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"SPATIAL & TEMPORAL CHANGES IN PAGLADIYA RIVER MORPHOLOGY"

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DECLARATION

I hereby declare that the work presented in the dissertation **"SPATIAL & TEMPORAL CHANGES IN PAGLADIYA RIVER MORPHOLOGY"** in partial fulfillment of the requirement for the award of the degree of **"MASTER OF TECHNOLOGY"** in Civil Engineering (With specialization in Water Resource Engineering), submitted in the Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-13 under Assam Science & Technology University, is a real record of the work carried out under the supervision of **DR. PULENDRA DUTTA**, Assistant Professor, Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-13.

I do hereby declare that this project report is solemnly done by me and is my effort and that no part of it has been plagiarized without citation.

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CERTIFICATE

This is to certify that the work presented in the project report entitled **"SPATIAL & TEMPORAL CHANGES IN PAGLADIYA RIVER MORPHOLOGY"** is submitted by **Dinkumani Deka** , [**Roll no- 220620061005**], a student of M.Tech 4th semester, Department of Civil Engineering, Assam Engineering College, to the Assam Science & Technology University in partial fulfillment of the requirement for award of the degree of Master of Technology in Civil Engineering with specialization in Water Resource Engineering under my guidance and supervision.

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ABSTRACT

The study investigates river morphology employing ArcGIS, an advanced Geographic Information System (GIS) software. This research explores the dynamic nature of river systems, focusing on their form, structure, and changes over time. Through ArcGIS, spatial data analysis and visualization techniques are employed to comprehend the intricate patterns and characteristics of river morphology.

The methodology involves acquiring various geospatial data, such as satellite imagery, digital elevation models (DEMs), and hydro-climatological data. Utilizing ArcGIS tools, these datasets are processed, integrated, and analyzed to derive valuable insights into river morphology parameters, including channel width, depth, sinuosity, and meander evolution.

This research aims to provide a comprehensive understanding of how natural processes and anthropogenic influences shape river systems. This study's outcomes can aid in effective river management, environmental conservation, and decision-making processes related to land use planning, flood risk assessment, and habitat preservation. By using ArcGIS, this study helps us understand how rivers change over time, promoting better ways to manage and protect these important natural resources.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

River morphology refers to the study of the structure, shape, and form of rivers, encompassing their physical features, processes, and how they evolve over time. Rivers are dynamic natural systems shaped by various factors, including geology, climate, human activities, and the interactions between water and the surrounding environment.

1.2 RIVER MORPHOLOGY

River morphology, also known as fluvial geomorphology, is the scientific study of the forms and processes associated with rivers and streams. It examines how rivers shape and are shaped by their landscapes over time. This discipline involves analyzing the river's channel patterns, sediment transport, and the dynamic interactions between water flow and the surrounding environment. River morphology explores various channel types, such as meandering, braided, and anastomosing channels, each with distinct characteristics and behaviors. Factors influencing river morphology include geology, climate, vegetation, and human activities. Erosion, transportation, and deposition are key processes in shaping river channels and floodplains. River morphology also considers the impact of events like floods and droughts on river structure and function. Understanding river morphology is crucial for effective river management, flood control, and ecological conservation. It helps in predicting changes in river systems due to natural and anthropogenic influences, guiding sustainable development practices. By studying river morphology, scientists and engineers can design better strategies to preserve aquatic habitats, manage water resources and mitigate the adverse effects of natural disasters, ensuring the health and resilience of riverine ecosystems.

1.3 OBJECTIVE OF THE STUDY

The study of river morphology focuses on understanding the form, structure, and processes that shape river channels and their surrounding environments. The field encompasses various scientific disciplines, including geology, hydrology, ecology, and geomorphology, aiming to unravel the intricate interactions shaping rivers and their landscapes.

At its core, river morphology aims to decipher the complex dynamics of river systems. This involves investigating the processes that dictate how rivers erode, transport, and deposit sediment. Erosion is a fundamental process that sculpts river channels, creating diverse landforms like meanders, river terraces, and . Understanding these mechanisms allows scientists and engineers to predict how rivers might change over time, which is crucial for managing river systems and mitigating potential hazards like flooding and bank erosion.

Moreover, river morphology plays a pivotal role in understanding the ecological significance of rivers. River ecosystems rely on the physical structure of the riverbed and banks, as well as the flow characteristics of the water, to support diverse habitats for various organisms. The intricate interplay between river morphology and ecology influences biodiversity, species distribution, and ecosystem functions, emphasizing the importance of preserving natural river processes for the health of these ecosystems.

The main objectives of this study are listed below:

1) LULC ANALYSIS.

2) To obtain the radius of curvature, center line distance, mender neck length, axis length, river width, and sinuosity in the Pagaldia River.

3) To study the impact of river migration on river morphology.

1.4 ORGANIZATION OF REPORT

- **Chapter 2** provides a comprehensive literature review on river morphology, covering studies by Apurba Nath & Susmita Ghosh, J. B. Alam et al., Abul Basar M Basi, Mukesh

Kumar, A.I. Craciun, Saleh Yousefi et al., Khurram Chohan et al., Severin Hohensinner et al., John Field et al., Iware Matsuda, etc. The literature explores various aspects of river morphology, including geomorphic responses to land use changes, remote sensing and GIS technology applications, riverbank migrations, erosion and accretion rates, and the impact of human activities on river systems. The studies emphasize the importance of understanding river morphology for effective river management and the mitigation of associated hazards.

- **Chapter 3** provides an insightful overview of the Pagladiya River in Assam, India. It details the river's origin, course, ecological significance, and its integral role in supporting local communities. The chapter highlights the socio-economic importance of the river, addressing the challenges it faces and its cultural significance. It also features visual representations, including an aerial view and specific geographical areas, providing a comprehensive understanding of the Pagladiya River's context.
- **Chapter 4** focuses on methodology. It outlines data collection using Landsat imagery, techniques like river path digitization and meander parameter analysis, and assessing morphological changes and LULC alterations. This chapter discusses crucial details impacting the investigation's findings.
- **Chapter 5** encompasses the analysis of Land Use Land Cover (LULC) and Meander Parameters, offering insights into environmental changes, river behavior, and their implications over three decades, facilitating informed decision-making in land management and conservation.
- **Chapter 6** concludes the report on river morphology & Future scope , emphasizing the pivotal role of ArcGIS in revealing intricate river patterns. It underscores its importance in informed decision-making for sustainable river management and environmental conservation.

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CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

River morphology, a fundamental aspect of fluvial geomorphology, examines the form and structure of river systems. It delves into the intricate interplay between water flow, sediment transport, and the evolution of river channels, encompassing their shapes, patterns, and processes. Understanding river morphology is vital for comprehending natural dynamics such as erosion, sedimentation, and meandering, which influence habitat diversity, water quality, and ecosystem stability. Literature exploring river morphology encompasses a breadth of studies, ranging from hydraulic principles to landscape evolution, providing invaluable insights into the intricate behavior of these dynamic natural systems.

2.2 LITERATURE REVIEW

A literature review serves as a foundational element in academic research, offering a comprehensive analysis of existing scholarship on a particular topic. It involves systematically searching, evaluating, and synthesizing relevant studies, articles, and books to identify trends, gaps, and key insights. By critically examining previous research, a literature review not only contextualizes the current study within the broader academic dialogue but also highlights the contributions and limitations of earlier works. This process not only helps to establish the credibility of the research but also guides the development of the research questions and methodology, ensuring a well-informed and robust approach to the study. Some paper discuss below :

- A. Nath & S. Ghosh (2022): They studied understanding geomorphic responses to global land use requires a historical perspective. Conditions, such as previous disturbances to which systems are responding, must be considered while making a change. The current study shows that, utilizing RS and GIS, multi-temporal satellite data (Landsat) may be used to monitor river morphological activity with LULC and meandering parameter variations.

- J.B. Alam et al. (2007): They studied Remote sensing and GIS technology show the great potential to study the morphological change of the river. This type of study is helpful for further planning of river training and management in an effective manner, as it could incorporate the long-term (historical) changes in the river morphology.

- A.B.M. Basi & T.Y.Gan (2013): The large braided Jamuna River or the lower Brahmaputra River, located in the Bangladesh portion of the Ganges-Brahmaputra basin, experienced high riverbank shifting rates and island dynamics. Based on remotely sensed images of Landsat MSS and TM collected between 1973 and 2003, estimate the short-term and long-term riverbank migrations. In the short-term analysis, the migration rate is calculated on the basis of short-term changes between two consecutive images.

- M. Kumar (2021): This studies utilizing Landsat satellite images have documented historical morphological changes in the Ganga River. These investigations highlight the dynamic nature of erosion and deposition processes, revealing continuous shifts in the river's place, shape, outline, and size. Flooding and bank line erosion significantly impact the region's physical and socio-cultural landscape, with notable channel widening observed in 2020.

- A.I. Craciun (2007): This paper review on GIS technology in hydrologic process analysis highlights its efficiency in rapid forecasting to prevent hydrologic hazards. This Studies emphasize the importance of understanding physical-geographical characteristics and simulating basin responses to manage water resources effectively. Key findings include the proportionality between river bed length and concentration time, and the impact of deforestation, soil texture, and slope on runoff coefficients.

- S. Yousefi et al. (2017): They Investigate and identify morphological changes in a part of the Karun River over the period 1989–2008 and the possible effects of land use on morphological changes using remote sensing data.

- K. Chohan (2022): This paper review highlights the critical role of understanding river morphology in sustainable disaster management and planning. Utilizing GIS and RS technologies, various studies have examined morphological changes in rivers, emphasizing the importance of spatial-temporal analysis. Specifically, research on the Chenab River illustrates significant post-1979 flood-induced alterations, underscoring the need for advanced, section-specific morphological assessments.

- S. Hohensinner et al. (2018): This paper review on the hydromorphological state of riverine ecosystems underscores the importance of understanding larger spatial scales, as local geomorphology alone does not dictate channel geometry and fluvial dynamics. Research highlights how upstream sediment transport, discharge, and human interventions affect downstream and upstream sections, influencing long-term ecological states and necessitating comprehensive consideration in river restoration and management strategies.

- J. Field et al. (2014): This paper review Channel migration is an essential natural process on meandering channels, braided rivers, and alluvial fans. Traditional structural approaches used to control flooding and erosion in these environments often constrain the river's natural movement. Without maintenance, such flood control efforts are not sustainable as the river returns to a natural form, whether reestablishing a meandering pattern along a straightened channel or reactivating braid paths blocked by embankments. Long-term success in flood control will be realized through solutions that leave natural channel processes undisturbed. The greatest reductions in flood damage will result from flood hazard management programs that maximize the amount of land available for attenuating flood flows.

- I.Matsuda (2004): He studied Channel processes reflected in river morphology are erosion, transportation, and sedimentation. These processes develop drainage basins. Every drainage basin has its own shape. Some indices are proposed to explain the shape of a drainage basin quantitatively. As for channels in a drainage basin, the concept of stream order is introduced and is related to the total length, the gradient of channels, and the area of drainage basins. A drainage pattern is a plan of a river system and reflects a variety of information about geology and the predominant slope of the drainage basin. Sediment loads are classified into bed loads and suspended loads. In contact with a river bed, a bed load consisting of material of larger diameter than fine sand is brought to the lower reaches. Fine materials such as clay and silt are held in suspension in stream water and are carried without contact with the river bed. The three main channel patterns in alluvial plains are: braided, meandering, and straight. Channels on an alluvial fan show a braided pattern, and their depth is shallow. The river bed is composed of gravelly deposits. Channels in a flood plain meander and have a river bed composed of sand.

- C. Rachelly et al. (2018): they studied River widening is a common restoration approach to mitigate the adverse effects of past stream alterations on infrastructure and the riparian ecosystem by stabilizing the river bed and enhancing habitat heterogeneity. In this study, two river widening approaches, excavated and dynamic, are described for the case of moderately steep gravel-bed rivers in the Alpine foothills, with a focus on dynamic river widening. As most channelized rivers exhibit ongoing degradation due to the lack of sediment supply and efforts to restore sediment transport are increasing, consideration of the response of river widenings to variable sediment supply is important. For this purpose, insights from regime theory are applied to river widening, and several experimental flume and field studies on channel response to variable sediment supply are reviewed. Dynamic river widenings are expected to be morphologically active in weakly degraded rivers with sufficient sediment supply, while they may not be an appropriate restoration approach for highly degraded rivers due to persistent impairment of morphological activity.

- R.J. Boothroyd et al. (2021): This paper review With the increasing availability of big geospatial data (e.g., multi-spectral satellite imagery) and access to platforms that support multi-temporal analyses (e.g., cloud-based computing, Geographical Information Systems, GIS), the use of remotely sensed information for monitoring riverine hydro-morpho-biodynamics is growing. Opportunities to map, quantify, and detect changes in the wider riverscape (i.e., water, sediment, and vegetation) at an unprecedented spatiotemporal resolution can support flood risk and river management applications. Focusing on a reach of the Po River (Italy), satellite imagery from Landsat 5, 7, and 8 for the period 1988–2018 was analyzed in Google Earth Engine (GEE) to investigate changes in river planform morphology and vegetation dynamics associated with transient hydrology.

- P. Mondal et al. (2018): All the research methodology tries to explain the geographic events, both physical and socio-economic, that exist over the earth's surface. Nobody can ignore the fact that the dynamic earth surface and spatial behavior are the source of any research orientation, and they should be analyzed using the principles of spatial analysis. The spatial analysis tries to focus on dualistic nature, like systematic and regional accounts, for a better representation of the dynamicity of the earth's events. In this connection, the river Khari is an essential embodied and natural system on the basis of the methodological principle of spatial analysis. The river Khari is very interesting from both perspectives, like river mechanism and impact analysis. It clearly detects the inland source point of this river at Maro village (near Mankar station), develops a long profile and wider basin, and ultimately transfers its energy into Bhagirathi at the meeting point. From source to river confluence, there are also different types of morphometric features, both areal and linear. This paper tries to highlight the characteristics of the morphological dimensions of the river Khori in a systematic way.

- A.Z.M.Z. Islam et al. (2017): They studied River planimetric morphological datasets were generated from multi-temporal satellite images and incorporated in a GIS framework to analyze the changes in the surface morphology of the rivers belonging to the JBM system. The study also depicted the possible impacts of climate change on the principal rivers of the system. Landsat MSS images of the year 1972 and Landsat TM images of the years 1989 and 2010 were used for the study. The study revealed that the JBM river system was morphologically highly unstable due to both erosion and accretion during the study period. The instability was higher for the larger-width rivers than the smaller-width rivers. Erosion was the dominant occurrence in the early decades, but the dominance of the morphological changing process was shifted to accretion in the later decades. The study revealed that the short-term impact of climate change will primarily be seen on the foreshore of the rivers and on the Char lands.

- M. Juliandar et al. (2020):They study for Meandering rivers, characterized by their sinuous paths, significantly influence fluvial landscapes. In the Citarum watershed, Majalaya Sub-district, Kab. Bandung, such a river exhibits notable morphological changes due to horizontal and centrifugal pressures. These alterations impact the river's geometry, influencing flow speed and meander formation. Comparative causal methods reveal that the meandering section, stretching approximately 975 meters and segmented into five parts, contains diverse materials like clay, gravel, sand, and stones. The study concludes that variations in velocity (V) and discharge (Q) correlate with the river's curvature (Rc) and morphological types (A, E, G, F, DA), offering insights into optimizing benefits and mitigating arising issues.

- P. Wang et al. (2020): This paper review on the lower reaches of the LCR from Jinghong to Guanlei highlights the significant impact of cascade hydropower development, river regulation, and sand-mining on river morphology. Studies reveal notable changes such as erosion, accretion, and shifts in water surface and beach areas, emphasizing the need to understand human interventions on fluvial dynamics between 1993 and 2016.

- A.A. Fathollahkhani et al. (2022): This study has identified and analyzed morphological changes in the Karun River using a time series of Landsat imagery from 1985–2015. On that basis, morphological dynamics, including the river's active channel width, meander's neck length, water flow length, sinuosity index, and cornice central angle, were quantitatively investigated. Additionally, the correlation between stream power and morphological factors was explored using the data adopted from the hydrometric stations. The results show that the dominant pattern of the Karun River, due to the sinuosity coefficient, is meandering, and the majority of the river falls in the category of developed meander rivers. Moreover, the number of arteries has reduced in an anabranch pattern, and the river has been migrating towards the downstream and eastern sides since 1985. This phenomenon presents a change in the future that can be hazardous to croplands and demands specific considerations for catchment management.

- A.Masrur et al. (2019): They study in Bangladesh's coastal regions used XGBoost and Random Forest for LULC mapping, revealing increased agriculture, built-up, and river areas over 28 years. Natural disasters and human activities impacted vegetation, yet reforestation efforts led to a significant vegetation increase from 2005 to 2017. These insights aid policy for mitigating human and natural disruptions. Utilizing XGBoost and Random Forest improves mapping accuracy for complex, large landscapes, despite lower-quality remote data. While beneficial, interpreting results cautiously is crucial due to data limitations. This study sets a valuable path for future research leveraging varied remotely sensed data qualities to analyze vast, intricate landscapes.

- G.Adhikari et al. (2015): The study explores links between soil organic carbon (C), nitrogen (N), phosphorous (P), potassium (K), and soil properties in Assam, India's rainforest. Across seven locations with varied textures and mineral compositions, findings reveal positive correlations of soil clay and negative associations of sand with organic carbon protection. Higher silt and clay content, lower sand, and increased total Fe and Al oxides enhance organic carbon preservation. Chlorite minerals facilitate higher SOC retention at specific sites. Natural and human-induced soil disruptions were observed to compromise SOC preservation in similar climatic and mineral conditions.

- A.Dewan et al. (2019): They studied a GIS-based study assessed flash flood hazards in the Karnaphuli and Sangu river basins, analyzing 22 morphometric parameters grouped into four categories. It linked peak runoff flows to susceptibility, creating a map overlaid with population data to highlight exposure. Findings emphasized volume, water velocity, infiltration, precipitation, elevation, and relief as key factors, especially impacting hilly areas. While effective at a watershed scale, limitations exist due to the lack of microscale flood data and challenges in satellite observation during monsoons. Nonetheless, the study aids in identifying hazard zones for targeted mitigation strategies, suggesting the use of SAR images and dynamic modeling for future research in flood-prone areas.

- S. Yousefi et al. (2017): Rivers are the most important indicators of environmental changes. In the present study, They investigate the effects of urbanization growth on river morphology in the downstream part of the Talar River, east of Mazandaran Province, Iran. Analyzed aerial photos of the 1955–2013 period. Morphological and morphometric parameters in ten equal sub-reaches were defined along a 11.5 km reach of the Talar River after land cover maps were produced for 1955, 1968, 1994, 2005, and 2013.

2.3 CRITICAL REVIEW

The collection of studies provided comprehensive insights into river morphology, employing various methodologies and focusing on different rivers across multiple geographic locations and time periods. Each study used remote sensing technologies such as GIS and RS to analyze historical changes and explore the intricate relationship between land use, meandering parameters, and river morphology. Together, these findings emphasized the dynamic nature of rivers and their vulnerability to diverse influences, including human activities like urbanization, agricultural expansion, and infrastructure development, as well as natural factors like erosion, sedimentation, and climate change.

The studies highlighted the significant impact of land use changes on river morphology, demonstrating the interconnectedness between land cover alterations and shifts in meandering parameters. They showed that changes in land cover substantially affect river migration rates, meandering patterns, and overall morphology. Notably, observations regarding erosion, accretion rates, and their effects on channel movement across different rivers underscored the complexity of morphological changes driven by both anthropogenic and natural factors.

Despite the diversity of findings and methodologies, several common themes emerged: the necessity for sustainable river management strategies, the importance of understanding historical land use patterns, and the potential of remote sensing techniques to predict future trends in river morphology. However, challenges in interpreting and integrating data across various scales and complexities were evident, emphasizing the need for caution when drawing conclusions. Overall, these studies collectively contributed valuable insights into riverine dynamics, underscoring the need for holistic approaches in river management that consider the intricate interplay between land use, meandering parameters, and the evolving morphology of river systems.

CHAPTER 3

STUDY AREA, DATA & TOOLS

3.1 INTRODUCTION

The Pagladiya River in Assam, India, is a significant tributary of the mighty Brahmaputra River. Originating from the Rongcheng range in Bhutan, it flows through the picturesque landscapes of Assam, contributing to the region's ecology and socio-economic aspects.The Pagladiya River meanders across the Indo-Bhutan border, offering sustenance to the adjoining areas with its water resources. Its course spans diverse terrains, from the mountainous regions of Bhutan to the plains of Assam, significantly impacting the surrounding ecosystems and supporting a rich variety of flora and fauna.

3.2 STUDY AREA

The Pagladiya River is also known for its seasonal flooding, which poses significant challenges to the local population. Floods are a recurrent phenomenon, often causing extensive damage to crops, property, and infrastructure. The river's hydrology is influenced by both natural factors, such as monsoonal rainfall and glacial melt, and anthropogenic activities, including deforestation, sand mining, and dam construction. Recent studies have focused on understanding the river's morphology, sediment transport, and flood dynamics to develop sustainable management practices. Addressing these challenges requires a comprehensive approach that combines scientific research with community engagement and policy interventions to mitigate the adverse impacts of flooding and ensure the sustainable development of the Pagladiya River basin. the Pagladiya River is a vital watercourse in Assam, integral to the region’s agriculture, ecology, and livelihoods. Its management poses significant challenges due to its dynamic nature and the pressures from human activities, necessitating comprehensive and sustainable river basin management strategies to mitigate flood risks and preserve its ecological functions.

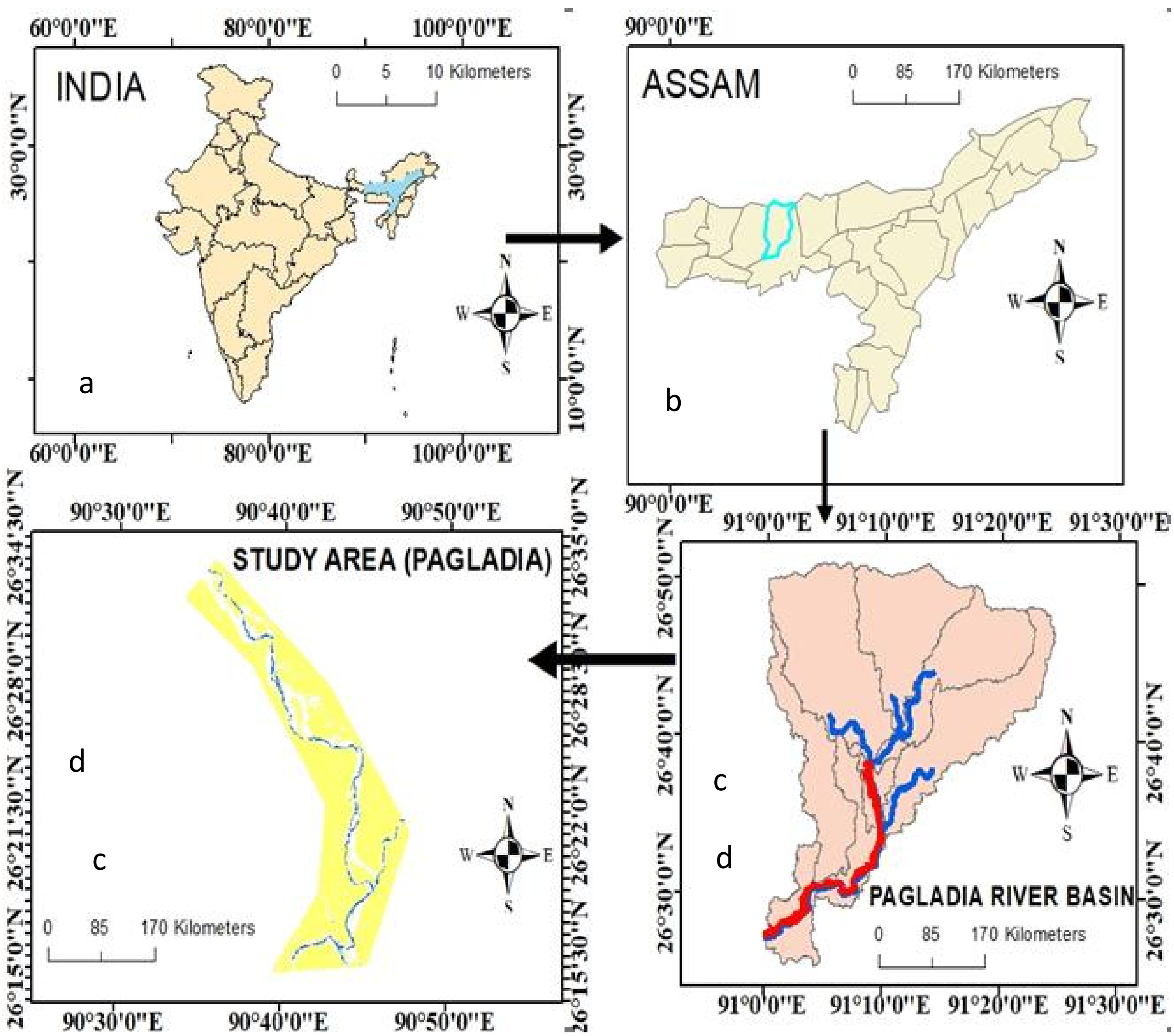

FIG 3.1- STUDY AREA , a) INDIA , b)ASSAM , c)PAGLADIA RIVER BASIN , d)STUDY AREA CROPED

3.2.1 Hydrology: The Pagladiya River exhibits a complex hydrological regime characterized by seasonal variations in water flow. During the monsoon season, heavy rainfall in the catchment areas leads to increased river discharge, often causing flooding in the lower plains. The river's flow is fed by both rainfall and snowmelt from the Himalayan region, contributing to its perennial nature. The hydrology of the Pagladiya is further influenced by its numerous tributaries, which enhance its water volume and sediment load.

3.2.2 Climate: The climate of the Pagladiya River basin varies significantly along its course. The upper reaches in Bhutan experience a temperate climate with cold winters and moderate summers, while the lower reaches in Assam are characterized by a humid subtropical climate. The region receives substantial rainfall, particularly during the monsoon months from June to September, which plays a crucial role in the river's hydrological dynamics. The area also experiences high humidity and significant temperature variations between summer and winter.

3.2.3 Population and Land Use: The Pagladiya River basin is home to a diverse population that relies on the river for various aspects of their livelihood. In the mountainous regions, the population density is relatively low, with communities primarily engaged in agriculture, livestock rearing, and traditional crafts. As the river flows into the plains of Assam, population density increases, and land use becomes more intensive with extensive agricultural activities, including paddy cultivation, horticulture, and fishing.

3.2.4 Environment: The river's dynamics play a vital role in shaping the local environment and socio-economic conditions. The fertile alluvial plains along the riverbanks support high agricultural productivity, which is the backbone of the local economy. However, the river's tendency to flood during the monsoon season poses significant challenges, leading to the loss of crops, property, and even lives. Efforts to manage and mitigate flood risks are crucial for the sustainable development of the region.

The Pagladiya River, with its diverse hydrology, climate, and socio-economic significance, continues to be a lifeline for the communities along its course, necessitating integrated management approaches to balance ecological health and human well-being.

3.3 DATA

The river morphology data utilized in this study were sourced from the United States Geological Survey (USGS). This dataset was accessed and downloaded to analyze changes in channel morphology, erosion patterns, sediment transport dynamics, and floodplain characteristics. The

USGS data provided essential information for understanding the impacts of human interventions and natural processes on river morphology in the study area.

Table 3.1 satellite data used

Spacecraft ID	LANDSAT 5	LANDSAT 7	LANDSAT 5	LANDSAT 8
DATE	25-12-1990	27-01-2000	16-12-2010	25-11-2020
SENSOR ID	TM	ETM	TM	OLI_TIRS
WRS PATH	137	137	137	137
WRS ROW	42	43	42	42
RESOLUTION(m)	30×30	30×30	30×30	30×30

3.4 TOOLS

The primary tool utilized in the present study is ArcGIS (Geographic Information System) software, developed by Esri. ArcGIS is instrumental for spatial analysis, mapping, and visualization of geographic data, crucial for studying river morphology, land use patterns, and environmental changes. It integrates various data formats such as satellite imagery, digital elevation models (DEMs), and field survey data, enabling sophisticated analysis and modeling of terrain, hydrology, and vegetation. ArcGIS facilitates the creation of maps, identification of spatial relationships, and generation of insightful outputs like flood risk maps and habitat suitability models, essential for informed decision-making in environmental and geographical research. some of the key tool discuss below:

3.4.1. Hydrology Tools

Hydrology tools in ArcGIS are used to analyze and model the movement, distribution, and quality of water within a watershed. Some sub tool are

a) Flow Direction: Determines the direction of flow from each cell to its steepest downslope neighbor.

b) Flow Accumulation: Calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell.

c) Watershed: Delineates drainage basins and watersheds.

d) Stream Order: Assigns a numeric order to streams.

3.4.2 Spatial Analyst Extension

The Spatial Analyst extension in ArcGIS provides advanced spatial modeling and analysis capabilities, including tools for surface analysis, hydrology, terrain analysis, and raster operations.Some sub tool are

a) Raster Calculator: Performs map algebra operations.

b) Slope: Creates a raster representing the slope (gradient) of the terrain.

c) Aspect: Determines the direction that each cell's slope faces.

d) Hillshade: Creates a shaded relief from a surface raster by considering the illumination source angle and shadows.

3.4.3. Analyst Extension

The Analyst Extension in ArcGIS provides advanced spatial analysis tools for tasks such as hydrological modeling, terrain analysis, and surface analysis to support complex geospatial decision-making.Some sub tool are

a) TIN (Triangulated Irregular Network) Creation: Converts raster data to TIN for detailed terrain modeling.

b) Elevation Analysis: Examines the elevation profile of the river.

3.4.4. Geostatistical Analyst Extension

The Geostatistical Analyst extension in ArcGIS provides advanced spatial data analysis tools for creating predictive surfaces and assessing the uncertainty of spatial predictions using various geostatistical methods.Some sub tool are discuss below

a) Interpolation Tools: Kriging, Inverse Distance Weighting (IDW), and other interpolation methods to estimate unknown values from scattered data points.

3.4.5. Model Builder

Model Builder in ArcGIS is a visual programming tool that allows users to create, edit, and manage geoprocessing workflows and models by connecting sequences of geoprocessing tools using a drag-and-drop interface.Some sub tool are discuss below

a) Custom Model Creation: Automates complex workflows by chaining together multiple geoprocessing tools.

3.4.6. Network Analyst

Network Analyst in ArcGIS is a toolset used for performing complex network-based spatial analyses, such as finding the best route, closest facility, service areas, and vehicle routing problems.Some sub tool are discuss below

a) Hydrological Network Analysis: Analyzes the river as a network, useful for understanding flow connectivity and stream ordering.

3.4.7. Data Management Tools

Data Management Tools in ArcGIS provide functionalities for organizing, maintaining, and manipulating geospatial data, including tasks like data conversion, projection, and attribute management.Some sub tool are discuss below

a) Feature Class to Shapefile: Converts data formats.

b) Merge: Combines multiple datasets into a single dataset.

c) Clip: Extracts input features that overlay the clip features.

3.4.8. Field Calculator

The Field Calculator in ArcGIS is a tool used to perform calculations on attribute table data, allowing users to update fields using mathematical expressions, logical statements, or string operations.Some sub tool are discuss below

a) Attribute Calculation: Computes new attributes or updates existing attributes based on expressions.

3.4.9. Charting and Visualization Tools

Charting and visualization tools in ArcGIS allow users to create dynamic and interactive maps, graphs, and charts to analyze and display spatial data effectively.Some sub tool are discuss below

a) Graphing Tools: Creates histograms, scatter plots, and other visual representations of data.

b) Symbology: Visualizes data using various symbology options to distinguish different river characteristics.

CHAPTER 4

METHODOLOGY

4.1 INTRODUCTION

The study utilized multispectral remote sensing data, specifically sourced from the United States Geological Survey (USGS). Landsat imagery spanning the years 1990 through 2020 was acquired at ten-year intervals for analysis (Table 3.1).

Used stacked Landsat images to assess changes in the meandering parameter, land use/land cover (LULC), and river migration. By analyzing Landsat data and digitized river pathways, the study tracked shifts in riverbank lines. Morphological evaluations, which relied on digitized river paths, proved valuable in understanding the formation and impact of oxbows. Additionally, supervised classification techniques were applied to map LULC, revealing trends in land use across the study area. Emphasizing morphological alterations in the river and identifying potential oxbow formation areas constituted the primary focus of this investigation.

The chosen study area's morphological changes and land use/land cover (LULC) alterations along the channel were assessed using various methods illustrated in Figure 4.1. The study employed different Landsat images, detailed in Table 3.1. These images were utilized without atmospheric correction due to clear sky conditions during observation. However, the 30-meter spatial resolution of the images used for generating land use maps stands out as a key concern in this investigation. These resolution limitations contribute to uncertainty in the study's findings.

4.2 METHODOLOGY

Methodology refers to the systematic, theoretical analysis of the methods applied to a field of study. It encompasses concepts such as paradigms, theoretical models, phases, and quantitative or qualitative techniques. Essentially, it is a framework for the collection and interpretation of data, guiding researchers in their approach to understanding phenomena. Methodology includes the principles underlying the methods used in any particular area of research. It aims to ensure the reliability, validity, and accuracy of the research results. In essence, it is the blueprint that helps researchers navigate their studies in a structured and coherent manner.The complete methodology in shown in the fig 4.1 .

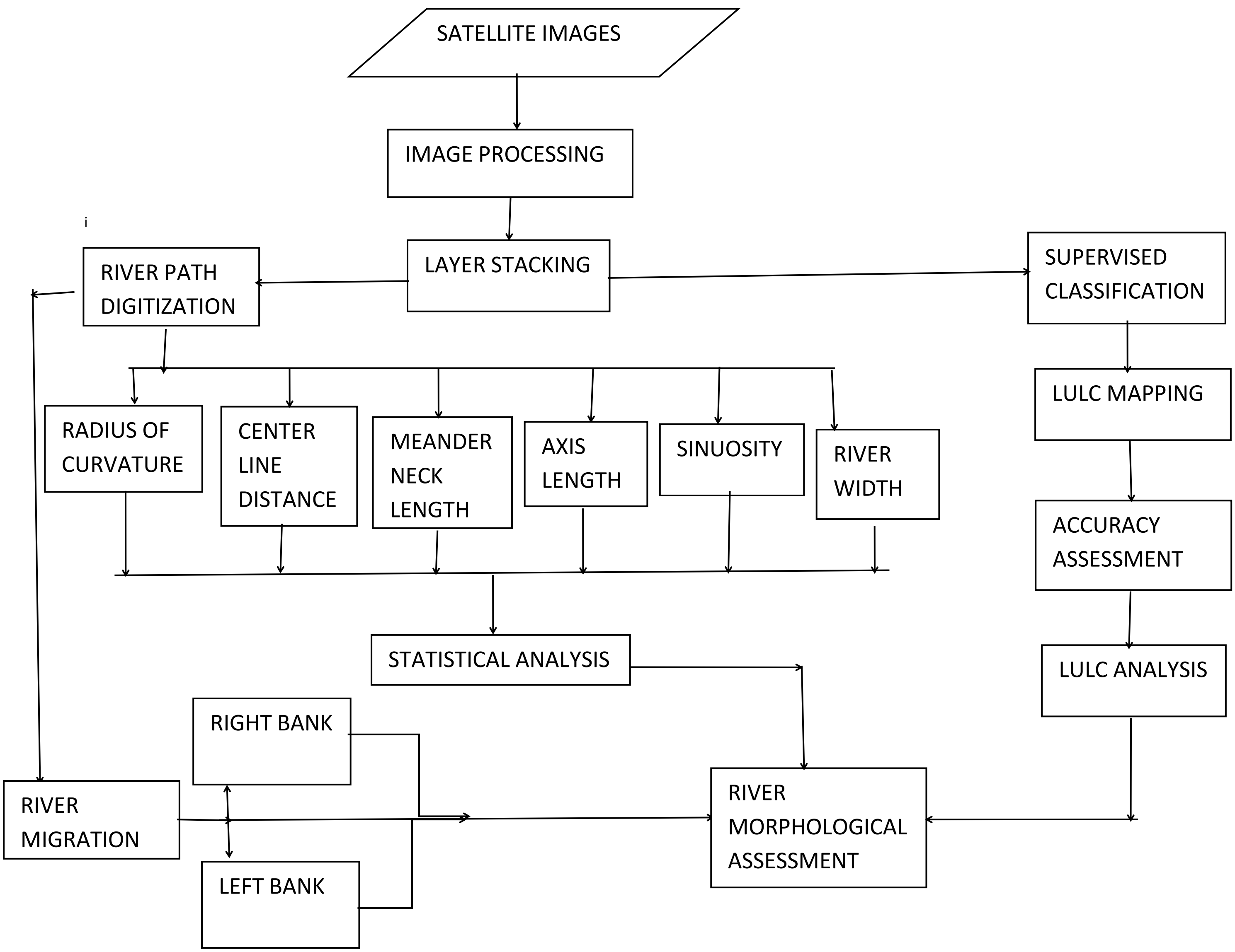

FIG 4.1 - FLOWCHART OF METHODOLOGY

4.2.1 LULC ANALYSIS

Land Use and Land Cover (LULC) analysis involves the study and mapping of the various ways land is utilized and the natural features present on the earth's surface. This analysis helps in understanding the distribution, patterns, and changes in land use and land cover over time. It uses remote sensing, geographic information systems (GIS), and other data collection methods to classify land into categories such as urban, agricultural, forested, and water bodies. LULC analysis is crucial for urban planning, environmental management, and assessing the impacts of human activities on ecosystems, aiding in sustainable development and conservation efforts.All steps are discuss below :

- Georeferencing: Ensure all images are accurately georeferenced to a common coordinate system.
- Radiometric and Atmospheric Corrections: Apply corrections to remove sensor noise and atmospheric interference.
- Cloud Masking: Remove clouds and cloud shadows if present in the images.
- Select Classification Method
    - Supervised Classification: Requires training data (samples of known land cover types).
        - Steps:
            1. Training Data Collection: Collect representative samples for each land cover class.
            2. Classification Algorithm: Use algorithms like Maximum Likelihood, Support Vector Machines (SVM), Random Forest, etc.
            3. Classification: Classify the image based on the training data.
    - Unsupervised Classification: Does not require training data.
        - Steps:

1. Clustering Algorithm: Use clustering algorithms like K-means or ISODATA.
2. Cluster Analysis: Group pixels into clusters based on spectral similarity.
3. Labeling: Manually label the clusters into meaningful land cover classes.

- Post-Classification Processing

1. Smoothing: Apply filters to remove classification noise.

2. Accuracy Assessment: Evaluate the accuracy of the classification using ground truth data or validation samples.

- Analysis and Interpretation

1. Change Detection: Compare LULC maps from different time periods to identify changes.

2. Statistical Analysis: Analyze the spatial distribution and area of each land cover class.

3. Visualization: Create maps and charts to visualize the results.

4.2.2 RIVER PATH DIGITIZATION

From 1990 to 2020, satellite images have been used to consistently delineate and characterize the river bank. The NDWI (Normalized Difference Water Index) imagery has been particularly instrumental in identifying the river bank line. The analysis primarily focuses on tracking the movement of the river channel, alterations in channel width due to erosion and deposition, and pinpointing specific sites prone to erosion and accretion.

The process involves converting the satellite imagery into classified images and generating vector profiles and reference points. By digitizing the distance between these reference points and the river banks on both sides, a line feature is created to quantify river channel migration. Utilizing the computed geometry options in the attribute table, the lengths of these lines are determined.

The recorded values indicate the directional shift of the channel concerning the vector line and channel bank. Positive values signify the channel's movement toward the inner side of the river, signifying accretion. Conversely, negative values indicate erosion as the channel shifts toward the outer banks, leading to a decreased distance between the vector line and the channel bank.

To estimate the erosion and deposition areas over the study period, GIS software tools are employed for calculating polygon areas based on shifting banklines. This approach aids in precisely quantifying the areas affected by erosion and deposition along the riverbanks.

4.2.3 MEANDER PARAMETERS

Meander parameters are fundamental aspects that characterize the behavior and morphology of meandering rivers, shaping their dynamics and features. These parameters encompass various factors crucial in understanding the behavior of these natural watercourses.

Firstly, meander wavelength refers to the distance between consecutive wave crests or troughs along a river's course. It plays a pivotal role in determining the overall length and shape of meanders.

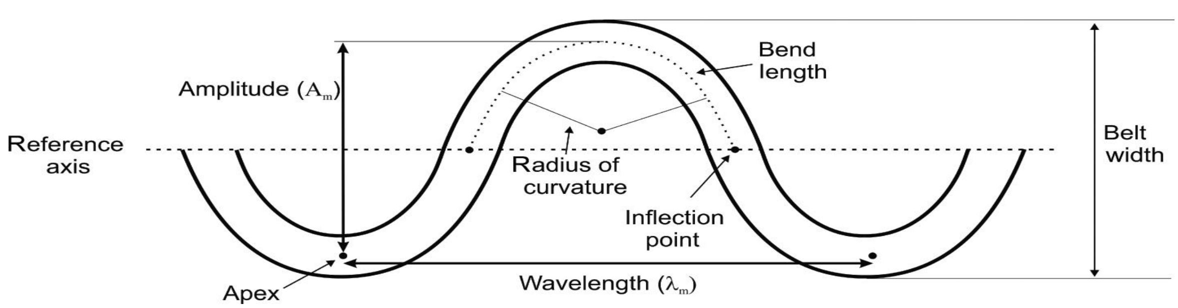

FIG 4.2 - MEANDER PERAMETER

The meander amplitude signifies the maximum distance between the meander's centerline and its bend, influencing the river's width and curvature.The meander migration rate reflects the speed at which a meander's bend shifts or moves across the landscape over time. This migration is influenced by sediment transport, bank erosion, and external factors like human interventions or natural changes.

Bankfull width represents the width of a river at its full capacity, indicating the size of the channel necessary to contain the average discharge during bankfull flow events.

Meander cutoffs occur when a river erodes through the neck of a meander, creating a new, shorter channel and leaving an oxbow lake as a remnant of the former bend.

Sinuosity, another critical parameter, measures the degree of channel curvature, comparing the actual path length of the river to the straight-line distance between its endpoints. Higher sinuosity values indicate more winding channels.

Channel slope refers to the rate of change in elevation along the river's course, influencing flow velocity, erosion, and sediment transport.

Flow velocity is the speed at which water moves within the river channel, affected by various factors like channel width, depth, and slope, impacting erosion and sedimentation rates.

Sediment load characterizes the amount and type of sediment carried by the river, affecting channel morphology, erosion, and deposition patterns.

Channel roughness describes the irregularities and obstructions along the riverbed and banks, influencing flow velocity and patterns.

These parameters collectively influence the behavior, morphology, and evolution of meandering rivers, impacting ecosystems, sediment transport, floodplains, and human activities along their courses. Understanding these parameters is crucial for effective river management, ecosystem preservation, and mitigating risks associated with riverine environments.

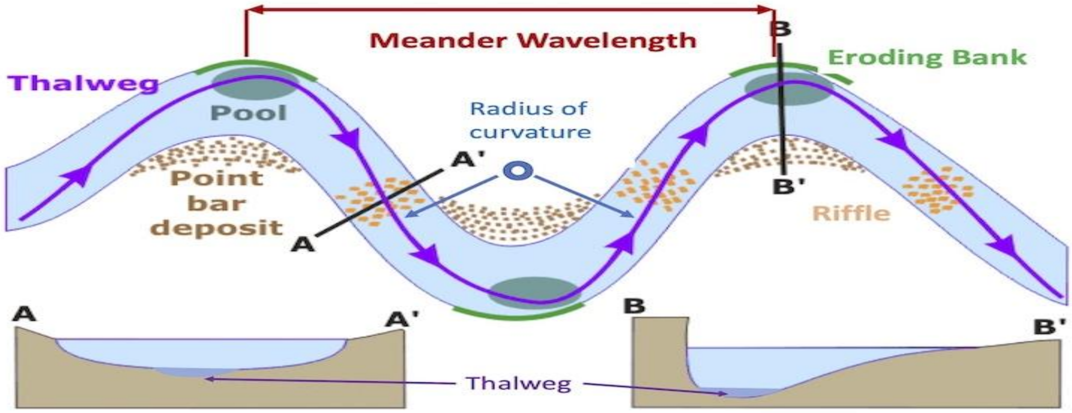

FIG 4.3 - Geometric Features of a Meander

4.2.4 RIVER MIGRATION

River migration is one of the most influential factors in changing river morphology. Unfortunately, most alluvial river lengths are inaccessible by field techniques. However, multi-temporal high-resolution data allows us to track changes in river configurations and riverbank erosion or deposition over time. The shifting of riverbank lines along the Pagladiya River was monitored using Landsat data from 1990 to 2020. River migration was analyzed by digitizing river paths from these Landsat images. To determine the river migration rate, the position of riverbank migration was examined, particularly when the distance between two river sections was significantly reduced.

CHAPTER 5

RESULTS & DISCUSSION

5.1 INTRODUCTION

Land Use Land Cover (LULC) and Meander Parameters are crucial components in understanding and assessing the dynamics of the Earth's surface and water bodies.

LULC refers to the classification and depiction of various types of landscapes based on their physical attributes and human-made structures. It encompasses the categorization of land surfaces into classes like forests, urban areas, agricultural lands, water bodies, etc. Understanding LULC is essential for numerous applications, including urban planning, environmental monitoring, natural resource management, and climate change studies.

On the other hand, meander parameters pertain to the characteristics and behaviors of river channels, specifically focusing on their winding or meandering patterns. These parameters include factors such as channel curvature, sinuosity, bank erosion, and the migration of river bends. Analyzing meander parameters aids in comprehending river behavior, sediment transport, floodplain management, and impacts on surrounding ecosystems.

Both LULC and Meander parameters play pivotal roles in various environmental studies, offering insights into landscape changes, hydrological processes, and human-environment interactions. Their integration and analysis contribute significantly to informed decision-making in land management, conservation efforts, and sustainable development initiatives.

5.2 RESULT & DISCUSSION

5.2.1 LULC ANALYSIS

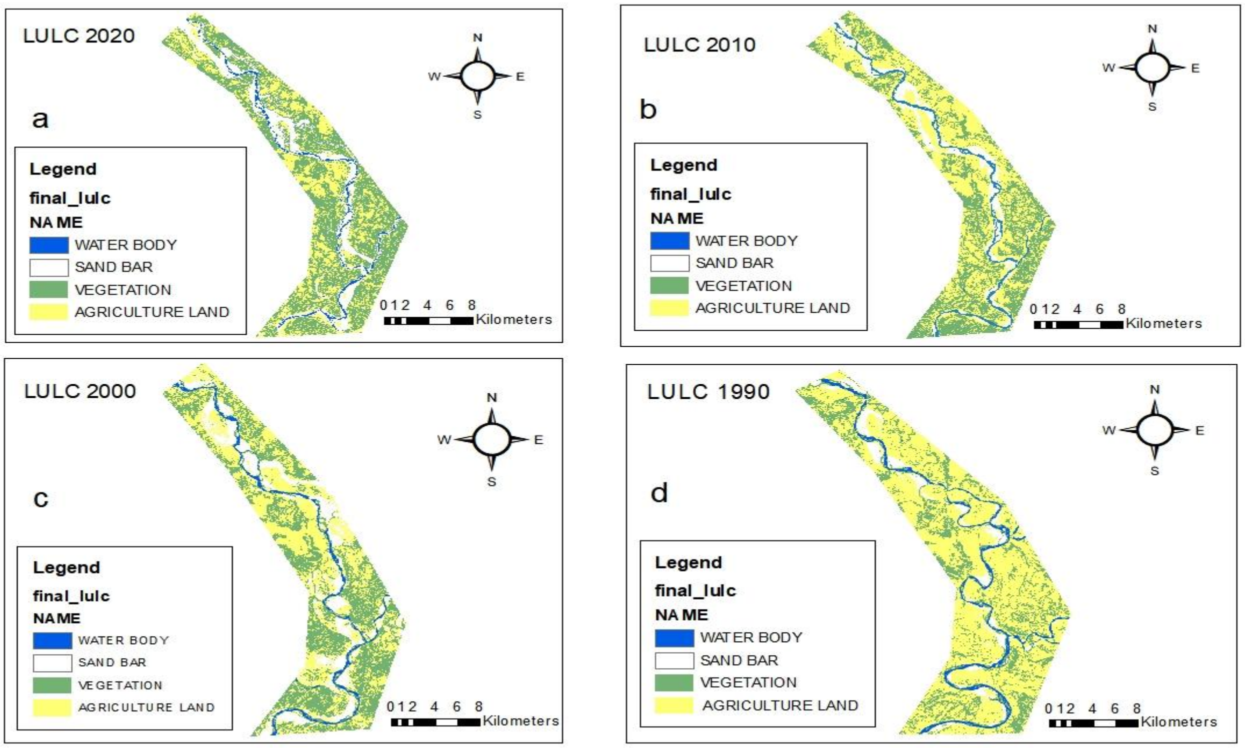

FIG 5.1 - LULC Mapping for years , a)2020 , b)2010 , c)2000, d) 1990

Table 5.1 RESULT OF LULC ANALYSIS :

NAME	1990		2000		2010		2020	
	Sum of Area(Km^2)	Total Area(%)	Sum of Area(Km^2)	Total Area(%)	Sum of Area(Km^2)	Total Area(%)	Sum of Area(Km^2)	Total Area(%)
AGRICULTURE LAND	157.29	70%	96.72	43%	102.60	46%	72.84	33%
RIVER	9.13	4%	6.32	3%	13.56	6%	7.67	3%
SAND BAR	14.17	6%	28.12	13%	25.02	11%	37.50	17%
VEGETATION	42.76	19%	92.19	41%	82.17	37%	105.33	47%
Total Area (Km^2)	223.35	100%	223.35	100%	223.35	100%	223.35	100%

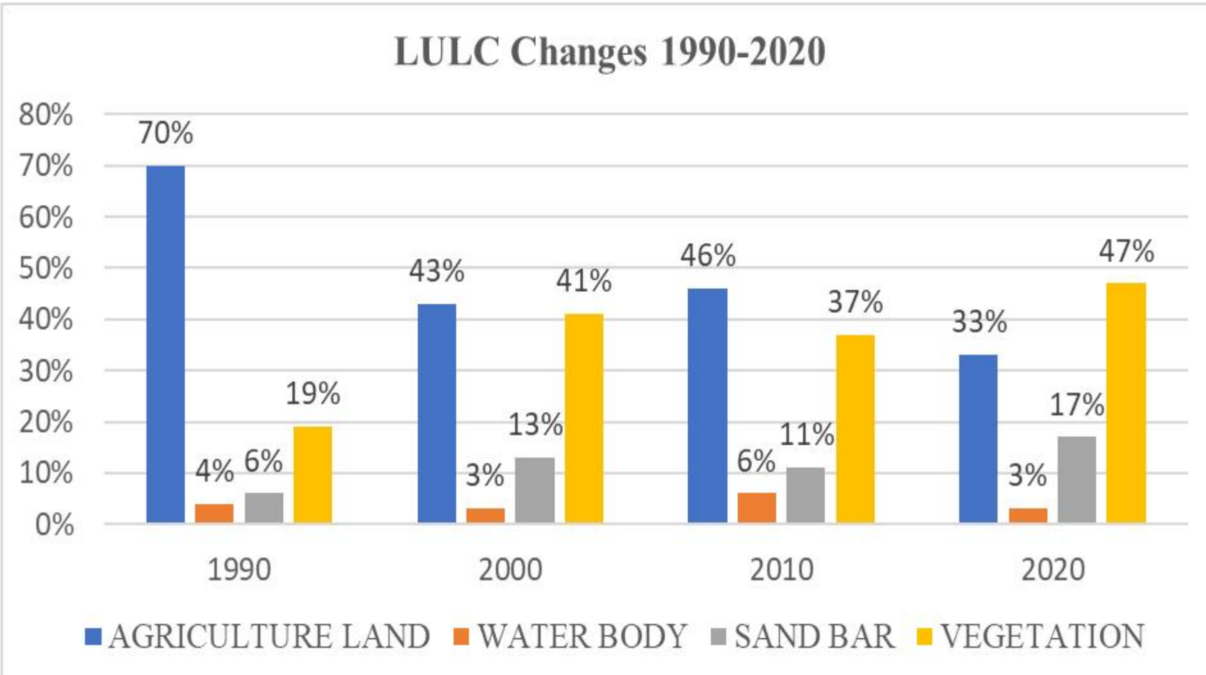

FIG 5.2 - LULC Changes 1990-2020

5.2.1.1 Agriculture Land : There's been a noticeable decline in agricultural land from 70% in 1990 to 33% in 2020, marking a substantial 27% decrease over the period. This decline might signify factors such as urbanization or changes in agricultural practices(Fig5.3).

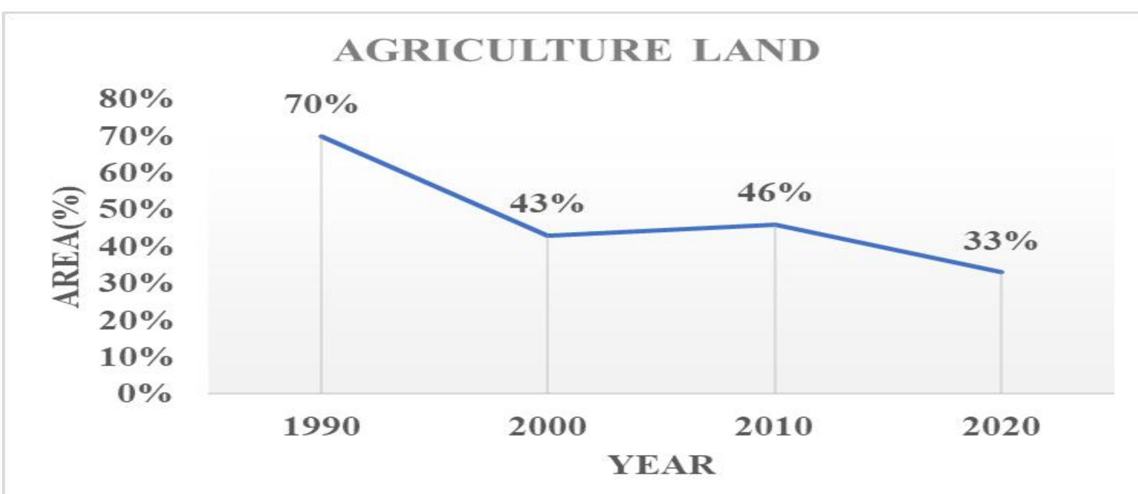

FIG 5.3 - Changes of Agriculture land 1990-2020

5.2.1.2 Water Body : While the river area remained relatively consistent between 1990 and 2020, there were minor fluctuations, with a 3% increase from 2000 to 2010, followed by a 3% decrease from 2010 to 2020. These changes could indicate alterations in water management or natural variations(fig5.4).

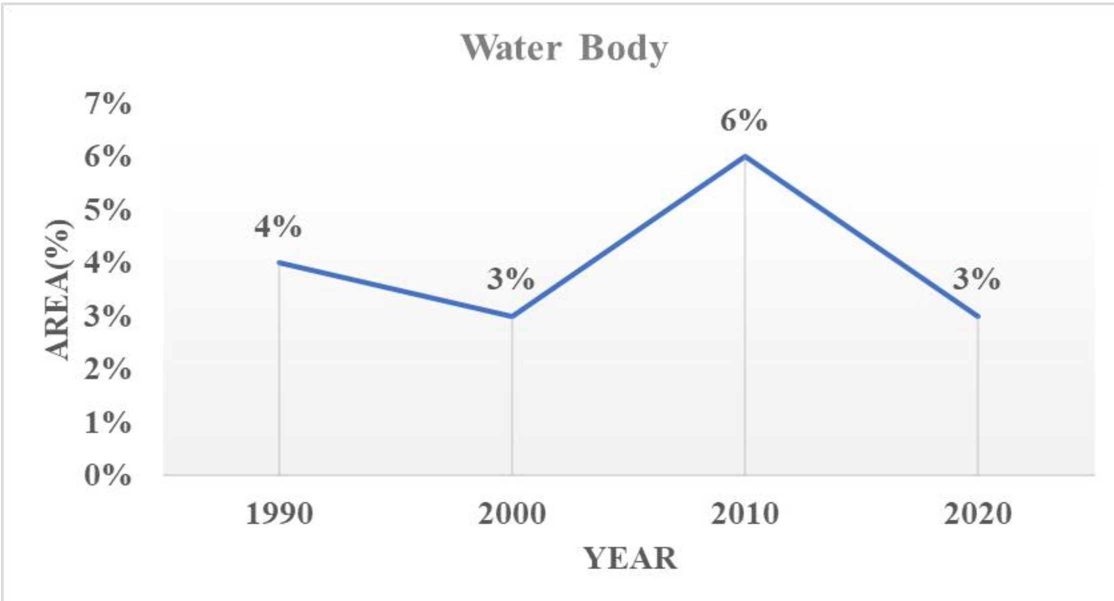

FIG 5.4 - Changes of Water Body 1990-2020

5.2.1.3 Sand Bar : The area classified as sand burn experienced a fluctuating pattern, with an initial rise from 6% in 1990 to 17% in 2020, notably peaking at 13% between 1990 and 2000, followed by a gradual decrease. Potential factors for these changes might include natural processes or human interventions(fig5.5).

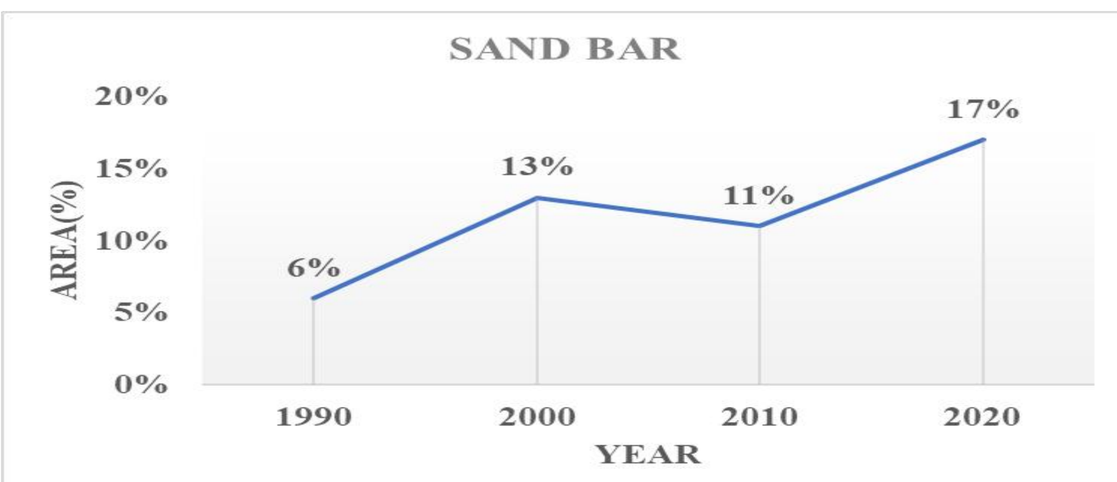

FIG 5.5 - Changes of Sand Bar 1990-2020

5.2.1.4 Vegetation : A remarkable increase in vegetation coverage has been observed, rising from 19% in 1990 to 47% in 2020. This significant 28% growth suggests potential reforestation efforts, land reclamation, or changes in climate conditions favoring vegetative growth(fig5.6).

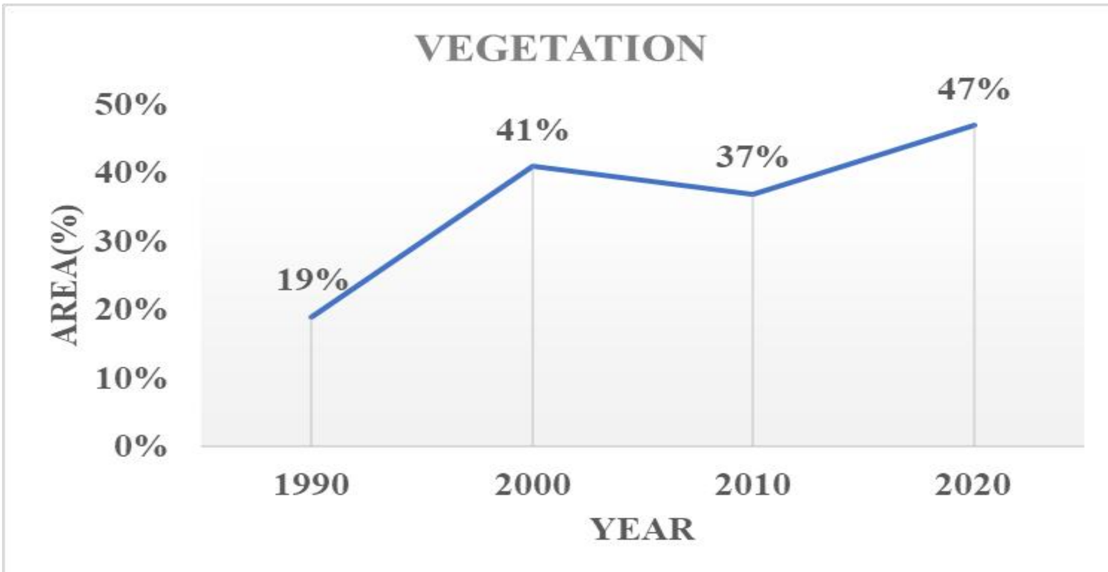

FIG 5.6 - Changes of Vegetation 1990-2020

5.2.2 MEANDER PARAMETER CHANGES

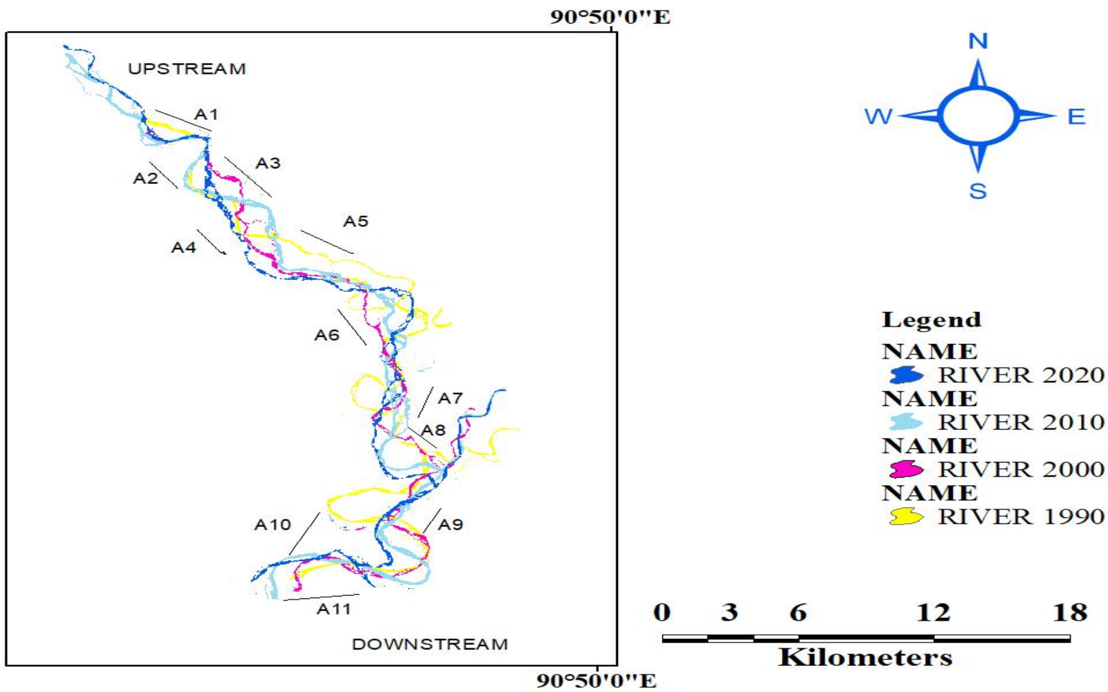

FIG 5.7-Different section (location) for study of changes in meander parameter

5.2.2.1 **Radius of curvature(R)** : The changes in Radius of curvature of pagladiya river at different section are shown in table 5.2, here

TABLE 5.2 Radius of curvature :

Section	Radius of curvature(m)			
	2020	2010	2000	1990
A1	332	508	254	264
A2	1059	988	835	738
A3	1039	569	925	830
A4	846	613	520	654

A5	334	723	364	200
A6	1028	369	450	947
A7	402	294	423	786
A8	863	831	160	515
A9	490	490	490	878
A10	516	830	764	542
A11	436	881	846	208

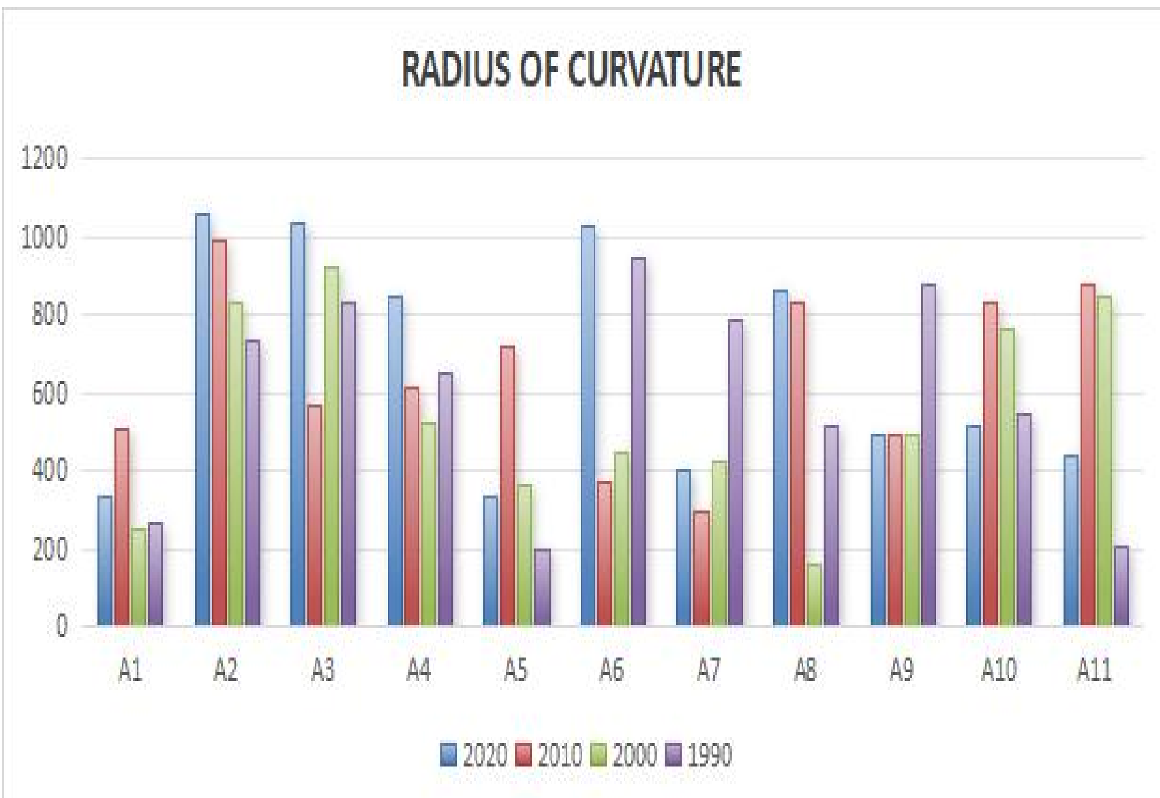

FIG 5.8 - RADIUS OF CURVATURE

Radius of Curvature Indicates the curvature of the river. Fluctuations across the years in different sections suggest changes in the river's shape. Sections like A6 and A7 show significant variations in curvature.

5.2.2.2 **Center line distance(S)** : The changes in Center line distance of pagladiya river at different section are shown in table 5.3, here

TABLE 5.3 Center line distance (S) :

Section	Center line distance(m)			
	2020	2010	2000	1990
A1	3164	3535	3110	2380
A2	4254	4623	4475	3597
A3	4503	5776	4523	4258
A4	3238	4168	3849	4579
A5	4514	3810	3990	3118
A6	6290	5000	4271	8177
A7	2707	2473	3188	7025
A8	3524	4302	4919	3633
A9	3261	2163	2591	6984
A10	3495	6168	5868	5361

A11	6123	6663	5299	3680

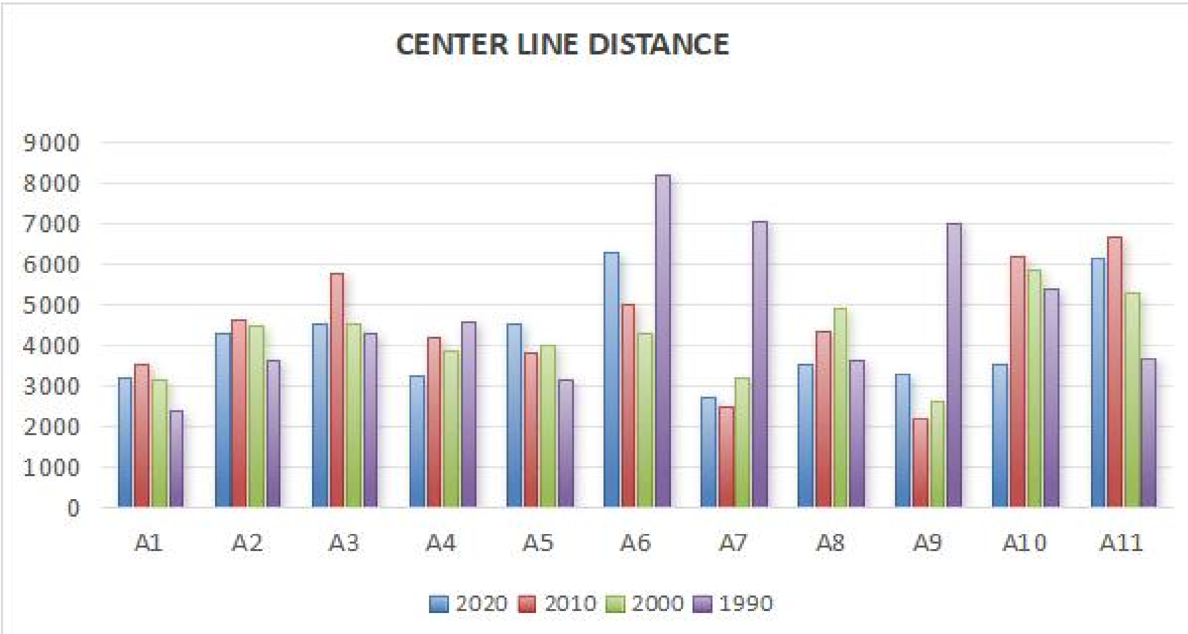

FIG 5.9 - CENTER LINE DISTANCE

Center Line Distance represents the distance along the centerline of the river. Fluctuations imply alterations in the river's path. A6 and A7 seem to have experienced significant changes.

5.2.2.3 **Mender neck length(L)** : The changes in Center line distance of pagladiya river at different section are shown in table 5.4, here

TABLE 5.4 Mender neck length (L) :

Section	Mender neck length(meter)			
	2020	2010	2000	1990
A1	2363	2488	2007	2368

A2	2106	2100	1636	2565
A3	3393	3750	3459	3508
A4	3013	3518	2512	3345
A5	3643	2957	3534	3029
A6	2834	4020	4112	1536
A7	1580	1336	1884	1370
A8	3186	2881	3071	2948
A9	1846	1846	1846	1402
A10	1789	1977	3164	3033
A11	5260	4146	2297	2998

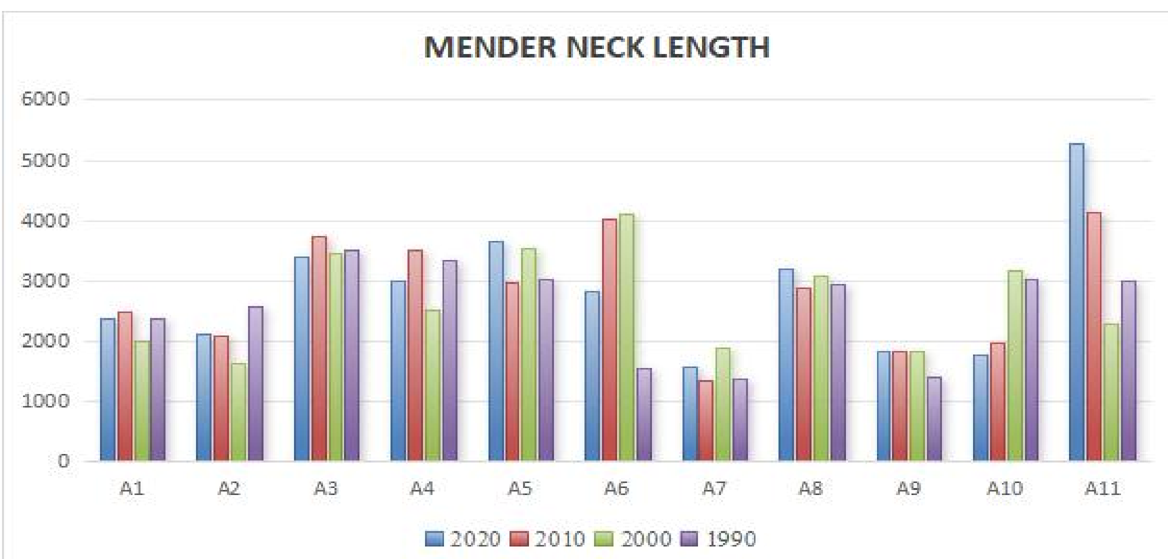

FIG 5.10 - MEANDER NECK LENGTH

Meander Neck Length shows the length of the meander. Sections like A6 and A11 exhibit substantial changes in meander length across the years.

5.2.2.4 **Axis length (A)** : The changes in Axis length of pagladiya river at different section are shown in table 5.5, here

TABLE 5.5 Axis length (A) :

Section	Axis length(meter)			
	2020	2010	2000	1990
A1	857	1010	802	56
A2	1889	1814	1920	1828
A3	443	1424	656	1136
A4	464	984	473	969
A5	1034	1021	813	312
A6	1520	770	464	801
A7	232	365	745	1175
A8	978	1408	1253	925
A9	520	520	520	2878
A10	744	2530	2017	1688
A11	1109	1595	1293	522

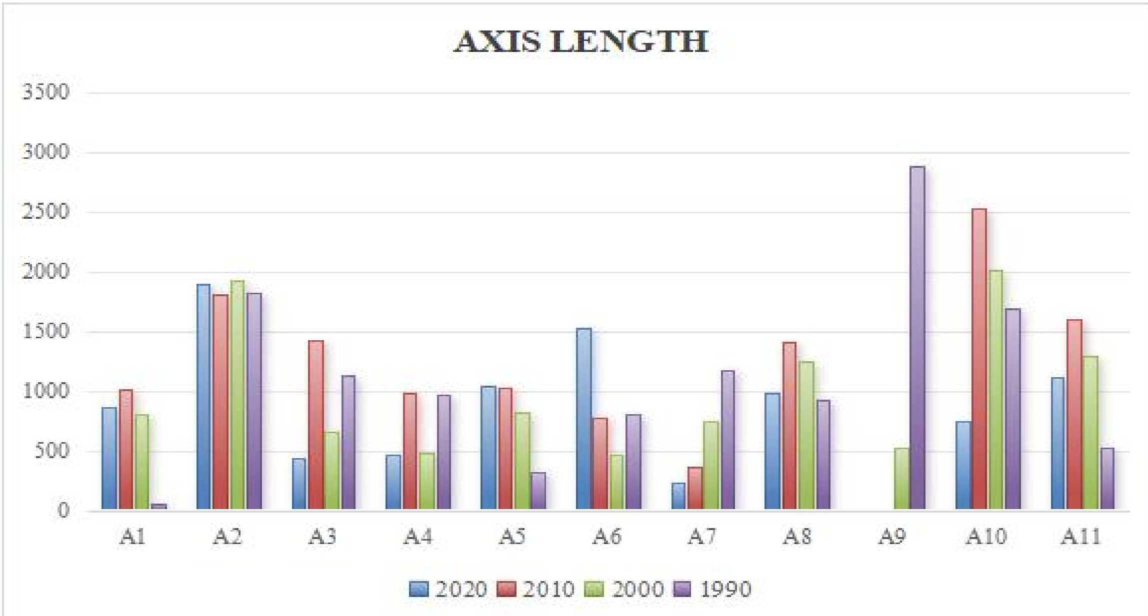

FIG 5.11 AXIS LENGTH

Axis Length indicates the length of the river's axis. A3, A6, and A9 show significant variations, possibly due to changes in the river's width.

5.2.2.5 **River width (W)** : The changes in Axis length of pagladiya river at different section are shown in table 5.6, here

TABLE 5.6 River width (W) :

Section	River width(meter)			
	2020	2010	2000	1990
A1	297	576	248	231
A2	236	123	132	151
A3	426	449	492	394

A4	333	395	160	158
A5	206	247	184	155
A6	303	254	170	550
A7	550	806	146	128
A8	200	318	155	264
A9	295	236	294	275
A10	245	363	252	413
A11	193	256	165	140

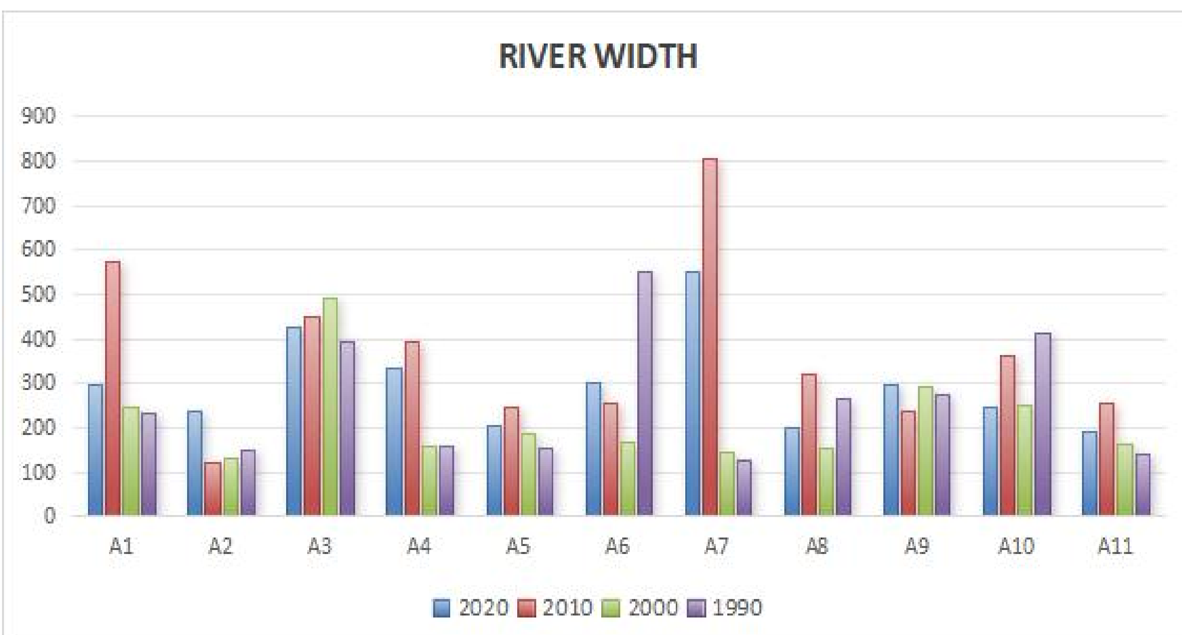

FIG 5.12 RIVER WIDTH

River Width data from 1990 to 2020 shows diverse trends across different categories. Categories like A1 and A4 exhibit notable increases over the period, while categories like A2 and A6 have generally decreased. Some categories, such as A5 and A11, show relative stability with minor fluctuations. Understanding these trends can provide valuable insights for decision-making processes, resource allocation, and policy development in related areas. Further analysis might be required to explore the reasons behind these trends and their implications.

5.2.2.6 **SINUOSITY (C)** : The changes in Axis length of pagladiya river at different section are shown in table 5.7, here

TABLE 5.7 SINUOSITY (C) :

Section	Sinuosity(meter)			
	2020	2010	2000	1990
A1	1.34	1.42	1.55	1.01
A2	2.02	2.20	2.74	1.40
A3	1.33	1.54	1.31	1.21
A4	1.07	1.18	1.53	1.37
A5	1.24	1.29	1.13	1.03
A6	2.22	1.24	1.04	5.32
A7	1.71	1.85	1.69	5.13
A8	1.11	1.49	1.60	1.23
A9	1.40	1.40	1.40	4.98
A10	1.95	3.12	1.85	1.77

A11	1.16	1.61	2.31	1.23

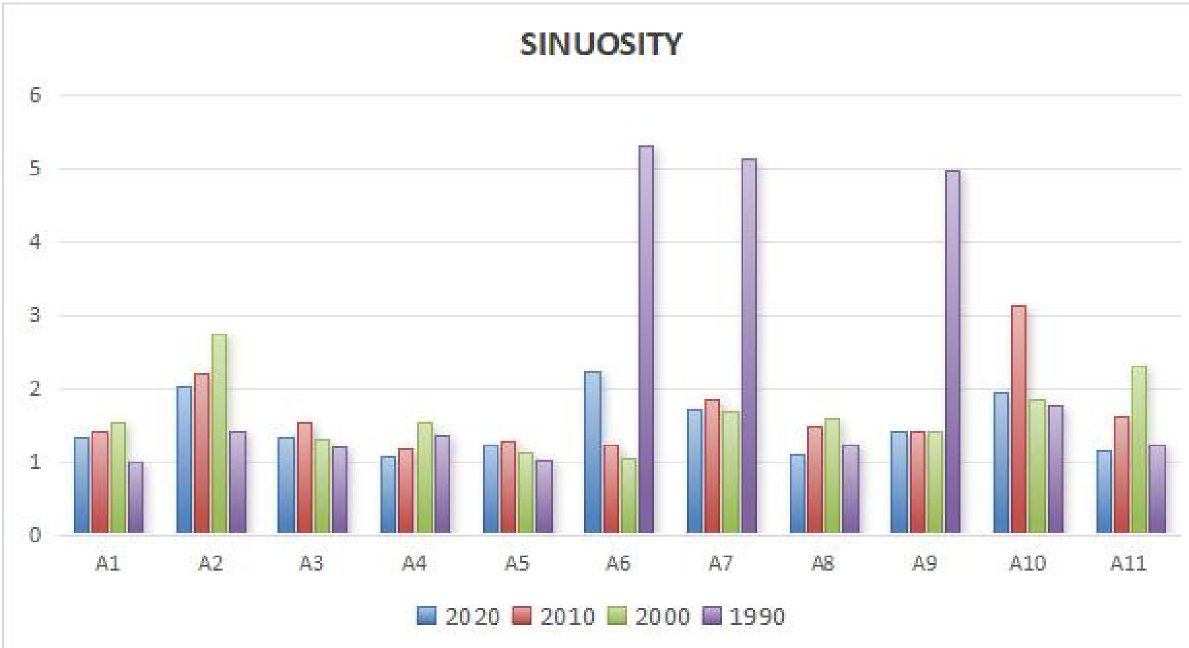

FIG 5.13 SINUOSITY

Sinuosity shows the level of meandering in the river. Sections A6, A7, and A9 show drastic changes, particularly in the year 1990, indicating considerable alterations in the river's path.

In conclusion, several sections of the river underwent significant changes in their curvature, length, width, and meandering pattern between 1990 and 2020. Sections A6 and A7 seem to have experienced the most notable alterations, showcasing changes in curvature, meander length, width, and sinuosity. These changes could be due to various factors such as erosion, sedimentation, or human interventions affecting the river's course and shape over time.

5.2.3 IMPACT OF RIVER MIGRATION ON RIVER MORPHOLOGY

TABLE 5.8 RIVER MIGRATION RATE :

SECTION	TOTAL MIGRATION (1990-2000) METER	MIGRATION RATE (1990-2000) (M/YEAR)			MIGRATION RATE (1990-2010) (M/YEAR)			MIGRATION RATE (1990-2020) (M/YEAR)		
		RIGHT	LEFT	AVG . M/YEAR	RIGHT	LEFT	AVG . M/YEAR	RIGHT	LEFT	AVG . M/YEAR
A1	916	0	51.5	51.5	0	70.25	70.25	0	51.91	51.91
A2	53	8.33	7.92	8.12	8.92	0	8.92	0	5	5
A3	603	139.58	0	139.58	0	13.33	13.33	46.33	0	46.33
A4	55	0	21.33	21.33	0	110.33	110.33	4.58	0	4.58
A5	1907	0	120.83	120.83	0	102.67	102.67	0	158.91	158.91
A6	670	0	130.83	130.83	0	17.75	17.75	55.83	0	55.83
A7	1300	183	0	183	136.5	0	136.5	0	108.33	108.33
A8	1770	4.17	0	4.17	0	133.33	133.33	0	147.5	147.5
A9	2818	207.5	0	207.5	241.66	0	241.66	234.83	0	234.83
A10	1418	0	0	0	0	42.67	42.67	0	118.17	118.17
A11	665	0	17.83	17.83	0	89.33	89.33	0	55.42	55.42

5.2.3.1 Migration during (1990-2000) :

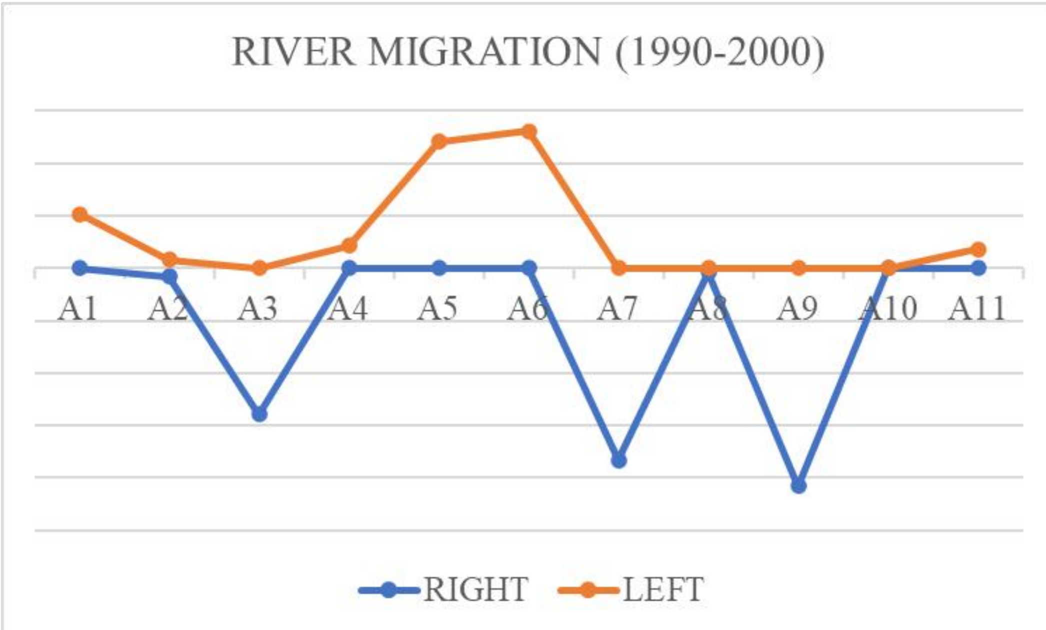

FIG 5.14 RIVER MIGRATION (1990-2000)

- RIGHT Migration:

1. Categories A3, A7, A9 show significant peaks, indicating a high migration rate to the right direction during the 1990-2000 period.
2. These peaks suggest substantial movement or relocation in these specific categories.

- LEFT Migration:

1. Category A5, A6 shows a significant peak, indicating a high migration rate to the left direction.
2. Other categories such as A1, A4 and A11 show moderate migration rates in the left direction.

- Stable or No Migration:

1. Several categories, including A1, A4, A5, A6, A10 and A11 show zero migration rates in the right direction, indicating stability or no significant migration in these directions.
2. Categories A3, A7, A8, A9 and A10 show zero migration rates in the left direction.

The migration rate data from 1990 to 2000 shows distinct patterns in different categories. There are notable peaks in categories A3, A7, and A9 for the right migration, while category A5, A6 shows a significant peak for left migration. These trends suggest that certain categories experienced substantial migration movements, while others remained relatively stable during this period. Understanding these patterns can help in identifying the factors driving migration and aid in planning and resource allocation.

5.2.3.2 MIGRATION RATE (1990-2010) :

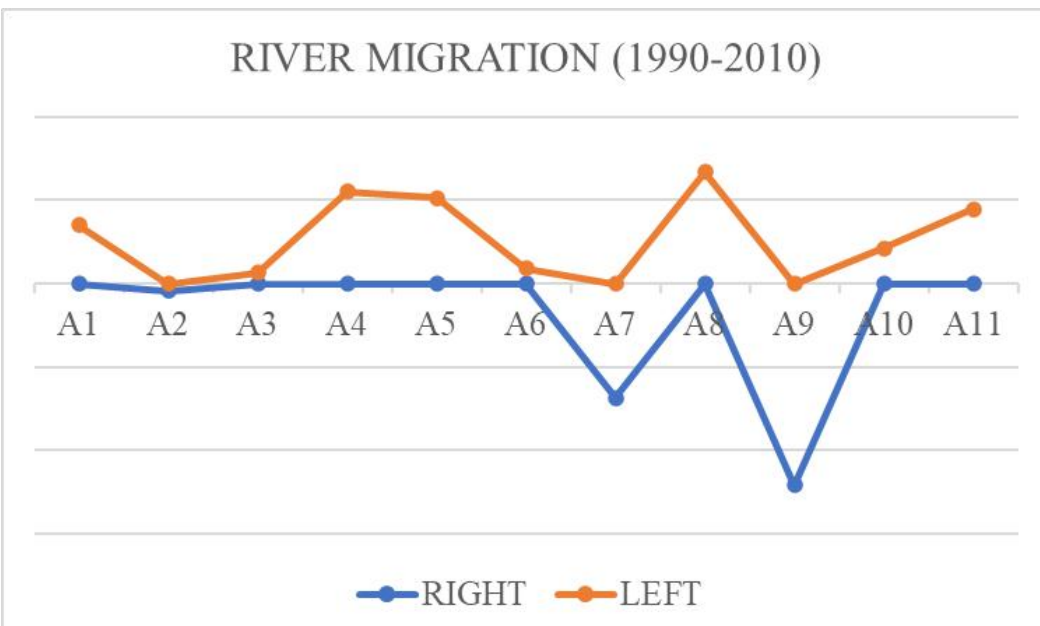

FIG 5.15 RIVER MIGRATION (1990-2010)

- RIGHT Migration:

1. Categories A7 and A9 show significant peaks, indicating a high migration rate to the right direction during the 1990-2010 period.

2. These peaks suggest substantial movement or relocation in these specific categories.

- LEFT Migration:

1. Categories A1, A4, A5, A8, A10 and A11 show notable migration rates in the left direction.
2. These peaks indicate that there was considerable movement or relocation in these categories to the left direction.

- Stable or No Migration:

1. Several categories, including A1, A3, A4, A5, A6 ,A8, A10 and A11, show zero migration rates in the right direction, indicating stability or no significant migration in these directions.
2. Categories A2, A7, and A9 show zero migration rates in the left direction.

The migration rate data from 1990 to 2010 shows distinct patterns in different categories. There are notable peaks in categories A7 and A9 for the right migration, indicating significant movements in these directions. On the left migration side, categories A1, A4, A5, A8, A10 and A11 exhibit notable peaks, suggesting substantial movements in these directions. Understanding these patterns can help in identifying the factors driving migration and aid in planning and resource allocation.

5.2.3.3. MIGRATION RATE (1990-2020) :

- RIGHT Migration:

1. Categories A3, A6, and A9 show significant peaks, indicating a high migration rate to the right direction during the 1990-2020 period (fig5.12).
2. These peaks suggest substantial movement or relocation in these specific categories.

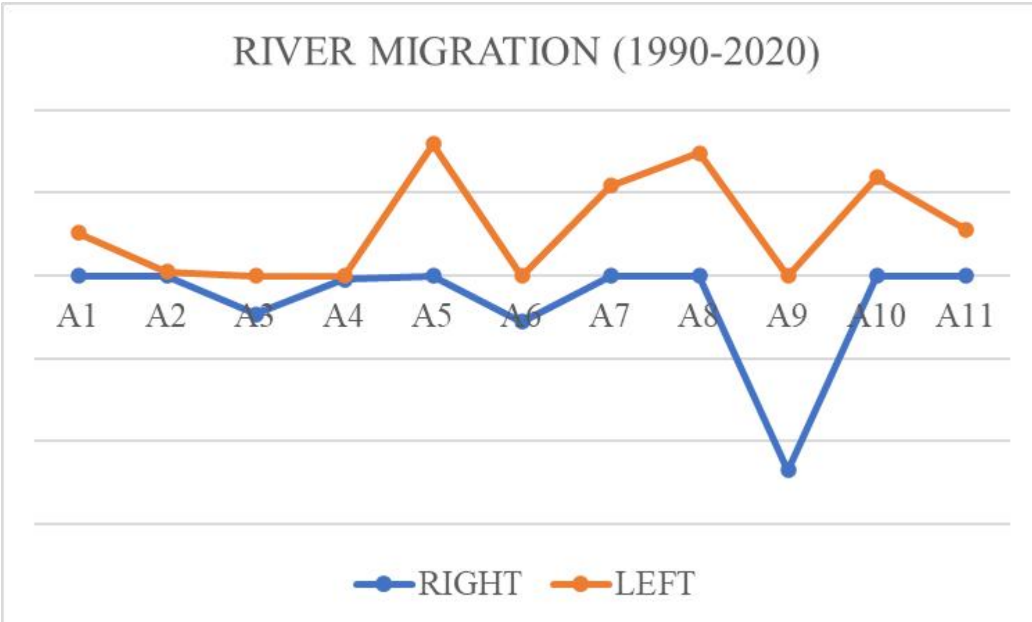

FIG 5.16 RIVER MIGRATION (1990-2020)

- LEFT Migration:

  1. Categories A1, A5, A7, A8, A10 and A11 show significant peaks, indicating a high migration rate to the left direction.
  2. These peaks indicate considerable movement or relocation in these categories to the left direction.

- Stable or No Migration:

  1. Several categories, including A1, A2, A5, A7, A8, A10 and A11, show zero migration rates in the right direction, indicating stability or no significant migration in these directions.
  2. Categories A3, A4, A6 and A9 show zero migration rates in the left direction.

The migration rate data from 1990 to 2020 reveals distinct patterns in different categories. Notable peaks in categories A3, A6, and A9 for right migration indicate significant movements in these directions. For left migration, categories A1, A2, A5, A7, A8, A10 and A11 exhibit notable peaks, suggesting substantial movements in these directions. Understanding these patterns can help in identifying the factors driving migration and aid in planning and resource allocation.

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CHAPTER 6

CONCLUSION & FUTURE SCOPE

6.1 CONCLUSION

In summary, the LULC analysis and meander parameter assessment reveal significant transformations in the river area over the past three decades. The decline in agricultural land and increase in vegetation highlight changing land use practices, possibly influenced by urbanization, reforestation efforts, and improved land management. The meander parameter analysis underscores the dynamic nature of river morphology, with significant changes in curvature, length, width, and meandering pattern observed in several sections. The migration analysis reveals substantial variations in migration rates and directions across different sections, reflecting the complex interplay of natural processes and human interventions.

Understanding these changes is crucial for sustainable land management and policy formulation aimed at preserving ecosystems and ensuring a balanced environment for future generations. The insights gained from this analysis can guide resource allocation and planning efforts to manage river morphology and mitigate the impacts of river migration effectively.

6.2 FUTURE SCOPE

Here are five potential future scopes for river morphology analysis:

1)Advanced Remote Sensing Techniques : Integration of high-resolution satellite imagery and drone technology for precise monitoring of river changes.Utilization of LiDAR and multispectral imaging to obtain detailed topographic and vegetative data.

2)Climate Change Impact Studies : Investigating the effects of climate change on river dynamics, including altered flow regimes and sediment transport.Assessing the resilience and adaptability of river systems to extreme weather events and changing precipitation patterns.

3)Sediment Transport and Deposition : Detailed study of sediment sources, pathways, and deposition patterns to understand their impact on river morphology.Development of models to predict future sediment transport and deposition under varying environmental conditions.

4)Ecosystem and Biodiversity Assessment : Analysis of how changes in river morphology affect aquatic and riparian ecosystems.Evaluating the impacts on biodiversity, habitat availability, and ecosystem services.

5)Human and Infrastructure Interactions : Examination of the influence of human activities, such as dam construction, urbanization, and agriculture, on river morphology.Planning and implementing sustainable infrastructure projects that account for river dynamics and reduce negative impacts.

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