# A STUDY ON BANKLINE MIGRATION OF RIVER BRAHMAPUTRA AND SOME OF ITS TRIBUTARIES

***A dissertation submitted in***

***Partial fulfilment of the requirements for the award of the degree of***

***MASTER OF TECHNOLOGY***

*in*

***CIVIL ENGINEERING***

*(With specialisation in Water Resources Engineering)*

*Under*

***ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY***

***SESSION: 2022-2024***


***Submitted by:***

***BHASKAR BARUAH***

***Roll No:*** **220620061004**

***ASTU Registration No:*** **107403117**

***Under the guidance of:***

***PROF. PANKAJ GOSWAMI***

***Department of Civil Engineering***

***ASSAM ENGINEERING COLLEGE***

**JALUKBARI, GUWAHATI-13, ASSAM.**

# DECLARATION

I hereby certify that the work presented in the dissertation entitled "**A STUDY ON BANKLINE MIGRATION OF RIVER BRAHMAPUTRA AND SOME OF ITS TRIBUTARIES**" is accorded for the award of the Degree of Master of Technology in Civil Engineering with specialization in Water Resources Engineering submitted in the Department of Civil Engineering, Assam Engineering College , Guwahati, Assam, in authentic record of my work carried out under the guidance of Prof. Pankaj Goswami, Department of Civil Engineering, Assam Engineering College, Guwahati.

The matter embodied in this project has not been submitted by me for the award of any other degree.

This is to certify that the above statement made is correct to the best of my knowledge.

Dated

**BHASKAR BARUAH**

ASTU Roll No: 220620061004

M. Tech 4th Semester

Department of Civil Engineering

Assam Engineering College

# CERTIFICATE OF SUPERVISION

This is to certify that the work presented in the this report entitled "**A STUDY ON BANKLINE MIGRATION OF RIVER BRAHMAPUTRA AND SOME OF ITS TRIBUTARIES**" is submitted by **Bhaskar Baruah**, **Roll No: 220620061004**, a student of M.Tech 4th semester, Department of Civil Engineering, Assam Engineering College, to the Assam Science and Technology University 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 under my guidance and supervision.

Date:

Place: Guwahati

**DR. PANKAJ GOSWAMI**
Professor
Department of Civil Engineering
Assam Engineering College

# CERTIFICATE OF APPROVAL

This is to certify that **Bhaskar Baruah**, Roll No: **220620061004** a student of M.Tech 4th semester of Civil Engineering Department (Water Resources Engineering), Assam Engineering College, has submitted his project on **"A STUDY ON BANKLINE MIGRATION OF RIVER BRAHMAPUTRA AND SOME OF ITS TRIBUTARIES"** for partial fulfillment of the requirement for the award of the degree of Master of Technology in Civil Engineering with specialization in Water Resources Engineering under Assam Science and Technology University.

Date:

Place: Guwahati

**DR. JAYANTA PATHAK**
Professor and Head of Department
Civil Engineering Department
Assam Engineering College
Jalukbari, Guwahati-13, Assam

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Date

Place: Guwahati

**BHASKAR BARUAH**

M.Tech, 3rd Semester

Water Resources Engineering

Assam Engineering College

# ABSTRACT

This study presents a comprehensive 30-year analysis (1990-2020) of the Brahmaputra River and its ten tributaries, emphasizing changes in river width and patterns of erosion and deposition. Utilizing ArcGIS software and Landsat imagery, the study meticulously maps and quantifies river bank migration across various sections. Significant findings include the Brahmaputra River's average width increase, with notable expansions at XS-1 (Jonai Dhemaji to Baghjangaon Tinsukia) and XS-4 (Dhakuakhana to Sivasagar). The Subansiri River experienced pronounced lateral migration and channel avulsion between 1995 and 2000, while other rivers such as the Dikrong, Buroi, and Borgang showed substantial width fluctuations and shifts in bank positions. The Jia Bharali River demonstrated significant sediment deposition and channel contraction, while the Sankosh River exhibited consistent erosion primarily on its right banks. Other tributaries, including the Dikhow, Dudhnoi, Krishnai, and Murnoi Rivers, displayed varying trends in width and bank migration.

The study found more pronounced bank-line migration in the north bank tributaries of the Brahmaputra River compared to the south bank tributaries, indicating differing geomorphological and hydrological dynamics. This differential migration pattern suggests influences from topography, land use, and hydrodynamic forces. The study underscores the dynamic and evolving nature of the Brahmaputra River system, highlighting the importance of continuous monitoring for effective river management. The findings provide valuable insights into the impacts of natural processes and anthropogenic activities on river morphology, contributing to the broader fields of fluvial geomorphology and environmental management. The study's methodology and results can serve as a reference for similar riverine studies, informing future river management and conservation efforts.

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# CHAPTER 1

# INTRODUCTION

The Brahmaputra River is a major river in Asia that flows through Tibet (China), India, and Bangladesh. The river originates from the Chemayungdung glacier in the Kailash Range of the Himalayas in Tibet, China. The glacier is located at an elevation of approximately 5,300 meters (17,400 feet) above sea level. The Brahmaputra river spans a total distance of 2880 km, encompassing 1625 km in Tibet, 918 km in India, and 354 km in Bangladesh. The Brahmaputra River's catchment area in Tibet covers 293,000 square kilometres, while in India and Bhutan, it spans 240,000 square kilometres. In Bangladesh, the catchment area is 47,000 square kilometres. The overall extent of the Brahmaputra basin encompasses a vast area of 580,000 square kilometres, extending until its confluence within Bangladesh.

The importance of studying the Brahmaputra River's morphology lies in its dynamic nature, significantly impacting the environment, ecosystems, and communities. It's crucial for sustainable water resource management, flood risk assessment, and infrastructure planning due to its large drainage basin and susceptibility to frequent floods and channel changes.

Baruah et al.'s (2013) research stresses assessing flood hazards and the river's behaviour amidst climate change and human interventions. Understanding channel patterns and sediment transport is vital for effective flood mitigation. Additionally, Hazarika et al. (2015) highlight the correlation between river morphology and aquatic species' distribution, emphasizing the need to preserve natural channel features for diverse ecosystems.

Consideration of the Brahmaputra's morphological dynamics in infrastructure planning is critical for the stability of structures like bridges and embankments. Ahmed et al. (2019) emphasize incorporating river morphology in engineering projects for resilience against geomorphic changes and sustainable development.

Furthermore, erosion and deposition in the Brahmaputra impact the landscape, habitats, and human settlements. These processes are vital for effective river management and sustainable development. Dutta et al. (2019) stress proactive management in erosion-prone areas to mitigate

risks to settlements and infrastructure. Conversely, Hazarika et al. (2020) highlight studying sediment deposition for optimizing agricultural practices in fertile regions formed by deposition.

The primary objective of this study is to investigate the bank-line migration of the Brahmaputra River from Sadiya to Dhubri, with a focus on its course and patterns. This study also seeks to investigate the migration patterns of the Brahmaputra River's major tributaries, namely the dikhow, subansiri, dikrong, buroi, borgang, kameng, dudhnoi,krishnai, murnoi and sankosh rivers, all of which are located within the borders of Assam.

ArcGIS software, a crucial tool in academic studies, plays a pivotal role in analysing river bank-line migration. This Geographic Information System (GIS) provides powerful spatial analysis and mapping tools, facilitating the study and monitoring of changes in river bank-lines over time. By leveraging spatial data, ArcGIS enables the visualization and interpretation of river dynamics, encompassing migration patterns and associated factors. Its significant advantage lies in the integration of diverse geospatial datasets, including satellite imagery, aerial photographs, and elevation models, allowing researchers to conduct comprehensive analyses of river bank-line migration. This integration considers factors such as land use changes, climate variations, and human activities. For instance, researchers utilize ArcGIS to generate time-series maps illustrating the evolution of river bank-lines, aiding in the identification of trends, patterns, and potential contributing factors to migration. Moreover, the software allows for the overlay of different thematic layers, facilitating the identification of areas prone to erosion or deposition (ESRI, 2021)

# CHAPTER 2

# LITERATURE REVIEW

**Kumar & Siddiqui (2021)** examines course changes in the Ganga River, utilizing satellite-derived data from 1980 to 2020. The research employs Remote Sensing (RS) and Geographic Information System (GIS) techniques to detect shifts near Mirzapur city, India. Its objective is understanding morphological and hydrological factors influencing channel migration. The study contributes insights for river management, addressing agricultural, housing, and economic losses due to channel shifts. Landsat imagery reveals erosion and deposition as common occurrences, pinpointing vulnerable cross-sections requiring proactive construction measures. Observations indicate a gradual return of the river's flow to its former path, showcasing a course alteration during the 40-year span.

**Nabi et al. (2016**) employs GIS and Remote Sensing techniques to scrutinize the evolving bankline of the Meghna River from the 1760s, with a specific focus on Rennell's Atlas Plate-19 region. The study aims to identify and compare bankline shifts, utilizing historical maps from the 1760s, Landsat Imagery from 1988 and 2014. The research assesses maximum bankline shifting, distinguishing depositional and erosional features. Additionally, it aims to comprehend changes in Meghna River channel width over time, attributing variations to factors like sedimentation and water level decline. The methodology utilized strives to generate high-quality maps depicting bankline shifting changes across the study area in both spatial and temporal dimensions. Notably, at cross-section 5, the study reveals significant bankline shifts, with the right bankline moving eastward by 12.87 km and the left bankline shifting westward by 9.67 km, indicative of a predominance of depositional features. Over the centuries, Meghna River's channel width has contracted by 11.13 km (1760s to 2014), attributed to sedimentation and declining water levels.

**Alam et al.(2007)** utilizes remote sensing and GIS techniques to analyze morphological changes in Bangladesh's Old Brahmaputra River and their social impacts. The study examines images from 1997 to 2004, focusing on the river's north-east area in Mymensingh sadar upazila and the lower region near Mymensingh town. It aims to pinpoint significant alterations in these areas and understand the factors driving these changes, particularly sediment transportation.

Additionally, a questionnaire survey among locals evaluates socio-economic repercussions. Notably, the study reveals substantial morphological shifts in the north-east but lesser changes near Mymensingh town. It identifies the China Bangladesh Friendship Bridge (Shambhuganj Bridge) as a contributing factor and underscores sediment transportation as a key driver. Insights garnered from the survey shed light on the effects on the local population. Overall, the findings offer valuable insights for future planning to safeguard agricultural land and the surrounding ecological balance.

**Nath et al. (2013)** examined river bank erosion trends in Chandpur district, Bangladesh, using remote sensing and GIS techniques. It aimed to track three decades of historical shifts in the left bank alignment of the Meghna River, identifying erosion and deposition areas. Findings revealed prolonged erosion along the Meghna's left bank, peaking between 1990 and 2002, causing a loss of 3517 sq meters of land. However, recent observations show a shift towards higher deposition than erosion. The left bank migration primarily occurred northwestward and southeastward due to tidal effects, Padma and Meghna river flows, and channel adjustments. Past protective measures proved ineffective, with unprotected areas experiencing increased erosion rates. It recommends further investigation into future channel shifts, erosion rates, location vulnerabilities, and strategies to mitigate erosion's impact effectively.

**Lovric & Tosic (2016)** conducted a comprehensive study utilizing remote sensing and GIS to evaluate the Bosna River's bank erosion, accretion rates, and lateral channel migration. The research aimed to comprehend these dynamics in the lower course of the river, addressing practical implications for engineering and planning by analyzing available data and GIS techniques. The study identified the Bosna River's average movement between 1958 and 2013 as 132.4 meters, reaching a maximum of 330.7 meters. Lateral channel migration averaged 2.5 meters annually during this period. Bank erosion (8.3430 km2) and accretion (10.7074 km2) were observed, impacting arable land, forests, pastures, meadows, and agricultural production. Additionally, the analysis highlighted bank erosion's influence on administrative border changes, necessitating further research to integrate fluvial processes with socio-economic factors for predictive and mitigative purposes.

**Sarma & Acharjee (2018)** conducted a comprehensive study aiming to investigate the temporal changes in channel width and braiding intensity of the Brahmaputra River in Assam, India, and to understand the underlying factors influencing these variations. The research, spanning nine decades, revealed a significant increase in the river's channel width throughout the Assam Valley. Moreover, it established a direct relationship between channel width and braiding intensity, highlighting the impact of factors such as discharge fluctuations, sediment loads, alluvial bank erosion, and width/depth ratios on braiding development. This study emphasizes the need for an interdisciplinary approach to river management, advocating collaboration among engineers, earth scientists, and social scientists to assess diverse management options considering economic and social implications across different timescales. The findings underscore the importance of these insights in comprehending the behavior of the Brahmaputra River and its substantial implications for the local environment and communities, thereby providing a valuable framework for informed river management strategies [T1-T6].

**Nath & Ghosh (2022)** conducted a comprehensive study with the primary objective of analyzing morphological transformations in a segment of the Barak River from 1990 to 2020, utilizing remote sensing data. The investigation further sought to evaluate the influence of alterations in land use and land cover (LULC) on the river's morphology. Within the study period, the Barak River exhibited substantial alterations in parameters such as river width, sinuosity, and meandering. Oxbow formation emerged as a pivotal factor contributing to sinuosity fluctuations, pinpointing specific areas as potential sites for future oxbow development. Urgent protective measures are imperative to avert additional cutoffs and downstream vulnerability. LULC changes, notably driven by agricultural and urban activities, significantly impacted river morphology, with declines in water bodies, forests, and bare land, alongside an increase in agricultural and settlement areas. The application of remote sensing, GIS techniques, and multi-temporal satellite data proved effective in monitoring river morphological activity and analyzing LULC changes. These methods offer valuable insights for enhanced river management and mitigation strategies addressing the consequences of morphological alterations.

**Ophra et al. (2018)** conducted a comprehensive study aiming to evaluate the dynamics of bank lines in Munshiganj, Madaripur, and Shariatpur districts along the Padma River in Bangladesh. The research focused on quantifying spatial and temporal morphological changes of

the Padma River, specifically addressing channel shifting, erosion, and deposition patterns. The study employed primarily analytical methods to assess trends in river bank movement over 29 years (1988-2017). Findings revealed a notable westward shift in the lower part of the river and increased width in the upper segment, while the middle portion remained relatively stable. The Padma River displayed persistent braided features and meandering tendencies, signifying an ongoing lack of equilibrium, suggesting potential future bank erosion. Throughout the study period, an average erosion rate of 1472.056 ha/year and an average accretion rate of 1610.152 ha/year were observed, with variations across different time intervals. The total land eroded accounted for 42,689.59 ha, while 46,694.46 ha experienced accretion. The study concludes by emphasizing the continued likelihood of bank erosion due to the Padma River's evolving meandering and braided characteristics, particularly in its southern course, highlighting the absence of an equilibrium state.

**Sharma et al.(2006)** research aims to comprehensively analyze the Brahmaputra river's characteristics and dynamics, focusing on bank line alterations, wetland ecosystem changes in Deepor Beel, and identifying turbidity patterns from satellite imagery. The study involves mapping wetland dynamics and turbidity patterns in Deepor Beel, utilizing multi-temporal satellite imagery within the Brahmaputra basin. Employing a rule-based decision tree classification method, the research targets wetland identification and extraction for subsequent analysis, correlating observed wetland changes with turbidity patterns noted in satellite imagery. Utilizing Indian Remote Sensing (IRS) LISS-III sensor images from 1990, 1997, 2000, and 2002, the study analyzes morphological features and dynamics of the Brahmaputra river and the local wetland ecosystem. Encompassing the Brahmaputra River from Kobo to the Bangladesh border (a span of 622.73 km), the research selected cloud-free imagery during the dry season, ensuring consistency in water levels, vegetation cover, and ground conditions. Utilizing a decision tree classification technique based on NDWI, LISS I, and LISS III data, the study delineates wetlands, unveiling hierarchical, non-linear data relationships.

**Khan et al. (2020)** conducted a comprehensive investigation into erosion and deposition along the Padma River's riverbank at the International boundary zone, focusing on the region spanning from Dhuliyan in the Murshidabad District of India to Chapainawabganj District in Bangladesh. The primary objectives were to establish a database for trans-boundary rivers in

South-western Bangladesh, assess erosion and deposition rates between 1995 and 2015, and analyze the dynamics of the riverbank. The study concluded that river channel migration, erosion, and deposition significantly contribute to poverty in Bangladesh, impacting rural unemployment in both Bangladesh and India. It emphasized the importance of continuous monitoring of riverbank lines to mitigate potential risks and losses. Furthermore, the research highlighted spatial and temporal variations in bank lines, erosion, and deposition while identifying underlying causes. These findings underscore the need for further research and the development of strategies to manage the impacts of river channel migration.

**Dutta et. al (2010)** conducted a comprehensive investigation into erosion-deposition processes around Majuli Island, Assam, utilizing Survey of India toposheets and Indian Remote Sensing satellite imagery spanning over 33 years.. The study's primary objectives encompassed analyzing migration patterns, erosion-deposition phenomena driven by the Brahmaputra and Subansiri rivers, assessing floodplain geomorphology, channel and bank morphology, and erosion/deposition activities. Additionally, it aimed to furnish crucial insights into erosion's repercussions on Majuli Island's landscape and ecosystem. The study conclusively revealed the substantial impact of the Brahmaputra and Subansiri rivers' erosive forces on Majuli Island, resulting in considerable alterations in its landmass. Erosion significantly outweighed deposition, especially in specific regions experiencing elevated erosion rates. The investigation underscored the braided nature of the Brahmaputra River, in tandem with sedimentary strata comprising silt and sand along the banks, as the predominant contributors to erosion. The study's findings hold significant implications for comprehending spatial alterations and the erosive effects on Majuli Island's inhabitants and ecosystem.

# CHAPTER 3

# STUDY AREA

The Brahmaputra River, which originates in Tibet, China, traverses through India and Bangladesh, covering an extensive distance of 2,880 km. The river basin, characterized by a vast catchment area, spans across Tibet (293,000 square kilometres), India and Bhutan (240,000 square kilometres), and Bangladesh (47,000 square kilometres), resulting in a total basin area of 580,000 square kilometres. This complex river system holds significant geographical and ecological importance within the region.

This academic study focuses on a specific stretch of the Brahmaputra River, namely from Sadiya to Dhubri, covering a distance of 891 km. The river courses through the heart of the Assam valley, intricately connected to various tributaries such as Subansiri, Jia Bharali, Dihing, Burhi Dihing, Disang, Dhansiri, and Kopili.

We examined the bankline migration patterns of the Brahmaputra River and several of its tributaries, including the Dikhow, Subansiri, Dikrong, Buroi, Borgang, Kameng, Dudhnoi, Krishnai, Murnoi, and Sankosh rivers, as illustrated in Figure 3.1. The Subansiri, Dikrong, Buroi, Borgang, Kameng, and Sankosh are tributaries located on the north bank of the Brahmaputra River, while the Dikhow, Murnoi, Krishnai, and Dudhnoi are tributaries situated on the south bank

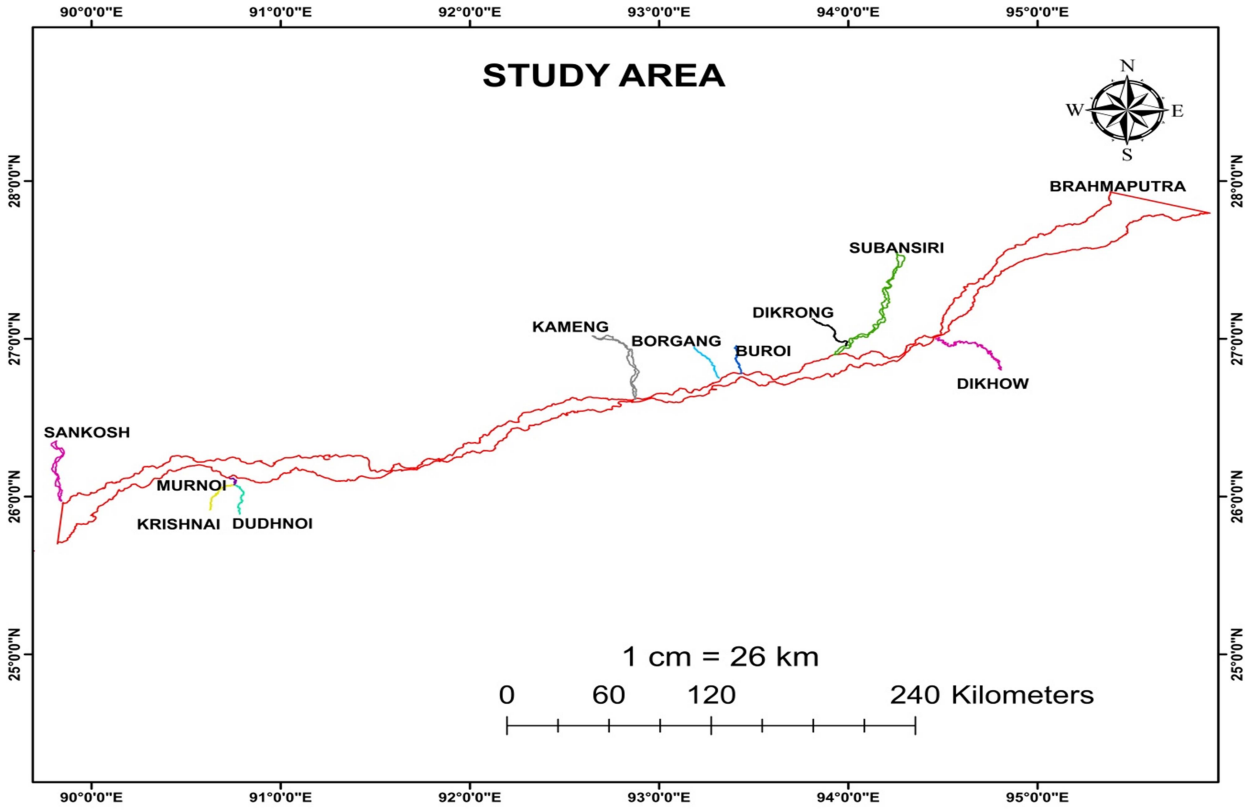


**Figure 3.1**- The Brahmaputra River and some of its tributaries

**Dikhow River**

The Dikhow River is a tributary of the Brahmaputra River. Originating in the Naga Hills of Nagaland, it traverses a distance of approximately 200 km before joining the Brahmaputra. This river is vital for irrigation, supporting agriculture in the Sivasagar district. The Dikhow also holds cultural significance, with historical connections to the Ahom kingdom. Its waters sustain diverse aquatic ecosystems and local livelihoods, making it an essential component of the region's socio-economic fabric

**Subansiri River**

The Subansiri River or gold river is a principal tributary of the Brahmaputra River, forming one of its largest sub-basins spanning Tibet (China) and India. The Brahmaputra River originates in the Himalayas, in china. It flows east and south east into India, then south to the Assam valley, where it joins the Brahmaputra river in lakhimpur district.

**Dikrong River**

The Dikrong River, a sub-tributary of the Brahmaputra River, originates in the hills of Arunachal Pradesh. It flows through major cities like Nirjuli in Arunachal Pradesh and Bihpuria in Assam before joining the Subansiri River. The river, with a total length of 145 km, primarily traverses the hilly region of Arunachal Pradesh for approximately 113 km, with the remaining 32 km passing through the plains of Lakhimpur district in Assam.

**Buroi River**

The Buroi River, a lesser-known tributary of the Brahmaputra, originates from the eastern Himalayan ranges known as the Dafala Hills in the East Kameng district of Arunachal Pradesh. This north bank river flows southwards and eventually joins the Brahmaputra in Assam

**Borgang River**

The Borgang River is a tributary of the Brahmaputra River in the Indian state of Assam. The Borgang river originates from Daphla Hills of Arunachal Pradesh. After flowing through the Daphla Hills, the river receives its tributary Naomara and Dikal before its confluence with Brahmaputra River

**Jia bharali River**

The Jia Bharali, a significant tributary of the Brahmaputra River, originates from the lower Himalayas in Arunachal Pradesh, northeastern India. It flows through the middle of Sonitpur district in Assam for approximately 66 km before joining the Brahmaputra at Tezpur. Known as the Kameng in Arunachal Pradesh, the river flows perpendicular to the Himalayas before entering the plains at Bhalukpung, where it is referred to as the Jia Bharali

**Dudhnoi River**

The Dudhnoi River, a sub tributary of the Brahmaputra, originates in the Garo Hills of Meghalaya and flows through the Goalpara district of Assam. It meets the Krishnai River at Matia village and then flows as the Mornoi River before merging with the Brahmaputra. The Dudhnoi River is known for its scenic beauty and supports agriculture and fisheries in the region.

**Krishnai River**

The Krishnai River is a sub-tributary of the Brahmaputra River in the Indian state of Assam. The Krishnai River originates in the West Garo Hills of Meghalaya. Flowing through the Goalpara district of Assam. The Krishnai River meets Dudhnoi River at Matia of Goalpara district and then flows as Mornoi River before its confluence with the Brahmaputra River

**Mornoi River**

The Mornoi River is a tributary of the Brahmaputra River. The Mornoi river originates at Matia village of Goalpara district. The Krishnai River meets Dudhnoi River at Matia village and then flows as Mornoi river before its confluence with the Brahmaputra River.

**Sankosh River**

The Sankosh River, a major north bank tributary of the Brahmaputra River, originates from the snow-clad Greater Himalayan ranges of Tibet. Known as Mo-chu in Bhutan and Gangadhar in Assam, it flows 214 km in Bhutan and 107 km in India, primarily through Kokrajhar and Dhubri districts. The river significantly contributes to local agriculture and water resources

# CHAPTER 4

# METHODOLGY

This study employed high-resolution Google Earth satellite imagery to precisely delineate the bank-lines of the Brahmaputra River and several of its tributaries. Satellite images covering the Brahmaputra River and its tributaries were acquired from 1990 to 2020 at 5-year intervals (1990, 1995, 2000, 2005, 2010, 2015, 2020) through Earth Explorer. All Landsat images were downloaded during non-monsoon periods.

Using ArcGIS 10.4.1, Landsat 4-5 TM, Landsat 7 ETM+, and Landsat 8-9 images for the study area were downloaded and initially processed. The Landsat images underwent band-compositing, and where multiple images were available for the same year, mosaic images were created to merge them. Specifically, mosaic techniques were applied to Landsat images of the Brahmaputra River due to the availability of six images in certain years, whereas tributaries did not require mosaic processing.

Utilizing GIS software tools, the bank-lines of the Brahmaputra River and its tributaries were delineated using polyline creation, resulting in seven sets of river bank-lines documented for the years 1990, 1995, 2000, 2005, 2010, 2015, and 2020. Subsequently, each river's cross-sections were determined based on changes observed in the bank-lines. The width of the Brahmaputra River's main channel was segmented into sixteen cross-sections labelled as XS-1 through XS-16, as depicted in Figure 4.1

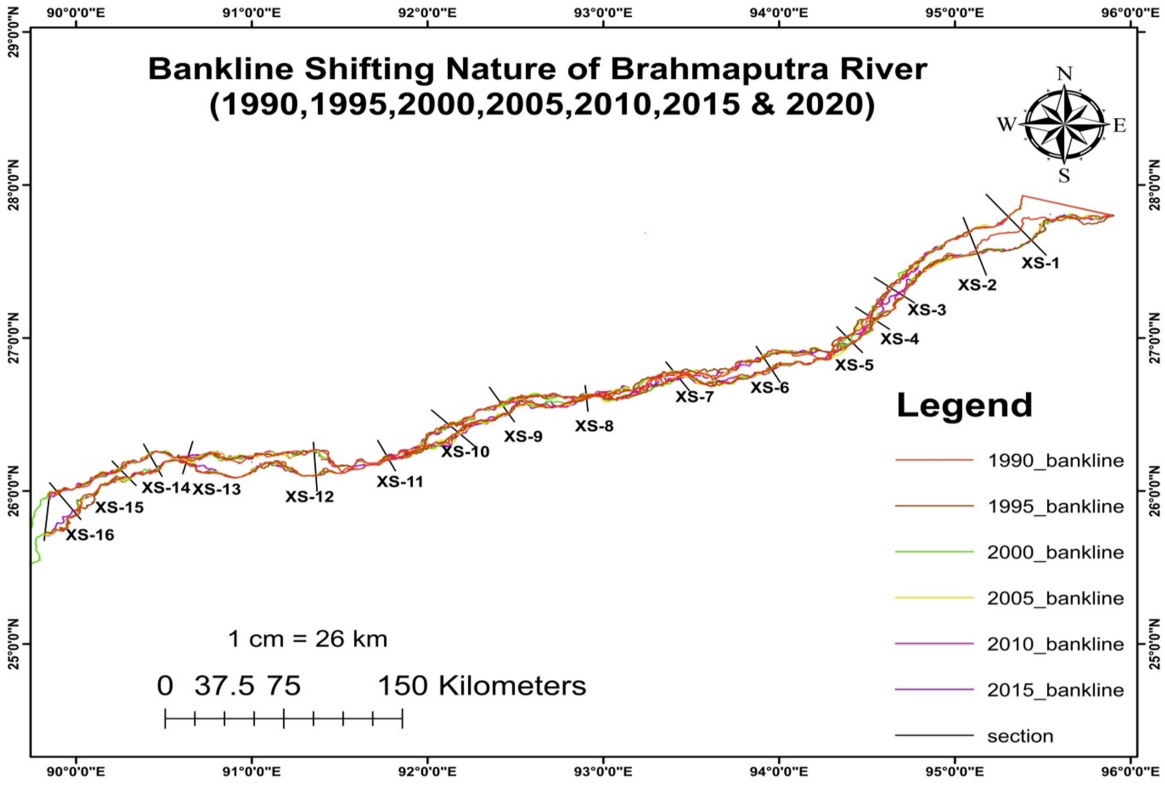


**Figure 4.1-** cross- section of Brahmaputra river

Similar to the Brahmaputra River, cross-section analyses were conducted for its tributaries. The Subansiri River was divided into 6 sections, while the Sankosh and Jia Bharali Rivers were divided into 5 sections each. Additionally, the Krishnai, Dudhnoi, Borgang, Buroi, Dikrong, and Dikhow Rivers were divided into 4 sections each, and the Murnoi River into 3 sections.

Using measurement tools within ARC GIS software, each section was analysed to quantify changes in the riverbank's profile, identifying erosion and deposition patterns on either side. The width of each section for all specified years was determined using the same GIS software tools. Subsequently, comprehensive analyses were conducted by generating graphical representations in Excel.

In summary, this study utilized advanced satellite imagery, GIS software tools, and analytical techniques to systematically evaluate and measure changes in the bank-lines of the Brahmaputra River over a 30-year period. The findings provide valuable insights into erosion, accretion, and overall river dynamics within the study area.

# CHAPTER 5

# RESULTS AND DISCUSSION

## 5.1 BRAHMAPUTRA RIVER

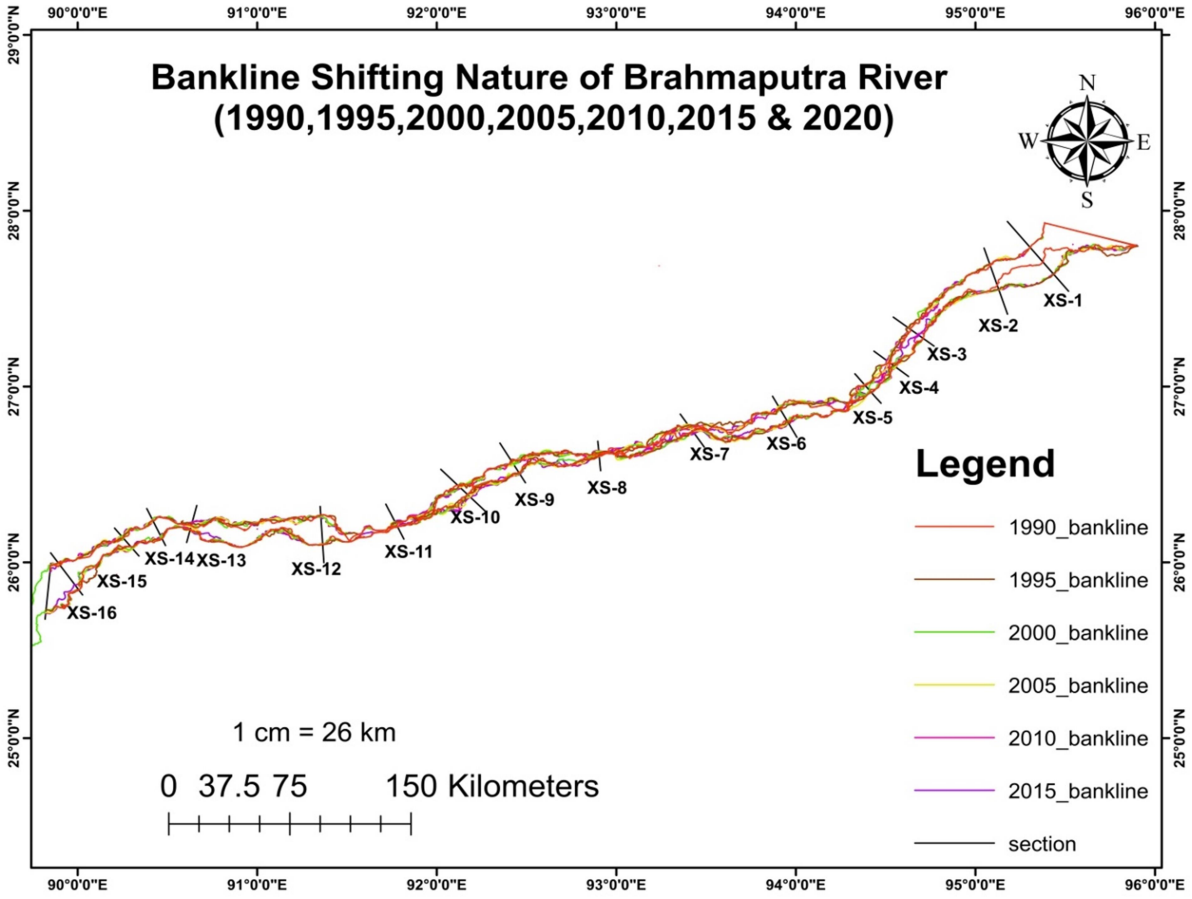


**Figure 5.1-** Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of the Brahmaputra River from 1990 to 2020 has been taken into 16 cross-sections that denote the river course continuously changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.1, it is clear that the river bank line is not like the same cross-section.

### 5.1.1 Shifting Pattern of The Brahmaputra River Course from 1990 To 1995

Table 5.1 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995(Km) | Right Bank (km) | Left Bank (km) |
|---|---|---|---|---|
| **XS-1** | 11.61 | 21.39 | -0.06 | -9.72 |
| **XS-2** | 12.85 | 16.55 | -0.92 | -2.78 |
| **XS-3** | 8.84 | 10.71 | -1.83 | -0.04 |
| **XS-4** | 0.96 | 3.5 | -0.19 | -2.35 |
| **XS-5** | 5.05 | 5.74 | 0.21 | -0.9 |
| **XS-6** | 8.37 | 10.63 | -1.14 | -1.12 |
| **XS-7** | 3.02 | 4.48 | -1.31 | -0.15 |
| **XS-8** | 1.8 | 1.25 | -0.35 | 0.9 |
| **XS-9** | 7.93 | 9.45 | -1.22 | -0.3 |
| **XS-10** | 7.84 | 7.09 | 0.51 | 0.24 |
| **XS-11** | 1.15 | 3.01 | -1.9 | 0.04 |
| **XS-12** | 18.39 | 18.38 | 0.03 | -0.02 |
| **XS-13** | 2.58 | 3.73 | -1.15 | 0 |
| **XS-14** | 12.57 | 12.39 | 0.27 | -0.09 |
| **XS-15** | 6.95 | 7.29 | -0.17 | -0.17 |
| **XS-16** | 20.76 | 20.76 | 0.03 | -0.03 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase**: Cross-section XS- 1 has the largest increase in river width of 9.78 kilometers.
- **Maximum Decrease**: Cross-section XS-10 has the largest decrease in river width of 0.75 kilometers..

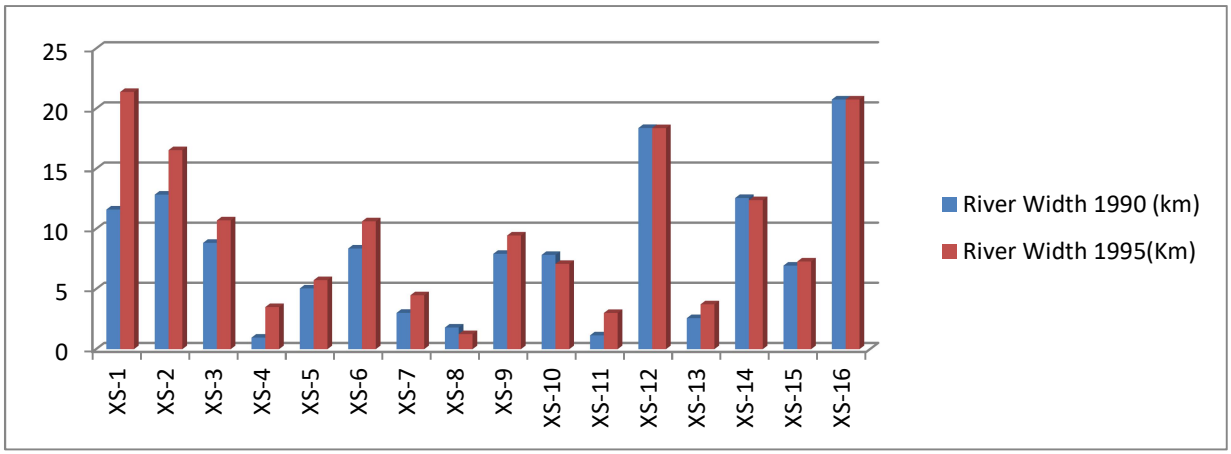


**Figure 5.2-** The Channel Width Variation from 1990 to 1995

**Right bank(1990-1995):**

- **Maximum Deposition in Right Bank line:** The maximum deposition in the right bank occurs at cross-section XS-10, with a value of 0.51 km.
- **Maximum Erosion in Right Bank line:** The maximum erosion in the right bank occurs at cross-section XS-11, with a value of 1.9 km.

**Left bank(1990-1995):**

- **Maximum Deposition in Left Bank:** The maximum deposition in the left bank occurs at cross-section XS-8, with a value of 0.9km
- **Maximum Erosion in Left Bank:** The maximum erosion in the left bank occurs at cross-section XS-1, with a value of 9.72 km.

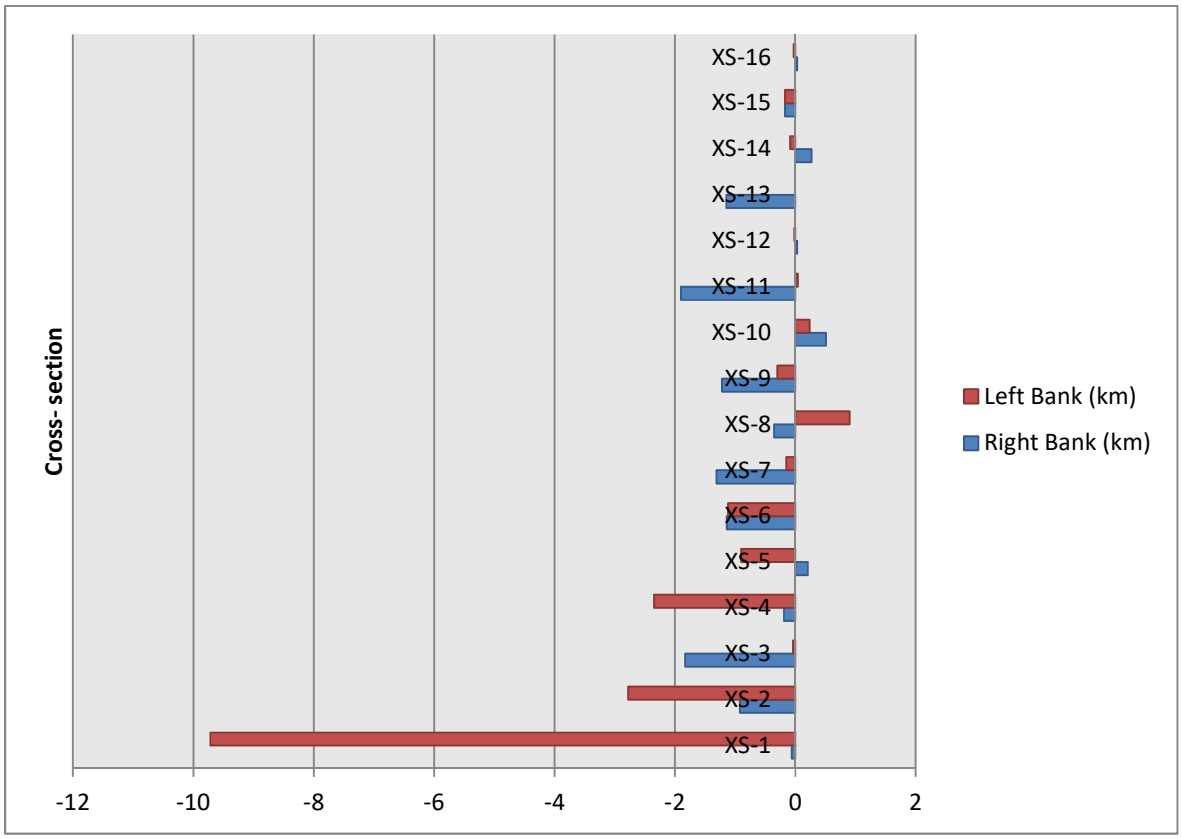


**Figure 5.3-** River Course Shifting line from 1990 to 1995

### 5.1.2 Shifting Pattern of The Brahmaputra River Course from 1995 to 2000

Table 5.2 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000(Km) | Right Bank (km) | Left Bank (km) |
|---|---|---|---|---|
| **XS-1** | 21.39 | 20.95 | 0.27 | 0.17 |
| **XS-2** | 16.55 | 16.23 | 0.35 | -0.03 |
| **XS-3** | 10.71 | 10.46 | 0.22 | 0.03 |
| **XS-4** | 3.5 | 3.72 | 0.18 | -0.4 |
| **XS-5** | 5.74 | 5.27 | 0.5 | -0.03 |
| **XS-6** | 10.63 | 10.07 | 0.18 | 0.38 |
| **XS-7** | 4.48 | 3.29 | 1.35 | -0.16 |
| **XS-8** | 1.25 | 1.86 | -0.75 | 0.14 |
| **XS-9** | 9.45 | 7.26 | 2.53 | -0.34 |
| **XS-10** | 7.09 | 7.72 | 0.03 | -0.66 |
| **XS-11** | 3.01 | 3.27 | -0.28 | 0.02 |
| **XS-12** | 18.38 | 17.56 | 0.9 | -0.08 |
| **XS-13** | 3.73 | 2.96 | 0.8 | -0.03 |
| **XS-14** | 12.39 | 12.23 | -0.54 | 0.7 |
| **XS-15** | 7.29 | 9.67 | -1.34 | -1.04 |
| **XS-16** | 20.76 | 19.62 | 1.14 | 0 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width:**

- **Maximum Increase**: XS-15 has the largest increase in river width of 2.38 kilometers.
- **Maximum Decrease**: XS-9 has the largest decrease in river width of 2.19 kilometers.

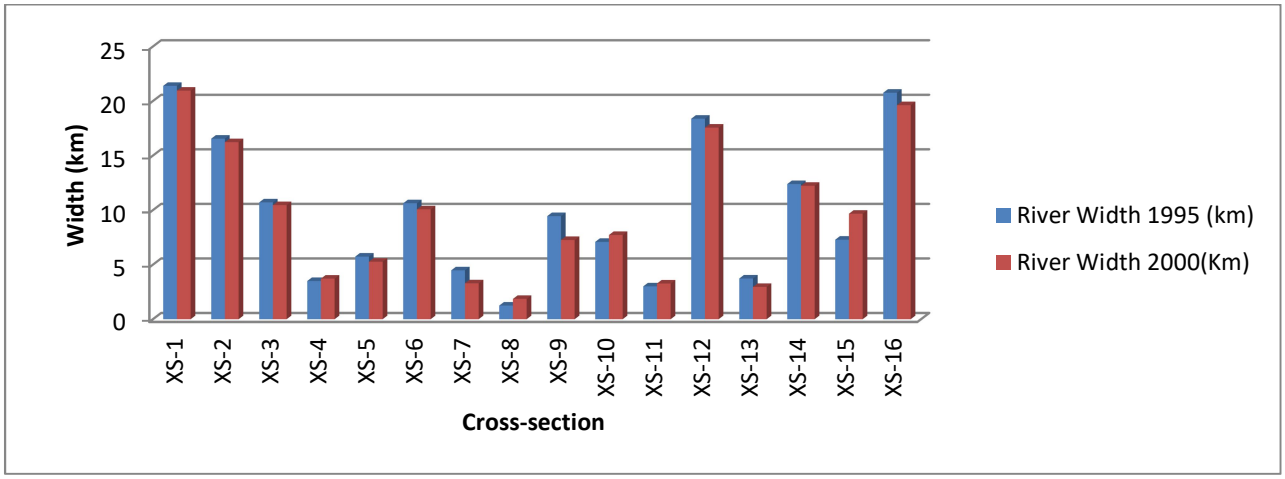


**Figure 5.4-** The Channel Width Variation from 1995 to 2000

**Right bank (1995-2000)**

- **Maximum Deposition in Right Bank line:** The maximum deposition in the right bank occurs at cross-section XS-9, with a value of 2.53 km.
- **Maximum Deposition in Left Bank line:** The maximum deposition in the left bank occurs at cross-section XS-15, with a value of -1.34 km

**Left bank (1995-2000)**

- **Maximum deposition in Left Bank:** The maximum deposition in the left bank occurs at cross-section XS-14, with a value of 0.7 km
- **Maximum erosion in Left Bank:** The maximum deposition in the left bank occurs at cross-section XS-15, with a value of -1.04 km

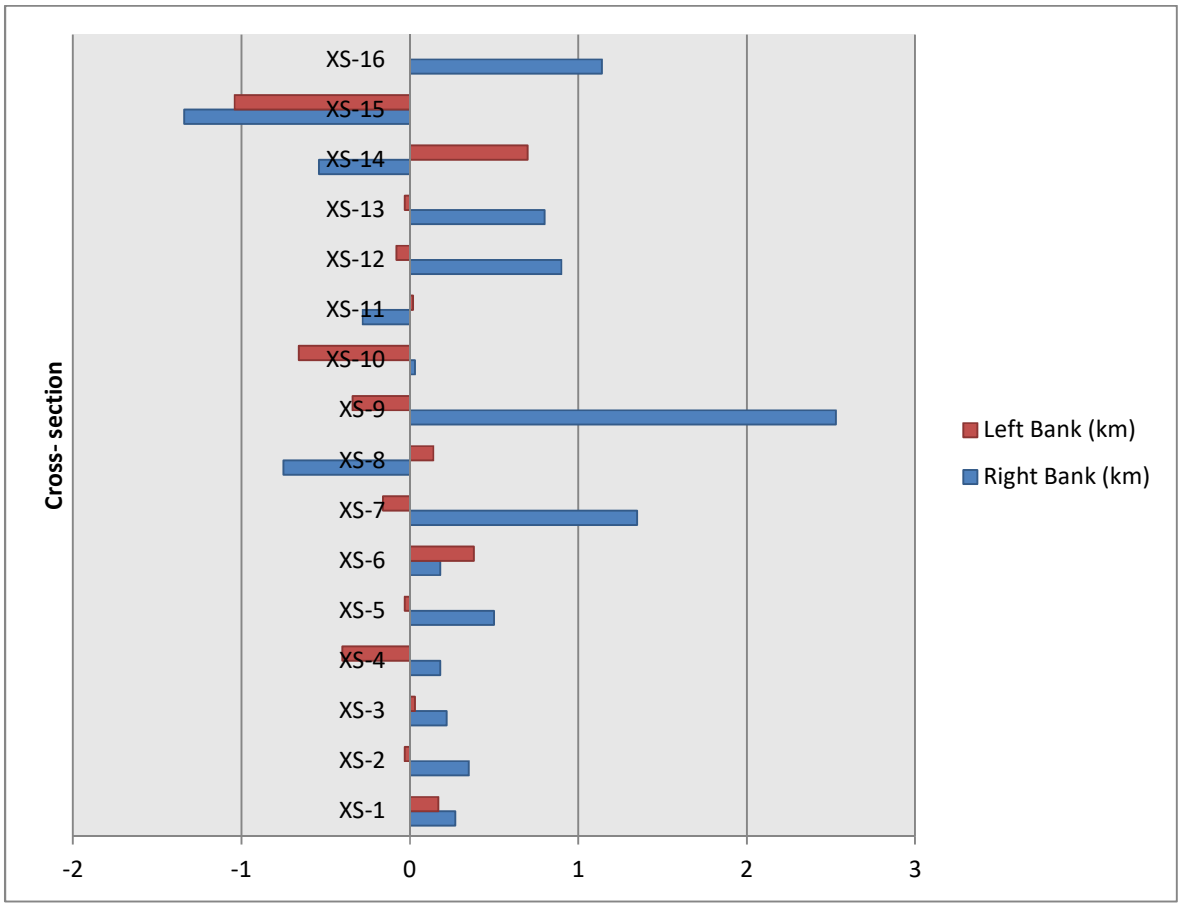


**Figure 5.5-** River Course Shifting line from 1995 to 2000

### 5.1.3 Shifting Pattern of The Brahmaputra River Course from 2000 to 2005

Table 5.3 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005(Km) | Right Bank (km) | Left Bank (km) |
|---|---|---|---|---|
| **XS-1** | 20.95 | 21.31 | 0 | -0.36 |
| **XS-2** | 16.23 | 16.25 | 0.15 | -0.17 |
| **XS-3** | 10.46 | 10.46 | 0 | 0 |
| **XS-4** | 3.72 | 5.48 | -0.9 | -0.86 |
| **XS-5** | 5.27 | 5.42 | 0.02 | -0.17 |
| **XS-6** | 10.07 | 11.02 | -1.29 | 0.34 |
| **XS-7** | 3.29 | 5.2 | -2.05 | 0.14 |
| **XS-8** | 1.86 | 1.93 | -0.4 | 0.33 |
| **XS-9** | 7.26 | 6.48 | 0.12 | 0.66 |
| **XS-10** | 7.72 | 8.22 | 0.87 | -1.37 |
| **XS-11** | 3.27 | 3.43 | -0.1 | -0.06 |
| **XS-12** | 17.56 | 17.5 | -0.09 | 0.15 |
| **XS-13** | 2.96 | 1.76 | 1.38 | -0.18 |
| **XS-14** | 12.23 | 12.98 | -0.05 | -0.7 |
| **XS-15** | 9.67 | 9.43 | 0.63 | -0.39 |
| **XS-16** | 19.62 | 19.69 | -0.09 | 0.02 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width:**

- **Maximum Increase**: XS-7 has the largest increase in river width of 1.91 kilometers.
- **Maximum Decrease:** XS-13 has the largest decrease in river width of 1.2 kilometers.

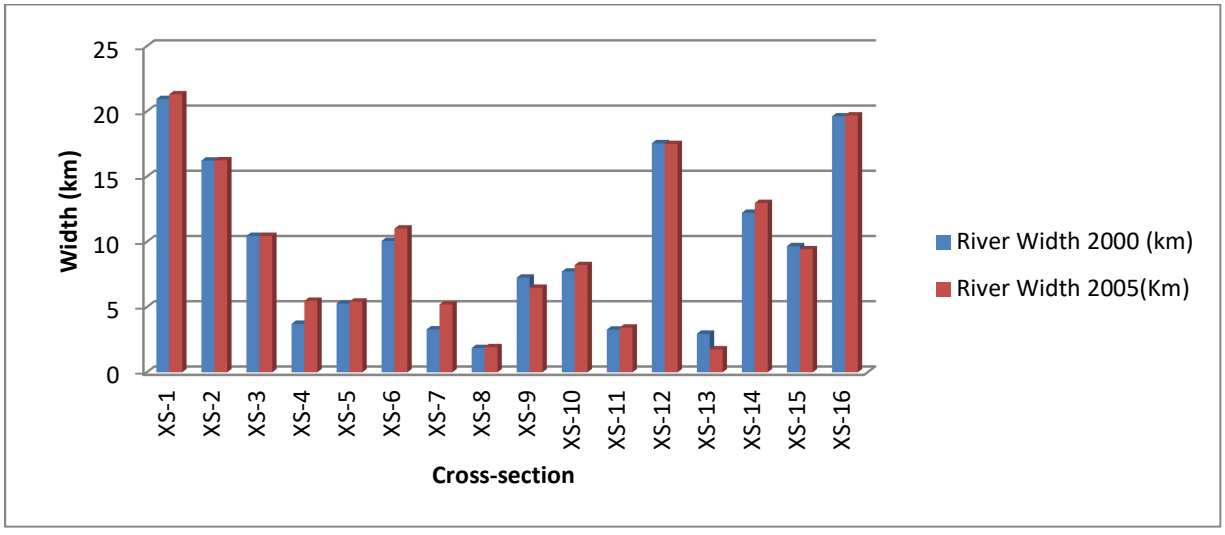


**Figure 5.6-** The Channel Width Variation from 2000 to 2005

**Right bank (2000-2005)**

- **Maximum Deposition in Right Bank line**: The maximum deposition in the right bank occurs at cross-section XS-4, with a value of 1.38 km.
- **Maximum Erosion in right Bank line:** The maximum erosion in the left bank occurs at cross-section XS-10, with a value of 2.05 km.

**Left bank (2000-2005)**

- **Maximum deposition in Left Bank line:** The maximum erosion in the left bank occurs at cross-section XS-8, with a value of 0.66km
- **Maximum Erosion in Left Bank line:** The maximum erosion in the left bank occurs at cross-section XS-7, with a value of 1.37 km

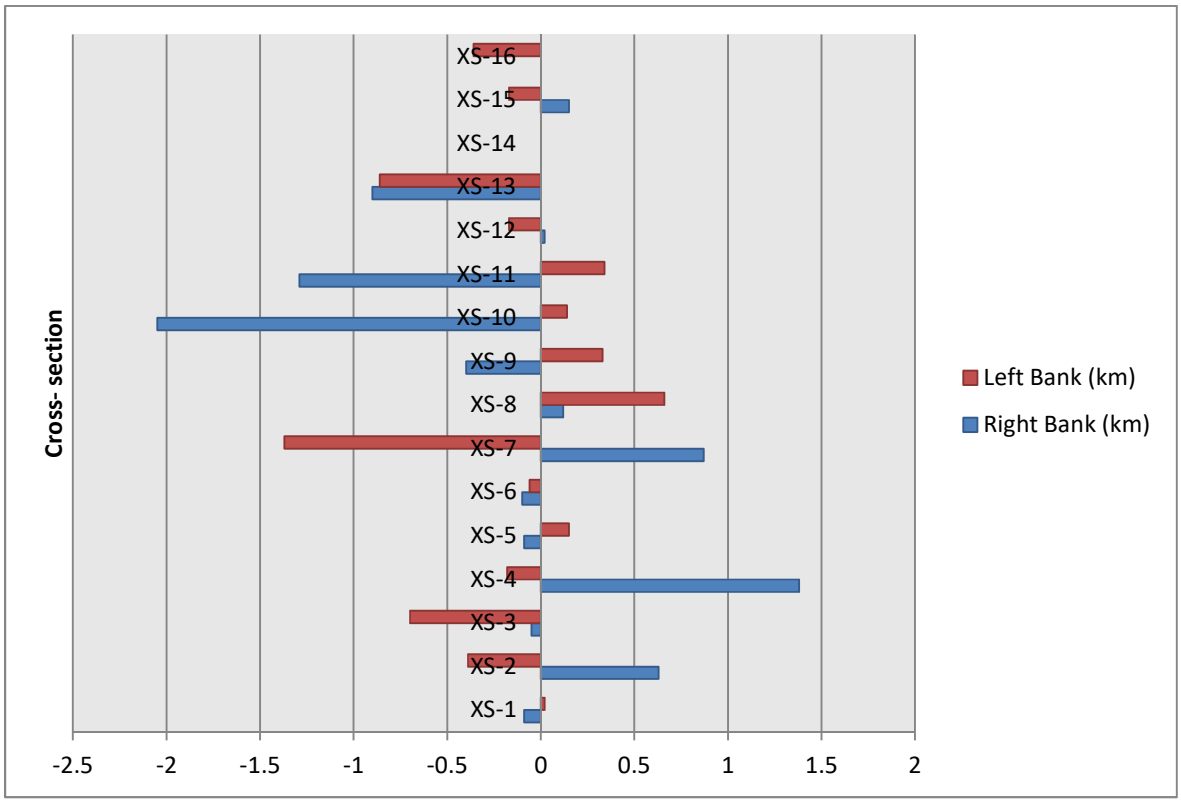


**Figure 5.7-** River Course Shifting line from 2000-2005

### 5.1.4 Shifting Pattern of The Brahmaputra River Course from 2005 to 2010

Table 5.4 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010(Km) | Right Bank (km) | Left Bank (km) |
|---|---|---|---|---|
| **XS-1** | 21.31 | 21.23 | -0.04 | 0.12 |
| **XS-2** | 16.25 | 16.27 | 0.05 | -0.07 |
| **XS-3** | 10.46 | 6.34 | 0.12 | 4 |
| **XS-4** | 5.48 | 6.03 | -0.43 | -0.12 |
| **XS-5** | 5.42 | 5.08 | 0.34 | 0 |
| **XS-6** | 11.02 | 11.87 | 0 | -0.85 |
| **XS-7** | 5.2 | 6.39 | -0.08 | -1.11 |
| **XS-8** | 1.93 | 1.43 | -0.28 | 0.78 |
| **XS-9** | 6.48 | 7.75 | -0.45 | -0.82 |
| **XS-10** | 8.22 | 8.11 | 0.42 | -0.31 |
| **XS-11** | 3.43 | 3.16 | 0 | 0.27 |
| **XS-12** | 17.5 | 17.47 | -0.12 | 0.15 |
| **XS-13** | 1.76 | 4.96 | -3.45 | 0.25 |
| **XS-14** | 12.98 | 11.31 | -0.1 | 1.77 |
| **XS-15** | 9.43 | 10.05 | -0.55 | -0.07 |
| **XS-16** | 19.69 | 20.28 | -0.55 | -0.04 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width:**

- **Maximum Increase**: XS-13 has the largest increase in river width of 3.2 kilometers.
- **Maximum Decrease:** XS-3 has the largest decrease in river width of 4.12 kilometers.

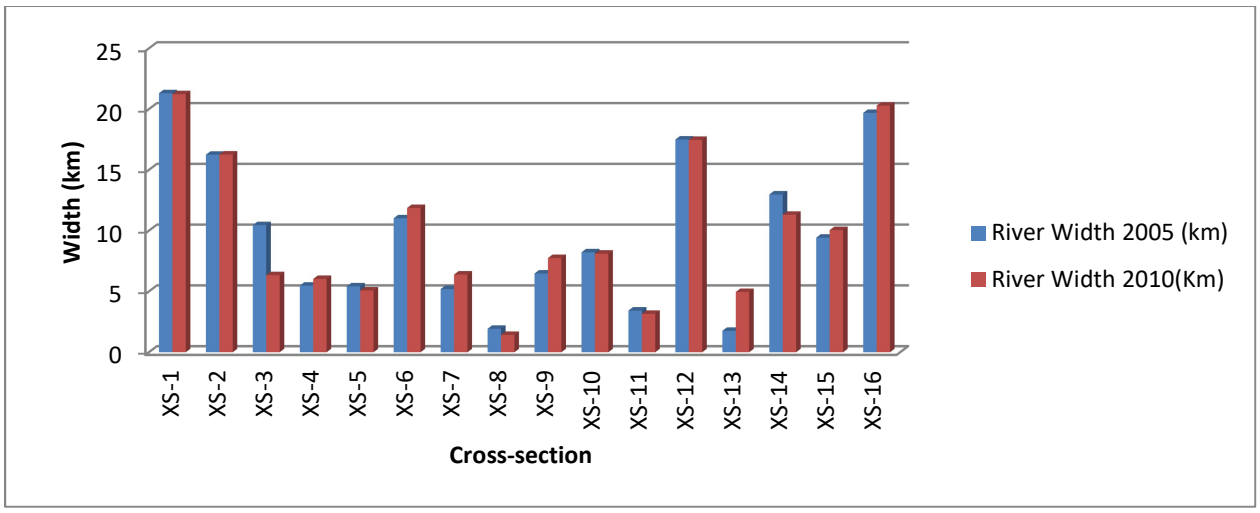


**Figure 5.8-** The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010)**

- **Maximum Deposition in Right Bank line:** The maximum deposition in the right bank occurs at cross-section XS-10, with a value of 0.42 km.
- **Maximum Erosion in Right Bank line**: The maximum erosion in the right bank occurs at cross-section XS-13, with a value of -3.45 km.

**Left Bank (2005-2010):**

- **Maximum Deposition in Left Bank line:** The maximum deposition in the left bank occurs at cross-section XS-3, with a value of 4 km.
- **Maximum erosion in Left Bank line:** The maximum deposition in the left bank occurs at cross-section XS-7, with a value of 1.11 km.

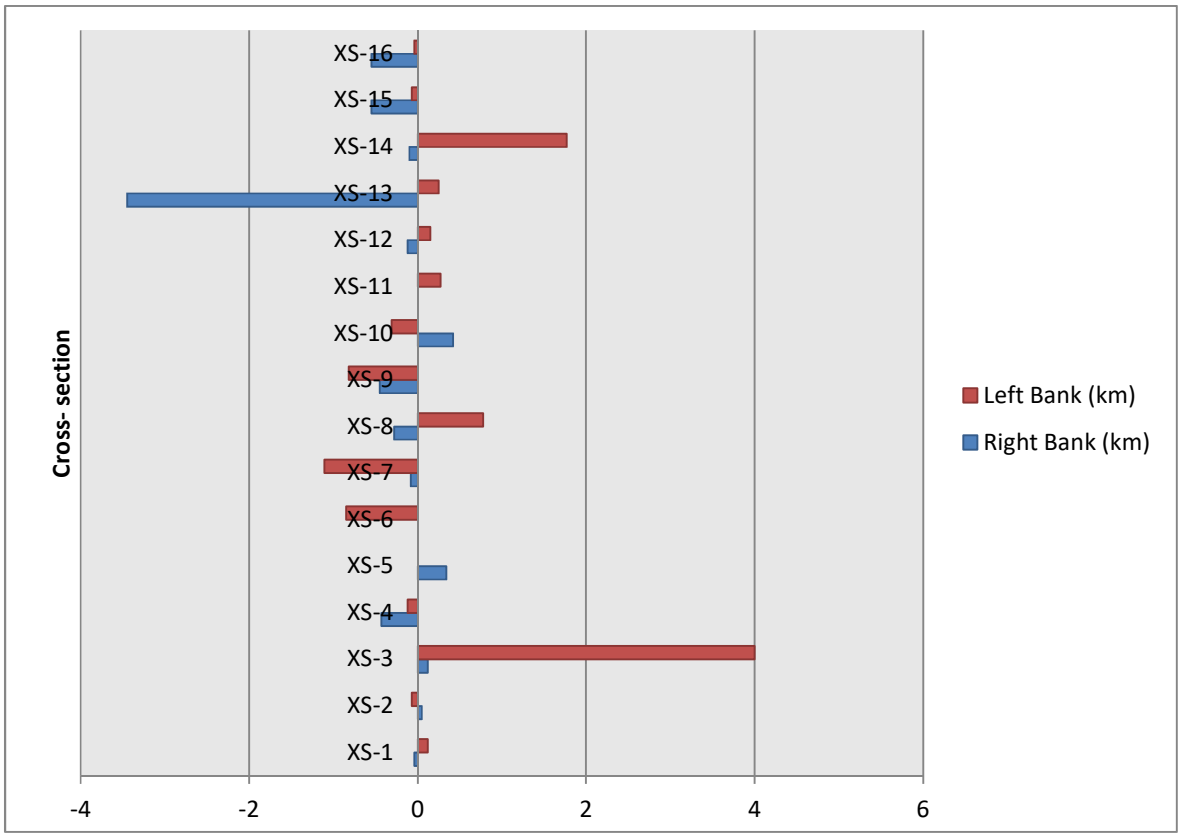


**Figure 5.9-** River Course Shifting line from 2005-2010

**5.1.5 Shifting Pattern of The Brahmaputra River Course from 2010 to 2015**

Table 5.5 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015(Km) | Right Bank (km) | Left Bank (km) |
|---|---|---|---|---|
| **XS-1** | 21.23 | 21.37 | 0 | -0.14 |
| **XS-2** | 16.27 | 16.36 | -0.14 | 0.05 |
| **XS-3** | 6.34 | 7.43 | 0.14 | -1.23 |
| **XS-4** | 6.03 | 6.54 | -0.55 | 0.04 |
| **XS-5** | 5.08 | 4.83 | 0.37 | -0.12 |
| **XS-6** | 11.87 | 11.45 | 0.46 | -0.04 |
| **XS-7** | 6.39 | 6.94 | 0.07 | -0.62 |
| **XS-8** | 1.43 | 1.32 | 0.79 | -0.68 |
| **XS-9** | 7.75 | 8.63 | -0.68 | -0.2 |
| **XS-10** | 8.11 | 8.78 | -0.47 | -0.2 |
| **XS-11** | 3.16 | 3.74 | -0.35 | -0.23 |
| **XS-12** | 17.47 | 16.37 | 1.1 | 0 |
| **XS-13** | 4.96 | 3.93 | 0.81 | 0.22 |
| **XS-14** | 11.31 | 11.15 | 0 | 0.16 |
| **XS-15** | 10.05 | 9.89 | 0.13 | 0.03 |
| **XS-16** | 20.28 | 20.5 | -0.22 | 0 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase**: The maximum increase in width among the cross-sections is 1.09 km for XS-3.
- **Maximum Decrease:** The maximum decrease in width among the cross-sections is 1.1 km for XS-12.

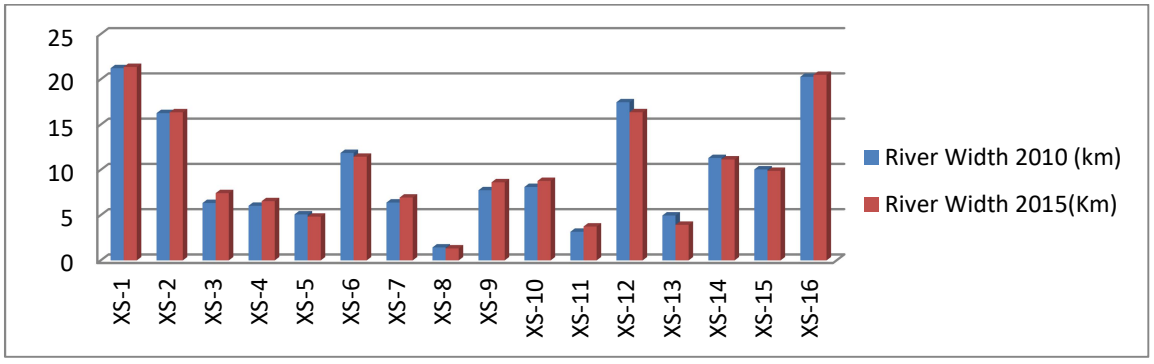


**Figure 5.10-** The Channel Width Variation from 2010 to 2015

**Right bank:**

- **Maximum Deposition in Right Bank:** The maximum deposition in the right bank occurs at cross-section XS-12, with a value of 1.1 km.
- **Maximum Erosion in Right Bank:** The maximum erosion in the right bank occurs at cross-section XS-9, with a value of 0.68 km.

**Left bank:**

- **Maximum Deposition in Left Bank:** The maximum deposition in the left bank occurs at cross-section XS-13, with a value of 0.22 km.
- **Maximum Erosion in Left Bank:** The maximum erosion in the left bank occurs at cross-section XS-3, with a value of 1.23 km.

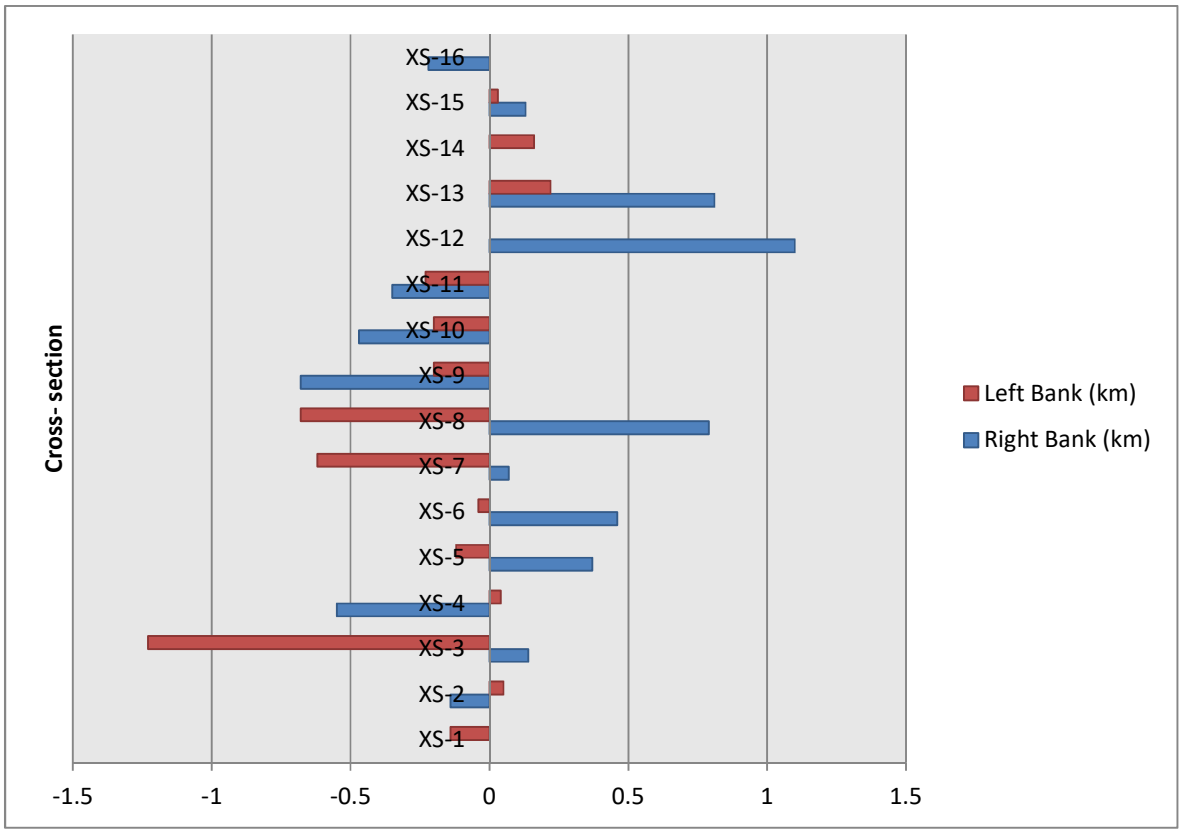


**Figure 5.11-** River Course Shifting line from 2010-2015

### 5.1.6 Shifting Pattern of The Brahmaputra River Course from 2015 to 2020

Table 5.6 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020(Km) | Right Bank (km) | Left Bank (km) |
|---|---|---|---|---|
| **XS-1** | 21.37 | 21.51 | -0.26 | 0.12 |
| **XS-2** | 16.36 | 15.76 | 0.6 | 0 |
| **XS-3** | 7.43 | 7.12 | 0.13 | 0.18 |
| **XS-4** | 6.54 | 5.85 | -0.04 | 0.73 |
| **XS-5** | 4.83 | 5.02 | -0.19 | 0 |
| **XS-6** | 11.45 | 12.14 | -0.69 | 0 |
| **XS-7** | 6.94 | 4.64 | 0.02 | 2.28 |
| **XS-8** | 1.32 | 1.7 | 0.97 | -1.35 |
| **XS-9** | 8.63 | 9.24 | -0.55 | -0.06 |
| **XS-10** | 8.78 | 8.48 | 0.06 | 0.24 |
| **XS-11** | 3.74 | 3.87 | -0.19 | 0.06 |
| **XS-12** | 16.37 | 17.45 | -1.18 | 0.1 |
| **XS-13** | 3.93 | 4.6 | -0.49 | -0.18 |
| **XS-14** | 11.15 | 9.12 | 0.03 | 2 |
| **XS-15** | 9.89 | 9.47 | 0.48 | -0.06 |
| **XS-16** | 20.5 | 20.83 | -0.3 | -0.03 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width:**

- **Maximum Increase**: The cross-section with the maximum increase in river width between 2015 and 2020 is XS-12, with a change of 1.08 km.
- **Maximum Decrease:** The cross-section with the maximum decrease in river width between 2015 and 2020 is XS-7, with a change of 2.3 km

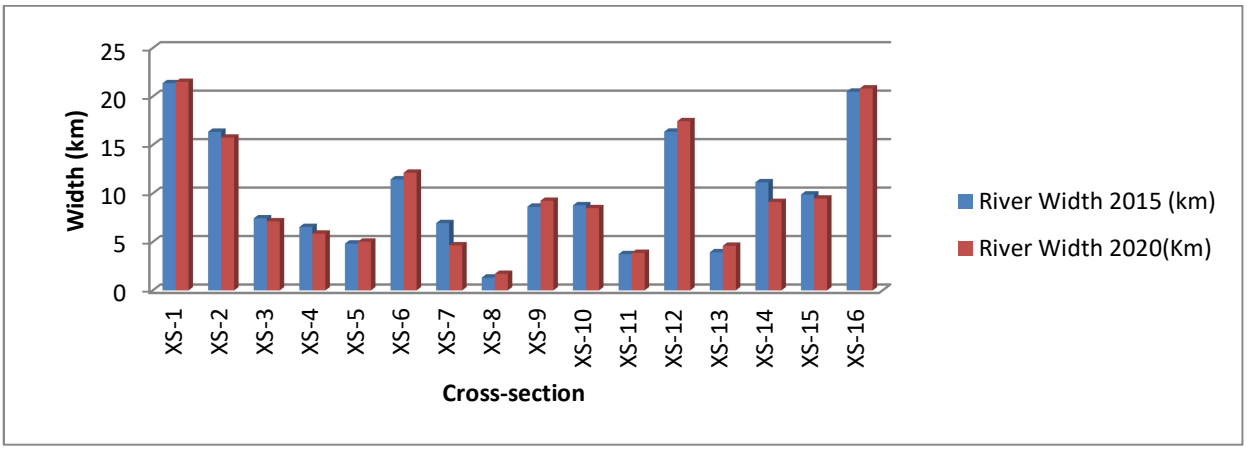


**Figure 5.12-** The Channel Width Variation from 2015 to 2020

**Right bank(2015-2020):**

- **Maximum Deposition in Right Bank**: The maximum deposition in the right bank occurs at cross-sections XS-8 with a value of 0.97 km.
- **Maximum Erosion in Right Bank:** The maximum erosion in the right bank occurs at cross-section XS-12, with a value of -1.18 km.

**Left Bank (2015-2020):**

- **Maximum Deposition in Left Bank:** The maximum deposition in the left bank occurs at cross-section XS-7, with a value of 2.28 km.
- **Maximum Erosion in Left Bank:** The maximum erosion in the left bank occurs at cross-sections XS-8, with a value of 1.35 km.

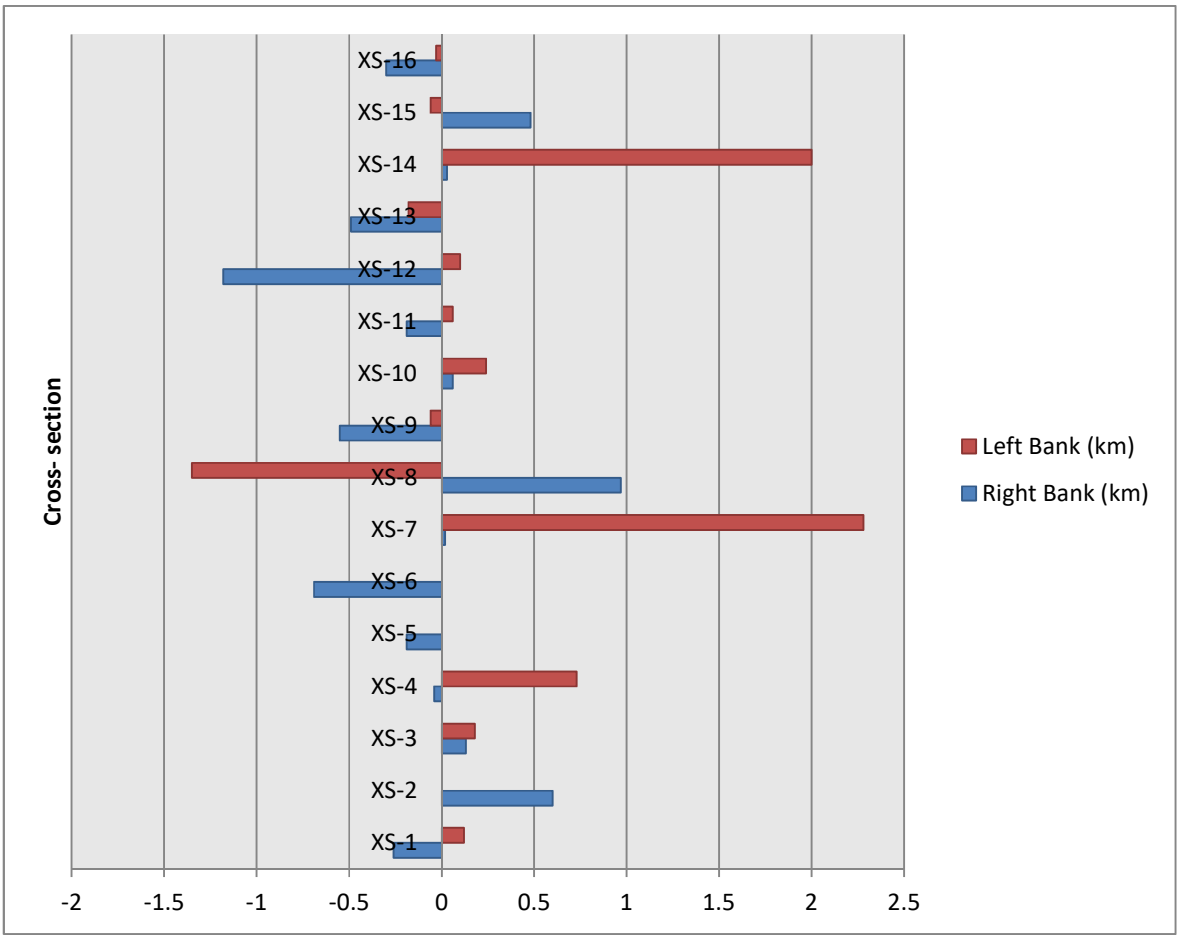


**Figure 5.13-** River Course Shifting line from 2015-2020

## 5.2 SUBANSIRI RIVER

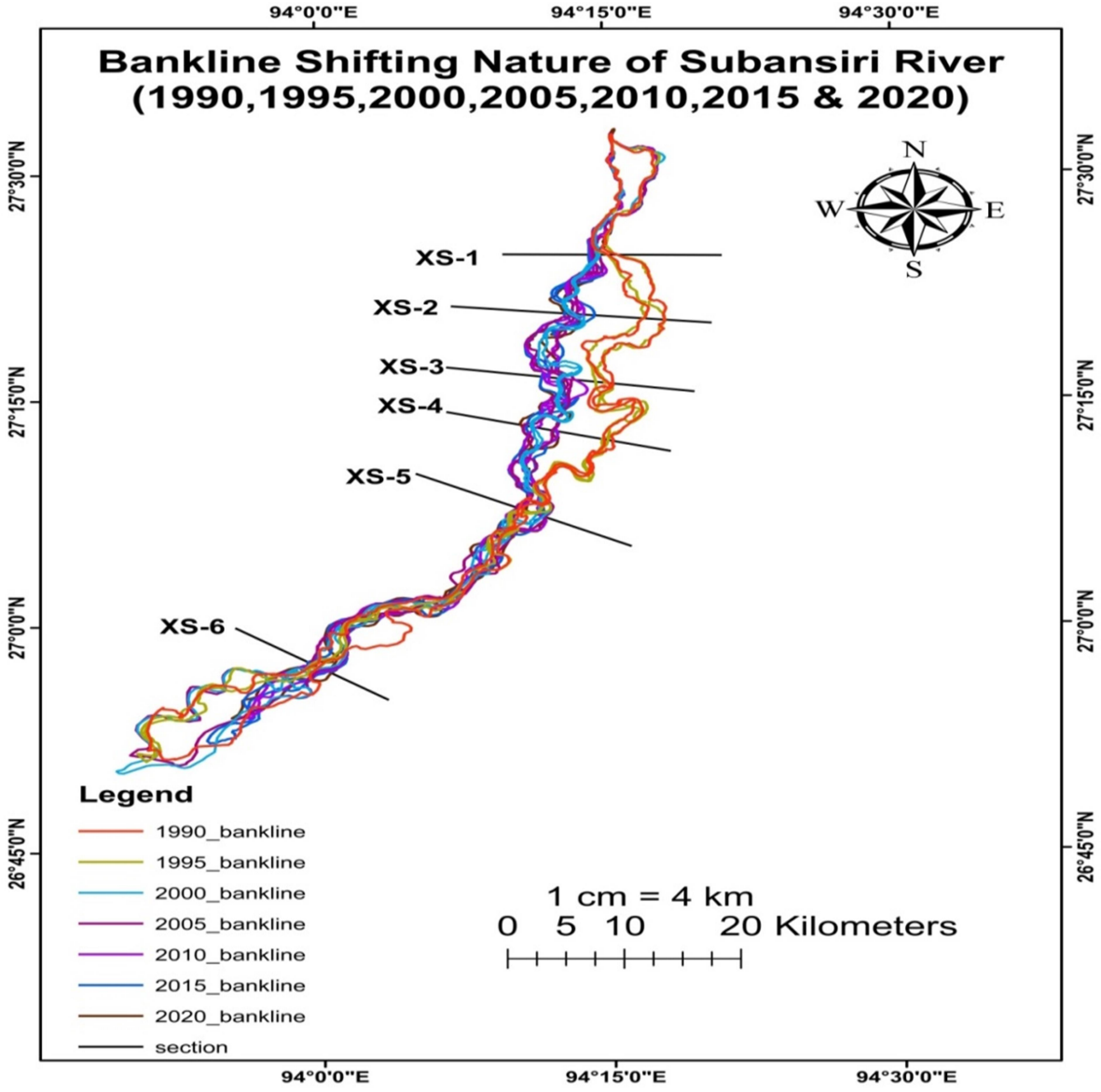


**Figure 5.14-** Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Subansiri River from 1990 to 2020 has been taken into 6 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.14, it is clear that the river bank line is not like the same cross-section

### 5.2.1 Shifting Pattern of Subansiri River Course from 1990 to 1995

Table 5.7 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.832 | 0.87 | -0.014 | -0.024 |
| **XS-2** | 1.854 | 1.762 | 0.052 | 0.04 |
| **XS-3** | 0.338 | 0.824 | -1.147 | 0.661 |
| **XS-4** | 0.786 | 0.446 | -0.103 | 0.443 |
| **XS-5** | 0.364 | 0.342 | 1.086 | -1.064 |
| **XS-6** | 0.476 | 0.63 | -0.238 | 0.084 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.486 km
- **Maximum Decrease**: Cross-section XS-4 has the largest decrease in river width of 0.340 km

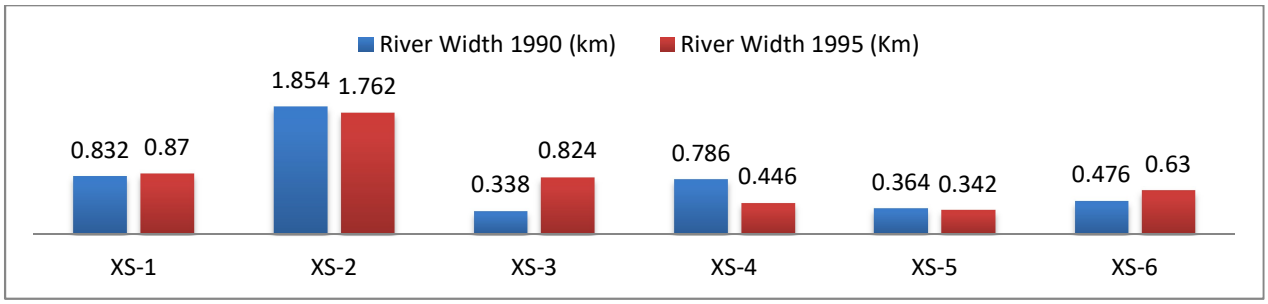


**Figure 5.15-** The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-5, with a value of 1.086 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-3, with a value of 1.147 km.

**Left Bank ( 1990-1995):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-5, with a value of 1.064 km.

- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-3, with a value of 0.661 km.

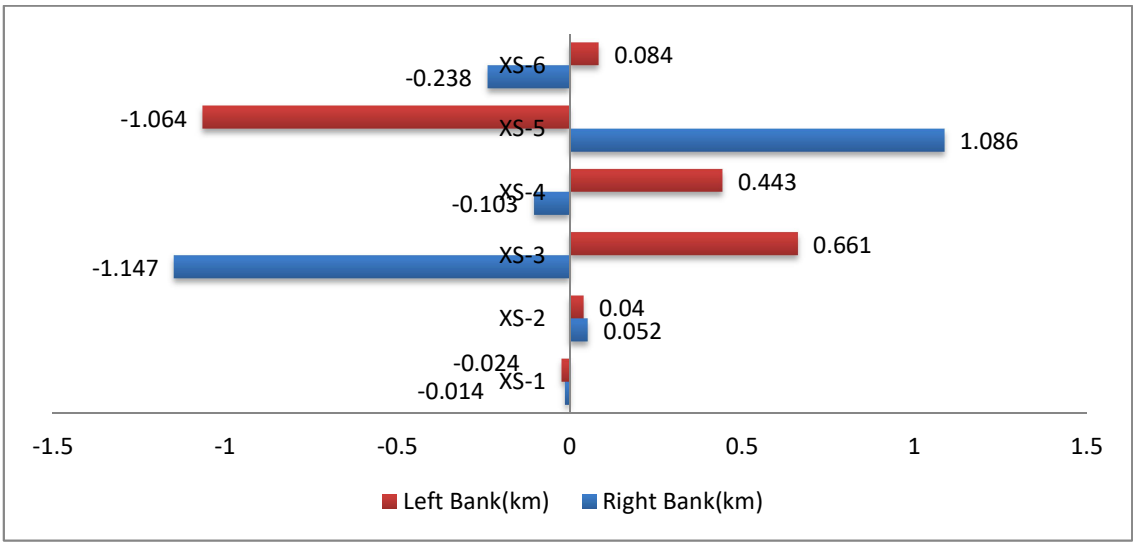


**Figure 5.16-** River Course Shifting line from 1990 to 1995

### 5.2.2 Shifting Pattern of Subansiri River Course from 1995 to 2000

Table 5.8 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.87 | 0.236 | -0.924 | 1.558 |
| **XS-2** | 1.762 | 0.458 | -6.4 | 7.704 |
| **XS-3** | 0.824 | 0.215 | -3.224 | 3.833 |
| **XS-4** | 0.446 | 0.23 | -6.36 | 6.576 |
| **XS-5** | 0.342 | 0.61 | 0.606 | -0.874 |
| **XS-6** | 0.63 | 1.032 | -0.064 | -0.338 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-6 shows the most significant increase in river width, expanding by 0.402 km
- **Maximum Decrease:** Cross-section XS-2 has decrease in river width of 1.304 km.

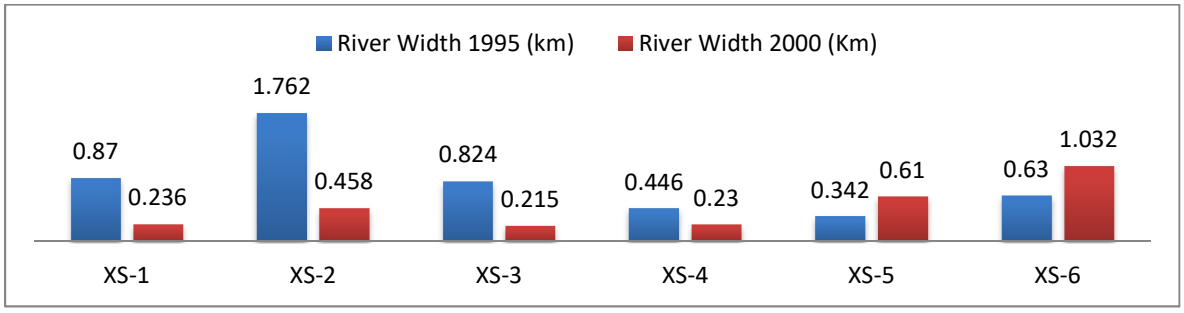


**Figure 5.17**- The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-5, with a value of 0.606 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-2, with a value of 6.4 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-5, with a value of 0.874 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-2, with a value of 7.704 km.

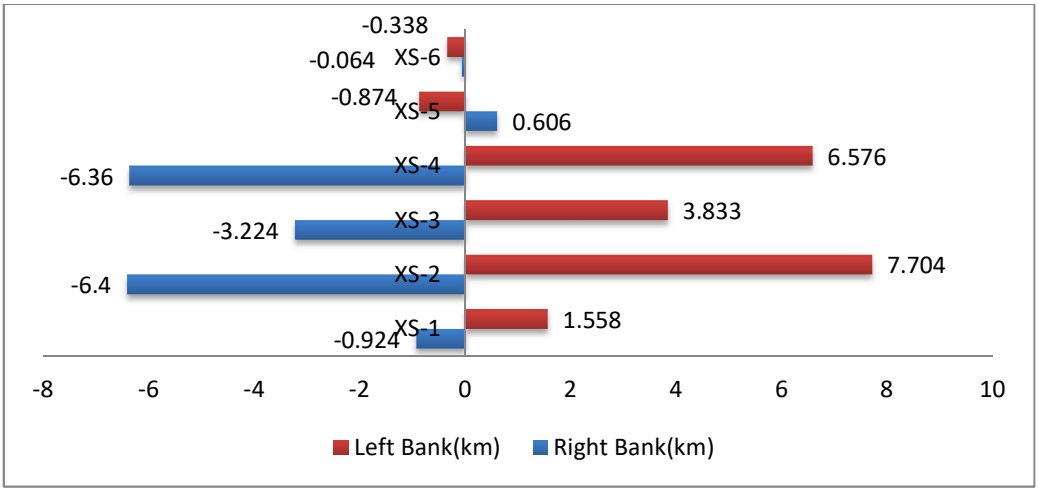


**Figure 5.18-** River Course Shifting line from 1995 to 2000

### 5.2.3 Shifting Pattern of Subansiri River Course from 2000 to 2005

Table 5.9 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.236 | 0.574 | -0.327 | -0.011 |
| **XS-2** | 0.458 | 0.446 | 0.162 | -0.15 |
| **XS-3** | 0.215 | 0.688 | 0.585 | -1.058 |
| **XS-4** | 0.23 | 2.504 | -0.615 | -1.659 |
| **XS-5** | 0.61 | 2.711 | -1.917 | -0.184 |
| **XS-6** | 1.032 | 1.378 | -0.1 | -0.246 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 2.274 km
- **Maximum decrease:** The cross-section XS-2 shows the significant decrease in river width, expanding by 0.012 km.

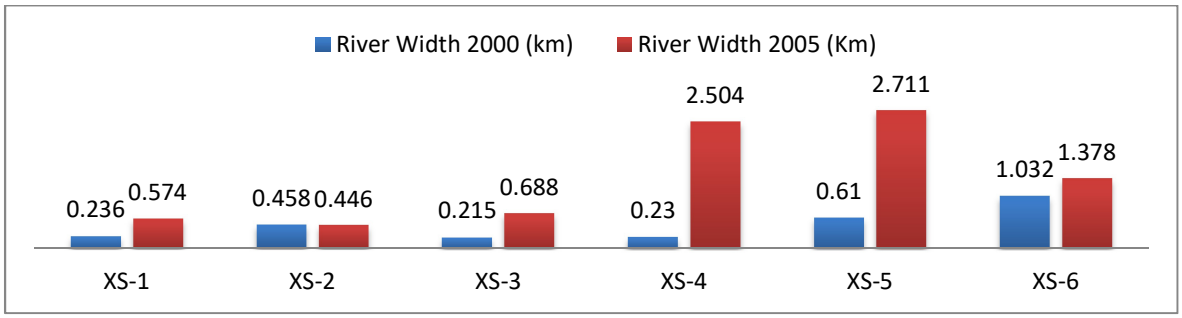


**Figure 5.19-** The Channel Width Variation from 2000 to 2005:

**Right Bank (2000-2005):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 0.585 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-5, with a value of 1.917 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-4, with a value of 1.659 km.
- **Maximum Deposition**: No river deposition occurred on the left bank between 2000 and 2005..

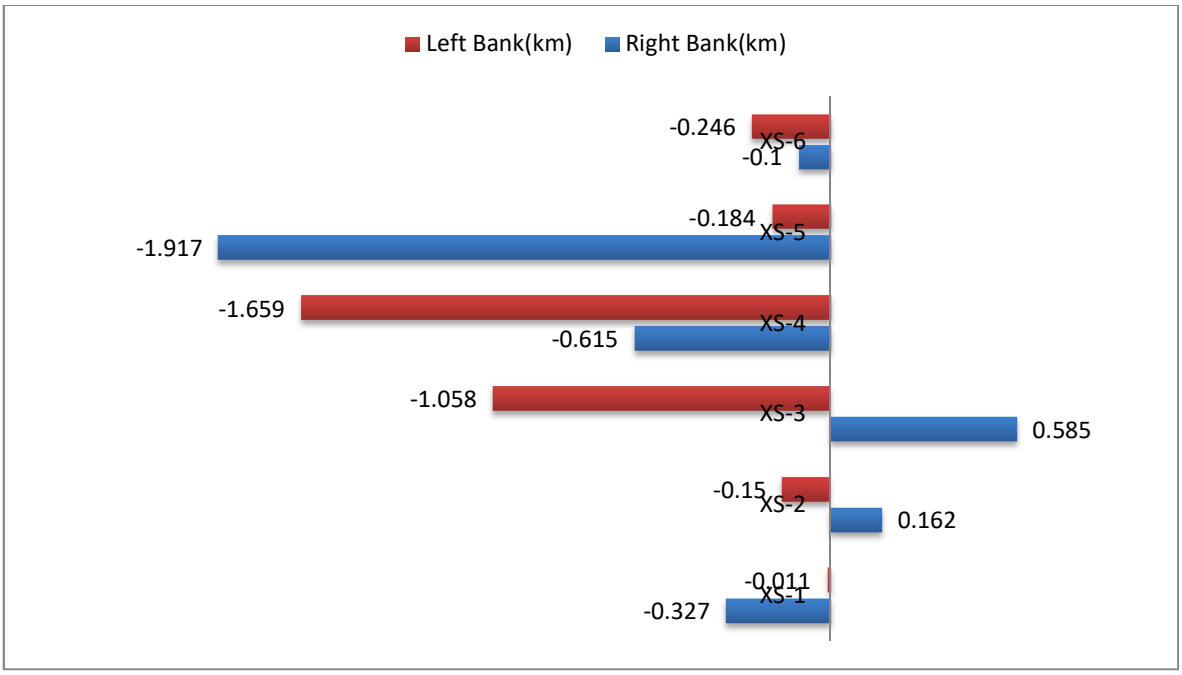


**Figure 5.20-** River Course Shifting line from 2000 to 2005

### 5.2.4 Shifting Pattern of Subansiri River Course from 2005 to 2010

Table5.10 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.574 | 0.531 | -0.148 | 0.191 |
| **XS-2** | 0.446 | 0.799 | 0.236 | -0.589 |
| **XS-3** | 0.688 | 0.443 | -1.871 | 2.116 |
| **XS-4** | 2.504 | 1.843 | 1.098 | -0.437 |
| **XS-5** | 2.711 | 1.975 | 0.25 | 0.486 |
| **XS-6** | 1.378 | 1.296 | 0.449 | -0.367 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.353 km
- **Maximum decrease:** The cross-section XS-5 shows the most significant decrease in river width, expanding by 0.736 km.

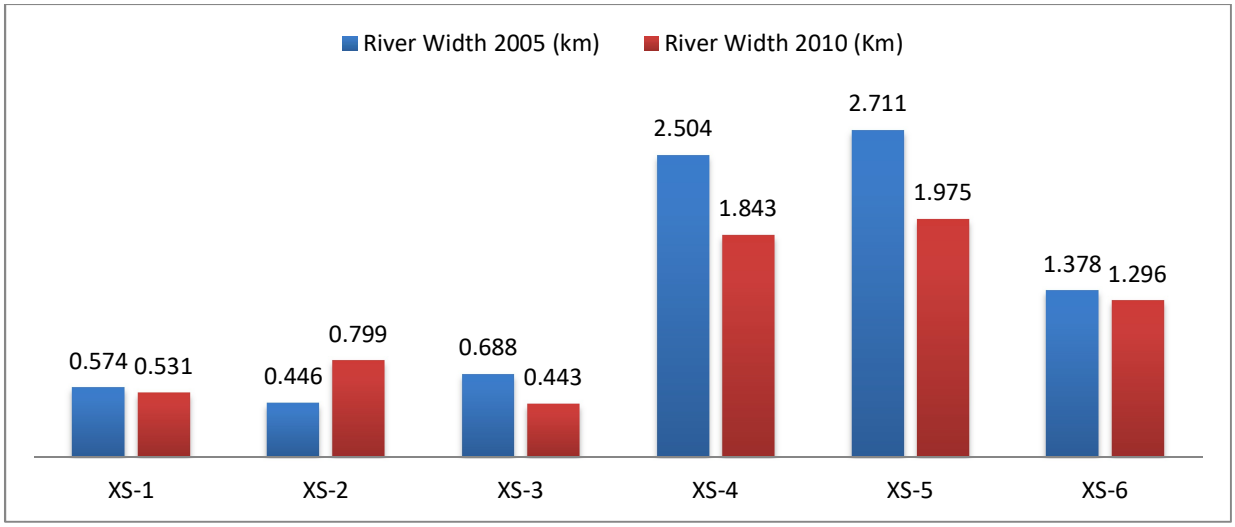


**Figure 5.21-** The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-4, with a value of 1.098 km.
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-3, with a value of 1.871 km.

**Left Bank (2005-2010):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-2, with a value 0.589km
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-3, with a value of 2.116km.

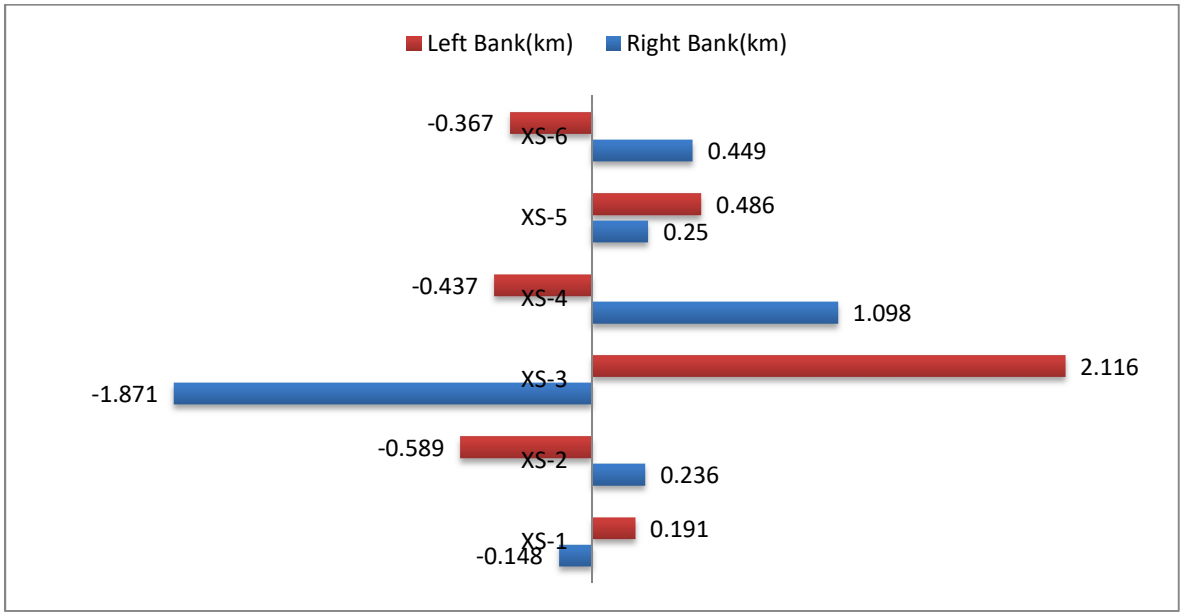


Figure 5.22 River Course Shifting line from 2005 to 2010

### 5.2.5 Shifting Pattern of Subansiri River Course from 2010 to 2015

Table 5.11 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.531 | 0.273 | -0.186 | 0.444 |
| **XS-2** | 0.799 | 2.584 | -0.865 | -0.92 |
| **XS-3** | 0.443 | 1.11 | 0.247 | -0.914 |
| **XS-4** | 1.843 | 2.563 | -0.87 | 0.15 |
| **XS-5** | 1.975 | 2.236 | -0.185 | -0.076 |
| **XS-6** | 1.296 | 2.134 | -0.67 | -0.168 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 1.785 km
- **Maximum decrease:** The cross-section XS-1 shows the most significant decrease in river width, expanding by 0.258 km

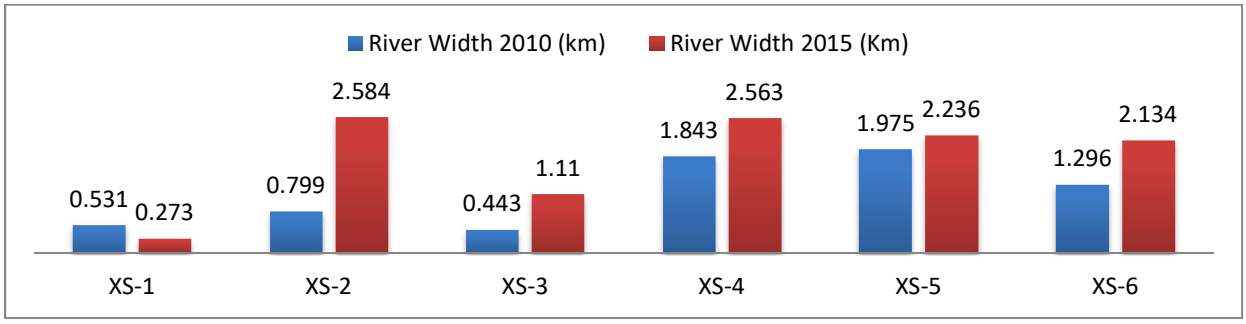


**Figure 5.23-** The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 0.247 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-4, with a value of 0.87 km.

**Left Bank (2010-2015):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-2, with a value 0.92 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-1, with a value of 0.444 km

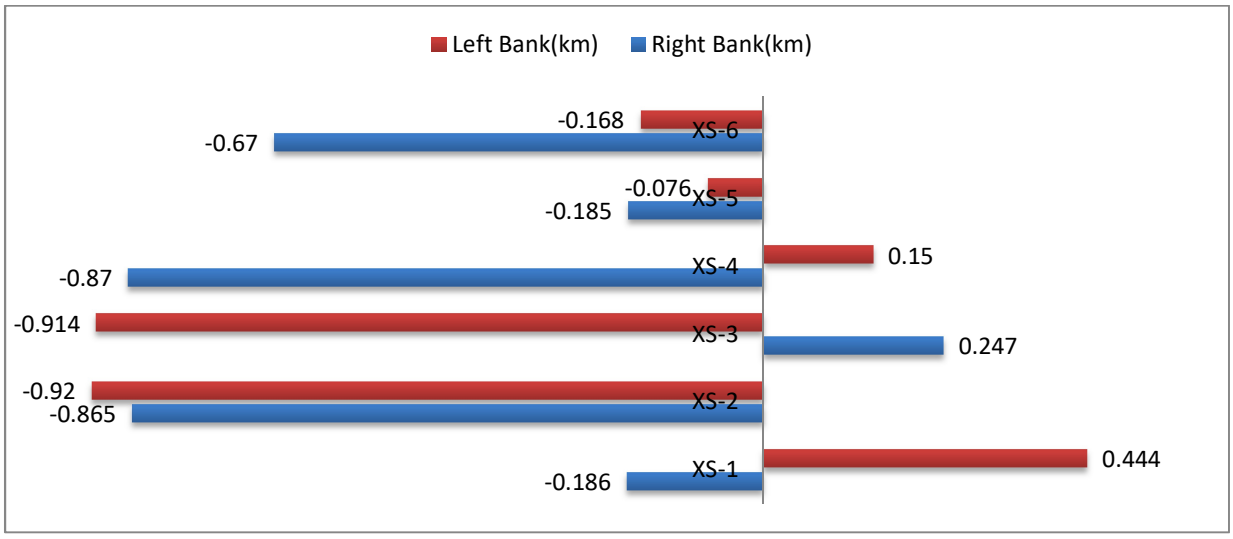


**Figure 5.24**- River Course Shifting line from 2010 to 2015

### 5.2.6 Shifting Pattern of Subansiri River Course from 2015 to 2020

Table 5.12 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.273 | 0.502 | 0.017 | -0.246 |
| **XS-2** | 2.584 | 0.578 | 0.342 | 1.664 |
| **XS-3** | 1.11 | 1.848 | -0.4 | -0.338 |
| **XS-4** | 2.563 | 2.946 | -0.493 | 0.11 |
| **XS-5** | 2.236 | 1.834 | 0.802 | -0.4 |
| **XS-6** | 2.134 | 2.134 | 0.294 | -0.294 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.738 km
- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 2.006 km.

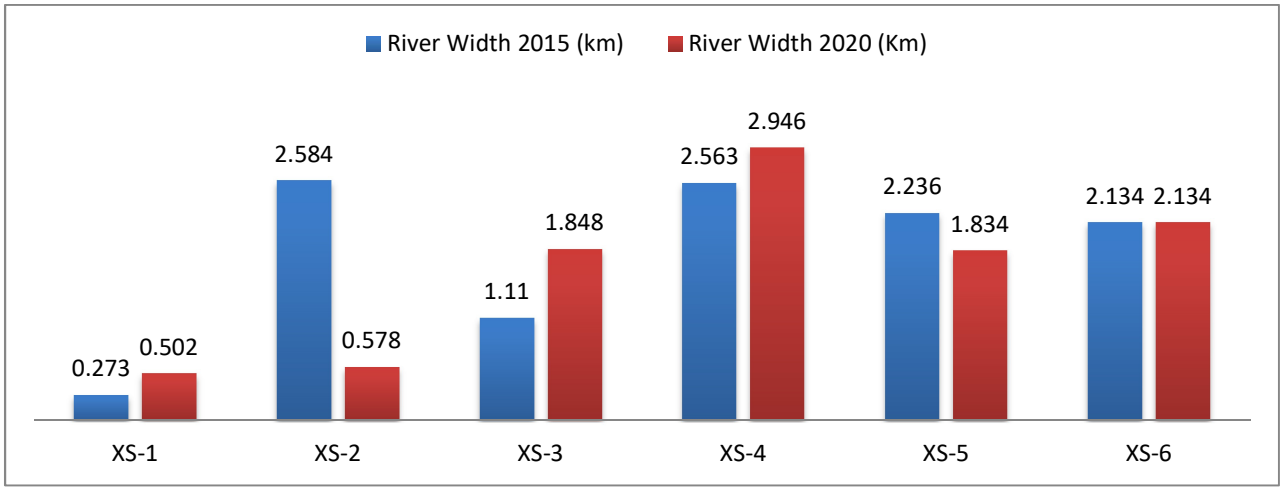


**Figure 5.25-** The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-5, with a value of 0.802 km.
- **Maximum Erosion**. The highest erosion on the right bank occurred at cross-section XS-4, with a value of 0.493 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-5, with a value 0.4 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 1.664 km

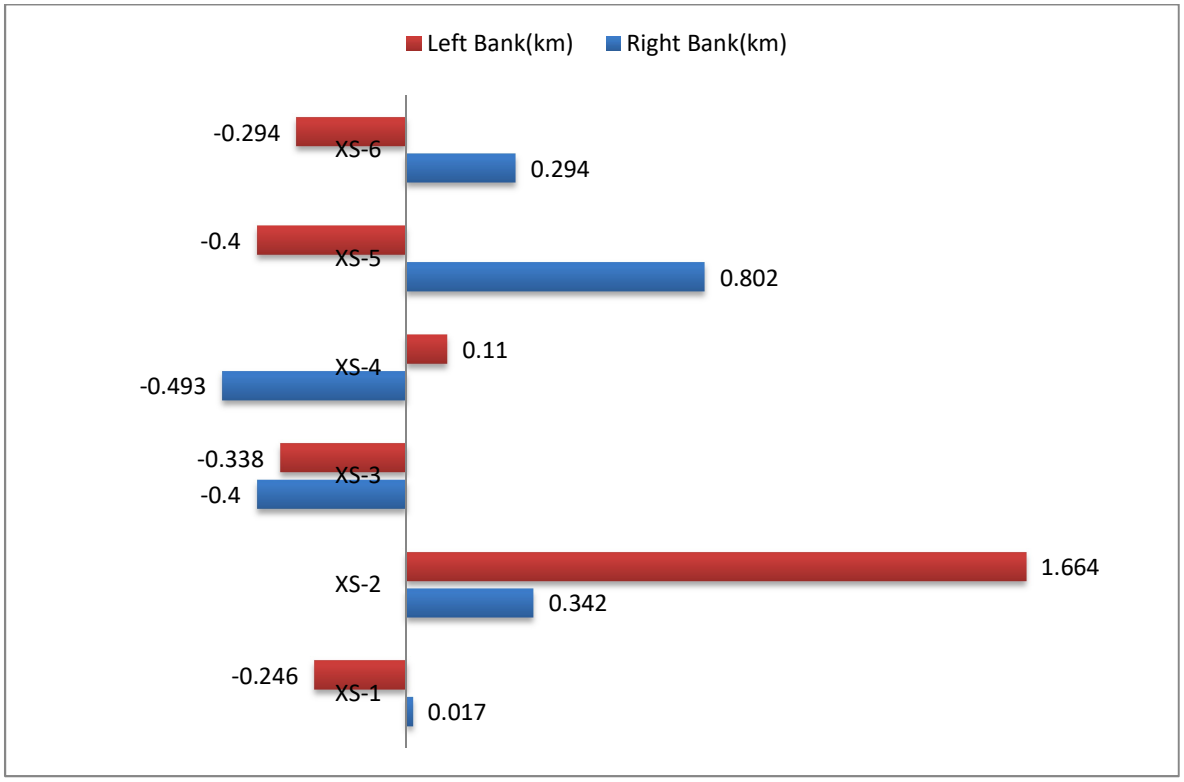


**Figure 5.26-** River Course Shifting line from 2015 to 2020

## 5.3 DIKRONG RIVER

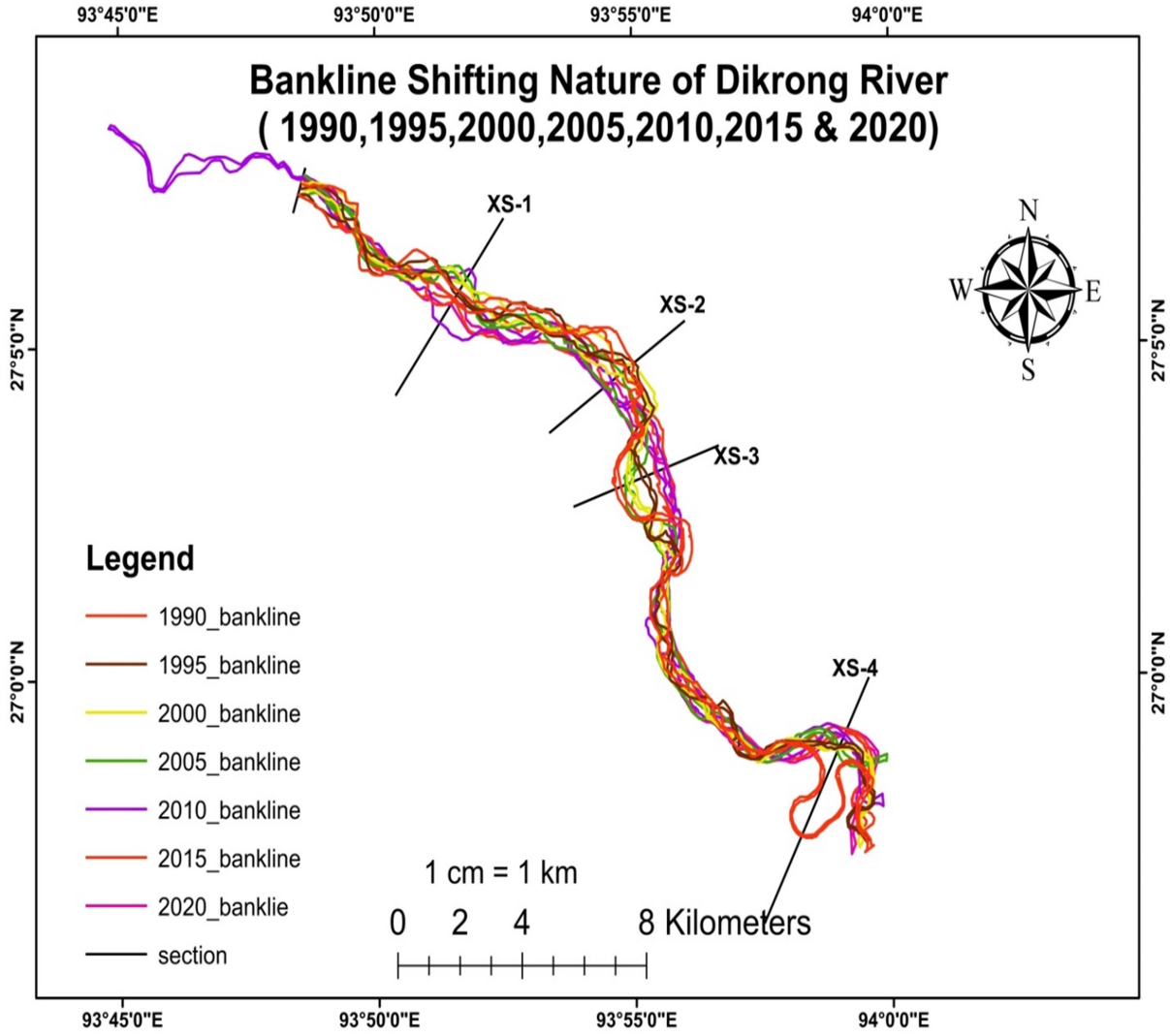


**Figure 5.27-** Apparent Positions of the river in seven-time and river width the different cross-sections of calculating banklines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Dikrong River from 1990 to 2020 has been taken into 4 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.27, it is clear that the river bank line is not like the same cross-section

### 5.3.1 Shifting Pattern of Dikrong River Course from 1990 to 1995

Table 5.13 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.372 | 0.1 | 0.24 | 0.032 |
| **XS-2** | 0.343 | 0.294 | 0.08 | -0.031 |
| **XS-3** | 0.168 | 0.197 | 0.884 | -0.913 |
| **XS-4** | 0.054 | 0.054 | 2.759 | -2.759 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.029 km.
- **Maximum Decrease:** Cross-section XS-1 has the largest decrease in river width of 0.272 km

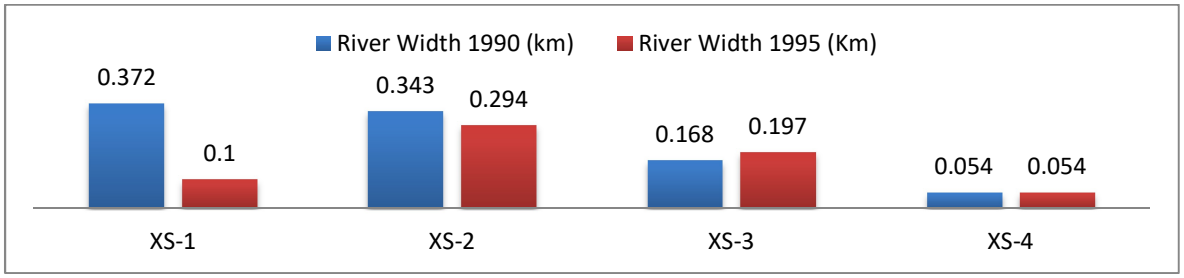


**Figure 5.28-** The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-4, with a value of 2.759 km.
- **Maximum Erosion**: No erosion occurred.

**Left Bank ( 1990-1995):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-4, with a value of 2.759 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-1, with a value 0.032 km.

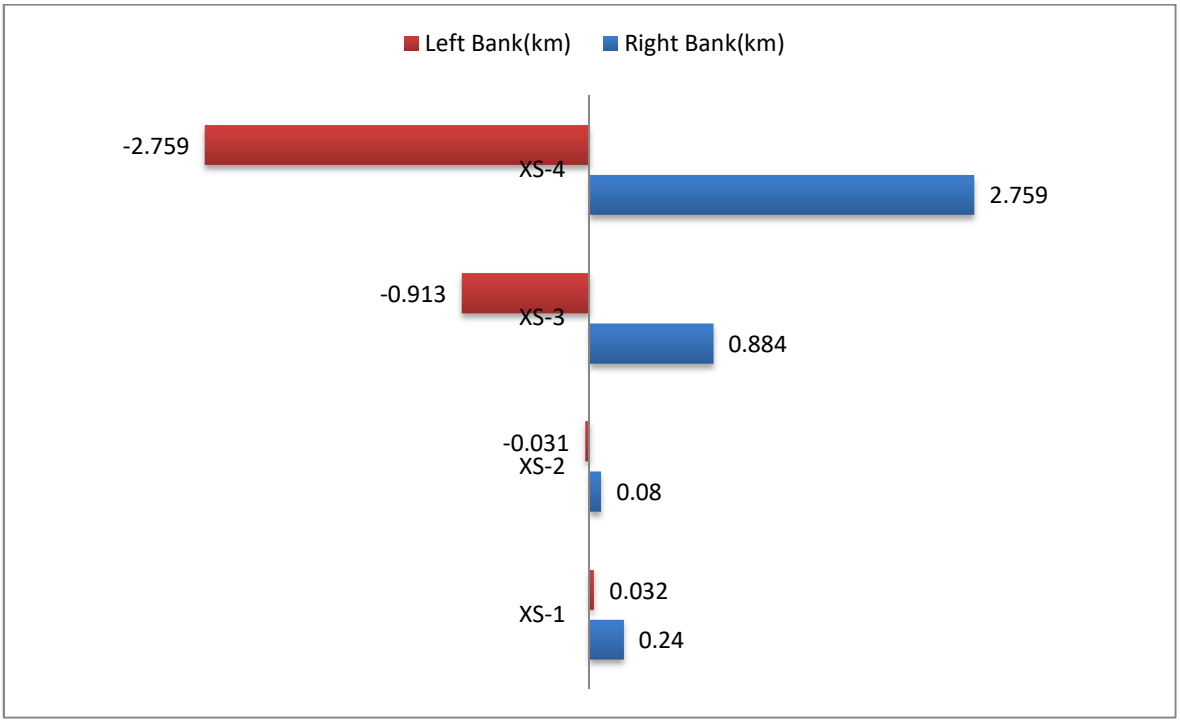


**Figure 5.29**- River Course Shifting line from 1990 to 1995

### 5.3.2 Shifting Pattern of Dikrong River Course from 1995 to 2000

Table 5.14 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.1 | 0.037 | 0.376 | -0.313 |
| **XS-2** | 0.294 | 0.452 | -0.287 | 0.129 |
| **XS-3** | 0.197 | 0.153 | -0.495 | 0.539 |
| **XS-4** | 0.054 | 0.047 | -0.062 | 0.069 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.158 km
- **Maximum Decrease**: Cross-section XS-1 has decrease in river width of 0.063 km.

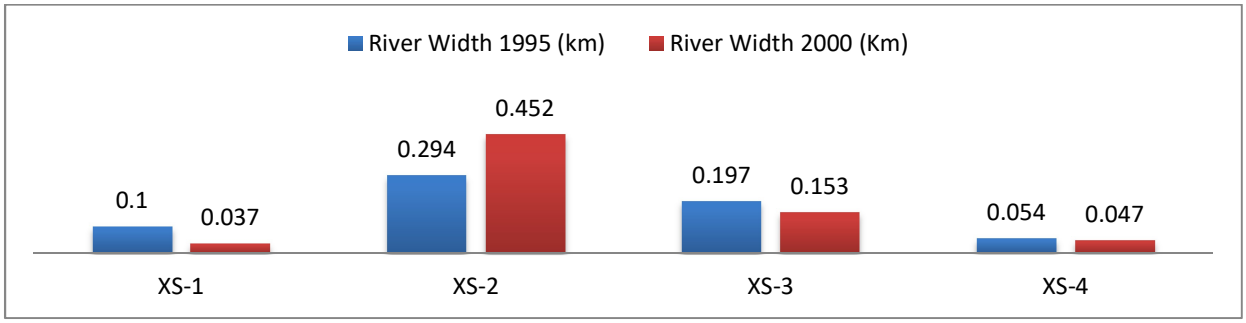


**Figure 5.30-** The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-1, with a value of 0.376 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-3, with a value of 0.495 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-1, with a value of 0.313 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-3, with a value of 0.539 km.

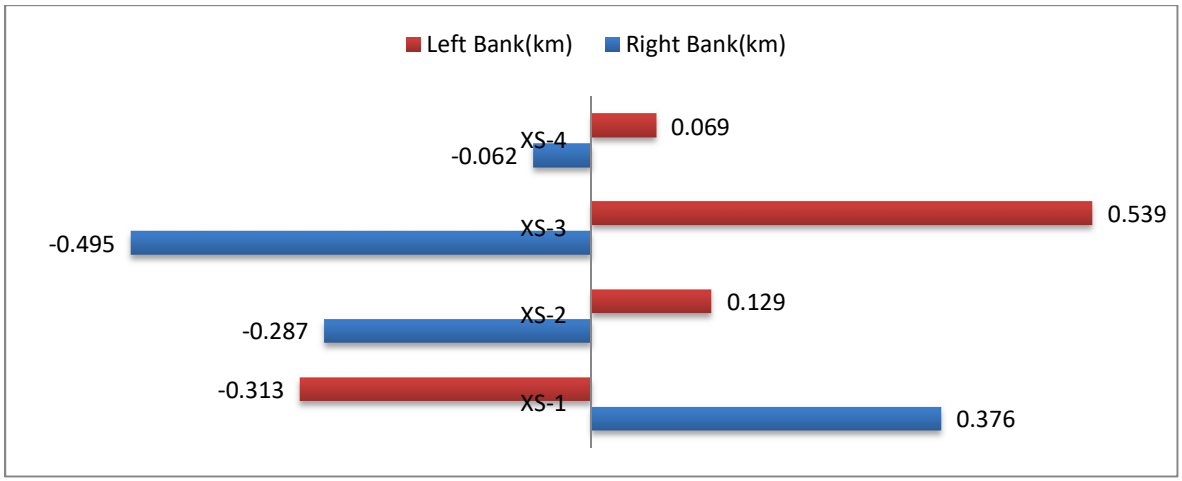


**Figure 5.31-** River Course Shifting line from 1995 to 2000

### 5.3.3 Shifting Pattern of Dikrong River Course from 2000 to 2005

Table 5.15 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.037 | 0.207 | -0.025 | -0.145 |
| **XS-2** | 0.452 | 0.684 | -0.6 | 0.368 |
| **XS-3** | 0.153 | 0.164 | -0.067 | 0.056 |
| **XS-4** | 0.047 | 0.146 | -0.064 | -0.035 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.232 km
- **Maximum decrease:** no decrease in width.

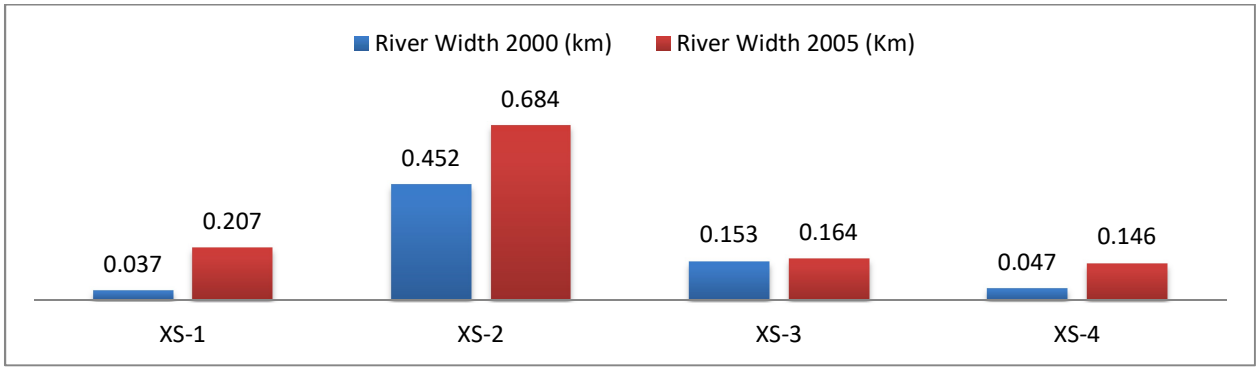


**Figure 5.32-** The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: No river deposition occurred on the Right bank between 2000 and 2005.
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-2, with a value of 0.6 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-1, with a value of 0.145 km.
- **Maximum Deposition**: The most significant deposition on the left bank occurred at cross-section XS-2, with a value of 0.368 km

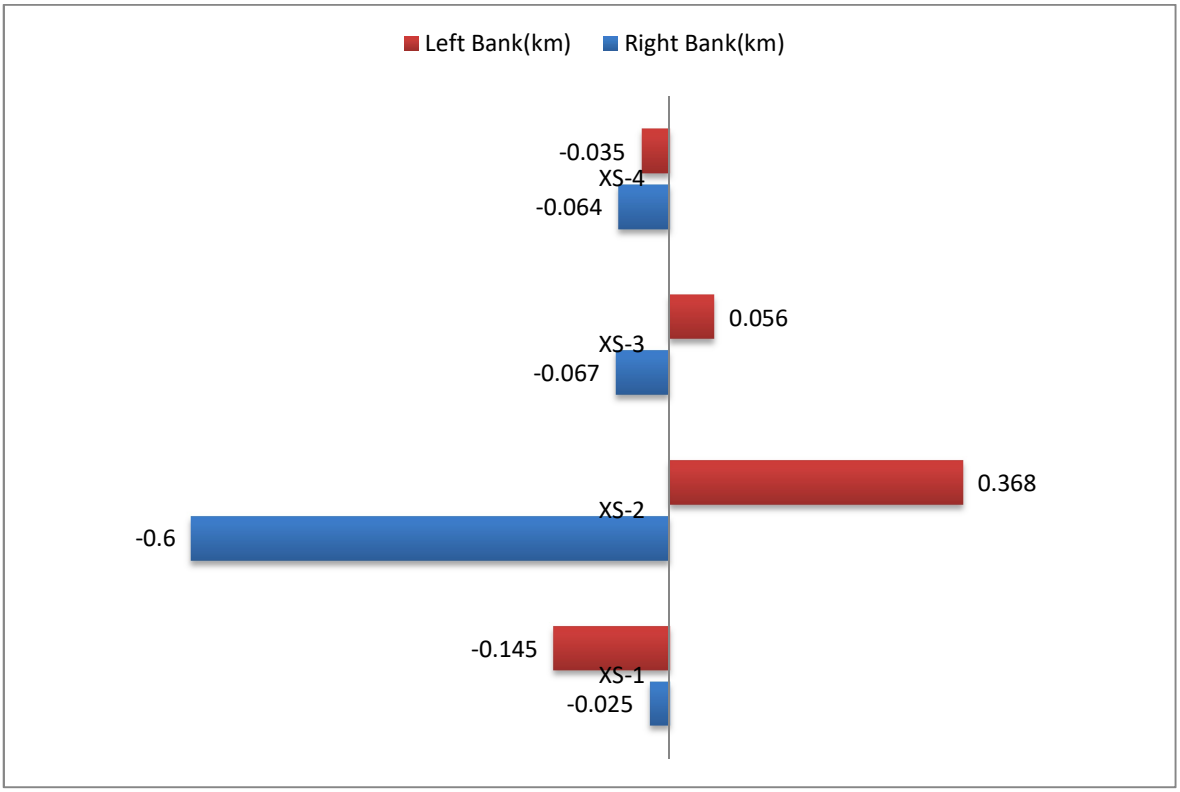


**Figure 5.33-** River Course Shifting line from 2000 to 2005

### 5.3.4 Shifting Pattern of Dikrong River Course from 2005 to 2010

Table 5.16 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.207 | 1.783 | -1.32 | -0.256 |
| **XS-2** | 0.684 | 0.321 | -0.044 | 0.407 |
| **XS-3** | 0.164 | 0.31 | 1.09 | -1.236 |
| **XS-4** | 0.146 | 0.097 | 0.435 | -0.386 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-1 shows the most significant increase in river width, expanding by 1.576 km
- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 0.363 km.

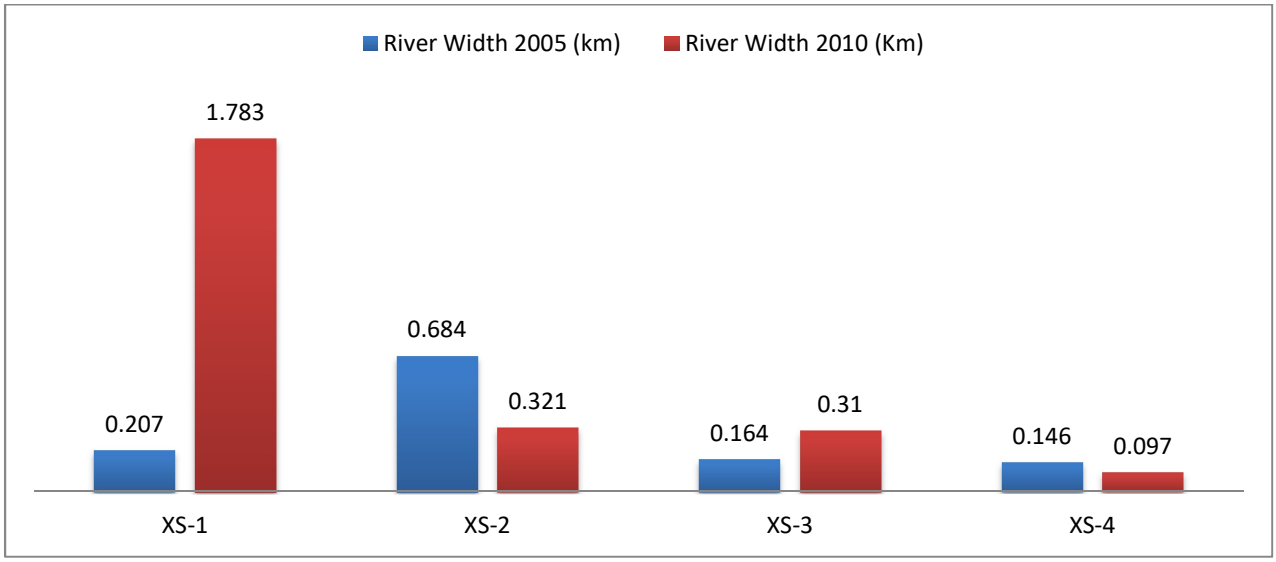


**Figure 5.34**- The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 1.09 km.
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-1, with a value of 1.32 km.

**Left Bank (2005-2010):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 1.236 km
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 0.407 km.

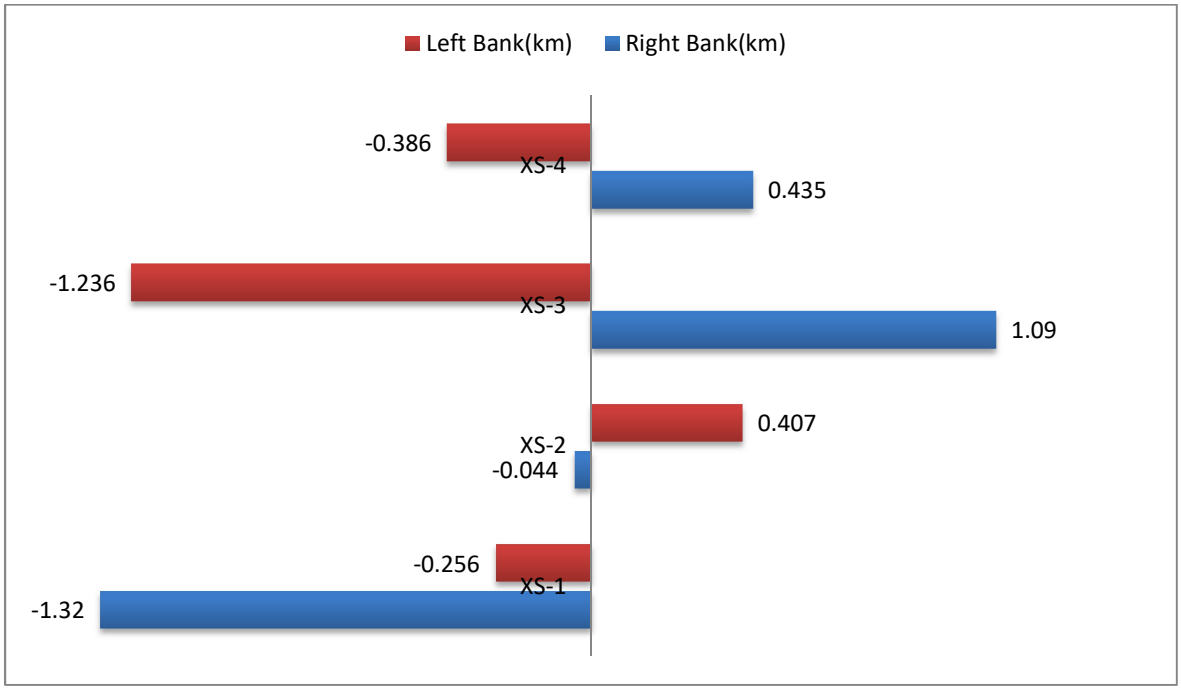


**Figure 5.35**- River Course Shifting line from 2005 to 2010

### 5.3.5 Shifting Pattern of Dikrong River Course from 2010 to 2015

Table 5.17 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 1.783 | 0.072 | 0.78 | 0.931 |
| **XS-2** | 0.321 | 0.392 | 0.126 | -0.197 |
| **XS-3** | 0.31 | 0.431 | -0.092 | -0.029 |
| **XS-4** | 0.097 | 0.121 | 0.119 | -0.143 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.121 km
- **Maximum decrease:** The cross-section XS-1 shows the most significant decrease in river width, expanding by 1.711 km

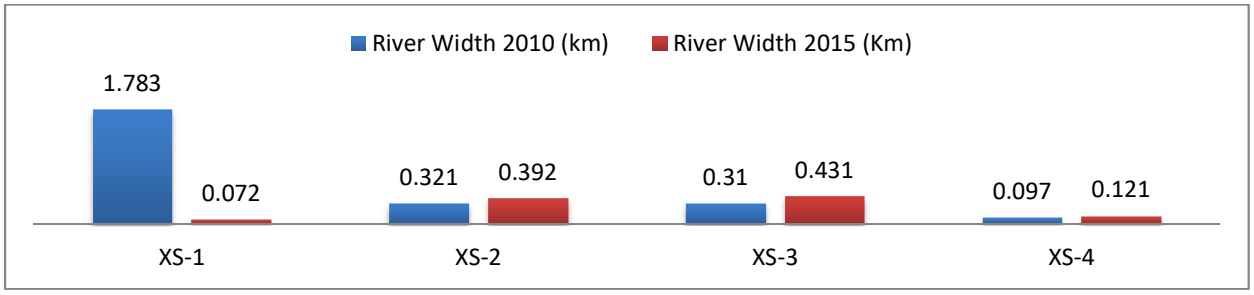


**Figure 5.36** -The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.78 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-3, with a value of 0.092 km.

**Left Bank (2010-2015):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-2, with a value 0.197 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-1, with a value of 0.931 km

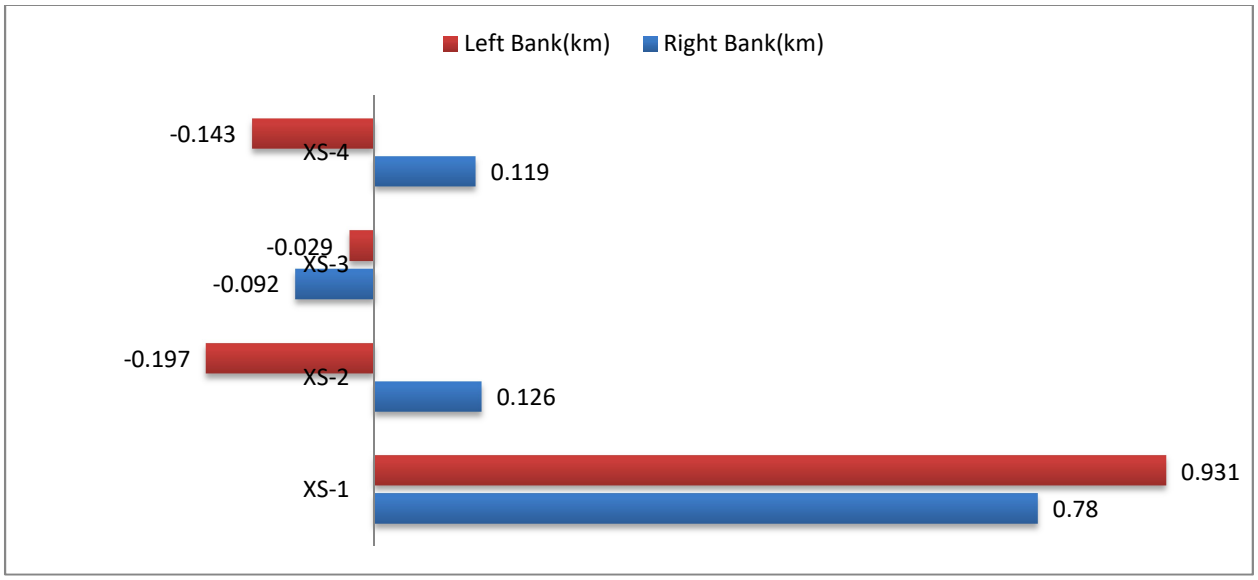


**Figure 5.37**- River Course Shifting line from 2010 to 2015

### 5.3.6 Shifting Pattern of Dikrong River Course from 2015 to 2020

Table 5.18 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.072 | 0.206 | -0.156 | 0.022 |
| **XS-2** | 0.392 | 0.256 | -0.136 | 0.272 |
| **XS-3** | 0.431 | 0.098 | 0.35 | -0.017 |
| **XS-4** | 0.121 | 0.112 | 0.025 | -0.016 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-1 shows the most significant increase in river width, expanding by 0.134 km
- **Maximum decrease:** The cross-section XS-3 shows the most significant decrease in river width, expanding by 0.333 km.

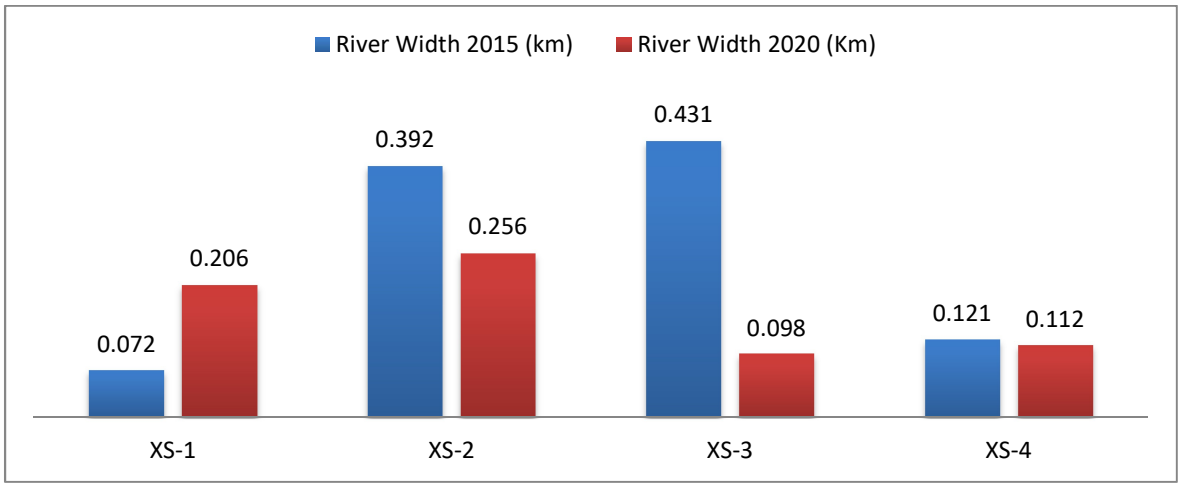


**Figure 5.38** -The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 0.35 km.

- **Maximum Erosion**. The highest erosion on the right bank occurred at cross-section XS-1, with a value of 0.156 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.017 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 0.272 km

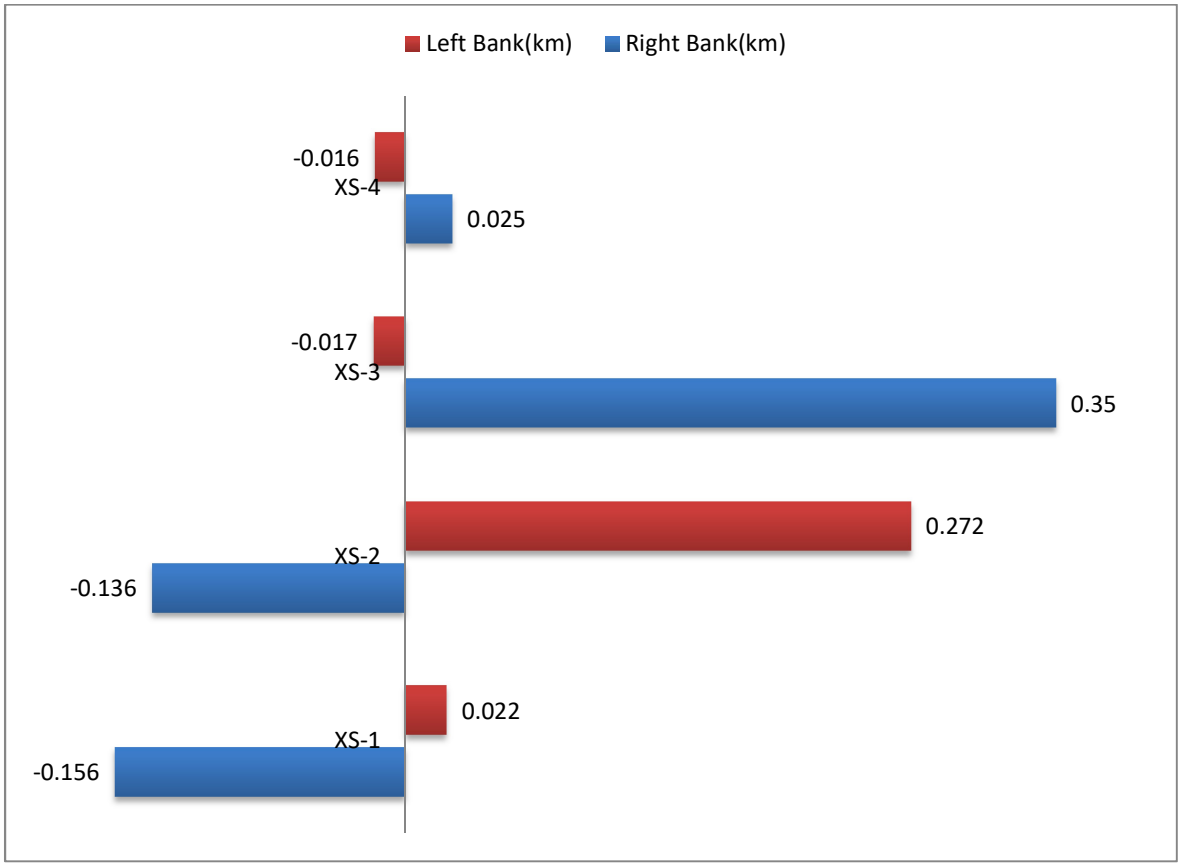


**Figure 5.39-** River Course Shifting line from 2015 to 2020

## 5.4 BUROI RIVER

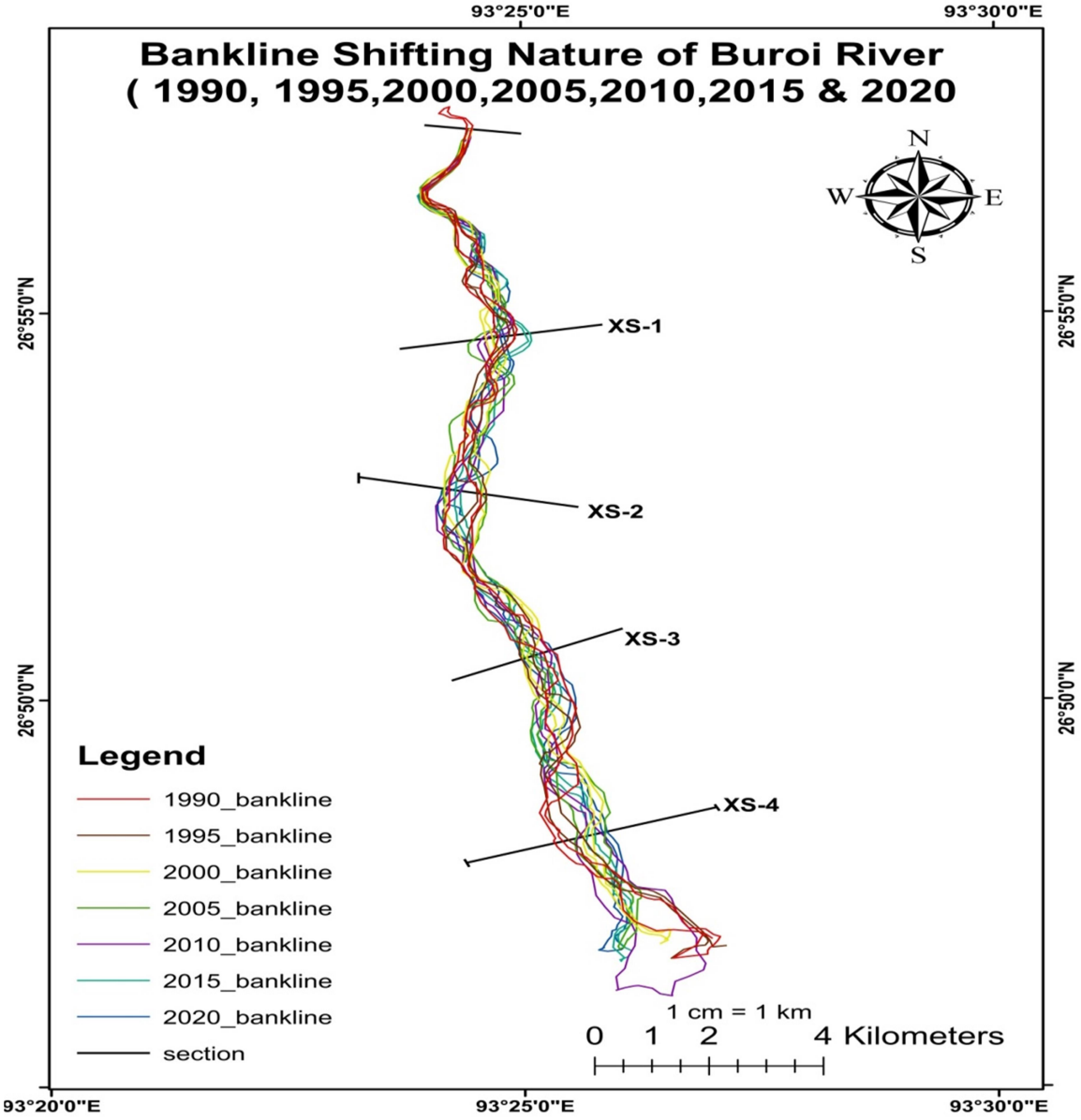


**Figure 5.40**- Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Buroi River from 1990 to 2020 has been taken into 4 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.40, it is clear that the river bank line is not like the same cross-section

### 5.4.1 Shifting Pattern of Buroi River Course from 1990 to 1995

Table 5.19 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.296 | 0.103 | 0.178 | 0.015 |
| **XS-2** | 0.56 | 0.16 | 0.5 | -0.1 |
| **XS-3** | 0.141 | 0.225 | -0.413 | 0.329 |
| **XS-4** | 0.149 | 0.265 | 0.248 | -0.364 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.116 km.
- **Maximum Decrease:** Cross-section XS-2 has the largest decrease in river width of 0.4 km

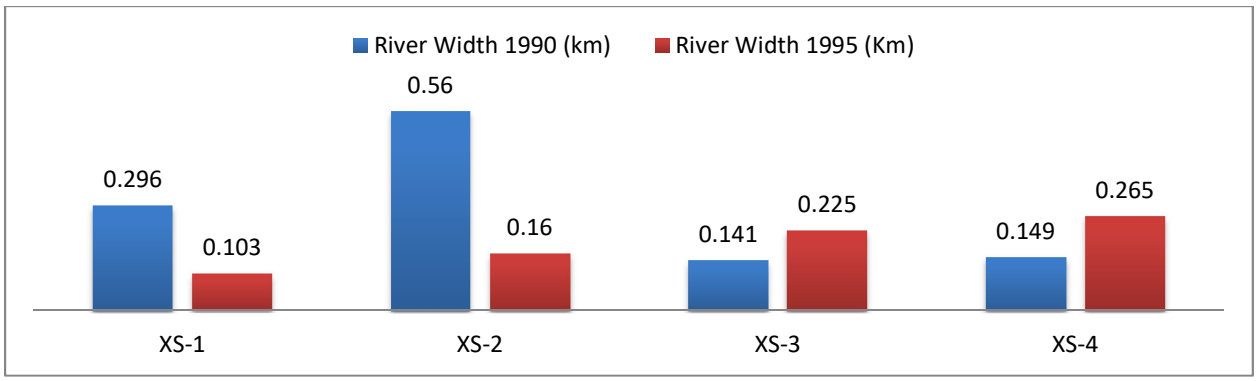


**Figure 5.41**- The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-2, with a value of 0.5 km.
- **Maximum Erosion**: The greatest erosion on the right bank occurred at cross-section XS-3, with a value of 0.413 km

**Left Bank ( 1990-1995):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-4, with a value of 0.364 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-3, with a value 0.329 km.

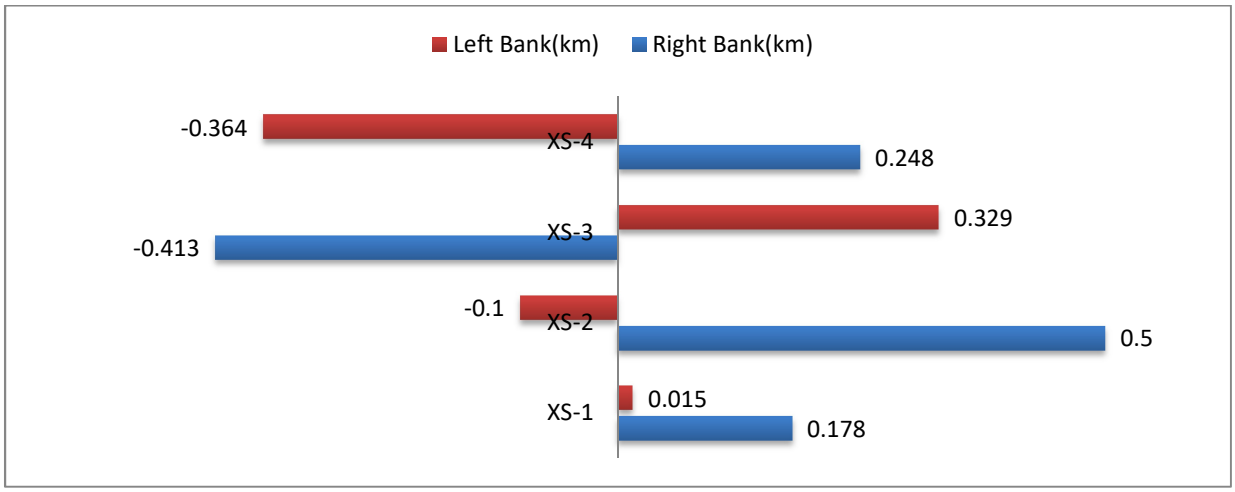


**Figure 5.42-** River Course Shifting line from 1990 to 1995

### 5.4.2 Shifting Pattern of Buroi River Course from 1995 to 2000

Table 5.20 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.103 | 0.116 | -0.403 | 0.39 |
| **XS-2** | 0.16 | 0.661 | -0.582 | 0.081 |
| **XS-3** | 0.225 | 0.097 | 0.009 | 0.119 |
| **XS-4** | 0.265 | 0.15 | 0.293 | -0.178 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.501 km
- **Maximum Decrease:** Cross-section XS-3 has decrease in river width of 0.128 km

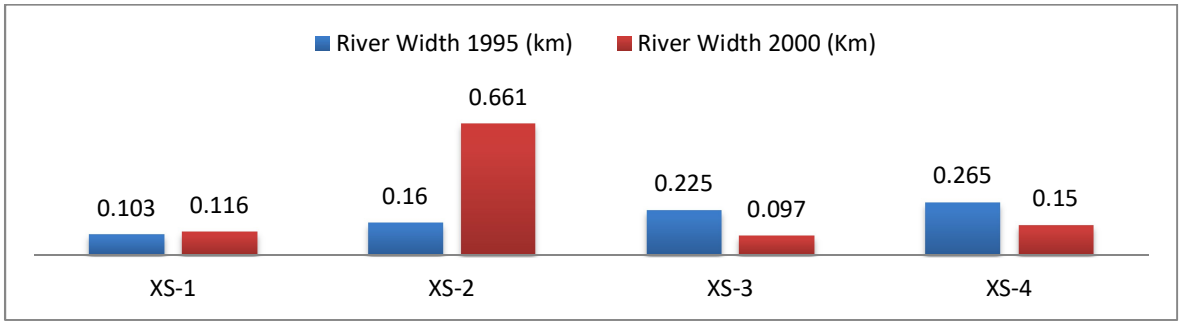


**Figure 5.43**- The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-4, with a value of 0.293 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-2, with a value of 0.582 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-4, with a value of 0.178 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-1, with a value of 0.39 km.

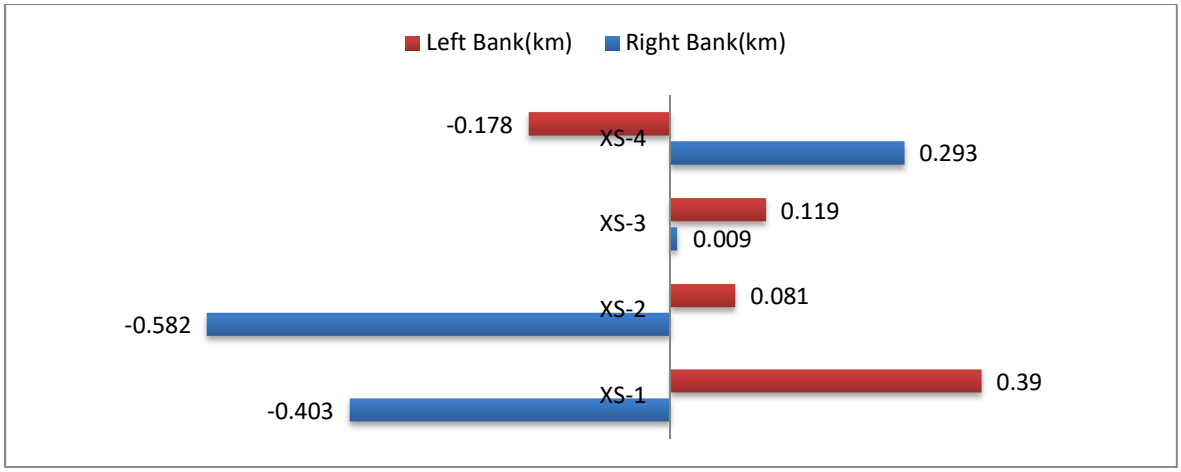


**Figure 5.44-** River Course Shifting line from 1995 to 2000

**5.4.3 Shifting Pattern of Buroi River Course From 2000 to 2005**

Table 5.21 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.116 | 0.377 | -0.221 | -0.04 |
| **XS-2** | 0.661 | 0.64 | -0.005 | 0.026 |
| **XS-3** | 0.097 | 0.17 | 0.067 | -0.14 |
| **XS-4** | 0.15 | 0.544 | -0.157 | -0.237 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.394 km
- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 0.021 km

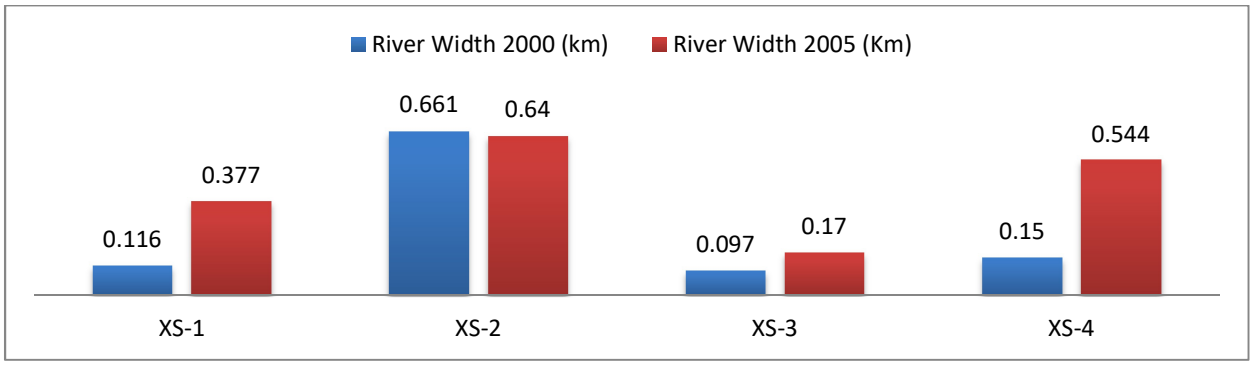


**Figure 5.45-** The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: : The most significant deposition on the right bank occurred at cross-section XS-3, with a value of 0.067 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-1, with a value of 0.221 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-4, with a value of 0.237 km.
- **Maximum Deposition**: The most significant deposition on the left bank occurred at cross-section XS-2, with a value of 0.026 km

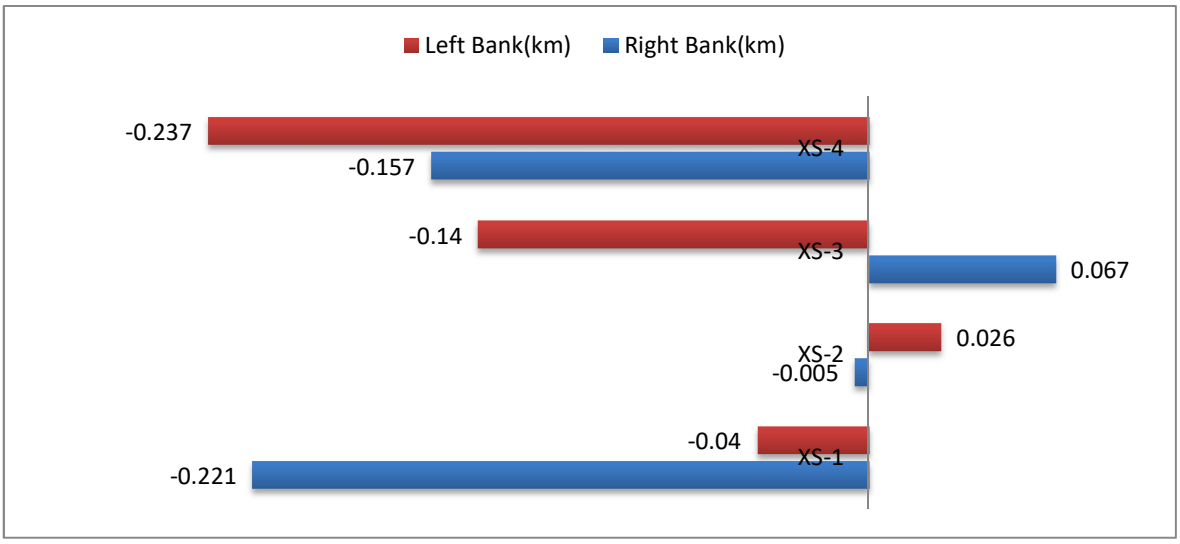


**Figure 5.46-** River Course Shifting line from 2000 to 2005

### 5.4.4 Shifting Pattern of Buroi River Course from 2005 to 2010

Table 5.22 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.377 | 0.102 | 0.146 | 0.129 |
| **XS-2** | 0.64 | 0.228 | 0.066 | 0.346 |
| **XS-3** | 0.17 | 0.163 | 0.277 | -0.27 |
| **XS-4** | 0.544 | 0.422 | 0.039 | 0.083 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** no significant increase in river width was observed in our selected section between 2005-2010.

- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 0.412 km.

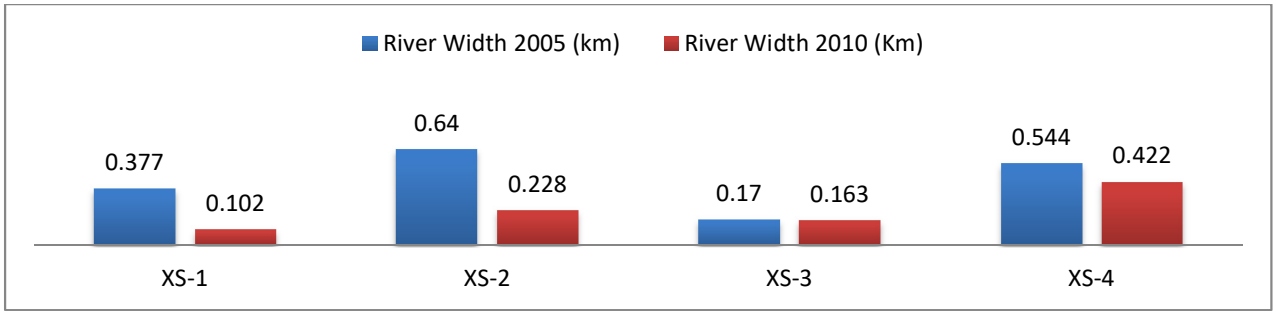


**Figure 5.46-** The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 0.227 km.
- **Maximum Erosion**: no erosion during this time period.

**Left Bank (2005-2010):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.270 km
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 0.346 km.

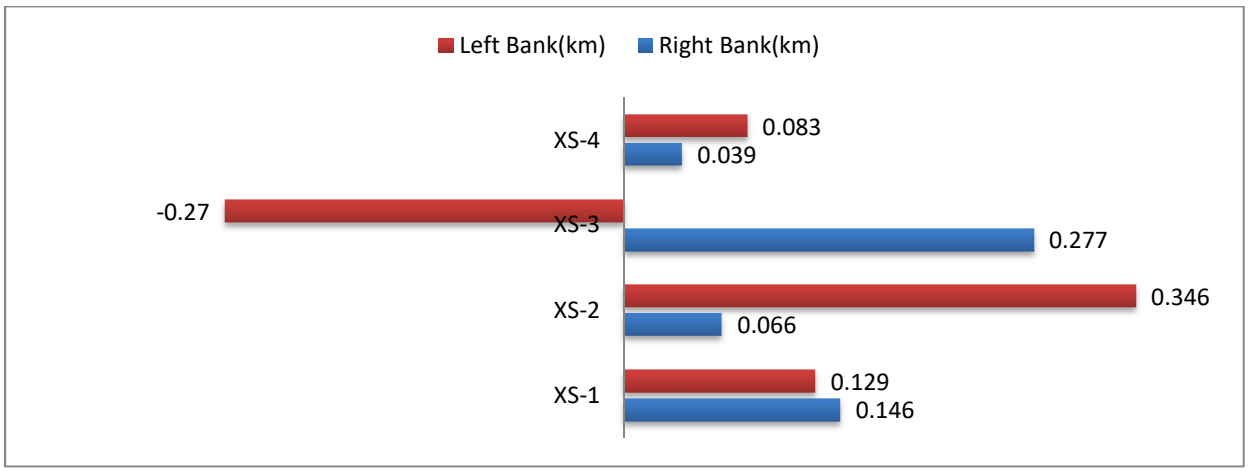


**Figure 5.47-** River Course Shifting line from 2005 to 2010

### 5.4.5 Shifting Pattern of Buroi River Course from 2010 to 2015

Table 5.23 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.102 | 0.083 | 0.767 | -0.748 |
| **XS-2** | 0.228 | 0.081 | 0.137 | 0.01 |
| **XS-3** | 0.163 | 0.107 | -0.138 | 0.194 |
| **XS-4** | 0.422 | 0.151 | 0.168 | 0.103 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** no increase in river width during this time period.
- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 0.271 km

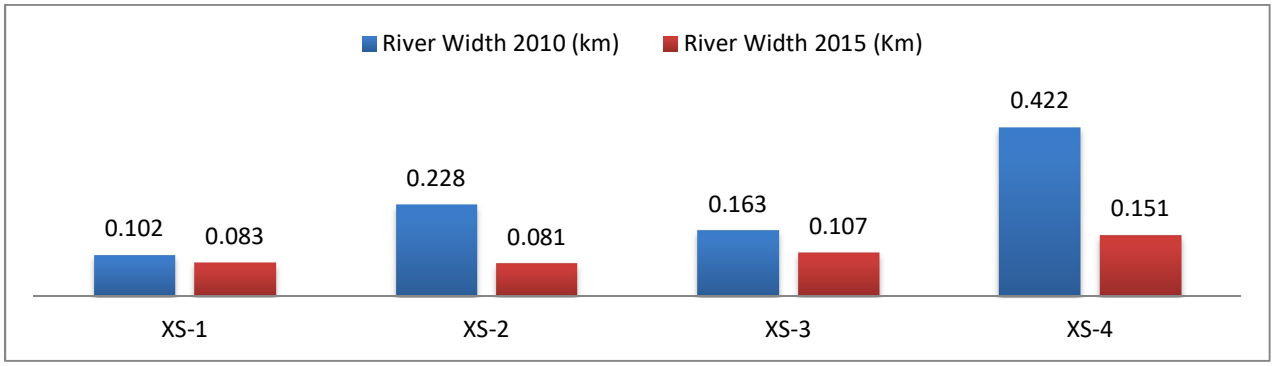


**Figure 5.48-** The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.767 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-3, with a value of 0.138 km.

**Left Bank (2010-2015):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-1, with a value 0.748 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-3, with a value of 0.194 km

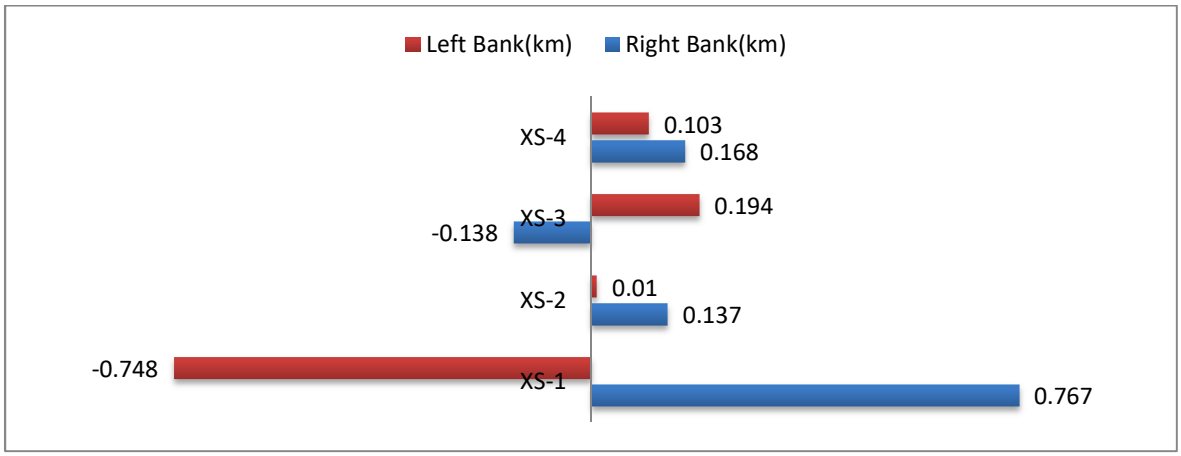


**Figure 5.49-** River Course Shifting line from 2010 to 2015

### 5.4.6 Shifting Pattern of Buroi River Course from 2015 to 2020

Table 5.24 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.083 | 0.062 | -0.43 | 0.451 |
| **XS-2** | 0.081 | 0.151 | -0.21 | 0.14 |
| **XS-3** | 0.107 | 0.56 | -0.194 | -0.259 |
| **XS-4** | 0.151 | 0.079 | 0.288 | -0.216 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.453 km
- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 0.072 km.

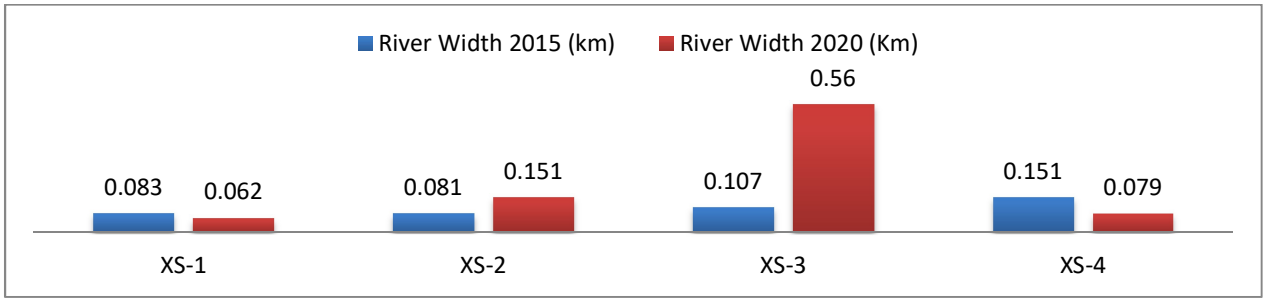


**Figure 5.50**- The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-4, with a value of 0.288 km.
- **Maximum Erosion**. The highest erosion on the right bank occurred at cross-section XS-1, with a value of 0.430 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.259 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-1, with a value of 0.451 km

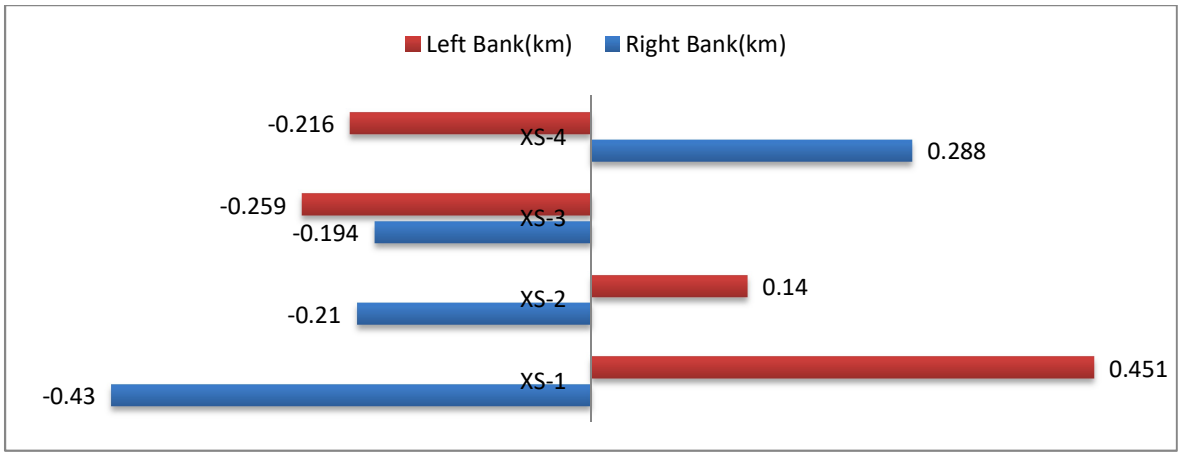


**Figure 5.51-** River Course Shifting line from 2015 to 2020

## 5.5 BORGANG RIVER

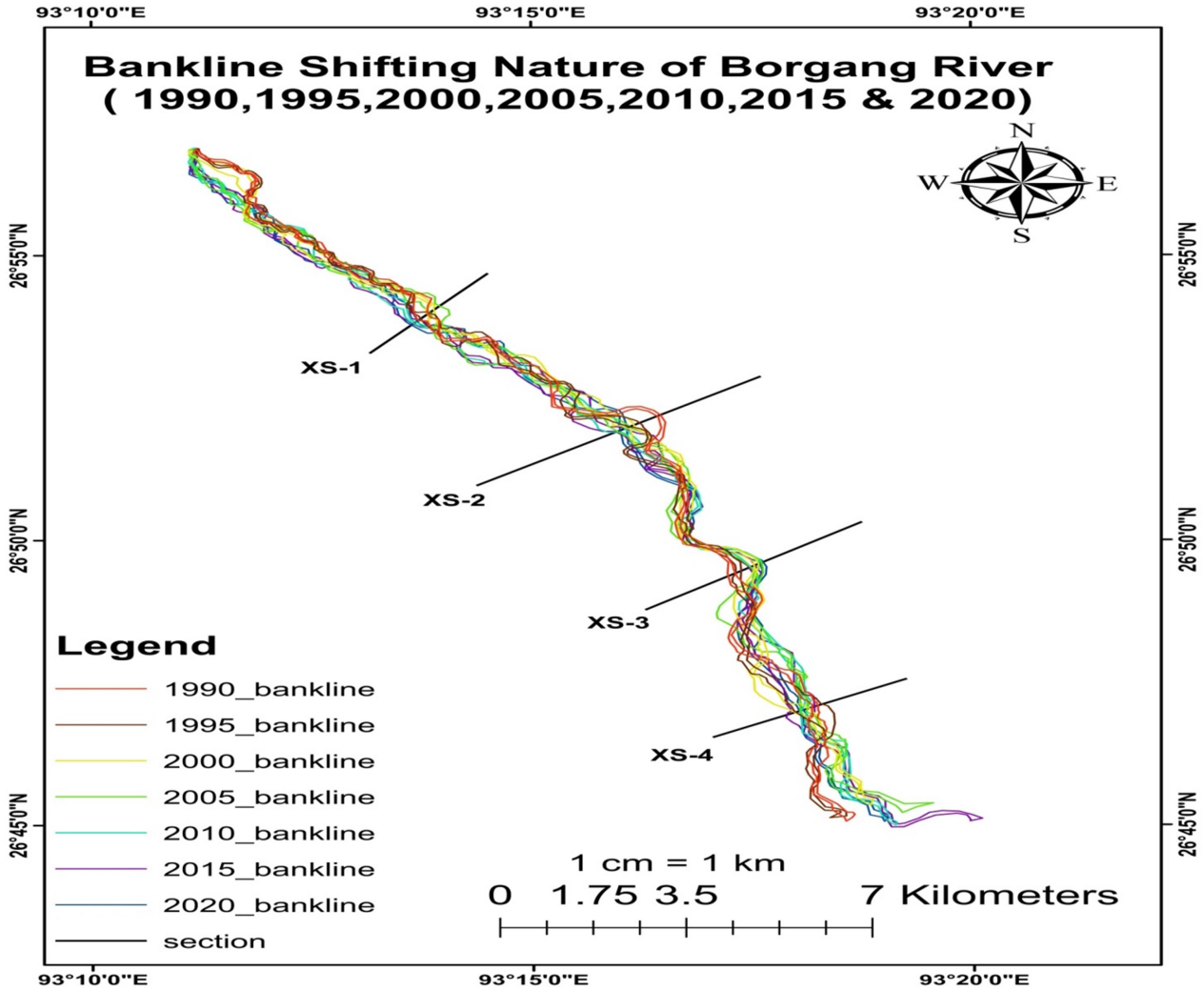


**Figure 5.52**- Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Borgang River from 1990 to 2020 has been taken into 4 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.52, it is clear that the river bank line is not like the same cross-section

### 5.5.1 Shifting Pattern of Borgang River Course from 1990 to 1995

Table 5.25 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.27 | 0.247 | 0.061 | -0.038 |
| **XS-2** | 0.073 | 0.22 | -0.62 | 0.473 |
| **XS-3** | 0.164 | 0.138 | 0.161 | -0.135 |
| **XS-4** | 0.127 | 0.565 | -0.344 | -0.094 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.438 km.
- **Maximum Decrease**: Cross-section XS-3 has the largest decrease in river width of 0.026 km

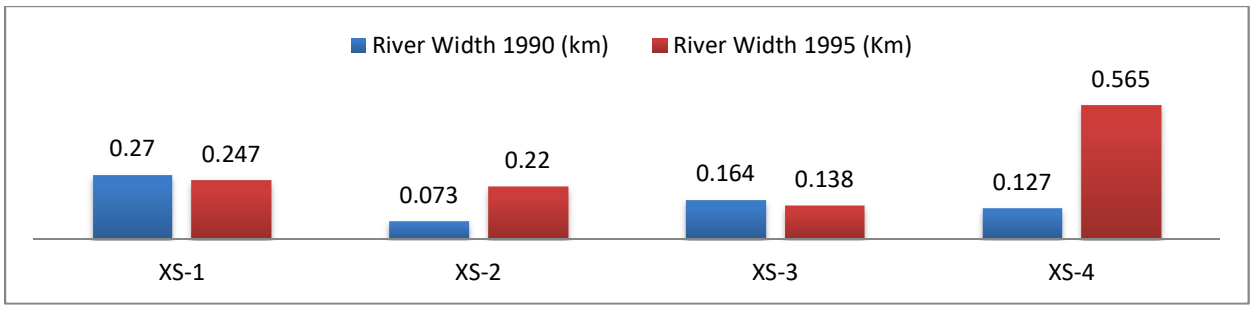


**Figure 5.53** The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-3, with a value of 0.161 km.
- **Maximum Erosion**: The greatest erosion on the right bank occurred at cross-section XS-2, with a value of 0.62 km

**Left Bank ( 1990-1995):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-3, with a value of 0.135 km.

- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-2, with a value 0.473 km

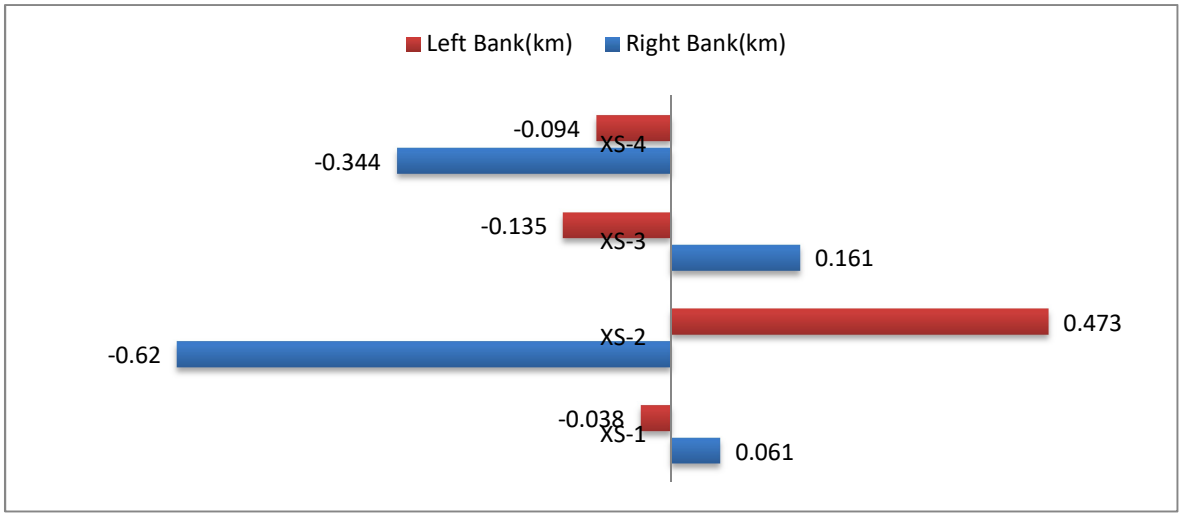


**Figure 5.54-** River Course Shifting line from 1990 to 1995

### 5.5.2 Shifting Pattern of Borgang River Course from 1995 to 2000

Table 5.26 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.247 | 0.179 | 0.198 | -0.13 |
| **XS-2** | 0.22 | 0.164 | -0.072 | 0.128 |
| **XS-3** | 0.138 | 0.107 | 0.43 | -0.399 |
| **XS-4** | 0.565 | 0.309 | -0.023 | 0.279 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** no significant increase in river width was observed in our selected section between 1995-2000
- **Maximum Decrease:** Cross-section XS-4 has decrease in river width of 0.256 km

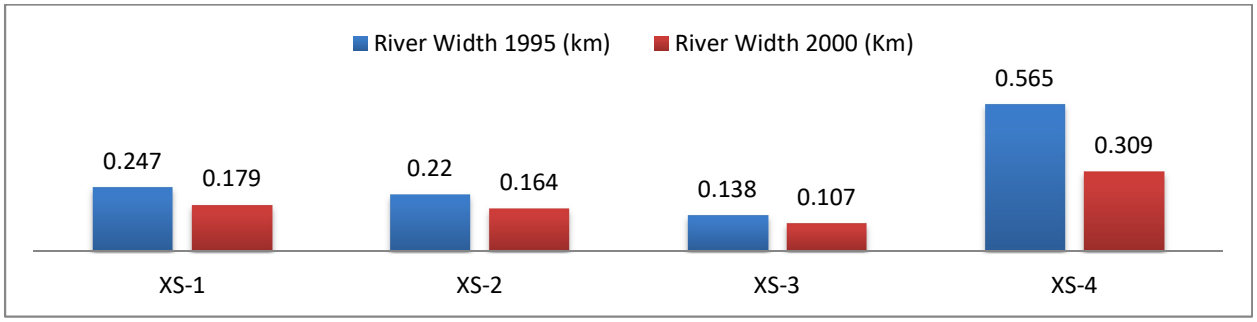


**Figure 5.55 -**The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-3, with a value of 0.43 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-2, with a value of 0.072 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-3, with a value of 0.399 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-4, with a value of 0.279 km.

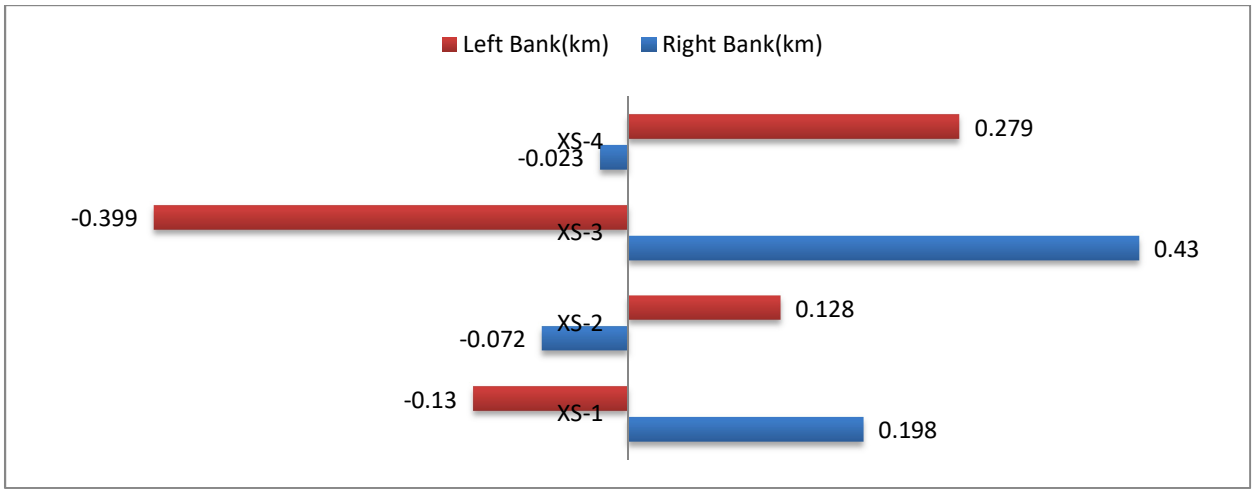


**Figure 5.56-** River Course Shifting line from 1995 to 2000

### 5.5.3 Shifting Pattern of Borgang River Course from 2000 to 2005

Table 5.27 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.179 | 0.27 | 0.071 | -0.162 |
| **XS-2** | 0.164 | 0.272 | -0.202 | 0.094 |
| **XS-3** | 0.107 | 0.259 | -0.087 | -0.065 |
| **XS-4** | 0.309 | 0.147 | 0.113 | 0.049 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.152 km
- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 0.162 km

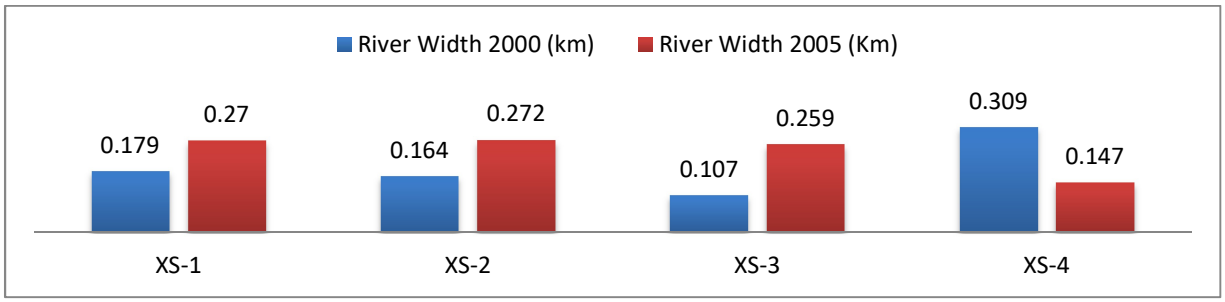


**Figure 5.57**- The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: : The most significant deposition on the right bank occurred at cross-section XS-4, with a value of 0.113 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-2, with a value of 0.202 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-1, with a value of 0.162 km.
- **Maximum Deposition**: The most significant deposition on the left bank occurred at cross-section XS-2, with a value of 0.094 km

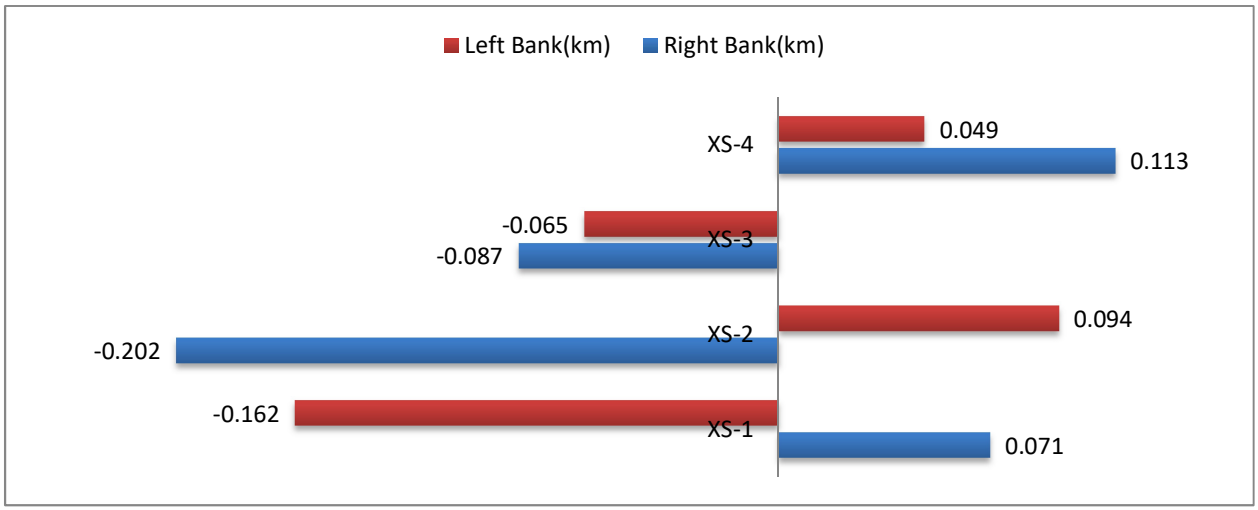


**Figure 5.58-** River Course Shifting line from 2000 to 2005

### 5.5.4 Shifting Pattern of Borgang River Course from 2005 to 2010

Table 5.28 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.27 | 0.055 | -0.474 | 0.689 |
| **XS-2** | 0.272 | 0.211 | -0.049 | 0.11 |
| **XS-3** | 0.259 | 0.196 | 0 | 0.063 |
| **XS-4** | 0.147 | 0.121 | 0.026 | 0 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** no significant increase in river width was observed in our selected section between 2005-2010
- **Maximum decrease:** The cross-section XS-1 shows the most significant decrease in river width, expanding by 0.215 km.

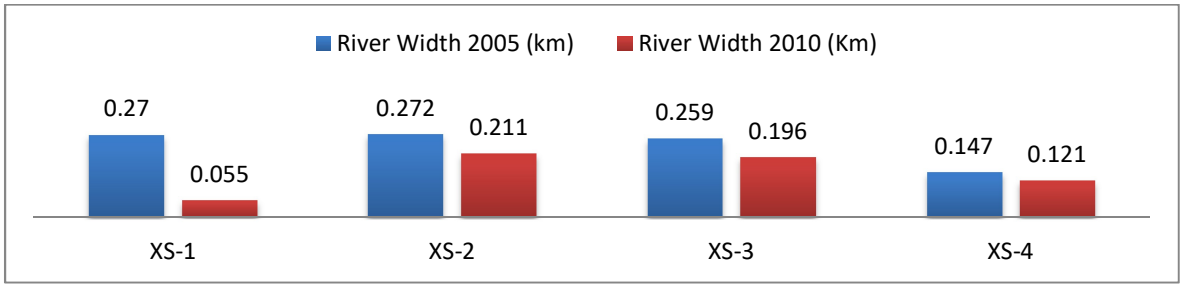


**Figure 5.59** -The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-4, with a value of 0.026 km.
- **Maximum Erosion**:. The most significant erosion on the right bank occurred at cross-section XS-1, with a value 0.474 km

**Left Bank (2005-2010):**

- **Maximum Erosion**: Between 2005 and 2010, no erosion was observed in the sections of river's left bank that were monitored.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-1, with a value of 0.689 km.

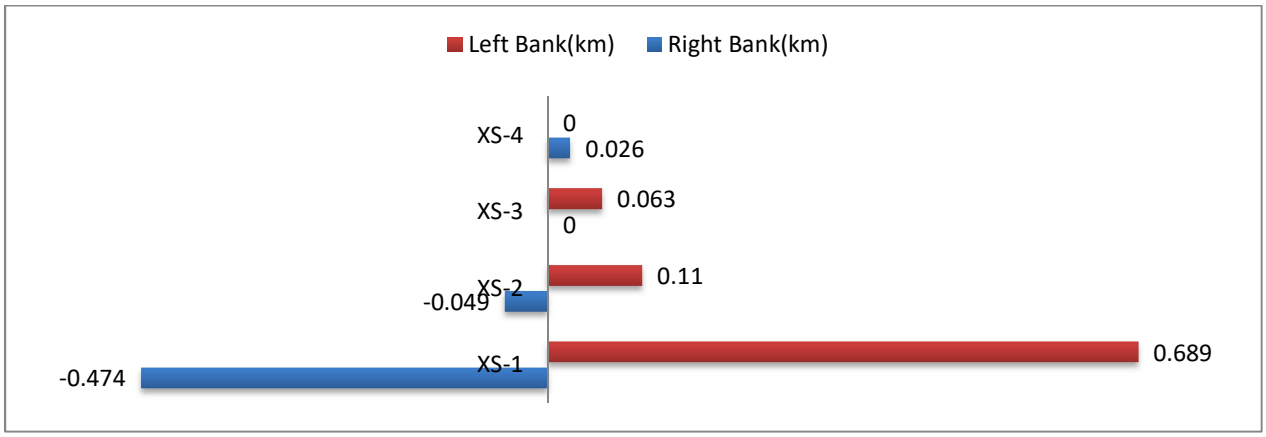


**Figure 5.60-** River Course Shifting line from 2005 to 2010

**5.5.5 Shifting Pattern of Borgang River Course from 2010 to 2015**

Table 5.29 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.055 | 0.178 | -0.023 | -0.1 |
| **XS-2** | 0.211 | 0.199 | 0.012 | 0 |
| **XS-3** | 0.196 | 0.142 | -0.036 | 0.09 |
| **XS-4** | 0.121 | 0.585 | -0.308 | -0.156 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.464 km
- **Maximum decrease:** The cross-section XS-3 shows the most significant decrease in river width, expanding by 0.054 km

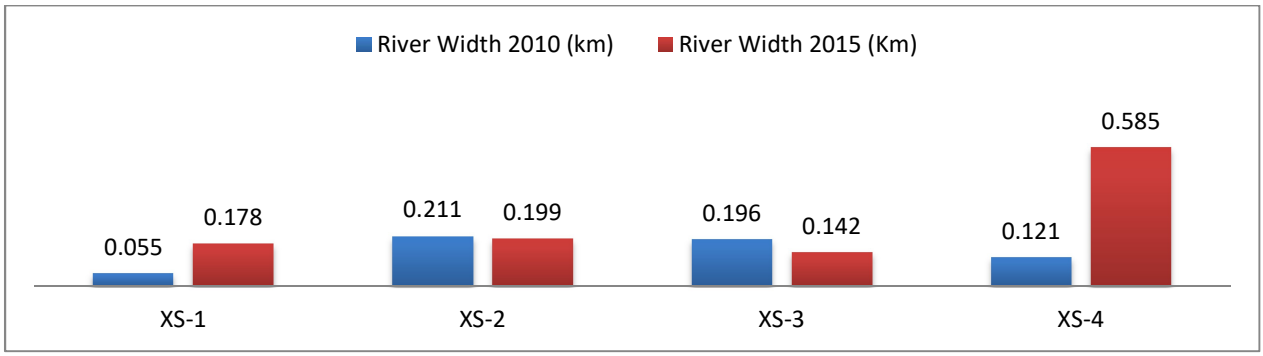


**Figure 5.61-** The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-2, with a value of 0.012 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-4, with a value of 0.308 km.

**Left Bank (2010-2015):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-4, with a value 0.156 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-3, with a value of 0.09 km

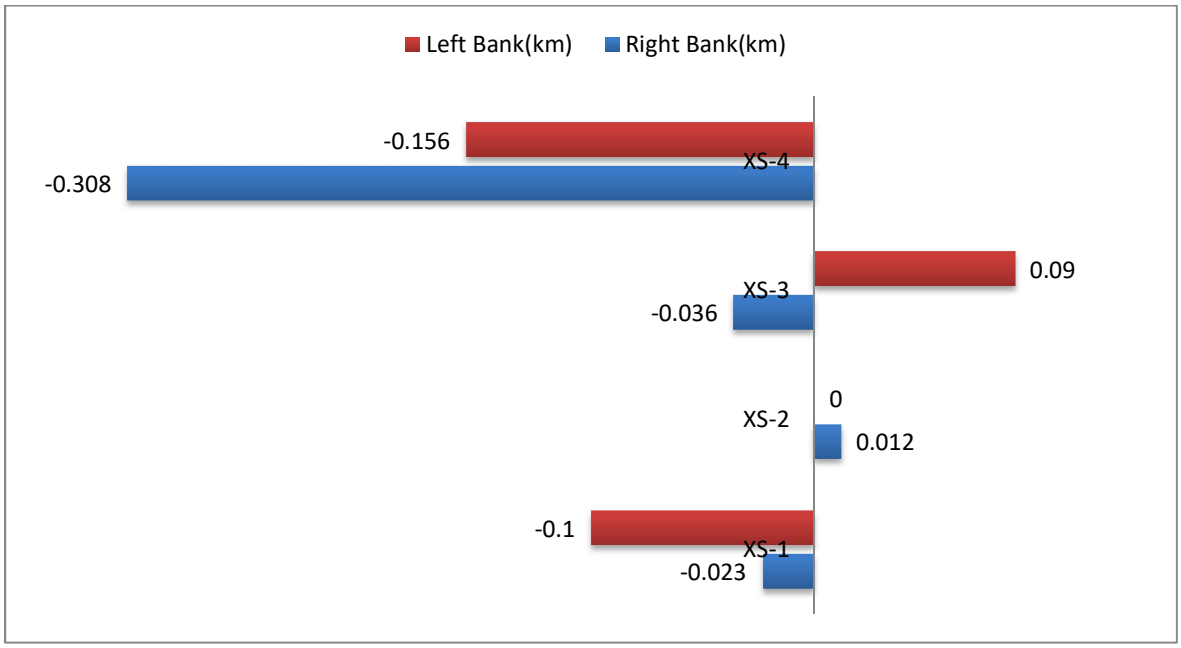


**Figure 5.62**- River Course Shifting line from 2010 to 2015

### 5.5.6 Shifting Pattern of Borgang River Course from 2015 to 2020

Table 5.30 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.178 | 0.182 | -0.055 | 0.051 |
| **XS-2** | 0.199 | 0.141 | 0.092 | -0.034 |
| **XS-3** | 0.142 | 0.069 | 0.259 | -0.186 |
| **XS-4** | 0.585 | 0.09 | 0.259 | 0.236 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-1 shows the most significant increase in river width, expanding by 0.004 km
- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 0.495 km.

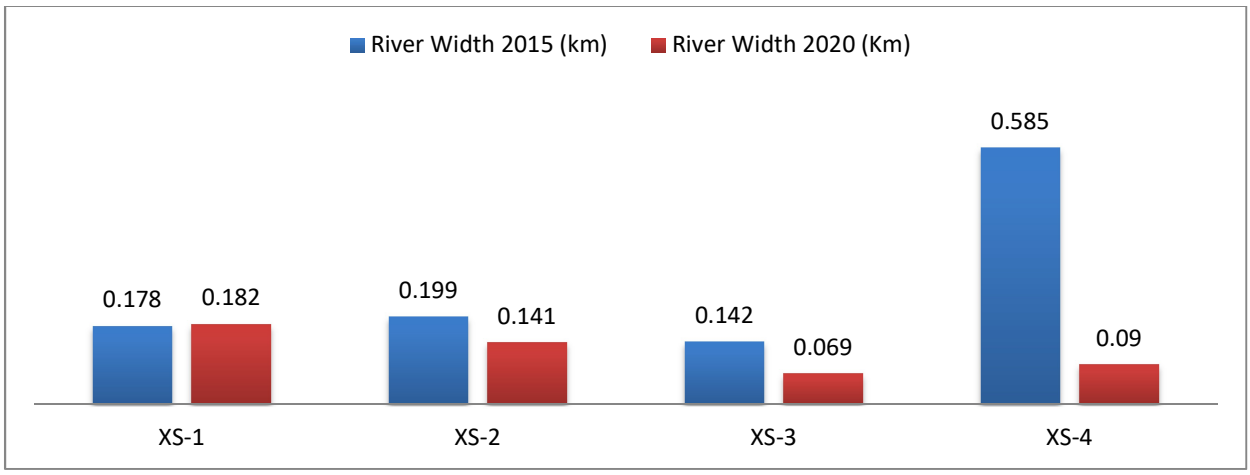


**Figure 5.63 -**The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3 & XS-4, with a value of 0.259 km.
- **Maximum Erosion**. The highest erosion on the right bank occurred at cross-section XS-1, with a value of 0.055 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.186 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-4, with a value of 0.236 km

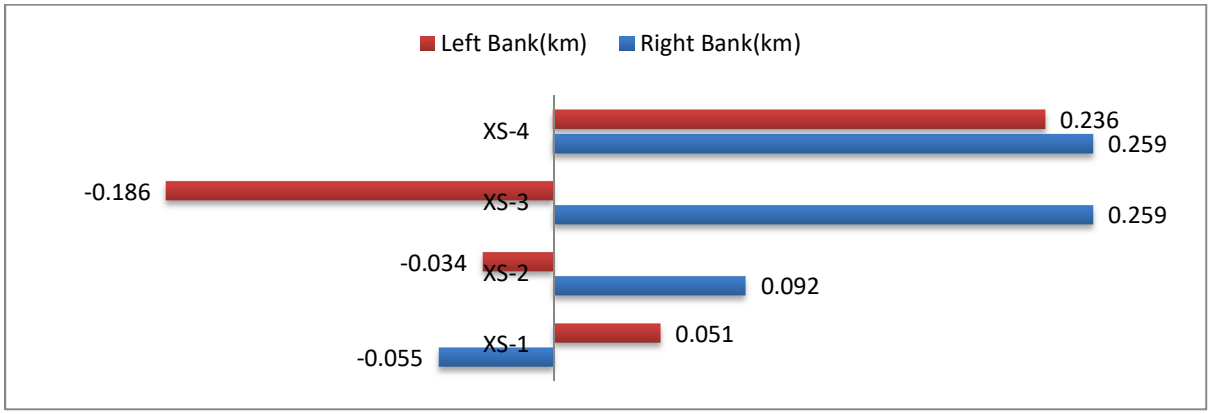


**Figure 5.64**- River Course Shifting line from 2015 to 2020

## 5.6 JIA BHARALI RIVER

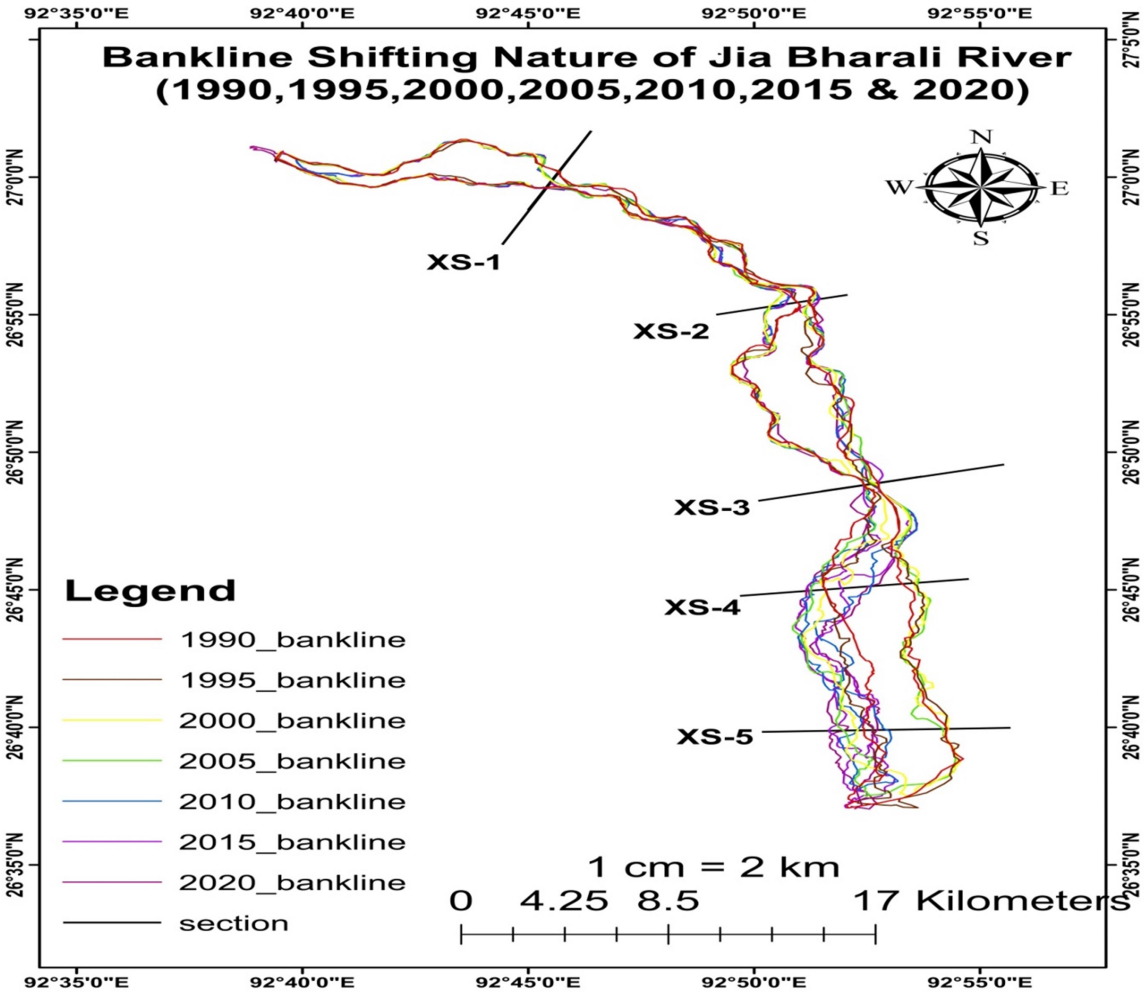


**Figure 5.65** Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Jia Bharali River from 1990 to 2020 has been taken into 5 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.65, it is clear that the river bank line is not like the same cross-section

### 5.6.1 Shifting Pattern of Jia Bharali River Course from 1990 to 1995

Table 5.31 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 1.14 | 1.189 | 0.04 | -0.089 |
| **XS-2** | 0.45 | 0.447 | 0.015 | -0.012 |
| **XS-3** | 0.542 | 0.251 | -0.019 | 0.31 |
| **XS-4** | 2.849 | 3.259 | -0.018 | -0.392 |
| **XS-5** | 3.06 | 2.689 | 0.333 | 0.038 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.410 km.
- **Maximum Decrease:** Cross-section XS-5 has the largest decrease in river width of 0.371 km

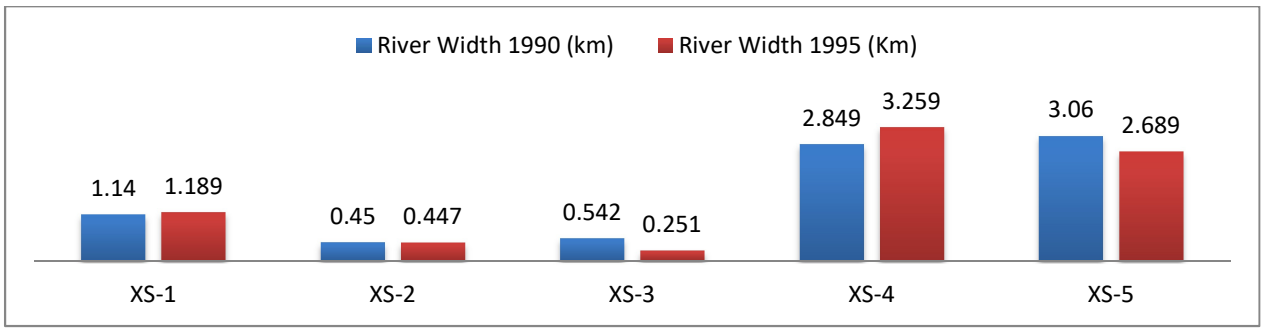


**Figure 5.66-** The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-5, with a value of 0.333 km.
- **Maximum Erosion**: The greatest erosion on the right bank occurred at cross-section XS-3, with a value of 0.019 km

**Left Bank ( 1990-1995):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-4, with a value of 0.392 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-3, with a value 0.31 km

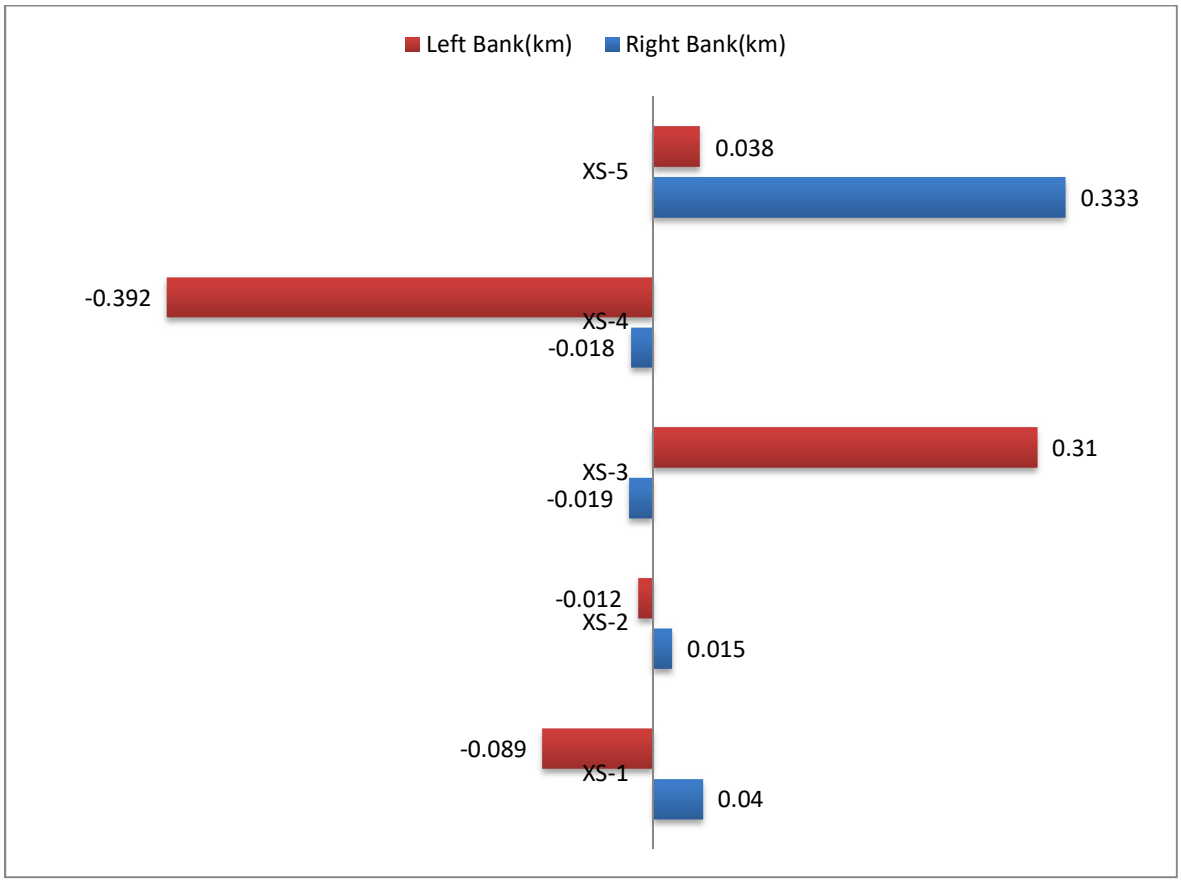


**Figure 5.67**- River Course Shifting line from 1990 to 1995

**5.6.2 Shifting Pattern of Jia Bharali River Course from 1995 to 2000**

Table 5.32 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 1.189 | 0.526 | -0.037 | 0.7 |
| **XS-2** | 0.447 | 1.671 | -1.07 | -0.148 |
| **XS-3** | 0.251 | 0.435 | 0.005 | -0.189 |
| **XS-4** | 3.259 | 3.338 | 0.029 | -0.108 |
| **XS-5** | 2.689 | 3.338 | -0.566 | -0.083 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

**Maximum Increase:** Cross-section XS-2 has increase in river width of 1.224 km

**Maximum Decrease**: Cross-section XS-1 has decrease in river width of 0.663 km

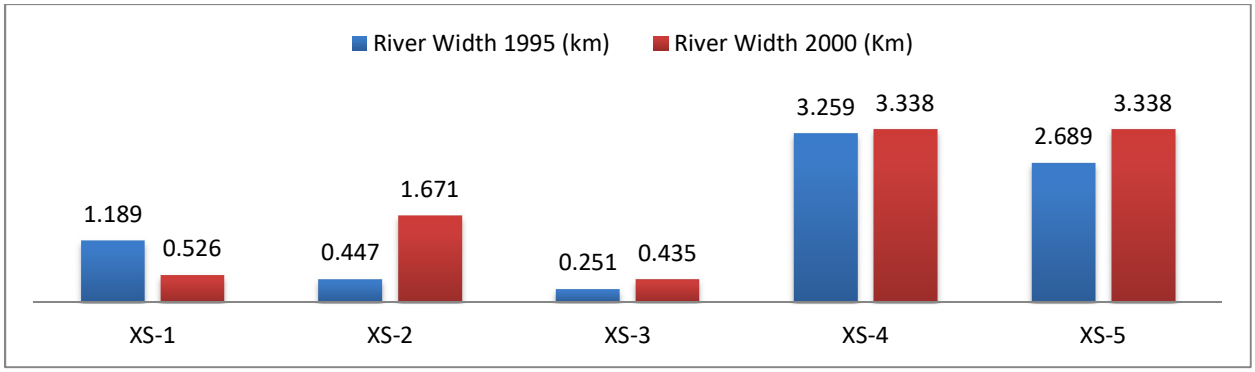


**Figure 5.68**- The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-4, with a value of 0.029 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-2, with a value of 1.07 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-3, with a value of 0.189 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-1, with a value of 0.7 km.

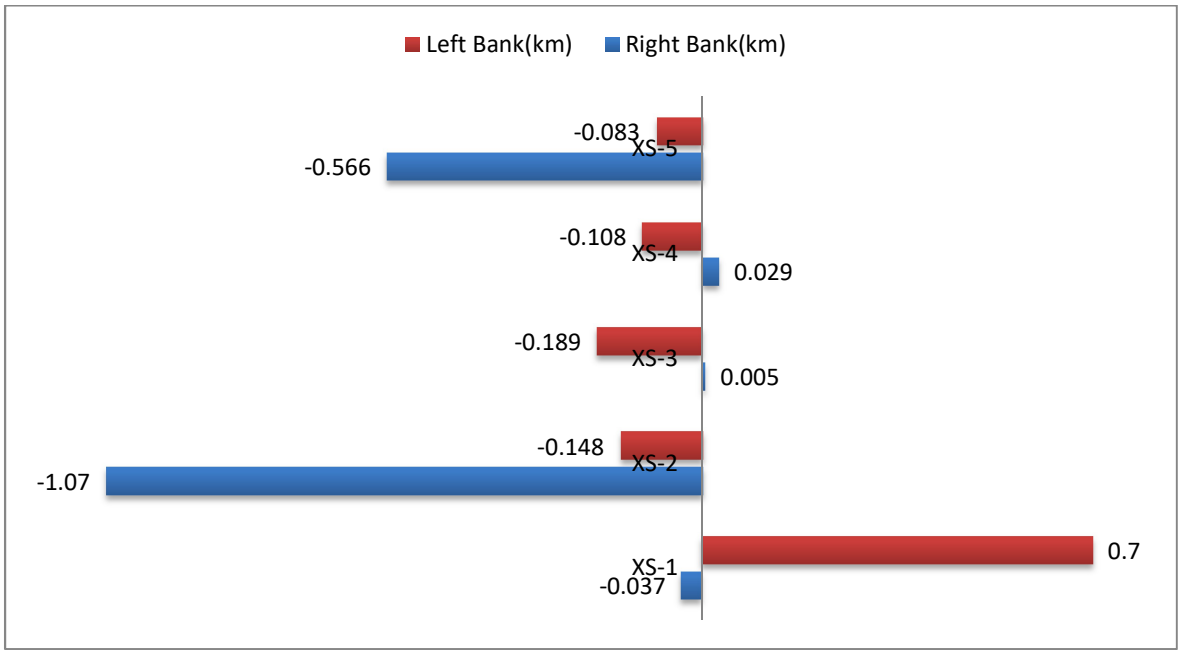


**Figure 5.69-** River Course Shifting line from 1995 to 2000

### 5.6.3 Shifting Pattern of Jia Bharali River Course from 2000 to 2005

Table 5.33 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.526 | 0.561 | 0 | -0.035 |
| **XS-2** | 1.671 | 1.641 | 0.02 | 0.01 |
| **XS-3** | 0.435 | 0.345 | 0 | 0.09 |
| **XS-4** | 3.338 | 3.96 | -0.553 | -0.069 |
| **XS-5** | 3.338 | 3.68 | -0.536 | 0.194 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.622 km
- **Maximum decrease:** The cross-section XS-3 shows the most significant decrease in river width, expanding by 0.09 km

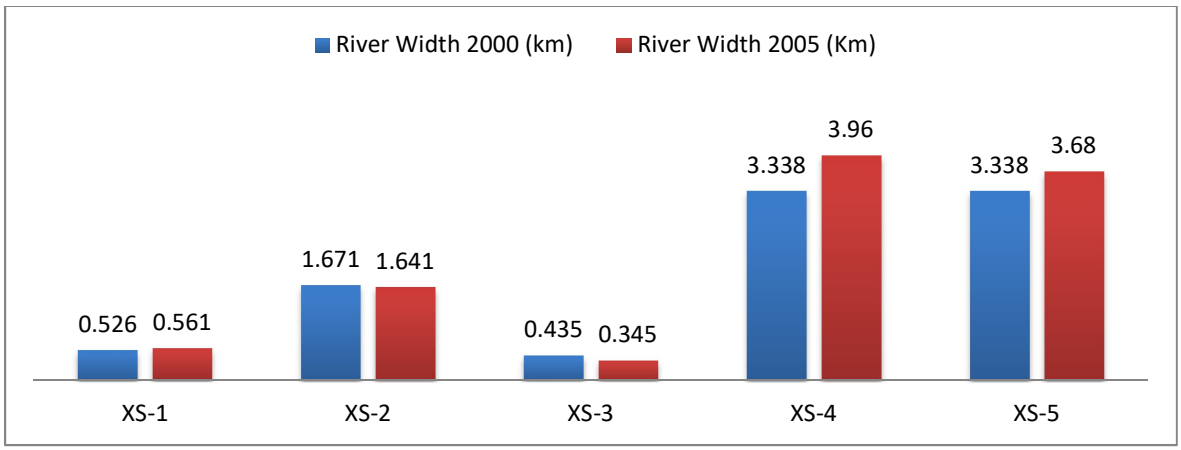


**Figure 5.70**- The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: : The most significant deposition on the right bank occurred at cross-section XS-2, with a value of 0.02 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-4, with a value of 0.553 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-4, with a value of 0.069 km.
- **Maximum Deposition**: The most significant deposition on the left bank occurred at cross-section XS-5, with a value of 0.194 km

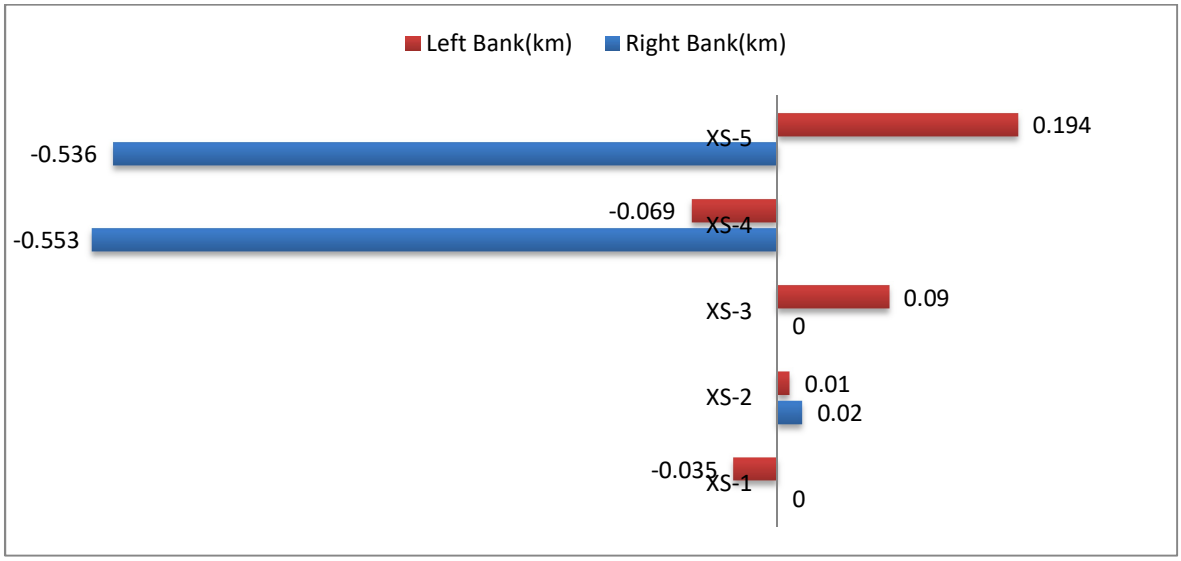


**Figure 5.71-** River Course Shifting line from 2000 to 2005

### 5.6.4 Shifting Pattern of Jia Bharali River Course from 2005 to 2010

Table 5.34 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.561 | 0.557 | 0.004 | 0 |
| **XS-2** | 1.641 | 1.346 | 0.402 | -0.107 |
| **XS-3** | 0.345 | 0.317 | -0.017 | 0.045 |
| **XS-4** | 3.96 | 2.473 | 0.014 | 1.743 |
| **XS-5** | 3.68 | 1.089 | 0.511 | 2.08 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** no significant increase in river width was observed in our selected section between 2005-2010
- **Maximum decrease:** The cross-section XS-5 shows the most significant decrease in river width, expanding by 2.591 km.

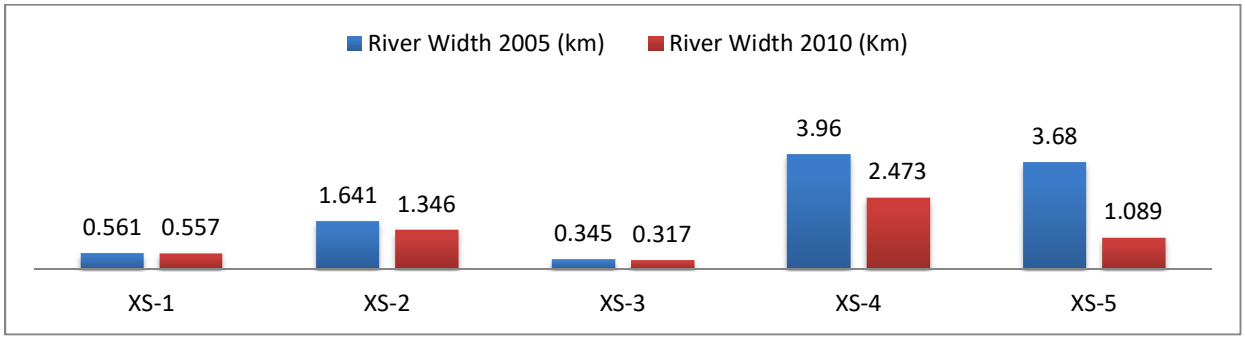


**Figure 5.72-** The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-5, with a value of 0.511 km.
- **Maximum Erosion**:. The most significant erosion on the right bank occurred at cross-section XS-3, with a value 0.017 km

**Left Bank (2005-2010):**

- **Maximum Erosion**: The highest erosion on the left bank was observed at cross-section XS-2, with a value of 0.107 km
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-5, with a value of 2.08 km

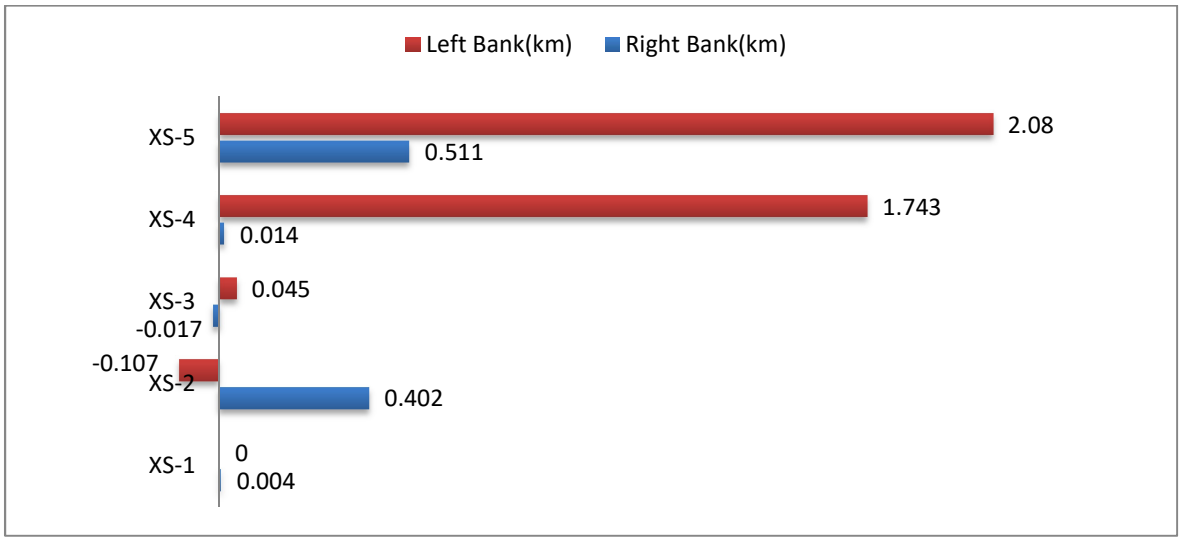


**Figure 5.73** -River Course Shifting line from 2005 to 2010

### 5.6.5 Shifting Pattern of Jia Bharali River Course from 2010 to 2015

Table 5.35 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.557 | 0.601 | -0.044 | 0 |
| **XS-2** | 1.346 | 1.277 | 0.192 | -0.123 |
| **XS-3** | 0.317 | 0.604 | -0.006 | -0.281 |
| **XS-4** | 2.473 | 1.499 | -0.097 | 1.071 |
| **XS-5** | 1.089 | 1.597 | -1.024 | 0.516 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-5 shows the most significant increase in river width, expanding by 0.508 km
- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 0.974 km

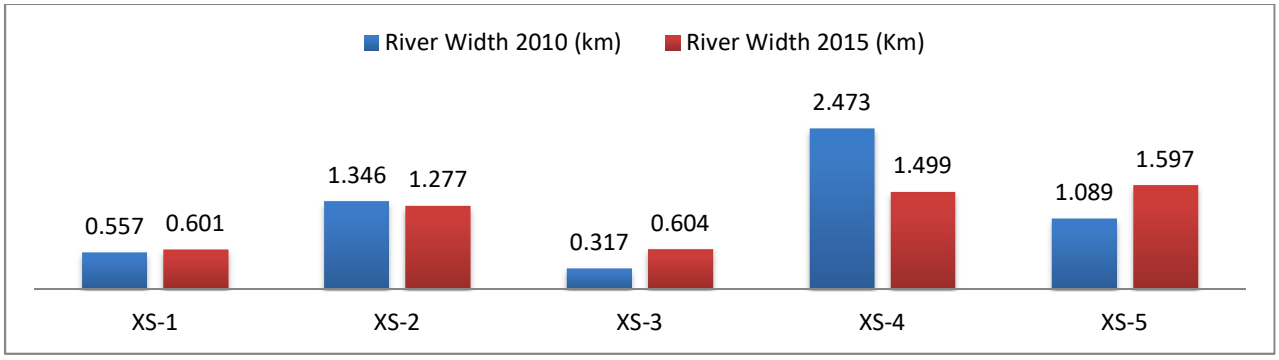


**Figure 5.74-** The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-2, with a value of 0.192 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-5, with a value of 1.024 km.

**Left Bank (2010-2015):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.281 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-4, with a value of 1.071 km

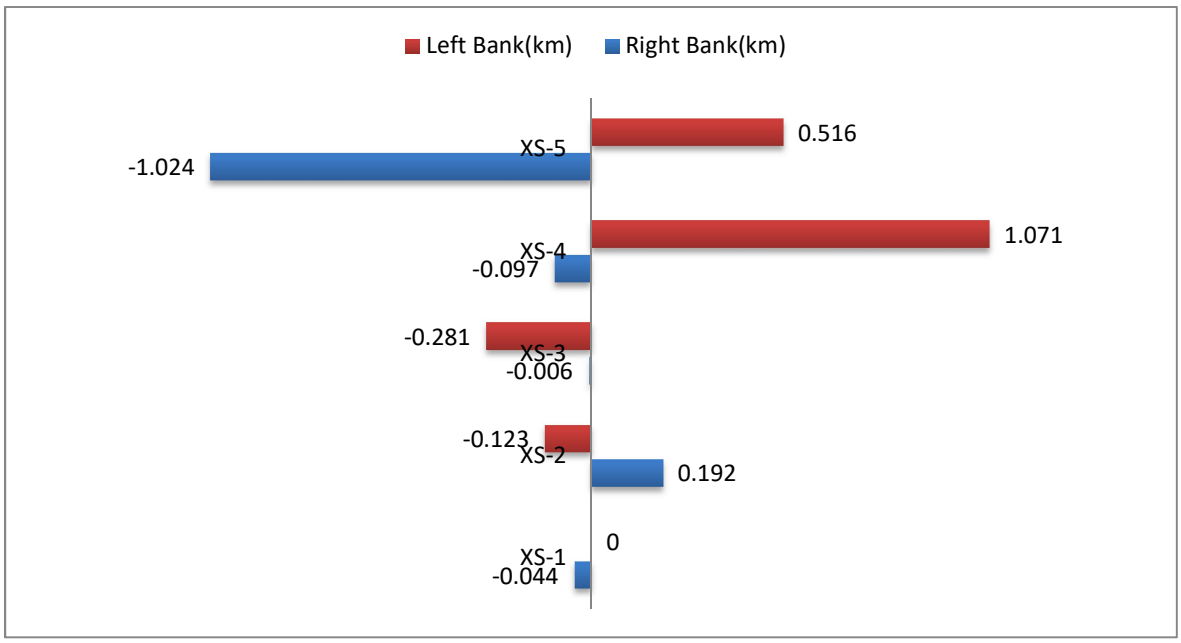


**Figure 5.75-** River Course Shifting line from 2010 to 2015

### 5.6.6 Shifting Pattern of Jia Bharali River Course from 2015 to 2020

Table 5.36 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.601 | 0.582 | -0.014 | 0.033 |
| **XS-2** | 1.277 | 1.307 | 0 | -0.03 |
| **XS-3** | 0.604 | 0.281 | 0.029 | 0.294 |
| **XS-4** | 1.499 | 2.594 | -0.083 | -1.012 |
| **XS-5** | 1.597 | 1.25 | 0.51 | -0.163 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 1.095 km
- **Maximum decrease:** The cross-section XS-5 shows the most significant decrease in river width, expanding by 0.347 km.

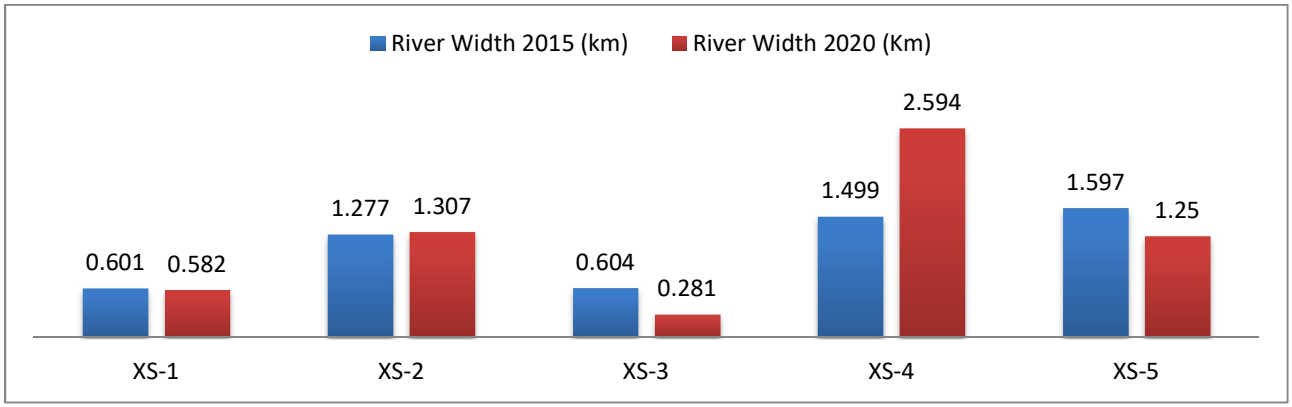


**Figure 5.76-** The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-5, with a value of 0.51 km.
- **Maximum Erosion**. The highest erosion on the right bank occurred at cross-section XS-4, with a value of 0.083 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-4, with a value 1.012 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-3, with a value of 0.294 km

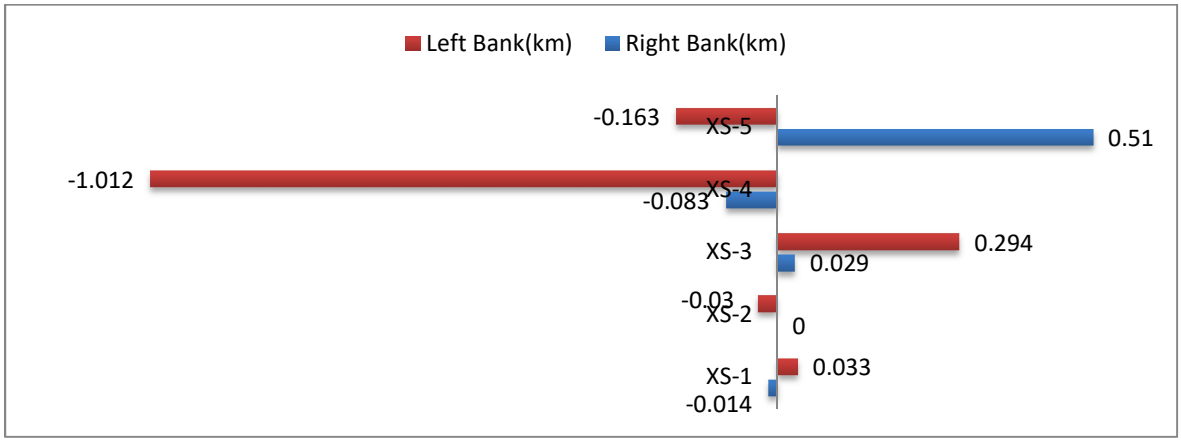


**Figure 5.77-** River Course Shifting line from 2015 to 2020

## 5.7 SANKOSH RIVER

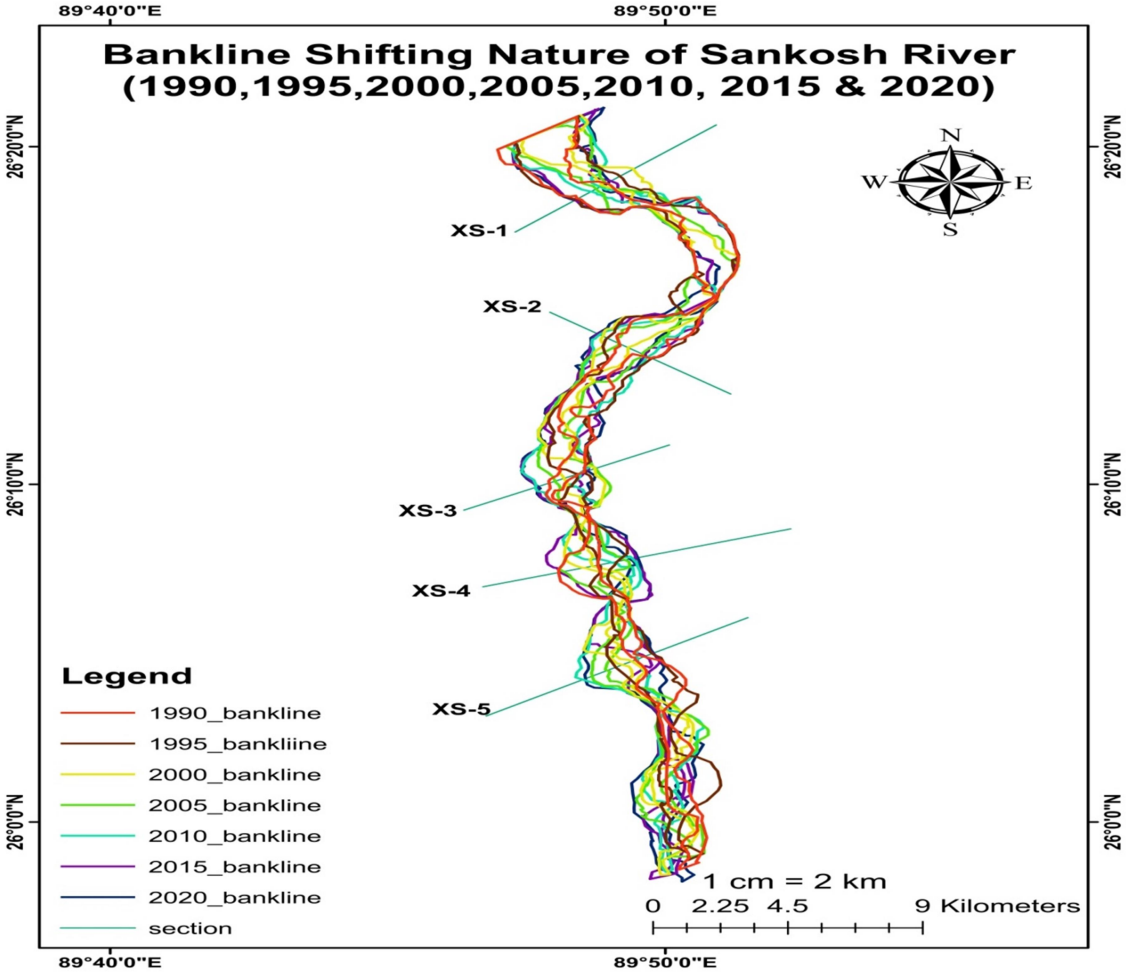


**Figure 5.78-** Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Sankosh River from 1990 to 2020 has been taken into 5 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.78, it is clear that the river bank line is not like the same cross-section

### 5.7.1 Shifting Pattern of Sankosh River Course from 1990 to 1995

Table 5.37 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 1.2 | 1.819 | -0.071 | -0.548 |
| **XS-2** | 1.24 | 1.752 | -0.476 | -0.036 |
| **XS-3** | 1 | 0.302 | 0.96 | -0.263 |
| **XS-4** | 1.24 | 0.607 | 1.25 | -0.617 |
| **XS-5** | 0.312 | 1.337 | -0.722 | -0.303 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** Cross-section XS-5 has the largest increase in river width of 1.025 km.
- **Maximum Decrease:** Cross-section XS-3 has the largest decrease in river width of 0.698 km

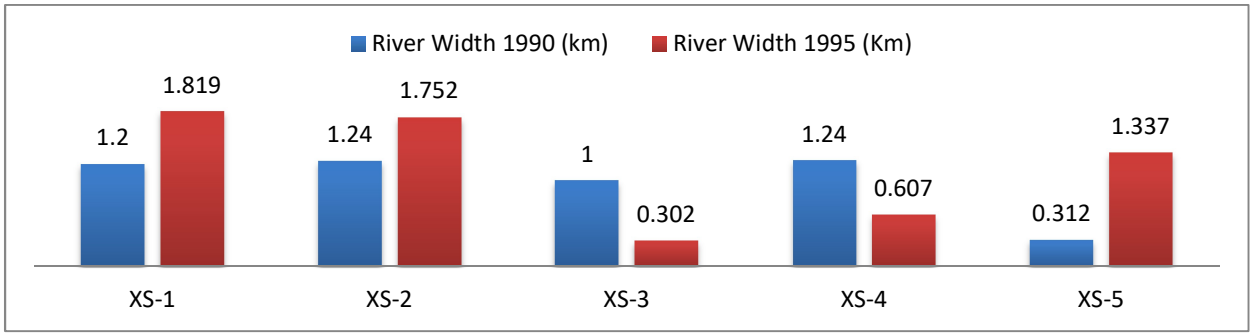


**Figure 5.79**- The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-4, with a value of 1.25 km..
- **Maximum Erosion**: The greatest deposition on the right bank occurred at cross-section XS-5, with a value of 0.722 km...

**Left Bank ( 1990-1995):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-4, with a value of 0.617 km.
- **Maximum Deposition**: In the sections we observed, there was no deposition on the left bank of the river

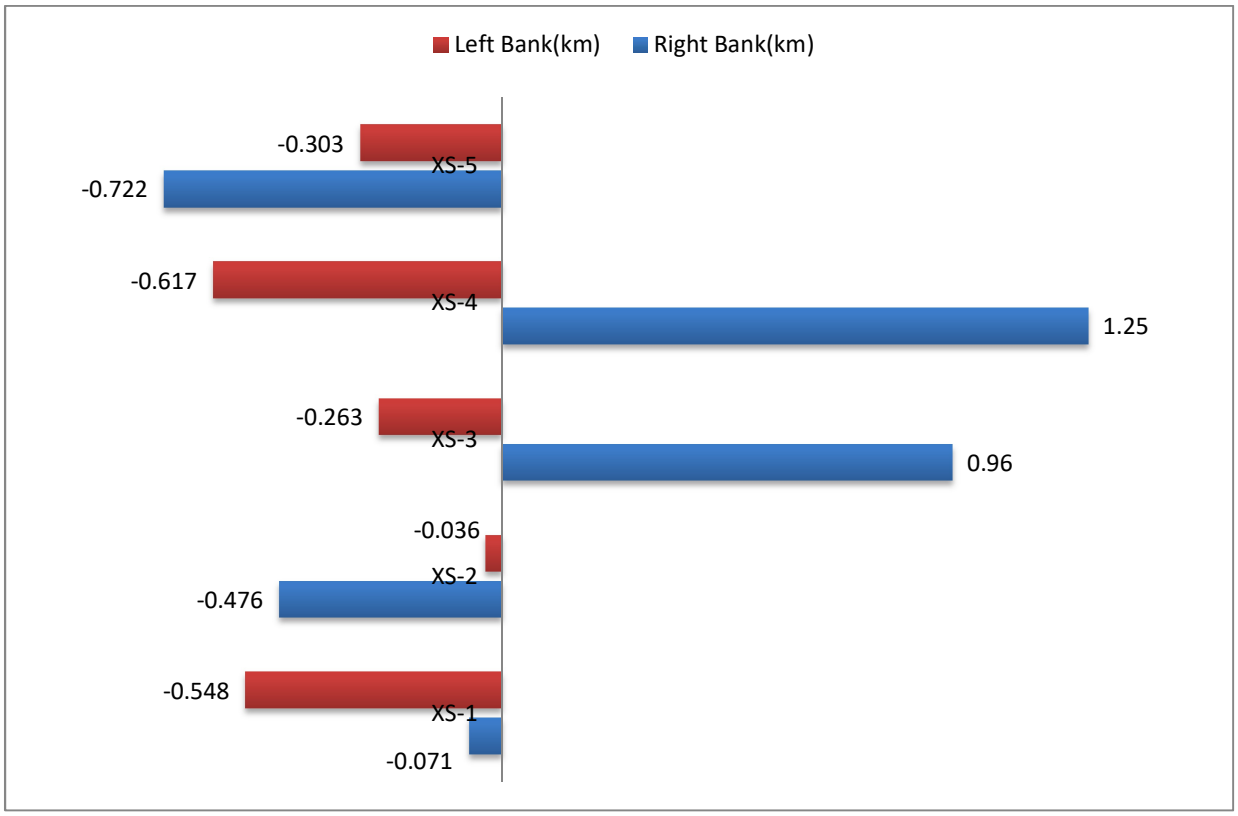


**Figure 5.80-** River Course Shifting line from 1990 to 1995

### 5.7.2 Shifting Pattern of Sankosh River Course from 1995 to 2000

Table 5.38 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 1.819 | 1.278 | 1.097 | -0.556 |
| **XS-2** | 1.752 | 1.003 | -0.167 | 0.918 |
| **XS-3** | 0.302 | 1.079 | -0.448 | -0.329 |
| **XS-4** | 0.607 | 0.265 | -0.464 | 0.806 |
| **XS-5** | 1.337 | 0.34 | 0.244 | 0.753 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** Cross-section XS-3 has increase in river width of 0.777 km
- **Maximum Decrease:** Cross-section XS-5 has decrease in river width of 0.997 km

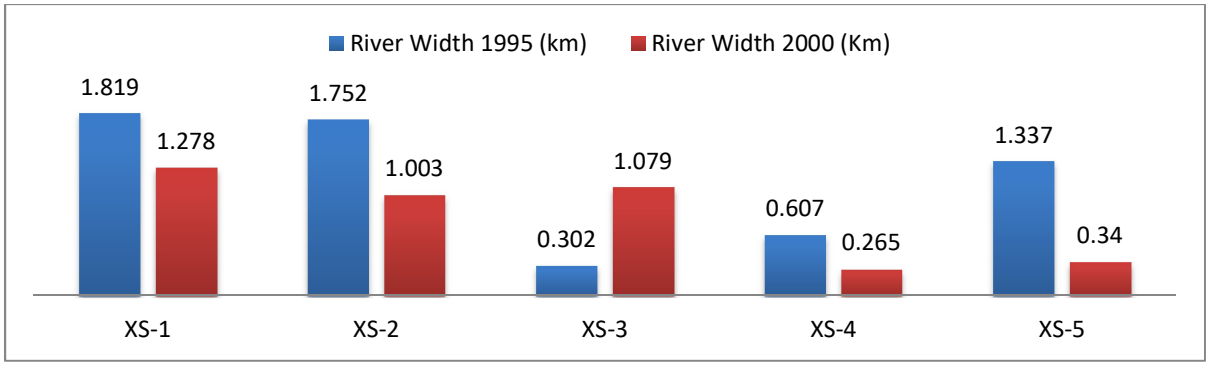


**Figure 5.81** The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-1, with a value of 1.097 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-4, with a value of 0.464 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-1, with a value of 0.556 km.
- **Maximum Deposition**: The greatest deposition on the left bank occurred at cross-section XS-2, with a value of 0.918 km.

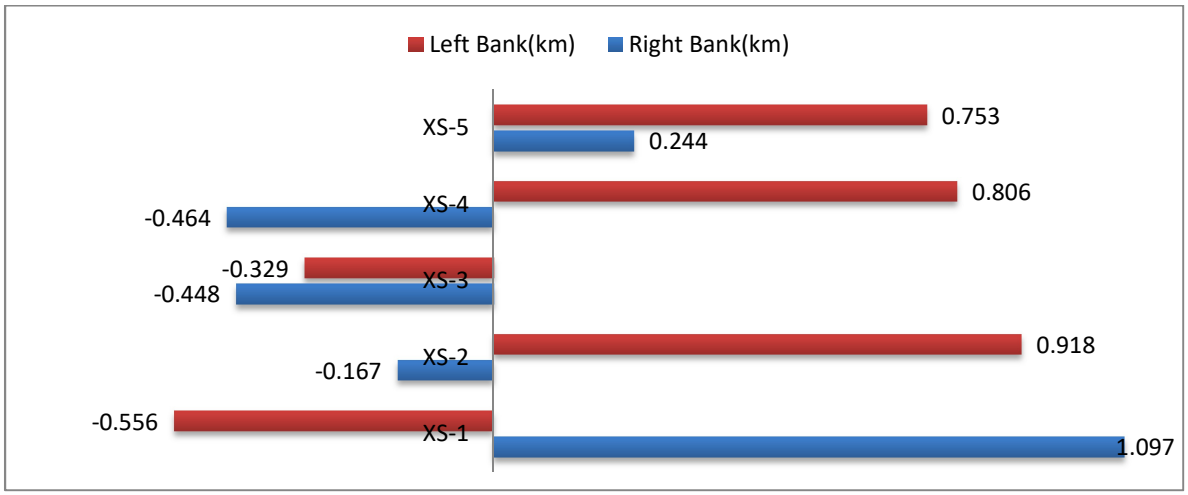


**Figure 5.82-** River Course Shifting line from 1995 to 2000

### 5.7.3 Shifting Pattern of Sankosh River Course from 2000 to 2005

Table 5.39 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 1.278 | 0.252 | -0.296 | 1.322 |
| **XS-2** | 1.003 | 0.926 | 0.642 | -0.565 |
| **XS-3** | 1.079 | 1.427 | -0.319 | -0.029 |
| **XS-4** | 0.265 | 1.933 | -0.63 | -1.038 |
| **XS-5** | 0.34 | 0.55 | -1.105 | 0.895 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 1.668 km
- **Maximum decrease:** The cross-section XS-1 shows the most significant decrease in river width, expanding by 1.026 km

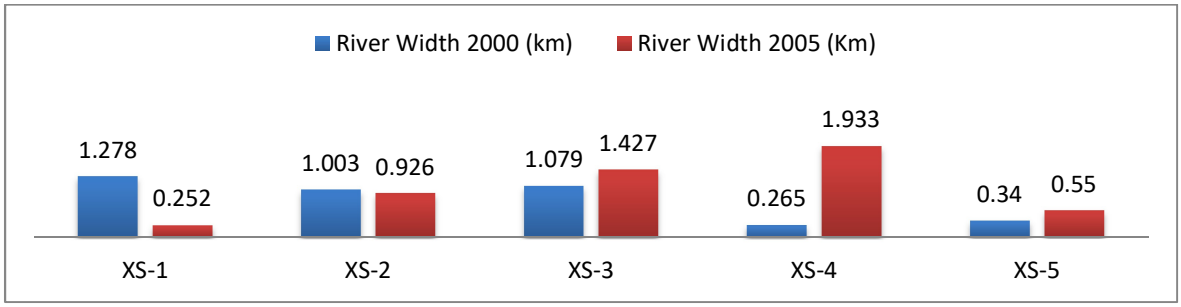


**Figure 5.83-** The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: : The most significant deposition on the right bank occurred at cross-section XS-2, with a value of 0.642 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-5, with a value of 1.105 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The greatest erosion on the left bank was observed at cross-section XS-1, with a value of 1.322 km.
- **Maximum Deposition**: The most significant deposition on the left bank occurred at cross-section XS-4, with a value of 1.038 km

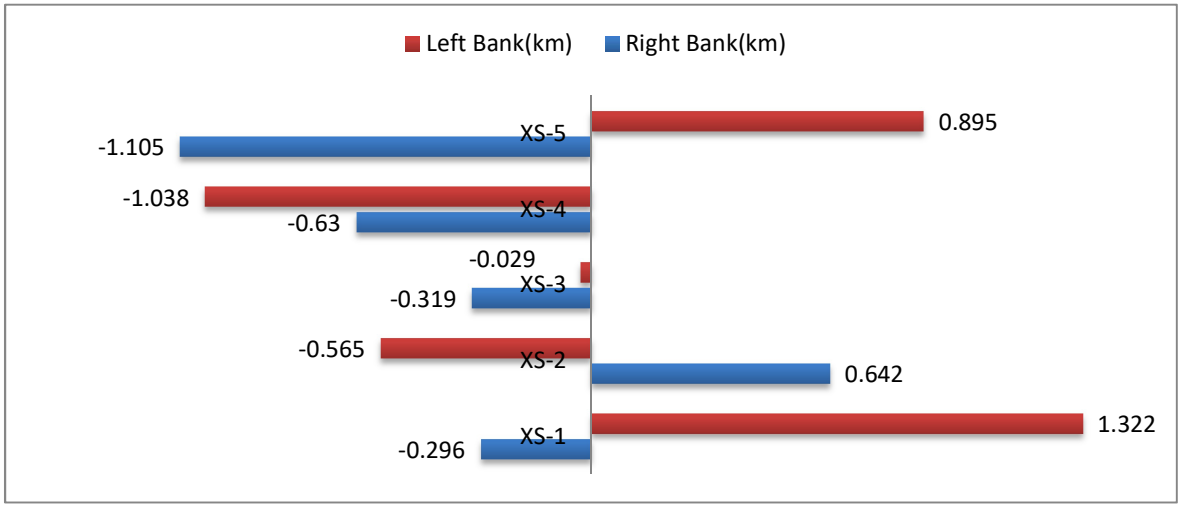


**Figure 5.84-** River Course Shifting line from 2000 to 2005

### 5.7.4 Shifting Pattern of Sankosh River Course from 2005 to 2010

Table 5.40 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.252 | 0.394 | -0.211 | 0.069 |
| **XS-2** | 0.926 | 1.89 | -0.747 | -0.217 |
| **XS-3** | 1.427 | 1.603 | -0.695 | 0.519 |
| **XS-4** | 1.933 | 0.651 | 1.523 | -0.241 |
| **XS-5** | 0.55 | 1.991 | -0.351 | -1.09 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase: :** The cross-section XS-5 shows the most significant increase in river width, expanding by 1.441 km.
- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 1.282 km

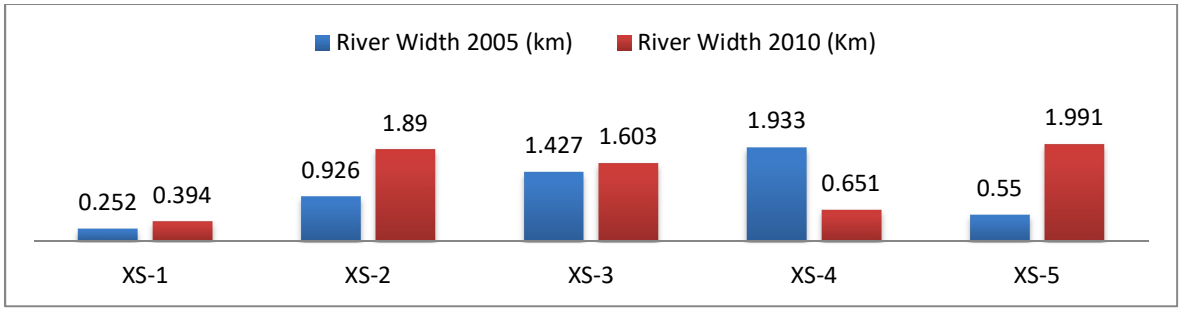


**Figure 5.85-** The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-4, with a value of 1.523 km.
- **Maximum Erosion**:. The most significant erosion on the right bank occurred at cross-section XS-2, with a value 0.747 km

**Left Bank (2005-2010):**

- **Maximum Erosion**: The highest erosion on the left bank was observed at cross-section XS-5, with a value of 1.09 km
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-3, with a value of 0.519 km

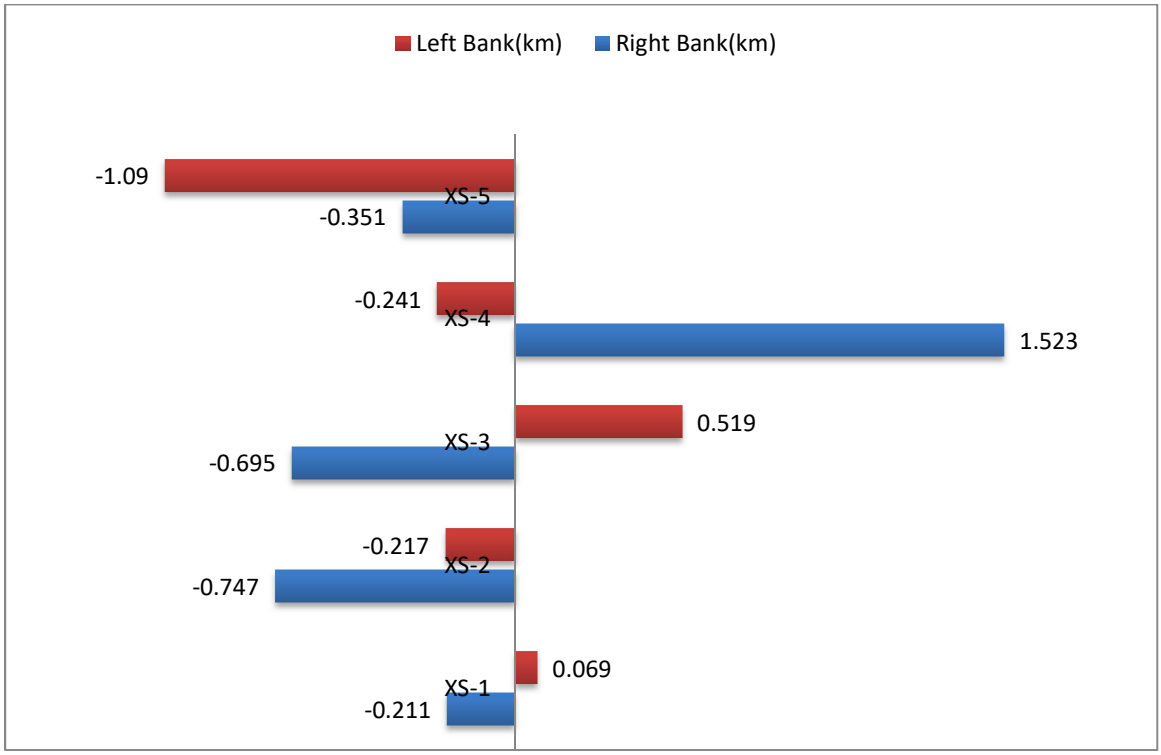


**Figure 5.86**- River Course Shifting line from 2005 to 2010

### 5.7.5 Shifting Pattern of Sankosh River Course from 2010 to 2015

Table 5.41 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.394 | 1.515 | -0.66 | -0.461 |
| **XS-2** | 1.89 | 1.795 | -0.076 | 0.171 |
| **XS-3** | 1.603 | 1.644 | 0.05 | -0.091 |
| **XS-4** | 0.651 | 2.402 | -1.662 | -0.089 |
| **XS-5** | 1.991 | 0.301 | 2.256 | -0.566 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 1.751 km
- **Maximum decrease:** The cross-section XS-5 shows the most significant decrease in river width, expanding by 1.69 km

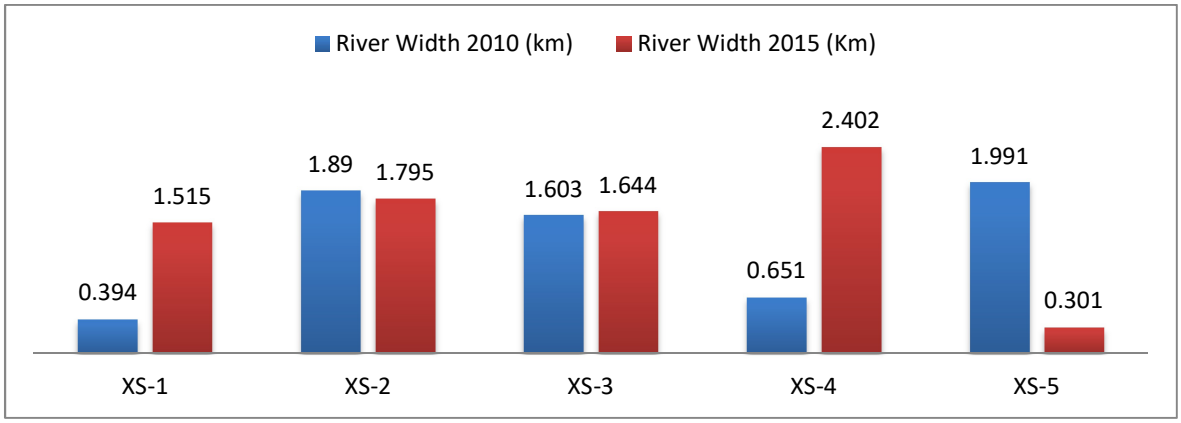


**Figure 5.87-** The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-5, with a value of 2.256 km
- **Maximum Erosion**: The most significant erosion on the right bank occurred at cross-section XS-4, with a value 1.662 km

**Left Bank (2010-2015):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-5, with a value 0.566 km.
- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-2, with a value of 2.256 km

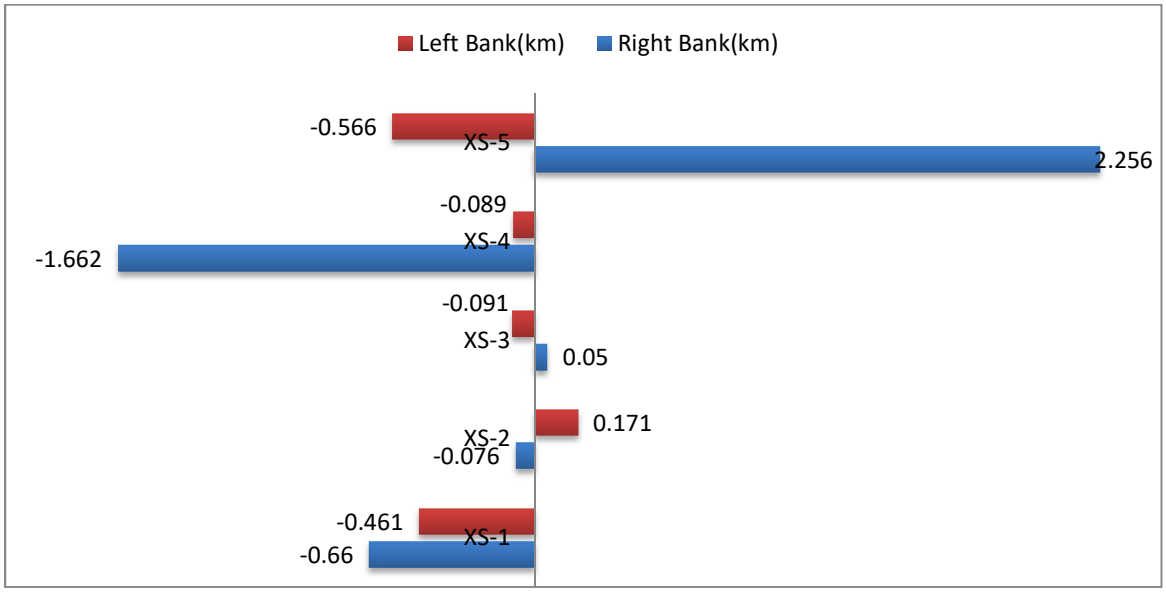


**Figure 5.88-** River Course Shifting line from 2010 to 2015

### 5.7.6 Shifting Pattern of Sankosh River Course from 2015 to 2020

Table 5.42 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 1.515 | 1.444 | -0.019 | 0.09 |
| **XS-2** | 1.795 | 1.865 | -0.01 | -0.06 |
| **XS-3** | 1.644 | 1.746 | 0.045 | -0.147 |
| **XS-4** | 2.402 | 0.246 | 2.235 | -0.079 |
| **XS-5** | 0.301 | 2.492 | -2.166 | -0.025 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-5 shows the most significant increase in river width, expanding by 2.191 km
- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 2.156 km.

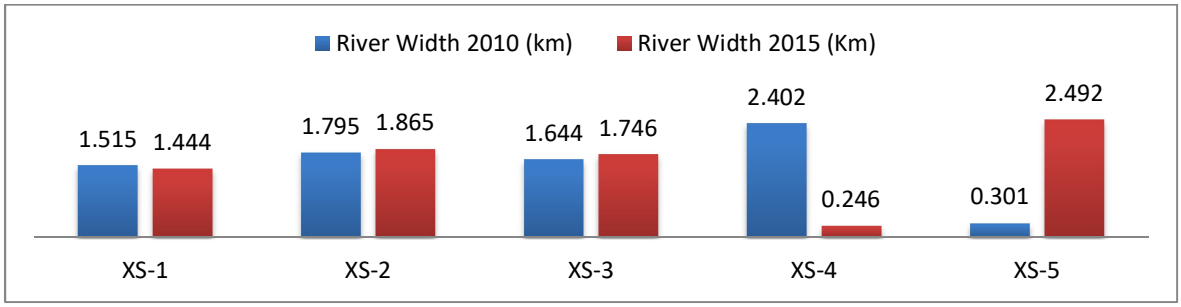


**Figure 5.89-** The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-4, with a value of 2.235 km.
- **Maximum Erosion**. The highest erosion on the right bank occurred at cross-section XS-5, with a value of 2.166 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.147 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-1, with a value of 0.09 km

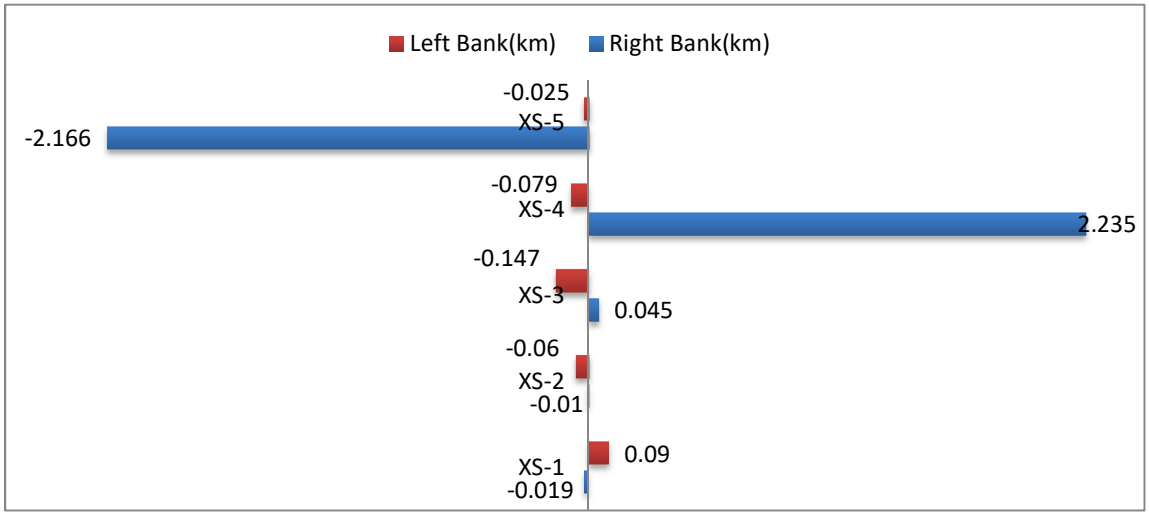


**Figure 5.90-** River Course Shifting line from 2015 to 2020

## 5.8 DIKHOW RIVER

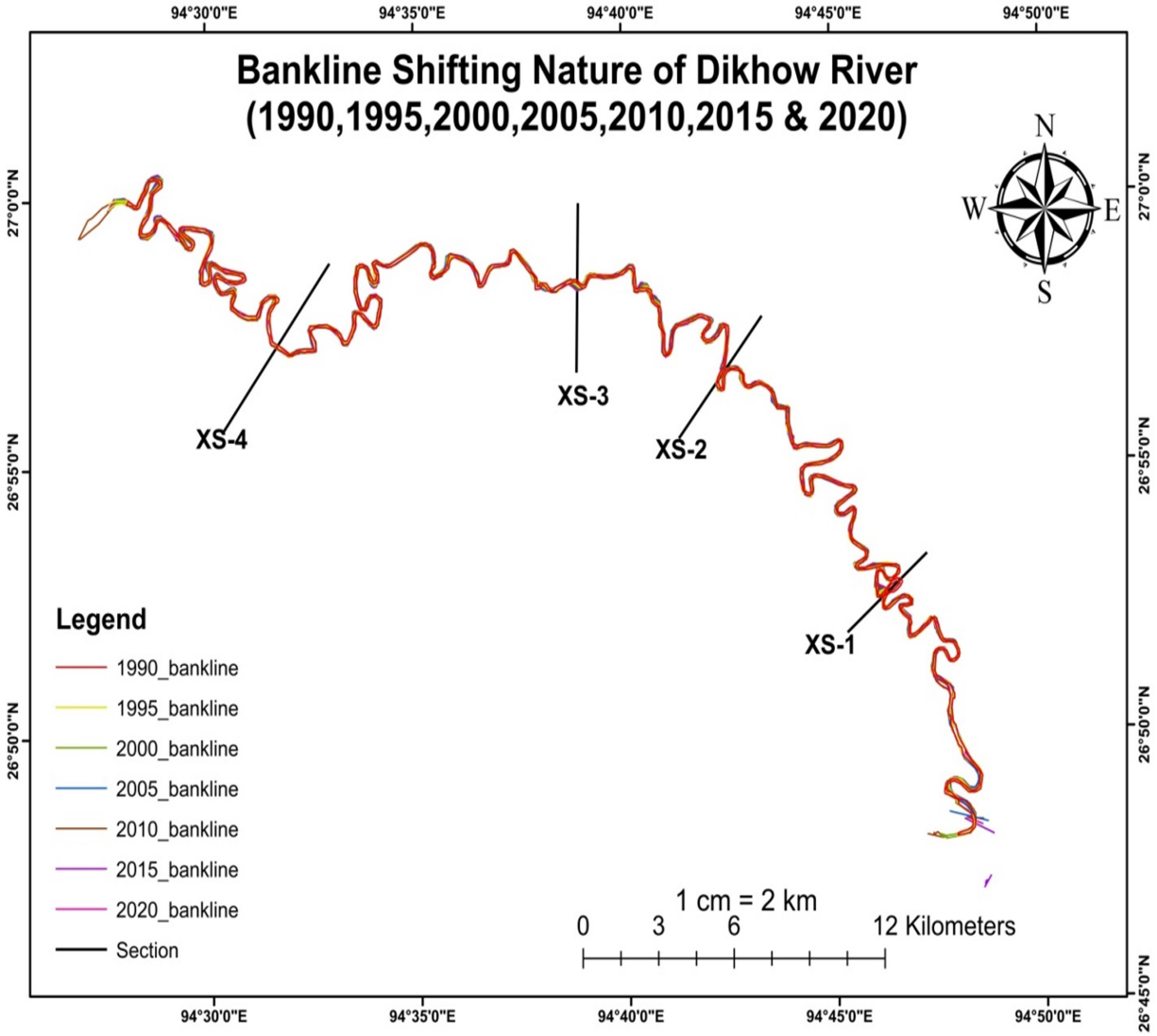


**Figure 5.91**- Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Dikhow River from 1990 to 2020 has been taken into 4 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.91, it is clear that the river bank line is not like the same cross-section

### 5.8.1 Shifting Pattern of Dikhow River Course from 1990 to 1995

Table 5.43 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.128 | 0.087 | 0.751 | -0.71 |
| **XS-2** | 0.212 | 0.154 | 0.087 | -0.029 |
| **XS-3** | 0.097 | 0.096 | 0.092 | -0.091 |
| **XS-4** | 0.108 | 0.109 | 0.019 | -0.02 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.001 km. In contrast, the river width decreases across all other cross-sections.
- **Maximum Decrease:** Cross-section XS-2 has the largest decrease in river width of 0.058km.

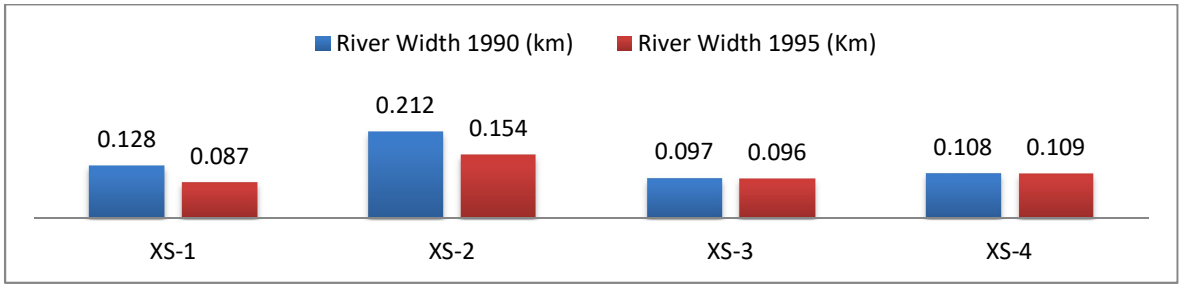


**Figure 5.92-** The Channel Width Variation from 1990 to 1995

**Right Bank(1990-1995):**

- **Maximum Deposition :** The most significant deposition occurred at XS-1 with 0.751 km.

**Left Bank(1990-1995)** :

- **Maximum Erosion**: most significant erosion occurred at XS-1 with -0.71 km.

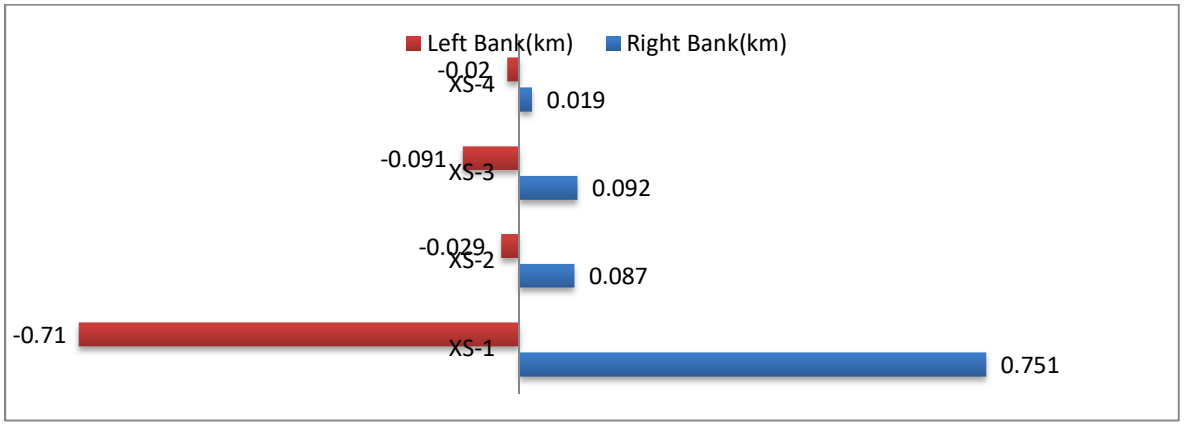


**Figure 5.93**- River Course Shifting line from 1990 to 1995

### 5.8.2 Shifting Pattern of Dikhow River Course from 1995 to 2000

Table 5.44 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.087 | 0.101 | 0.018 | -0.032 |
| **XS-2** | 0.154 | 0.184 | -0.03 | 0 |
| **XS-3** | 0.096 | 0.083 | 0.049 | -0.036 |
| **XS-4** | 0.109 | 0.089 | 0 | 0.02 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.03 km
- **Maximum Decrease**: Cross-section XS-4 has decrease in river width of 0.02 km.

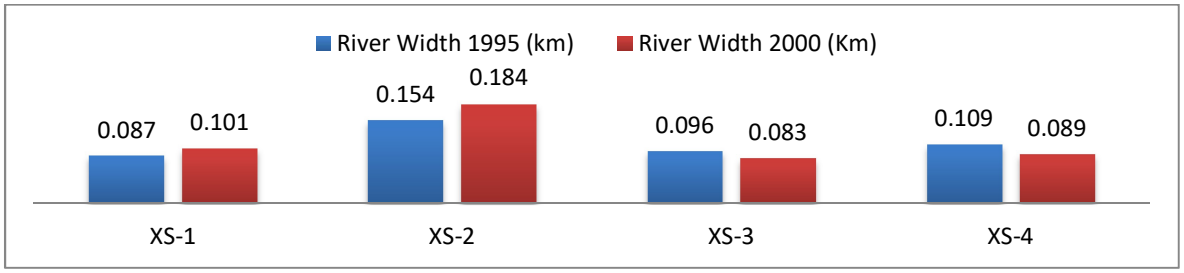


**Figure 5.94**- The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-3, with a value of 0.049 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-2, with a value of -0.03 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-3, with a value of -0.036 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-4, with a value of 0.02 km.

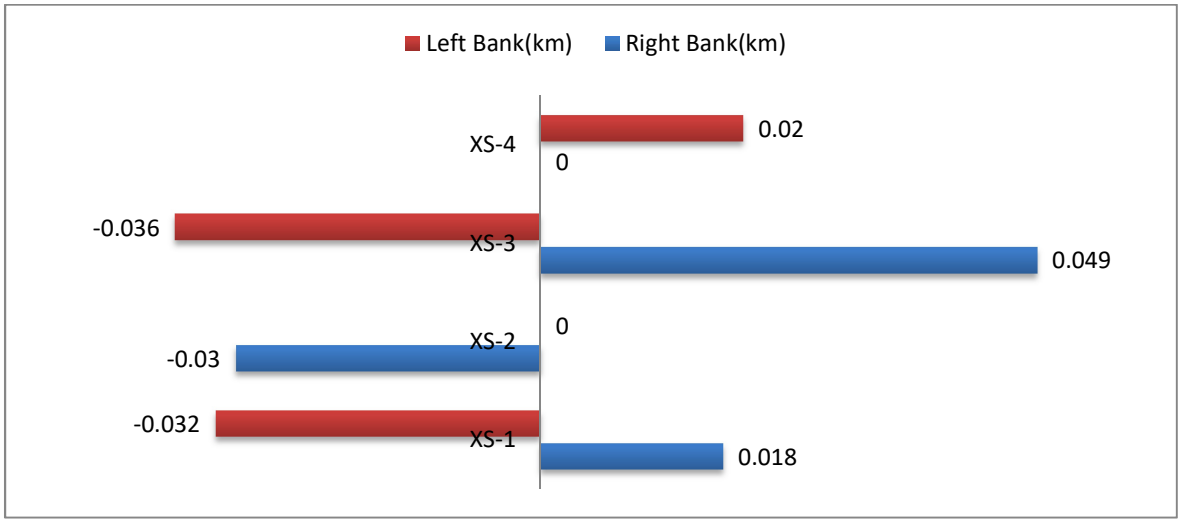


**Figure 5.95-** River Course Shifting line from 1995 to 2005:

### 5.8.3 Shifting Pattern of Dikhow River Course from 2000 to 2005

Table 5.45 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000(km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.101 | 0.151 | -0.006 | -0.044 |
| **XS-2** | 0.184 | 0.256 | -0.414 | 0.342 |
| **XS-3** | 0.083 | 0.118 | 0.006 | -0.041 |
| **XS-4** | 0.089 | 0.096 | 0.005 | -0.012 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.072 km
- **Maximum decrease:** Throughout the period from 2000 to 2005, there was no observed decrease in river width.

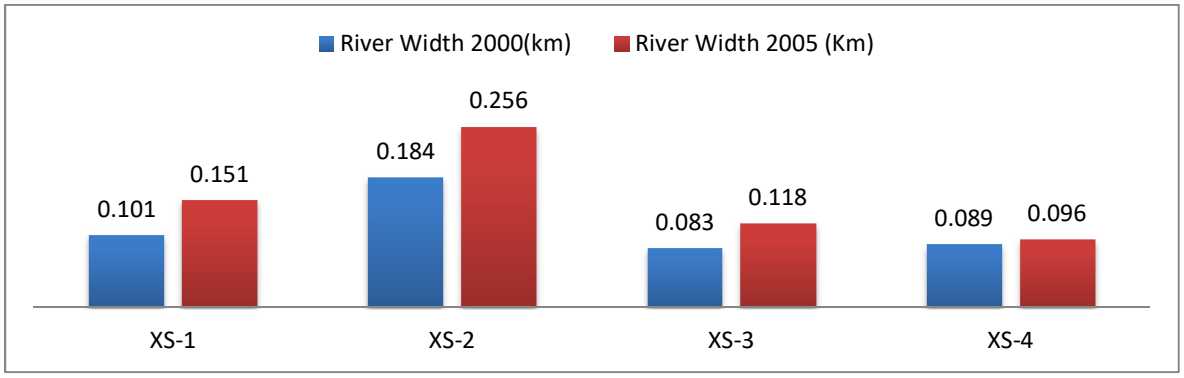


**Figure 5.96**- The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 0.006 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-2, with a value of 0.414 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-1, with a value of 0.044 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 0.342 km.

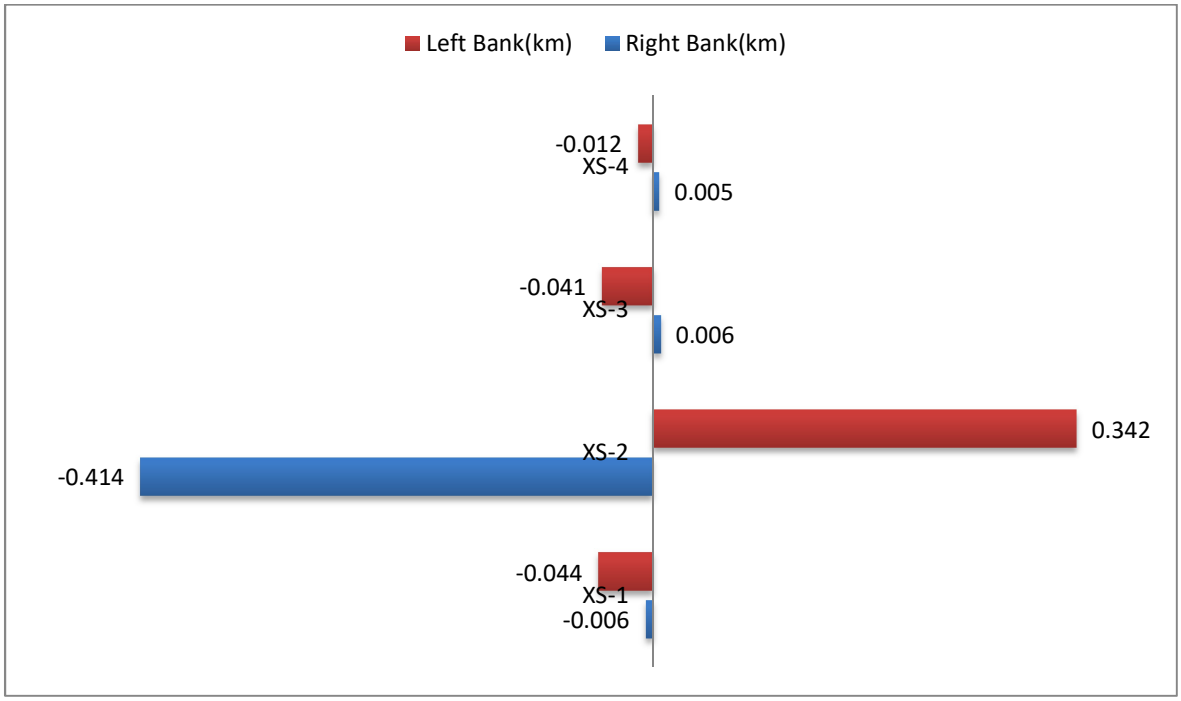


**Figure 5.97** -River Course Shifting line from 2000 to 2005

### 5.8.4 Shifting Pattern of Dikhow River Course from 2005 to 2010

Table 5.46 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.151 | 0.184 | -0.033 | 0 |
| **XS-2** | 0.256 | 0.187 | -0.039 | 0.108 |
| **XS-3** | 0.118 | 0.089 | 0.072 | -0.043 |
| **XS-4** | 0.096 | 0.113 | -0.007 | -0.01 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-1 shows the most significant increase in river width, expanding by 0.033 km
- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 0.069 km.

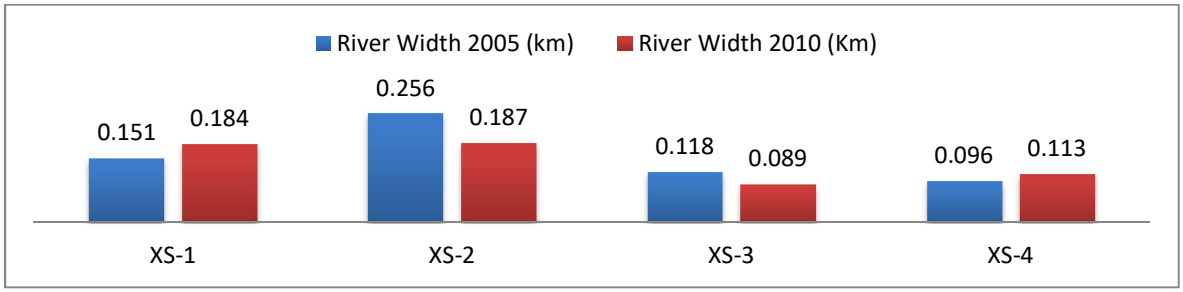


**Figure 5.98** The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 0.072 km.
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-2, with a value of 0.039 km.

**Left Bank (2005-2010):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.043 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 0.108 km.

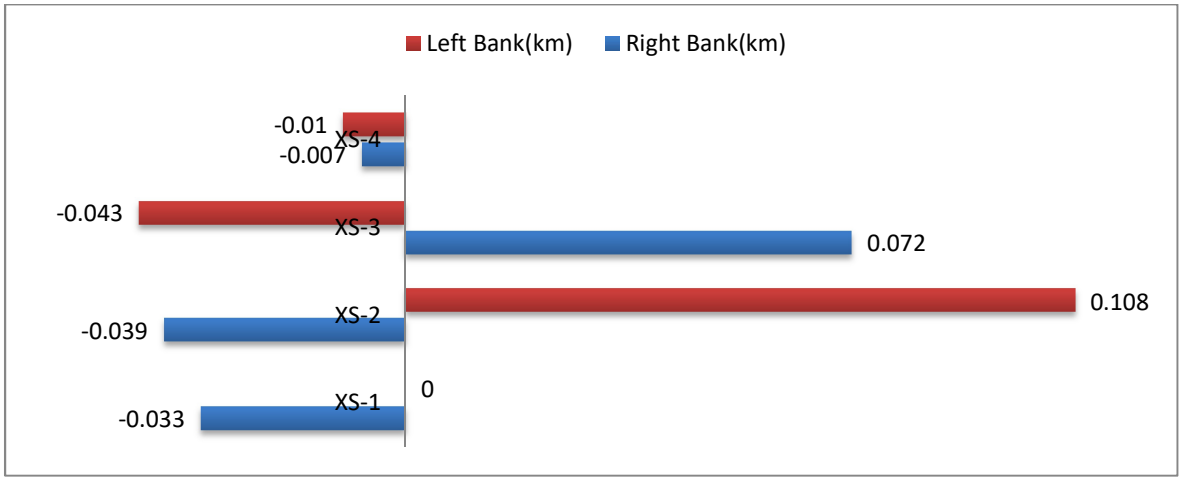


**Figure 5.99-** River Course Shifting line from 2005 to 2010

**5.8.5 Shifting Pattern of Dikhow River Course from 2010 to 2015**

Table 5.47 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.184 | 0.098 | 0.067 | 0.019 |
| **XS-2** | 0.187 | 0.207 | -0.008 | -0.012 |
| **XS-3** | 0.089 | 0.089 | 0 | 0 |
| **XS-4** | 0.113 | 0.118 | -0.01 | 0.005 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.020 km
- **Maximum decrease:** The cross-section XS-1 shows the most significant decrease in river width, expanding by 0.086 km.

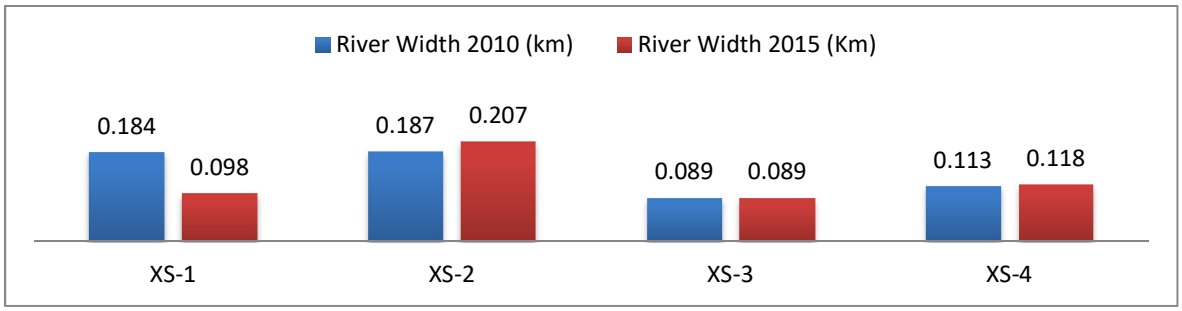


**Figure 5.100**- The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.067 km.
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-4, with a value of 0.010 km.

**Left Bank (2010-2015):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-2, with a value 0.012 km.

- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-1, with a value of 0.019 km.

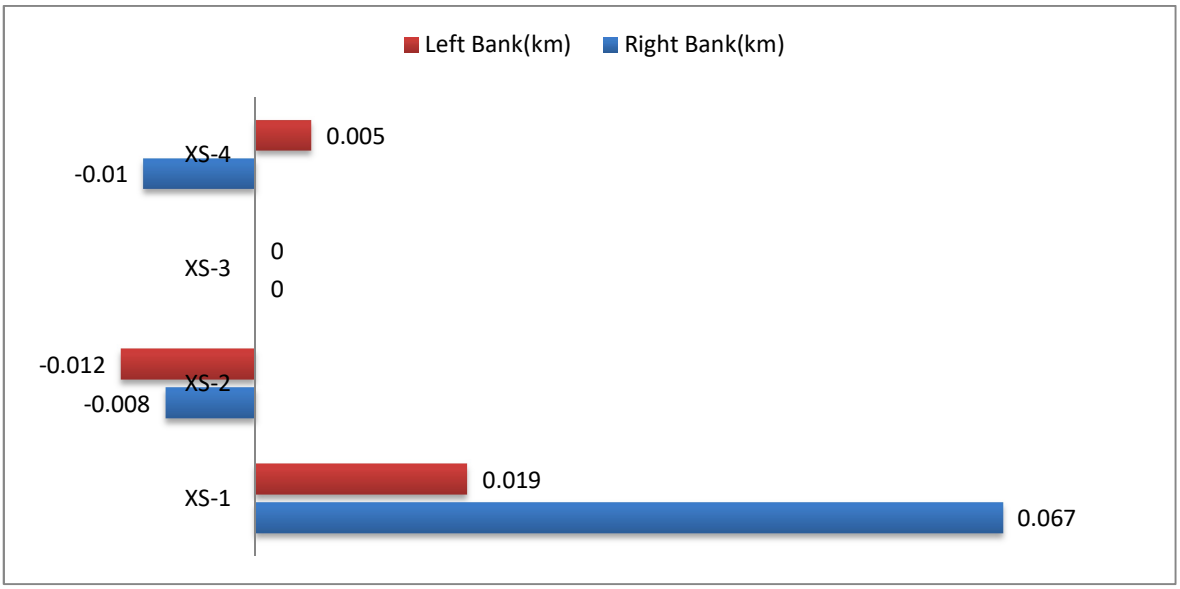


**Figure 5.101-** River Course Shifting line from 2010 to 2015

### 5.8.6 Shifting Pattern of Dikhow River Course from 2015 to 2020

Table 5.48 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.098 | 0.098 | 0 | 0 |
| **XS-2** | 0.207 | 0.126 | 0.026 | 0.055 |
| **XS-3** | 0.089 | 0.119 | 0.02 | -0.05 |
| **XS-4** | 0.118 | 0.091 | 0.011 | 0.016 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.030 km
- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 0.081 km.

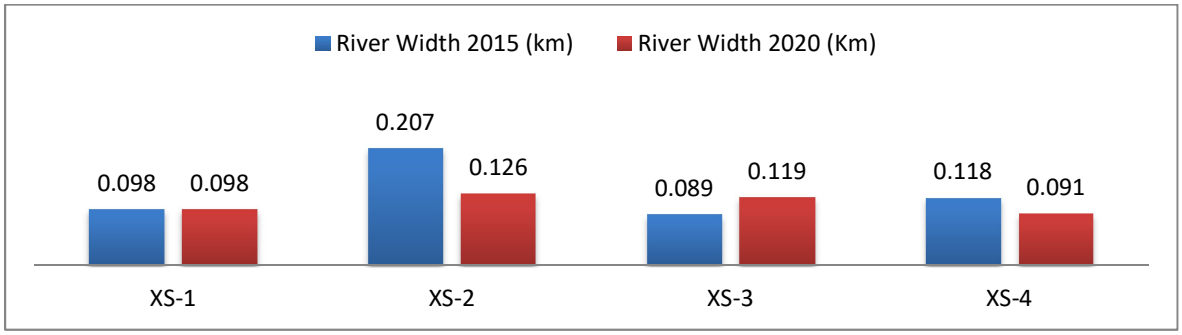


**Figure 5.102** - The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-2, with a value of 0.026 km.
- **Maximum Erosion**: The analysis of the Dikhow River's bank position between 2015 and 2020 suggests minimal bank erosion at the measured cross-sections.

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.050 km
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 0.055 km.

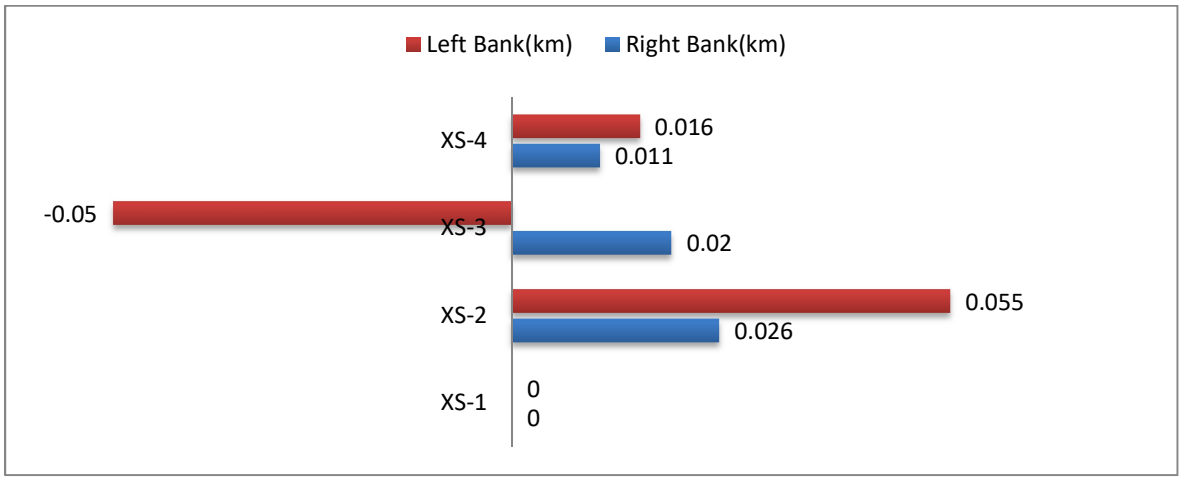


**Figure 5.103**- River Course Shifting line from 2015 to 2020

## 5.9 MURNOI RIVER

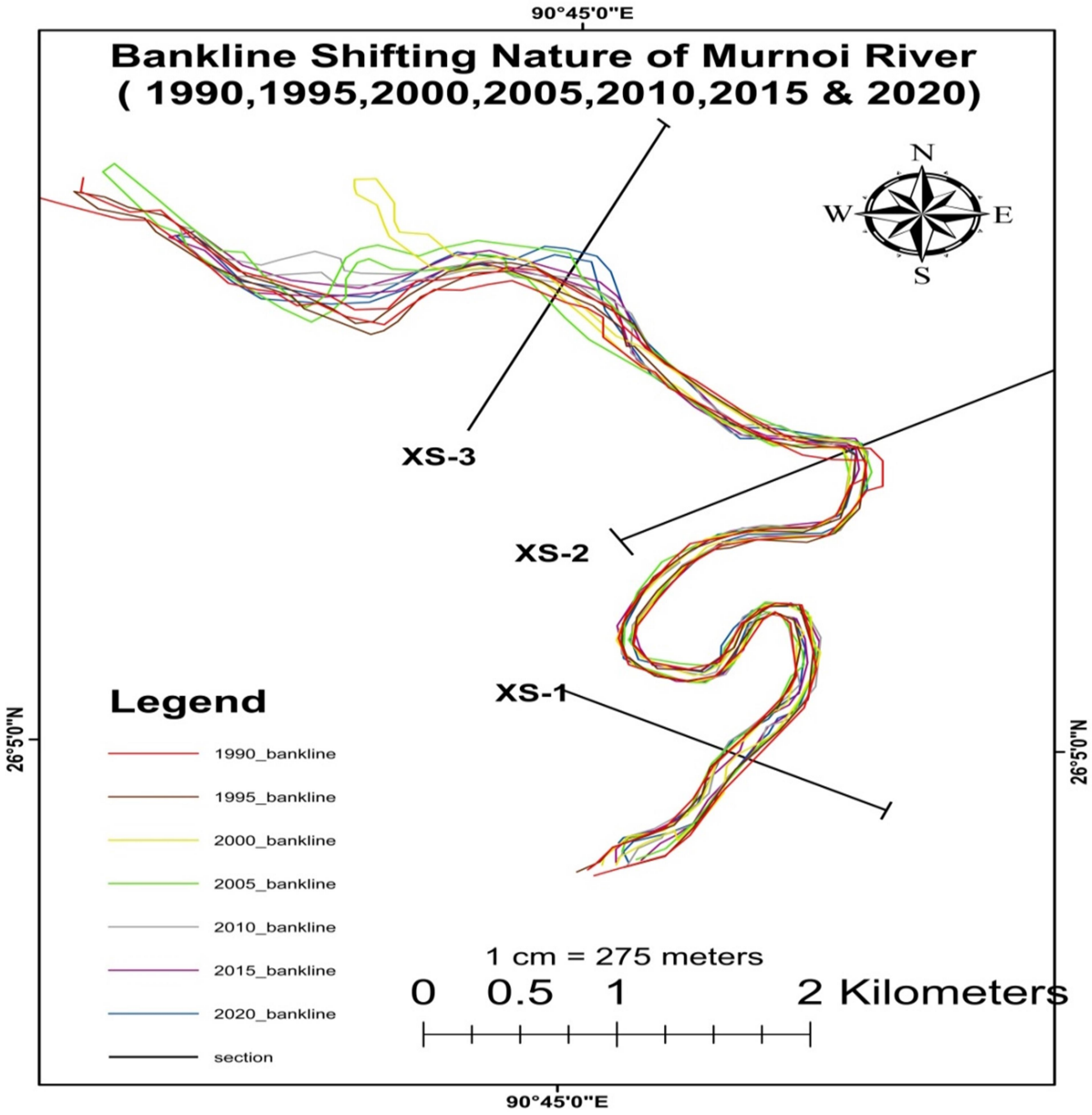


**Figure 5.104-** Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Murnoi River from 1990 to 2020 has been taken into 3 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.104, it is clear that the river bank line is not like the same cross-section

### 5.9.1 Shifting Pattern of Murnoi River Course from 1990 to 1995

Table 5.49 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.142 | 0.111 | 0.031 | 0 |
| **XS-2** | 0.165 | 0.045 | 0 | 0.12 |
| **XS-3** | 0.11 | 0.073 | -0.015 | 0.052 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** No increase in river width was detected in the sections under observation during this timeframe
- **Maximum Decrease**: Cross-section XS-2 has the largest decrease in river width of 0.12 km

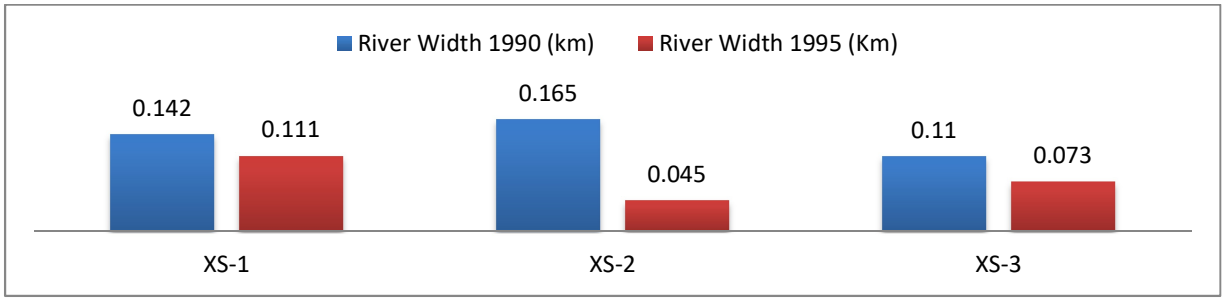


**Figure 5.105-** The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-1, with a value of 0.031 km..
- **Maximum Erosion**: The greatest deposition on the right bank occurred at cross-section XS-3, with a value of 0.015km.

**Left Bank ( 1990-1995):**

- **Maximum Erosion**: No erosion was detected on the left bank in the sections under observation.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-2, with a value 0.12 km

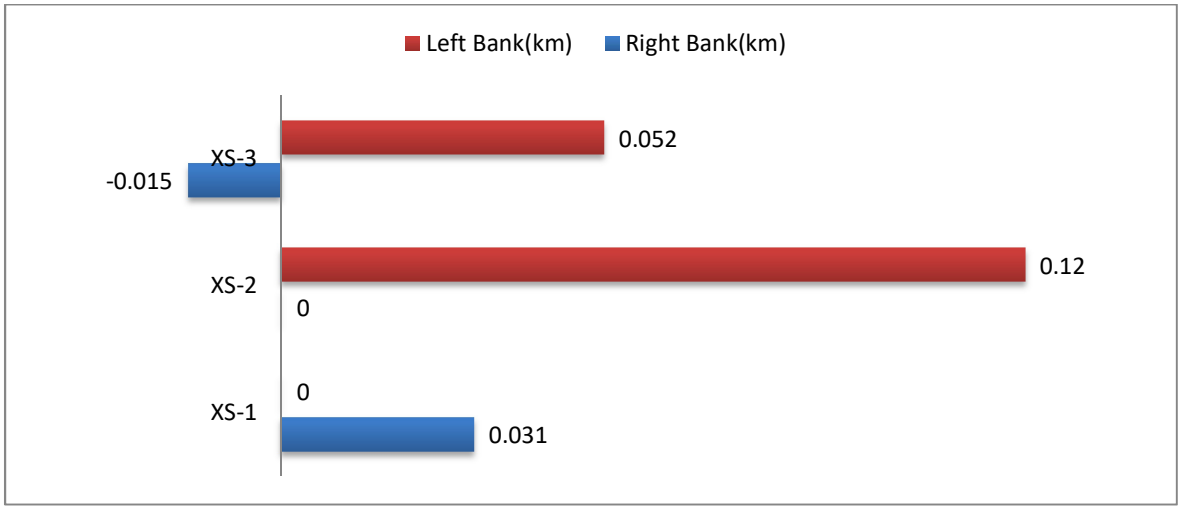


**Figure 5.106-** River Course Shifting line from 1990 to 1995

### 5.9.2 Shifting Pattern of Murnoi River Course from 1995 to 2000

Table 5.50 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.111 | 0.051 | 0.06 | 0 |
| **XS-2** | 0.045 | 0.089 | -0.02 | -0.024 |
| **XS-3** | 0.073 | 0.054 | 0.041 | -0.022 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** Cross-section XS-2 has increase in river width of 0.44 km
- **Maximum Decrease:** Cross-section XS-1 has decrease in river width of 0.06 km

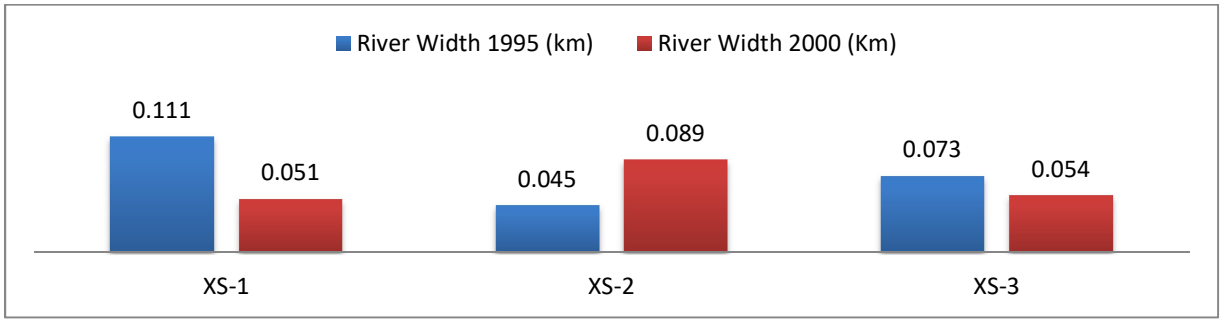


**Figure 5.107**- The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-1, with a value of 0.06 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-2, with a value of 0.02 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-2, with a value of 0.024 km.
- **Maximum Deposition**: No deposition was detected on the left bank in the sections under observation.

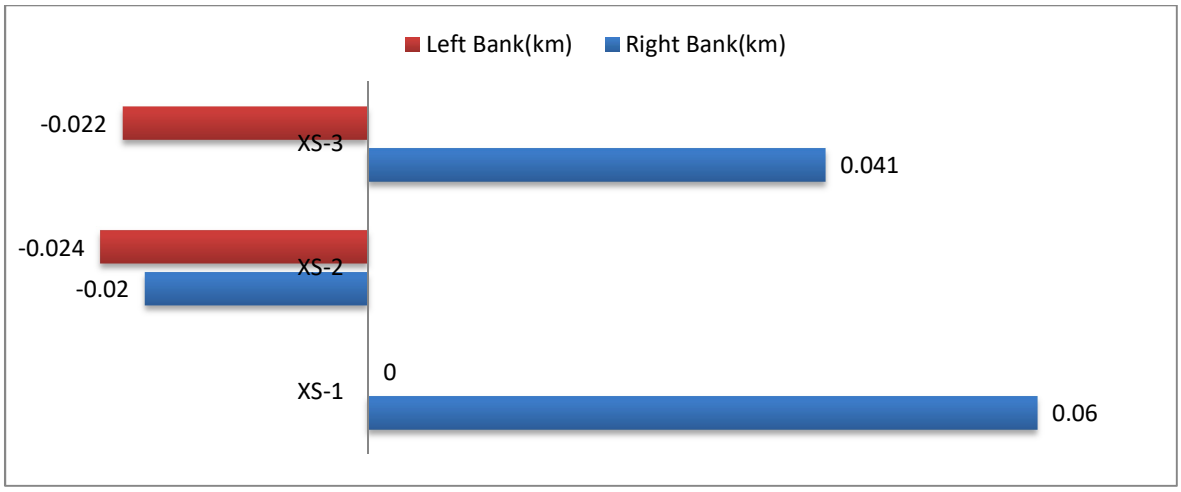


**Figure 5.108 -** River Course Shifting line from 1995 to 2000

### 5.9.3 Shifting Pattern of Murnoi River Course from 2000 to 2005

Table 5.51 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.051 | 0.131 | -0.059 | -0.021 |
| **XS-2** | 0.089 | 0.102 | -0.013 | 0 |
| **XS-3** | 0.054 | 0.308 | -0.18 | -0.074 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.254 km
- **Maximum decrease:** No decrease in river width was detected in the sections under observation during this timeframe.

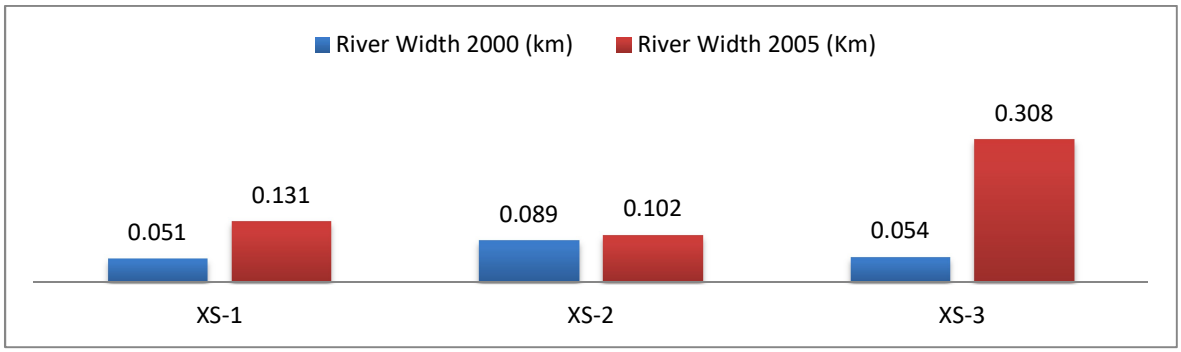


**Figure 5.109**- The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: no deposition in observed section.
- **Maximum Erosion**:. The most significant erosion on the right bank occurred at cross-section XS-3, with a value 0.18 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The highest erosion on the left bank was observed at cross-section XS-3, with a value of 0.074 km
- **Maximum Deposition**: no deposition in observed section.

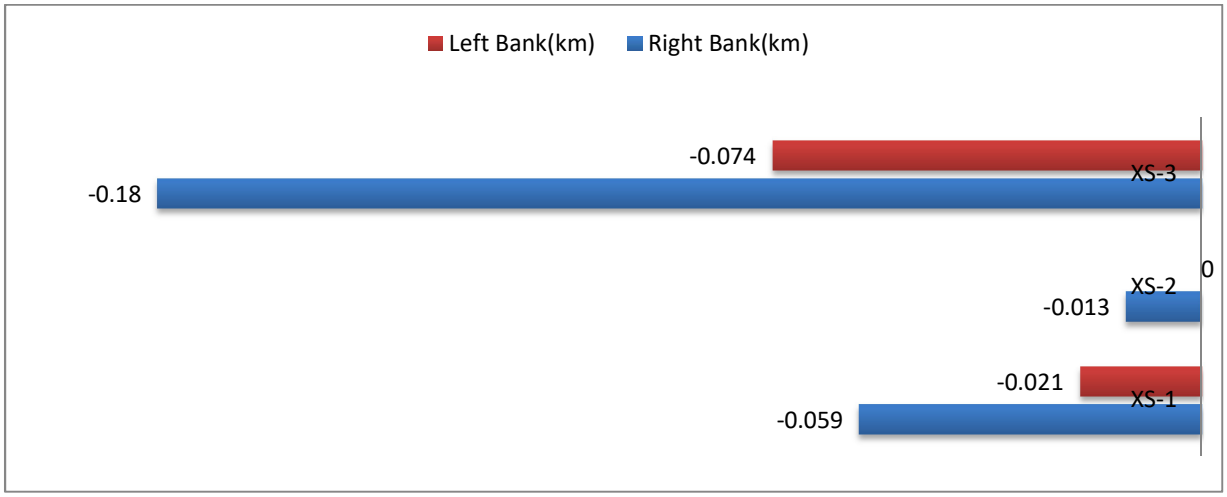


**Figure 5.110** -River Course Shifting line from 2000 to 2005

### 5.9.4 Shifting Pattern of Murnoi River Course from 2005 to 2010

Table 5.52 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.131 | 0.137 | 0 | -0.006 |
| **XS-2** | 0.102 | 0.072 | 0.006 | 0.024 |
| **XS-3** | 0.308 | 0.565 | -0.102 | -0.155 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase: :** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.257 km.
- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 0.03 km

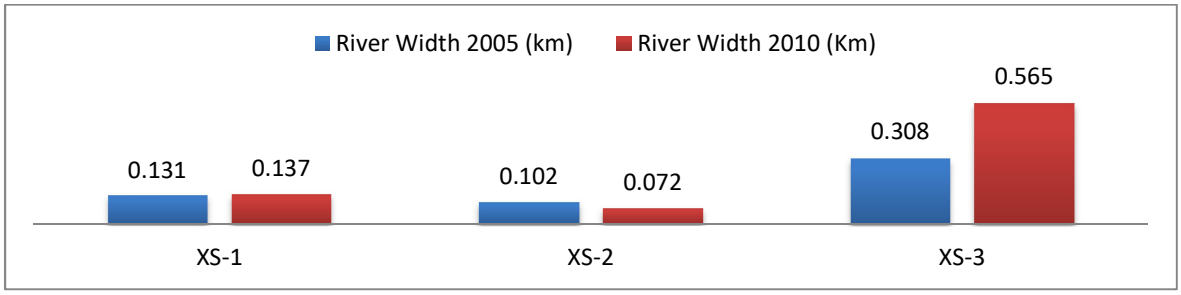


**Figure 5.111 -**The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-2, with a value of 0.006 km.
- **Maximum Erosion**:. The most significant erosion on the right bank occurred at cross-section XS-3, with a value 0.102 km

**Left Bank (2005-2010):**

- **Maximum Erosion**: The highest erosion on the left bank was observed at cross-section XS-3, with a value of 0.155 km
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 0.024 km

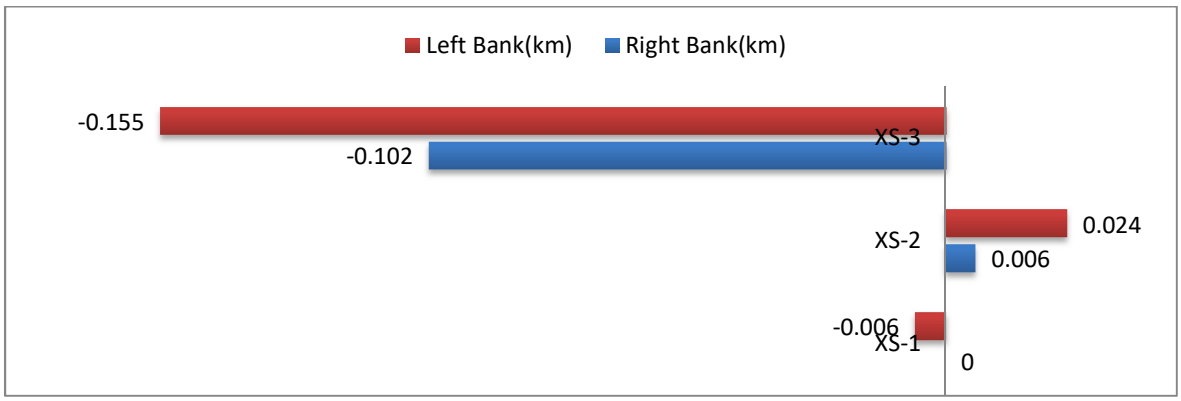


**Figure 5.112-** River Course Shifting line from 2005 to 2010

**5.9.5 Shifting Pattern of Murnoi River Course from 2010 to 2015**

Table 5.53 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.137 | 0.059 | 0.009 | 0.069 |
| **XS-2** | 0.072 | 0.035 | -0.007 | 0.044 |
| **XS-3** | 0.565 | 0.575 | -0.033 | 0.023 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.01 km
- **Maximum decrease:** The cross-section XS-1 shows the most significant decrease in river width, expanding by 0.078 km

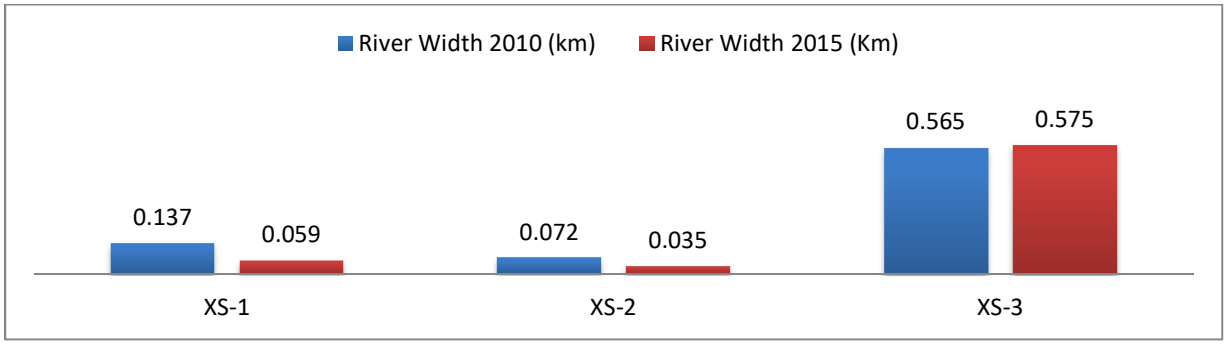


**Figure 5.113-** The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.009 km
- **Maximum Erosion**: The most significant erosion on the right bank occurred at cross-section XS-3, with a value 0.033 km

**Left Bank (2010-2015):**

- **Maximum Erosion**: No erosion was detected on the left bank in the sections under observations.
- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.069 km

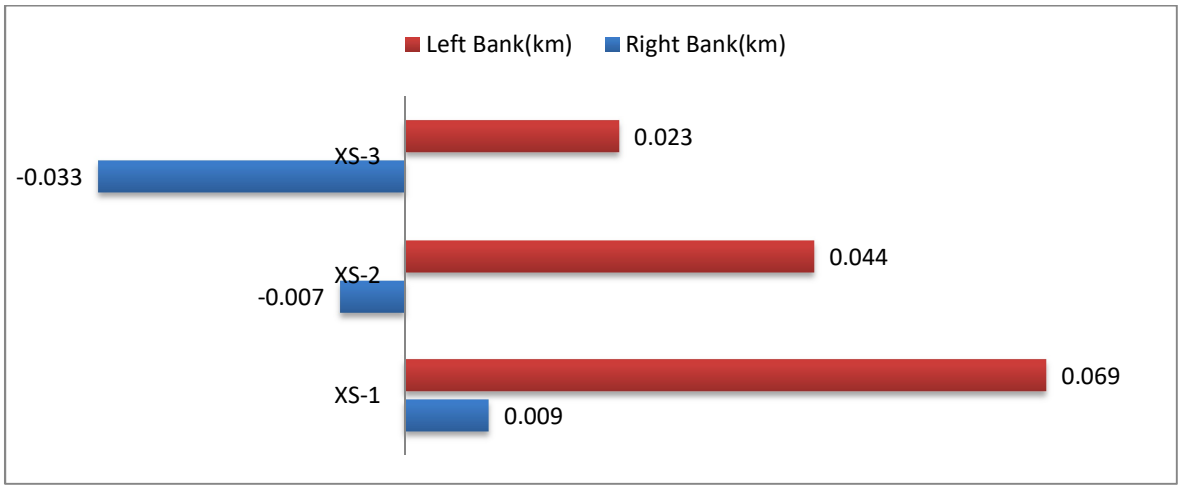


**Figure 5.114-** River Course Shifting line from 2010 to 2015

### 5.9.6 Shifting Pattern of Murnoi River Course from 2015 to 2020

Table 5.54 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.059 | 0.114 | 0.008 | -0.063 |
| **XS-2** | 0.035 | 0.066 | 0 | -0.031 |
| **XS-3** | 0.575 | 0.57 | -0.165 | 0.17 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-1 shows the most significant increase in river width, expanding by 0.055 km
- **Maximum decrease:** The cross-section XS-3 shows the most significant decrease in river width, expanding by 0.005 km.

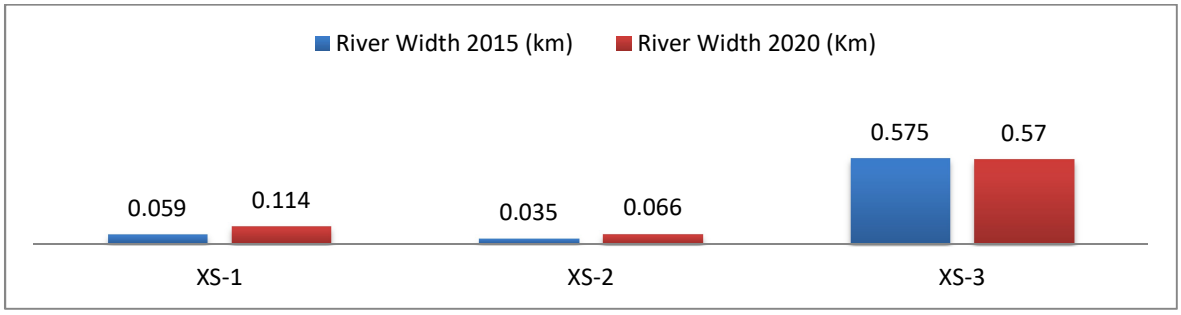


**Figure 5.115-** The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.008 km.
- **Maximum Erosion**. The highest erosion on the right bank occurred at cross-section XS-3, with a value of 0.165 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-1, with a value 0.063 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-3, with a value of 0.17 km

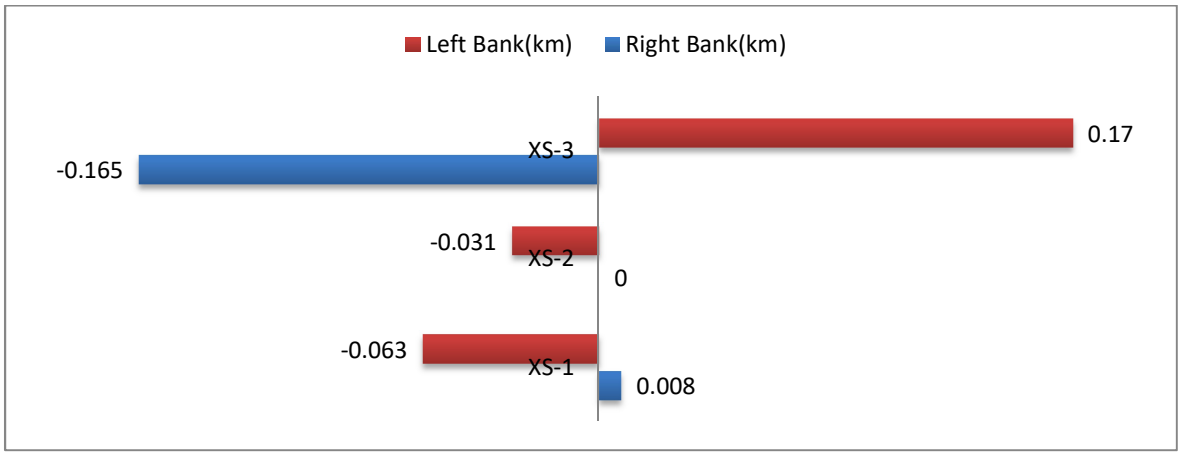


**Figure 5.116** River Course Shifting line from 2015 to 2020

## 5.10 KRISHNAI RIVER

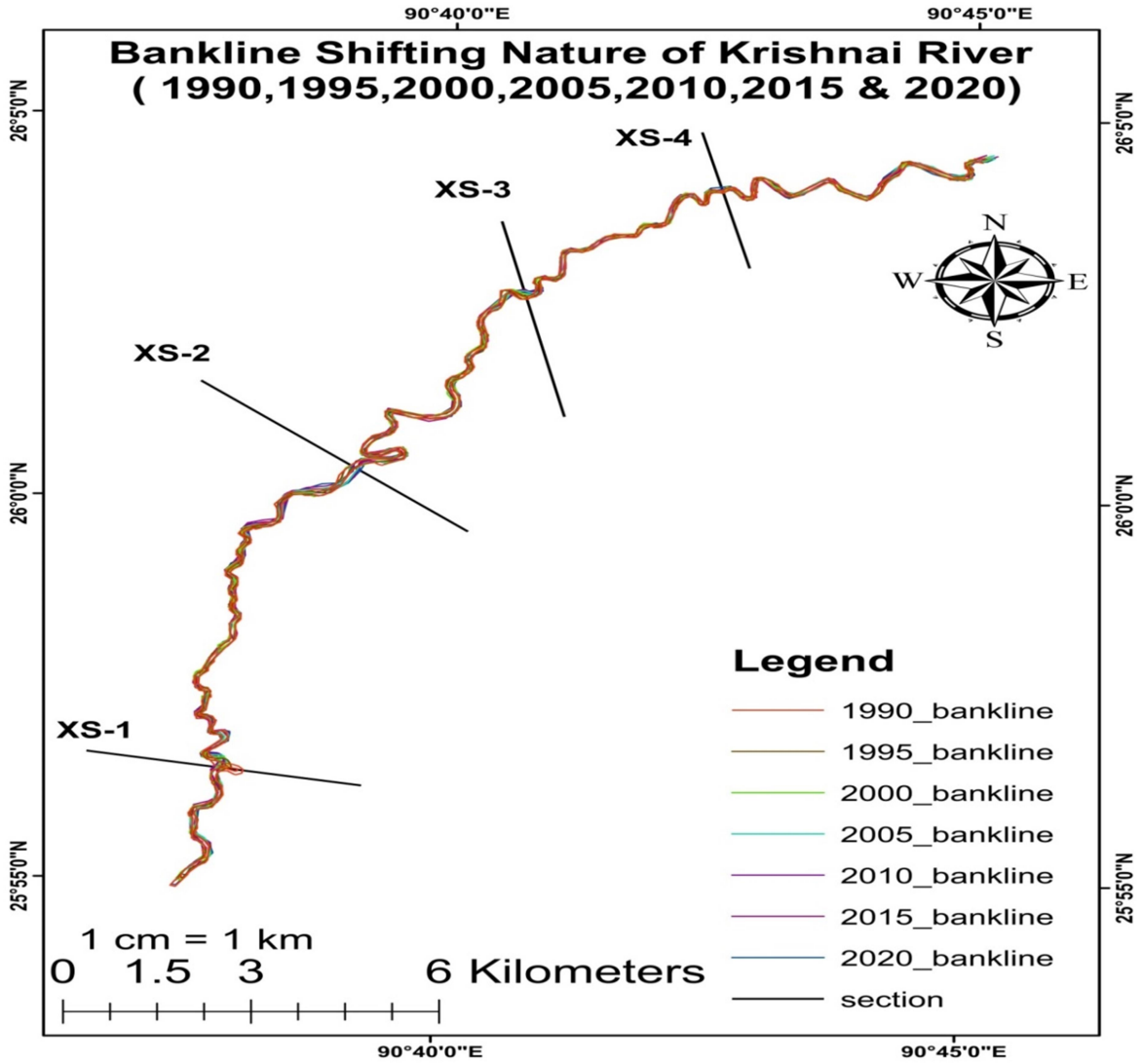


**Figure 5.117-** Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Krishnai River from 1990 to 2020 has been taken into 4 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.117, it is clear that the river bank line is not like the same cross-section

### 5.10.1 Shifting Pattern of Krishnai River Course from 1990 to 1995

Table 5.55 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.09 | 0.116 | 0.259 | -0.285 |
| **XS-2** | 0.104 | 0.078 | 0.026 | 0 |
| **XS-3** | 0.06 | 0.058 | 0.014 | -0.012 |
| **XS-4** | 0.054 | 0.052 | -0.017 | 0.019 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** Cross-section XS-1 has the largest increase in river width of 0.026 km**.**
- **Maximum Decrease:** Cross-section XS-2 has the largest decrease in river width of 0.026 km

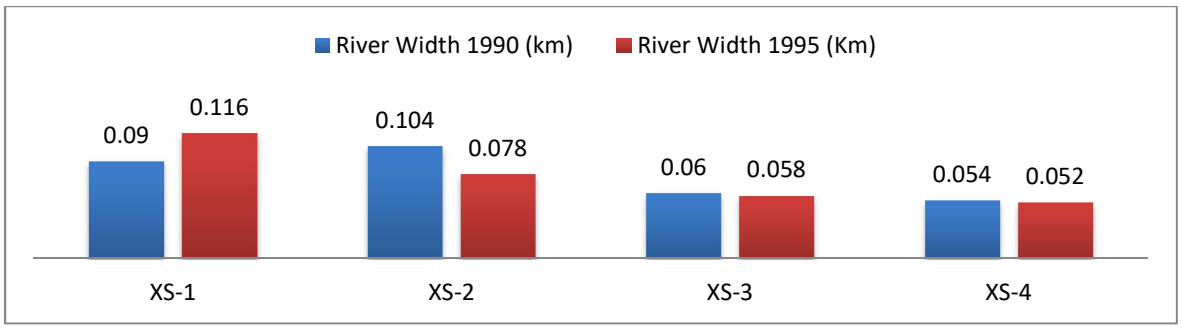


**Figure 5.118**- The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-1, with a value of 0.259 km..
- **Maximum Erosion**: The greatest deposition on the right bank occurred at cross-section XS-4, with a value of 0.017 km...

**Left Bank ( 1990-1995):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-1, with a value of 0.285 km.
- **Maximum Deposition**: The most significant deposition on the left bank was observed at cross-section XS-4, with a value 0.019 km

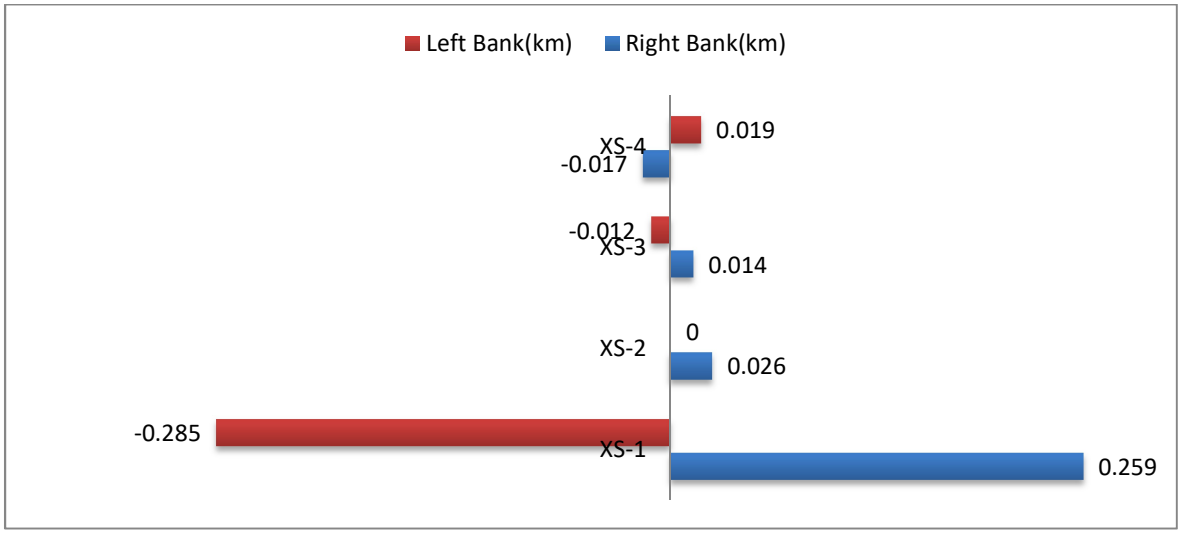


**Figure 5.119**- River Course Shifting line from 1990 to 1995

### 5.10.2 Shifting Pattern of Krishnai River Course from 1995 to 2000

Table 5.56 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.116 | 0.096 | 0.046 | -0.026 |
| **XS-2** | 0.078 | 0.098 | -0.012 | -0.008 |
| **XS-3** | 0.058 | 0.107 | 0 | -0.049 |
| **XS-4** | 0.052 | 0.012 | 0.04 | 0 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** Cross-section XS-3 has increase in river width of 0.049 km
- **Maximum Decrease**: Cross-section XS-4 has decrease in river width of 0.04 km

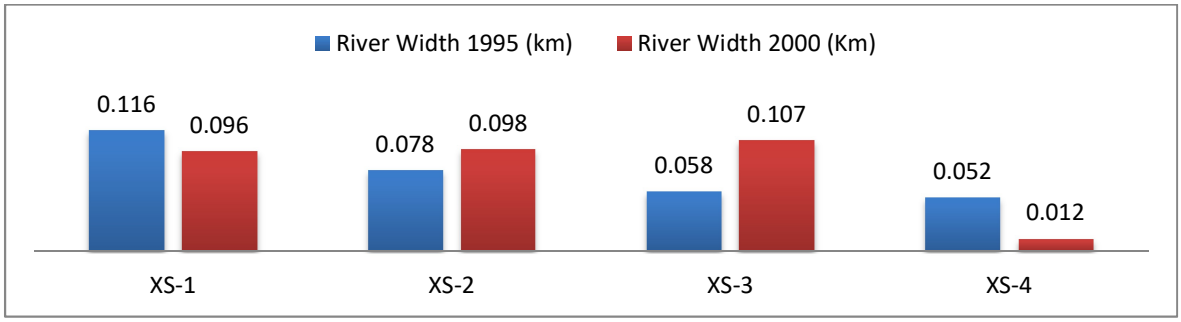


**Figure 5.120**- The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The greatest deposition on the right bank occurred at cross-section XS-1, with a value of 0.046 km.
- **Maximum Erosion**: The most significant erosion on the right bank was observed at cross-section XS-2, with a value of 0.012 km.

**Left Bank ( 1995-2000):**

- **Maximum Erosion**: The greatest erosion on the left bank occurred at cross-section XS-3, with a value of 0.049 km.
- **Maximum Deposition**: no deposition occurred during this period of observed section.

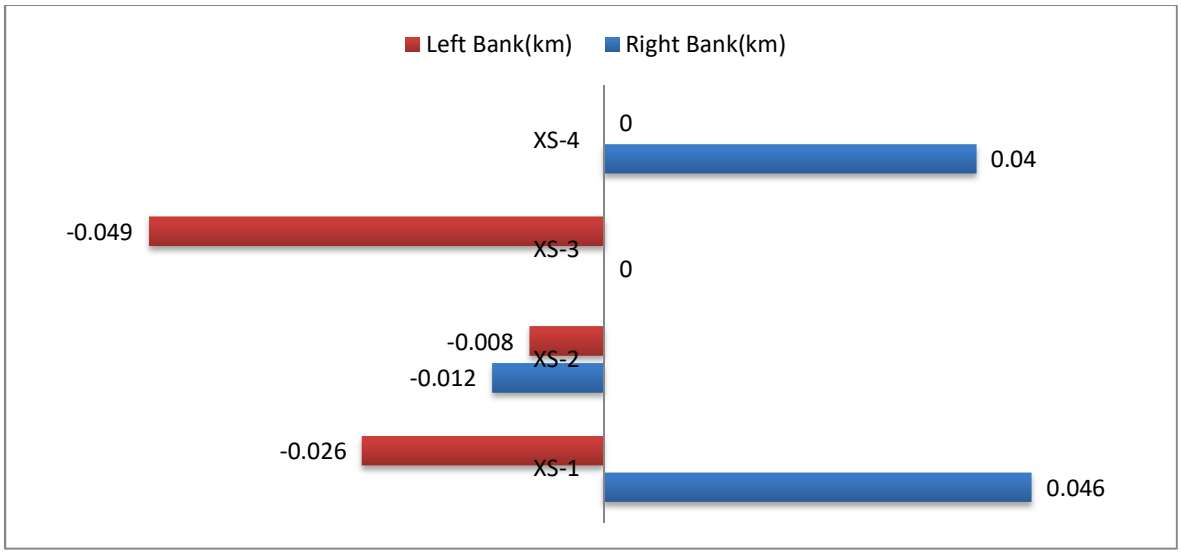


**Figure 5.121-** River Course Shifting line from 1995 to 2000

### 5.10.3 Shifting Pattern of Krishnai River Course from 2000 to 2005

Table 5.57 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.096 | 0.09 | 0.031 | -0.025 |
| **XS-2** | 0.098 | 0.13 | -0.049 | 0.017 |
| **XS-3** | 0.107 | 0.065 | 0.125 | -0.083 |
| **XS-4** | 0.012 | 0.048 | -0.026 | -0.01 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.036 km
- **Maximum decrease:** The cross-section XS-3 shows the most significant decrease in river width, expanding by 0.042 km

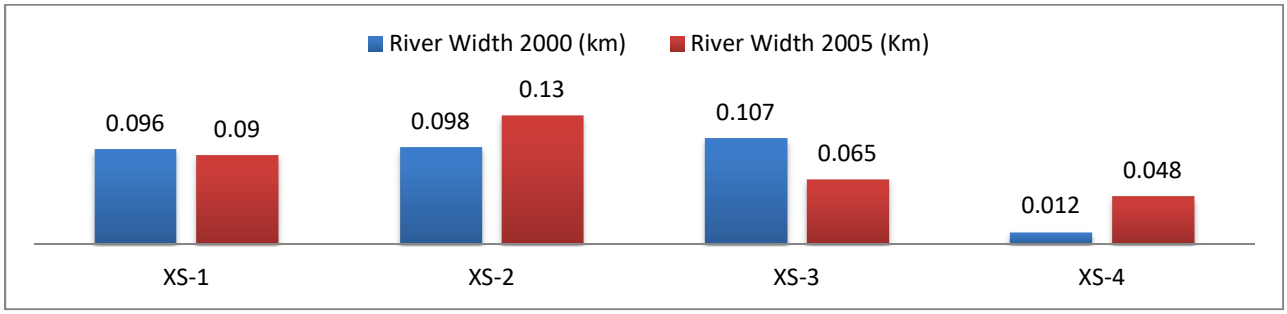


**Figure 5.122-** The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: : The most significant deposition on the right bank occurred at cross-section XS-3, with a value of 0.125 km
- **Maximum Erosion**: The greatest erosion on the right bank was observed at cross-section XS-2, with a value of 0.049 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: The greatest erosion on the left bank was observed at cross-section XS-3, with a value of 0.083 km.
- **Maximum Deposition**: The most significant deposition on the left bank occurred at cross-section XS-2, with a value of 0.017 km

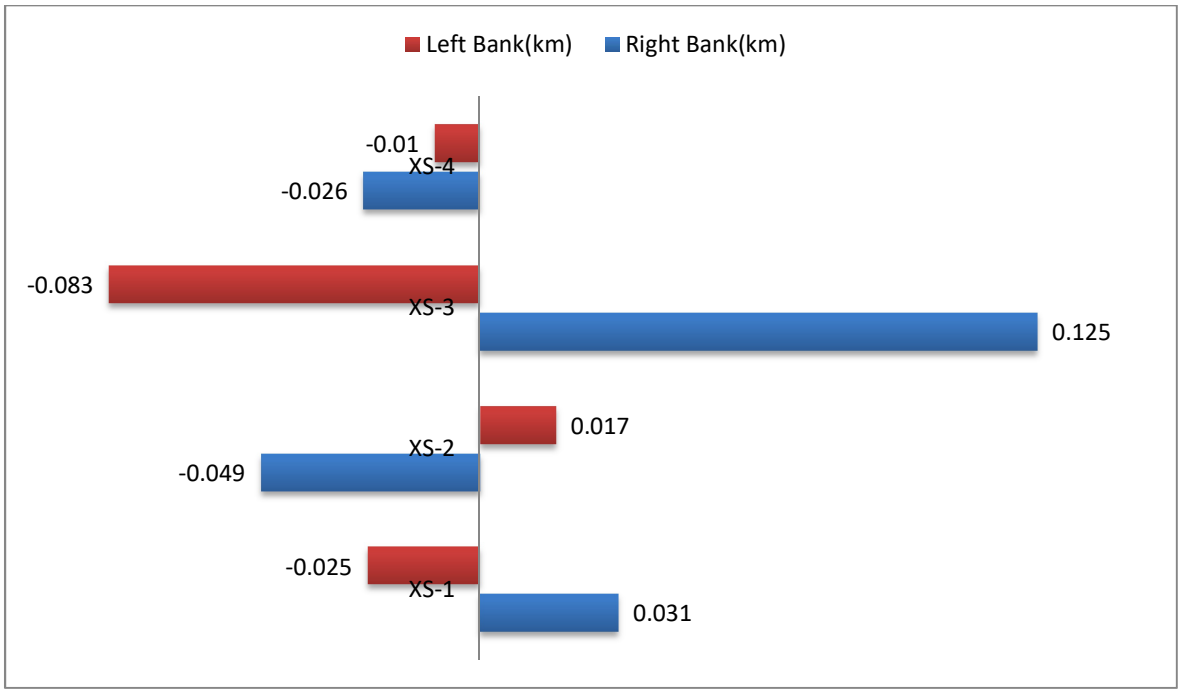


**Figure 5.123**- River Course Shifting line from 2000 to 2005

### 5.10.4 Shifting Pattern of Krishnai River Course from 2005 to 2010

Table 5.58 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 2005 (km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.09 | 0.075 | 0.034 | -0.019 |
| **XS-2** | 0.13 | 0.111 | -0.021 | 0.04 |
| **XS-3** | 0.065 | 0.055 | 0 | 0.01 |
| **XS-4** | 0.048 | 0.047 | -0.007 | 0.008 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** between 2005 and 2010, the width of the river decreased in all four sections we observed.
- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 0.019 km.

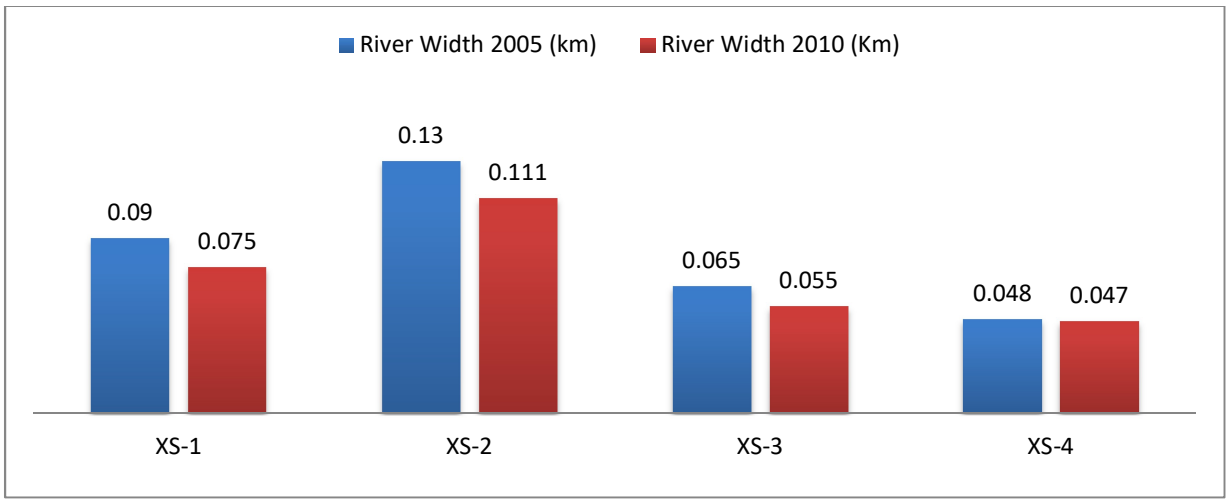


**Figure 5.124-** The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.034 km.
- **Maximum Erosion**:. The most significant erosion on the right bank occurred at cross-section XS-2, with a value 0.021 km

**Left Bank (2005-2010):**

- **Maximum Erosion**: The highest erosion on the left bank was observed at cross-section XS-1, with a value of 0.019 km
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-2, with a value of 0.04 km

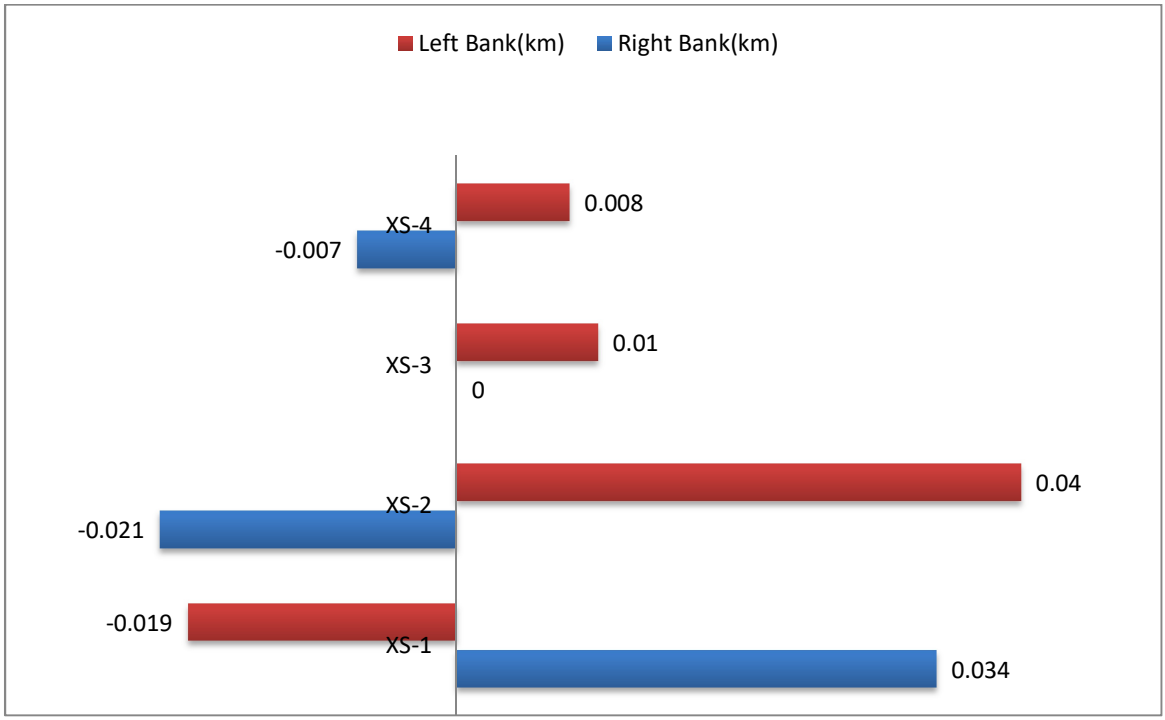


**Figure 5.125-** River Course Shifting line from 2005 to 2010

### 5.10.5 Shifting Pattern of Krishnai River Course from 2010 to 2015

Table 5.59 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.075 | 0.091 | 0.006 | -0.022 |
| **XS-2** | 0.111 | 0.101 | 0.01 | 0 |
| **XS-3** | 0.055 | 0.072 | 0.031 | -0.048 |
| **XS-4** | 0.047 | 0.035 | 0.024 | -0.012 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.017 km
- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 0.012 km

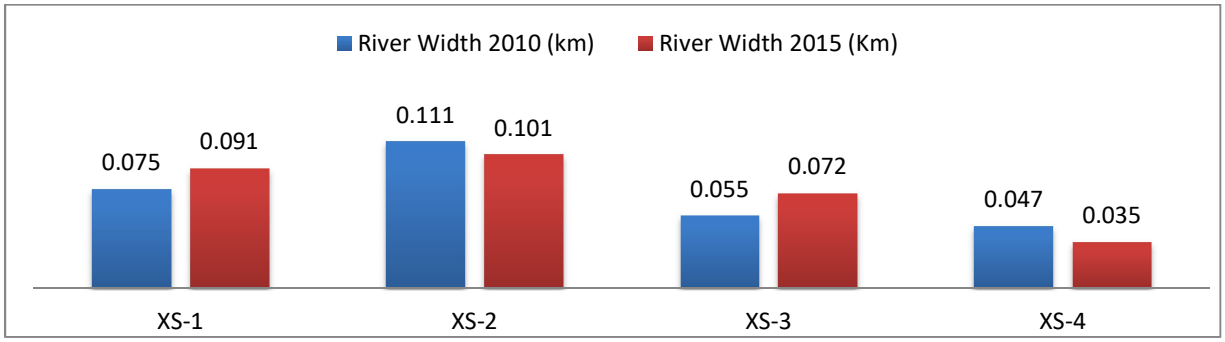


**Figure 5.126-** The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 0.031 km
- **Maximum Erosion**: no erosion in observed section.

**Left Bank (2010-2015):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.048 km.
- **Maximum Deposition**: no deposition in observed section

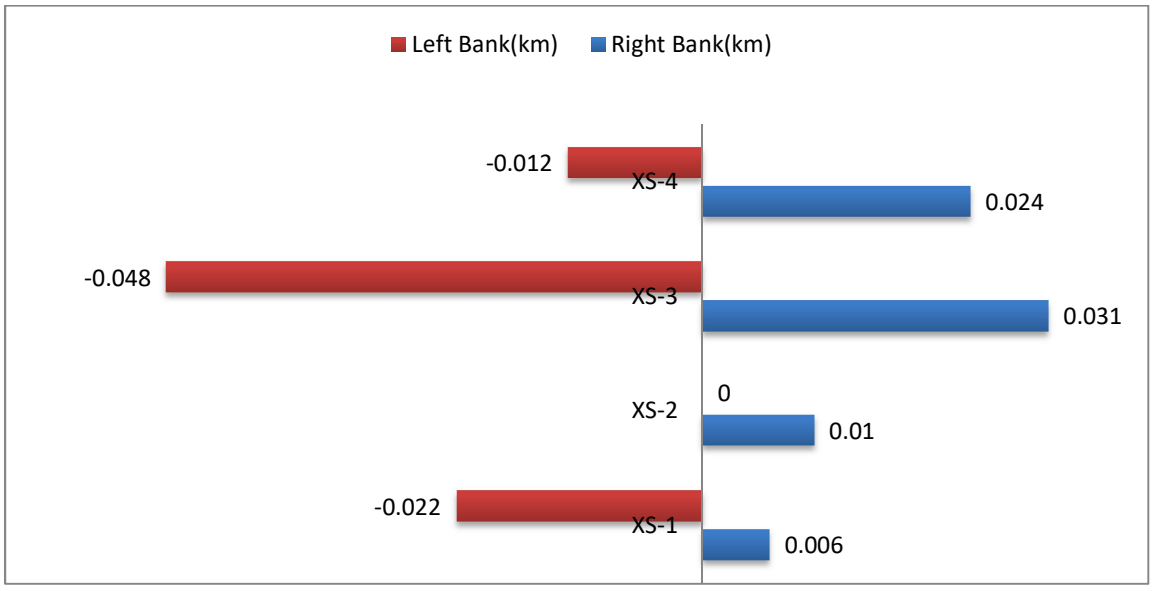


**Figure 5.127-** River Course Shifting line from 2010 to 2015

### 5.10.6 Shifting Pattern of Krishnai River Course from 2015 to 2020

Table 5.60 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.091 | 0.074 | 0.027 | -0.01 |
| **XS-2** | 0.101 | 0.169 | -0.045 | -0.023 |
| **XS-3** | 0.072 | 0.046 | -0.018 | 0.044 |
| **XS-4** | 0.035 | 0.05 | 0.067 | -0.082 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.068 km
- **Maximum decrease:** The cross-section XS-3 shows the most significant decrease in river width, expanding by 0.026 km.

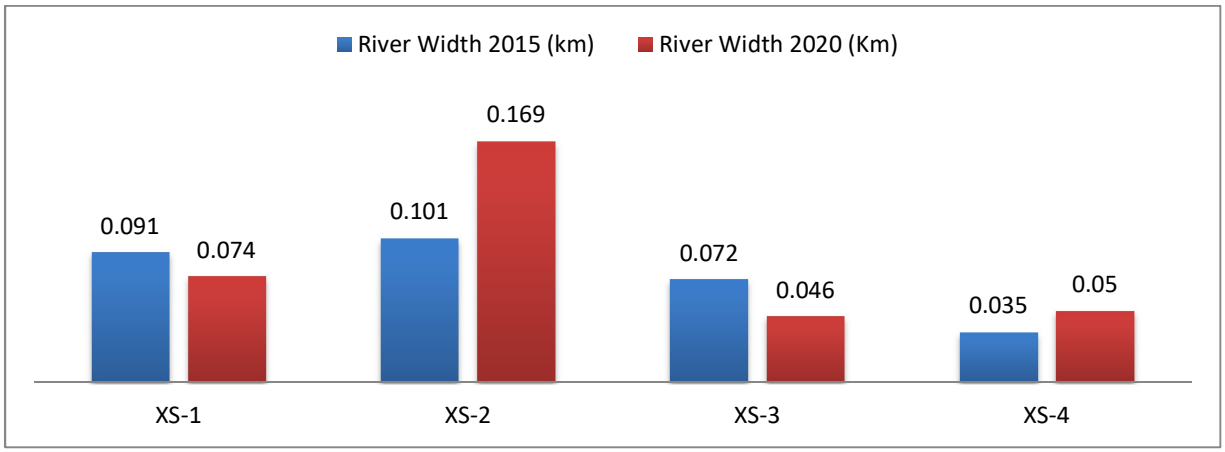


**Figure 5.128** -The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-4, with a value of 0.067 km.

- **Maximum Erosion**. The highest erosion on the right bank occurred at cross-section XS-2, with a value of 0.045 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.044 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-4, with a value of 0.082 km

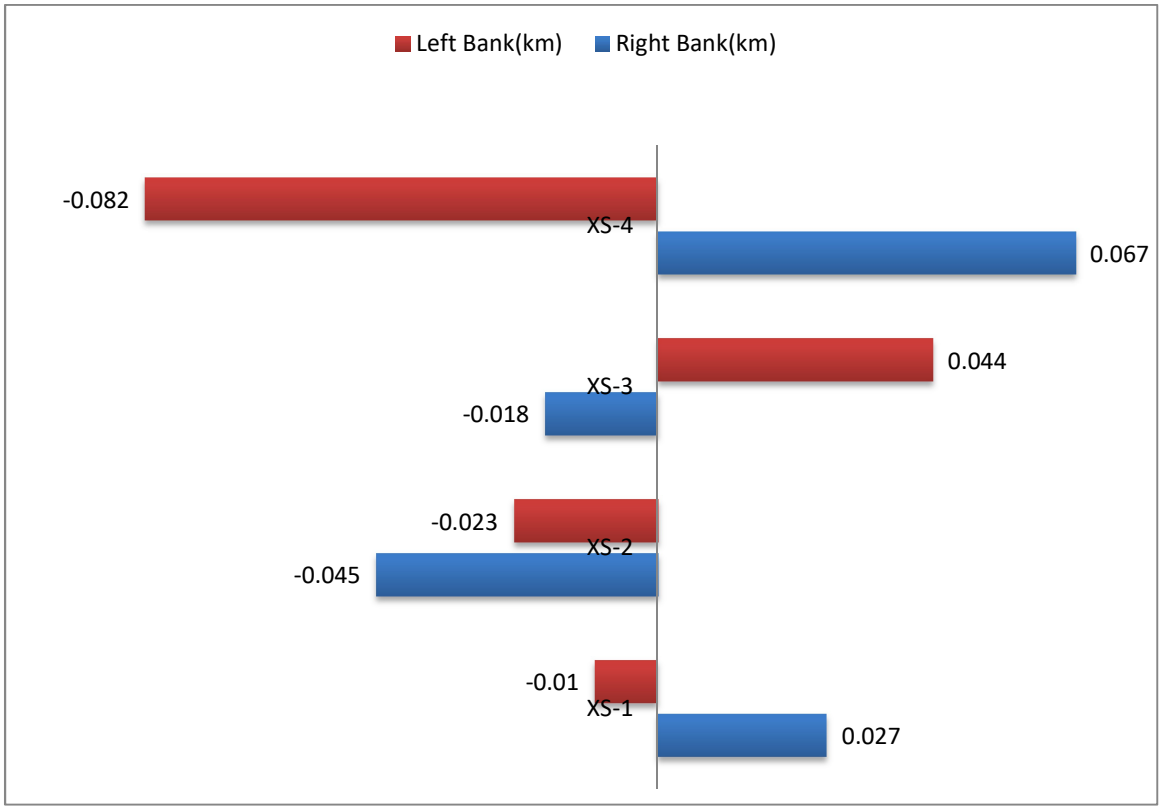


**Figure 5.129**- River Course Shifting line from 2015 to 2020

## 5.11 DUDHNOI RIVER

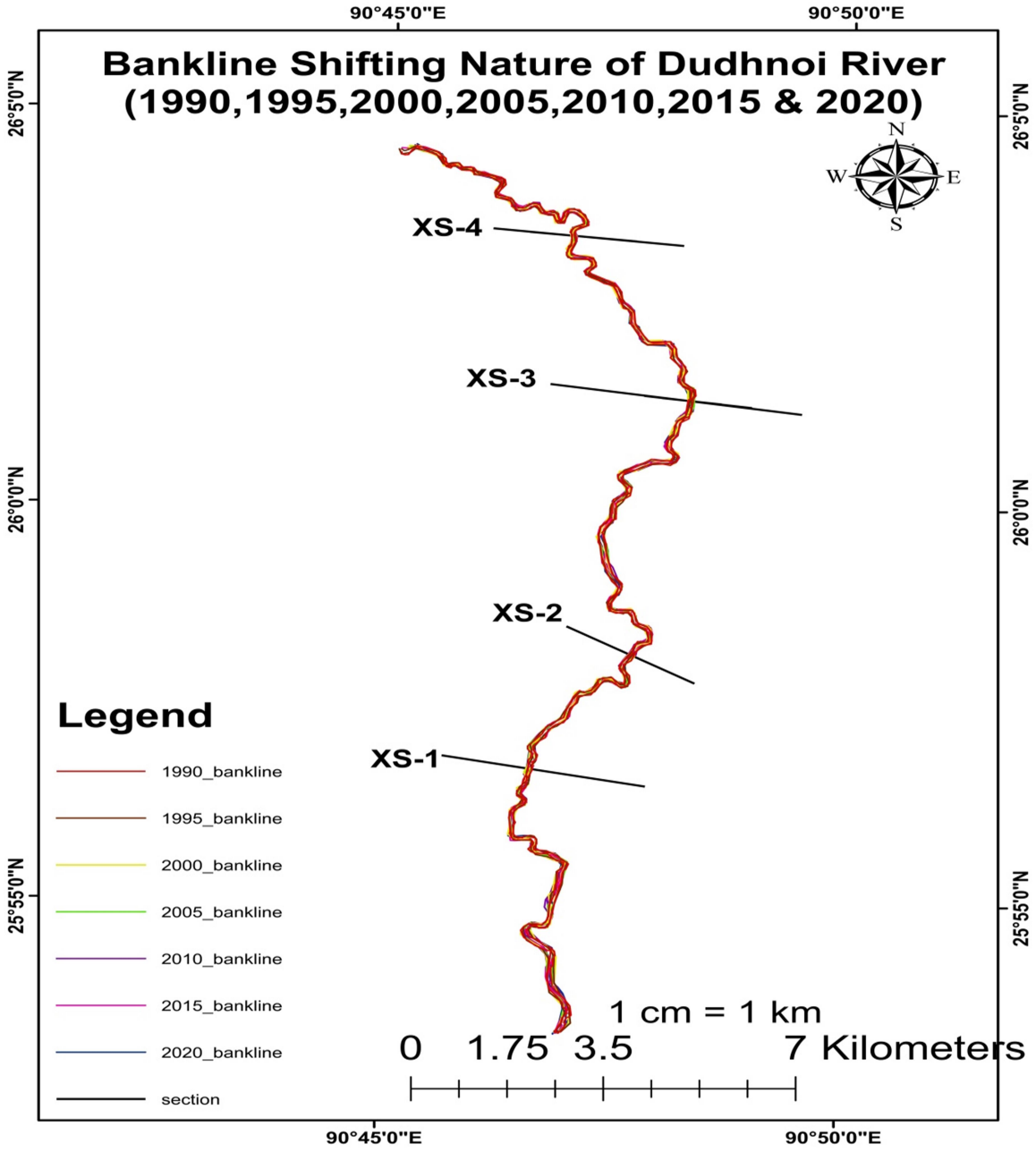


**Figure 5.130** Apparent Positions of the river in seven-time and river width the different cross-sections of calculating bank-lines migration (1990, 1995, 2000, 2005, 2010, 2015 & 2020)

The shifting of Dudhnoi River from 1990 to 2020 has been taken into 4 cross-sections that denote the river course changing its plan form through the shifting river course line. Here, it describes in the field area the erosion and deposition activities at the different cross-sections. From figure 5.130, it is clear that the river bank line is not like the same cross-section

### 5.11.1 Shifting Pattern of Dudhnoi River Course from 1990 to 1995

Table 5.61 Bank-line Migration Status along different Cross-Sections from 1990 to 1995

| Cross-section | River Width 1990 (km) | River Width 1995 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.076 | 0.076 | 0.01 | -0.01 |
| **XS-2** | 0.066 | 0.059 | 0.035 | -0.028 |
| **XS-3** | 0.095 | 0.03 | 0.036 | 0.029 |
| **XS-4** | 0.063 | 0.051 | 0.022 | -0.01 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** No increase in river width was detected in the sections under observation during this timeframe
- **Maximum decrease:** The cross-section XS-3 shows the most significant decrease in river width, expanding by 0.065 km.

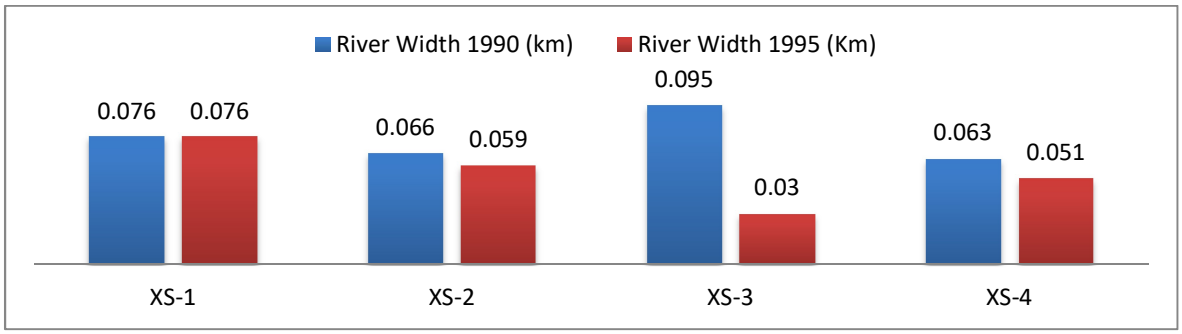


**Figure 5.131** -The Channel Width Variation from 1990 to 1995

**Right Bank (1990-1995):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-3, with a value of 0.036 km.
- **Maximum Erosion**. No erosion was detected on the right bank in the sections under observation

**Left Bank (1990-1995):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-2, with a value 0.028 km.
- **Maximum Deposition**: The highest deposition on the left bank was observed at cross-section XS-3, with a value of 0.029 km

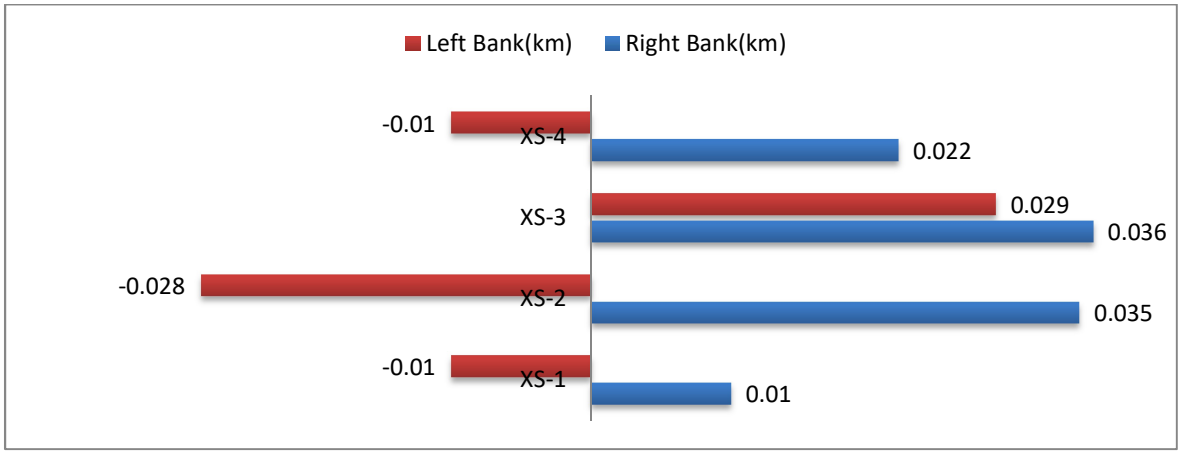


**Figure 5.132** -River Course Shifting line from 1990 to 1995

### 5.11.2 Shifting Pattern of Dudhnoi River Course from 1995 to 2000

Table 5.62 Bank-line Migration Status along different Cross-Sections from 1995 to 2000

| Cross-section | River Width 1995 (km) | River Width 2000 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.076 | 0.057 | 0.046 | -0.027 |
| **XS-2** | 0.059 | 0.113 | -0.049 | -0.005 |
| **XS-3** | 0.03 | 0.065 | 0 | -0.035 |
| **XS-4** | 0.051 | 0.036 | 0.026 | -0.011 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-2 shows the most significant increase in river width, expanding by 0.054 km
- **Maximum decrease:** The cross-section XS-1 shows the most significant decrease in river width, expanding by 0.019 km

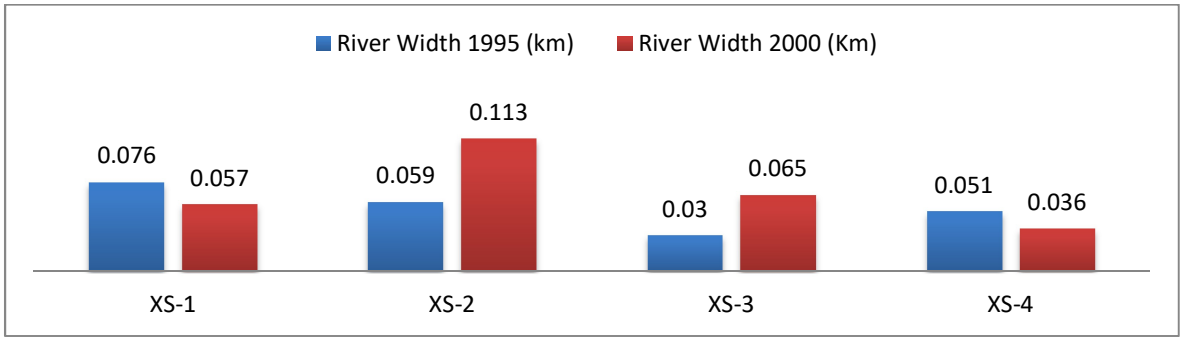


**Figure 5.133**- The Channel Width Variation from 1995 to 2000

**Right Bank (1995-2000):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.046 km.
- **Maximum Erosion**. : The highest deposition on the right bank was observed at cross-section XS-2, with a value of 0.049 km

**Left Bank (1990-1995):**

- **Maximum Erosion**: The most significant erosion on the left bank occurred at cross-section XS-3, with a value 0.035 km.
- **Maximum Deposition**: .No depostion was detected on the leftt bank in the sections under observation

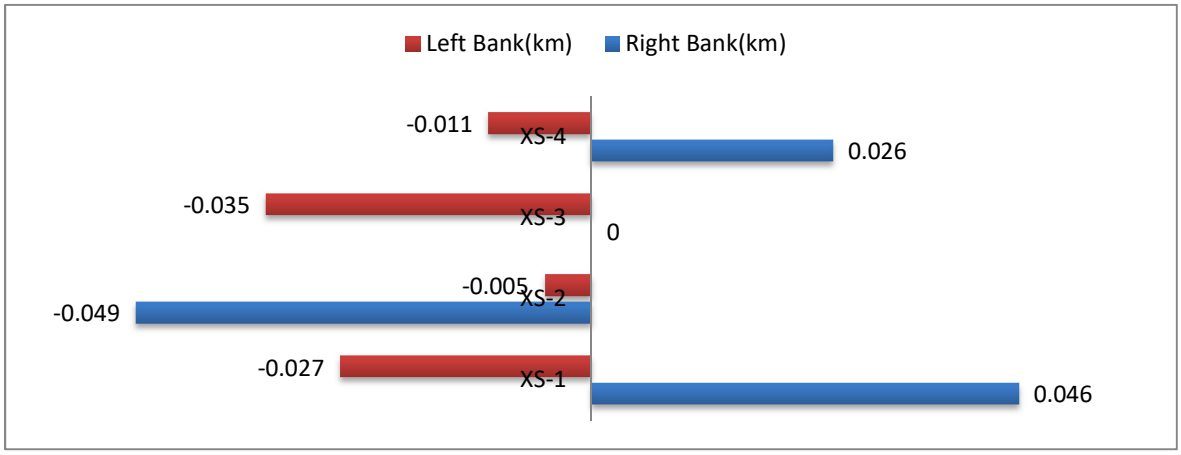


**Figure 5.134-** River Course Shifting line from 1995 to 2000

### 5.11.3 Shifting Pattern of Dudhnoi River Course from 2000 to 2005

Table 5.63 Bank-line Migration Status along different Cross-Sections from 2000 to 2005

| Cross-section | River Width 2000 (km) | River Width 2005 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.057 | 0.086 | -0.038 | 0.009 |
| **XS-2** | 0.113 | 0.082 | 0.016 | 0.015 |
| **XS-3** | 0.065 | 0.079 | -0.05 | 0.036 |
| **XS-4** | 0.036 | 0.064 | -0.06 | 0.032 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-1 shows the most significant increase in river width, expanding by 0.029 km
- **Maximum decrease:** The cross-section XS-2 shows the most significant decrease in river width, expanding by 0.031 km

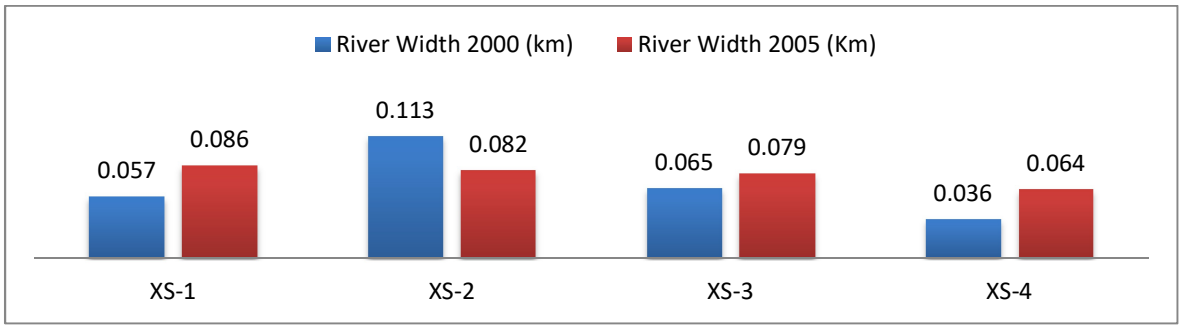


**Figure 5.135**- The Channel Width Variation from 2000 to 2005

**Right Bank (2000-2005):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-2, with a value of 0.016 km.
- **Maximum Erosion**. : The highest erosion on the right bank was observed at cross-section XS-4, with a value of 0.06 km

**Left Bank (2000-2005):**

- **Maximum Erosion**: No erosion was detected on the left bank in the sections under observation
- **Maximum Deposition**: The highest deposition on the left bank occurred at cross-section XS-3, with a value of 0.036 km

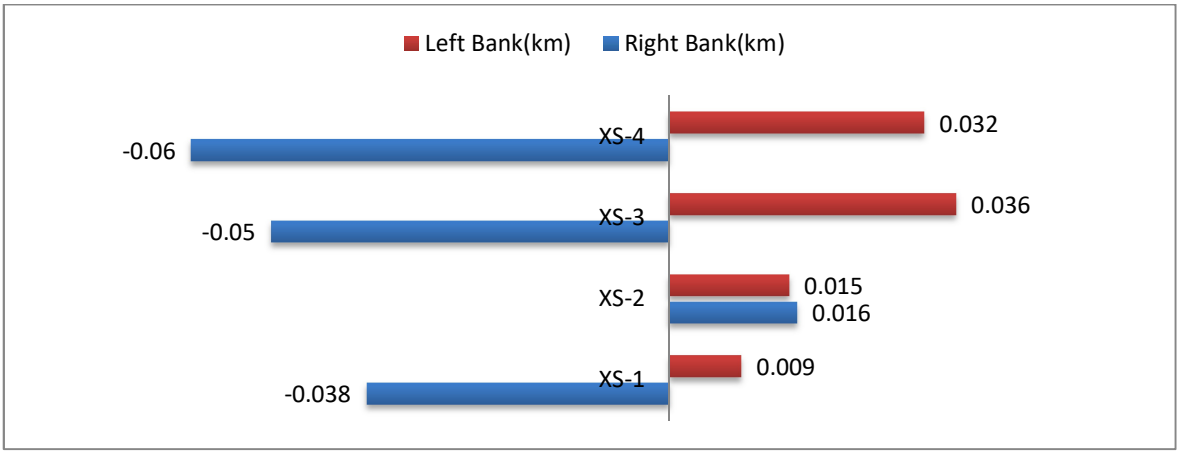


Figure **5.136-** River Course Shifting line from 2000 to 2005

### 5.11.4 Shifting Pattern of Dudhnoi River Course from 2005 to 2010

Table 5.64 Bank-line Migration Status along different Cross-Sections from 2005 to 2010

| Cross-section | River Width 20005(km) | River Width 2010 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.086 | 0.072 | 0.025 | -0.011 |
| **XS-2** | 0.082 | 0.08 | -0.016 | 0.018 |
| **XS-3** | 0.079 | 0.042 | 0.014 | 0.023 |
| **XS-4** | 0.064 | 0.066 | 0.015 | -0.017 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-4 shows the most significant increase in river width, expanding by 0.002 km
- **Maximum decrease:** The cross-section XS-3 shows the most significant decrease in river width, expanding by 0.037 km

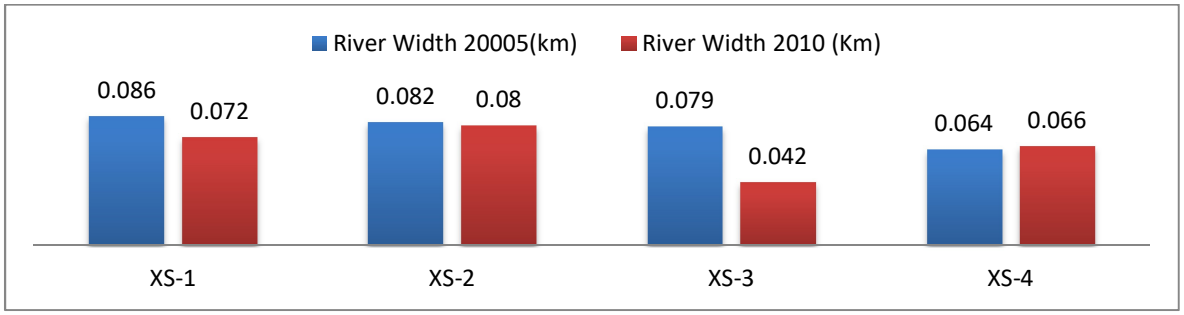


**Figure 5.137** The Channel Width Variation from 2005 to 2010

**Right Bank (2005-2010):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-1, with a value of 0.025 km.
- **Maximum Erosion**. : The highest erosion on the right bank was observed at cross-section XS-2, with a value of 0.016 km

**Left Bank (2005-2010):**

- **Maximum Erosion**: The highest erosion on the left bank was observed at cross-section XS-4, with a value of 0.017 km
- **Maximum Deposition**: The highest deposition on the left bank occurred at cross-section XS-3, with a value of 0.023 km

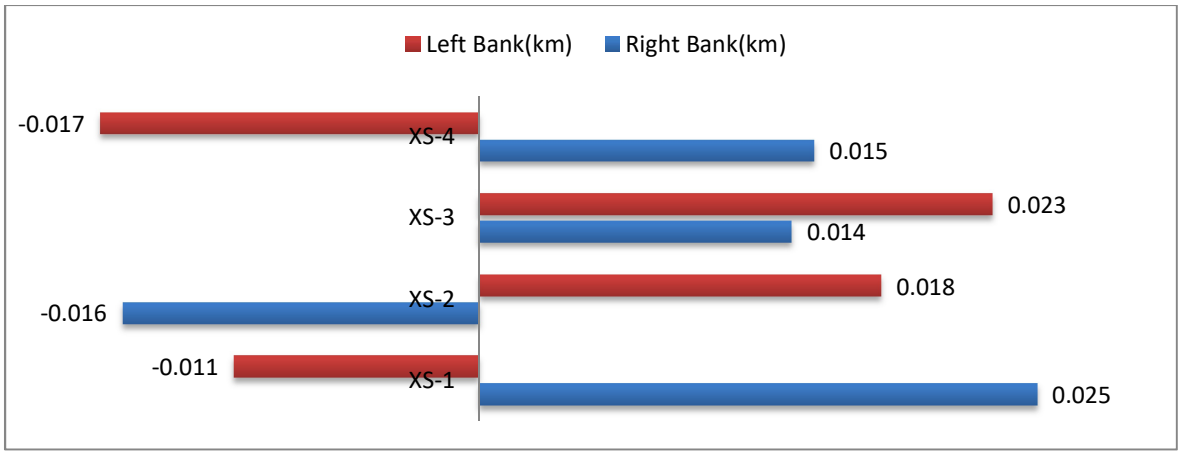


**Figure 5.138** River Course Shifting line from 2005 to 2010

**5.11.5 Shifting Pattern of Dudhnoi River Course from 2010 to 2015**

Table 5.65 Bank-line Migration Status along different Cross-Sections from 2010 to 2015

| Cross-section | River Width 2010 (km) | River Width 2015 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.072 | 0.05 | -0.034 | 0.056 |
| **XS-2** | 0.08 | 0.072 | 0.054 | -0.046 |
| **XS-3** | 0.042 | 0.064 | -0.012 | -0.01 |
| **XS-4** | 0.066 | 0.067 | -0.033 | 0.032 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-3 shows the most significant increase in river width, expanding by 0.022 km
- **Maximum decrease:** The cross-section XS-1 shows the most significant decrease in river width, expanding by 0.022 km

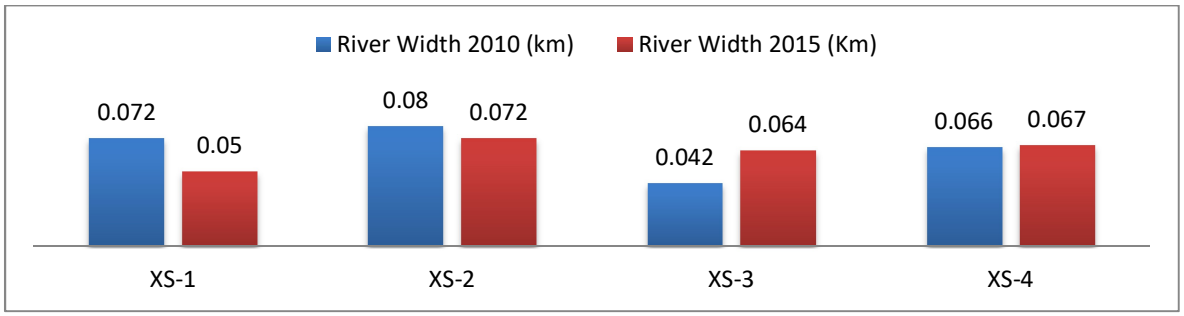


**Figure 5.139-** The Channel Width Variation from 2010 to 2015

**Right Bank (2010-2015):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-2, with a value of 0.054 km.
- **Maximum Erosion**. : The highest erosion on the right bank was observed at cross-section XS-1, with a value of 0.034 km

**Left Bank (2010-2015):**

- **Maximum Erosion**: The highest erosion on the left bank was observed at cross-section XS-2, with a value of 0.046 km
- **Maximum Deposition**: The highest deposition on the left bank occurred at cross-section XS-1, with a value of 0.056 km

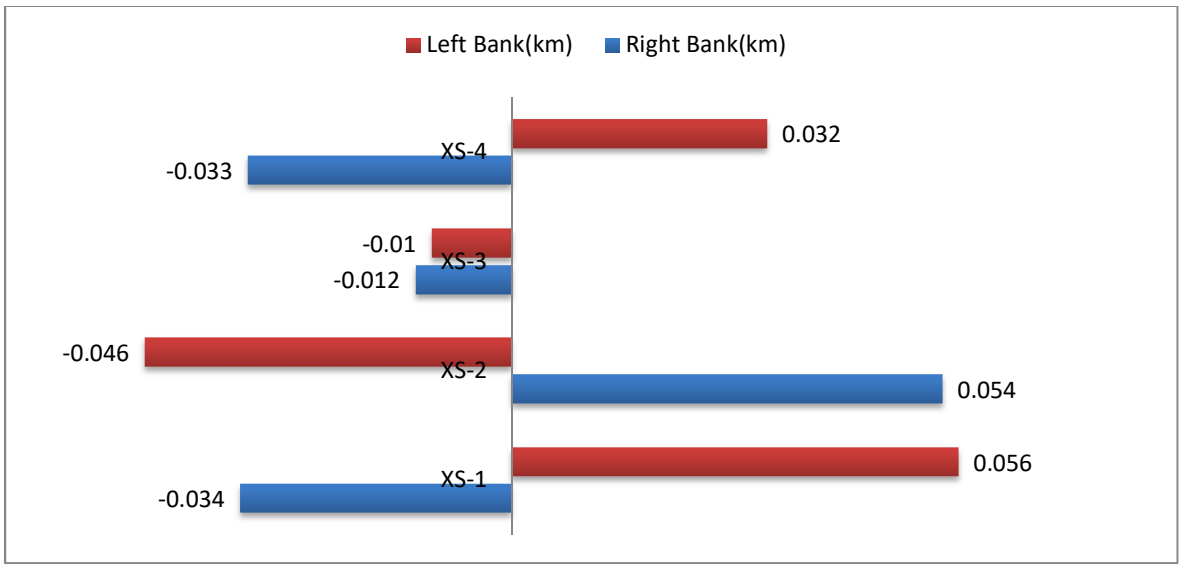


**Figure 5.140**- River Course Shifting line from 2010 to 2015

### 5.11.6 Shifting Pattern of Dudhnoi River Course from 2015 to 2020

Table 5.66 Bank-line Migration Status along different Cross-Sections from 2015 to 2020

| Cross-section | River Width 2015 (km) | River Width 2020 (Km) | Right Bank(km) | Left Bank(km) |
|---|---|---|---|---|
| **XS-1** | 0.05 | 0.088 | 0.012 | -0.05 |
| **XS-2** | 0.072 | 0.083 | -0.044 | 0.033 |
| **XS-3** | 0.064 | 0.077 | 0.006 | -0.019 |
| **XS-4** | 0.067 | 0.044 | 0.041 | -0.018 |

In the above table, negative values in the "Right Bank" and "Left Bank" columns represent erosion and positive values signify deposition

**Change in width**

- **Maximum Increase:** The cross-section XS-1 shows the most significant increase in river width, expanding by 0.038 km

- **Maximum decrease:** The cross-section XS-4 shows the most significant decrease in river width, expanding by 0.023 km

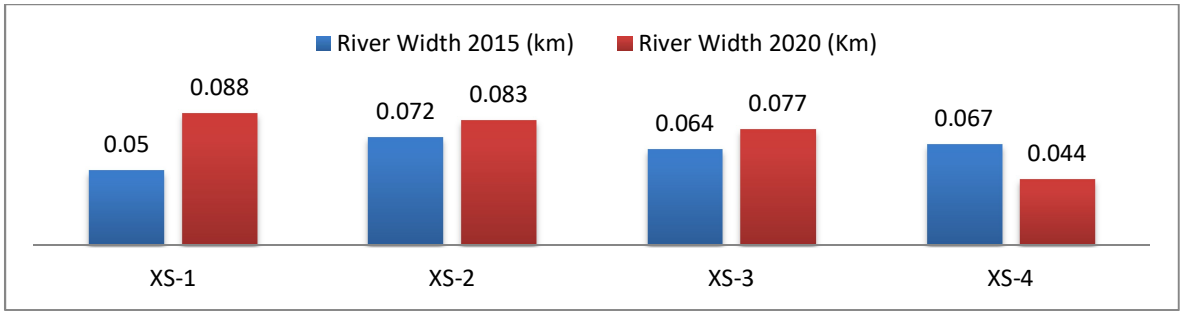


**Figure 5.141-** The Channel Width Variation from 2015 to 2020

**Right Bank (2015-2020):**

- **Maximum Deposition**: The highest deposition on the right bank occurred at cross-section XS-4, with a value of 0.041 km.
- **Maximum Erosion**. : The highest erosion on the right bank was observed at cross-section XS-2, with a value of 0.044 km

**Left Bank (2015-2020):**

- **Maximum Erosion**: The highest erosion on the left bank was observed at cross-section XS-1, with a value of 0.05 km
- **Maximum Deposition**: The highest deposition on the left bank occurred at cross-section XS-2, with a value of 0.033 km

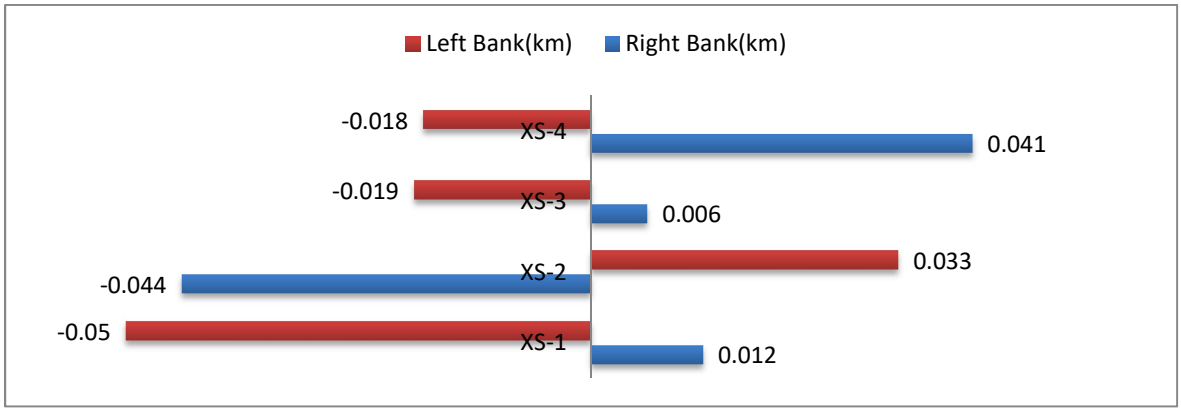


**Figure 5.142-** River Course Shifting line from 2015 to 2020

# CHAPTER 6

# CONCLUSION

This study conducts a comprehensive 30-year analysis (1990-2020) of the Brahmaputra River and its ten tributaries, focusing on changes in river width and patterns of erosion and deposition. The analysis utilized ArcGIS software and Landsat imagery obtained from Earth Explorer.

River bank migration for the studied rivers can be summarized as follows:

- From 1990 to 2020, the Brahmaputra River's average width slightly increased. Significant changes occurred at XS-1 (Jonai Dhemaji to Baghjangaon Tinsukia), where the width increased from 11.61 km to 21.51 km, and at XS-4 (Dhakuakhana to Sivasagar), where it expanded from 0.96 km to 5.85 km.

- The Subansiri River, a significant tributary of the Brahmaputra, experienced a notable channel avulsion between 1995 and 2000, characterized by pronounced lateral migration. This included a 7.04 km shift at XS-2 (Bhimpara Deori, Boginadi - Aduttengakulatalia N.C., Dhemaji), a 3.54 km shift at XS-3 (No.1 Badhkara, Lakhimpur – No.2 Ghagarmukh, Lakhimpur), and a 6.48 km shift at XS-4 (No.1 Mahaijan, Lakhimpur – Chalichuk N.C., Lakhimpur). These changes resulted in a significant westward shift in river flow between sections XS-1 (Katari Chapari No. 2, Lakhimpur) and XS-5 (Khagajugalpur, Lakhimpur – Ghagarmukh N.C., Lakhimpur).

- The Dikrong River showed fluctuating width changes from 1990 to 2020. In XS-3, the river shifted northeastward between 2005 and 2010 by 1.123 km, with its width increasing substantially from 0.164 km to 0.31 km. In 2005, section 3 of the river was located at Parbatipur, Bihpuria, but by 2010, it had shifted near Bangal Mara, Lakhimpur.

- The Buroi River exhibited significant width changes between 1990 and 2020 at XS-2 (Lal Pukhuri, Biswanath – Pachim Tokowbari, Biswanath) and XS-4 (No.2 Batiamari - Kurua Pathar, Sonitpur).

- The Borgang River analysis from 1990 to 2020 shows a significant shift in XS-2 (Barjharni, Sonitpur – Bagari Suti, Sonitpur) towards the southwest between 1990 and

1995, with a shift value of 0.55 km. The river width increased substantially from 0.073 km to 0.22 km, indicating considerable bank movement.

- The Jia Bharali River's channel dynamics underwent significant changes between 1990 and 2010, particularly from section XS-4 (Khalihamri, Tezpur – Bharali Chapori) to its confluence with the Brahmaputra River. Initially, a subtle left-bank migration towards the right bank occurred between 1990 and 2005, followed by a pronounced river width contraction between 2005 and 2010, with significant sediment deposition on the left bank, measuring 1.743 km at XS-4 and 2.08 km at XS-5 (Panch Mile, Tezpur – Jamugurihat).

- The Sankosh River has overall widened over the years, with consistent and significant erosion primarily on the right banks of XS-2 (Atgharitari, Dhubri - Kachakhana, Dhubri), XS-3 (Belguri, Dhubri - Boro Charikhola, Dhubri), and XS-5 (Nalia, Dhubri - Pub Gaikhowa Pt. II, Dhubri), making these areas more prone to higher erosion rates.

- The Dikhow River experienced substantial shifts in both its right and left banks. Notably, in XS-2, the river shifted northeastward in 2000 and 2005. In XS-1 (Hulal Kalita, Sivasagar – Changdhora, Sivasagar), the river shifted southwestward between 1990 and 1995.

- The Dudhnoi River displayed significant fluctuations in width and asymmetric bank migration from 1990 to 2020. XS-2 (Thekashu Pt. II, Dudhnoi, Goalpara) and XS-3 (Karipara Pt-IV, Dudhnoi, Goalpara) exhibited notable width changes, such as XS-2 increasing from 0.059 km in 1995 to 0.113 km in 2000, and XS-3 decreasing from 0.095 km in 1990 to 0.03 km in 1995.

- The Krishnai River exhibited significant fluctuations in width and asymmetric bank migration from 1990 to 2020. Cross-sections XS-1 (Khardang, Matia, Goalpara) and XS-2 (Asudubi, Matia, Goalpara) showed notable changes, such as XS-1 widening from 0.09 km in 1990 to 0.116 km in 1995, and XS-2 widening significantly from 0.101 km in 2015 to 0.169 km in 2020.

- The Murnoi River has shown varying trends across different cross-sections.

The study also found that the north bank tributaries of the Brahmaputra River exhibited more pronounced bank-line migration compared to the south bank tributaries. This differential migration pattern indicates varying geomorphological and hydrological dynamics between the northern and southern tributaries, potentially influenced by factors such as topography, land use, and hydrodynamic forces.

In conclusion, this study highlights the dynamic and evolving nature of the Brahmaputra River and its tributaries. The observed changes in river width and bank-line migration underscore the importance of continuous monitoring to understand and manage these critical water resources effectively. These findings provide valuable insights into the impact of natural processes and anthropogenic activities on river morphology, thereby informing future river management and conservation efforts. The study's methodology and results can serve as a reference for similar riverine studies, contributing to the broader field of fluvial geomorphology and environmental management.

# REFERENCES:


Ahmed, A. S., Rahman, A. F. M. A., & Khan, A. N. (2019). Geomorphic Study of the Brahmaputra River and Its Implications on Bridge Construction in Bangladesh. In River Training and Sediment Management in a Rapidly Changing World (pp. 333-342). Springer

Apurba Nath and Susmita Ghosh, "Assessment of river morphology based on changes in land use and land cover and the spatial and temporal variation of meandering parameters of the barak river" Water Practice & Technology Vol 00 No 0, 1 doi: 10.2166/wpt.2022.114

Assam government Water Resources Department https://waterresources.assam.gov.in/portlet-innerpage/brahmaputra-river-system

Baruah, U., Goswami, D. C., & Kalita, B. K. (2013). Flood hazard assessment of Brahmaputra River basin using remote sensing and GIS. Natural Hazards, 65(1), 121-139.

Biswajit Nath , Sultana N. Naznin and Paul Alak "Trends analysis of river bank erosion at Chandpur, Bangladesh: A remote sensing and GIS approach" International Journal of Geomatics and Geosciences Volume 3 Issue 3, 2013

Brahmaputra Board : https://brahmaputraboard.gov.in/

Dutta, S., et al. (2019). Erosion Risk Mapping of the Brahmaputra River, India. Geosciences, 9(8), 348.

ESRI. (2021). ArcGIS Pro: Professional Mapping Software. Environmental Systems Research Institute, Inc. Retrieved from https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview

Hazarika, M. K., et al. (2020). Sediment Deposition Mapping for Sustainable Agriculture in Brahmaputra Valley, India. Environmental Monitoring and Assessment, 192, 485.

Hazarika, N., Das, D. N., & Devi, A. (2015). Impact of river morphology on fish diversity and distribution in Brahmaputra River, India. Journal of Applied Ichthyology, 31(2), 271-278.

J. B. Alam, M. Uddin, J. Uddin Ahmed, H.Cacovean , M. Habibur Rahman, B. K. Banik and N. Yesmin “study of morphological change of river old brahmaputra and its social impacts by remote sensing” Geographia Technica, no.2, 2007

Jogendra Nath Sarma and Shukla Acharjee , “A Study on Variation in Channel Width and Braiding Intensity of the Brahmaputra River in Assam, India” Geosciences 2018, 8, 343; doi:10.3390/geosciences8090343

M.K.Dutta1, Swapnali Barman , S.P. Aggarwal “A study of erosion-deposition processes around Majuli Island, Assam” Open access e-Journal Earth Science India, Vol. 3 (IV), October, 2010, pp. 206-216 http://www.earthscienceindia.info/; eISSN: 0974 – 835

Md. Rejaun Nabi, Dr. Md. Shahedur Rashid and Mohammad Ismail Hossain, “Historical Bankline Shifting Since 1760s: A GIS and Remote Sensing Based Case Study of Meghna River Plate of Rennell’s Atlas” International Journal of Scientific and Research Publications, ISSN 2250-3153, Volume 6, Issue 12, December 2016

Mukesh Kumar and Prof. A. R. Siddiqui, “Detection of the Change in the Morphology of the Courses of the River Ganga Using Satellite-derived Data: A Case Study Area” RESEARCH REVIEW International Journal of Multidisciplinary e-ISSN: 2455-3085 | Vol.06 | No.12 | December 2021

Nayan Sharma, Oinam Bakimchandra, Bikash Ranjan Parida, “Remote Sensing Based Study on Channel Changes and Wetland Ecosystem Dynamics of Brahmaputra River in India” https://www.researchgate.net/publication/269702083 l 2006

Novica Lovric, Radislav Tosic, “Assessment of bank erosion, accretion and channel shifting using remote sensing and GIS” Quaestiones Geographicae 35(1), 2016

Sultana Jahan Ophra, Sameena Begum , Raihanul Islam and Md. Nazrul Islam, “Assessment of bank erosion and channel shifting of Padma River in Bangladesh using RS and GIS techniques” https://doi.org/10.1007/s41324-018-0202-2 l 2018

Towfiqul Islam Khan , Shoriful Kabir Shamim , Md. Nurul Islam “Bank Line Dynamics of Trans-Boundary River: A Case Study on the Padma River” International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET) | e-ISSN: 2319-8753, p-ISSN: 2320-6710| www.ijirset.com | Impact Factor: 7.089| ||Volume 9, Issue 4, April 2020||