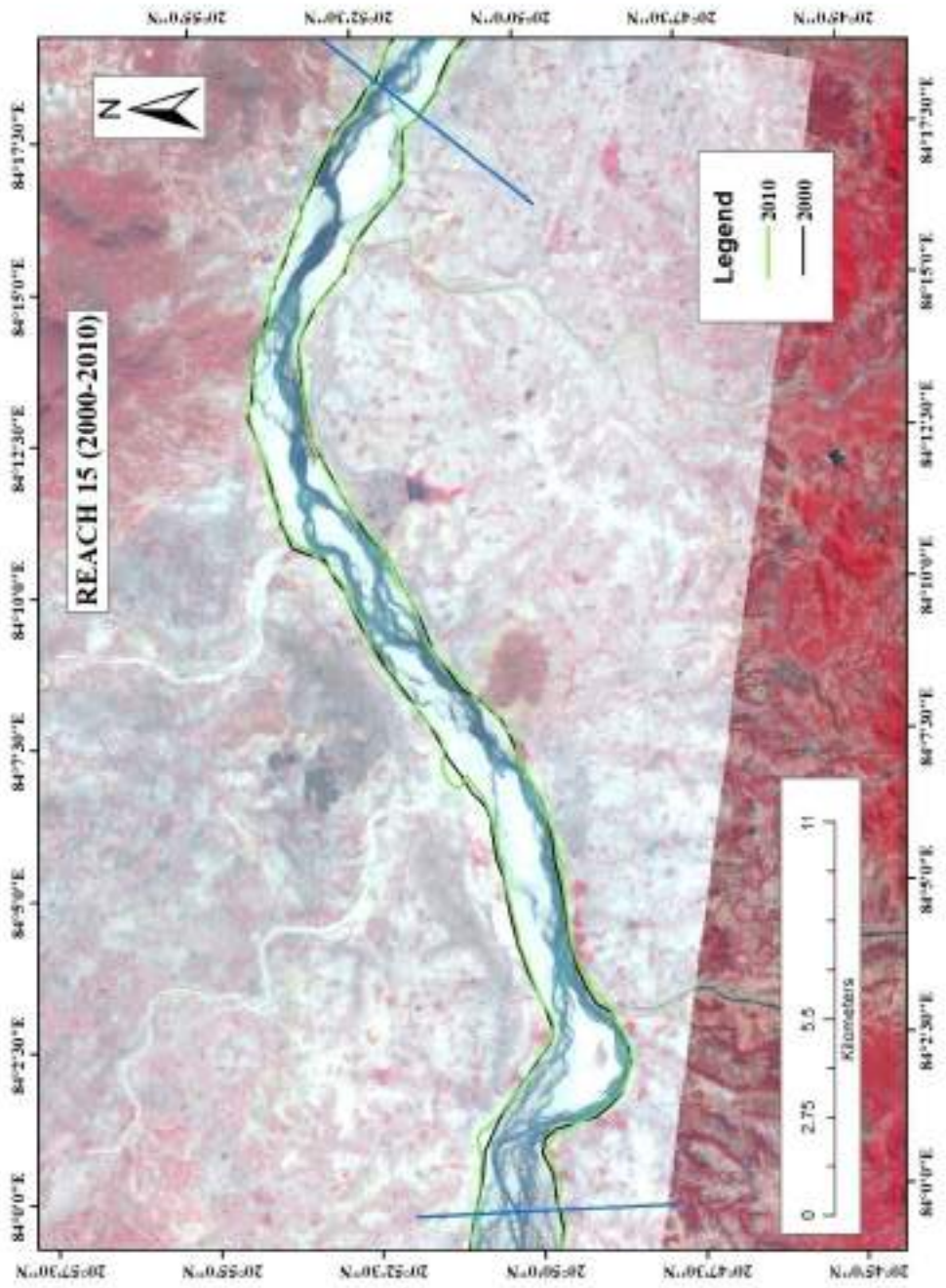


Figure 31.5: Changes in the course of Mahanadi River of Year 2000-2010

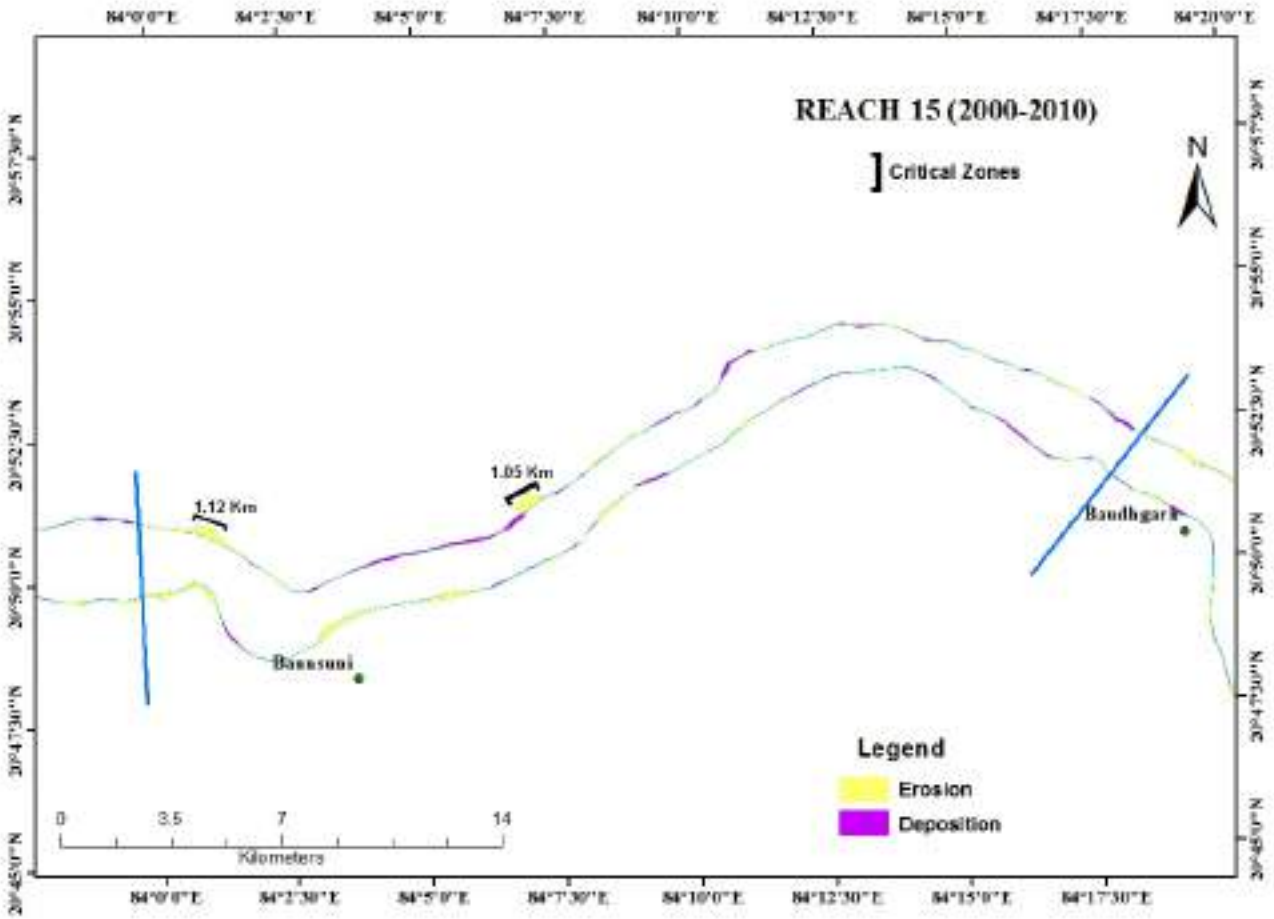


Figure 31.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 16

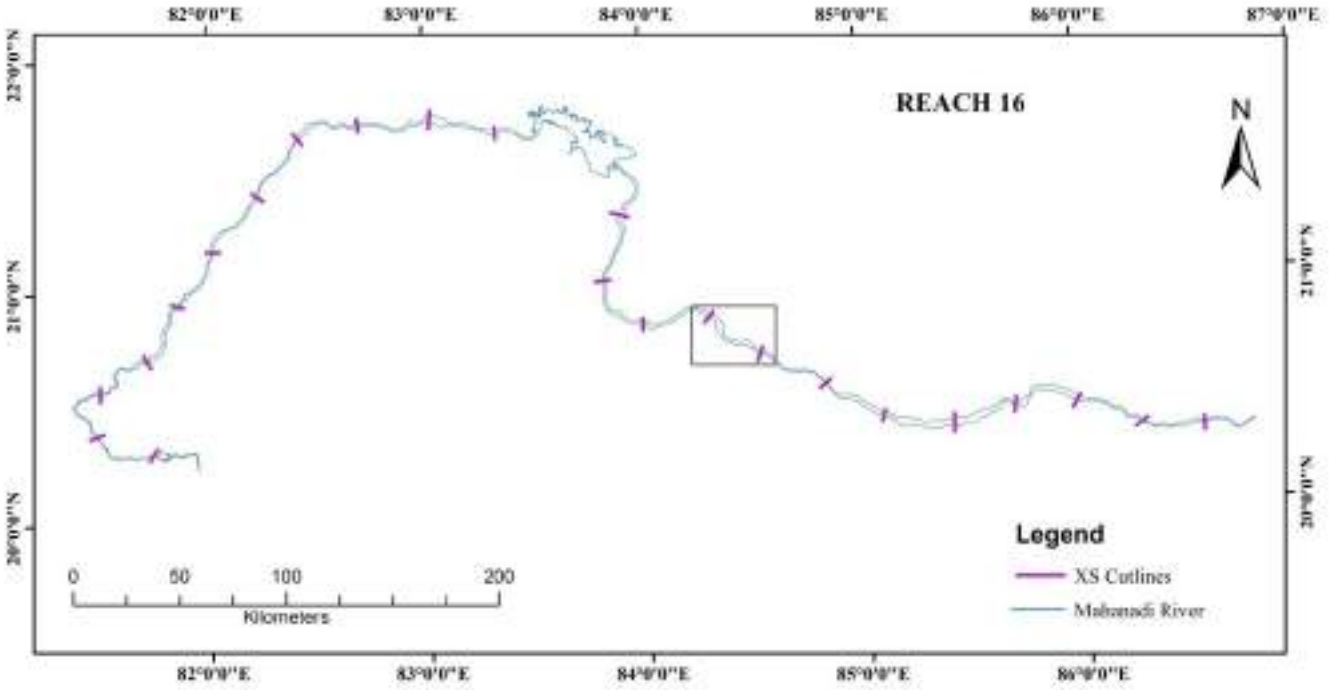


Figure 32.1: Location of reach number 16 in the Mahanadi river

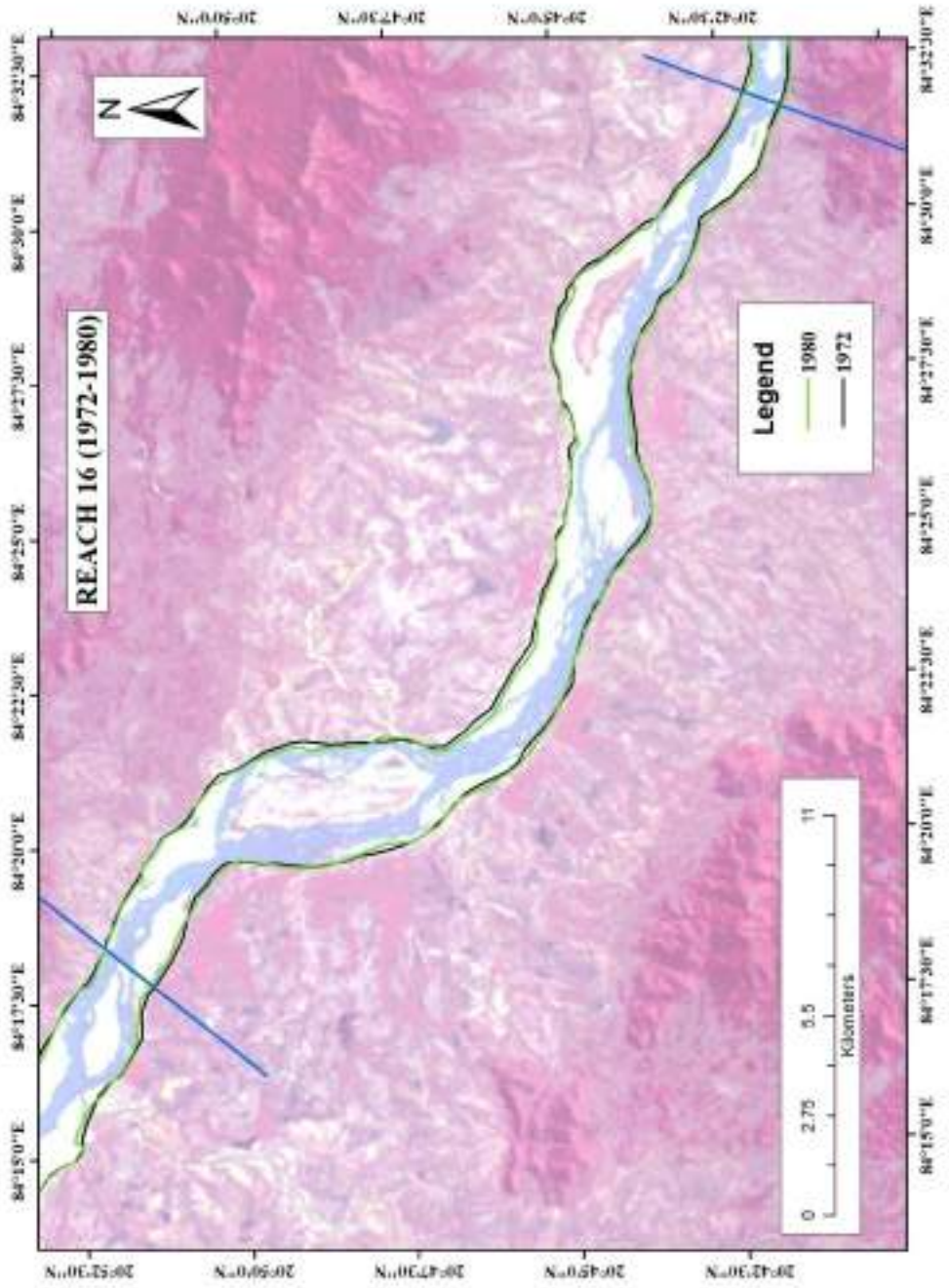


Figure 32.2: Changes in the course of Mahanadi River of Year 1972-1980

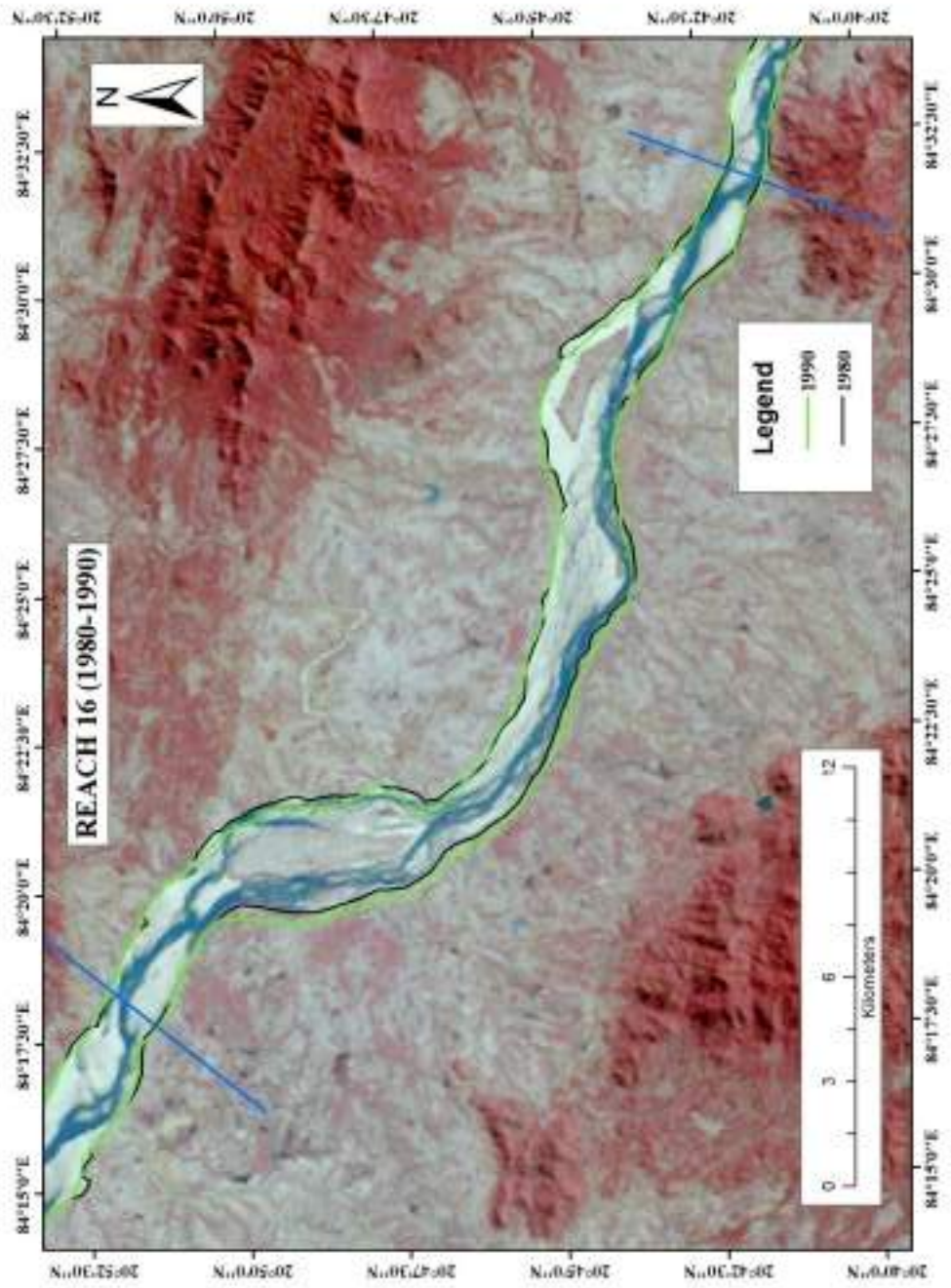


Figure 32.3: Changes in the course of Mahanadi River of Year 1980-1990

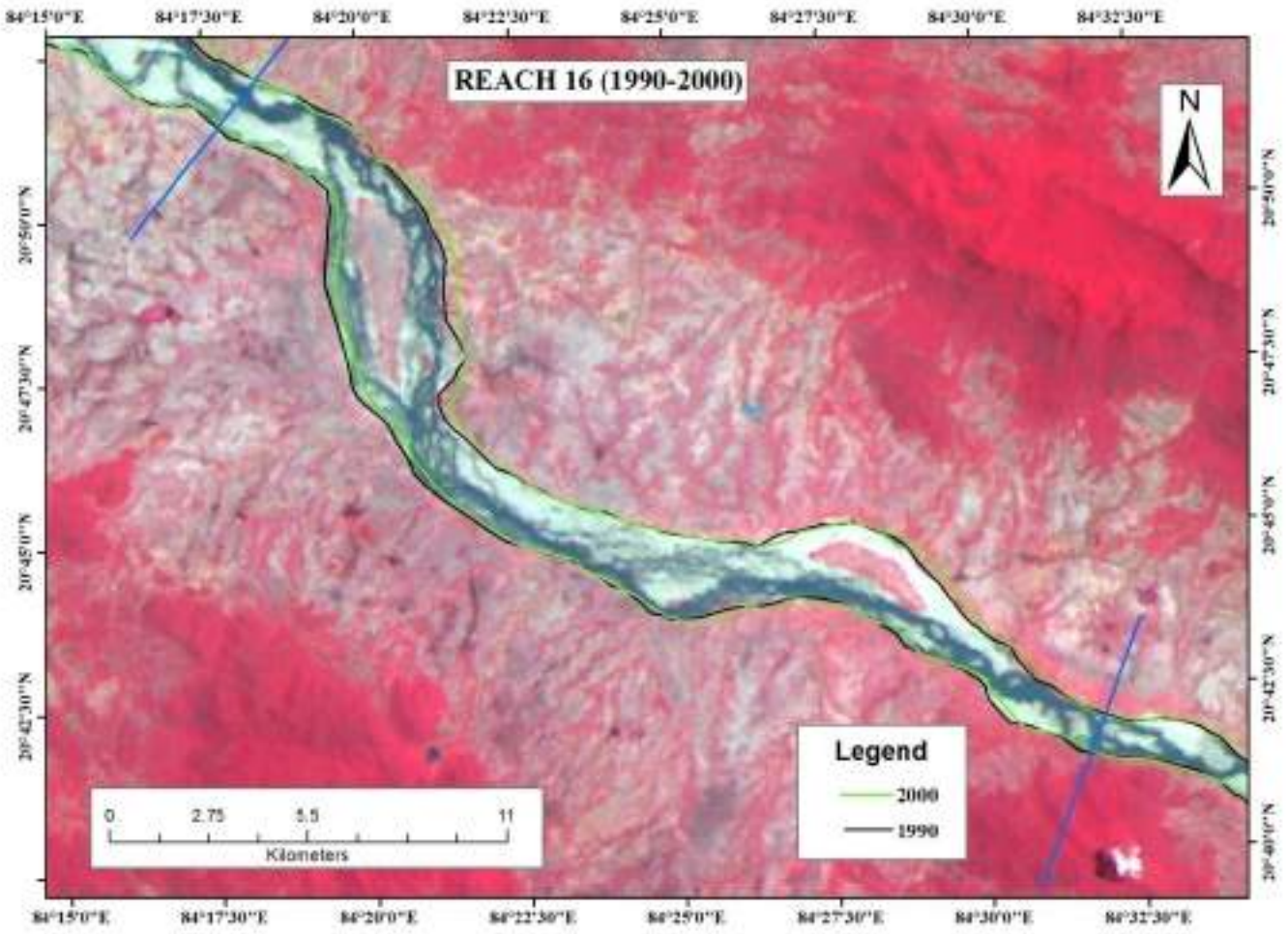


Figure 32.4: Changes in the course of Mahanadi River of Year 1990-2000

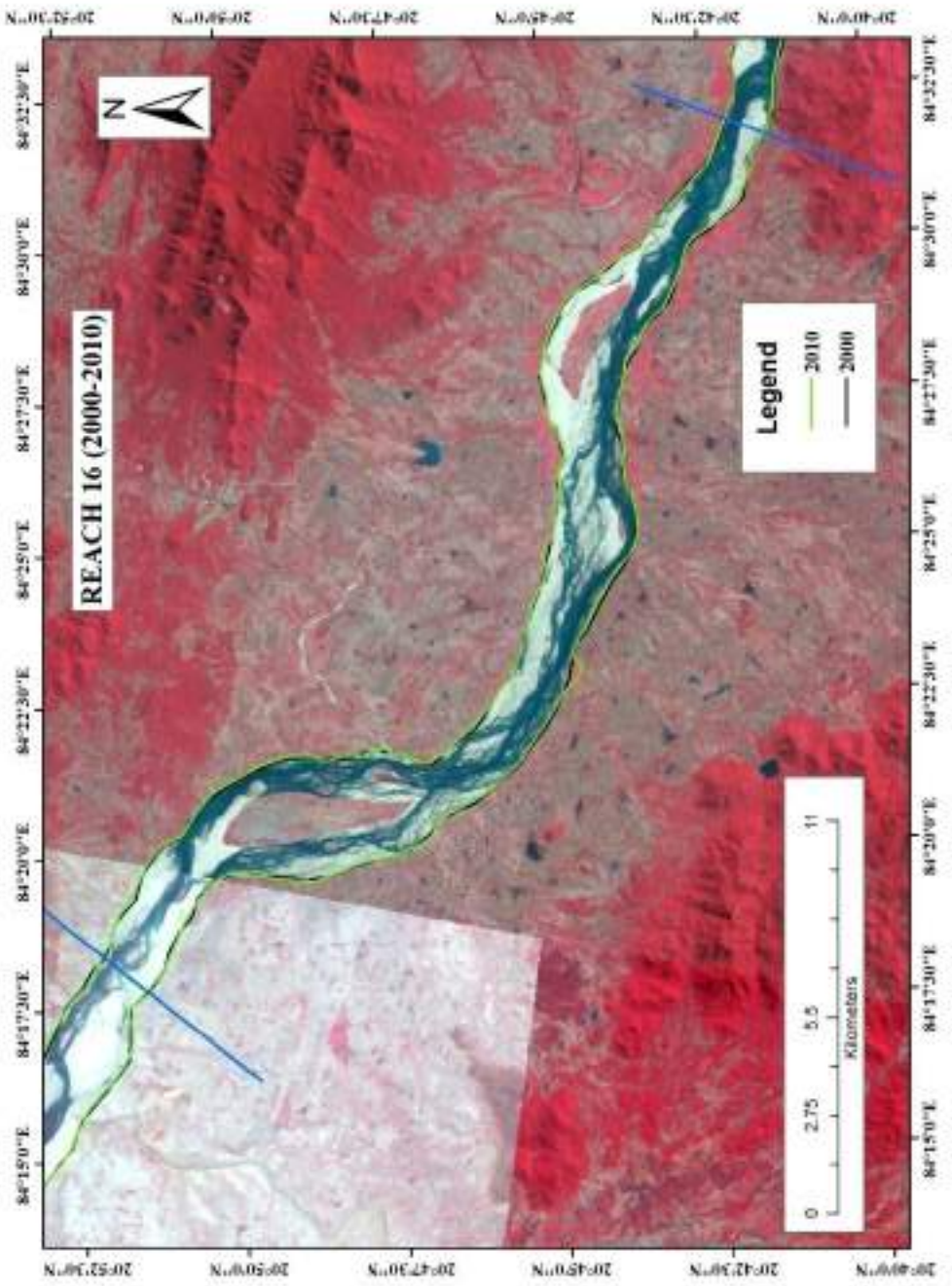


Figure 32.5: Changes in the course of Mahanadi River of Year 2000-2010

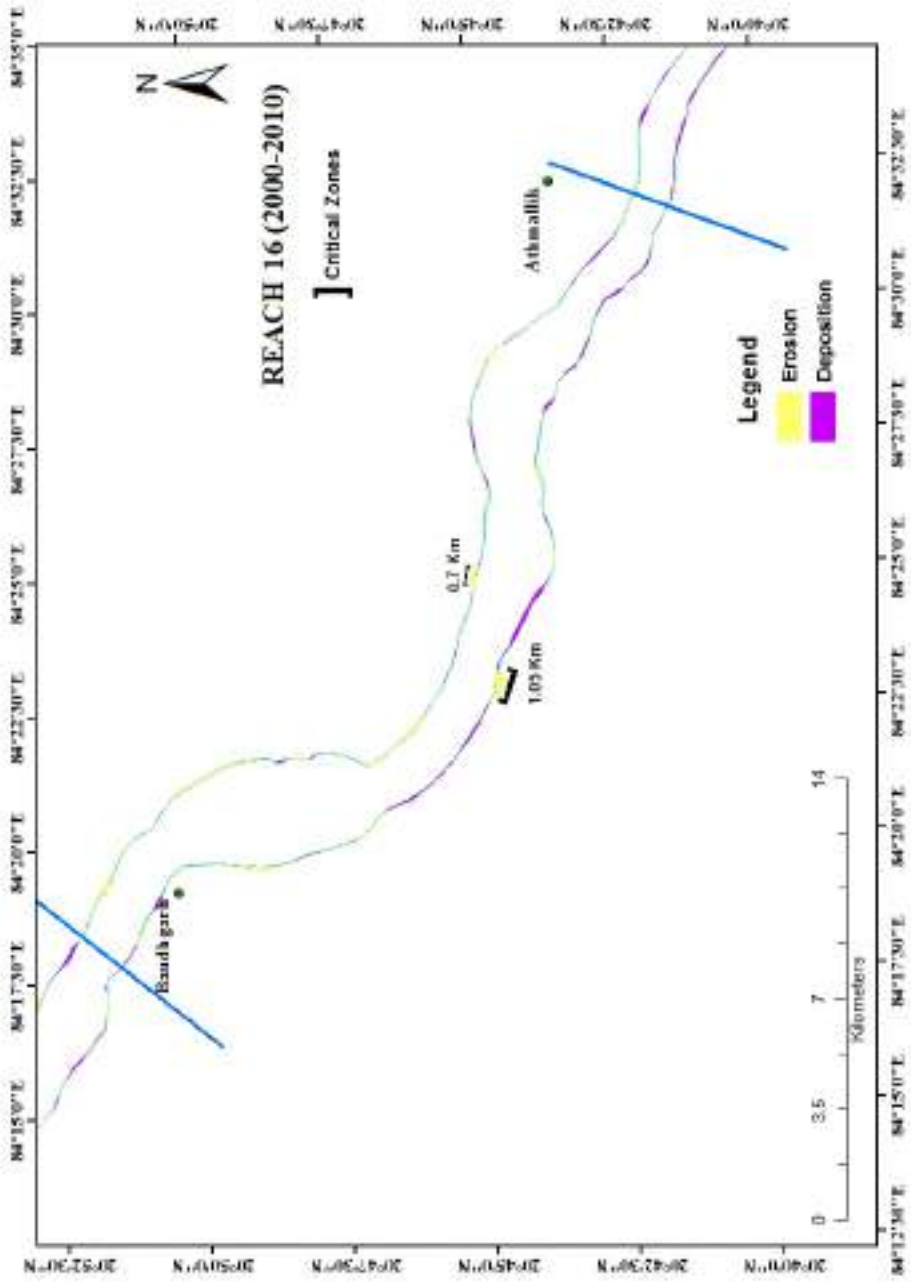


Figure 32.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 17

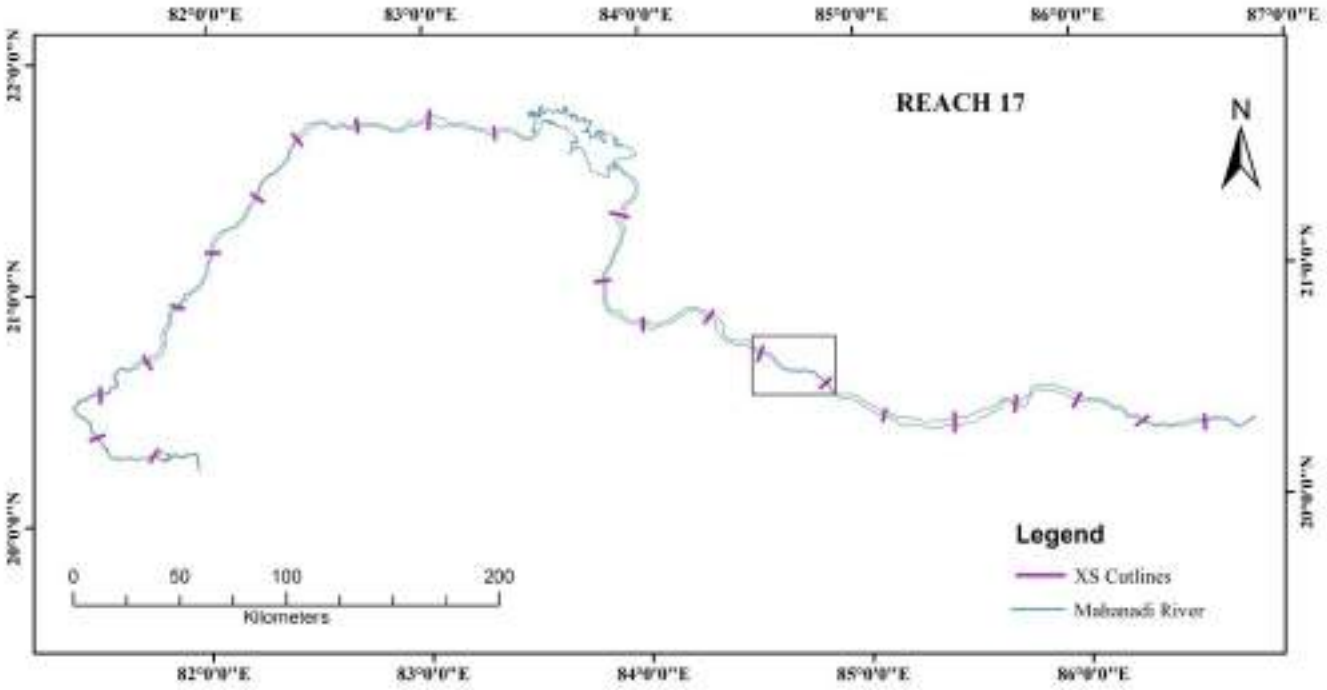


Figure 33.1: Location of reach number 17 in the Mahanadi river

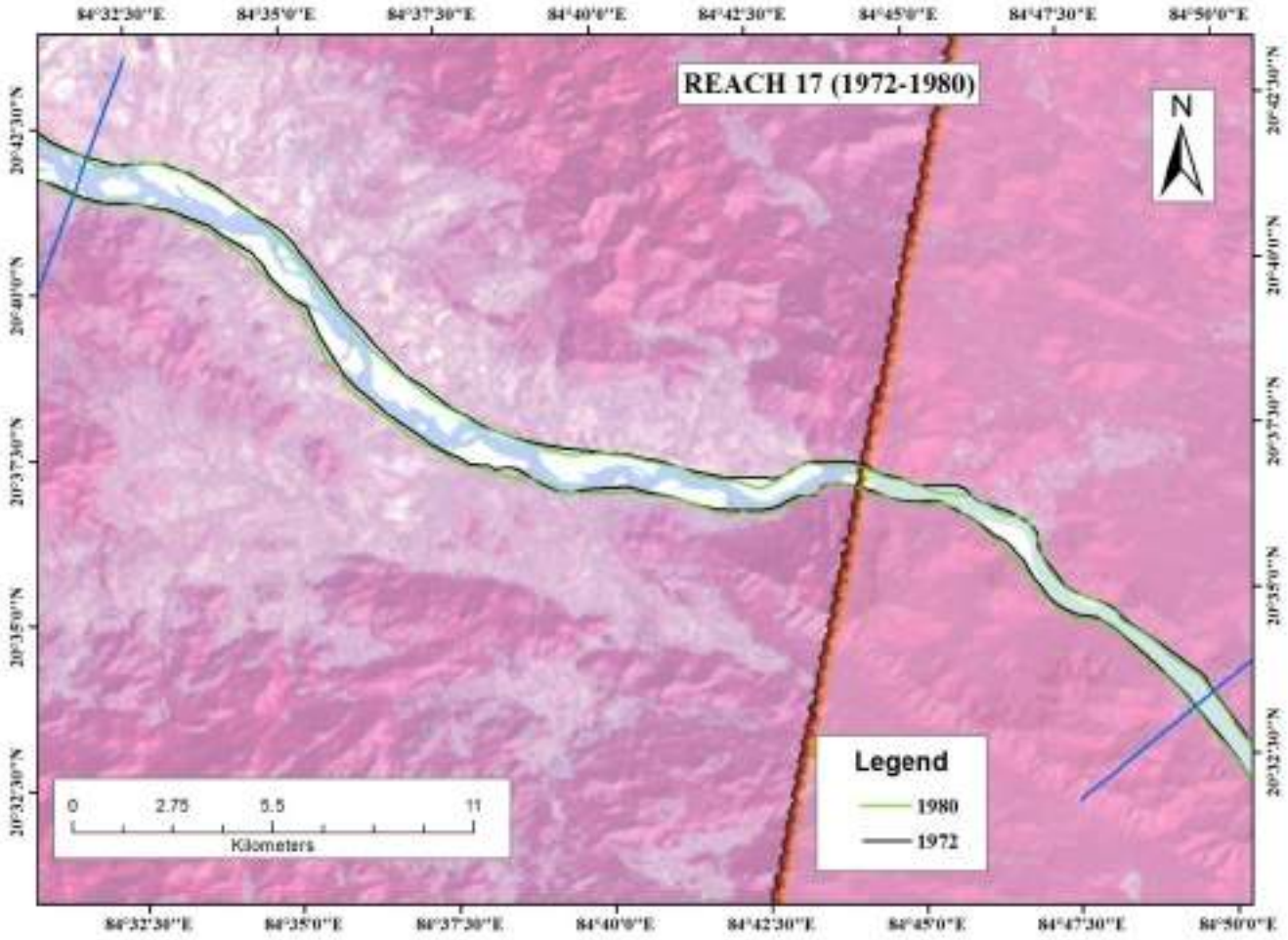


Figure 33.2: Changes in the course of Mahanadi River of Year 1972-1980

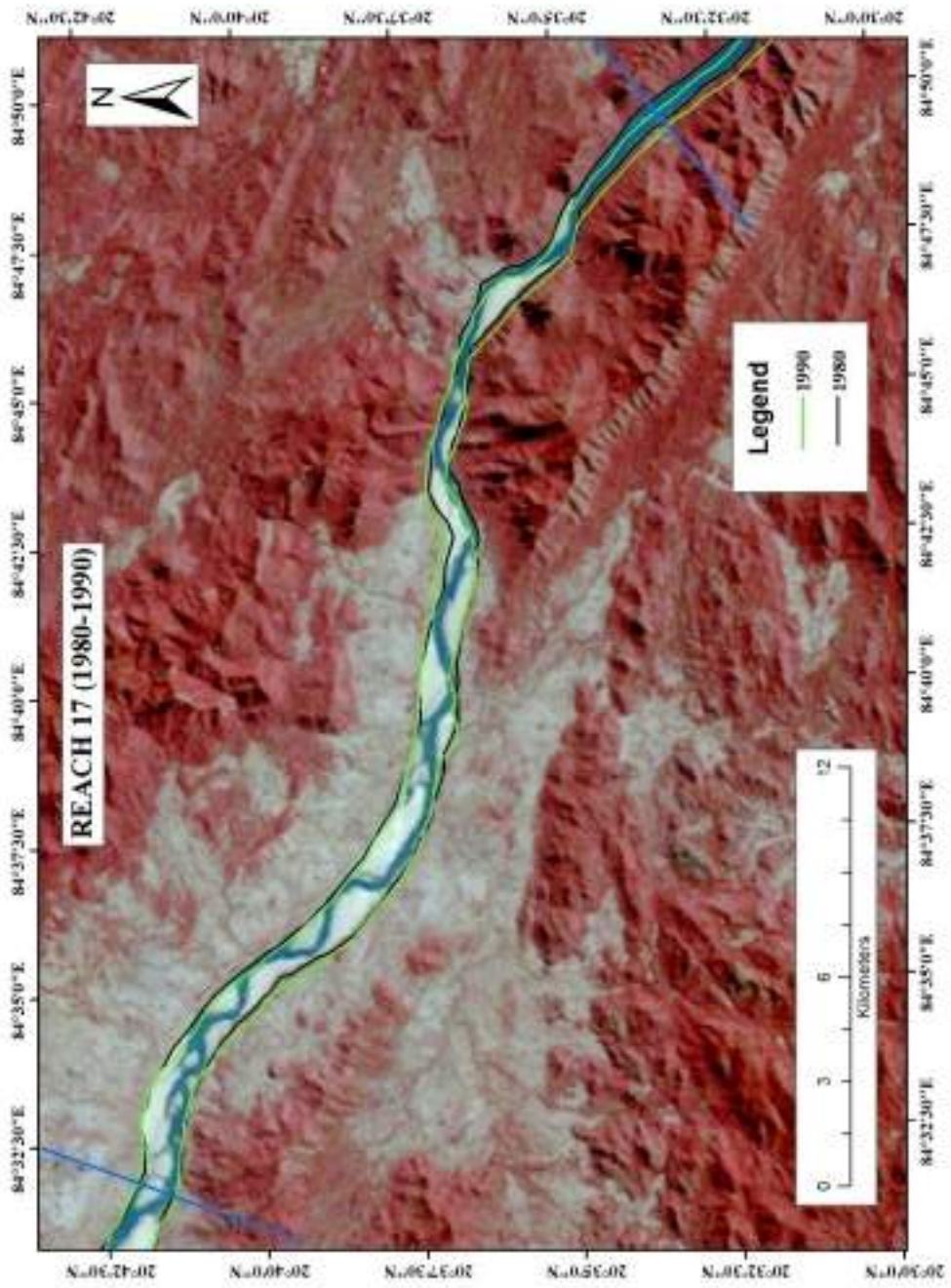


Figure 33.3: Changes in the course of Mahanadi River of Year 1980-1990

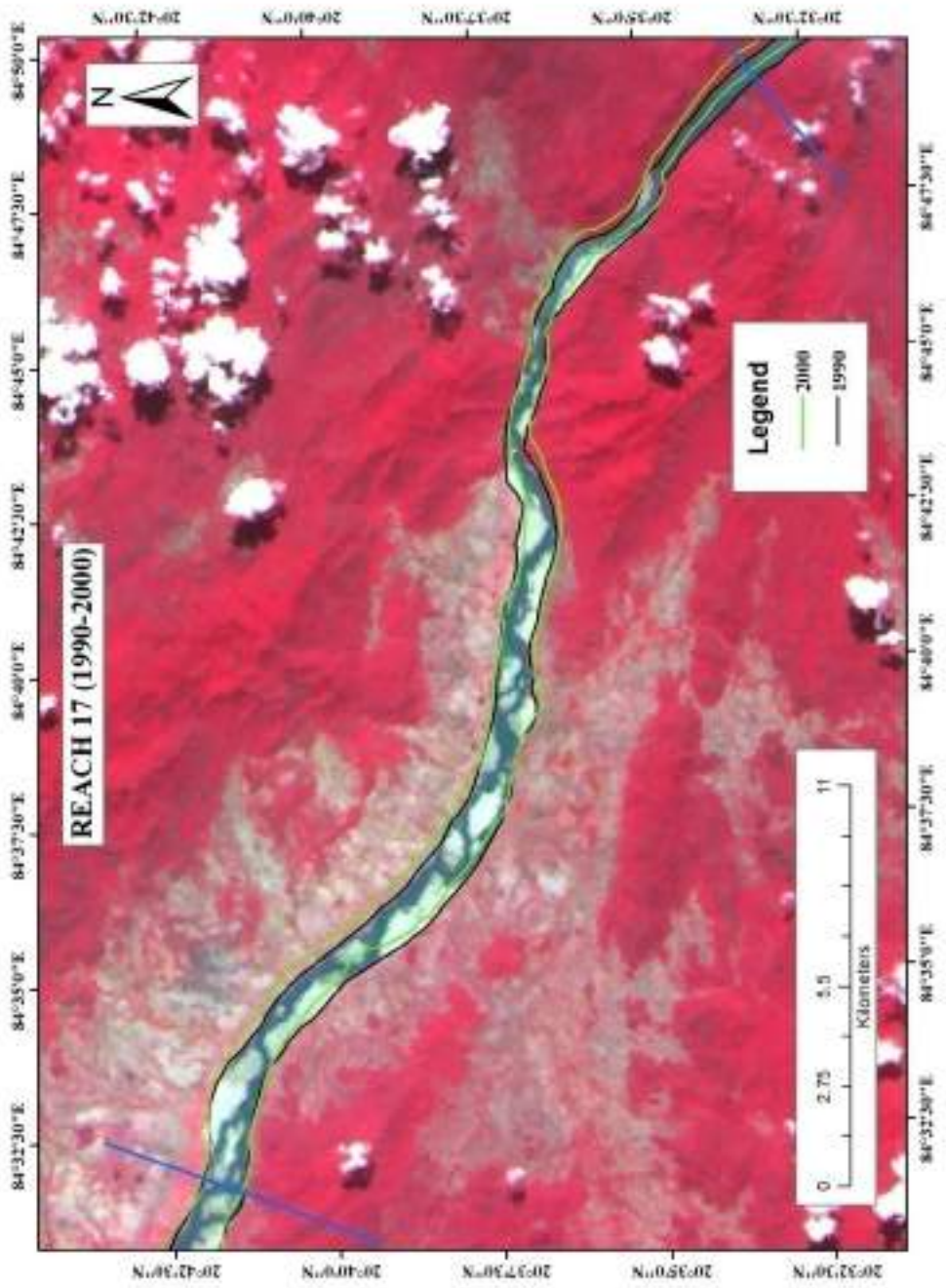


Figure 33.4: Changes in the course of Mahanadi River of Year 1990-2000

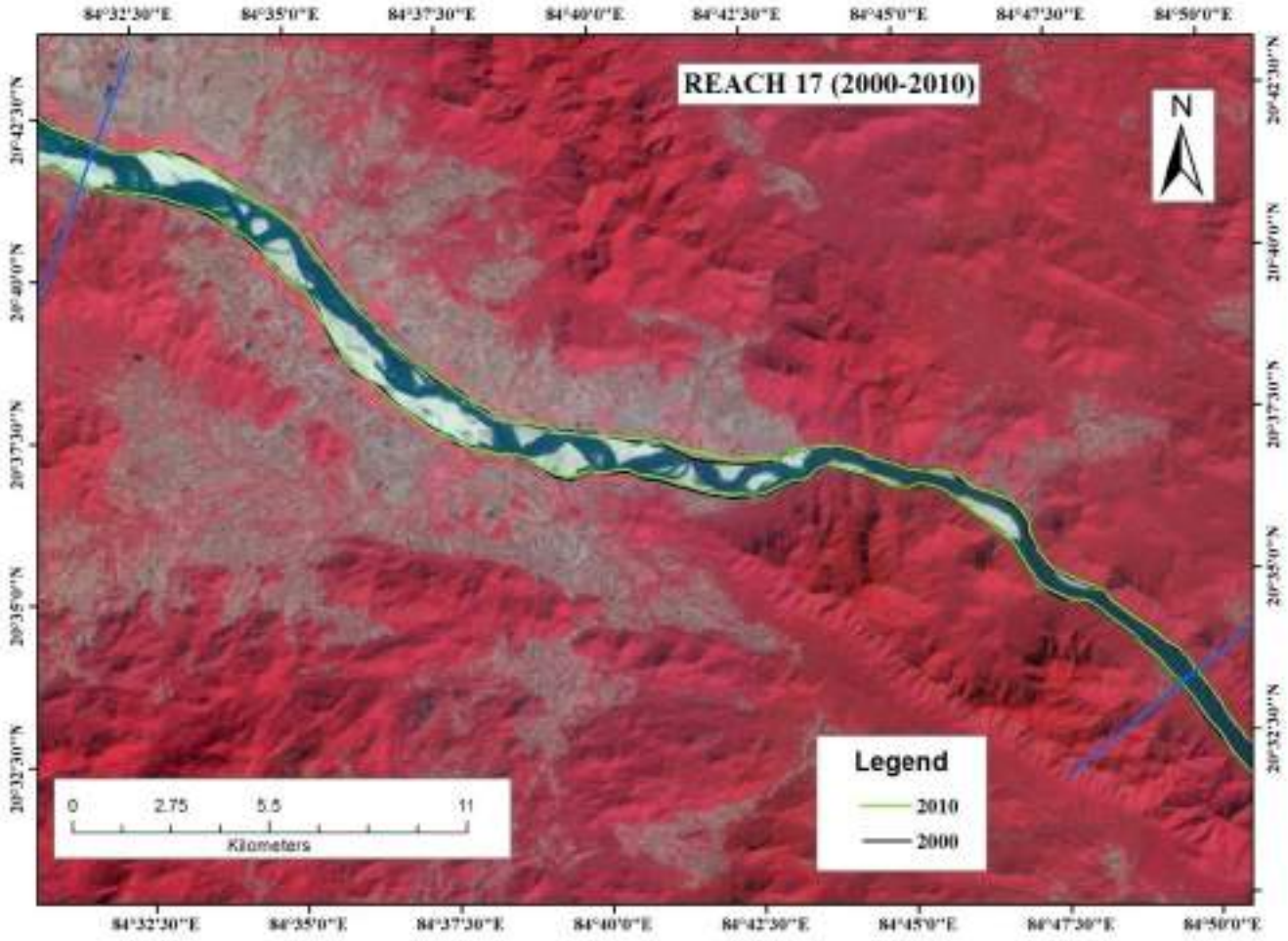


Figure 33.5: Changes in the course of Mahanadi River of Year 2000-2010

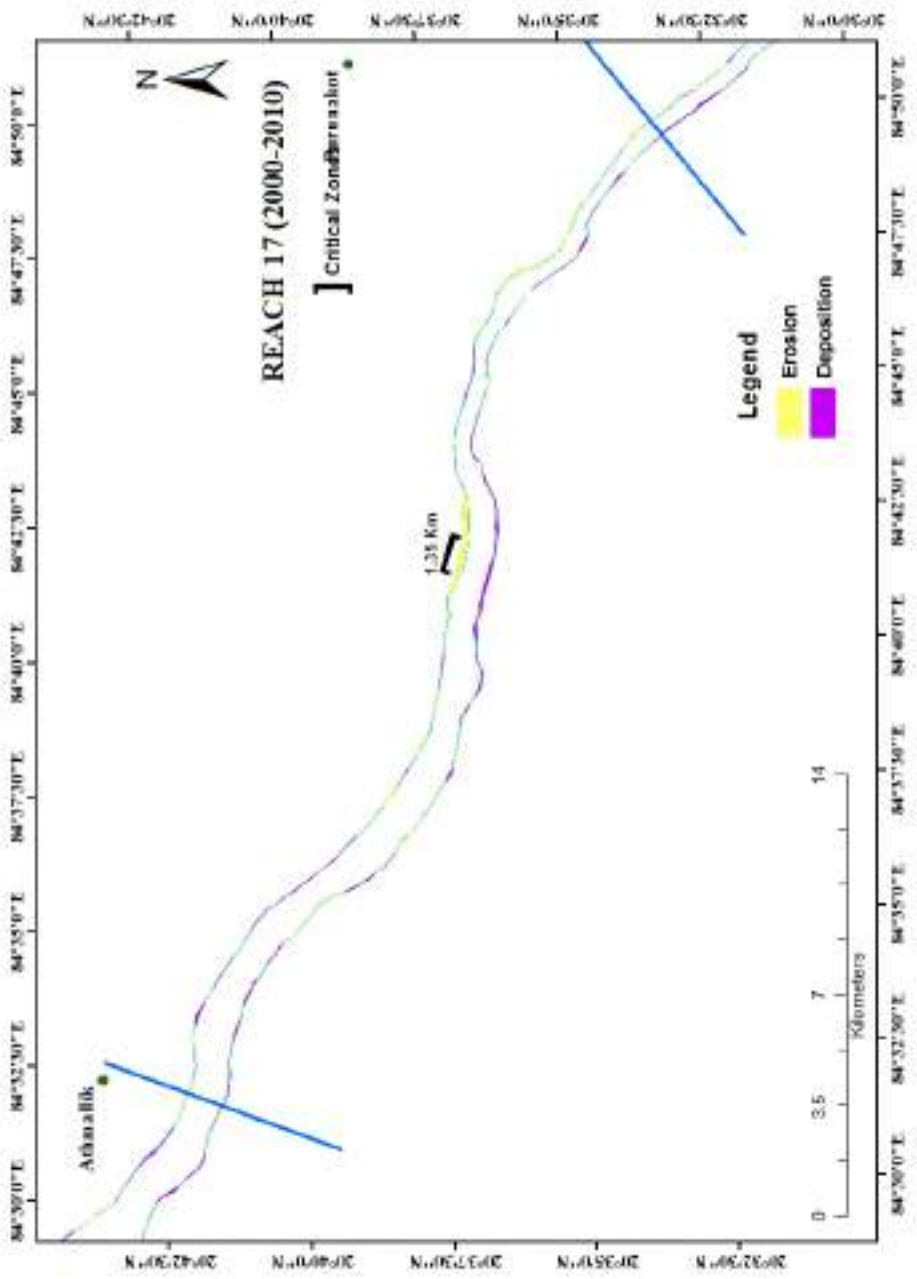


Figure 33.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 18

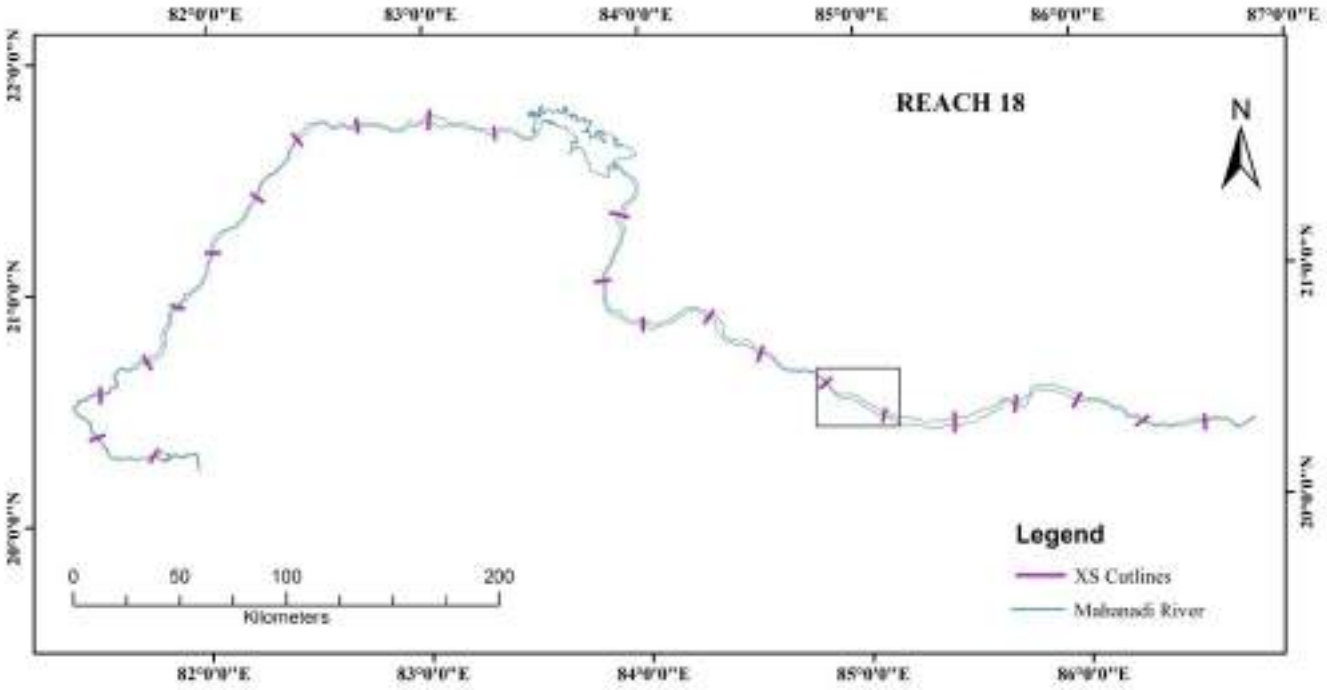


Figure 34.1: Location of reach number 18 in the Mahanadi river

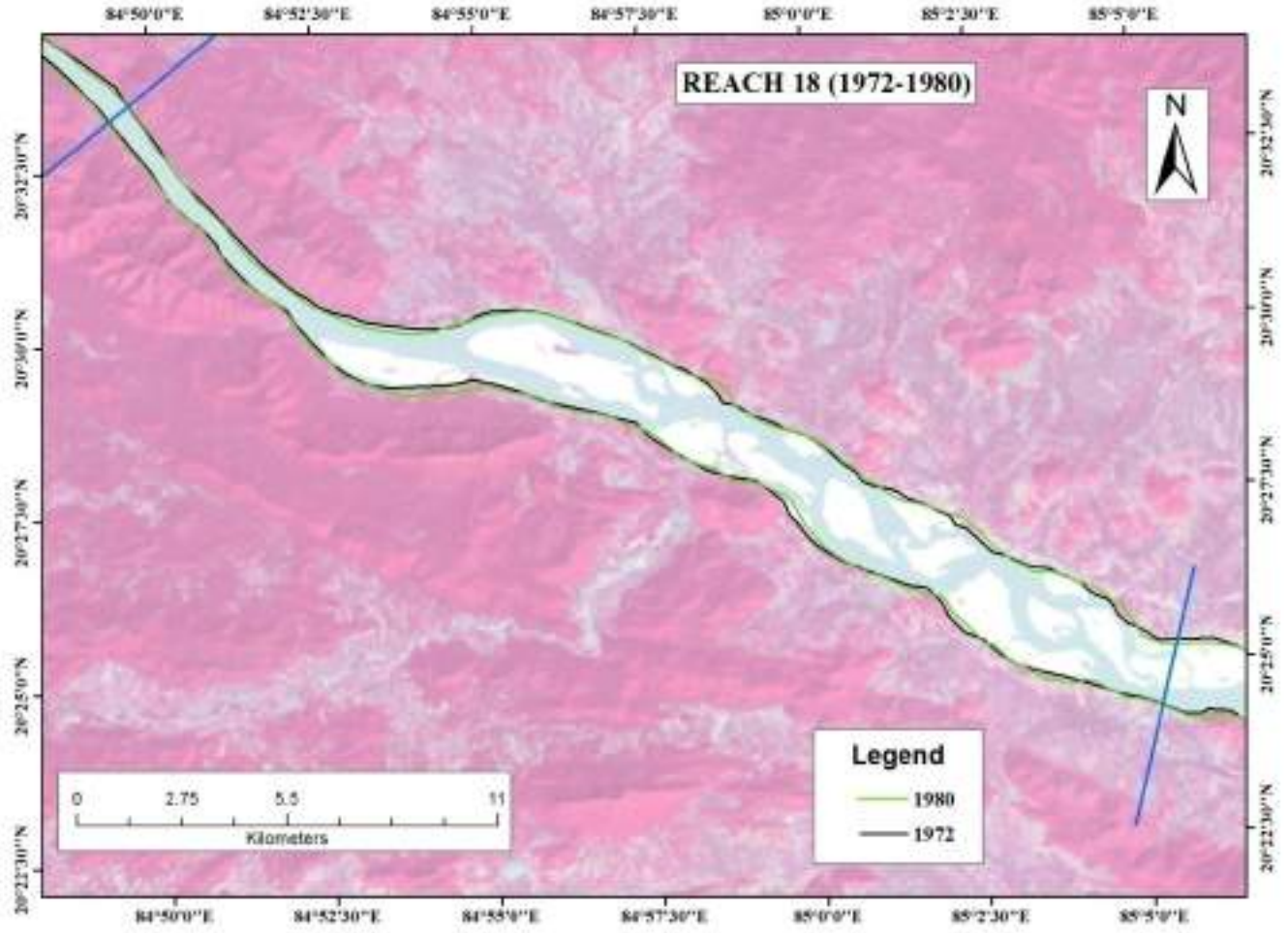


Figure 34.2: Changes in the course of Mahanadi River of Year 1972-1980

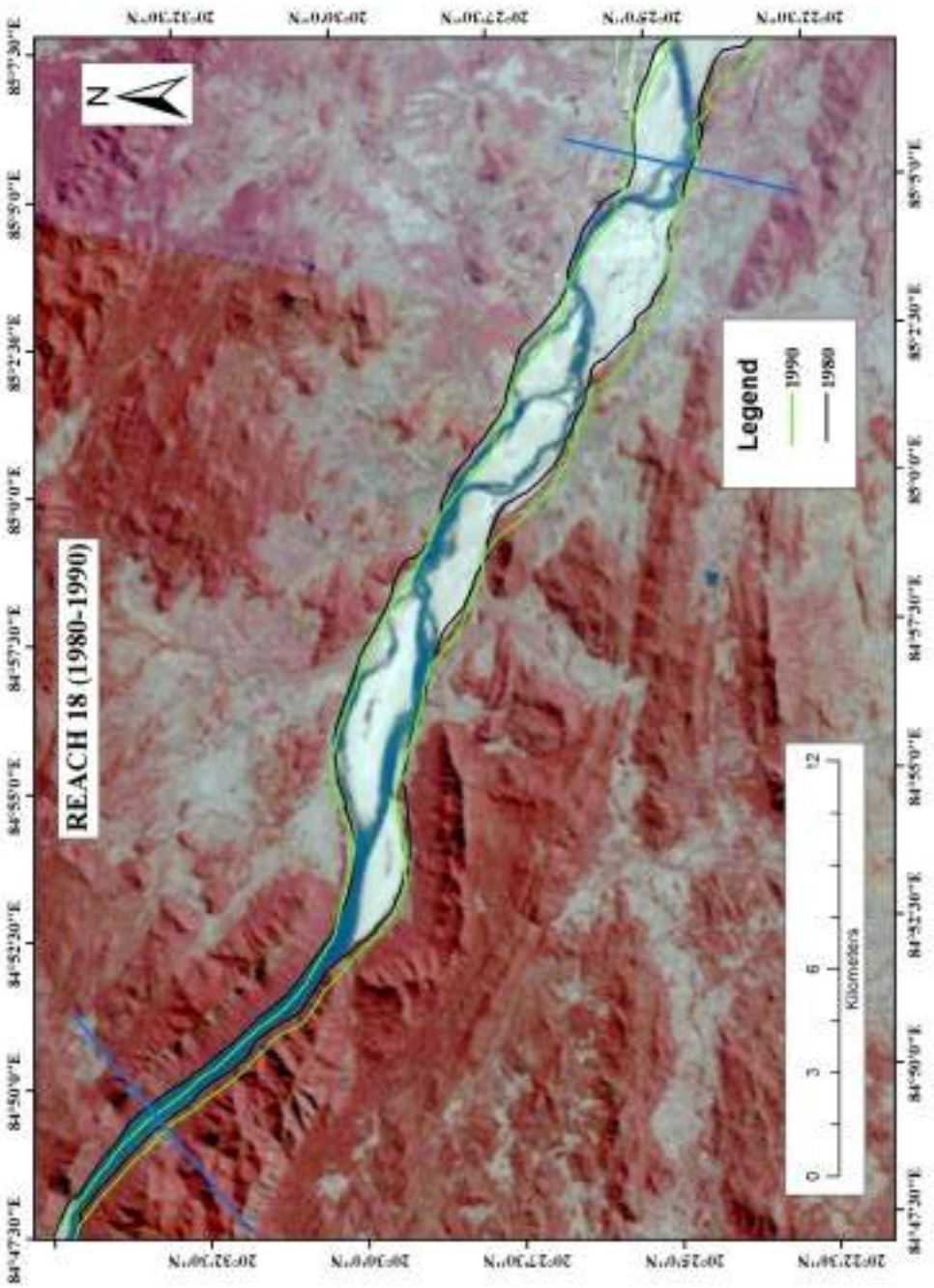


Figure 34.3: Changes in the course of Mahanadi River of Year 1980-1990

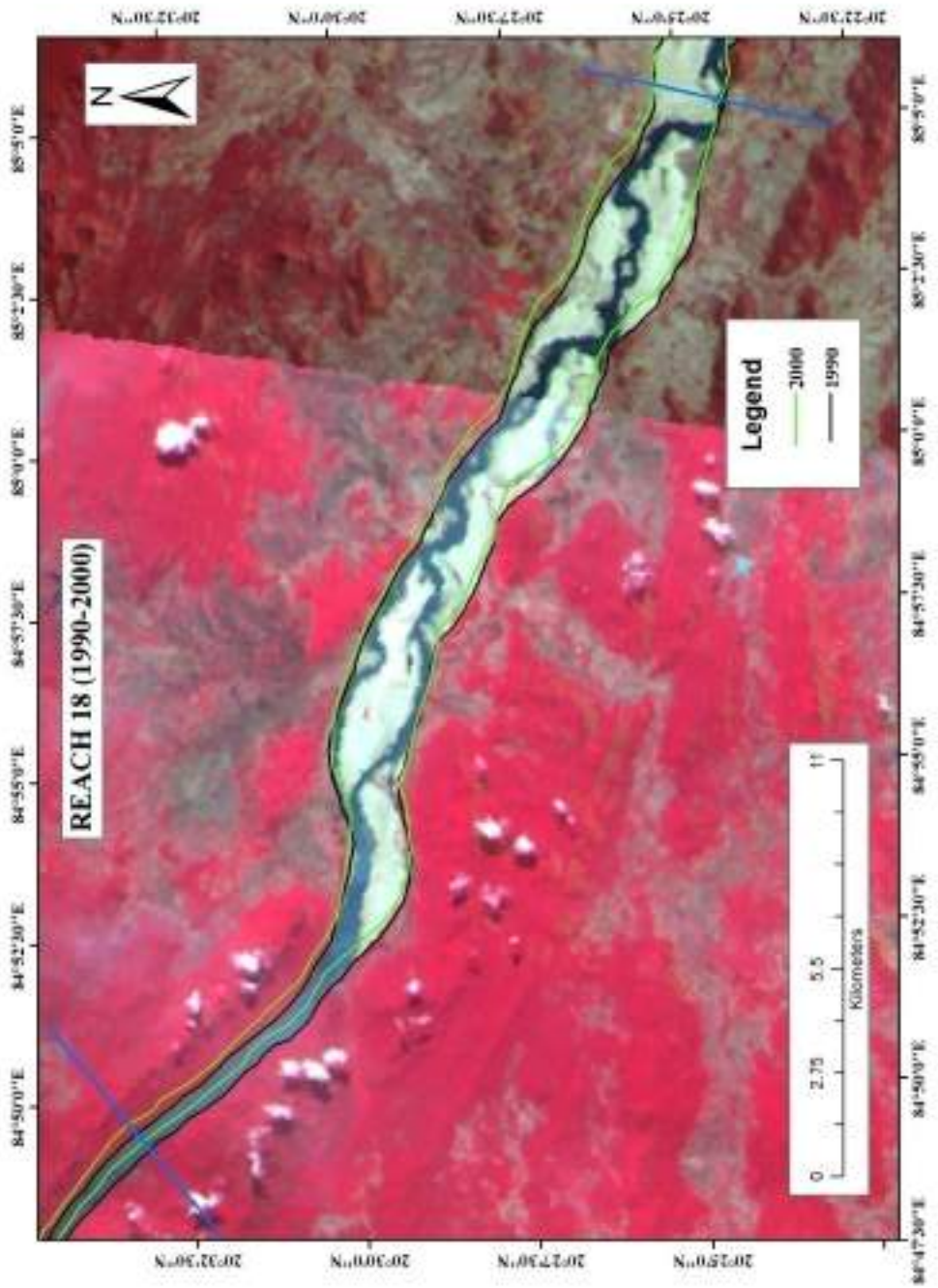


Figure 34.4: Changes in the course of Mahanadi River of Year 1990-2000

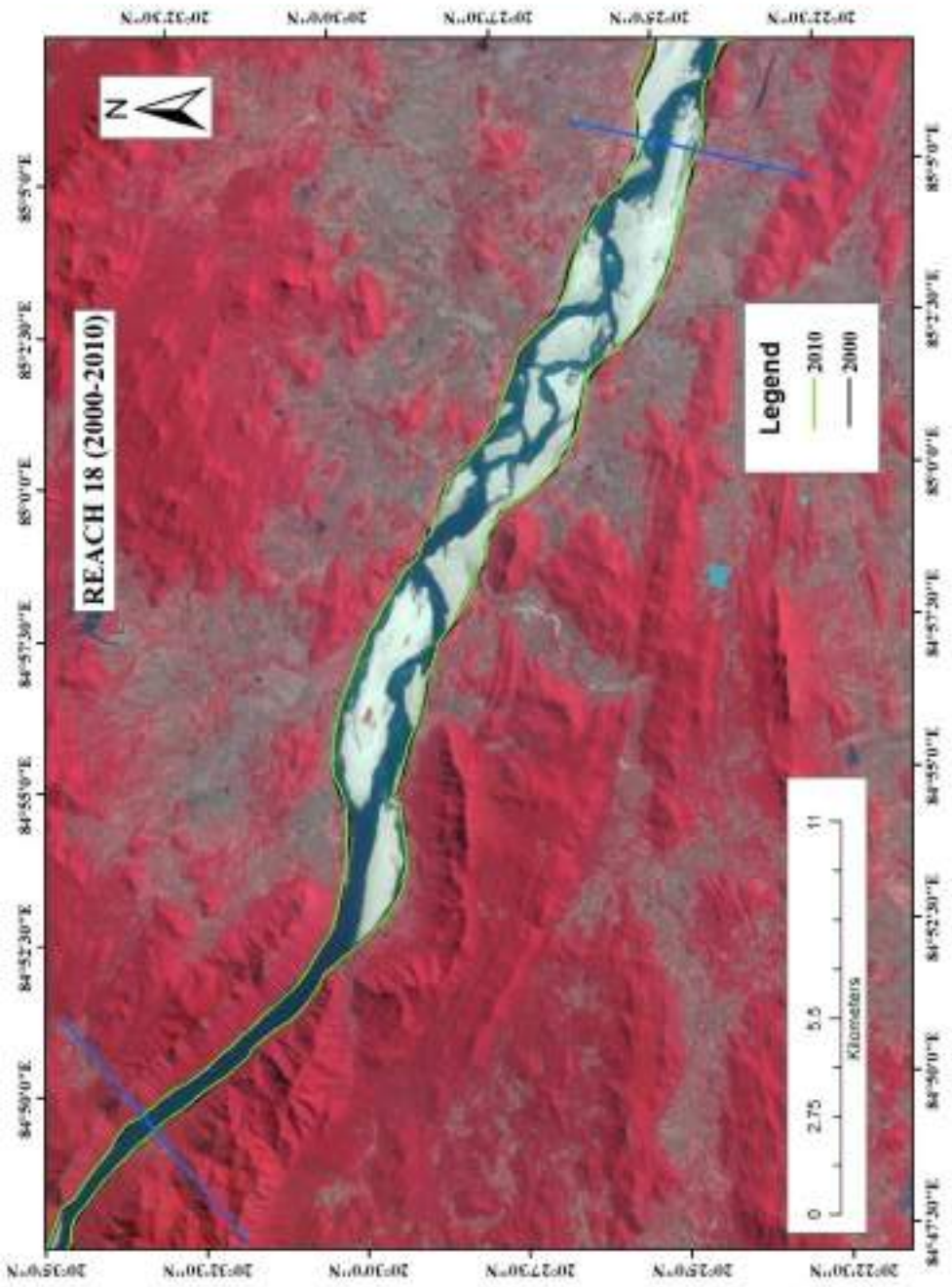


Figure 34.5: Changes in the course of Mahanadi River of Year 2000-2010

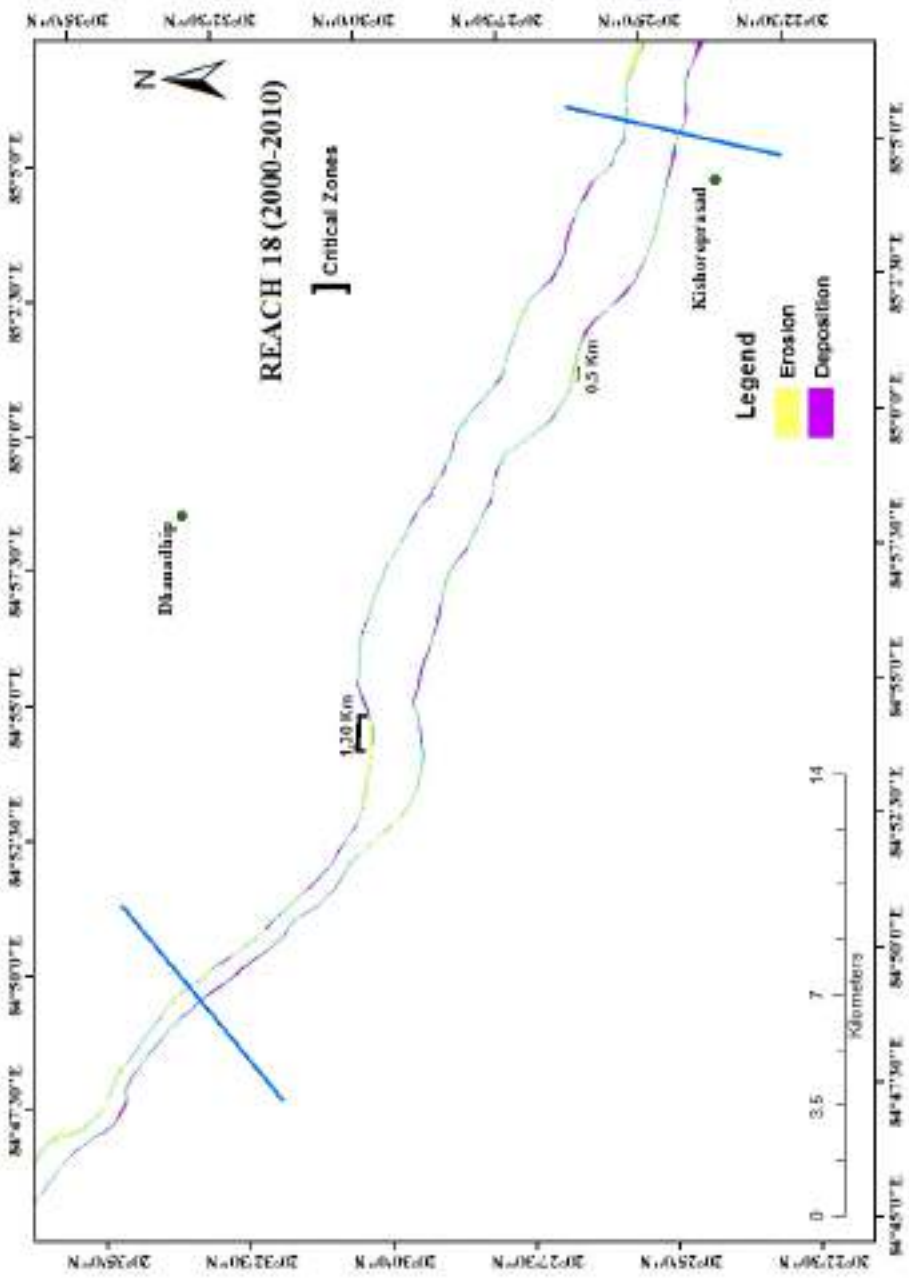


Figure 34.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 19

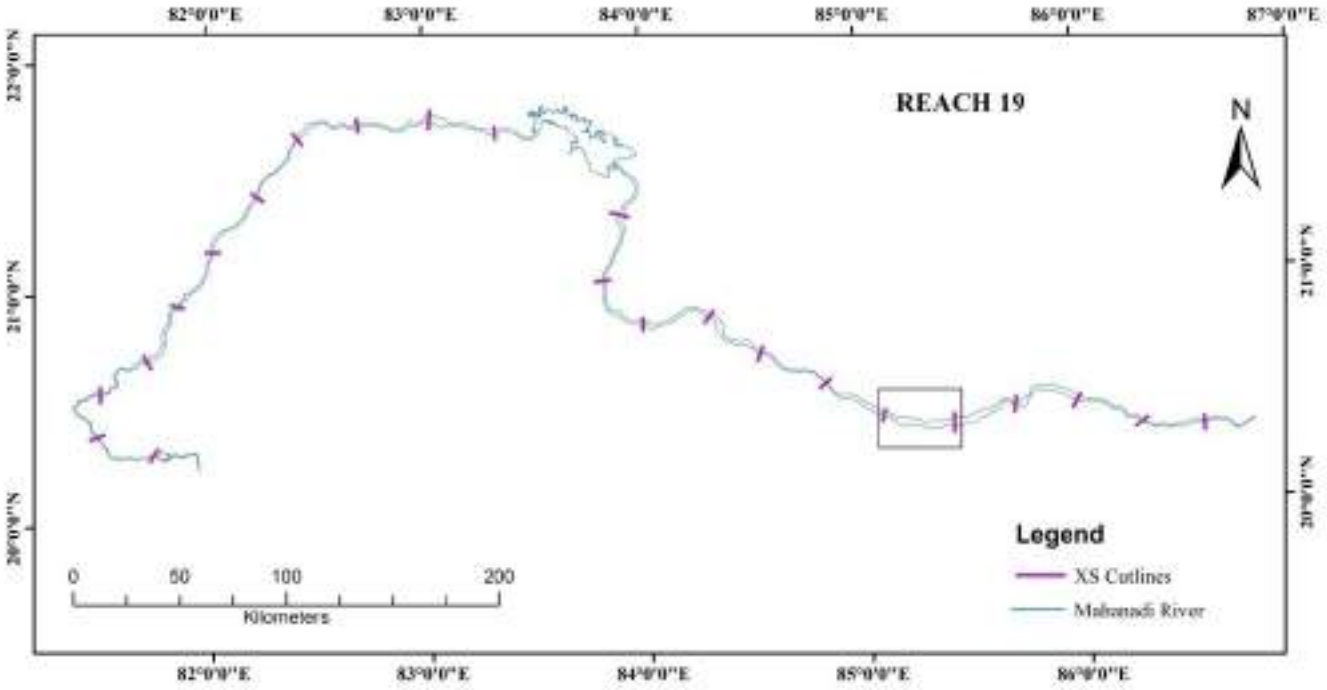


Figure 35.1: Location of reach number 19 in the Mahanadi river

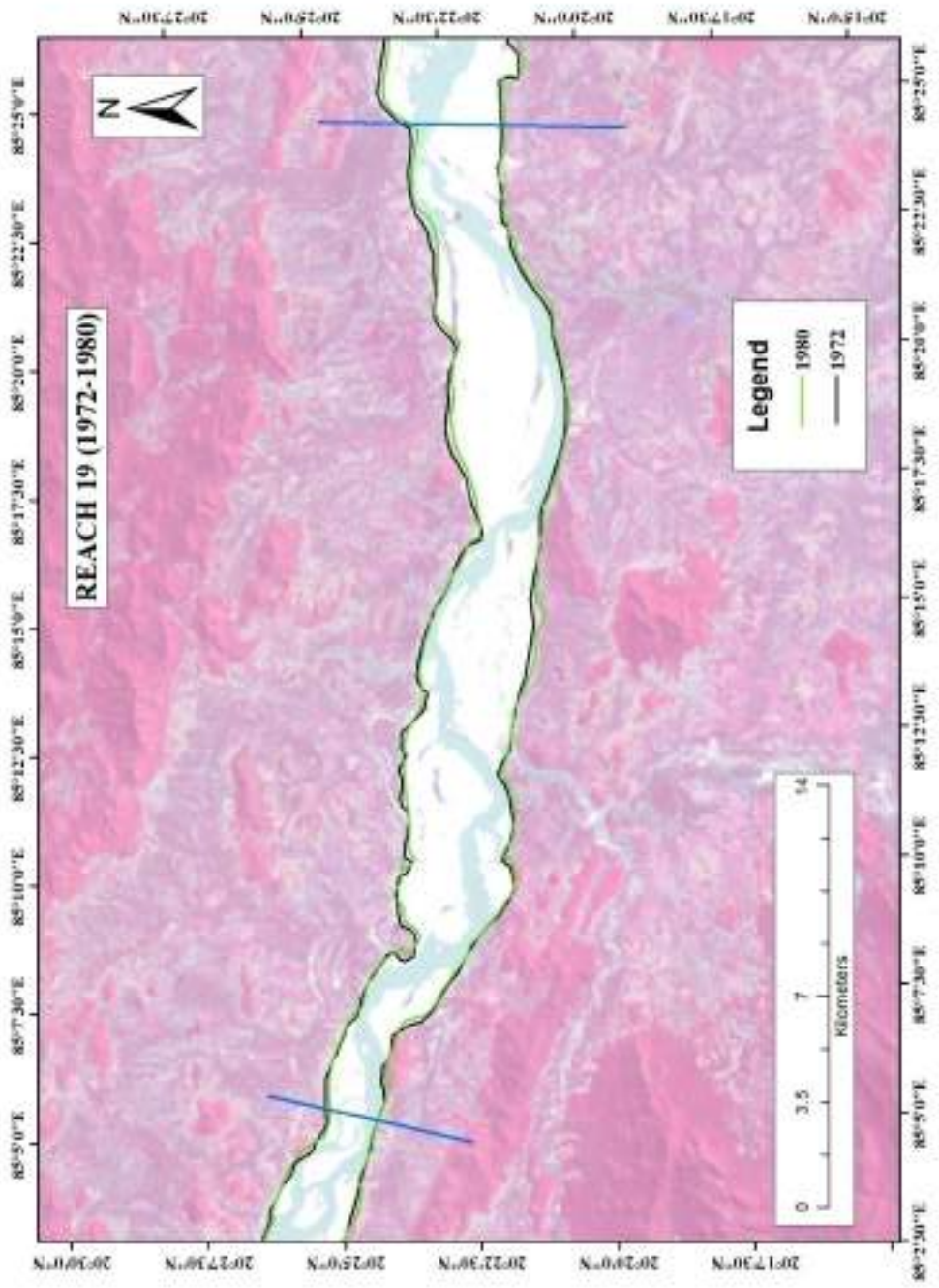


Figure 35.2: Changes in the course of Mahanadi River of Year 1972-1980

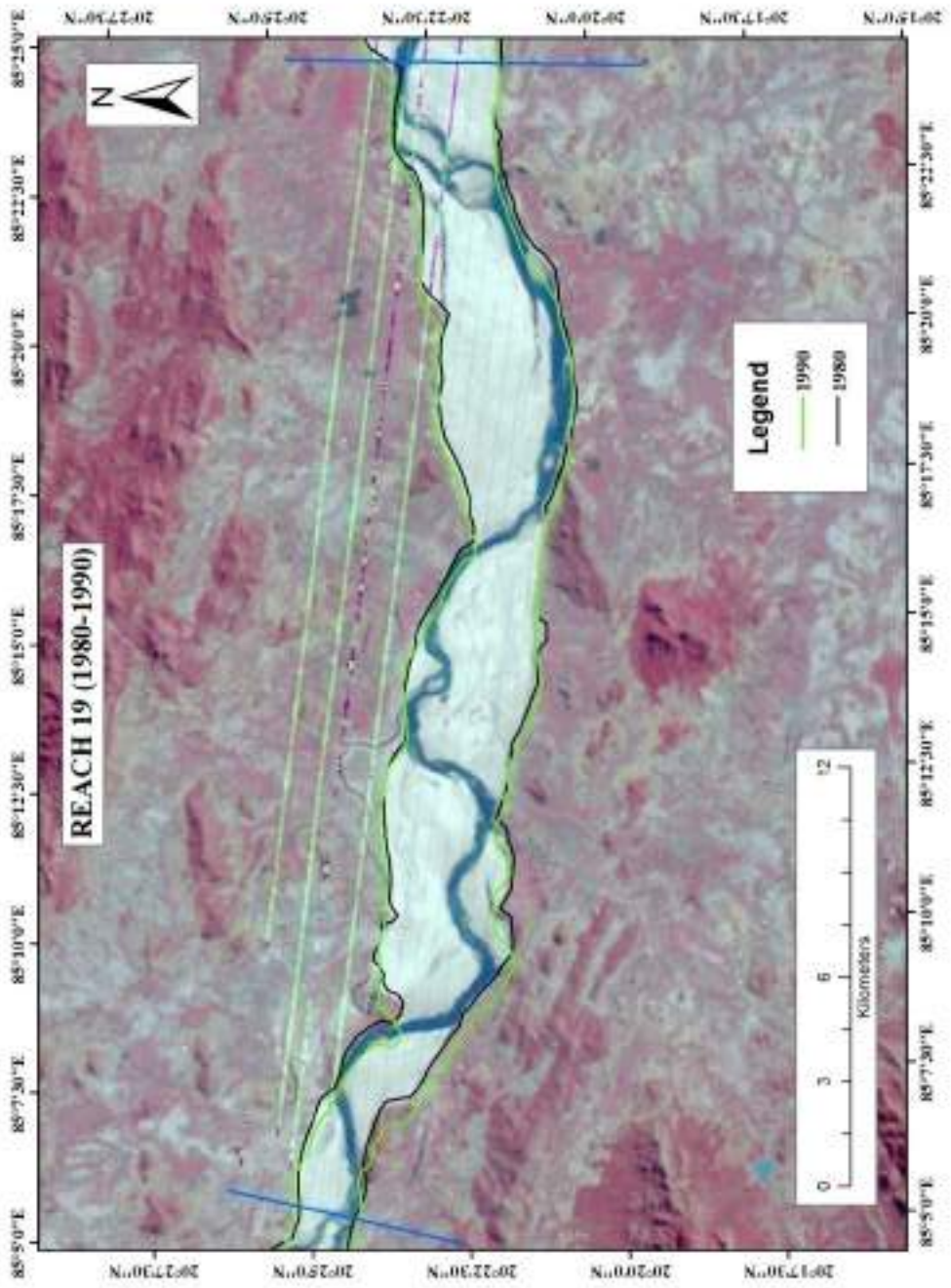


Figure 35.3: Changes in the course of Mahanadi River of Year 1980-1990

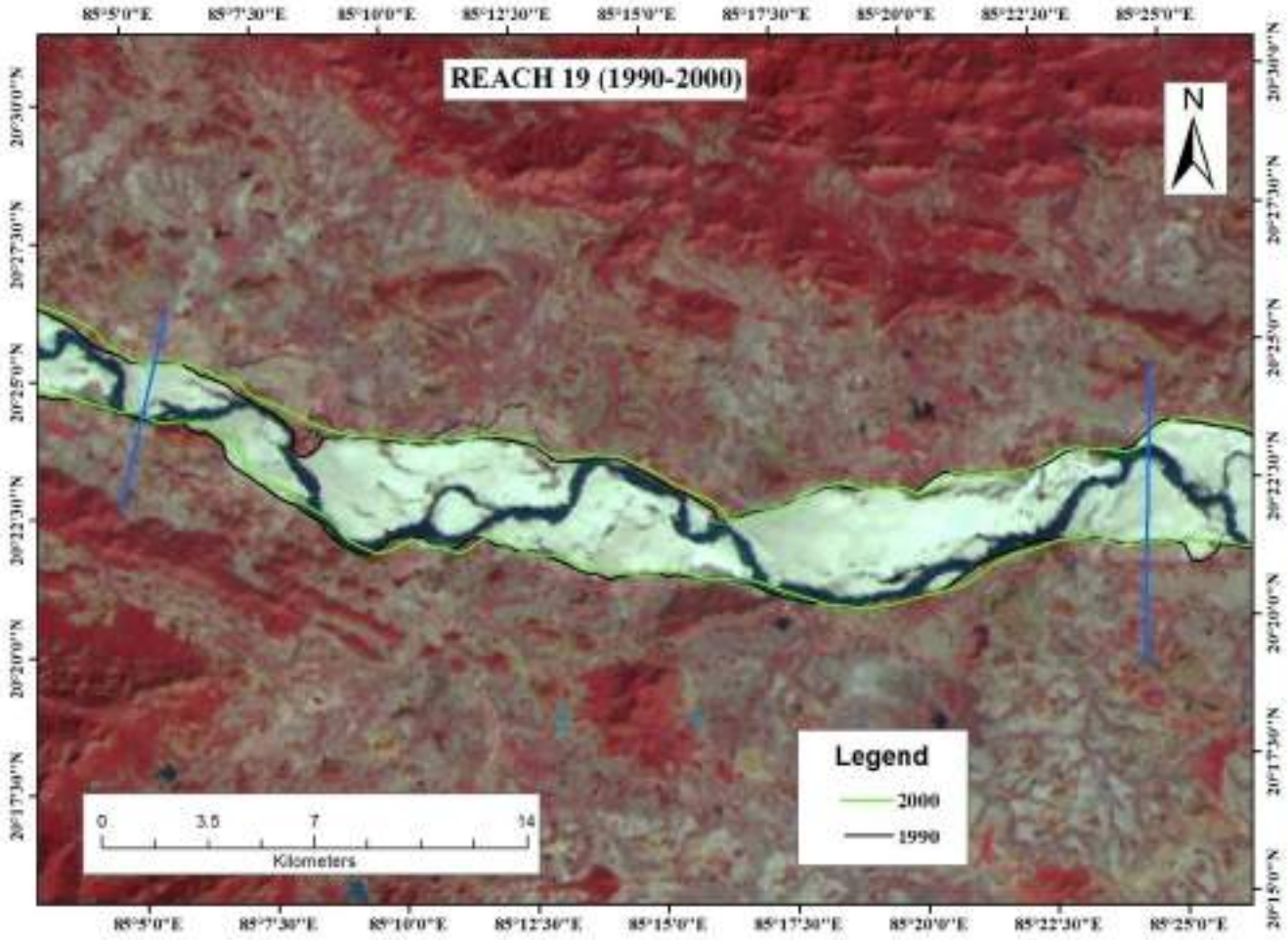


Figure 35.4: Changes in the course of Mahanadi River of Year 1990-2000

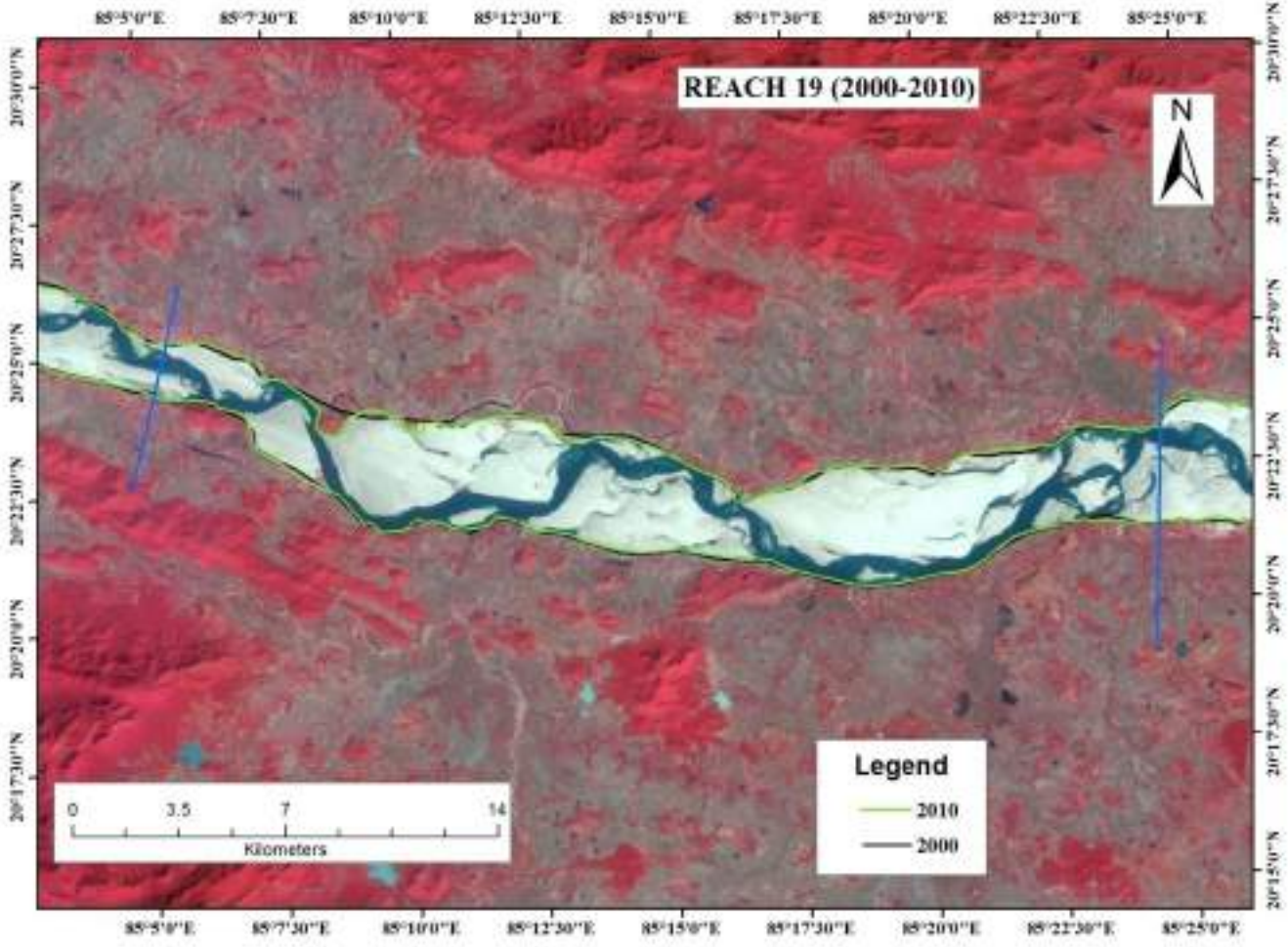


Figure 35.5: Changes in the course of Mahanadi River of Year 2000-2010

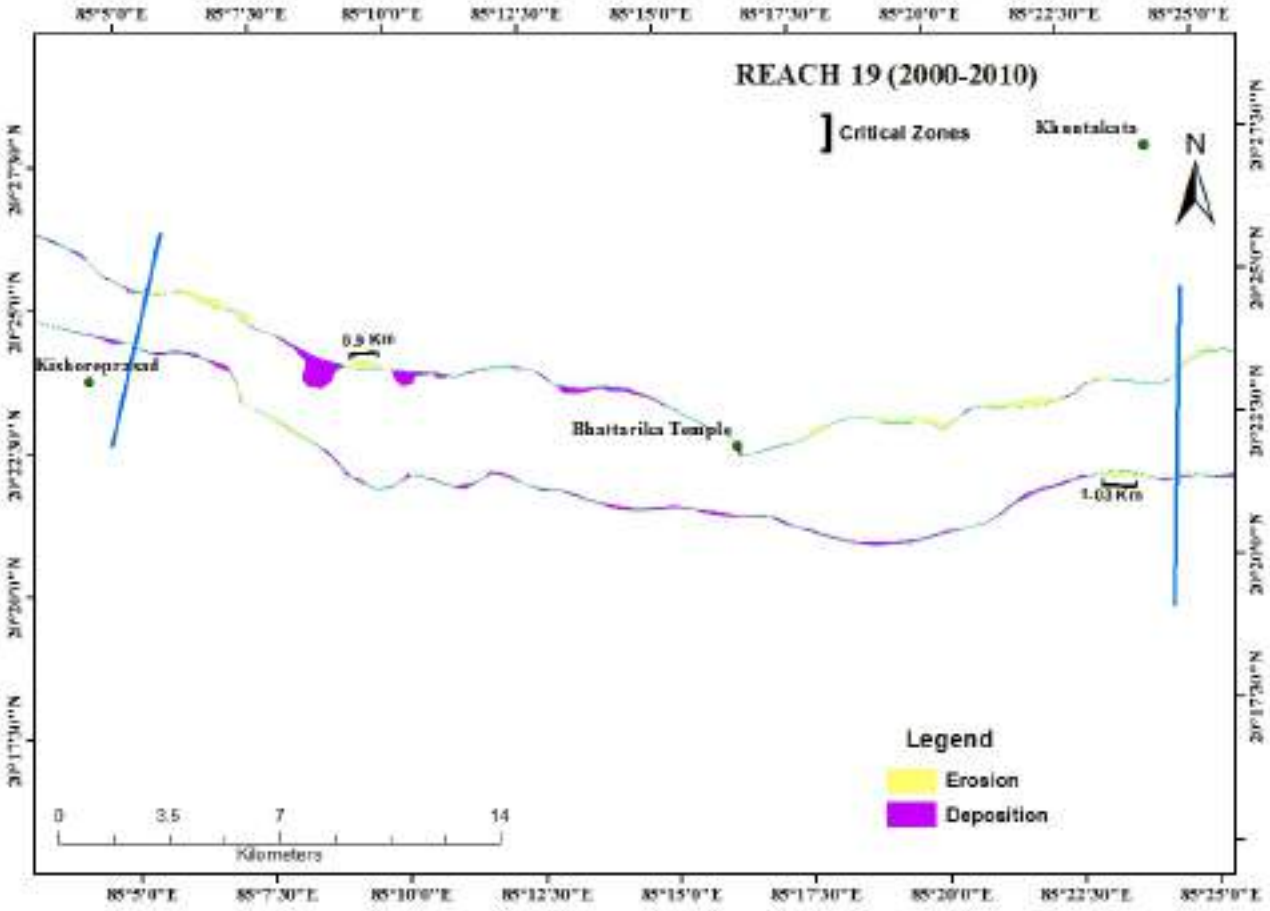


Figure 35.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 20

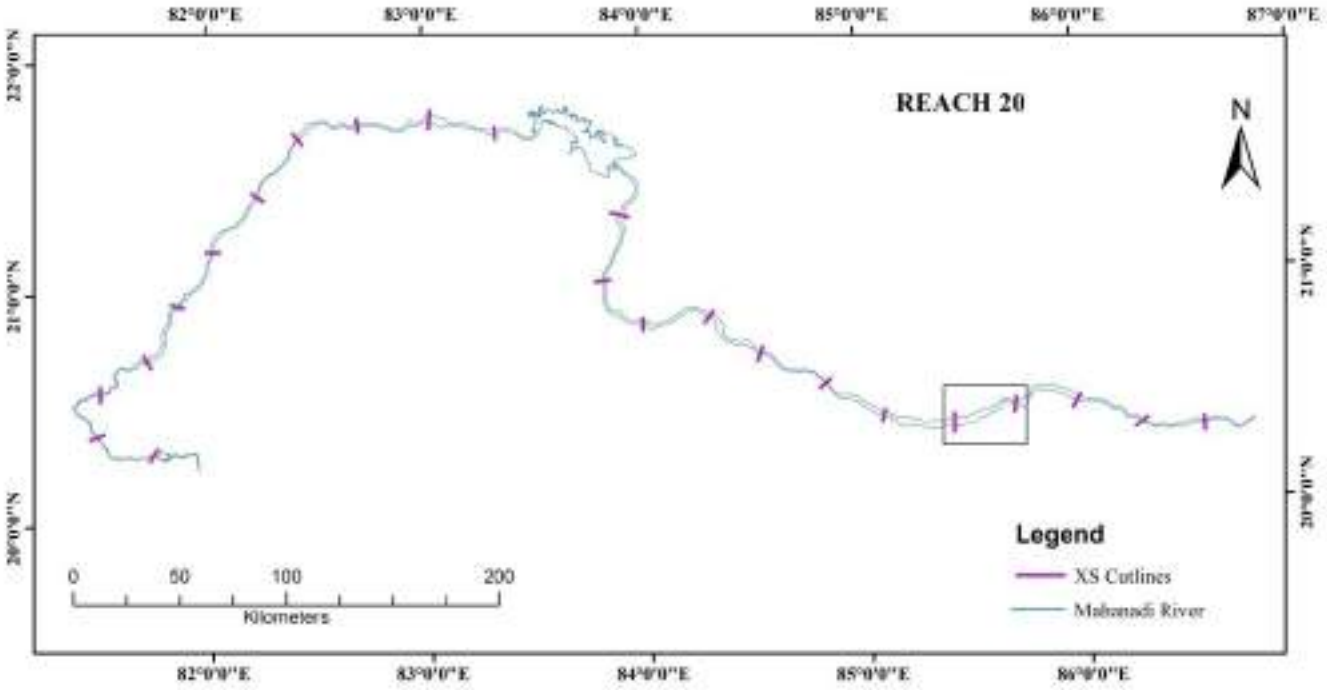


Figure 36.1: Location of reach number 20 in the Mahanadi river

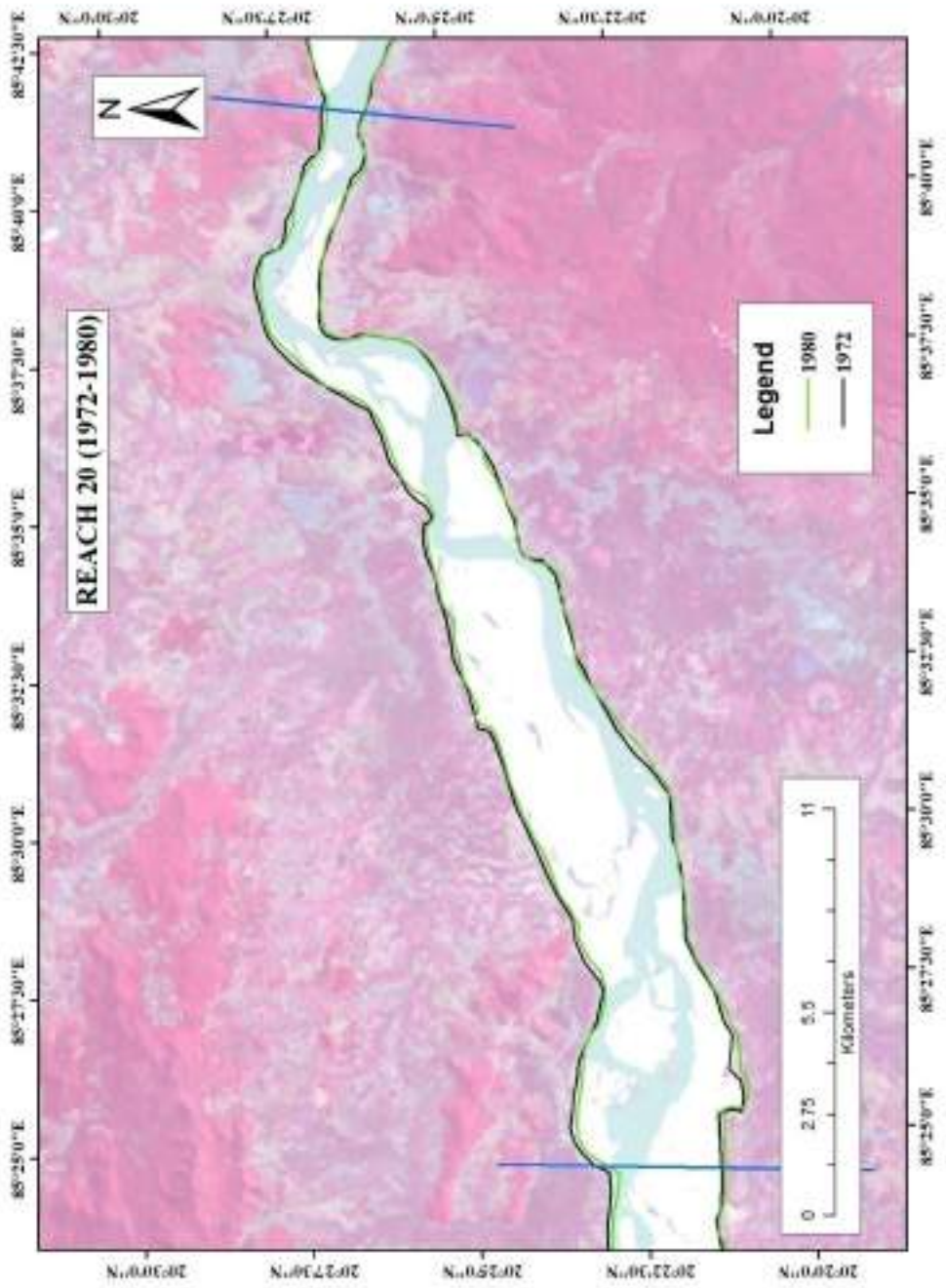


Figure 36.2: Changes in the course of Mahanadi River of Year 1972-1980

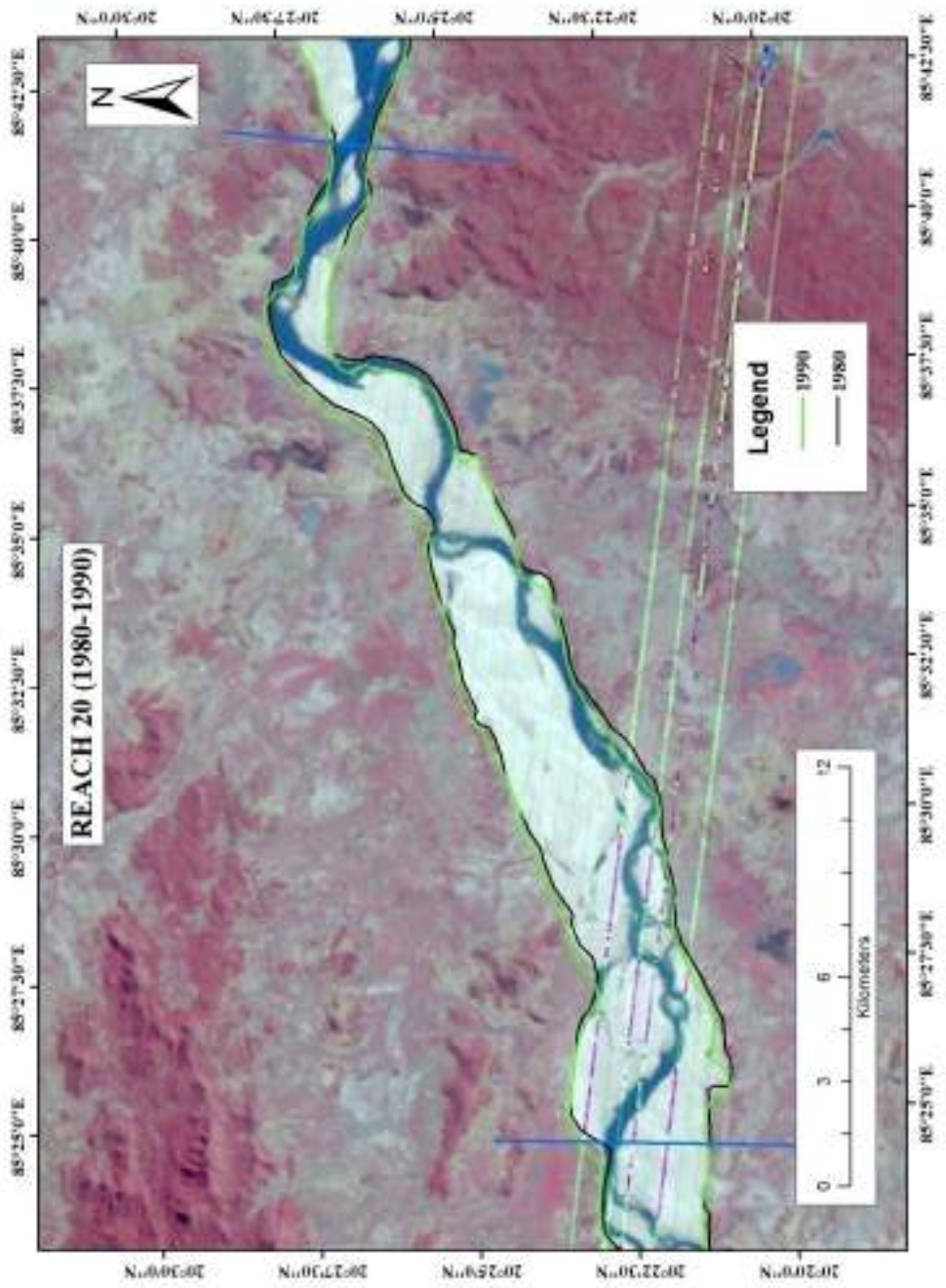


Figure 36.3: Changes in the course of Mahanadi River of Year 1980-1990

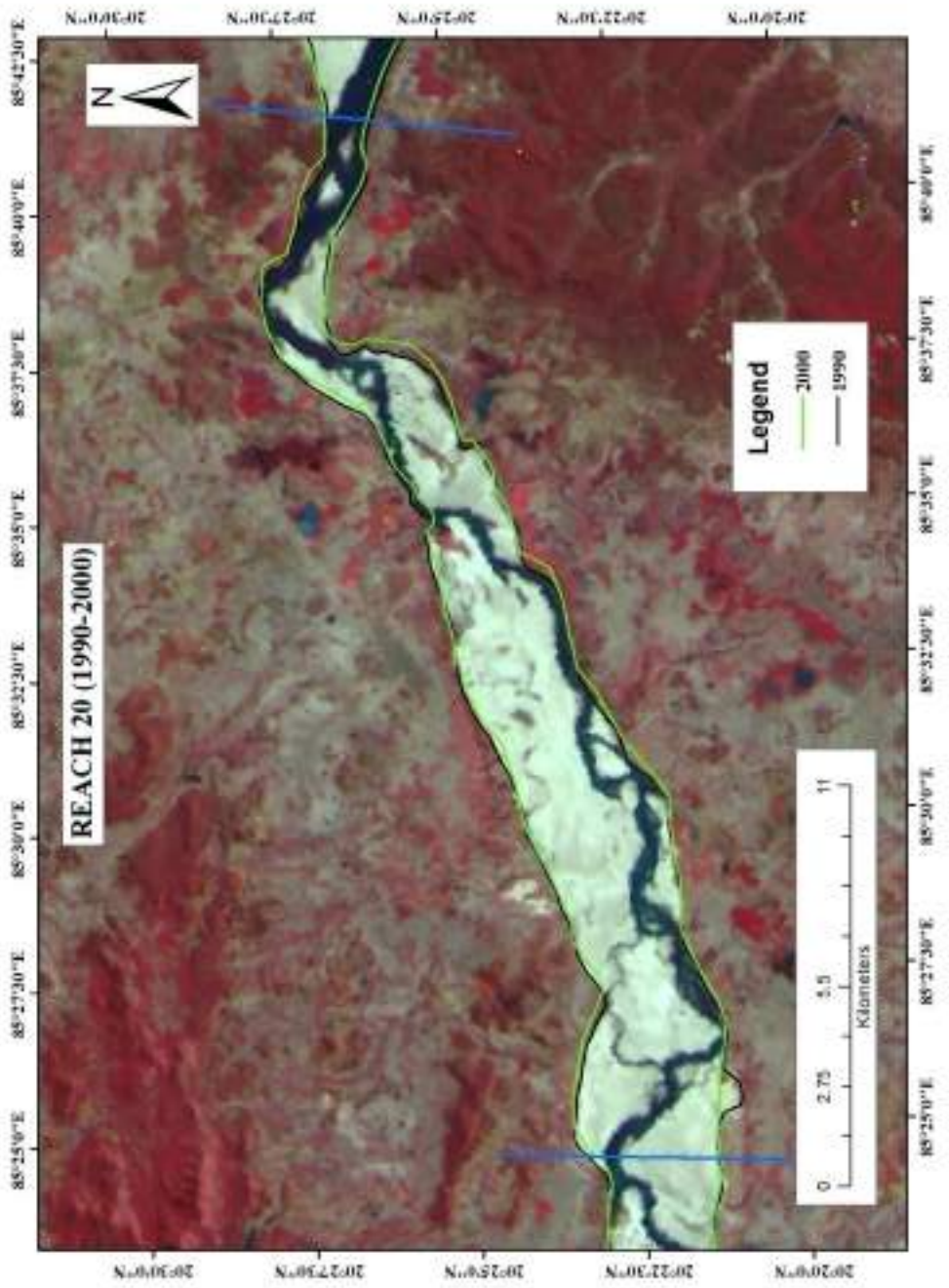


Figure 36.4: Changes in the course of Mahanadi River of Year 1990-2000

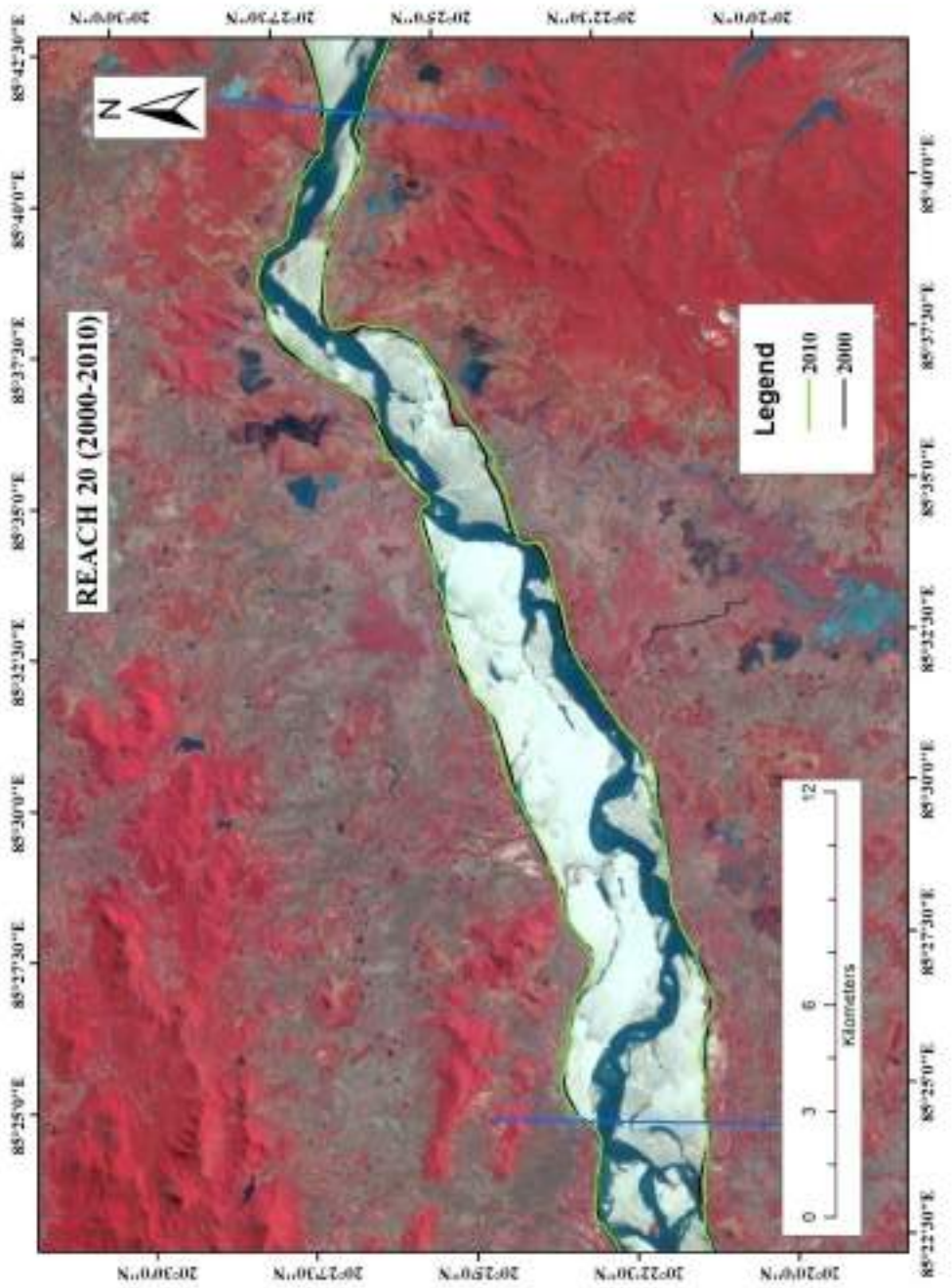


Figure 36.5: Changes in the course of Mahanadi River of Year 2000-2010

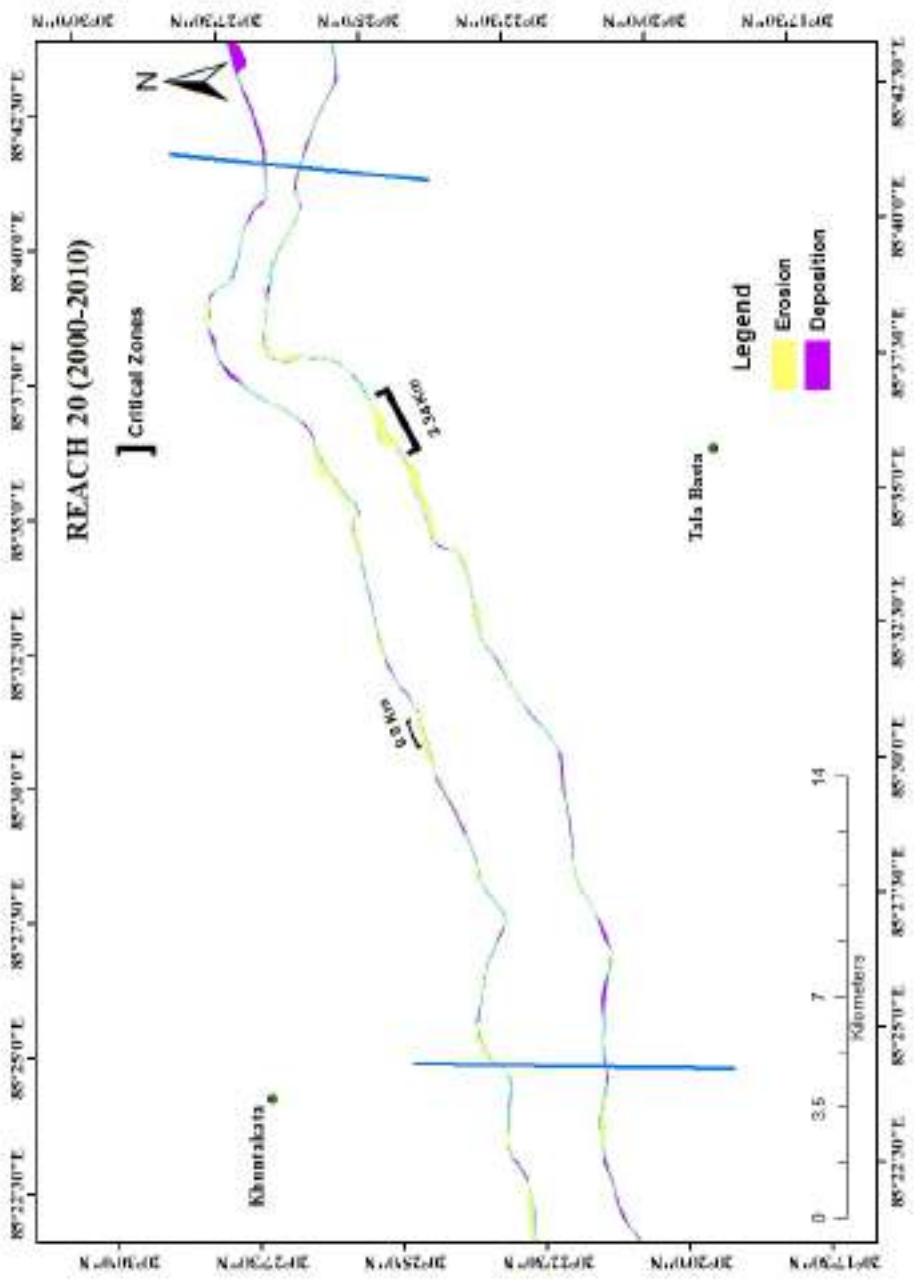


Figure 36.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 21

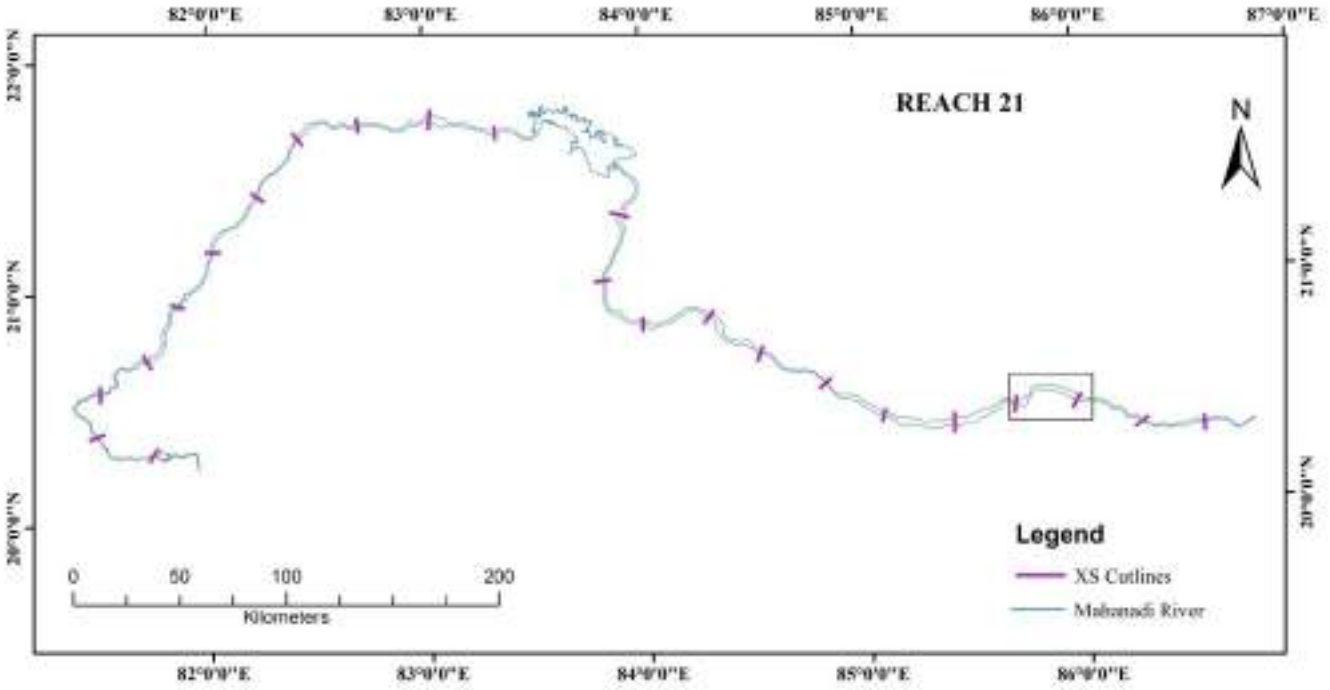


Figure 37.1: Location of reach number 21 in the Mahanadi river

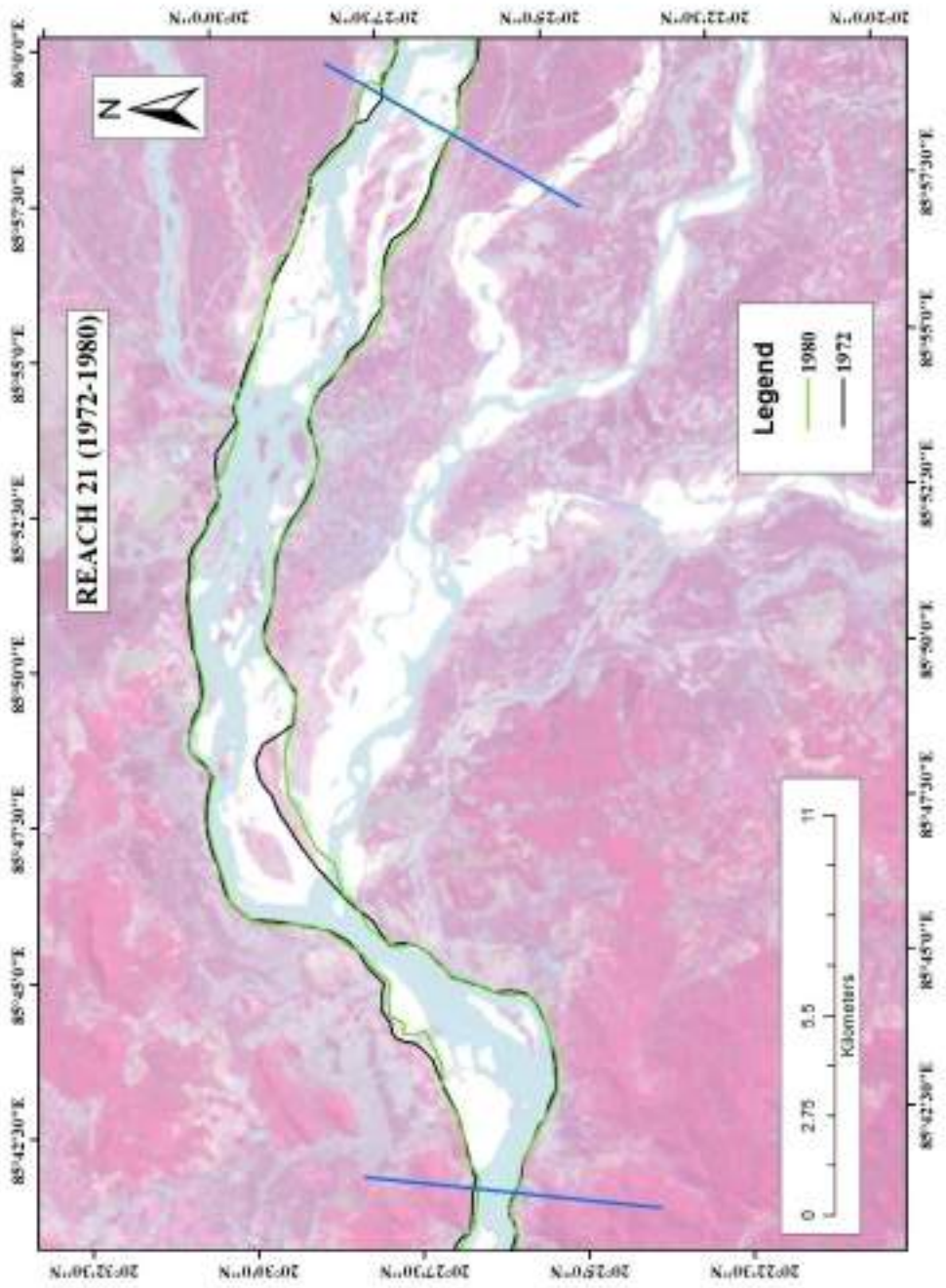


Figure 37.2: Changes in the course of Mahanadi River of Year 1972-1980

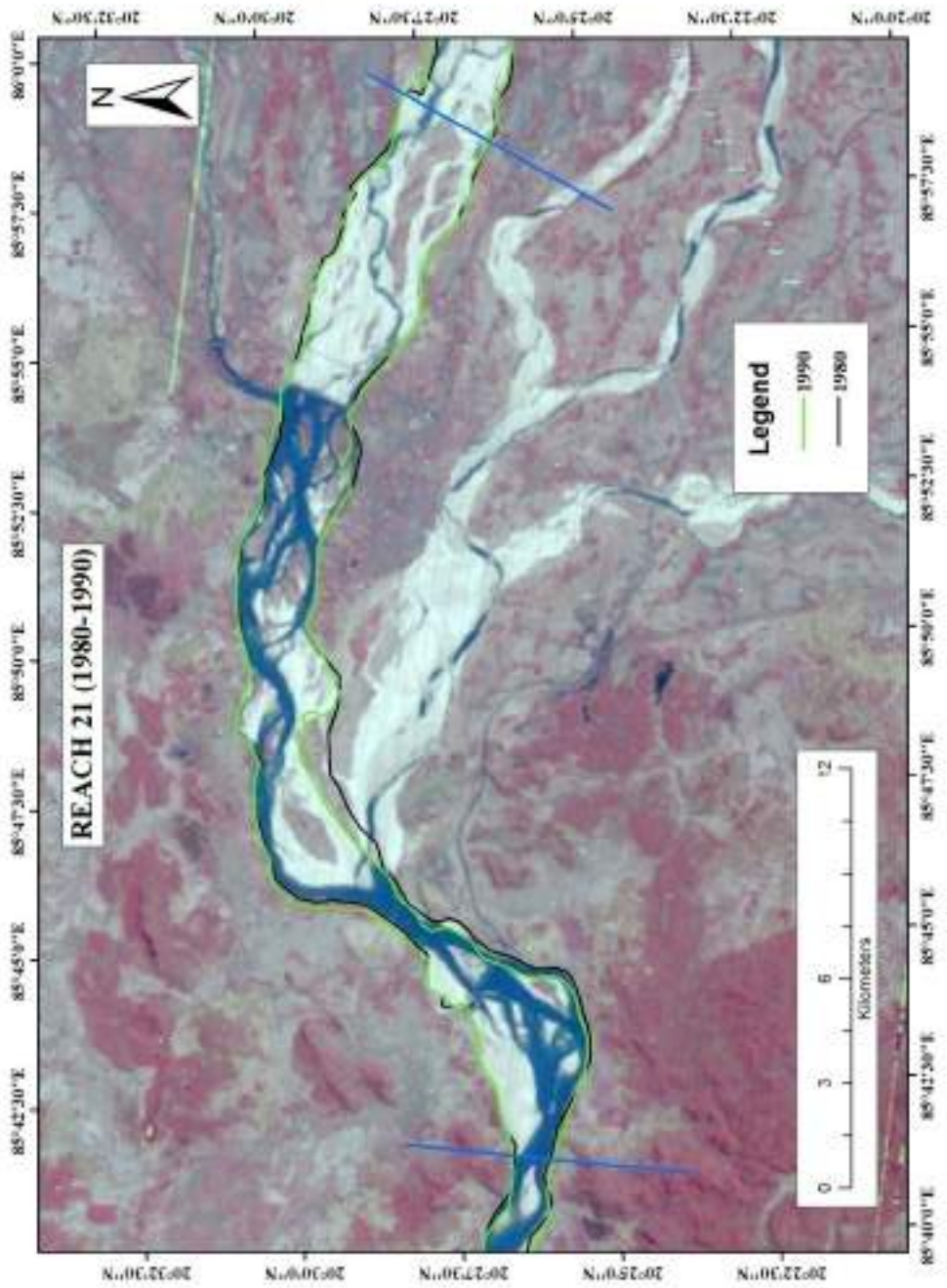


Figure 37.3: Changes in the course of Mahanadi River of Year 1980-1990

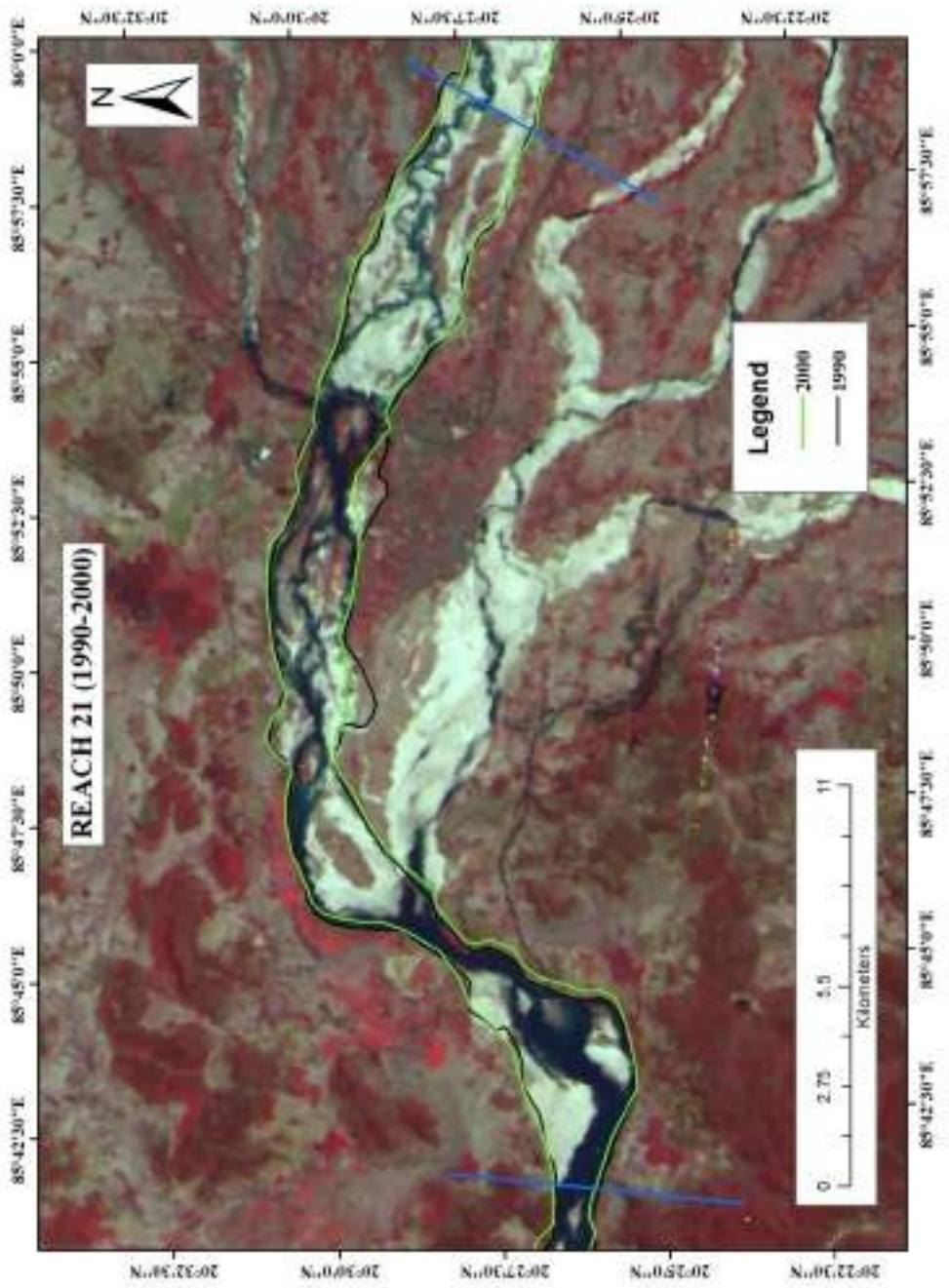


Figure 37.4: Changes in the course of Mahanadi River of Year 1990-2000

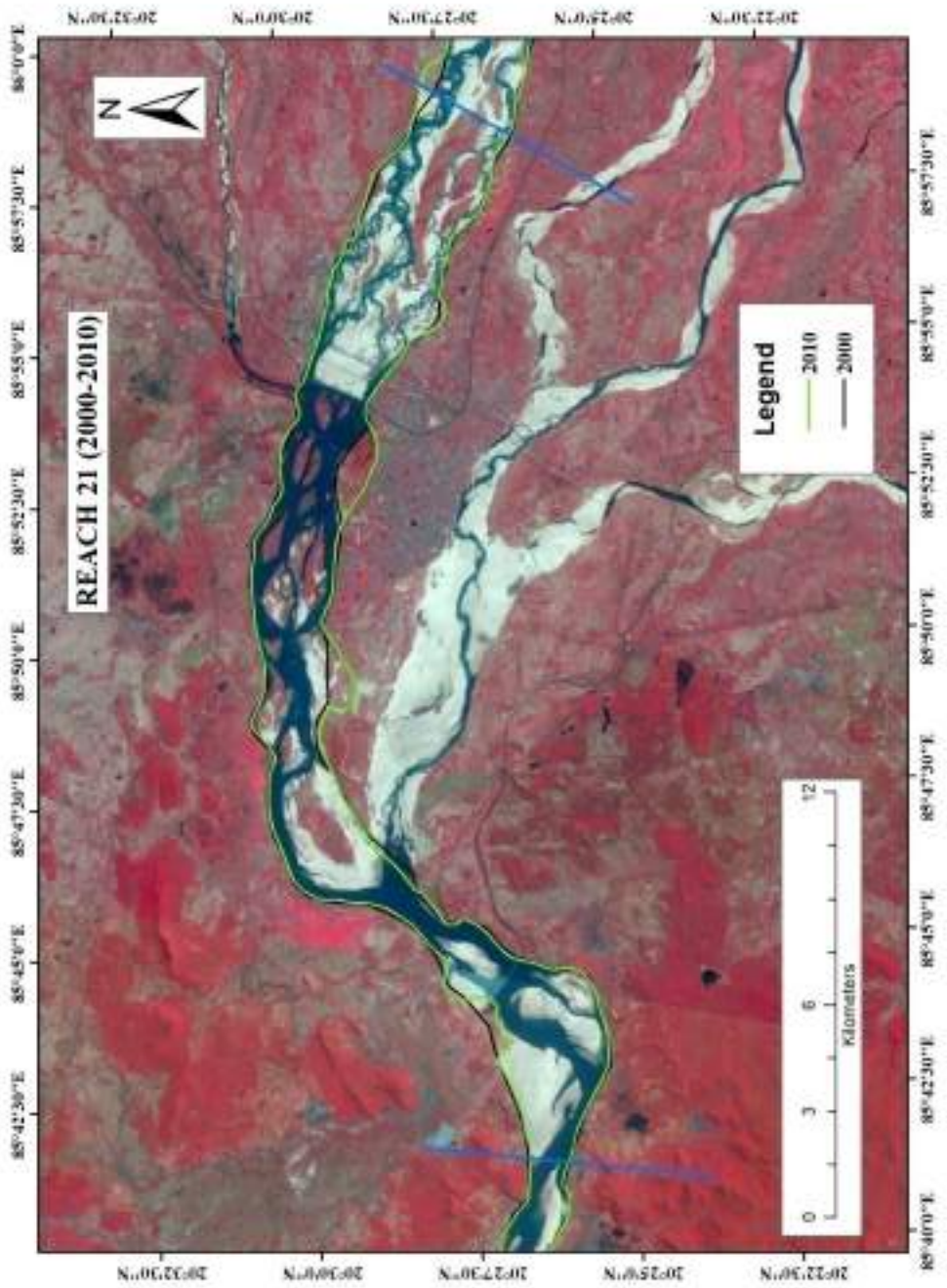


Figure 37.5: Changes in the course of Mahanadi River of Year 2000-2010

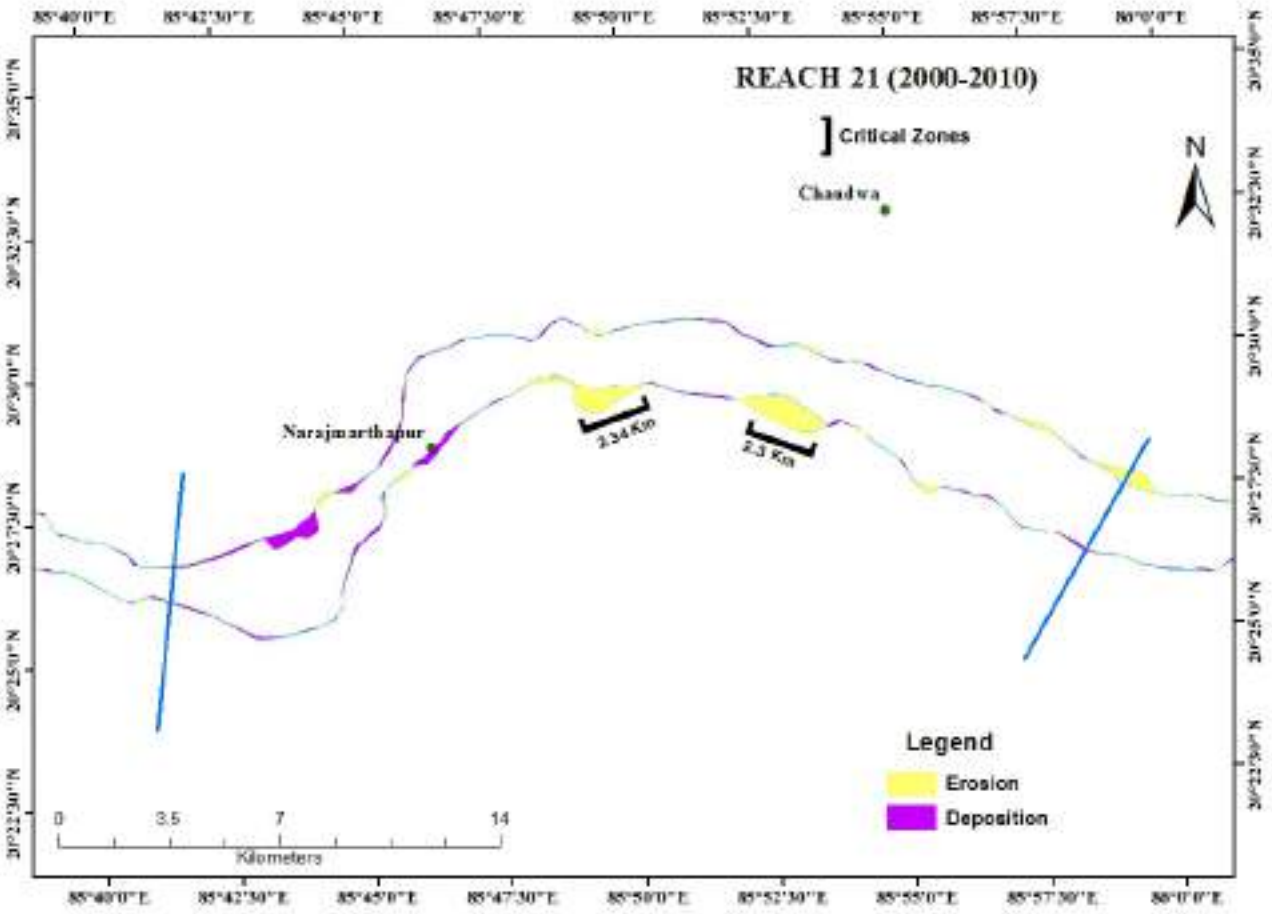


Figure 37.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 22

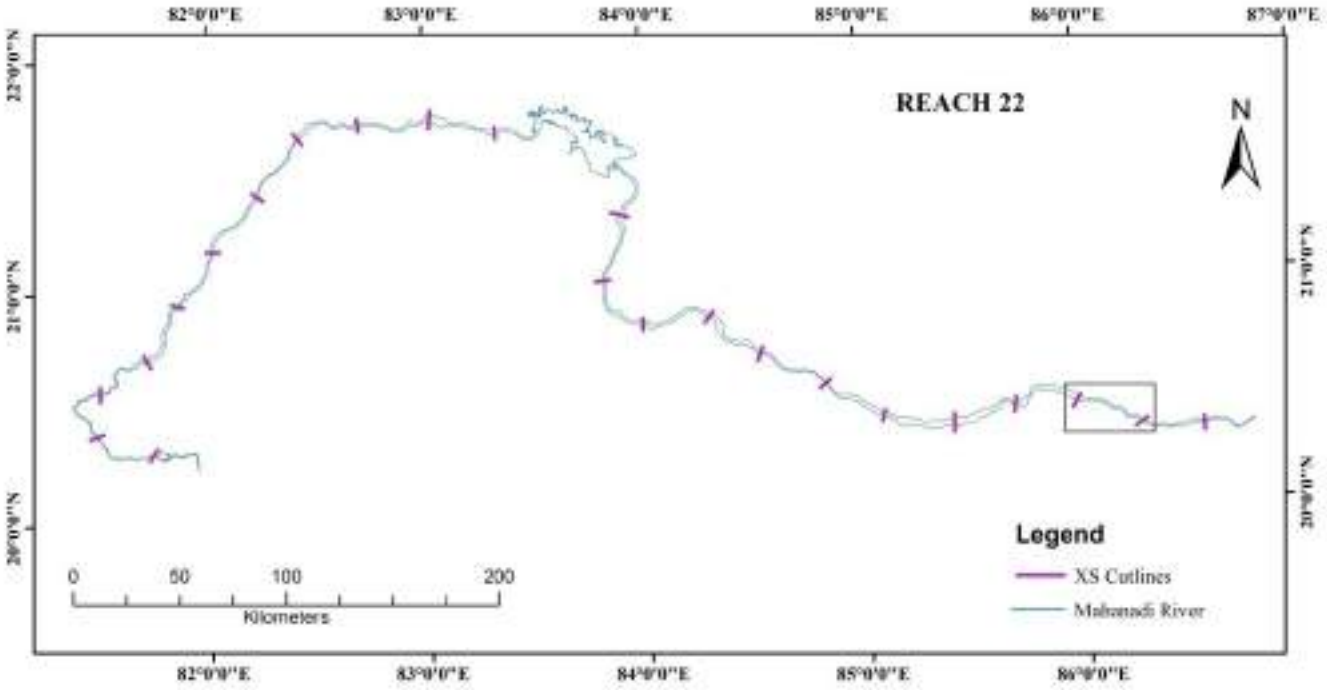


Figure 38.1: Location of reach number 22 in the Mahanadi river

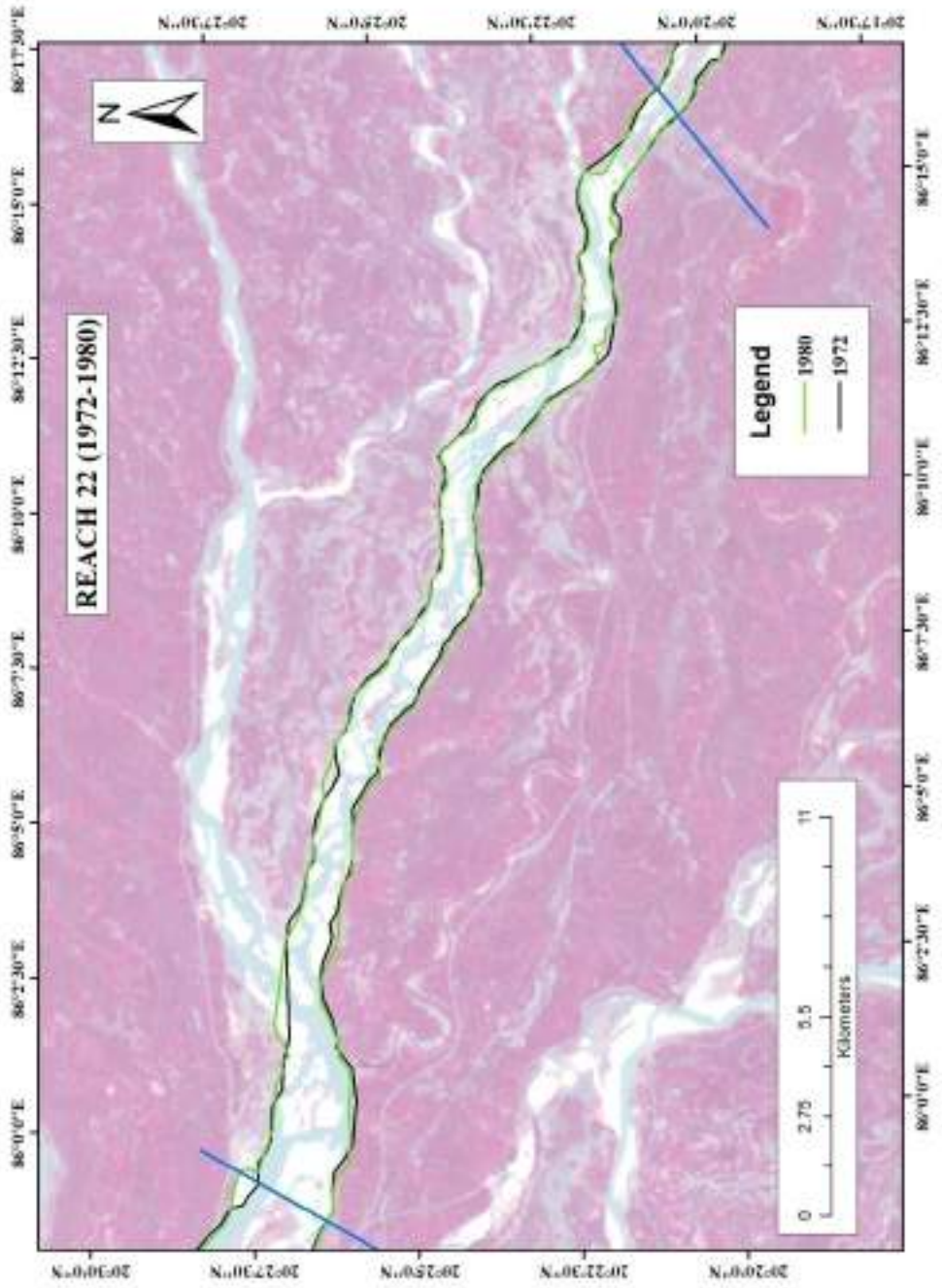


Figure 38.2: Changes in the course of Mahanadi River of Year 1972-1980

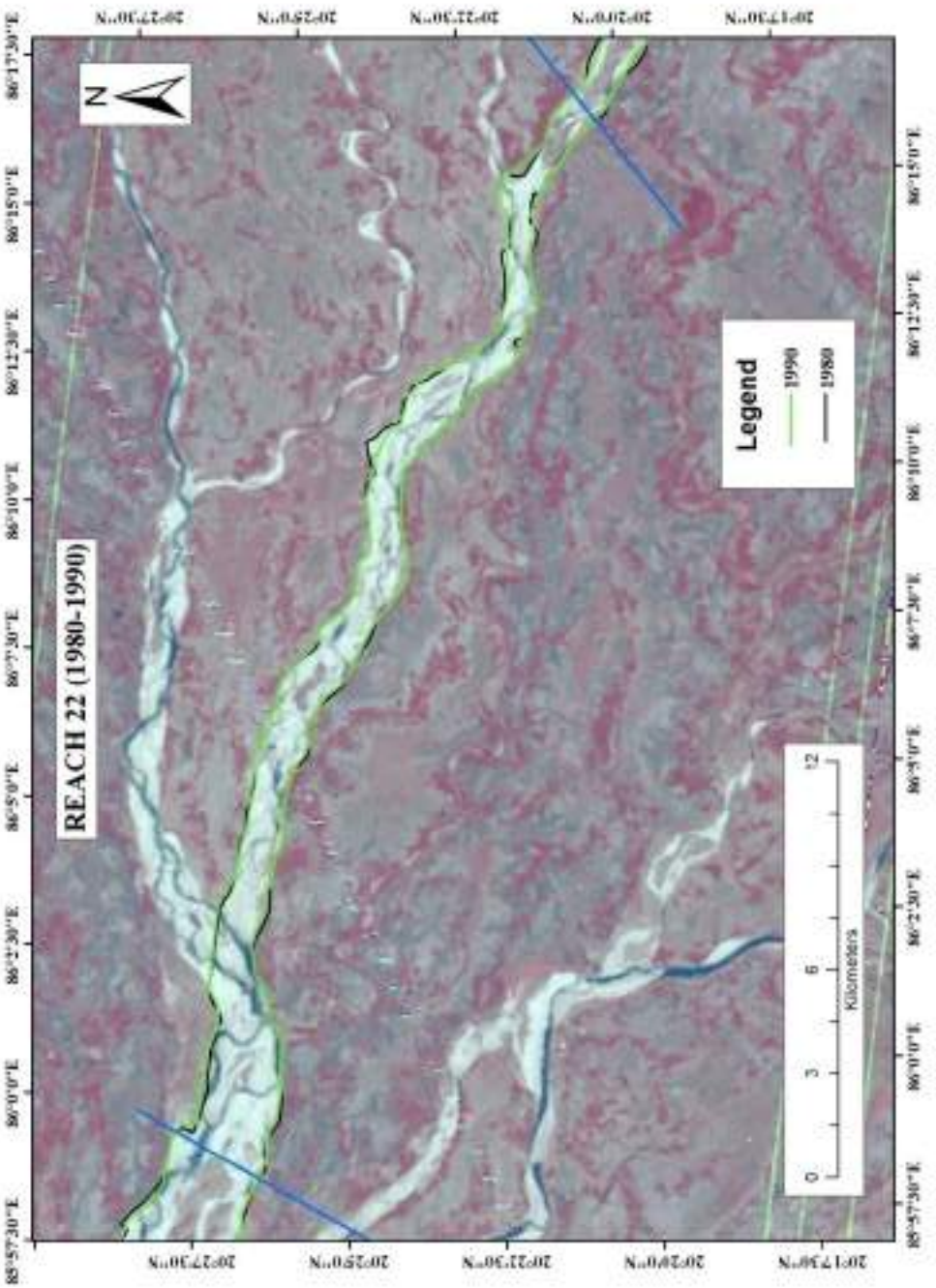


Figure 38.3: Changes in the course of Mahanadi River of Year 1980-1990

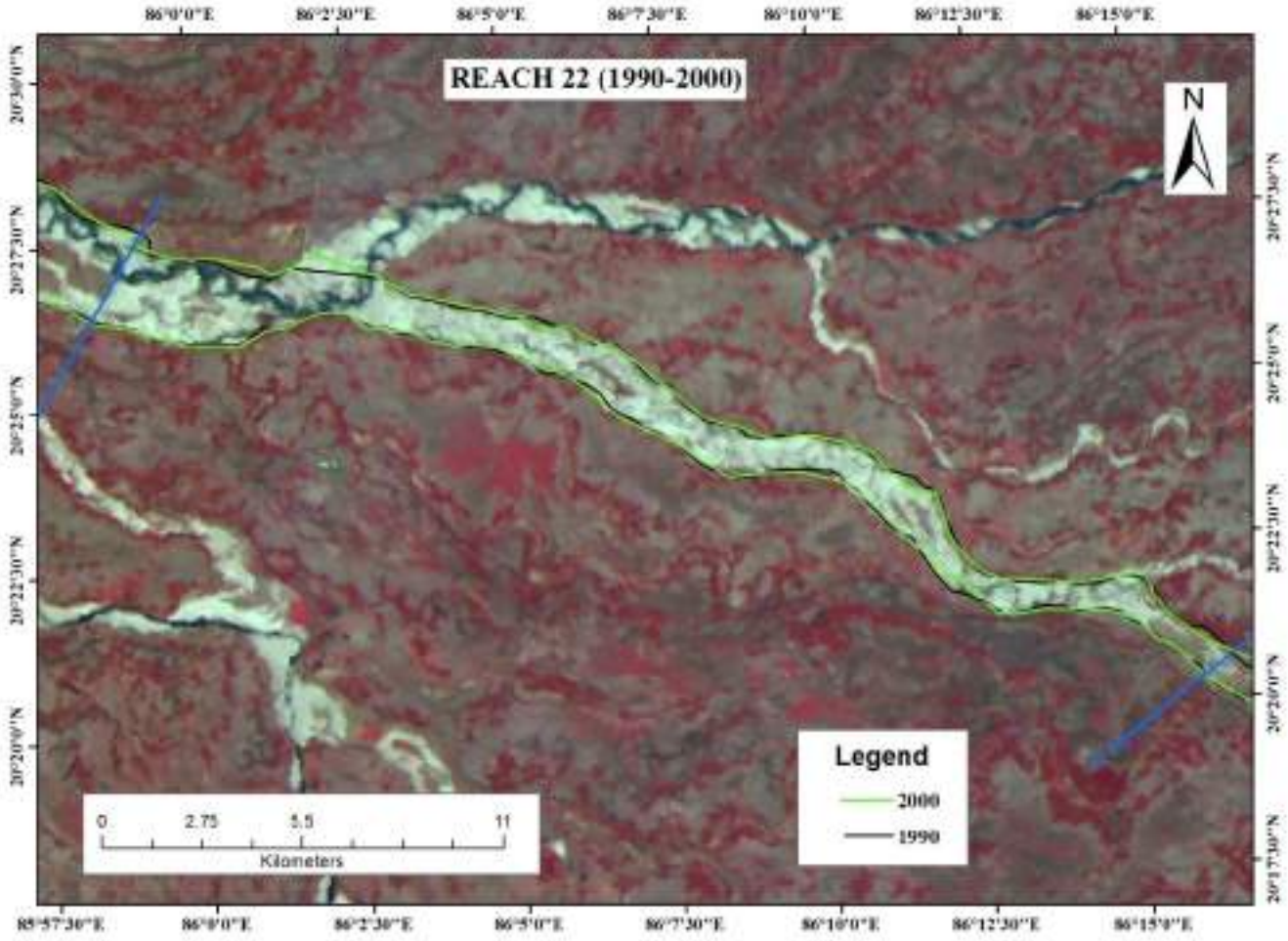


Figure 38.4: Changes in the course of Mahanadi River of Year 1990-2000

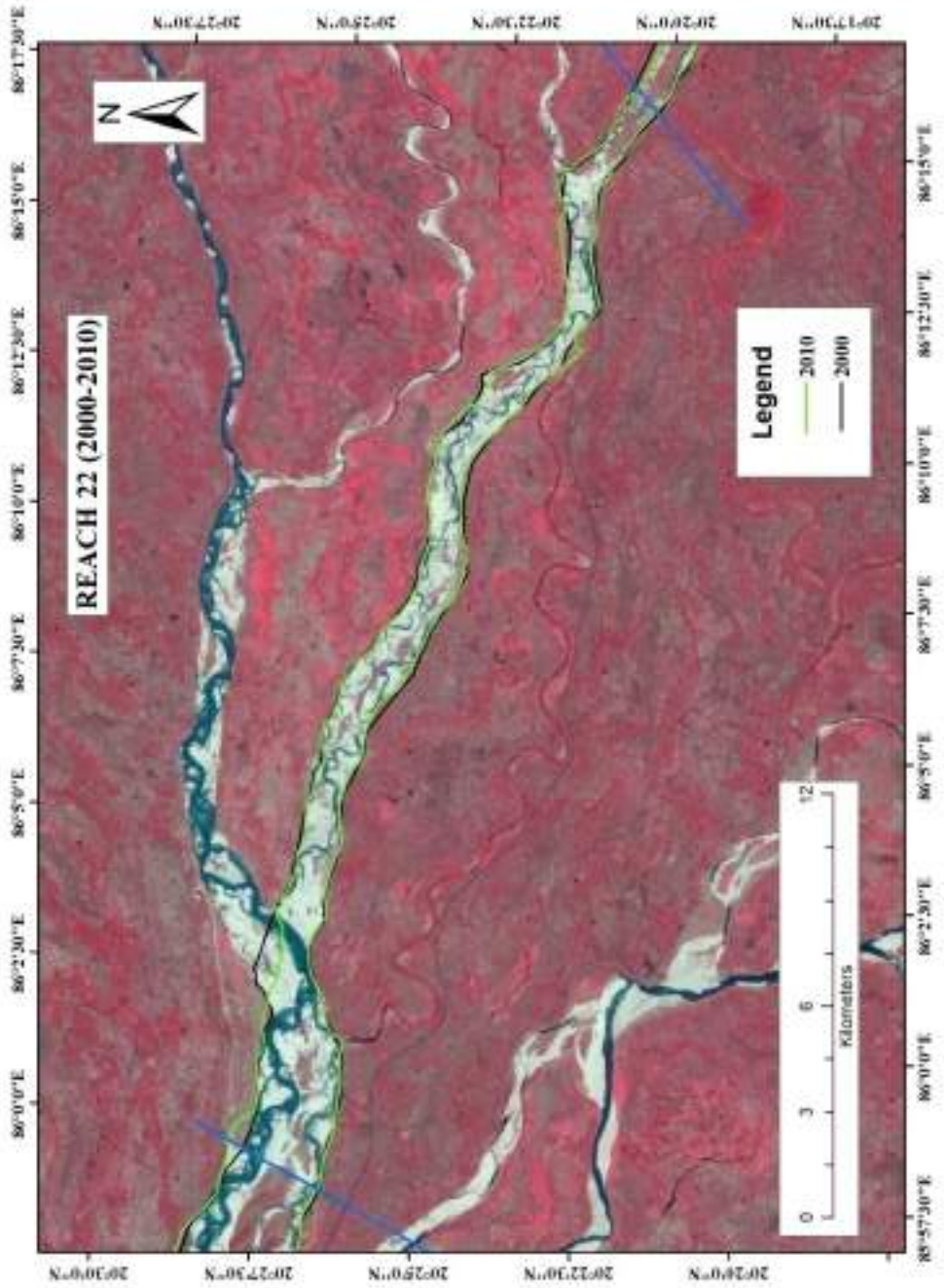


Figure 38.5: Changes in the course of Mahanadi River of Year 2000-2010

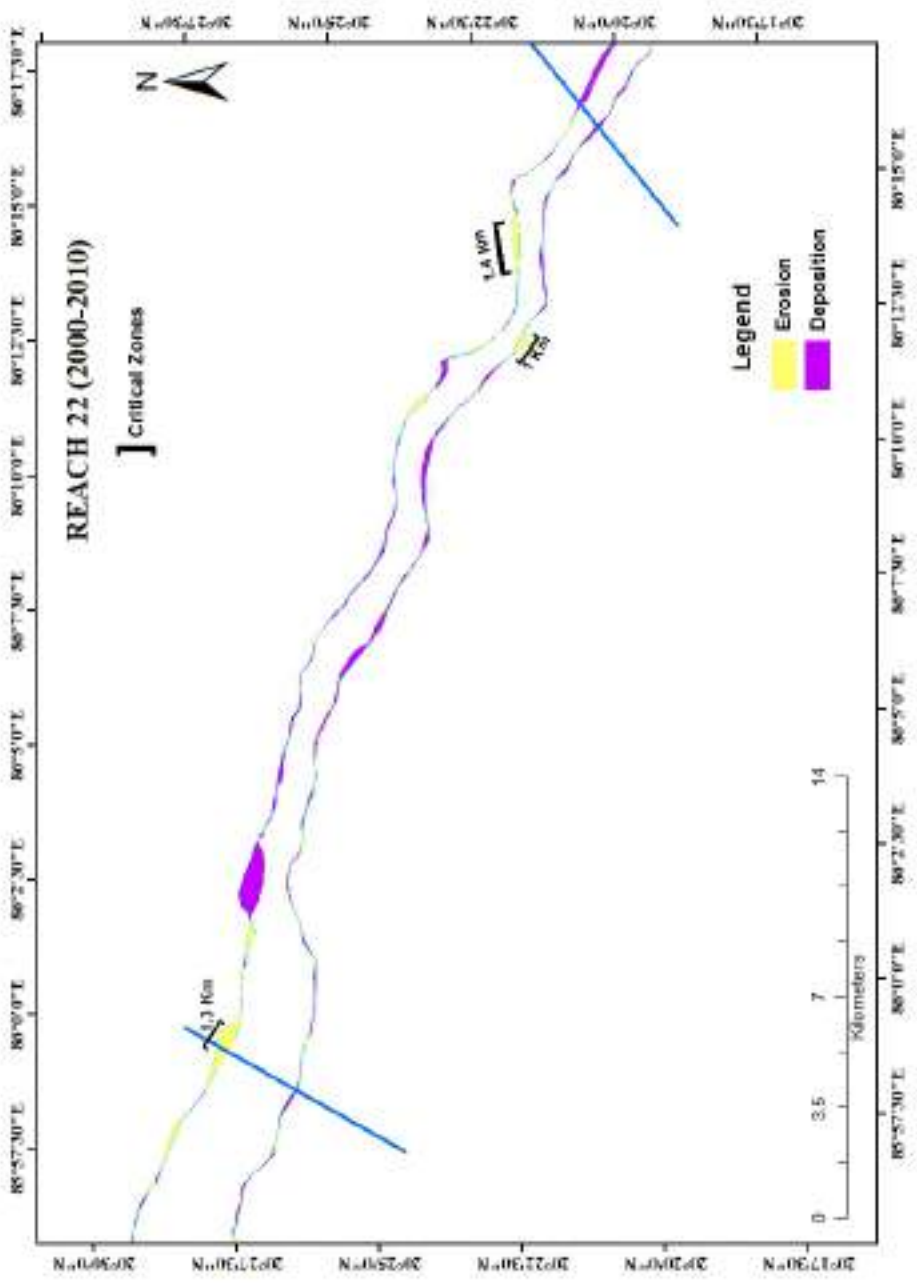


Figure 38.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 23

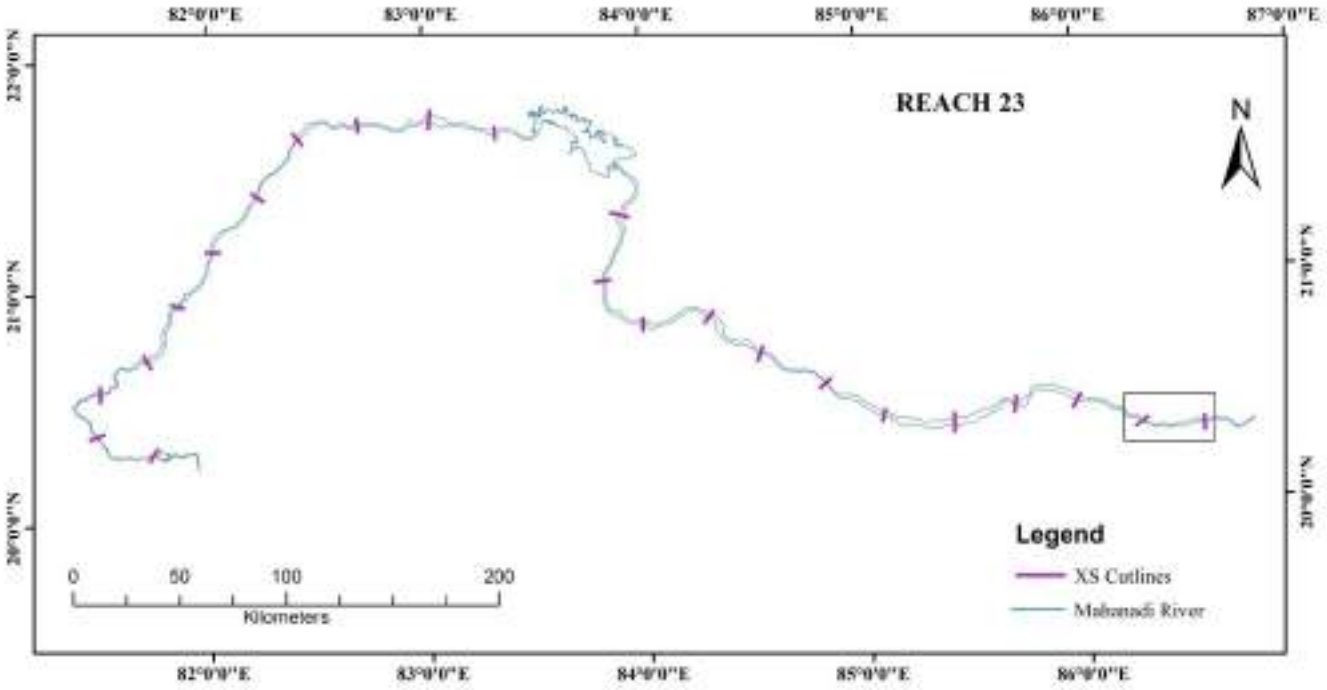


Figure 39.1: Location of reach number 23 in the Mahanadi river

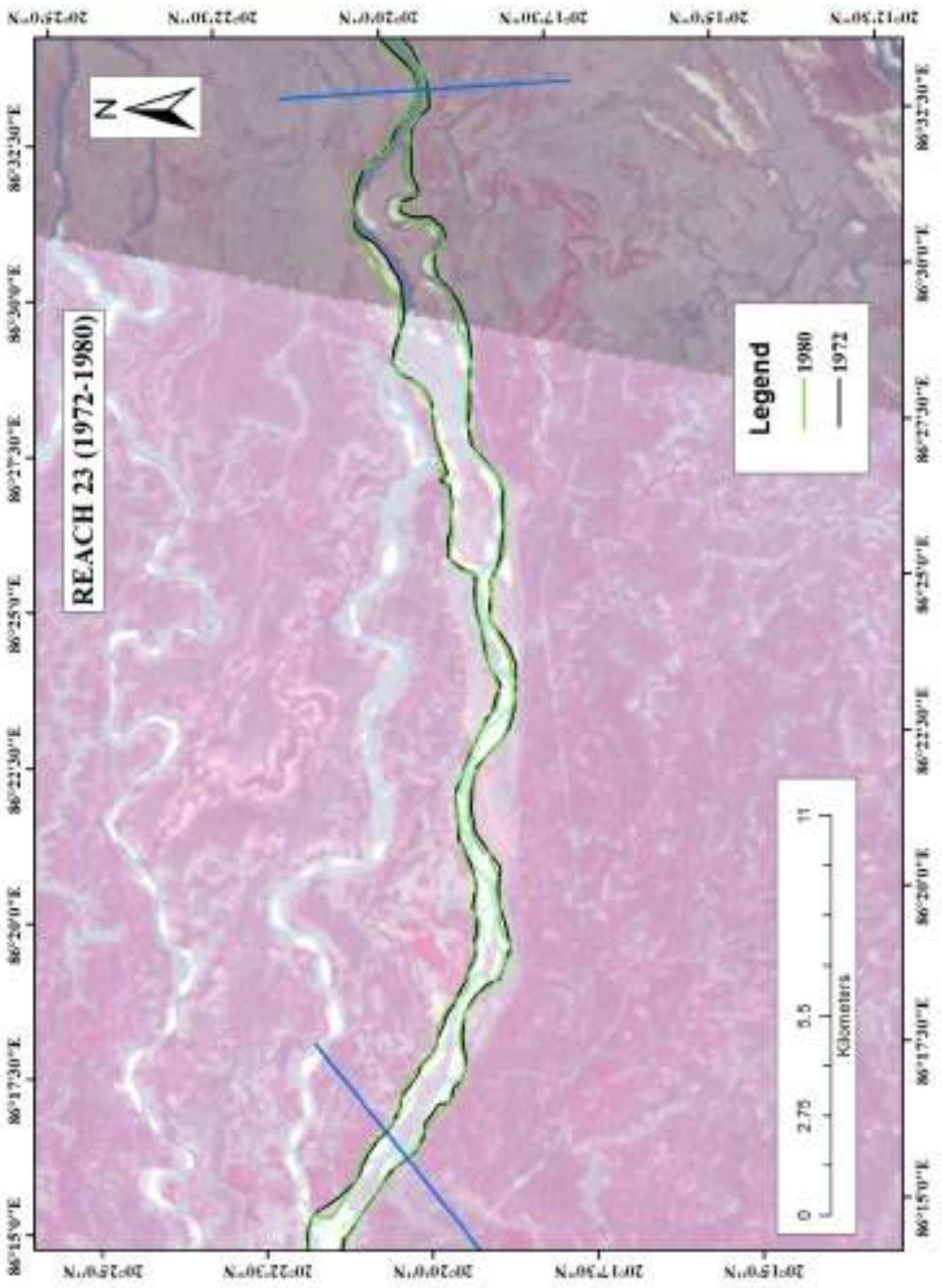


Figure 39.2: Changes in the course of Mahanadi River of Year 1972-1980

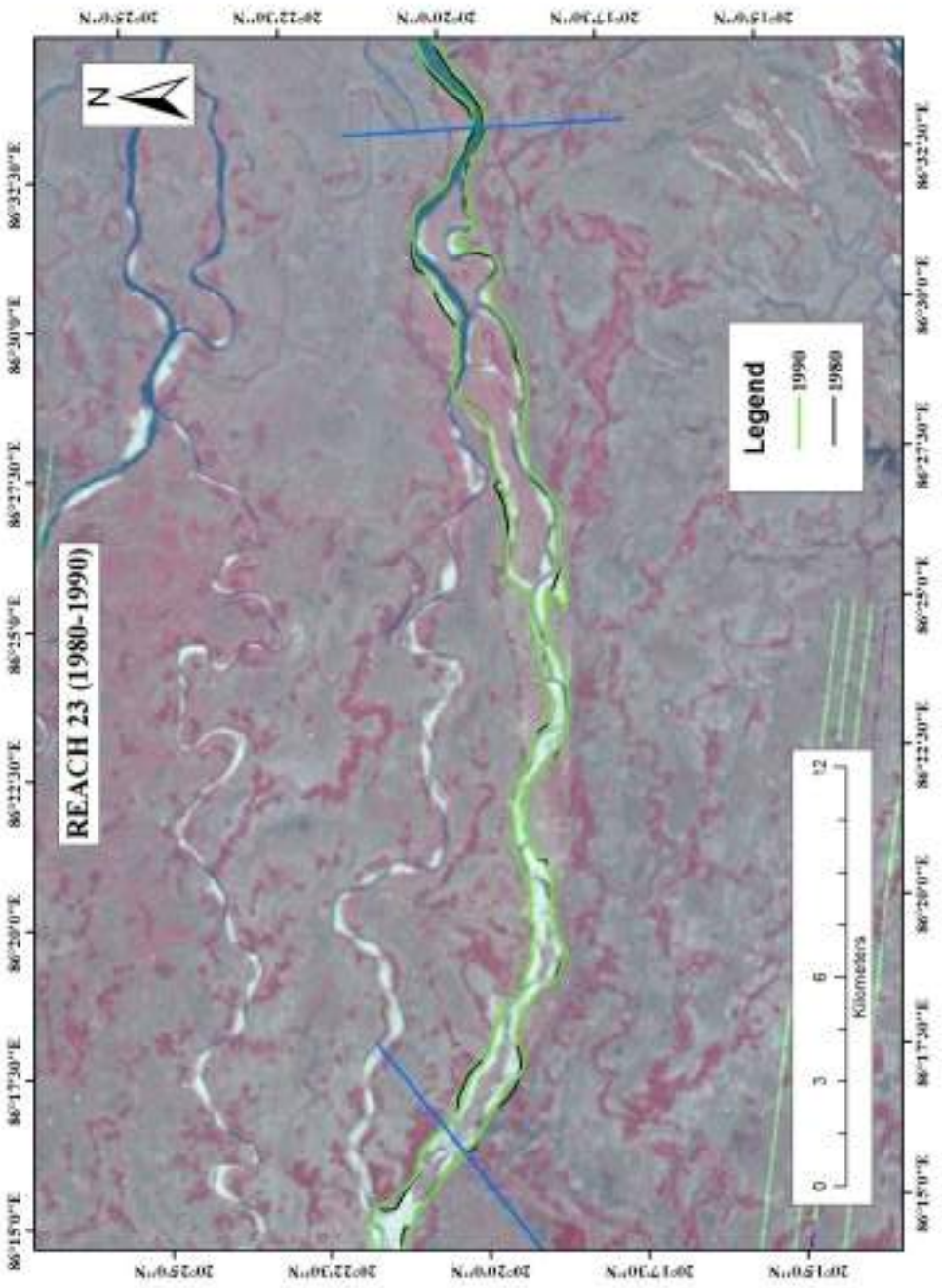


Figure 39.3: Changes in the course of Mahanadi River of Year 1980-1990

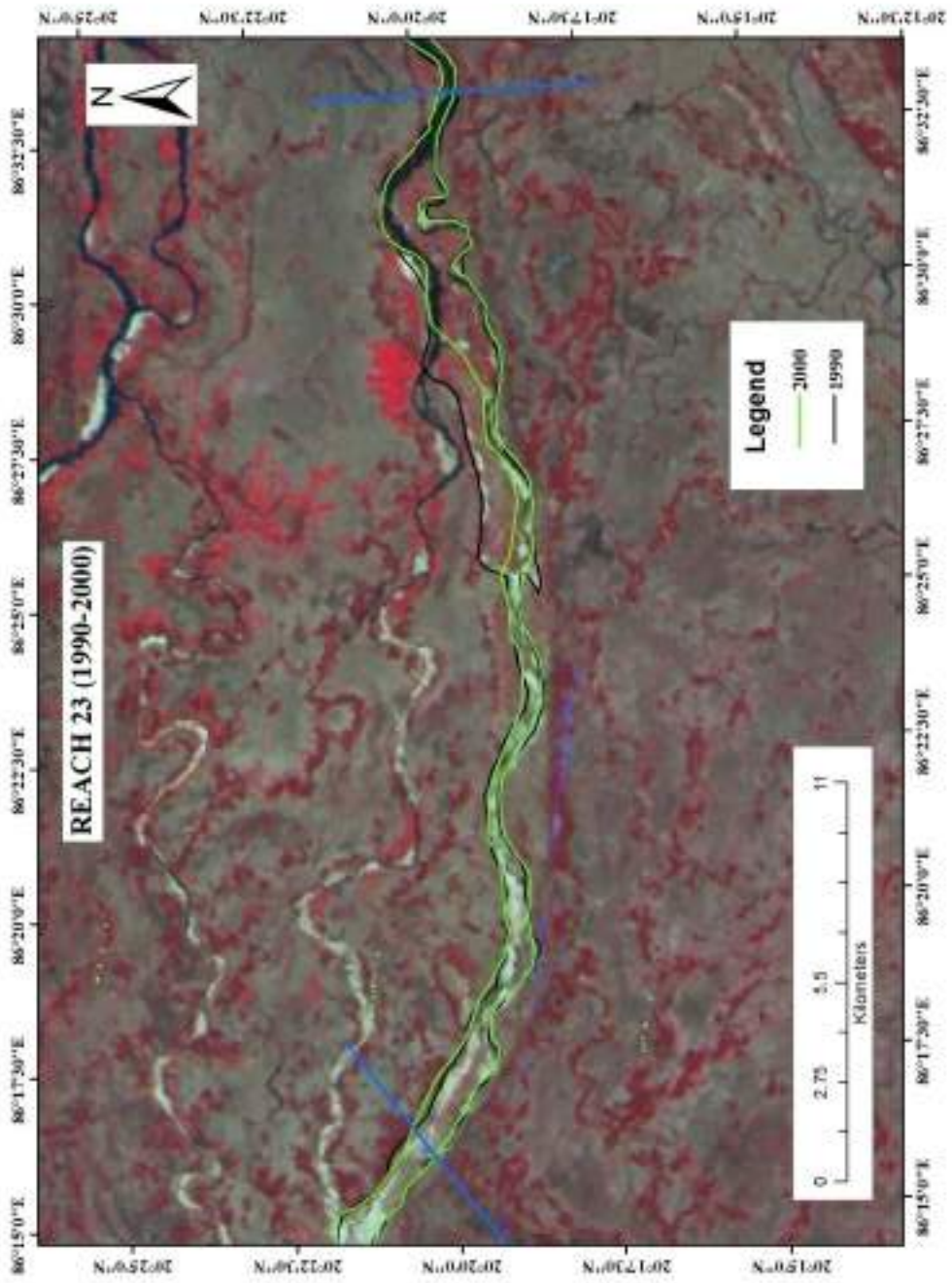


Figure 39.4: Changes in the course of Mahanadi River of Year 1990-2000

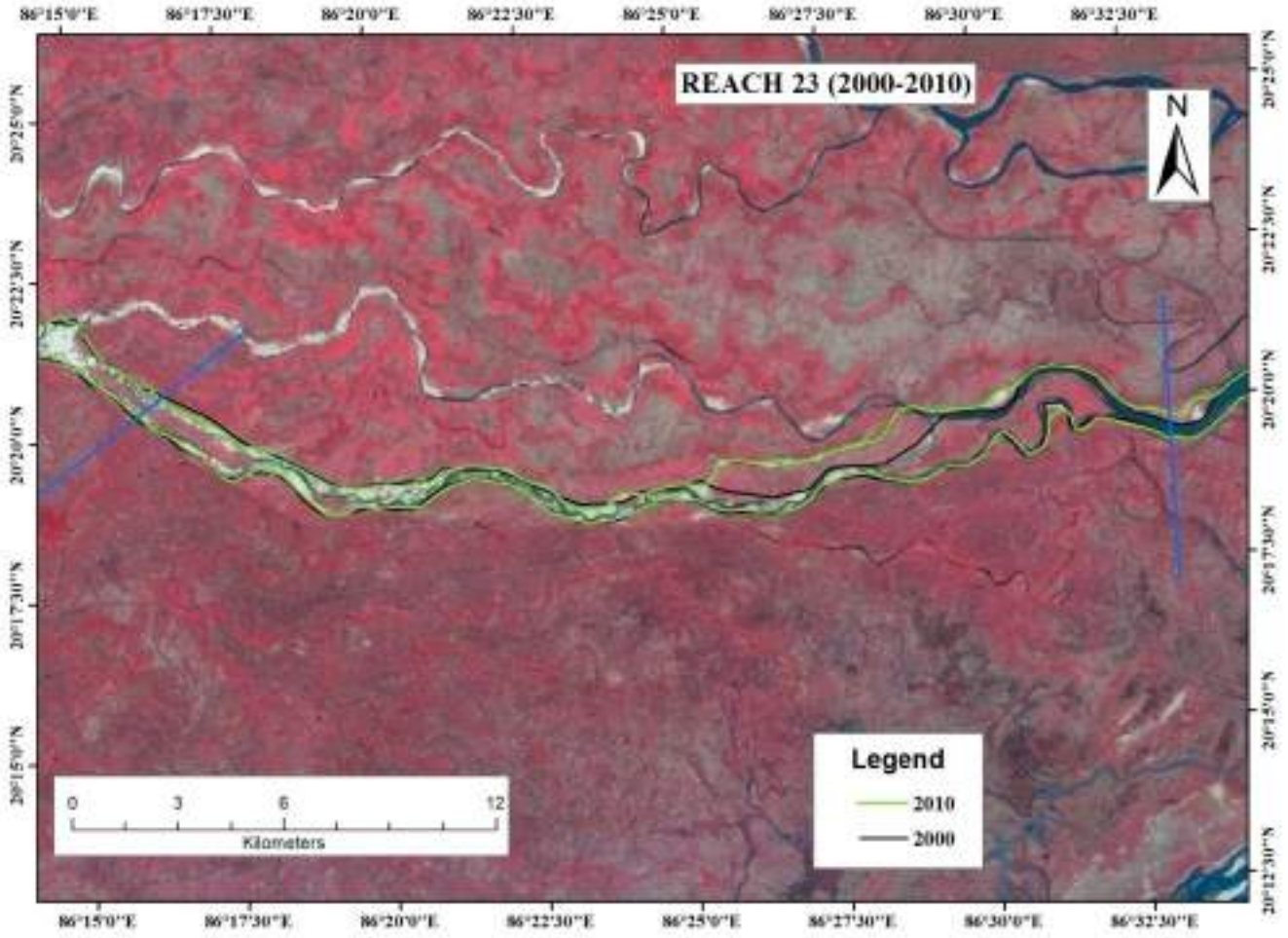


Figure 39.5: Changes in the course of Mahanadi River of Year 2000-2010

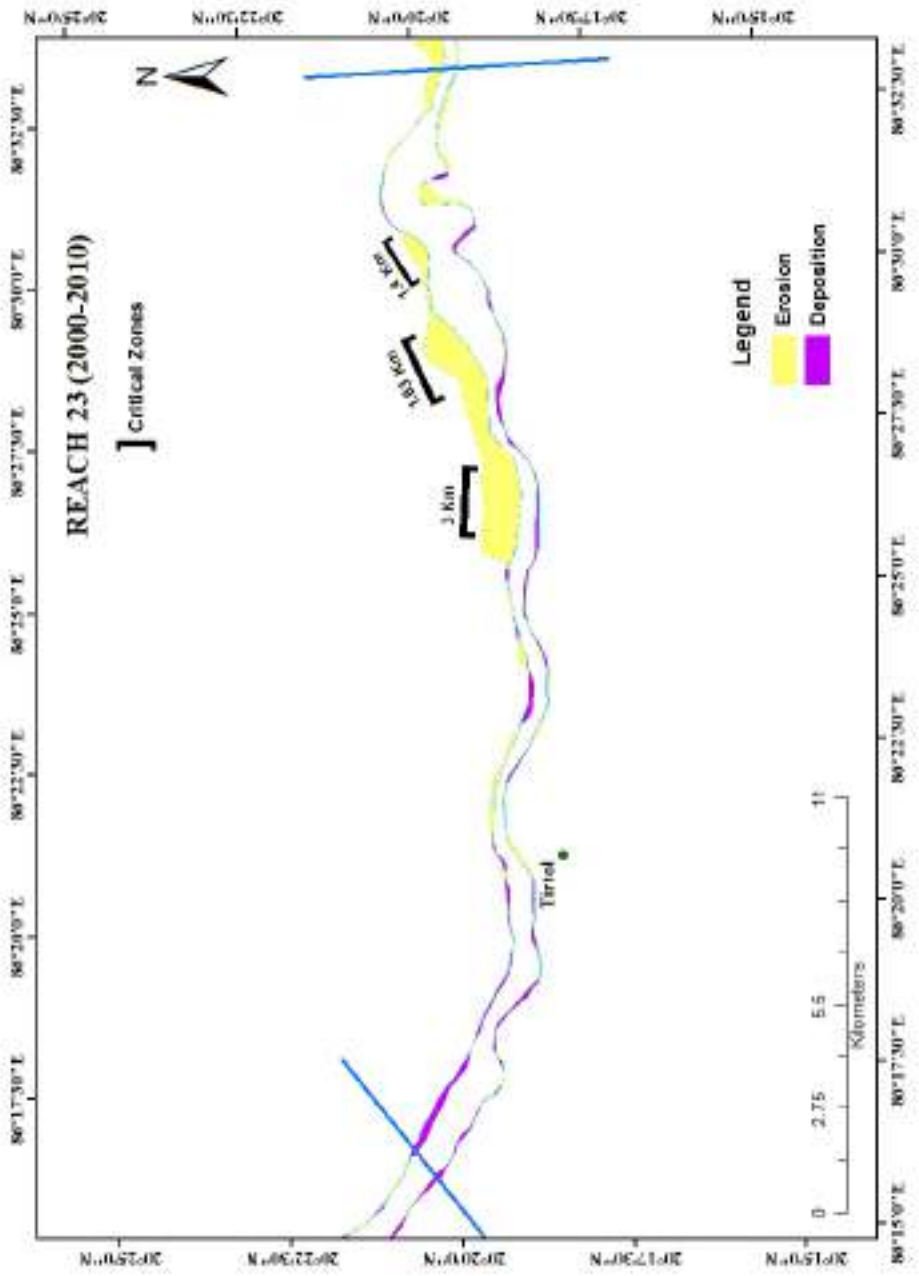


Figure 39.6: Identification of critical zones for Mahanadi River of Year 2000-2010

Reach 24

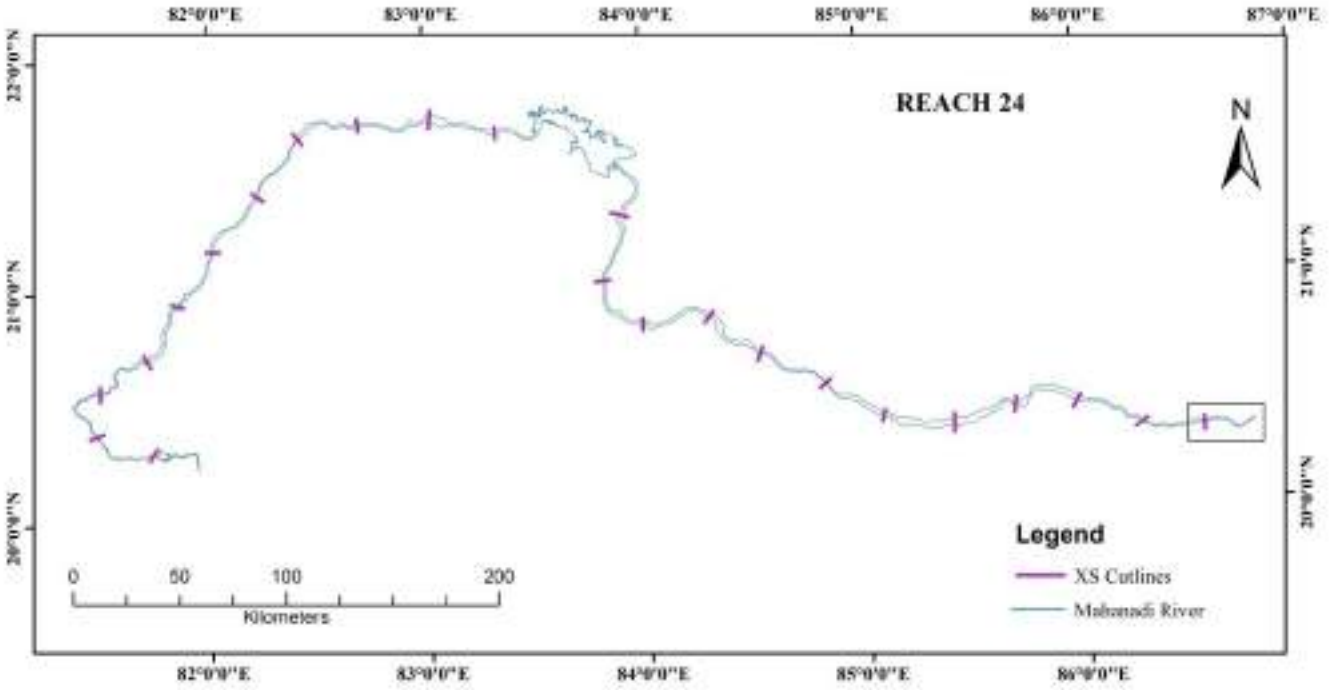


Figure 40.1: Location of reach number 24 in the Mahanadi river

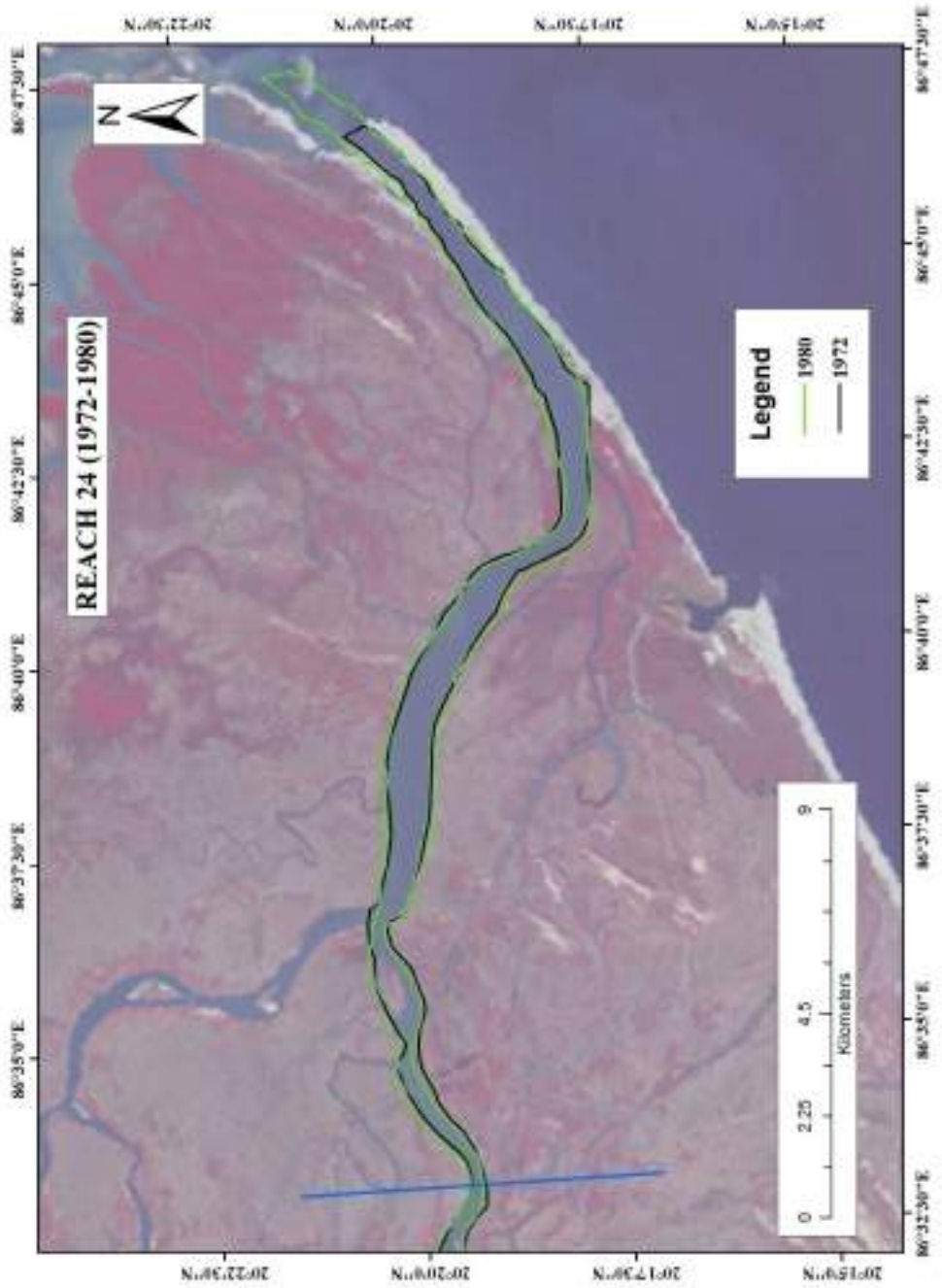


Figure 40.2: Changes in the course of Mahanadi River of Year 1972-1980

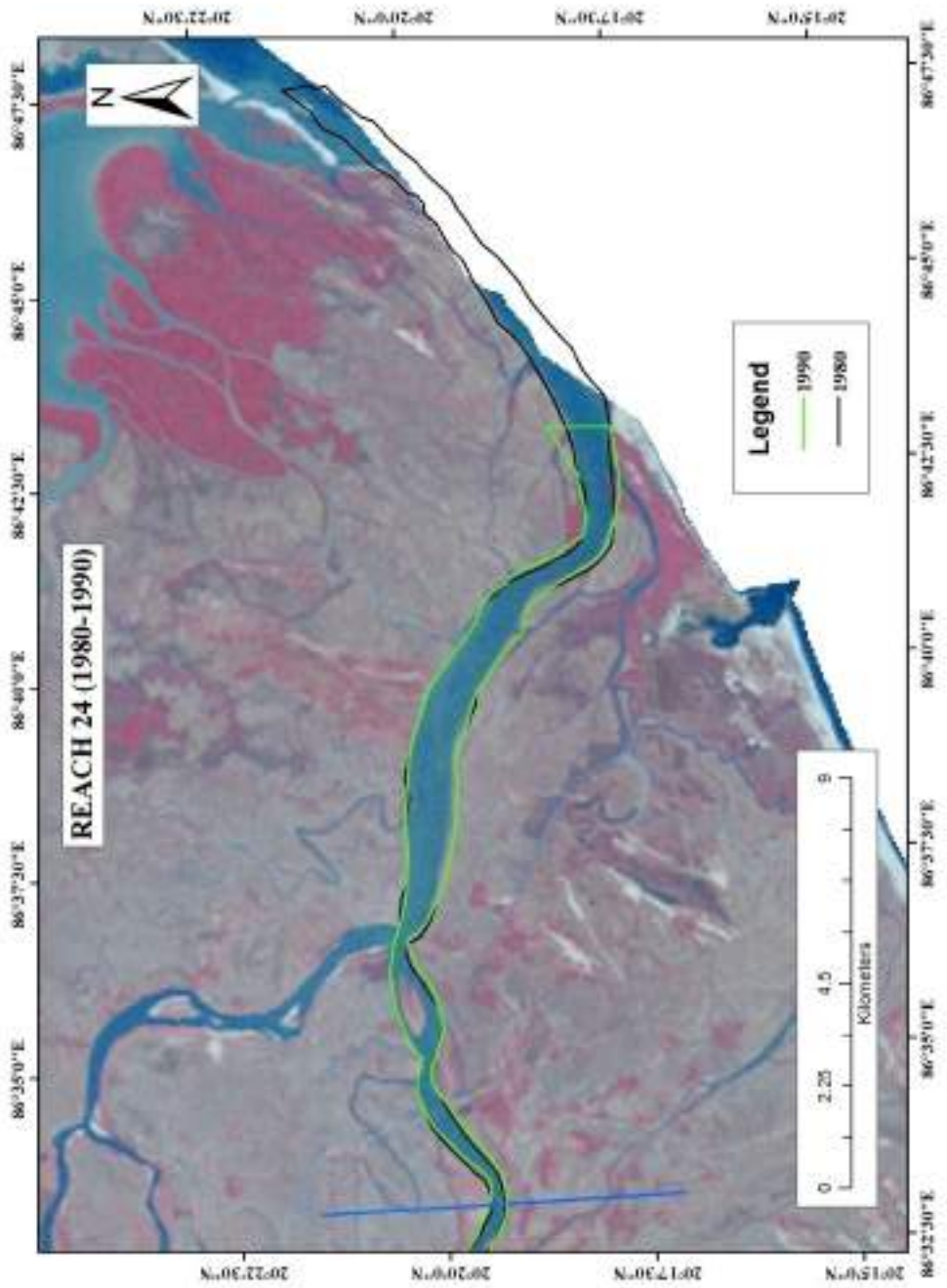


Figure 40.3: Changes in the course of Mahanadi River of Year 1980-1990

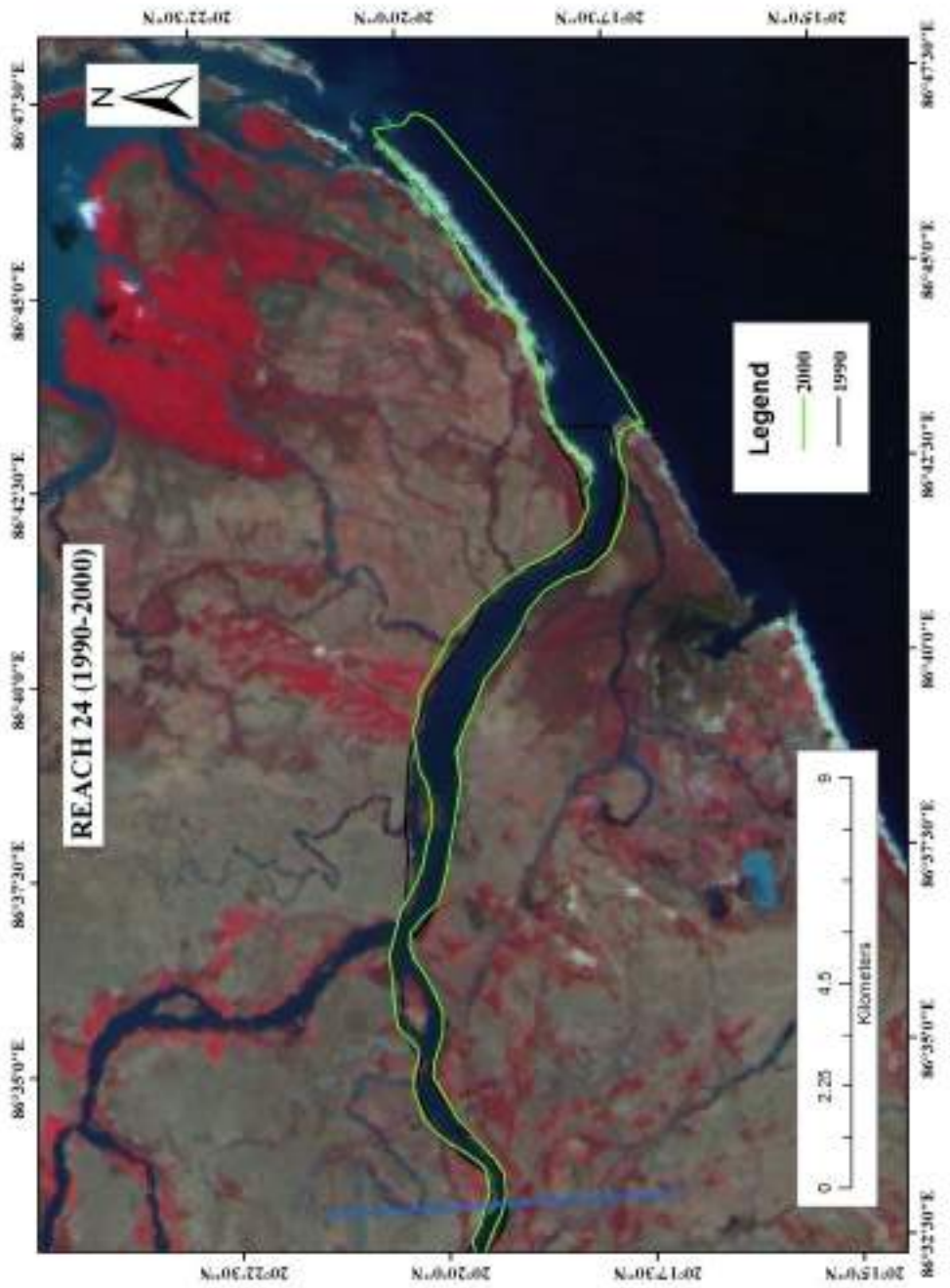


Figure 40.4: Changes in the course of Mahanadi River of Year 1990-2000

Figure 40.5: Changes in the course of Mahanadi River of Year 2000-2010

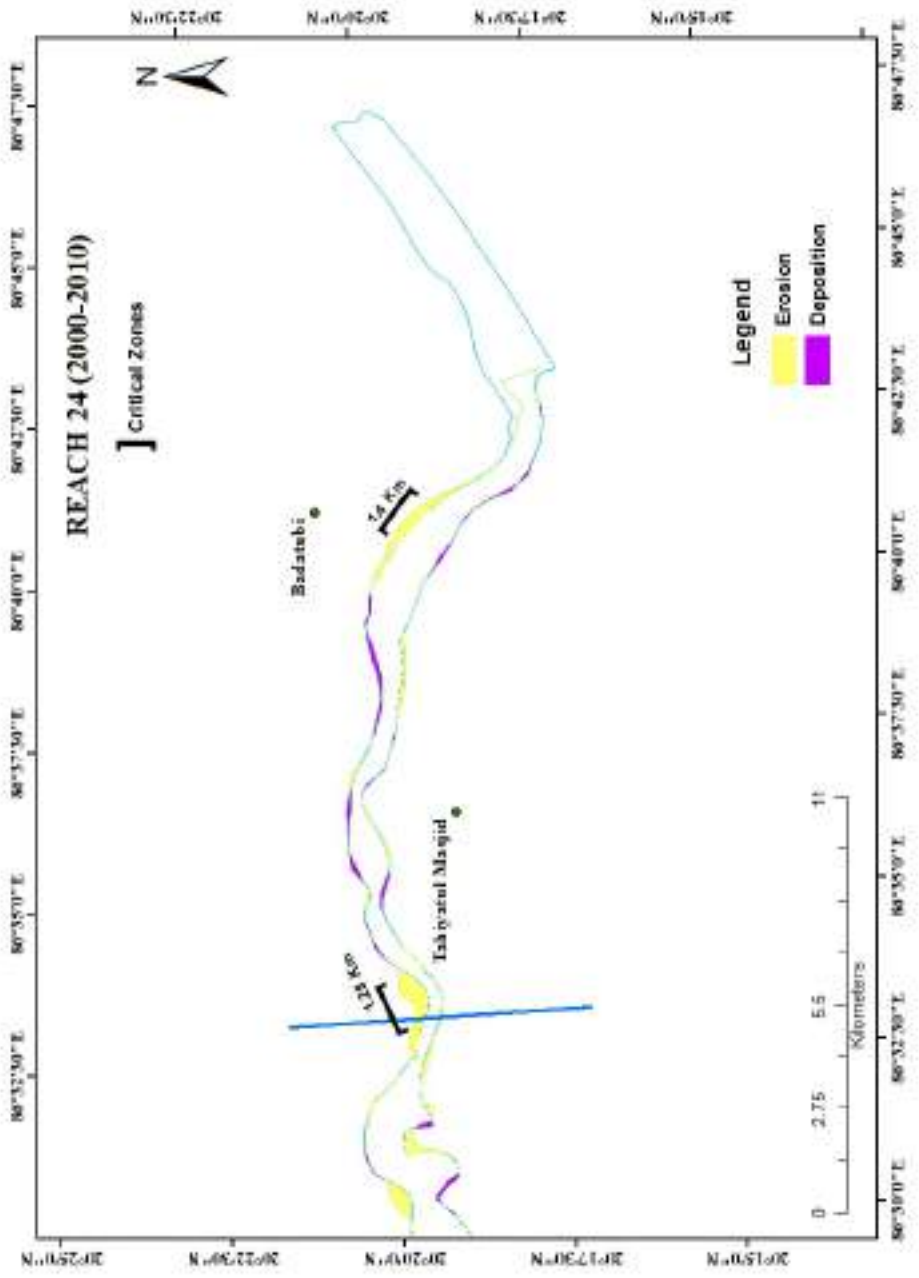


Figure 40.6: Identification of critical zones for Mahanadi River of Year 2000-2010

5.13 Site suitability for river sand mining

Sand mining is an anthropogenic activity referring to the process of the excavation and removal of sand from the foreshore including rivers, streams and lakes. Sand is mined from beaches and inland dunes and dredged from ocean beds and river beds. A related process is the mining of mineral sands, such as mineral deposits like diamond, gold and silver. These minerals typically occur combined with ordinary sand. The sand is dug up, the valuable minerals are separated in water by using their different density, and the remaining ordinary sand is re-deposited.

Excessive in-stream sand-and-gravel mining causes the degradation of rivers. In-stream mining lowers the stream bottom, which may lead to bank erosion. Depletion of sand in the stream bed and along coastal areas causes the deepening of rivers and estuaries, and the enlargement of river mouths and coastal inlets. It may also lead to saline-water intrusion from the nearby sea. The effect of mining is compounded by the effect of sea level rise. Any volume of sand exported from stream beds and coastal areas is a loss to the system. It is also a threat to bridges, river banks and nearby structures. Sand mining also affects the adjoining groundwater system and the uses that local people make on the river.

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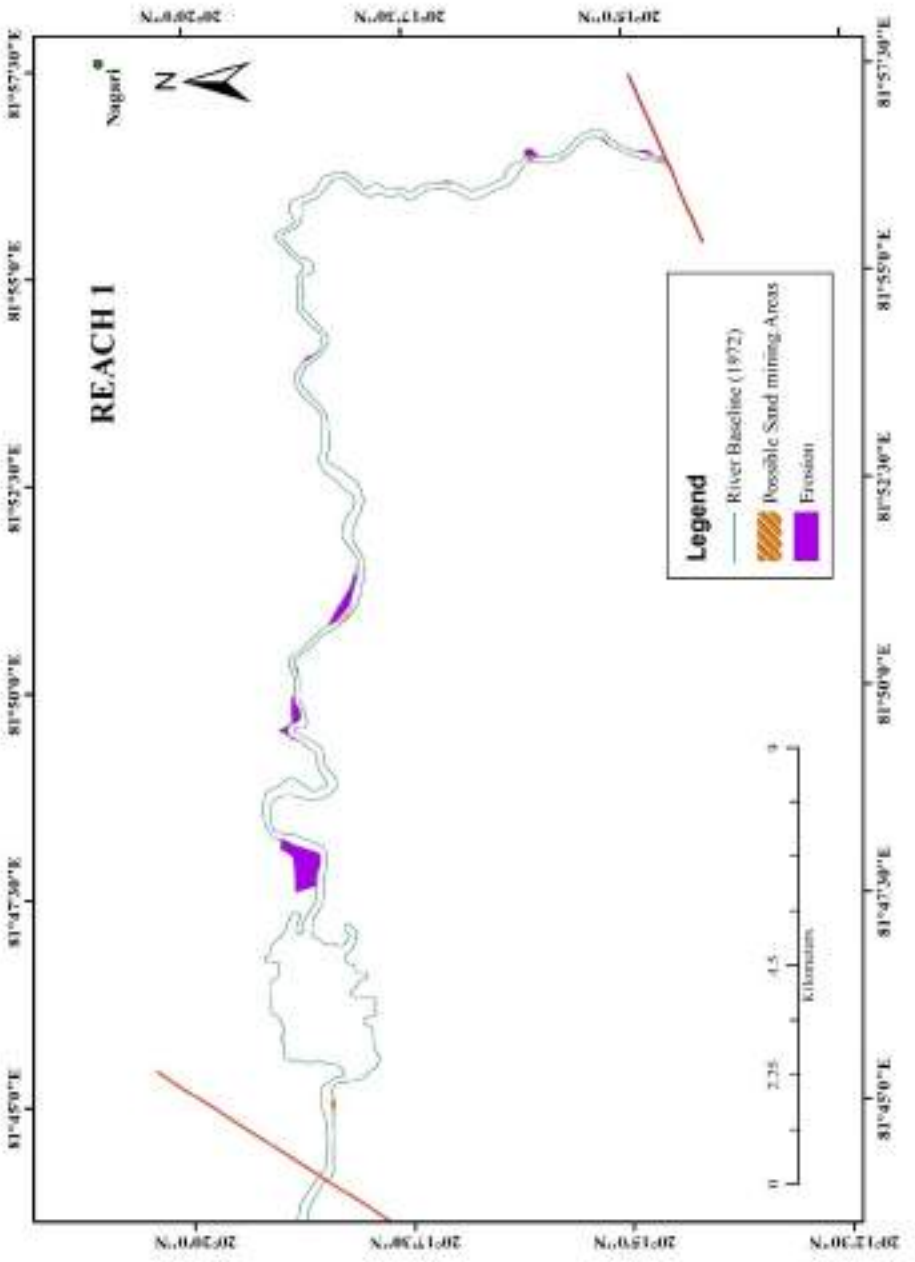

Figure 41.1: Possible sand mining areas in Mahanadi river

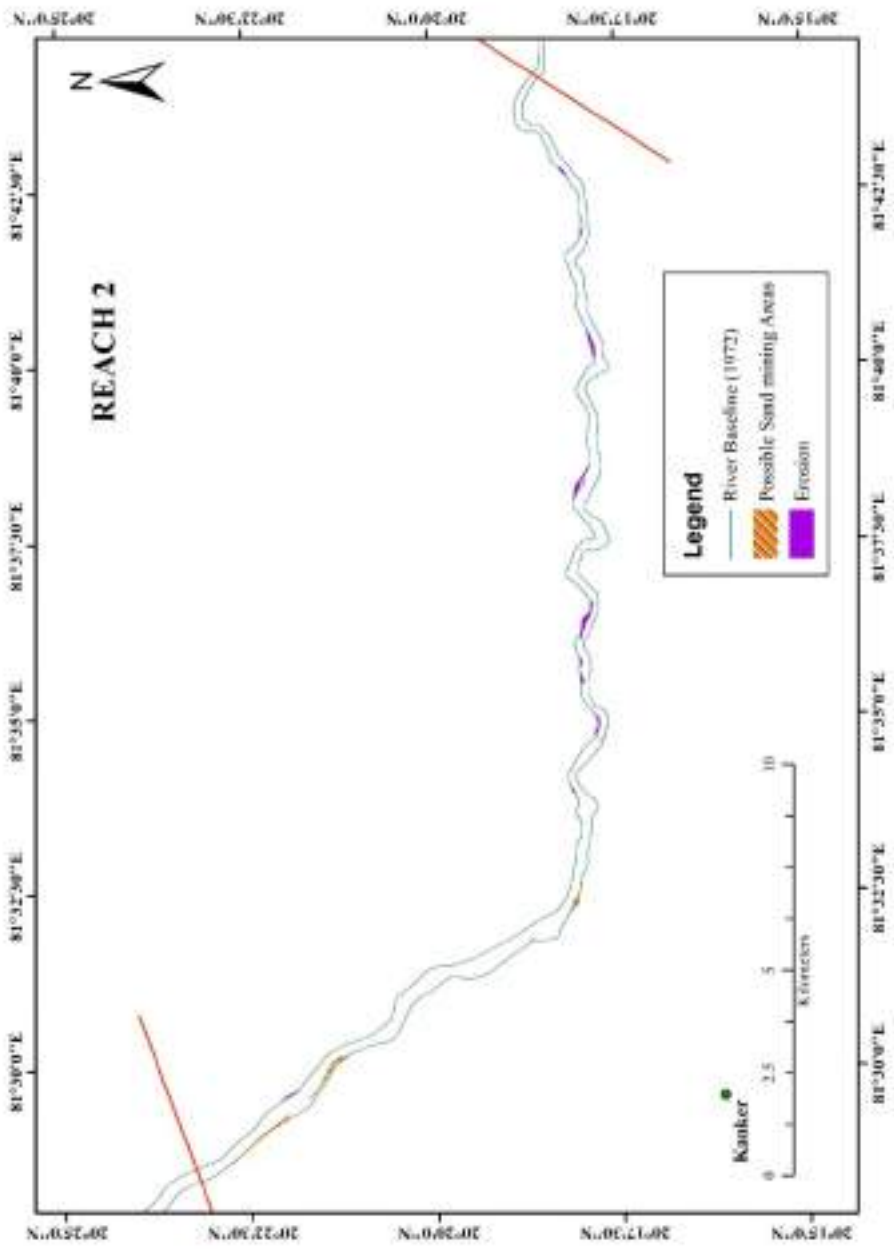

Figure 41.2: Possible sand mining areas in Mahanadi river

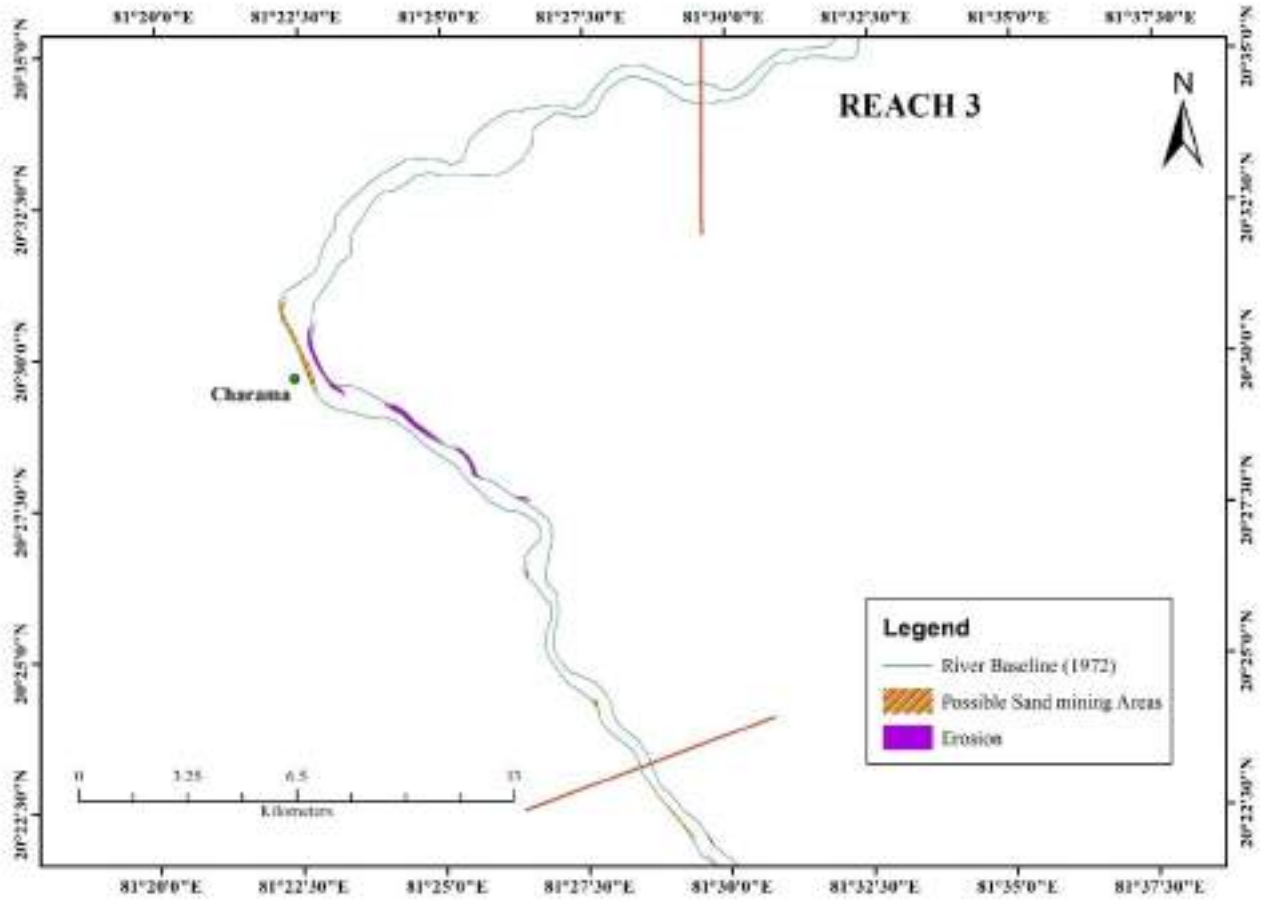

Figure 41.3: Possible sand mining areas in Mahanadi river

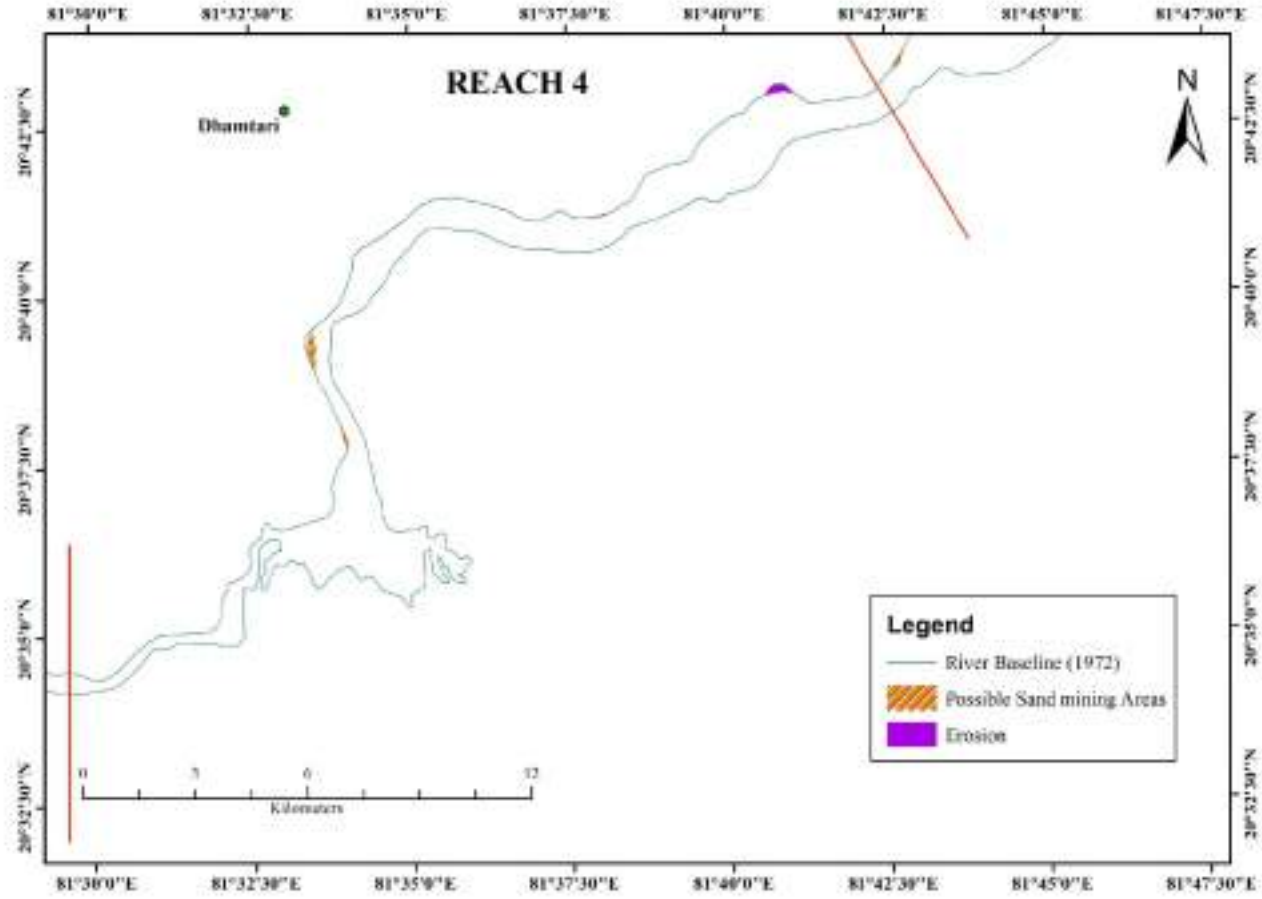

Figure 41.4: Possible sand mining areas in Mahanadi river

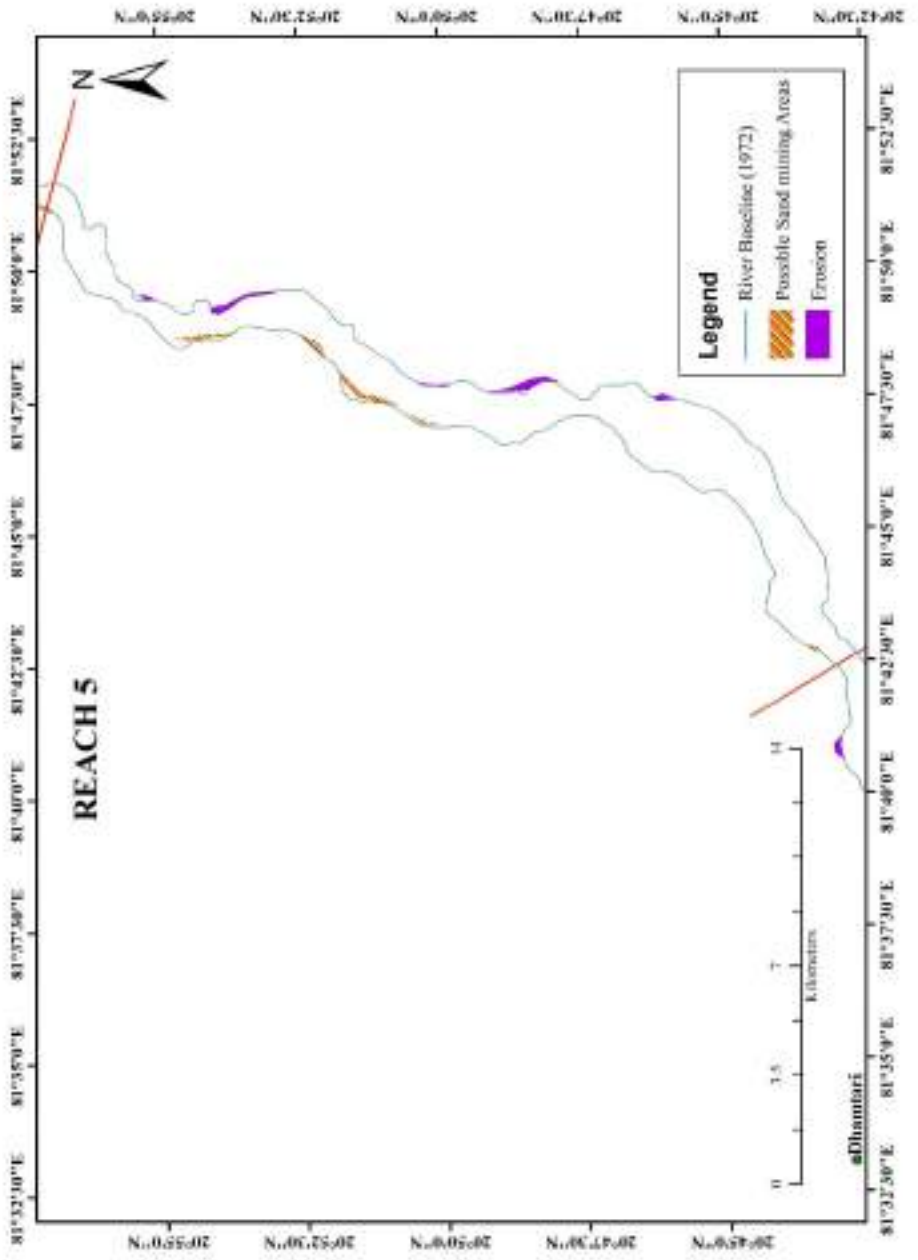

Figure 41.5: Possible sand mining areas in Mahanadi river

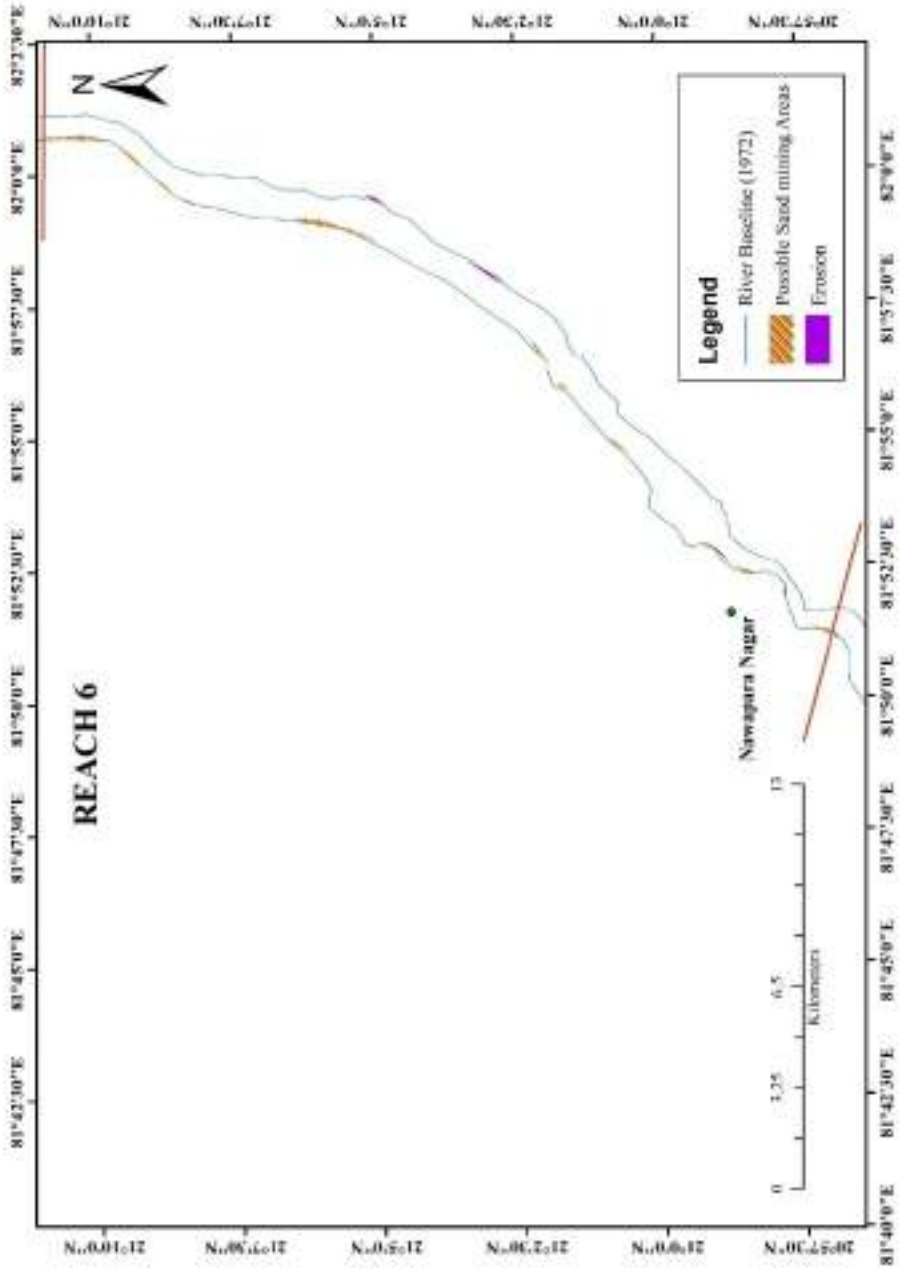

Figure 41.6: Possible sand mining areas in Mahanadi river

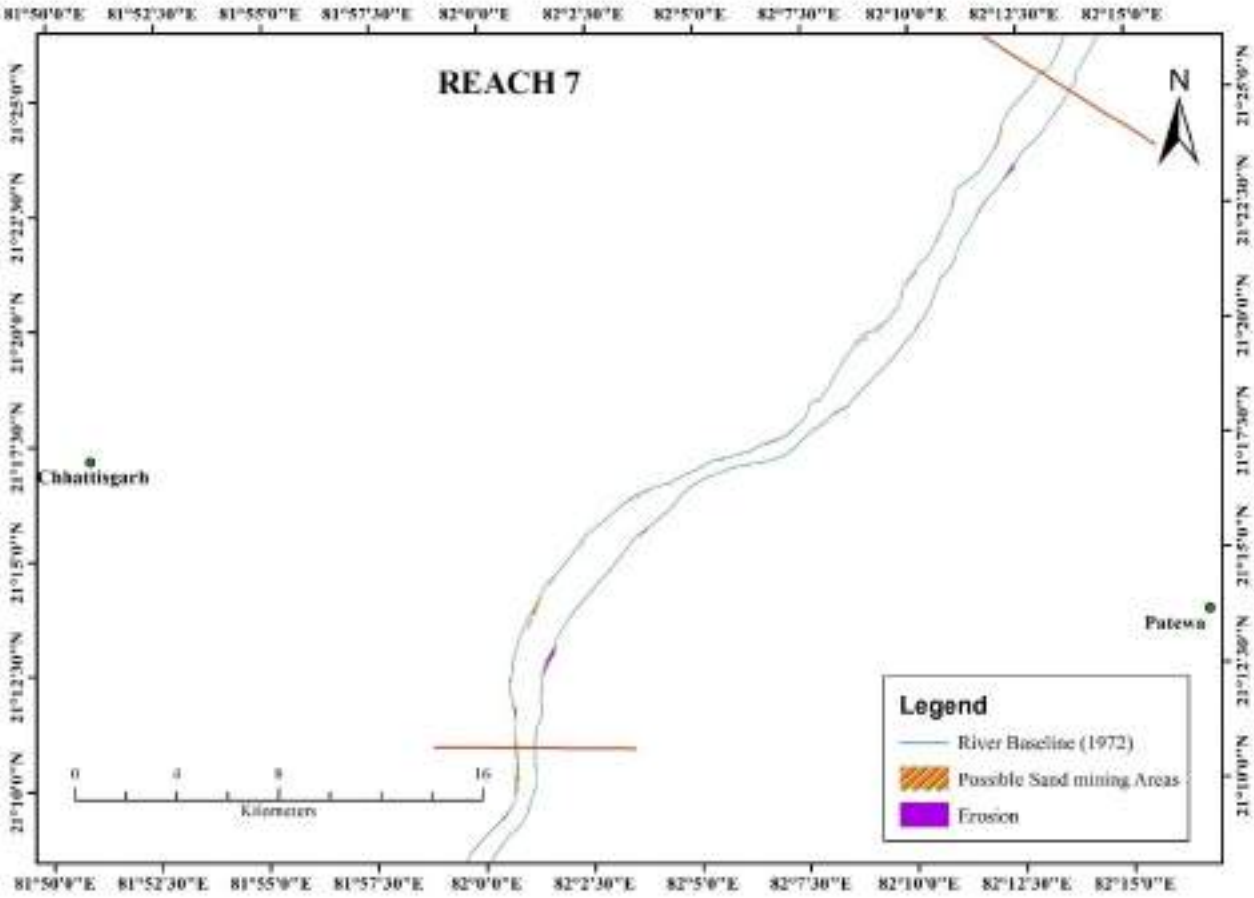

Figure 41.7: Possible sand mining areas in Mahanadi river

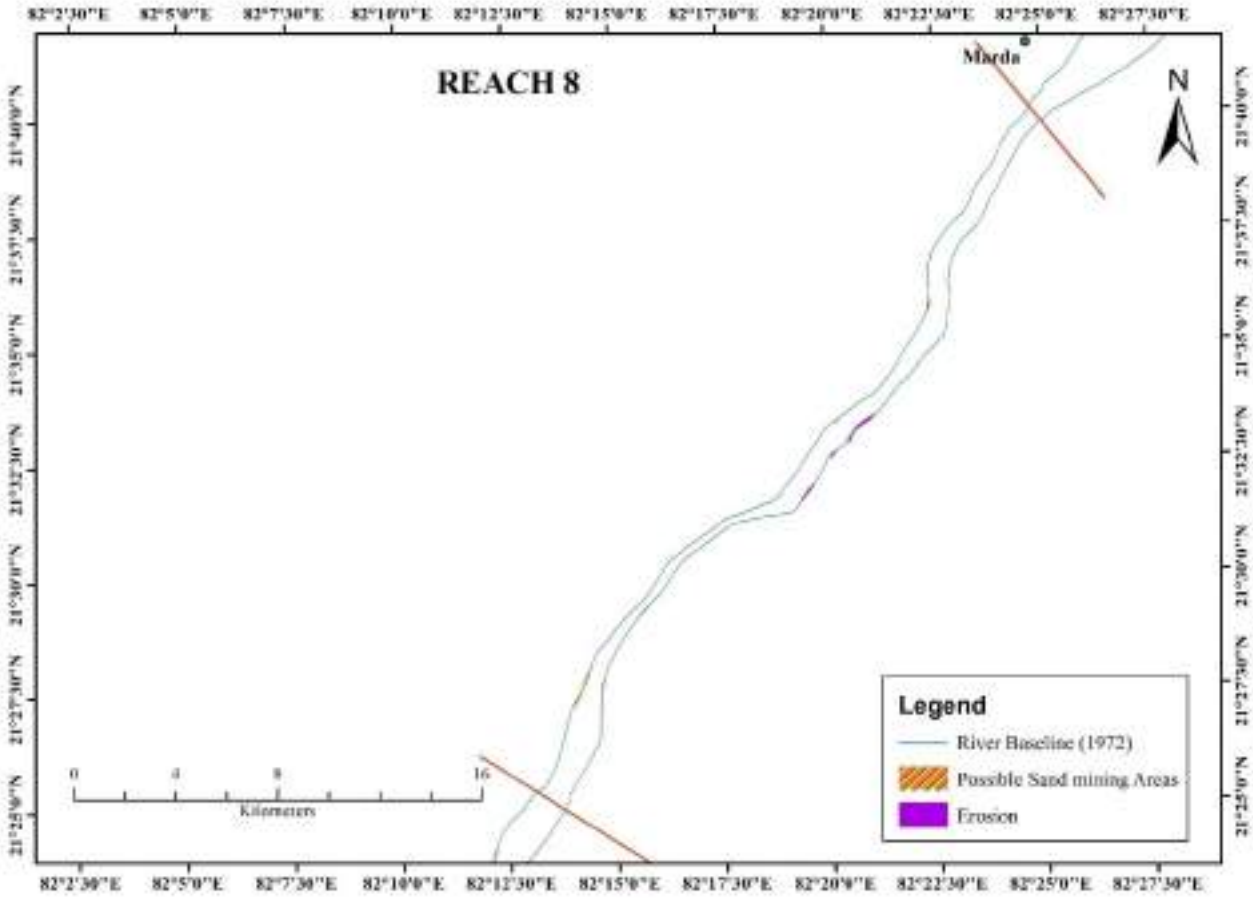

Figure 41.8: Possible sand mining areas in Mahanadi river

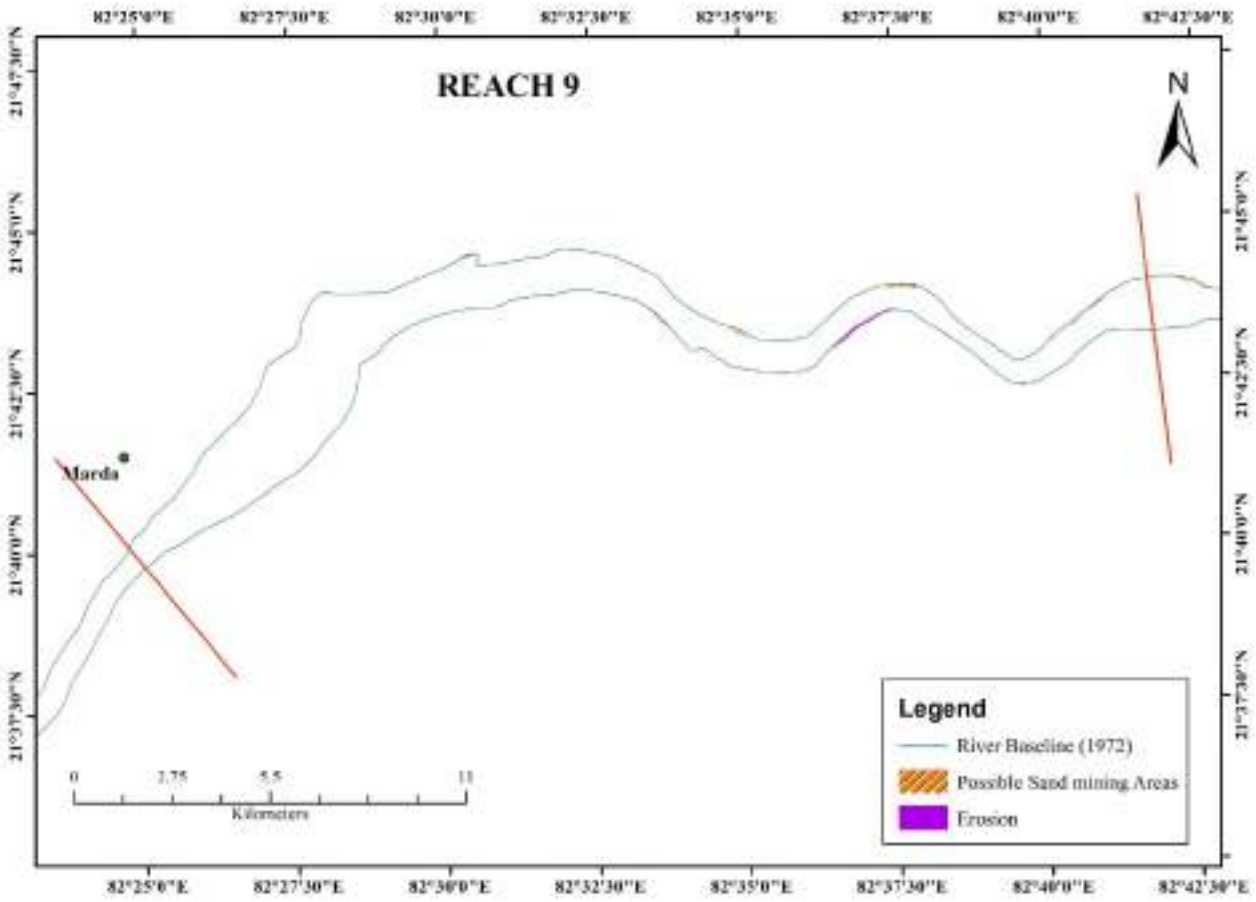

Figure 41.9: Possible sand mining areas in Mahanadi river

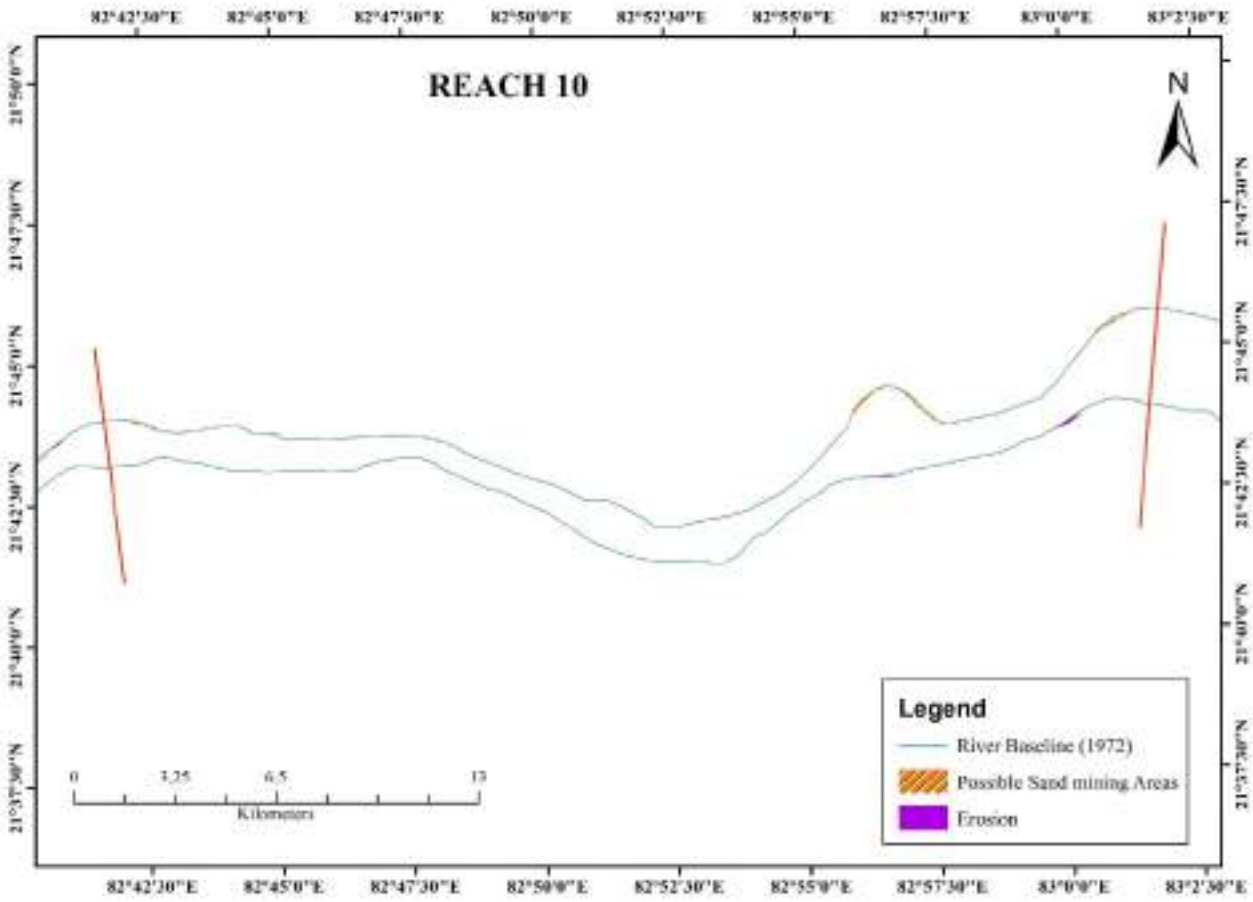

Figure 41.10: Possible sand mining areas in Mahanadi river

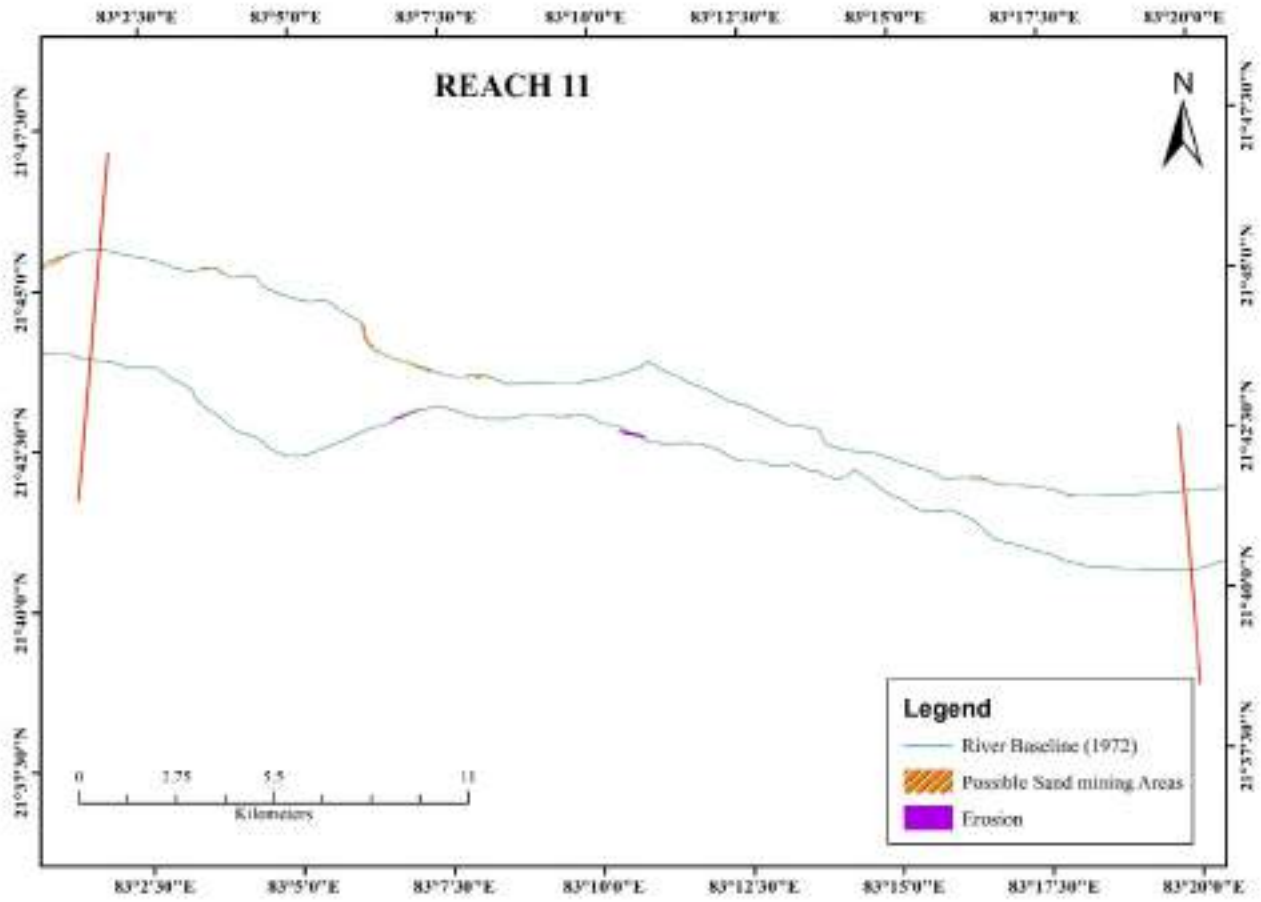

Figure 41.11: Possible sand mining areas in Mahanadi river

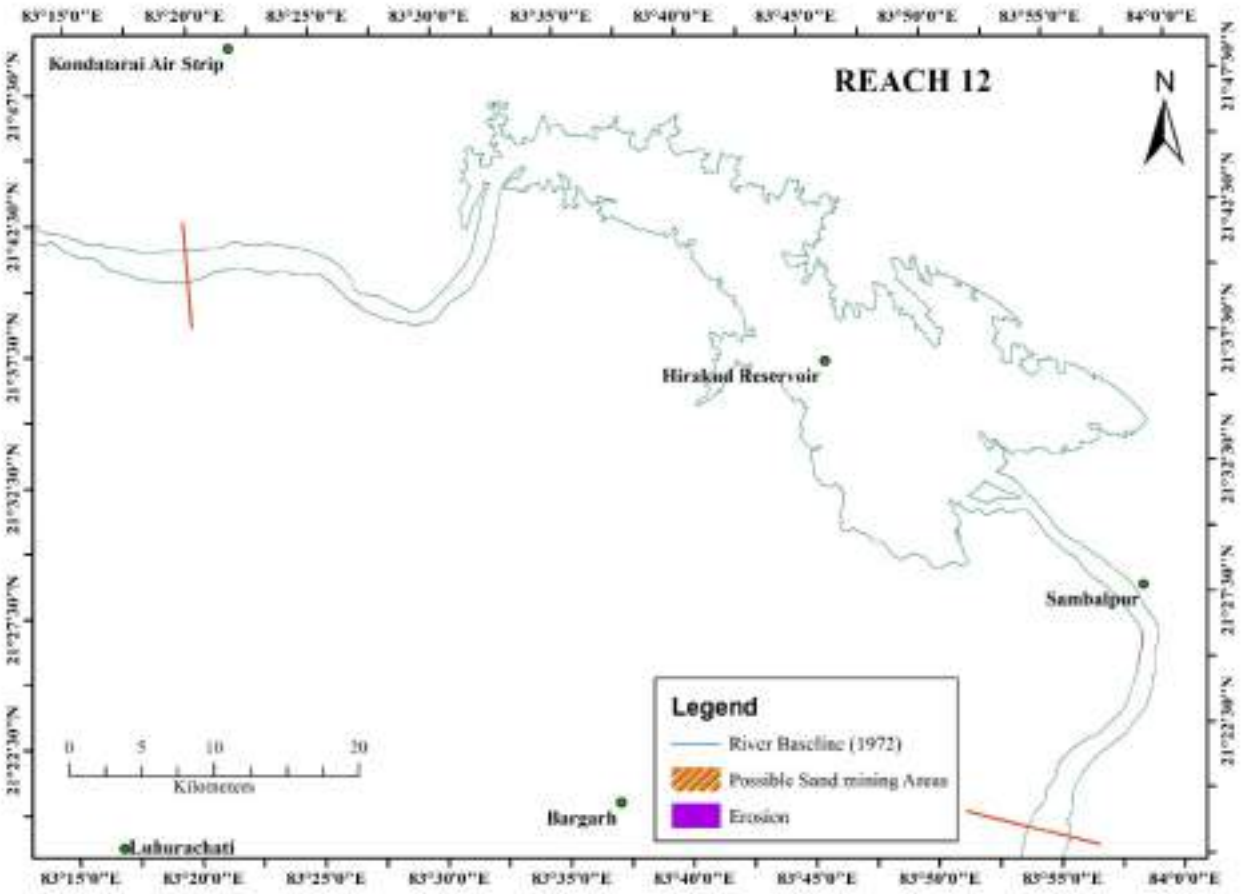

Figure 41.12: Possible sand mining areas in Mahanadi river

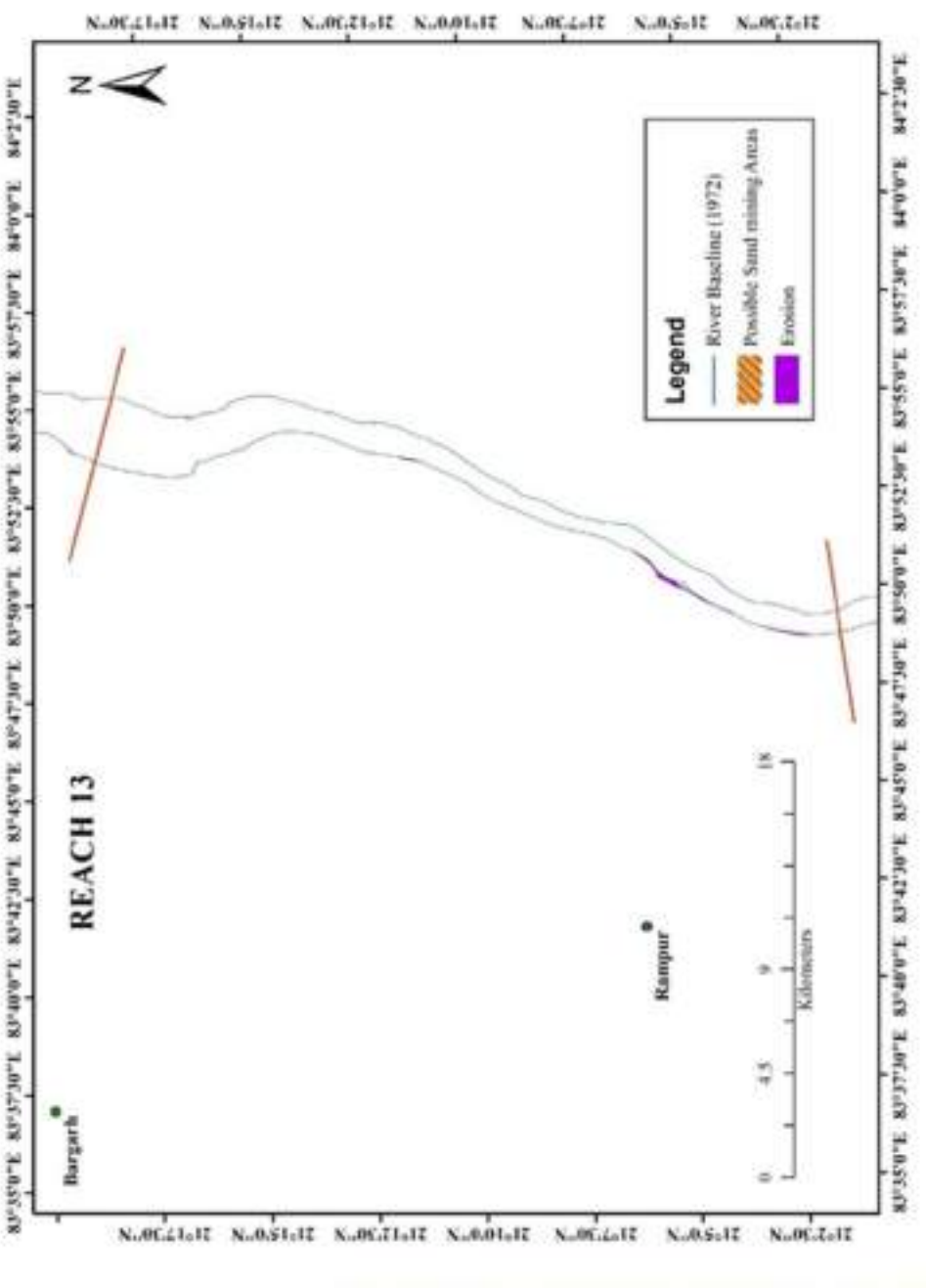

Figure 41.13: Possible sand mining areas in Mahanadi river

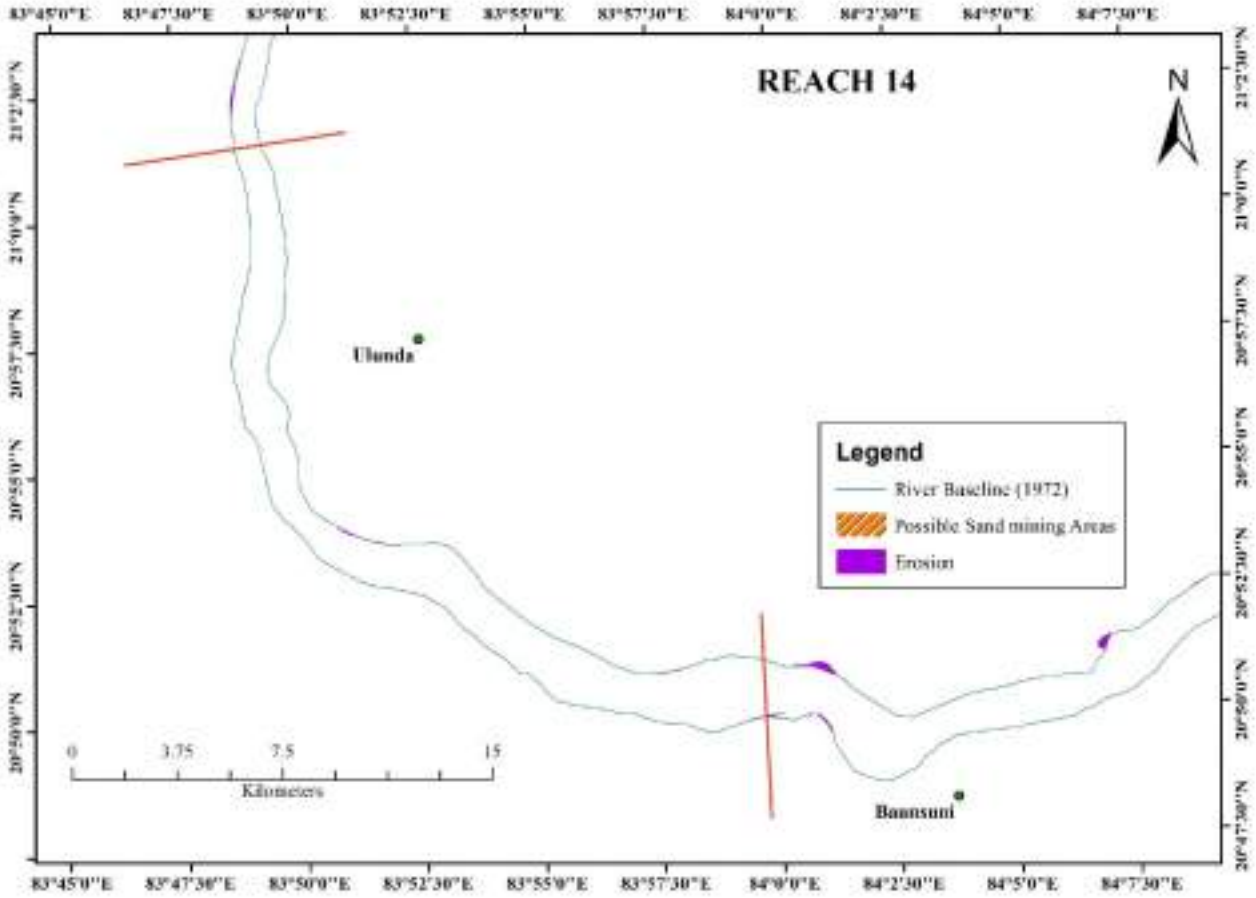

Figure 41.14: Possible sand mining areas in Mahanadi river

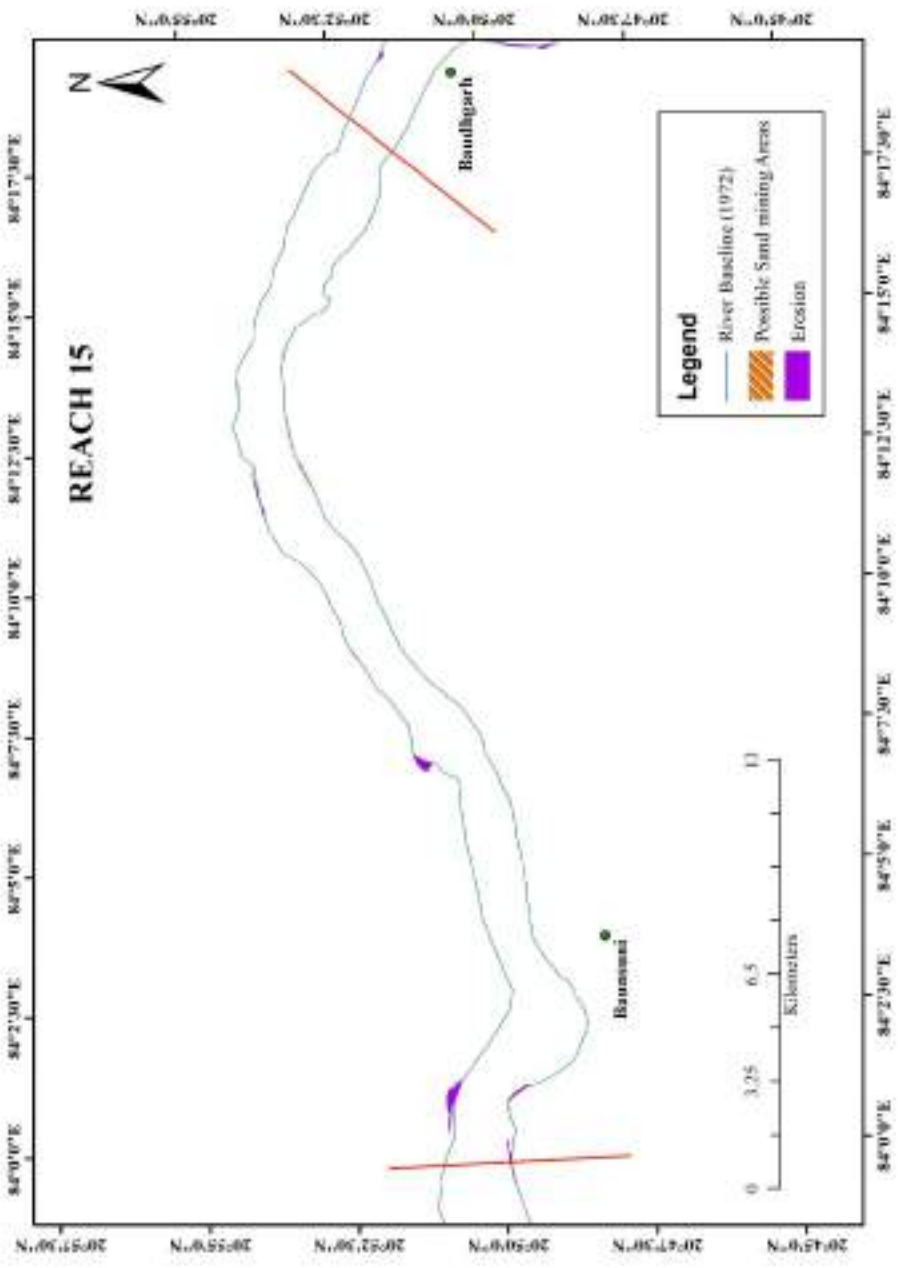

Figure 41.15: Possible sand mining areas in Mahanadi river

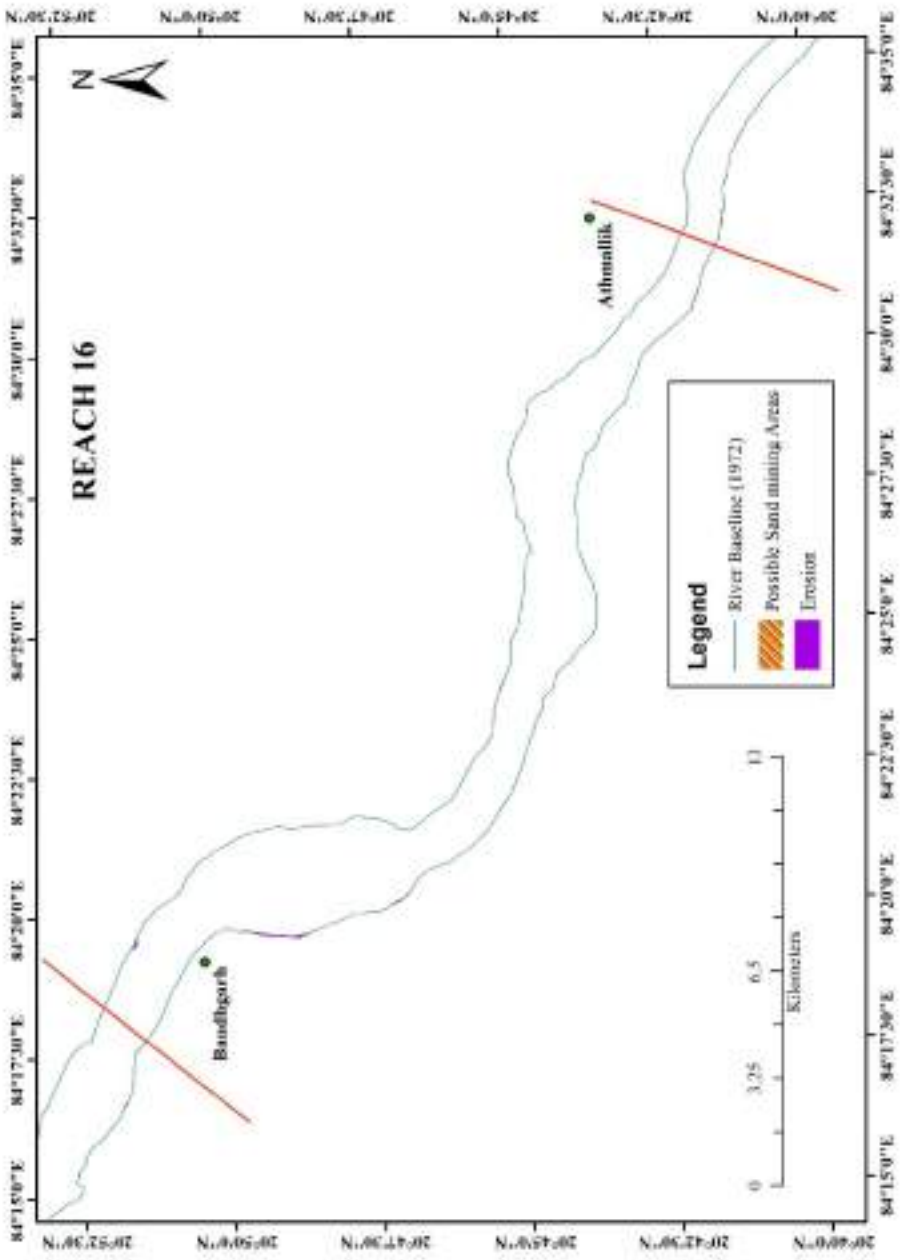

Figure 41.16: Possible sand mining areas in Mahanadi river

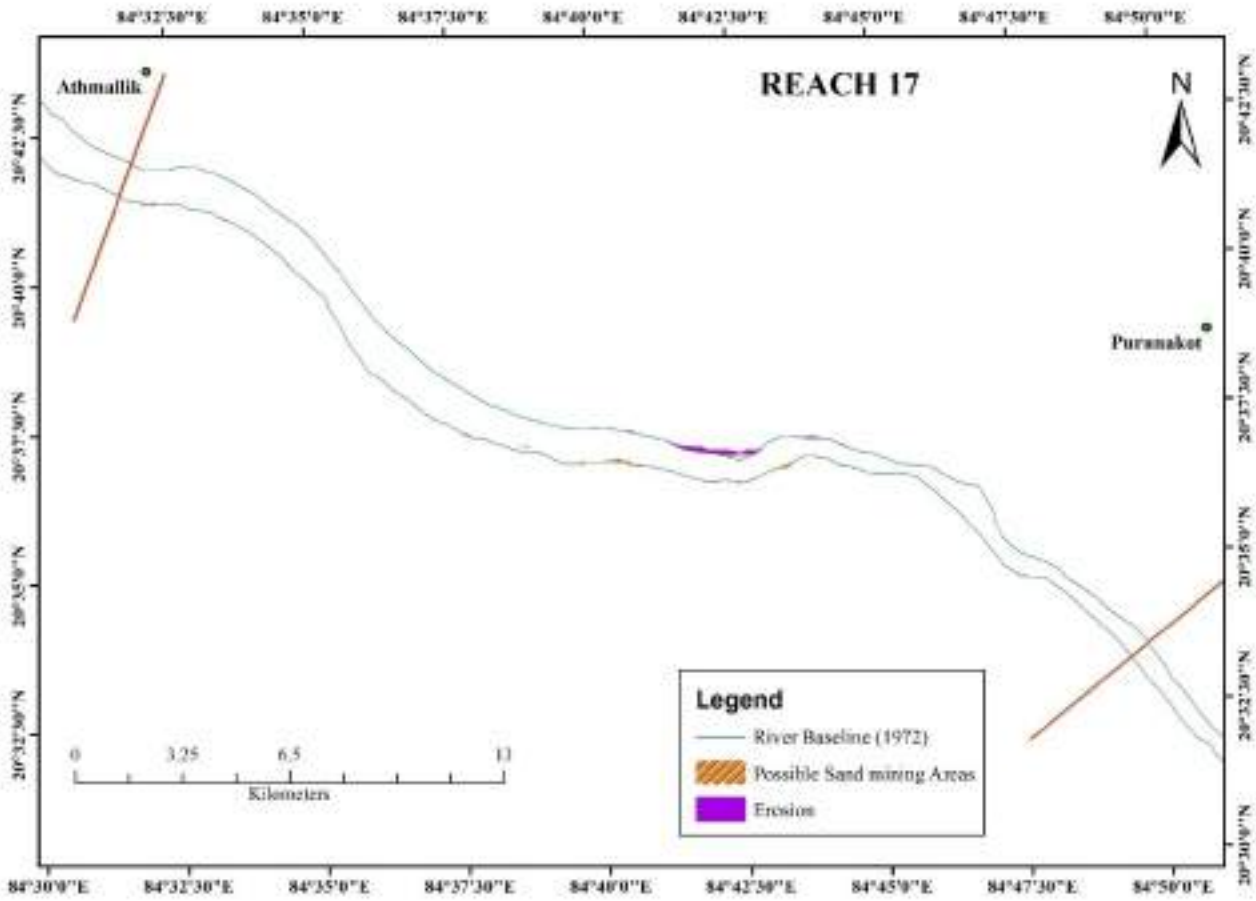

Figure 41.17: Possible sand mining areas in Mahanadi river

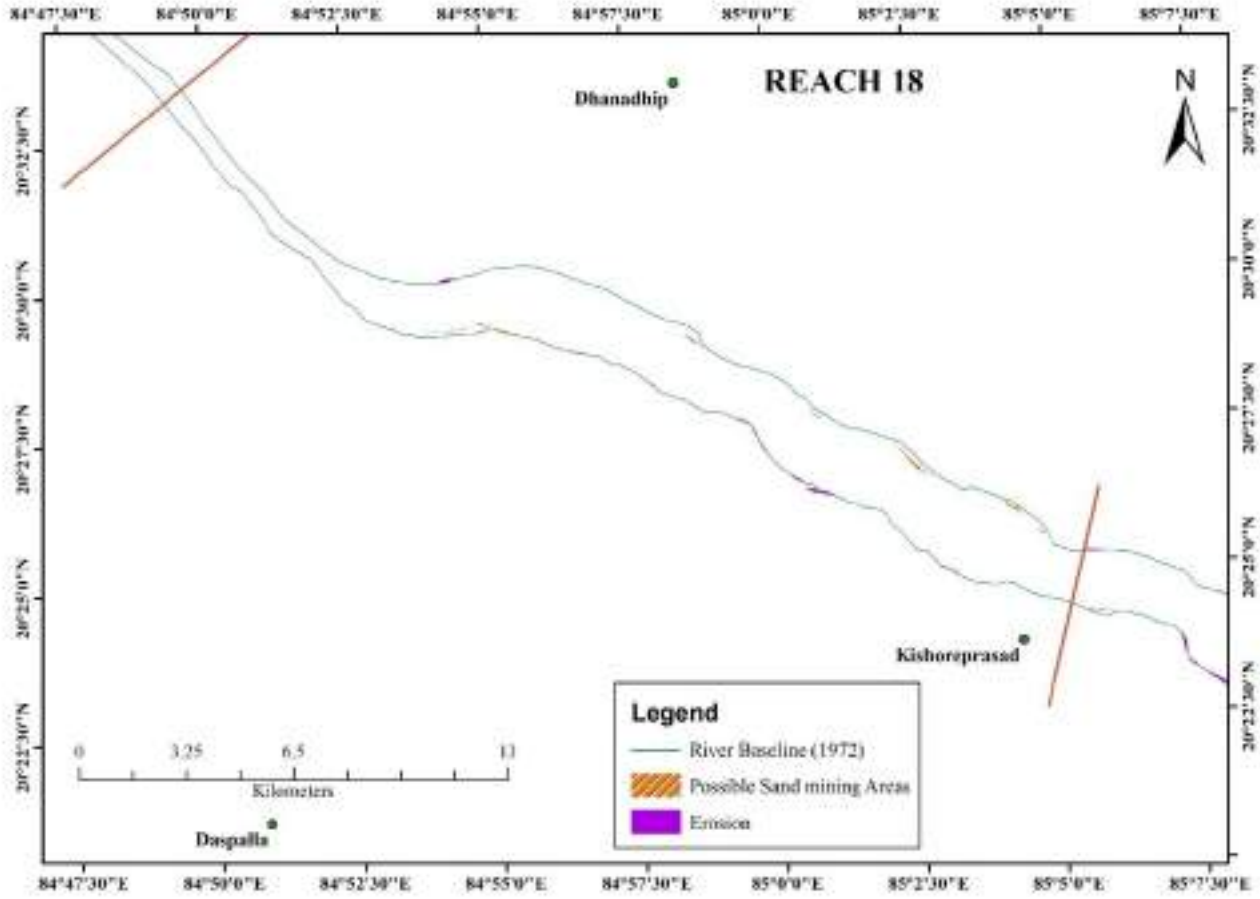

Figure 41.18: Possible sand mining areas in Mahanadi river

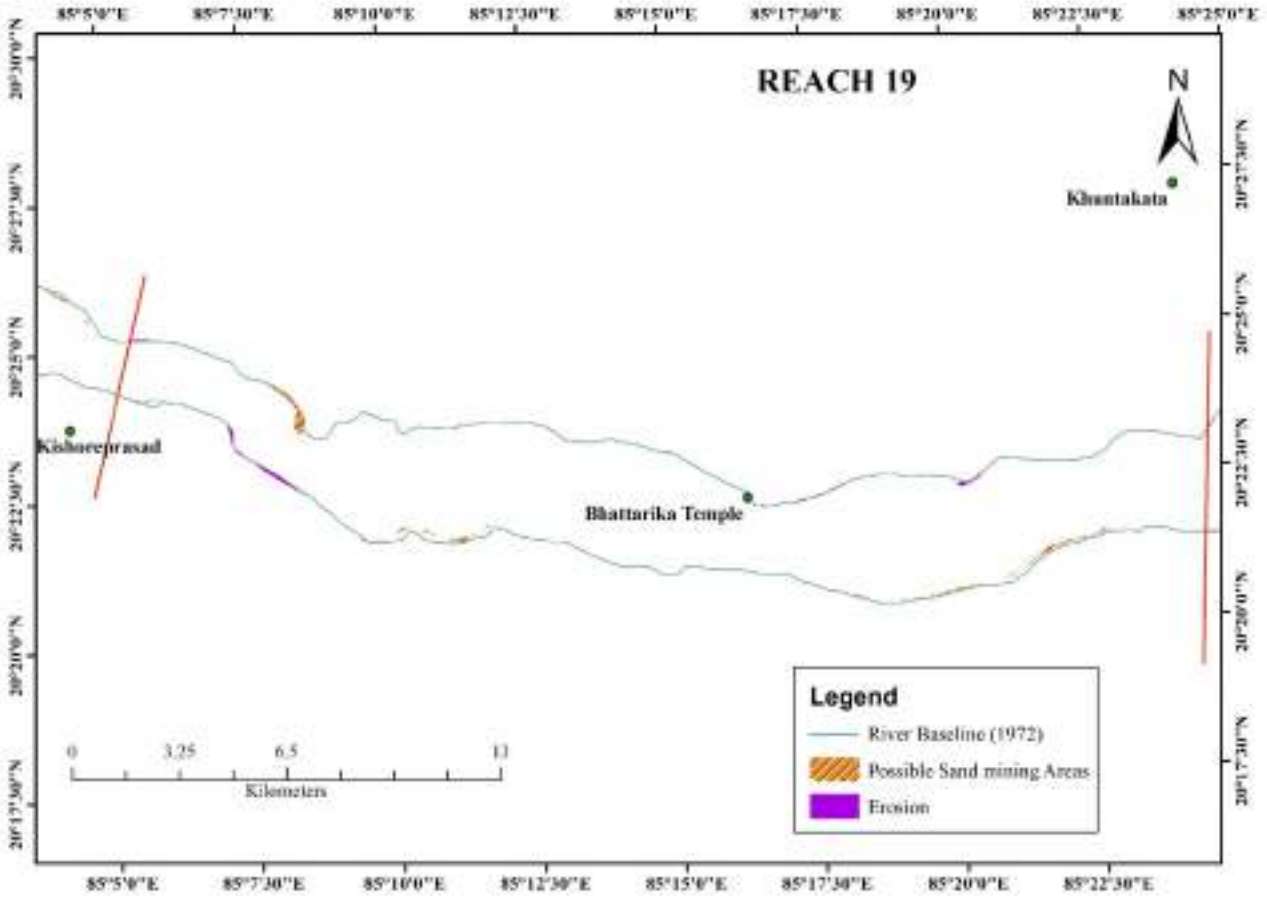

Figure 41.19: Possible sand mining areas in Mahanadi river

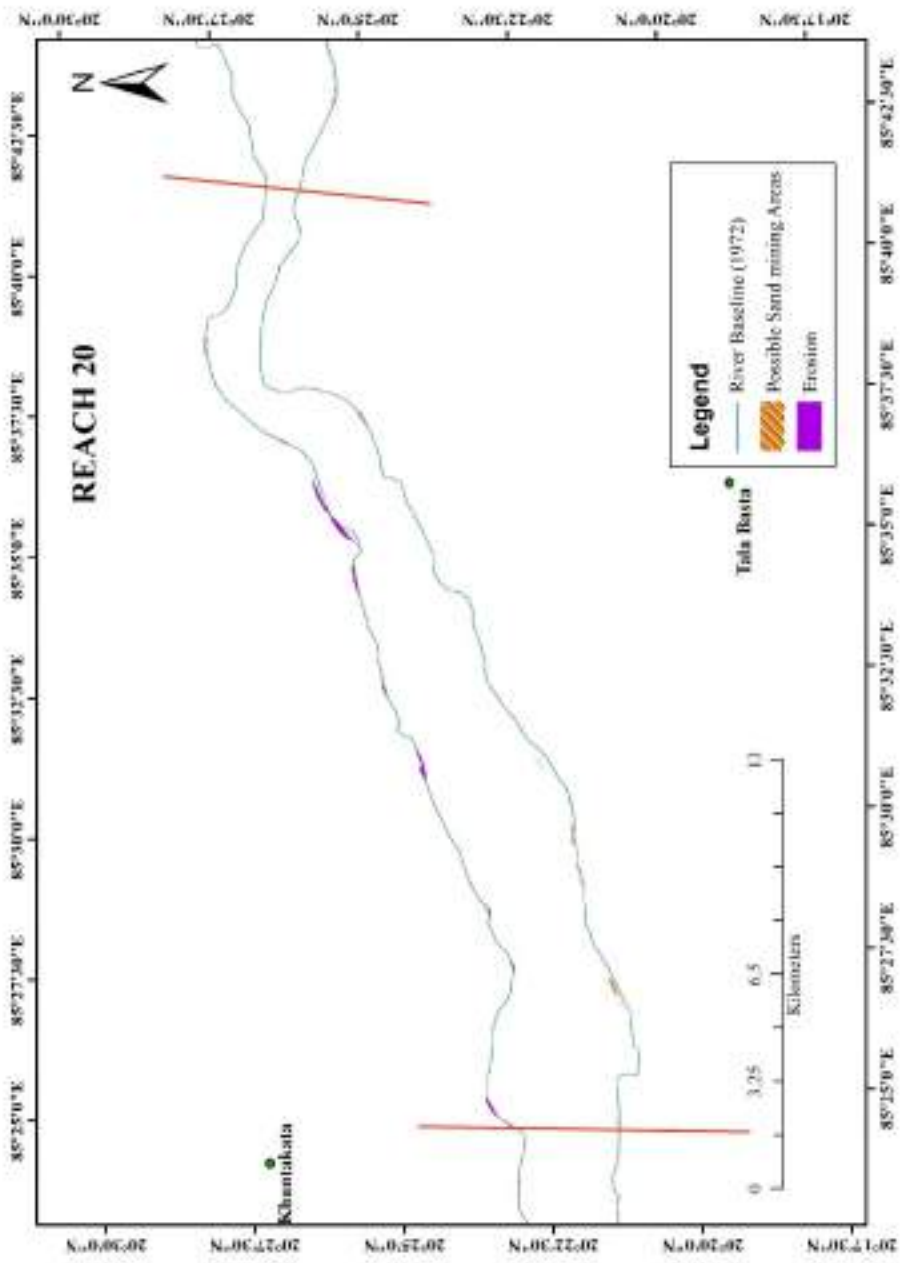

Figure 41.20: Possible sand mining areas in Mahanadi river

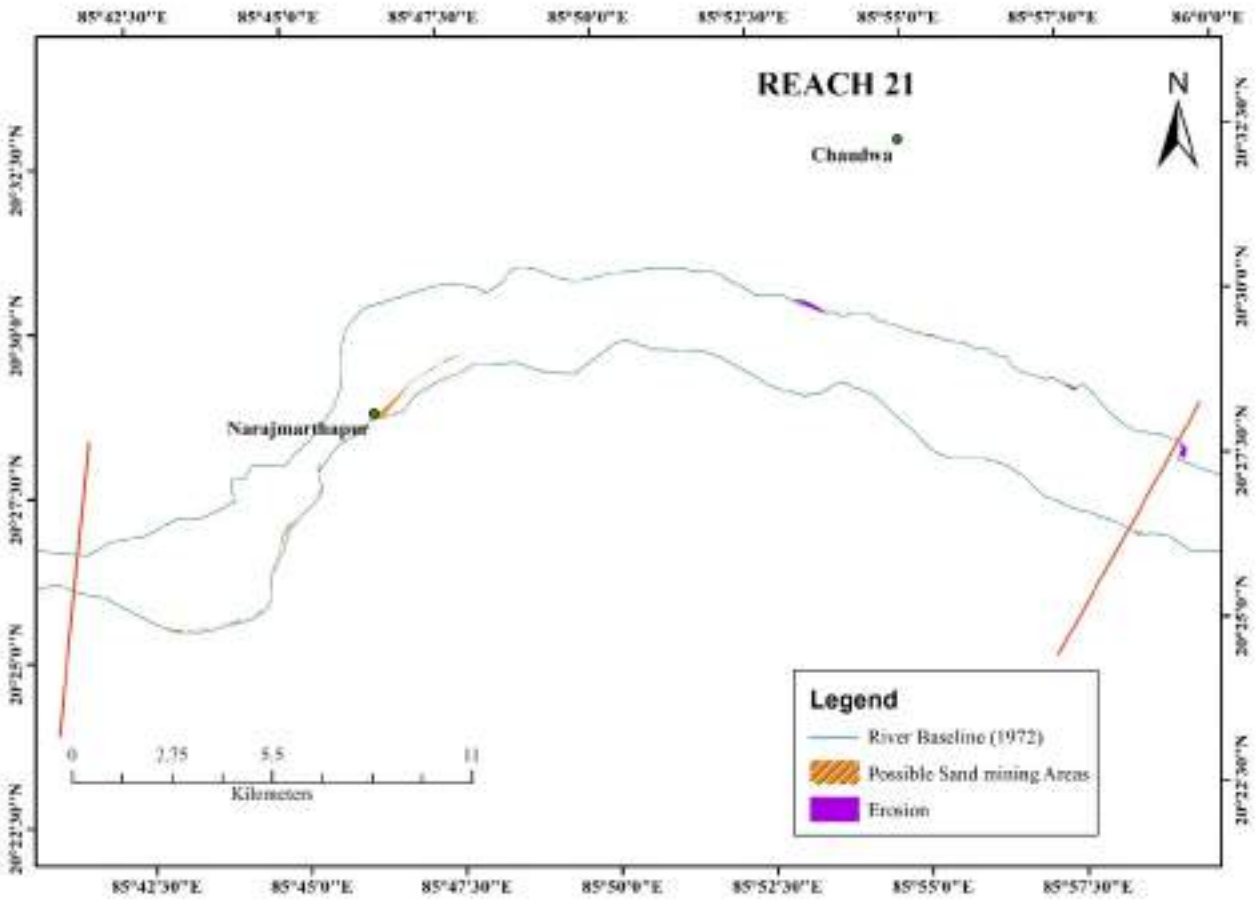

Figure 41.21: Possible sand mining areas in Mahanadi river

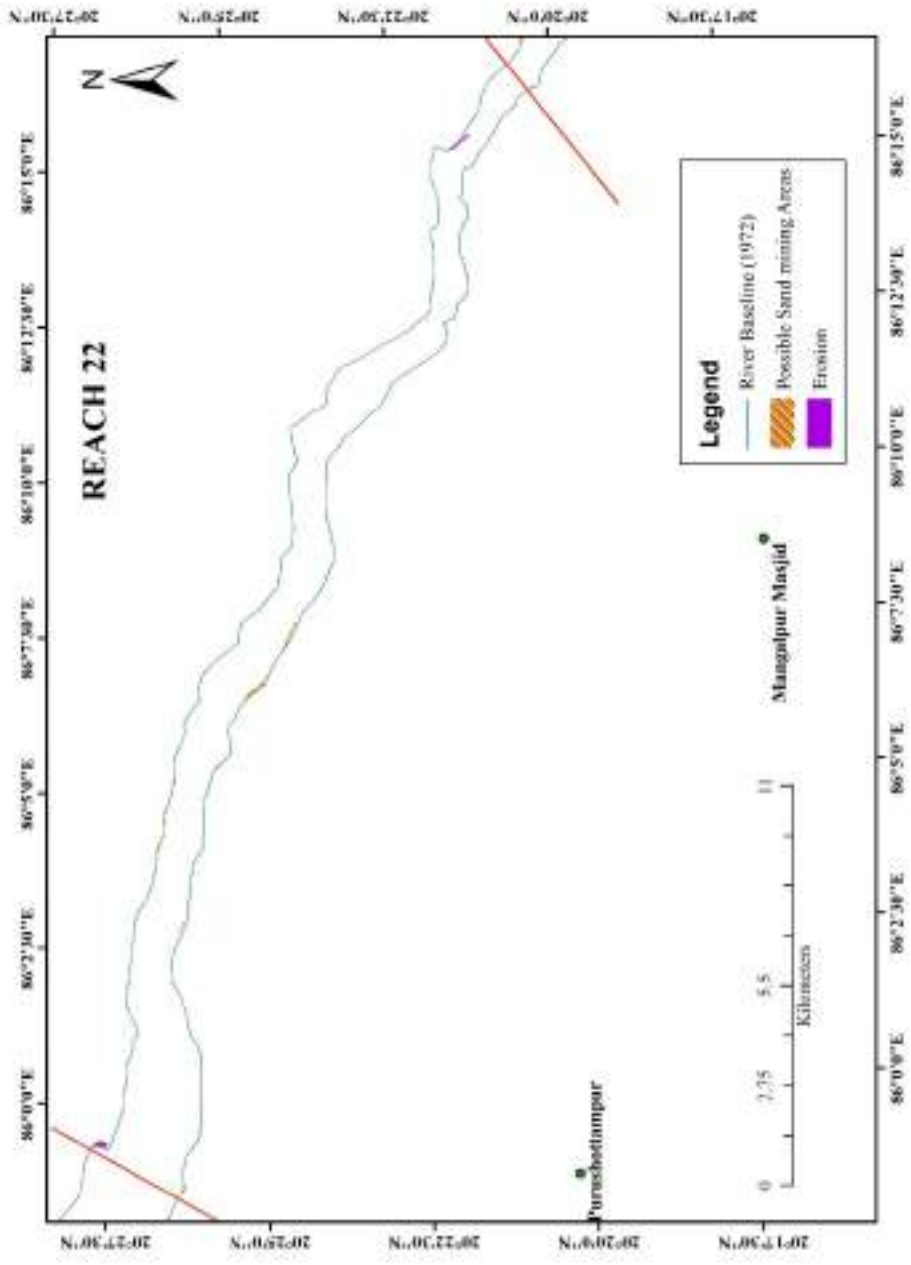

Figure 41.22: Possible sand mining areas in Mahanadi river

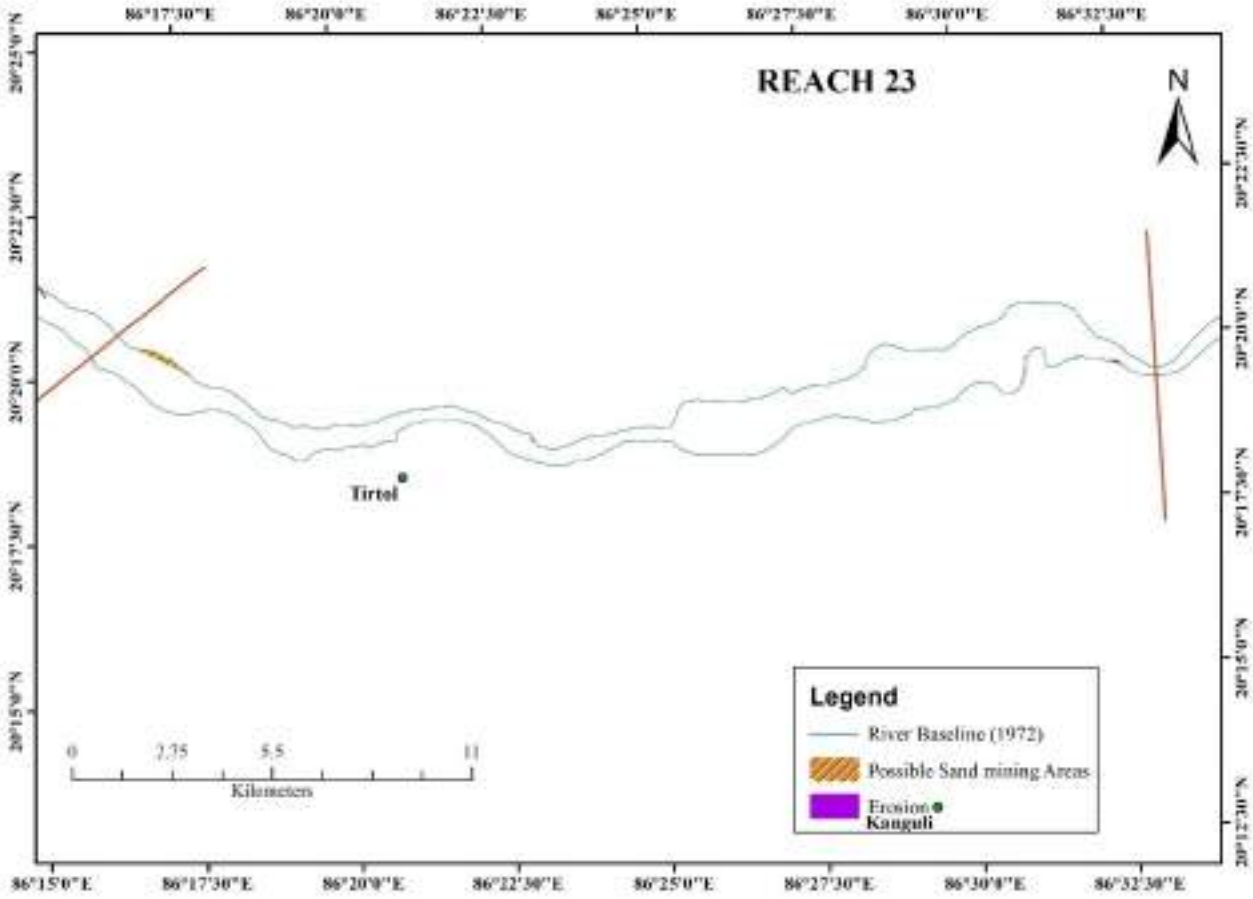

Figure 41.23: Possible sand mining areas in Mahanadi river

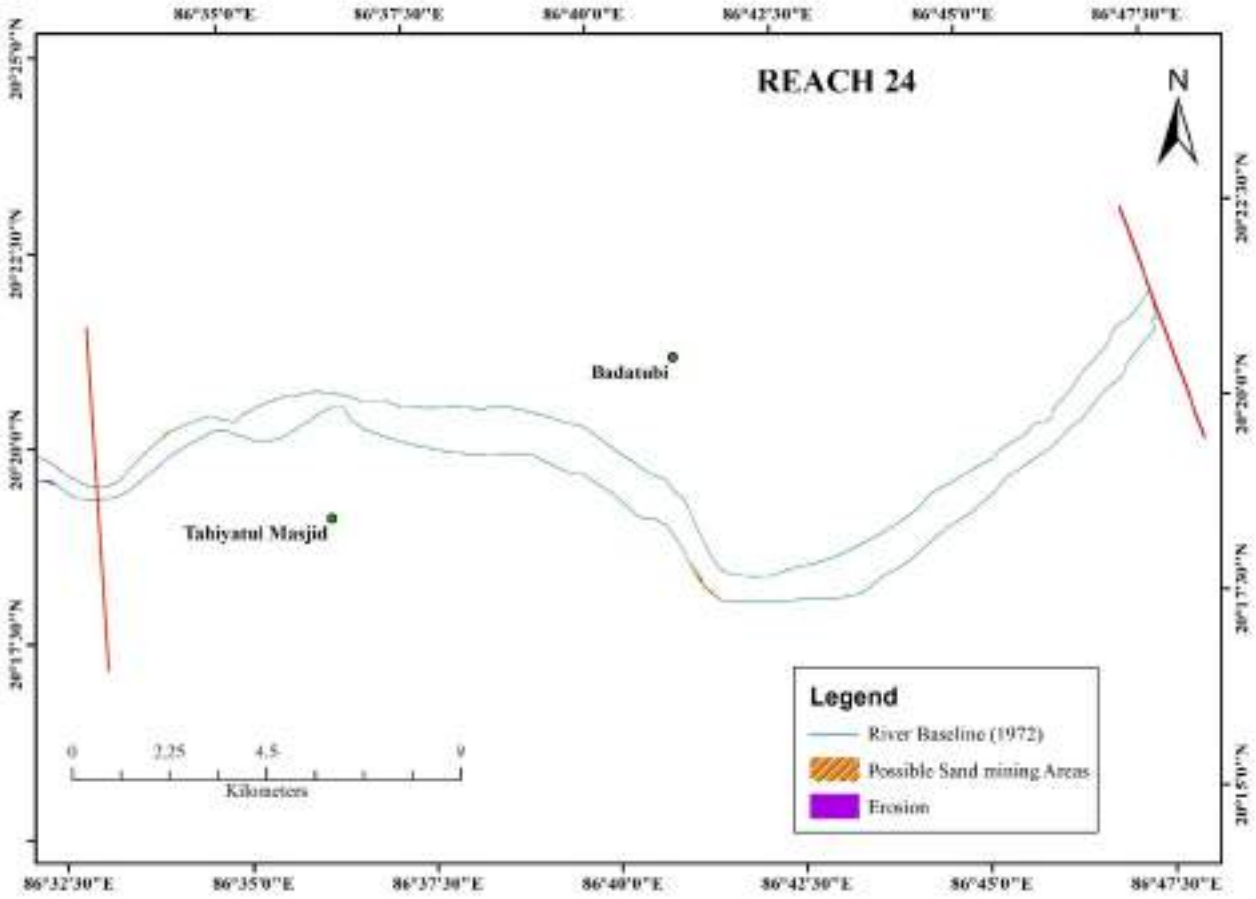

Figure 41.24: Possible sand mining areas in Mahanadi river

CHAPTER 6

CONCLUSIONS

This report gives a complete understanding of the different geomorphological aspects specific to the Mahanadi river system and provides references to its water resource management. It also provides a compilation of the information about the river bank shifting and erosion-deposition study from 1972 upto 2018 on the river. Land use/land cover for the year 1972, 1980, 1990 and 2000 are also identified. The probability of exceedance and recurrence intervals of peak discharge in the river is also calculated. Soil erosion scenario within a corridor of 2 km on both sides of the river is also estimated. The facts and data about the morphology of the basin have been gathered from different sources like satellite remote sensing data and field observation data by concerned agencies and our own practical (field) observations of specific locations. From an analysis of the basin, it is observed that it suffers from drought in its central region and is more prone to floods and cyclones near the eastern coast due to its geographic location. Sand mining, bank erosion, channel deepening are also carefully focussed and classified. The report is an attempt to give an insight to all important aspects which directly or indirectly decides the changes in physical properties of the river and is hoped to be helpful for further morphological studies of the river in future.

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ANNEXURE 1

ANX 1: Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
81	20.244	81.940	20.244	81.939
70	20.248	81.940	20.248	81.940
40	20.253	81.943	20.253	81.943
59	20.259	81.942	20.259	81.942
59	20.261	81.940	20.261	81.940
130	20.268	81.938	20.268	81.939
104	20.272	81.935	20.271	81.934
54	20.277	81.933	20.277	81.932
45	20.282	81.933	20.282	81.933
146	20.286	81.935	20.286	81.934
133	20.292	81.932	20.292	81.933
78	20.297	81.934	20.297	81.933
278	20.302	81.932	20.301	81.934
70	20.308	81.933	20.307	81.933
82	20.310	81.930	20.311	81.930
192	20.313	81.928	20.312	81.926
125	20.311	81.922	20.312	81.921
313	20.308	81.913	20.311	81.913
156	20.306	81.906	20.307	81.905
153	20.309	81.894	20.310	81.893
115	20.307	81.886	20.306	81.886
241	20.302	81.879	20.303	81.877
55	20.301	81.873	20.300	81.873
83	20.301	81.857	20.300	81.857
1008	20.304	81.835	20.313	81.832
479	20.309	81.826	20.314	81.825
443	20.303	81.751	20.307	81.753
202	20.305	81.738	20.307	81.738
180	20.310	81.728	20.312	81.729
127	20.305	81.722	20.306	81.721
79	20.297	81.699	20.298	81.698
117	20.300	81.691	20.301	81.691
141	20.297	81.679	20.298	81.679
106	20.296	81.665	20.295	81.664

ANX 1 (continued): Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
83	20.298	81.660	20.298	81.660
133	20.297	81.640	20.296	81.639
86	20.298	81.632	20.299	81.632
64	20.294	81.627	20.294	81.627
147	20.298	81.624	20.297	81.622
74	20.298	81.615	20.299	81.615
68	20.297	81.607	20.296	81.607
61	20.299	81.594	20.298	81.594
233	20.296	81.587	20.297	81.585
602	20.295	81.568	20.299	81.572
160	20.298	81.562	20.297	81.561
120	20.301	81.547	20.299	81.547
91	20.302	81.539	20.301	81.539
90	20.304	81.533	20.305	81.533
149	20.315	81.529	20.314	81.528
116	20.324	81.523	20.324	81.521
110	20.331	81.520	20.331	81.521
142	20.345	81.508	20.344	81.506
246	20.363	81.493	20.362	81.491
123	20.390	81.474	20.389	81.472
65	20.411	81.453	20.410	81.452
62	20.419	81.446	20.419	81.446
53	20.424	81.447	20.424	81.446
81	20.435	81.446	20.434	81.445
181	20.448	81.446	20.449	81.444
209	20.461	81.434	20.459	81.433
87	20.469	81.423	20.468	81.422
67	20.476	81.410	20.477	81.410
63	20.483	81.402	20.483	81.402
126	20.491	81.381	20.490	81.380
82	20.523	81.380	20.524	81.379
202	20.545	81.395	20.546	81.394
134	20.553	81.422	20.554	81.422
115	20.565	81.433	20.565	81.432
95	20.570	81.449	20.569	81.449
107	20.574	81.464	20.575	81.463
67	20.575	81.489	20.574	81.489
120	20.573	81.505	20.574	81.505

ANX 1 (continued): Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
102	20.583	81.520	20.584	81.520
252	20.592	81.536	20.592	81.533
142	20.656	81.557	20.657	81.556
152	20.666	81.564	20.665	81.565
95	20.680	81.575	20.680	81.574
139	20.686	81.622	20.687	81.622
76	20.690	81.641	20.689	81.641
102	20.695	81.646	20.696	81.646
553	20.705	81.655	20.702	81.659
130	20.712	81.673	20.712	81.672
589	20.721	81.677	20.716	81.678
85	20.715	81.705	20.715	81.704
131	20.726	81.714	20.726	81.713
298	20.739	81.737	20.736	81.738
101	20.741	81.747	20.740	81.747
143	20.756	81.763	20.756	81.761
68	20.790	81.787	20.790	81.786
111	20.814	81.778	20.814	81.777
143	20.825	81.782	20.825	81.783
143	20.844	81.788	20.844	81.787
214	20.866	81.801	20.864	81.803
232	20.877	81.811	20.876	81.813
305	20.888	81.812	20.888	81.815
556	20.923	81.814	20.920	81.818
396	20.948	81.845	20.945	81.845
206	20.964	81.861	20.962	81.861
147	20.968	81.871	20.968	81.872
170	20.980	81.873	20.979	81.874
123	20.984	81.881	20.984	81.880
686	20.999	81.882	20.996	81.887
599	21.008	81.892	21.003	81.894
294	21.010	81.914	21.012	81.912
151	21.036	81.946	21.037	81.944
168	21.065	81.969	21.065	81.967
150	21.095	81.984	21.095	81.983
167	21.100	81.982	21.100	81.984
118	21.105	81.986	21.105	81.985
108	21.126	81.990	21.126	81.988

ANX 1 (continued): Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
110	21.137	81.992	21.137	81.991
118	21.159	82.011	21.159	82.010
115	21.169	82.013	21.169	82.012
124	21.188	82.010	21.188	82.011
141	21.193	82.013	21.193	82.011
206	21.222	82.017	21.222	82.015
112	21.257	82.041	21.258	82.040
173	21.264	82.052	21.265	82.051
73	21.272	82.063	21.273	82.063
127	21.288	82.103	21.287	82.103
151	21.295	82.123	21.296	82.122
150	21.305	82.133	21.306	82.132
341	21.326	82.151	21.329	82.149
127	21.336	82.161	21.337	82.160
120	21.348	82.168	21.349	82.167
89	21.364	82.179	21.364	82.178
128	21.377	82.185	21.378	82.184
124	21.390	82.198	21.391	82.197
132	21.402	82.204	21.403	82.203
210	21.419	82.218	21.420	82.216
138	21.451	82.233	21.451	82.232
107	21.463	82.239	21.464	82.238
108	21.476	82.248	21.477	82.247
112	21.551	82.332	21.551	82.331
105	21.562	82.348	21.563	82.347
104	21.578	82.363	21.579	82.362
89	21.605	82.372	21.605	82.373
87	21.632	82.388	21.631	82.388
129	21.644	82.397	21.645	82.396
390	21.683	82.423	21.680	82.425
194	21.697	82.437	21.696	82.438
109	21.706	82.447	21.705	82.448
138	21.720	82.459	21.719	82.459
133	21.740	82.499	21.738	82.500
83	21.743	82.534	21.744	82.534
163	21.735	82.563	21.733	82.562
137	21.720	82.583	21.721	82.584
98	21.718	82.597	21.719	82.596

ANX 1 (continued): Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
60	21.732	82.631	21.733	82.631
82	21.721	82.647	21.720	82.647
133	21.714	82.660	21.713	82.661
63	21.723	82.676	21.724	82.676
47	21.734	82.702	21.734	82.702
56	21.729	82.721	21.730	82.721
138	21.728	82.753	21.727	82.753
91	21.728	82.784	21.727	82.784
92	21.710	82.845	21.709	82.844
128	21.701	82.864	21.702	82.865
135	21.702	82.890	21.701	82.890
92	21.713	82.917	21.713	82.917
103	21.726	82.931	21.727	82.931
138	21.735	82.938	21.736	82.937
67	21.727	82.962	21.728	82.962
104	21.731	82.978	21.730	82.978
116	21.731	82.984	21.732	82.984
119	21.736	82.992	21.735	82.992
134	21.741	83.001	21.742	83.000
82	21.758	83.016	21.758	83.016
86	21.755	83.054	21.755	83.054
111	21.755	83.062	21.756	83.062
216	21.750	83.072	21.752	83.074
80	21.748	83.083	21.747	83.083
191	21.734	83.103	21.735	83.104
76	21.728	83.119	21.728	83.119
101	21.725	83.134	21.726	83.134
128	21.725	83.143	21.723	83.143
81	21.725	83.167	21.724	83.167
61	21.726	83.175	21.726	83.175
139	21.727	83.182	21.729	83.182
98	21.727	83.187	21.726	83.186
94	21.719	83.205	21.718	83.204
78	21.716	83.211	21.716	83.211
119	21.712	83.222	21.711	83.221
206	21.702	83.253	21.701	83.252
159	21.695	83.273	21.697	83.274
95	21.691	83.296	21.692	83.297

ANX 1 (continued): Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
71	21.692	83.316	21.691	83.316
96	21.693	83.332	21.692	83.332
128	21.691	83.345	21.692	83.344
91	21.697	83.363	21.696	83.363
164	21.693	83.388	21.695	83.388
75	21.692	83.400	21.692	83.400
60	21.690	83.412	21.690	83.413
86	21.667	83.444	21.667	83.444
88	21.660	83.460	21.660	83.460
62	21.655	83.497	21.655	83.497
91	21.669	83.511	21.668	83.512
291	21.449	83.981	21.448	83.978
230	21.422	83.986	21.423	83.984
130	21.396	83.982	21.397	83.980
75	21.361	83.951	21.361	83.951
168	21.348	83.933	21.347	83.934
143	21.330	83.925	21.330	83.924
166	21.315	83.923	21.315	83.921
339	21.274	83.915	21.274	83.911
83	21.211	83.908	21.211	83.909
82	21.184	83.902	21.185	83.901
159	21.131	83.870	21.131	83.868
166	21.094	83.855	21.094	83.853
206	21.075	83.842	21.075	83.840
183	21.038	83.823	21.038	83.821
105	20.986	83.832	83.831	20.986
156	20.943	83.829	20.942	83.828
190	20.906	83.838	20.905	83.837
252	20.894	83.864	20.892	83.863
196	20.881	83.897	20.880	83.895
164	20.862	83.921	20.860	83.921
220	20.850	83.961	20.848	83.962
281	20.849	84.017	20.847	84.016
281	20.846	84.107	20.843	84.108
130	20.874	84.157	20.875	84.156
213	20.900	84.204	20.898	84.204
141	20.893	84.258	20.892	84.257
135	20.873	84.298	20.872	84.297

ANX 1 (continued): Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
151	20.860	84.325	20.859	84.325
77	20.846	84.342	20.846	84.341
147	20.839	84.352	20.838	84.350
235	20.815	84.360	20.815	84.358
149	20.796	84.360	20.796	84.361
107	20.781	84.358	20.781	84.357
192	20.771	84.367	20.770	84.365
158	20.759	84.385	20.758	84.384
147	20.746	84.439	20.745	84.438
165	20.747	84.477	20.746	84.476
128	20.735	84.491	20.734	84.490
121	20.716	84.509	20.715	84.508
115	20.706	84.520	20.706	84.520
156	20.700	84.535	20.699	84.534
89	20.693	84.565	20.692	84.565
59	20.688	84.572	20.688	84.572
146	20.677	84.586	20.677	84.585
147	20.651	84.607	20.650	84.606
123	20.640	84.620	20.639	84.620
155	20.624	84.659	20.622	84.658
288	20.615	84.709	20.612	84.709
97	20.609	84.762	20.618	84.729
222	20.611	84.762	20.609	84.762
124	20.605	84.774	20.604	84.774
107	20.599	84.783	20.599	84.782
89	20.577	84.805	20.576	84.804
80	20.563	84.824	20.562	84.824
95	20.548	84.836	20.547	84.835
85	20.534	84.846	20.534	84.846
111	20.510	84.872	20.509	84.871
156	20.502	84.899	20.500	84.899
83	20.505	84.919	20.504	84.919
268	20.482	84.977	20.483	84.980
112	20.461	85.012	20.462	85.013
128	20.458	85.023	20.457	85.022
165	20.445	85.043	20.446	85.044
234	20.427	85.077	20.428	85.079
179	20.412	85.119	20.413	85.121

ANX 1 (continued): Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
390	20.396	85.138	20.396	85.142
207	20.396	85.150	20.395	85.150
259	20.395	85.172	20.393	85.173
178	20.395	85.200	20.394	85.200
185	20.386	85.224	20.387	85.224
84	20.369	85.273	20.370	85.273
161	20.372	85.293	20.370	85.294
200	20.376	85.303	20.374	85.304
179	20.376	85.320	20.374	85.320
138	20.375	85.339	20.374	85.340
238	20.379	85.369	20.377	85.369
281	20.385	85.406	20.382	85.407
147	20.393	85.416	20.392	85.417
124	20.391	85.437	20.390	85.437
183	20.386	85.459	20.385	85.460
170	20.399	85.491	20.397	85.492
94	20.410	85.525	20.409	85.526
186	20.419	85.553	20.418	85.553
230	20.425	85.586	20.423	85.588
153	20.457	85.625	20.456	85.626
223	20.455	85.661	20.453	85.661
122	20.449	85.678	20.448	85.677
105	20.445	85.693	20.444	85.693
68	20.446	85.700	20.447	85.700
457	20.458	85.729	20.456	85.733
85	20.468	85.749	20.467	85.750
104	20.493	85.764	20.494	85.763
78	20.509	85.790	20.508	85.790
88	20.509	85.829	20.508	85.829
137	20.511	85.859	20.510	85.859
117	20.505	85.873	20.504	85.873
351	20.502	85.891	20.499	85.890
93	20.495	85.910	20.495	85.910
149	20.483	85.941	20.484	85.942
110	20.476	85.960	20.475	85.960
121	20.470	85.970	20.469	85.969
446	20.459	85.981	20.463	85.983
49	20.453	86.001	20.452	86.001

ANX 1 (continued): Shifting of river bank (Left bank 1972-1980)				
	1972		1980	
Shift (m)	Latitude	Longitude	Latitude	Longitude
176	20.450	86.010	20.451	86.010
381	20.447	86.026	20.451	86.027
167	20.446	86.055	20.444	86.054
322	20.432	86.093	20.435	86.094
112	20.419	86.122	20.419	86.121
128	20.402	86.170	20.401	86.170
208	20.395	86.186	20.393	86.185
128	20.387	86.197	20.386	86.195
77	20.365	86.214	20.366	86.214
104	20.364	86.239	20.363	86.239
342	20.360	86.255	20.358	86.252
115	20.349	86.268	20.350	86.268
136	20.337	86.287	20.338	86.287
117	20.329	86.301	20.330	86.301
131	20.319	86.333	20.322	86.312
93	20.320	86.333	20.319	86.333
66	20.322	86.352	20.322	86.352
94	20.314	86.383	20.314	86.383
76	20.312	86.387	20.311	86.387
91	20.315	86.421	20.315	86.421
76	20.321	86.432	20.321	86.432
175	20.322	86.452	20.324	86.452
388	20.332	86.503	20.335	86.501
103	20.341	86.527	20.342	86.527
68	20.331	86.540	20.331	86.540
123	20.335	86.569	20.336	86.569
95	20.339	86.589	20.340	86.588
117	20.343	86.609	20.342	86.609
115	20.338	86.634	20.339	86.634
87	20.332	86.662	20.333	86.663
95	20.325	86.675	20.324	86.674
102	20.300	86.703	20.299	86.703
164	20.302	86.721	20.303	86.720
118	20.314	86.741	20.315	86.740
119	20.326	86.763	20.327	86.763

ANX 1 (continued): Shifting of river bank (Right bank 1972-1980)				
	1972		1980	
Shift (m)	latitude	longitude	latitude	longitude
136	81.942	20.244	81.940	20.244
47	81.942	20.248	81.942	20.249
26	81.945	20.255	81.945	20.255
84	81.942	20.261	81.941	20.260
170	81.942	20.268	81.940	20.268
235	81.936	20.277	81.934	20.277
360	81.937	20.291	81.933	20.290
164	81.935	20.301	81.936	20.300
103	81.939	20.304	81.938	20.304
81	81.935	20.309	81.934	20.308
346	81.930	20.315	81.928	20.312
381	81.916	20.308	81.916	20.312
227	81.903	20.310	81.901	20.309
111	81.894	20.310	81.893	20.311
254	81.883	20.310	81.883	20.307
232	81.877	20.306	81.877	20.307
67	81.871	20.304	81.871	20.302
226	81.855	20.304	81.854	20.302
853	81.835	20.306	81.832	20.313
434	81.825	20.310	81.824	20.314
537	81.753	20.303	81.755	20.307
241	81.739	20.306	81.739	20.308
239	81.730	20.311	81.730	20.313
113	81.723	20.310	81.722	20.311
139	81.715	20.304	81.714	20.305
98	81.706	20.300	81.706	20.299
211	81.692	20.301	81.693	20.303
205	81.681	20.299	81.681	20.301
98	81.665	20.300	81.664	20.299
53	81.658	20.299	81.657	20.299
105	81.645	20.297	81.645	20.298
121	81.632	20.300	81.631	20.300
90	81.626	20.297	81.626	20.297
160	81.617	20.302	81.616	20.303
130	81.612	20.298	81.611	20.299
100	81.603	20.301	81.603	20.300
61	81.600	20.301	81.600	20.302

ANX 1 (continued): Shifting of river bank (Right bank 1972-1980)				
	1972		1980	
Shift (m)	latitude	longitude	latitude	longitude
374	81.529	20.578	81.530	20.582
629	81.545	20.589	81.539	20.589
247	81.565	20.659	81.563	20.660
96	81.597	20.684	81.597	20.683
155	81.624	20.676	81.625	20.677
84	81.642	20.682	81.641	20.683
92	81.677	20.694	81.676	20.695
132	81.704	20.707	81.704	20.708
116	81.717	20.718	81.718	20.717
120	81.728	20.721	81.727	20.720
68	81.743	20.721	81.743	20.722
77	81.754	20.730	81.754	20.729
214	81.772	20.739	81.773	20.738
404	81.791	20.752	81.787	20.753
105	81.792	20.765	81.791	20.765
78	81.790	20.771	81.791	20.770
143	81.797	20.776	81.796	20.777
328	81.794	20.791	81.791	20.791
241	81.799	20.804	81.797	20.803
212	81.795	20.817	81.793	20.818
123	81.798	20.831	81.796	20.831
211	81.800	20.842	81.798	20.842
142	81.809	20.853	81.807	20.853
65	81.815	20.860	81.815	20.859
80	81.827	20.872	81.826	20.873
126	81.822	20.896	81.821	20.896
127	81.825	20.904	81.824	20.904
178	81.821	20.909	81.820	20.910
143	81.826	20.922	81.824	20.923
95	81.844	20.933	81.844	20.932
115	81.847	20.931	81.847	20.932
134	81.860	20.942	81.859	20.942
175	81.875	20.963	81.874	20.964
166	81.892	20.980	81.891	20.981
97	81.909	20.996	81.909	20.996
116	81.924	21.011	81.923	21.012
107	81.939	21.020	81.939	21.021
103	81.958	21.035	81.958	21.035

ANX 1 (continued): Shifting of river bank (Right bank 1972-1980)				
	1972		1980	
Shift (m)	latitude	longitude	latitude	longitude
212	83.199	21.704	83.199	21.706
192	83.234	21.698	83.234	21.697
103	83.275	21.683	83.275	21.682
64	83.310	21.672	83.310	21.672
59	83.325	21.671	83.325	21.671
151	83.336	21.670	83.335	21.672
107	83.359	21.677	83.359	21.678
98	83.377	21.677	83.378	21.677
81	83.407	21.674	83.407	21.674
308	83.443	21.655	83.444	21.656
64	83.462	21.645	83.462	21.646
82	83.495	21.641	83.495	21.642
111	83.511	21.653	83.510	21.654
181	83.537	21.675	83.533	21.677
406	83.546	21.709	83.543	21.710
46	83.917	21.493	83.916	21.492
107	83.954	21.461	83.953	21.461
105	83.974	21.427	83.975	21.427
104	83.970	21.408	83.971	21.408
192	83.958	21.382	83.959	21.382
111	83.933	21.366	83.933	21.365
63	83.917	21.352	83.916	21.352
23	83.910	21.337	83.910	21.337
17	83.903	21.324	83.903	21.324
166	83.899	21.320	83.899	21.320
86	83.893	21.307	83.892	21.307
99	83.888	21.281	83.887	21.282
170	83.889	21.274	83.888	21.273
78	83.892	21.271	83.893	21.271
81	83.894	21.267	83.893	21.267
95	83.897	21.260	83.896	21.260
96	83.899	21.254	83.898	21.254
27	83.904	21.239	83.905	21.239
40	83.904	21.229	83.904	21.229
68	83.902	21.220	83.901	21.220
31	83.895	21.206	83.895	21.206
35	83.895	21.203	83.895	21.203
63	83.892	21.193	83.893	21.193

ANX 1 (continued): Shifting of river bank (Right bank 1972-1980)				
	1972		1980	
Shift (m)	latitude	longitude	latitude	longitude
103	83.877	21.164	83.878	21.164
58	83.867	21.146	83.867	21.146
49	83.863	21.136	83.863	21.136
46	83.858	21.118	83.857	21.118
40	83.850	21.103	83.850	21.103
151	83.834	21.084	83.836	21.084
88	83.828	21.073	83.827	21.074
97	83.819	21.059	83.819	21.060
72	83.813	21.041	83.814	21.041
69	83.813	21.031	83.813	21.031
53	83.815	21.017	83.816	21.017
94	83.819	20.990	83.818	20.990
106	83.816	20.975	83.815	20.975
124	83.812	20.954	83.811	20.953
81	83.813	20.940	83.813	20.940
88	83.825	20.906	83.824	20.906
119	83.840	20.889	83.839	20.888
151	83.869	20.878	83.869	20.877
151	83.886	20.870	83.885	20.869
113	83.909	20.850	83.909	20.849
83	83.921	20.840	83.921	20.839
98	83.930	20.836	83.930	20.837
215	83.968	20.832	83.968	20.830
390	83.994	20.829	83.994	20.832
262	84.013	20.830	84.014	20.832
109	84.026	20.814	84.026	20.813
103	84.050	20.817	84.050	20.817
141	84.055	20.820	84.055	20.821
87	84.107	20.831	84.107	20.832
53	84.121	20.837	84.121	20.837
130	84.133	20.843	84.132	20.844
224	84.147	20.855	84.146	20.857
161	84.192	20.879	84.191	20.880
43	84.225	20.890	84.225	20.889
201	84.254	20.876	84.255	20.878
143	84.282	20.860	84.282	20.861
145	84.292	20.859	84.293	20.860
151	84.309	20.849	84.309	20.850

ANX 1 (continued): Shifting of river bank (Right bank 1972-1980)				
	1972		1980	
Shift (m)	latitude	longitude	latitude	longitude
94	84.326	20.840	84.325	20.840
52	84.327	20.819	84.326	20.819
178	84.331	20.797	84.332	20.798
163	84.348	20.772	84.346	20.771
151	84.357	20.761	84.356	20.760
124	84.374	20.749	84.375	20.750
114	84.406	20.736	84.405	20.736
157	84.413	20.730	84.412	20.729
109	84.439	20.731	84.439	20.732
142	84.469	20.728	84.468	20.727
171	84.477	20.724	84.477	20.723
99	84.498	20.713	84.497	20.712
143	84.508	20.701	84.507	20.700
107	84.530	20.691	84.529	20.690
113	84.565	20.682	84.564	20.681
203	84.575	20.675	84.574	20.674
156	84.589	20.662	84.588	20.661
192	84.601	20.641	84.600	20.640
253	84.644	20.619	84.644	20.617
49	84.654	20.613	84.654	20.614
146	84.670	20.614	84.669	20.612
145	84.701	20.607	84.701	20.606
84	84.718	20.610	84.719	20.609
85	84.738	20.611	84.738	20.610
63	84.753	20.608	84.753	20.607
77	84.761	20.605	84.761	20.606
175	84.774	20.597	84.773	20.596
104	84.792	20.578	84.792	20.577
82	84.810	20.568	84.810	20.567
78	84.829	20.547	84.828	20.547
73	84.850	20.524	84.849	20.523
120	84.854	20.517	84.853	20.517
72	84.867	20.507	84.866	20.507
98	84.876	20.497	84.875	20.496
119	84.881	20.492	84.880	20.491
233	84.896	20.488	84.896	20.486
79	84.943	20.481	84.943	20.480
101	84.960	20.473	84.960	20.474

ANX 1 (continued): Shifting of river bank (Right bank 1972-1980)				
	1972		1980	
Shift (m)	latitude	longitude	latitude	longitude
100	84.974	20.465	84.974	20.466
137	84.980	20.463	84.980	20.462
223	84.993	20.454	84.995	20.455
106	85.022	20.436	85.022	20.435
164	85.034	20.428	85.035	20.429
179	85.058	20.414	85.057	20.412
84	85.070	20.411	85.070	20.411
193	85.097	20.403	85.098	20.402
198	85.117	20.395	85.119	20.396
78	85.142	20.374	85.143	20.375
68	85.152	20.366	85.152	20.367
224	85.168	20.363	85.169	20.362
125	85.194	20.363	85.195	20.363
61	85.218	20.359	85.218	20.360
255	85.235	20.354	85.234	20.352
379	85.250	20.353	85.251	20.349
110	85.281	20.349	85.281	20.348
119	85.310	20.341	85.310	20.339
208	85.349	20.345	85.350	20.344
165	85.369	20.355	85.369	20.354
125	85.387	20.358	85.387	20.356
121	85.415	20.357	85.415	20.356
327	85.434	20.354	85.434	20.351
78	85.468	20.363	85.468	20.363
238	85.519	20.375	85.520	20.373
86	85.550	20.389	85.550	20.389
58	85.566	20.393	85.566	20.392
77	85.580	20.402	85.580	20.401
129	85.596	20.407	85.595	20.408
78	85.611	20.416	85.611	20.415
129	85.631	20.439	85.629	20.439
100	85.633	20.448	85.633	20.447
110	85.674	20.436	85.674	20.435
51	85.687	20.436	85.687	20.436
45	85.694	20.433	85.694	20.433
43	85.707	20.428	85.706	20.428
69	85.713	20.425	85.712	20.425
64	85.721	20.424	85.721	20.423

ANX 1 (continued): Shifting of river bank (Right bank 1972-1980)				
	1972		1980	
Shift (m)	latitude	longitude	latitude	longitude
32	85.737	20.427	85.737	20.426
142	85.743	20.434	85.742	20.434
31	85.745	20.443	85.746	20.443
39	85.748	20.449	85.748	20.449
45	85.751	20.452	85.751	20.452
28	85.757	20.459	85.757	20.459
83	85.757	20.461	85.756	20.461
195	85.763	20.468	85.762	20.469
135	85.769	20.474	85.770	20.473
452	85.776	20.480	85.779	20.477
848	85.807	20.496	85.807	20.488
66	85.843	20.492	85.843	20.492
55	85.861	20.489	85.861	20.489
54	85.891	20.477	85.891	20.477
63	85.898	20.479	85.898	20.479
60	85.908	20.473	85.909	20.474
168	85.922	20.463	85.921	20.462
187	85.946	20.456	85.945	20.455
93	85.963	20.445	85.963	20.444
137	85.990	20.435	85.989	20.434
191	86.005	20.431	86.005	20.433
241	86.031	20.438	86.031	20.439
99	86.053	20.436	86.053	20.434
73	86.067	20.430	86.066	20.430
169	86.084	20.429	86.083	20.427
72	86.099	20.421	86.099	20.422
92	86.110	20.413	86.110	20.412
121	86.127	20.404	86.126	20.403
60	86.147	20.394	86.147	20.393
84	86.168	20.393	86.169	20.394
109	86.179	20.387	86.178	20.386
103	86.184	20.381	86.183	20.380
62	86.194	20.371	86.193	20.371
450	86.203	20.359	86.205	20.363
71	86.216	20.357	86.215	20.356
67	86.224	20.357	86.224	20.358
110	86.232	20.357	86.232	20.356
287	86.238	20.355	86.238	20.357

ANX 1 (continued): Shifting of river bank (Right bank 1972-1980)				
	1972		1980	
Shift (m)	latitude	longitude	latitude	longitude
61	86.264	20.341	86.265	20.341
47	86.267	20.337	86.267	20.337
57	86.272	20.334	86.272	20.335
132	86.275	20.334	86.275	20.333
143	86.280	20.330	86.279	20.329
132	86.284	20.326	86.283	20.326
167	86.292	20.323	86.292	20.323
145	86.299	20.323	86.299	20.324
285	86.310	20.319	86.310	20.319
99	86.313	20.314	86.313	20.314
60	86.320	20.311	86.320	20.310
73	86.327	20.312	86.327	20.313
141	86.339	20.313	86.339	20.314
58	86.343	20.312	86.342	20.314
45	86.349	20.316	86.349	20.317
133	86.370	20.317	86.370	20.316
178	86.380	20.308	86.381	20.309
107	86.397	20.306	86.397	20.307
139	86.413	20.312	86.413	20.311
80	86.421	20.311	86.422	20.311
39	86.427	20.309	86.427	20.308
40	86.443	20.307	86.443	20.307
99	86.457	20.315	86.457	20.314
91	86.465	20.315	86.466	20.316
125	86.476	20.314	86.475	20.314
56	86.488	20.314	86.487	20.317
116	86.518	20.323	86.516	20.323
74	86.531	20.327	86.532	20.328
74	86.547	20.321	86.548	20.323
209	86.579	20.334	86.579	20.335
132	86.599	20.335	86.598	20.336
102	86.639	20.329	86.639	20.328
152	86.675	20.314	86.674	20.313
126	86.688	20.300	86.687	20.299
117	86.723	20.293	86.722	20.294
82	86.754	20.315	86.755	20.315

ANX 1 (continued): Shifting of river bank (Left bank 1980-1990)				
	1980		1990	
Shift (m)	Latitude	longitude	Latitude	Longitude
153	20.267	81.939	20.267	81.941
193	20.275	81.933	20.276	81.935
156	20.287	81.934	20.287	81.935
262	20.311	81.929	20.313	81.930
358	20.311	81.914	20.307	81.914
135	20.307	81.889	20.308	81.889
374	20.302	81.876	20.302	81.877
242	20.301	81.869	20.300	81.868
138	20.302	81.849	20.303	81.849
92	20.313	81.839	20.310	81.838
110	20.310	81.812	20.309	81.810
259	20.307	81.741	20.306	81.741
78	20.312	81.729	20.310	81.728
130	20.306	81.721	20.305	81.721
91	20.301	81.691	20.299	81.691
86	20.298	81.679	20.297	81.679
188	20.296	81.575	20.297	81.576
76	20.297	81.561	20.299	81.561
138	20.312	81.530	20.313	81.530
93	20.330	81.521	20.329	81.520
75	20.349	81.505	20.348	81.504
107	20.356	81.501	20.357	81.501
166	20.362	81.491	20.363	81.492
158	20.372	81.485	20.372	81.486
161	20.400	81.462	20.400	81.461
181	20.405	81.460	20.405	81.461
291	20.420	81.446	20.420	81.445
277	20.428	81.448	20.428	81.447
151	20.444	81.440	20.444	81.441
287	20.449	81.444	20.449	81.445
777	20.455	81.442	20.456	81.443
75	20.460	81.431	20.461	81.432
73	20.483	81.402	20.482	81.401
117	20.497	81.377	20.498	81.378
169	20.515	81.369	20.515	81.371
163	20.528	81.381	20.528	81.384
191	20.543	81.390	20.541	81.392

ANX 1 (continued): Shifting of river bank (Left bank 1980-1990)				
	1980		1990	
Shift (m)	Latitude	longitude	Latitude	Longitude
64	20.555	81.407	20.553	81.408
104	20.554	81.422	20.555	81.421
123	20.567	81.436	20.570	81.435
183	20.568	81.456	20.574	81.452
959	20.573	81.502	20.582	81.501
258	20.696	81.646	20.692	81.647
432	20.710	81.668	20.709	81.670
299	20.731	81.717	20.729	81.719
443	20.860	81.792	20.858	81.796
343	20.868	81.806	20.866	81.808
256	20.907	81.811	20.907	81.813
288	20.920	81.818	20.921	81.815
370	20.938	81.827	20.936	81.830
295	20.963	81.868	20.965	81.868
225	20.995	81.886	20.998	81.884
353	21.023	81.925	21.020	81.927
375	21.052	81.957	21.049	81.960
354	21.077	81.974	21.076	81.977
338	21.137	81.991	21.137	81.994
374	21.161	82.011	21.162	82.015
444	21.239	82.024	21.236	82.027
263	21.293	82.119	21.291	82.120
240	21.329	82.150	21.326	82.152
403	21.356	82.173	21.355	82.175
478	21.381	82.186	21.379	82.190
350	21.414	82.212	21.413	82.214
381	21.451	82.232	21.450	82.236
414	21.473	82.243	21.471	82.246
382	21.504	82.270	21.502	82.273
231	21.526	82.311	21.525	82.312
279	21.564	82.350	21.562	82.352
218	21.610	82.372	21.610	82.374
331	21.648	82.398	21.646	82.402
329	21.701	82.444	21.699	82.446
275	21.715	82.453	21.713	82.454
306	21.739	82.501	21.736	82.502
311	21.744	82.534	21.741	82.535
267	21.729	82.614	21.727	82.615

ANX 1 (continued): Shifting of river bank (Left bank 1980-1990)				
	1980		1990	
Shift (m)	Latitude	longitude	Latitude	Longitude
276	21.728	82.683	21.726	82.685
271	21.718	82.922	21.716	82.924
245	21.728	83.182	21.727	83.183
118	21.433	83.985	21.433	83.984
200	21.409	83.983	21.409	83.981
282	21.387	83.977	21.388	83.975
321	21.378	83.971	21.380	83.968
144	21.364	83.955	21.365	83.954
411	21.347	83.934	21.350	83.931
162	21.337	83.927	21.338	83.925
235	21.318	83.922	21.319	83.920
307	21.299	83.921	21.301	83.918
283	21.290	83.917	21.292	83.914
329	21.241	83.920	21.241	83.917
346	21.212	83.909	21.214	83.906
349	21.190	83.904	21.192	83.901
356	21.174	83.896	21.176	83.893
322	21.153	83.880	21.154	83.878
272	21.126	83.866	21.127	83.863
301	21.106	83.861	21.106	83.859
187	21.088	83.847	21.089	83.846
242	21.081	83.842	21.082	83.840
214	21.072	83.838	21.074	83.837
293	21.061	83.828	21.062	83.826
318	21.047	83.825	21.048	83.822
232	21.031	83.821	21.031	83.819
283	21.017	83.827	21.016	83.824
274	21.005	83.829	21.005	83.826
282	20.983	83.830	20.984	83.828
286	20.970	83.829	20.970	83.827
335	20.956	83.824	20.956	83.821
397	20.938	83.830	20.938	83.826
330	20.929	83.830	20.929	83.827
287	20.920	83.833	20.920	83.830
135	20.910	83.834	20.909	83.833
133	20.894	83.856	20.895	83.857
126	20.891	83.885	20.892	83.886
106	20.882	83.894	20.883	83.895

ANX 1 (continued): Shifting of river bank (Left bank 1980-1990)				
	1980		1990	
Shift (m)	Latitude	longitude	Latitude	Longitude
218	20.848	83.962	20.850	83.961
210	20.848	84.013	20.850	84.013
116	20.833	84.054	20.834	84.054
229	20.842	84.087	20.844	84.087
507	20.843	84.108	20.847	84.106
310	20.854	84.115	20.855	84.112
159	20.862	84.133	20.863	84.132
251	20.875	84.157	20.877	84.156
149	20.891	84.178	20.892	84.177
424	20.898	84.204	20.902	84.202
191	20.902	84.227	20.904	84.227
190	20.821	84.358	20.821	84.357
308	20.785	84.357	20.784	84.354
224	20.758	84.384	20.760	84.385
204	20.747	84.446	20.749	84.446
159	20.750	84.457	20.751	84.457
242	20.740	84.486	20.739	84.484
177	20.731	84.493	20.731	84.491
104	20.710	84.514	20.710	84.513
130	20.699	84.534	20.700	84.535
194	20.686	84.574	20.685	84.572
128	20.677	84.585	20.676	84.585
101	20.648	84.609	20.647	84.608
133	20.639	84.620	20.638	84.619
77	20.630	84.635	20.629	84.635
286	20.615	84.699	20.617	84.699
245	20.612	84.709	20.615	84.708
179	20.607	84.768	20.605	84.767
238	20.599	84.781	20.598	84.779
185	20.588	84.786	20.587	84.785
247	20.580	84.801	20.578	84.800
201	20.569	84.815	20.568	84.813
299	20.561	84.825	20.559	84.823
273	20.550	84.833	20.548	84.831
173	20.534	84.845	20.533	84.844
249	20.522	84.856	20.521	84.854
133	20.511	84.869	20.510	84.868
127	20.504	84.917	20.505	84.917

ANX 1 (continued): Shifting of river bank (Left bank 1980-1990)				
	1980		1990	
Shift (m)	Latitude	longitude	Latitude	Longitude
136	20.498	84.950	20.497	84.950
437	20.485	84.978	20.482	84.976
399	20.470	85.004	20.467	85.001
280	20.462	85.014	20.459	85.013
413	20.453	85.036	20.449	85.034
313	20.444	85.046	20.442	85.044
521	20.432	85.074	20.428	85.071
117	20.420	85.095	20.421	85.095
332	20.414	85.119	20.411	85.117
458	20.402	85.139	20.399	85.135
264	20.395	85.150	20.397	85.150
166	20.393	85.183	20.394	85.183
188	20.394	85.197	20.395	85.198
142	20.377	85.262	20.376	85.261
214	20.371	85.296	20.373	85.295
233	20.378	85.374	20.380	85.374
246	20.389	85.412	20.391	85.411
295	20.389	85.472	20.392	85.471
229	20.397	85.492	20.399	85.491
253	20.409	85.526	20.411	85.524
219	20.423	85.570	20.423	85.569
307	20.434	85.608	20.436	85.607
162	20.450	85.621	20.452	85.619
217	20.462	85.640	20.464	85.640
185	20.448	85.676	20.447	85.676
66	20.472	85.755	20.473	85.754
278	20.493	85.763	20.494	85.762
136	20.499	85.890	20.511	85.843
203	20.510	85.843	20.502	85.890
186	20.491	85.922	20.489	85.922
433	20.481	85.946	20.480	85.946
164	20.469	85.970	20.468	85.968
132	20.452	85.998	20.454	85.999
314	20.446	86.051	20.447	86.052
148	20.439	86.076	20.438	86.076
183	20.418	86.121	20.419	86.122
186	20.403	86.179	20.400	86.176
136	20.386	86.195	20.387	86.196

ANX 1 (continued): Shifting of river bank (Left bank 1980-1990)				
	1980		1990	
Shift (m)	Latitude	longitude	Latitude	Longitude
94	20.365	86.226	20.364	86.226
138	20.358	86.252	20.360	86.254
115	20.338	86.286	20.337	86.285
94	20.322	86.449	20.321	86.450
90	20.335	86.502	20.334	86.503
156	20.327	86.559	20.327	86.560
101	20.340	86.618	20.339	86.618
167	20.311	86.687	20.311	86.688
101	20.304	86.690	20.305	86.691

ANX 1 (continued): Shifting of river bank (Right bank 1980-1990)				
	1980		1990	
Shift (m)	latitude	Longitude	latitude	Longitude
66	20.244	81.940	20.244	81.941
55	20.254	81.945	20.254	81.945
47	20.258	81.944	20.258	81.944
24	20.260	81.941	20.261	81.942
78	20.263	81.940	20.263	81.940
145	20.267	81.940	20.267	81.942
37	20.269	81.939	20.269	81.939
131	20.274	81.935	20.274	81.936
182	20.278	81.934	20.278	81.935
71	20.281	81.935	20.281	81.934
181	20.286	81.935	20.286	81.937
48	20.296	81.935	20.296	81.935
36	20.299	81.935	20.300	81.935
31	20.303	81.937	20.302	81.938
59	20.311	81.933	20.311	81.932
186	20.312	81.928	20.314	81.928
165	20.315	81.924	20.314	81.924
75	20.312	81.920	20.312	81.920
394	20.312	81.912	20.308	81.912
145	20.310	81.900	20.311	81.901
52	20.311	81.893	20.311	81.893
144	20.307	81.888	20.308	81.888
47	20.307	81.885	20.307	81.885

ANX 1 (continued): Shifting of river bank (Right bank 1980-1990)				
	1980		1990	
Shift (m)	latitude	Longitude	latitude	Longitude
70	20.308	81.879	20.308	81.879
221	20.304	81.874	20.302	81.876
43	20.304	81.866	20.303	81.866
75	20.301	81.860	20.302	81.859
189	20.303	81.850	20.304	81.851
61	20.309	81.845	20.309	81.844
186	20.314	81.839	20.313	81.839
149	20.311	81.822	20.309	81.815
183	20.312	81.828	20.314	81.828
137	20.308	81.815	20.312	81.821
140	20.314	81.816	20.314	81.814
198	20.319	81.807	20.321	81.806
464	20.309	81.797	20.314	81.797
87	20.308	81.742	20.307	81.742
179	20.312	81.732	20.311	81.731
117	20.313	81.723	20.312	81.723
66	20.306	81.716	20.305	81.716
63	20.303	81.713	20.303	81.712
42	20.301	81.709	20.301	81.709
57	20.299	81.702	20.300	81.702
262	20.303	81.693	20.300	81.692
146	20.301	81.681	20.299	81.681
92	20.297	81.671	20.297	81.671
114	20.300	81.659	20.299	81.660
97	20.299	81.648	20.298	81.648
152	20.300	81.637	20.301	81.638
81	20.298	81.628	20.297	81.629
98	20.303	81.617	20.302	81.617
170	20.299	81.606	20.300	81.607
81	20.300	81.592	20.300	81.591
119	20.297	81.578	20.298	81.579
57	20.301	81.564	20.302	81.563
107	20.300	81.556	20.301	81.556
55	20.304	81.540	20.304	81.540
94	20.323	81.527	20.323	81.526
109	20.335	81.523	20.335	81.522
57	20.358	81.503	20.359	81.504
74	20.362	81.498	20.362	81.498

ANX 1 (continued): Shifting of river bank (Right bank 1980-1990)				
	1980		1990	
Shift (m)	latitude	Longitude	latitude	Longitude
112	20.367	81.493	20.368	81.493
120	20.375	81.486	20.375	81.487
136	20.399	81.467	20.400	81.468
110	20.408	81.462	20.407	81.461
83	20.435	81.449	20.434	81.448
154	20.441	81.446	20.441	81.445
103	20.458	81.444	20.459	81.445
171	20.465	81.431	20.465	81.431
241	20.476	81.416	20.477	81.417
393	20.482	81.407	20.484	81.409
263	20.497	81.381	20.499	81.384
235	20.523	81.385	20.523	81.388
206	20.539	81.394	20.538	81.396
207	20.550	81.432	20.548	81.433
316	20.625	81.573	20.626	81.575
154	20.661	81.564	20.658	81.566
206	20.683	81.588	20.682	81.589
408	20.687	81.654	20.686	81.654
576	20.703	81.683	20.700	81.685
322	20.709	81.707	20.704	81.709
728	20.721	81.743	20.719	81.744
366	20.754	81.788	20.753	81.795
359	20.777	81.796	20.777	81.800
310	20.819	81.794	20.800	81.800
303	20.800	81.797	20.839	81.800
277	20.840	81.797	20.819	81.797
489	20.866	81.821	20.865	81.823
350	20.895	81.821	20.897	81.826
481	20.910	81.820	20.910	81.823
356	20.923	81.824	20.920	81.828
335	20.932	81.847	20.929	81.849
436	20.941	81.858	20.939	81.860
369	20.954	81.860	20.954	81.864
267	20.971	81.878	20.970	81.881
320	20.984	81.896	20.983	81.898
287	21.002	81.915	21.000	81.917
477	21.022	81.941	21.020	81.943
332	21.051	81.968	21.048	81.972

ANX 1 (continued): Shifting of river bank (Right bank 1980-1990)				
	1980		1990	
Shift (m)	latitude	Longitude	latitude	Longitude
433	21.081	81.991	21.079	81.993
283	21.127	81.999	21.126	82.004
259	21.158	82.017	21.157	82.019
341	21.192	82.022	21.192	82.024
424	21.228	82.034	21.227	82.037
370	21.251	82.054	21.248	82.057
400	21.274	82.080	21.271	82.082
361	21.294	82.128	21.291	82.131
512	21.319	82.159	21.317	82.162
415	21.376	82.196	21.374	82.200
361	21.467	82.247	21.466	82.251
273	21.495	82.268	21.493	82.272
364	21.515	82.292	21.513	82.294
322	21.544	82.335	21.542	82.338
309	21.563	82.357	21.561	82.360
241	21.680	82.448	21.678	82.450
128	21.720	82.613	21.719	82.614
116	21.710	82.670	21.709	82.671
141	21.718	82.744	21.717	82.744
77	21.720	82.796	21.719	82.795
196	21.688	82.879	21.688	82.879
198	21.711	82.928	21.710	82.929
314	21.722	82.987	21.720	82.988
91	21.730	83.045	21.727	83.044
153	21.717	83.127	21.717	83.126
130	21.713	83.169	21.711	83.169
104	21.673	83.341	21.672	83.341
72	21.677	83.379	21.676	83.378
105	21.674	83.408	21.674	83.408
83	21.669	83.429	21.669	83.428
63	21.656	83.443	21.656	83.443
129	21.648	83.456	21.649	83.457
69	21.642	83.496	21.641	83.496
95	21.657	83.514	21.656	83.515
268	21.684	83.537	21.685	83.536
408	21.709	83.543	21.709	83.546
305	21.423	83.975	21.424	83.971
226	21.368	83.941	21.370	83.939

ANX 1 (continued): Shifting of river bank (Right bank 1980-1990)				
	1980		1990	
Shift (m)	latitude	Longitude	latitude	Longitude
156	21.323	83.902	21.324	83.900
133	21.286	83.887	21.286	83.886
260	21.232	83.904	21.232	83.903
237	21.174	83.885	21.175	83.883
182	21.143	83.866	21.144	83.864
275	21.107	83.852	21.108	83.850
226	21.083	83.834	21.085	83.832
247	21.046	83.815	21.046	83.812
166	21.001	83.818	21.001	83.816
254	20.937	83.814	20.937	83.812
203	20.922	83.820	20.921	83.818
109	20.895	83.834	20.894	83.832
188	20.876	83.870	20.877	83.870
168	20.869	83.885	20.868	83.884
281	20.845	83.916	20.844	83.915
308	20.831	83.991	20.829	83.992
185	20.826	84.018	20.825	84.015
122	20.813	84.045	20.815	84.044
87	20.857	84.146	20.858	84.145
200	20.877	84.185	20.877	84.184
227	20.889	84.218	20.891	84.218
116	20.861	84.287	20.863	84.288
380	20.831	84.329	20.832	84.325
354	20.798	84.332	20.797	84.329
221	20.748	84.380	20.747	84.379
186	20.737	84.404	20.736	84.402
173	20.728	84.428	20.730	84.428
137	20.732	84.439	20.731	84.439
162	20.721	84.478	20.720	84.477
199	20.707	84.501	20.705	84.500
148	20.693	84.525	20.692	84.524
218	20.673	84.575	20.672	84.573
205	20.655	84.591	20.654	84.589
102	20.630	84.613	20.629	84.613
213	20.617	84.644	20.619	84.644
158	20.612	84.673	20.614	84.673
157	20.609	84.717	20.610	84.716
109	20.609	84.742	20.608	84.742

ANX 1 (continued): Shifting of river bank (Right bank 1980-1990)				
	1980		1990	
Shift (m)	latitude	Longitude	latitude	Longitude
180	20.600	84.768	20.599	84.766
131	20.585	84.783	20.584	84.781
192	20.571	84.805	20.570	84.804
263	20.543	84.832	20.542	84.830
347	20.519	84.852	20.518	84.849
304	20.486	84.911	20.489	84.911
326	20.473	84.961	20.471	84.959
615	20.455	84.995	20.452	84.990
217	20.437	85.019	20.435	85.018
338	20.423	85.040	20.421	85.038
113	20.407	85.083	20.406	85.083
284	20.386	85.125	20.384	85.124
365	20.366	85.153	20.364	85.150
164	20.355	85.226	20.354	85.225
152	20.345	85.291	20.344	85.291
242	20.352	85.362	20.354	85.361
108	20.356	85.413	20.357	85.413
222	20.355	85.452	20.357	85.451
458	20.371	85.516	20.374	85.513
240	20.397	85.569	20.398	85.567
131	20.403	85.585	20.404	85.584
186	20.417	85.614	20.418	85.613
395	20.435	85.630	20.436	85.627
145	20.439	85.669	20.438	85.668
199	20.432	85.698	20.431	85.697
276	20.437	85.742	20.438	85.740
239	20.464	85.758	20.466	85.756
537	20.488	85.799	20.493	85.797
389	20.477	85.886	20.481	85.887
118	20.435	86.046	20.436	86.047
77	20.414	86.109	20.414	86.109
93	20.404	86.124	20.405	86.124
86	20.356	86.234	20.356	86.234
207	20.326	86.283	20.327	86.284
146	20.323	86.292	20.322	86.292
132	20.317	86.487	20.316	86.488
85	20.325	86.517	20.324	86.518
78	20.323	86.557	20.322	86.558

ANX 1 (continued): Shifting of river bank (Right bank 1980-1990)				
	1980		1990	
Shift (m)	latitude	Longitude	latitude	Longitude
124	20.338	86.603	20.337	86.603
67	20.324	86.658	20.324	86.658
78	20.301	86.686	20.301	86.686
136	20.294	86.706	20.292	86.706

ANX 1 (continued): Shifting of river bank (Left bank 1990-00)				
	1990		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
93	20.247	81.940	20.247	81.941
202	20.250	81.939	20.250	81.941
49	20.258	81.943	20.258	81.943
80	20.268	81.939	20.269	81.939
248	20.272	81.935	20.273	81.937
194	20.281	81.933	20.281	81.934
208	20.290	81.933	20.290	81.935
126	20.313	81.930	20.314	81.931
81	20.312	81.921	20.313	81.920
79	20.307	81.904	20.307	81.904
117	20.310	81.898	20.311	81.898
70	20.306	81.886	20.307	81.886
124	20.302	81.866	20.303	81.866
343	20.307	81.842	20.309	81.845
385	20.307	81.753	20.304	81.751
107	20.311	81.726	20.312	81.726
127	20.298	81.704	20.299	81.704
94	20.294	81.666	20.295	81.666
134	20.296	81.654	20.297	81.654
404	20.294	81.627	20.298	81.627
119	20.298	81.597	20.299	81.597
133	20.298	81.588	20.299	81.587
91	20.301	81.566	20.302	81.566
118	20.298	81.554	20.300	81.554
158	20.306	81.532	20.307	81.533
100	20.339	81.514	20.339	81.515
69	20.356	81.502	20.356	81.502

ANX 1 (continued): Shifting of river bank (Left bank 1990-00)				
	1990		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
115	20.385	81.474	20.385	81.475
92	20.405	81.461	20.404	81.460
81	20.440	81.441	20.440	81.440
100	20.461	81.431	20.462	81.432
155	20.483	81.394	20.484	81.395
265	20.505	81.374	20.504	81.372
242	20.521	81.377	20.519	81.378
140	20.537	81.389	20.538	81.388
198	20.550	81.402	20.552	81.401
264	20.658	81.560	20.658	81.557
237	20.690	81.643	20.692	81.642
366	20.718	81.681	20.715	81.681
597	20.713	81.705	20.717	81.702
303	20.746	81.761	20.748	81.759
229	20.778	81.775	20.777	81.777
213	20.849	81.793	20.849	81.791
335	20.890	81.816	20.890	81.813
341	20.939	81.832	20.941	81.830
494	20.999	81.885	20.996	81.889
398	21.019	81.926	21.022	81.923
317	21.050	81.960	21.052	81.958
319	21.072	81.976	21.073	81.973
583	21.154	82.010	21.157	82.006
337	21.202	82.013	21.202	82.009
345	21.259	82.049	21.262	82.046
338	21.285	82.104	21.288	82.104
376	21.378	82.188	21.380	82.186
471	21.468	82.244	21.470	82.240
402	21.501	82.273	21.504	82.270
311	21.556	82.342	21.559	82.340
311	21.639	82.396	21.642	82.394
420	21.691	82.437	21.694	82.434
435	21.716	82.460	21.719	82.457
712	21.738	82.520	21.745	82.519
226	21.728	82.618	21.730	82.617
332	21.725	82.683	21.727	82.681
116	21.729	82.727	21.730	82.727
247	21.699	82.864	21.701	82.866

ANX 1 (continued): Shifting of river bank (Left bank 1990-00)				
	1990		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
329	21.725	82.932	21.726	82.929
212	21.731	82.980	21.732	82.979
172	21.755	83.054	21.756	83.054
246	21.749	83.078	21.751	83.079
370	21.730	83.110	21.733	83.112
192	21.724	83.177	21.726	83.177
209	21.702	83.249	21.704	83.249
174	21.692	83.351	21.690	83.352
174	21.692	83.401	21.694	83.401
190	21.510	83.912	21.511	83.913
212	21.474	83.954	21.476	83.955
365	21.447	83.979	21.448	83.982
291	21.377	83.965	21.375	83.967
404	21.361	83.947	21.358	83.949
132	21.310	83.921	21.310	83.919
277	21.295	83.915	21.295	83.917
155	21.269	83.912	21.269	83.913
273	21.230	83.913	21.230	83.916
288	21.189	83.900	21.188	83.902
279	21.159	83.880	21.158	83.883
438	21.133	83.866	21.131	83.870
366	21.100	83.854	21.098	83.857
361	21.076	83.838	21.074	83.841
379	21.052	83.823	21.051	83.827
293	20.982	83.828	20.981	83.830
400	20.956	83.821	20.955	83.825
358	20.940	83.826	20.940	83.829
404	20.909	83.833	20.911	83.837
121	20.852	83.983	20.853	83.983
316	20.849	84.017	20.846	84.016
517	20.856	84.114	20.853	84.116
269	20.903	84.205	20.901	84.206
246	20.876	84.292	20.878	84.294
146	20.861	84.323	20.860	84.322
290	20.821	84.357	20.821	84.359
316	20.785	84.354	20.785	84.357
183	20.748	84.444	20.747	84.444
345	20.739	84.483	20.741	84.486

ANX 1 (continued): Shifting of river bank (Left bank 1990-00)				
	1990		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
261	20.712	84.510	20.714	84.512
346	20.675	84.585	20.677	84.588
259	20.640	84.617	20.642	84.618
345	20.619	84.716	20.616	84.717
256	20.592	84.781	20.593	84.783
294	20.559	84.823	20.561	84.825
320	20.548	84.832	20.549	84.834
326	20.518	84.857	20.520	84.859
205	20.503	84.907	20.502	84.908
336	20.462	85.007	20.464	85.009
353	20.449	85.034	20.451	85.036
439	20.429	85.069	20.432	85.072
1142	20.392	85.136	20.401	85.141
169	20.394	85.203	20.396	85.203
286	20.368	85.270	20.369	85.273
247	20.377	85.338	20.375	85.340
154	20.384	85.381	20.385	85.380
252	20.388	85.407	20.386	85.408
223	20.384	85.449	20.386	85.450
116	20.394	85.476	20.393	85.476
222	20.409	85.519	20.407	85.520
148	20.423	85.569	20.422	85.570
301	20.428	85.586	20.426	85.588
172	20.448	85.616	20.447	85.617
302	20.458	85.650	20.460	85.652
302	20.448	85.674	20.450	85.676
234	20.456	85.733	20.457	85.731
194	20.499	85.763	20.498	85.765
149	20.509	85.865	20.510	85.865
127	20.490	85.920	20.490	85.920
210	20.480	85.946	20.482	85.946
223	20.468	85.968	20.469	85.970
278	20.460	85.988	20.458	85.987
292	20.449	86.015	20.452	86.016
428	20.450	86.034	20.454	86.034
222	20.436	86.091	20.434	86.090
156	20.404	86.147	20.405	86.147
326	20.391	86.191	20.390	86.188

ANX 1 (continued): Shifting of river bank (Left bank 1990-00)				
	1990		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
140	20.364	86.250	20.365	86.251
280	20.350	86.268	20.347	86.267
226	20.341	86.277	20.342	86.279
191	20.322	86.312	20.323	86.313
152	20.321	86.347	20.320	86.347
142	20.323	86.363	20.321	86.362
175	20.313	86.399	20.311	86.399
944	20.320	86.441	20.311	86.441
374	20.333	86.478	20.324	86.483
1055	20.334	86.504	20.332	86.506
176	20.330	86.542	20.328	86.542
593	20.339	86.634	20.333	86.634
308	20.326	86.672	20.327	86.675

ANX 1 (continued): Shifting of river bank (Right bank 1990-00)				
	1900		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
57	20.245	81.941	20.245	81.941
88	20.258	81.944	20.258	81.944
141	20.267	81.942	20.267	81.940
240	20.272	81.936	20.274	81.938
219	20.291	81.934	20.292	81.936
164	20.300	81.935	20.301	81.934
89	20.311	81.897	20.312	81.897
77	20.307	81.886	20.308	81.886
125	20.302	81.875	20.301	81.876
182	20.304	81.852	20.303	81.851
100	20.310	81.732	20.311	81.733
72	20.304	81.713	20.304	81.714
127	20.298	81.672	20.297	81.673
73	20.298	81.652	20.298	81.652
159	20.301	81.593	20.299	81.593
91	20.301	81.553	20.302	81.553
188	20.315	81.532	20.315	81.533
118	20.339	81.519	20.340	81.520

ANX 1 (continued): Shifting of river bank (Right bank 1990-00)				
	1900		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
384	20.382	81.479	20.383	81.482
182	20.403	81.465	20.404	81.466
268	20.431	81.450	20.432	81.452
89	20.461	81.441	20.460	81.441
181	20.469	81.426	20.468	81.425
155	20.486	81.406	20.485	81.405
328	20.523	81.388	20.524	81.385
303	20.547	81.407	20.550	81.405
364	20.666	81.578	20.668	81.575
249	20.687	81.657	20.689	81.656
1246	20.709	81.726	20.719	81.720
719	20.791	81.803	20.790	81.796
1373	20.929	81.849	20.937	81.839
387	20.974	81.885	20.977	81.882
424	21.049	81.973	21.051	81.969
382	21.156	82.019	21.158	82.016
339	21.215	82.031	21.217	82.028
468	21.252	82.061	21.255	82.058
370	21.360	82.190	21.362	82.187
404	21.455	82.247	21.455	82.244
393	21.490	82.270	21.493	82.267
360	21.541	82.338	21.543	82.335
315	21.595	82.384	21.595	82.380
250	21.621	82.391	21.622	82.389
607	21.668	82.431	21.671	82.430
284	21.710	82.477	21.711	82.471
248	21.718	82.614	21.720	82.612
165	21.722	82.992	21.724	82.991
157	21.720	83.058	21.719	83.057
141	21.717	83.123	21.718	83.123
149	21.707	83.194	21.705	83.193
152	21.688	83.265	21.687	83.265
118	21.656	83.442	21.657	83.442
167	21.642	83.500	21.644	83.499
286	21.709	83.546	21.709	83.543
303	21.423	83.971	21.423	83.974
257	21.354	83.915	21.353	83.918
229	21.282	83.884	21.282	83.887

ANX 1 (continued): Shifting of river bank (Right bank 1990-00)				
	1900		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
197	21.233	83.903	21.232	83.905
191	21.190	83.891	21.189	83.892
180	21.165	83.876	21.164	83.877
363	21.096	83.841	21.094	83.844
257	21.039	83.811	21.038	83.813
240	21.006	83.815	21.006	83.818
203	20.978	83.815	20.978	83.817
289	20.890	83.836	20.891	83.838
358	20.837	83.931	20.834	83.931
399	20.829	84.013	20.831	84.016
230	20.817	84.048	20.814	84.049
342	20.866	84.162	20.864	84.163
191	20.861	84.291	20.862	84.293
326	20.827	84.325	20.827	84.328
242	20.767	84.346	20.768	84.348
221	20.702	84.503	20.703	84.504
162	20.692	84.524	20.693	84.525
413	20.656	84.587	20.658	84.591
252	20.635	84.606	20.636	84.608
280	20.614	84.658	20.611	84.659
345	20.613	84.722	20.610	84.723
276	20.595	84.771	20.597	84.773
336	20.561	84.814	20.563	84.816
352	20.518	84.849	20.520	84.851
242	20.475	84.953	20.477	84.954
454	20.457	84.986	20.459	84.990
369	20.427	85.029	20.430	85.032
542	20.392	85.113	20.394	85.117
279	20.365	85.190	20.363	85.191
197	20.351	85.234	20.353	85.235
192	20.344	85.291	20.345	85.291
308	20.350	85.352	20.348	85.353
647	20.350	85.423	20.356	85.424
269	20.376	85.516	20.374	85.517
302	20.397	85.566	20.396	85.569
327	20.432	85.627	20.432	85.630
293	20.438	85.740	20.437	85.743
815	20.485	85.821	20.493	85.823

ANX 1 (continued): Shifting of river bank (Right bank 1990-00)				
	1900		2000	
Shift (m)	Latitude	longitude	Latitude	longitude
940	20.480	85.877	20.488	85.879
167	20.416	86.108	20.415	86.107
212	20.394	86.169	20.392	86.168
374	20.363	86.199	20.365	86.201
119	20.358	86.225	20.357	86.226
100	20.341	86.265	20.341	86.264
121	20.327	86.285	20.327	86.285
153	20.310	86.323	20.312	86.322
145	20.314	86.339	20.312	86.339
131	20.309	86.379	20.311	86.379
257	20.322	86.505	20.325	86.505
195	20.330	86.521	20.332	86.521
148	20.323	86.547	20.324	86.547
85	20.334	86.576	20.333	86.576
134	20.335	86.613	20.336	86.614
104	20.313	86.674	20.314	86.675
160	20.293	86.699	20.292	86.699

ANX 1 (continued): Shifting of river bank (Left bank 2000-2010)				
	2000		2010	
Shift (m)	Latitude	longitude	Latitude	longitude
441	20.237	81.937	20.236	81.941
860	20.263	81.939	20.263	81.947
754	20.263	81.939	20.294	81.939
472	20.294	81.934	20.320	81.934
682	20.307	81.909	20.313	81.908
722	20.301	81.851	20.308	81.854
653	20.308	81.805	20.313	81.809
735	20.306	81.747	20.312	81.749
824	20.298	81.695	20.306	81.695
662	20.298	81.638	20.304	81.640
691	20.298	81.603	20.304	81.604
756	20.341	81.511	20.345	81.517
643	20.368	81.488	20.371	81.493
602	20.410	81.454	20.412	81.459

ANX 1 (continued): Shifting of river bank (Left bank 2000-2010)				
	2000		2010	
Shift (m)	Latitude	longitude	Latitude	longitude
281	20.437	81.443	20.439	81.447
494	20.448	81.445	20.449	81.443
527	20.473	81.416	20.476	81.420
596	20.491	81.377	20.494	81.382
612	20.521	81.379	20.524	81.374
491	20.548	81.397	20.551	81.394
338	20.642	81.561	20.643	81.564
236	20.673	81.569	20.674	81.567
344	20.683	81.620	20.686	81.621
705	20.715	81.682	20.721	81.683
339	20.721	81.706	20.719	81.709
345	20.737	81.725	20.740	81.724
300	20.777	81.777	20.779	81.774
192	20.806	81.780	20.806	81.782
206	20.870	81.807	20.868	81.809
544	20.921	81.811	20.918	81.816
116	20.943	81.838	20.944	81.838
127	20.964	81.867	20.965	81.867
80	21.042	81.950	21.041	81.951
143	21.098	81.984	21.098	81.985
232	21.157	82.005	21.155	82.007
700	21.305	82.131	21.309	82.126
157	21.425	82.223	21.426	82.222
133	21.730	82.465	21.730	82.463
119	21.728	82.569	21.728	82.568
142	21.730	82.734	21.731	82.734
301	21.734	82.957	21.732	82.955
233	21.757	83.051	21.755	83.051
366	21.736	83.106	21.734	83.105
224	21.723	83.195	21.722	83.194
76	21.519	83.904	21.519	83.903
125	21.476	83.955	21.475	83.954
398	21.445	83.983	21.447	83.986
443	21.343	83.930	21.341	83.934
250	21.310	83.919	21.310	83.922
298	21.275	83.912	21.275	83.915
352	20.847	84.014	20.850	84.016
389	20.853	84.117	20.855	84.114

ANX 1 (continued): Shifting of river bank (Left bank 2000-2010)				
	2000		2010	
Shift (m)	Latitude	longitude	Latitude	longitude
217	20.615	84.695	20.617	84.696
925	20.400	85.145	20.392	85.142
461	20.395	85.170	20.391	85.169
539	20.457	85.731	20.453	85.734
645	20.456	85.990	20.460	85.992
486	20.452	86.039	20.446	86.038
921	20.312	86.438	20.320	86.437
1023	20.325	86.484	20.332	86.478
609	20.326	86.560	20.331	86.558
285	20.323	86.678	20.325	86.680

ANX 1 (continued): Shifting of river bank (Right bank 2000-2010)				
	2000		2010	
Shift (m)	Latitude	longitude	Latitude	longitude
852	20.264	81.940	20.265	81.948
708	20.276	81.936	20.277	81.943
497	20.297	81.935	20.297	81.940
713	20.311	81.932	20.314	81.938
718	20.308	81.911	20.315	81.910
624	20.302	81.860	20.308	81.860
819	20.309	81.805	20.316	81.808
658	20.308	81.748	20.313	81.751
745	20.299	81.697	20.306	81.697
695	20.300	81.639	20.306	81.642
720	20.300	81.604	20.307	81.606
780	20.344	81.513	20.348	81.520
385	20.370	81.492	20.372	81.495
555	20.412	81.457	20.415	81.461
350	20.438	81.448	20.440	81.451
499	20.459	81.445	20.463	81.448
629	20.495	81.386	20.499	81.390
236	20.646	81.564	20.647	81.567
369	20.680	81.606	20.683	81.607
564	20.721	81.735	20.726	81.736
268	21.703	82.471	21.703	82.474
623	21.713	82.573	21.708	82.572