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Geomorphological Dynamics and Environmental Challenges in the Lower Damodar Basin, West Bengal, India

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Abstract:- Geographical research has four main traditions: spatial, regional, man-land, and earth science. By discussing these traditions, the field of geography can achieve both internal coherence and external comprehensibility. Geographers often blend these traditions in their research, sometimes incorporating all simultaneously. Regardless of their traditions, geographical research typically serves a fundamental or applied purpose. In this context, the current study falls into the applied category, as it employs fundamental geographical principles to examine the geometry and morphometry of channel form and pattern, focusing on identifying causes of flooding problems in the lower course of the Damodar River in Howrah District. This research aims to address real-world issues and provide practical insights, making it action-oriented and relevant for addressing contemporary environmental challenges. The current volume focuses on morphometric analysis within the Damodar Lower Course Basin area, utilizing Remote Sensing and GIS techniques and Datasets to delineate the causes of sedimentation and flooding. This research is motivated by the intricate interplay between human activities and natural landscapes, particularly the relationship between people, rivers, and their surrounding environments.

Keywords:- *Lower Course Basin, Sedimentation, River Morphometry, Flood Risk Assessment.*

I. INTRODUCTION

Damodar is a rain-fed, shallow, and wide river that originates from Khamarpat Hill in the Chota Nagpur plateau region approximately at 23º37'N and 84º41'E and the geographical boundary of the basin between 22º15' to 24º30'N latitude and 84º30' to 88º15'E longitude (**Bhattacharyya, K., 2011**). It is a part of the basin area of the river Ganges. The total length of the river basin area of about 23,370.98 km^2 in the states of Jharkhand and West Bengal (**Majumder, M., Roy, P. and Mazumdar, A., 2010**). The Damodar River mainly flows through the districts of Chandrapura, Ramgarh, Bokaro, Jhari Industrial Area, Sindri, Dhanbad, Asansol, Andal, Durgapur, Bardhhaman and Howrah. The Damodar River consists of the main river and its tributaries. Barakar, Konar, Bokaro, Haharo, Jamunia, Ghari, Guaia, Khadia, Bhera, etc. are the major tributaries of the Damodar River. This river was originally known as the 'Sorrow of Bengal' earlier, mainly due to heavy floods in West Bengal's Burdwan, Hooghly, Howrah, and Midnipur districts during the monsoon Season (**Bose, Dr. N.K.1943**).

II. LITERATURE REVIEW

A lot of authors published their research papers on the Damodar River Basin. Many objectives and ideas were developed based on research work. Every author separately describes many objects as per the study area. such as;

- According to **Sumantra Sarathi Biswas** in His Study **"Influences of changes in Land use/Land cover and precipitation variability on hydrology and morphology of middle course of Damodar River in East India, 2014, Page:326-338"** primarily discusses the effects of changes in land use, land cover and rainfall of the Damodar River in eastern India. This research has revealed the massive loss of vegetation from 1990 to 2010. In addition, the amount of agricultural land and buildup area has also increased along the river. The increase in agricultural land has caused changes in river channel beds. If the current pace of growth of industrialization and urbanization continues, the hydrological and morphological changes of Damodar River will undergo further changes as it is feared through this research paper.
- According to the Research paper written by **Mangolika Chatterjee, Debasri Roy, Subhasish Das, and Asis Mazumdar**, in their Study "**Assessment of water resources under climate change: Damodar River Basin**, **India**, **2014, Page.2183-2191**" delineate the climate change on the water resources of the Damodar River basin in eastern India. The study also highlights how a decrease in precipitation, potential evaporation, and changes in river flow may occur in future generations. Also, the decrease in estimated rainfall observed during certain periods of the year i.e. July and August have been identified with suitable evidence through this study.
- According to the Journal written by **Prasanta Kumar Ghosh, Sujay Bandyopadhyay, Narayan Chandra Jana and Ritendu Mukhopadhyay** in their Study "**Sand quarrying activities in an alluvial reach of Damodar River, Eastern India: towards a geomorphic assessment, 2016, Page.477-489"** explain that the hydrology and morphology of the Damodar River has been controlled by humans for the last 50 years. Because of urbanization and industrialization, a massive amount of sand

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extraction from the riverbed started in the mid-1990s, which has had an impact on the topography of the river. Resulting river erosion, river bank instability, and channel bifurcation are the main geomorphic effects of sand mining which have been identified through GIS software and survey work.

- An article written by **Sandipan Ghosh and Rahaman Ashique Ilahi,** in their Study **"Responses of fluvial forms and processes to human actions in the Damodar River Basin, 2020, Page: 213-252"** first to discuss human influence on fluvial geomorphology. Here, many of the complexities of human civilization and river interactions are presented, and how they can be addressed through dynamic anthropology. However, the extent to which the effects of climate change and extensive regional development may affect the future generations of the Damodar River is an important point of discussion. Damodar Valley Corporation (DVC) has borne the signature of past and present anthropogenic impacts since 1950. Damodar Valley Corporation has given special emphasis on industrialization urbanization and agricultural growth to boost the economic structure of Jharkhand and West Bengal. Which has affected the course of the Damodar River.
- In the Research Article written by **Sandipan Ghosh and Biswaranjan Mistri,** in their Study **"Hydrogeomorphic significance of sinuosity index about river instability: A case study of Damodar River, West Bengal, India, 2012, Page.49-57"** stated that the hydrogeomorphic changes have been given special importance while analyzing the course changes of the flood-prone Damodar River. Dam sites are monitored to predict river course and dynamics. For which the help of Topographical Maps, Satellite Images, and Geographical Information Systems (GIS) has been taken as per requirement. Also, Mueller's Sinuosity index is preferred to express the degree of instability of the temporal pattern (1943-2006) of the river.
- According to the Journal written by **Sandipan Ghosh and Biswaranjan Mistri**, in their Study "**Geographic concerns on flood climate and flood hydrology in monsoon-dominated Damodar River basin, Eastern India, 2015"** discuss the influence of monsoon on the flood trend of Damodar, one of the major rivers of West Bengal. At present, Damodar Valley Corporation's (DVC) dams on the Damodar River are not capable of holding excess water at all. As a result, the water holding capacity of the river has decreased due to excess sedimentation and drainage congestion in the Lower Damodar basin area. Because of this, over monsoons when DVC's dams are unable to control the flood flow, it causes flooding in the lower basin of the river (Example: West Bengal 1978 & 2000). Keeping these problems in mind, some of its flood mitigation potentials have been highlighted through this study.

III. LOCATION OF STUDY AREA

This report mainly studies the Lower Damodar area, which begins in Howrah District, just below the bend of the river's elbow. From the Dihibhursut under the Udaynarayanpur Block proceeds from north to south, and the flowing river joins the Bhagirathi-Hooghly (Ganges) river. My study area covers approximately 60 kilometers of the Damodar River basin (**Figure 1).**

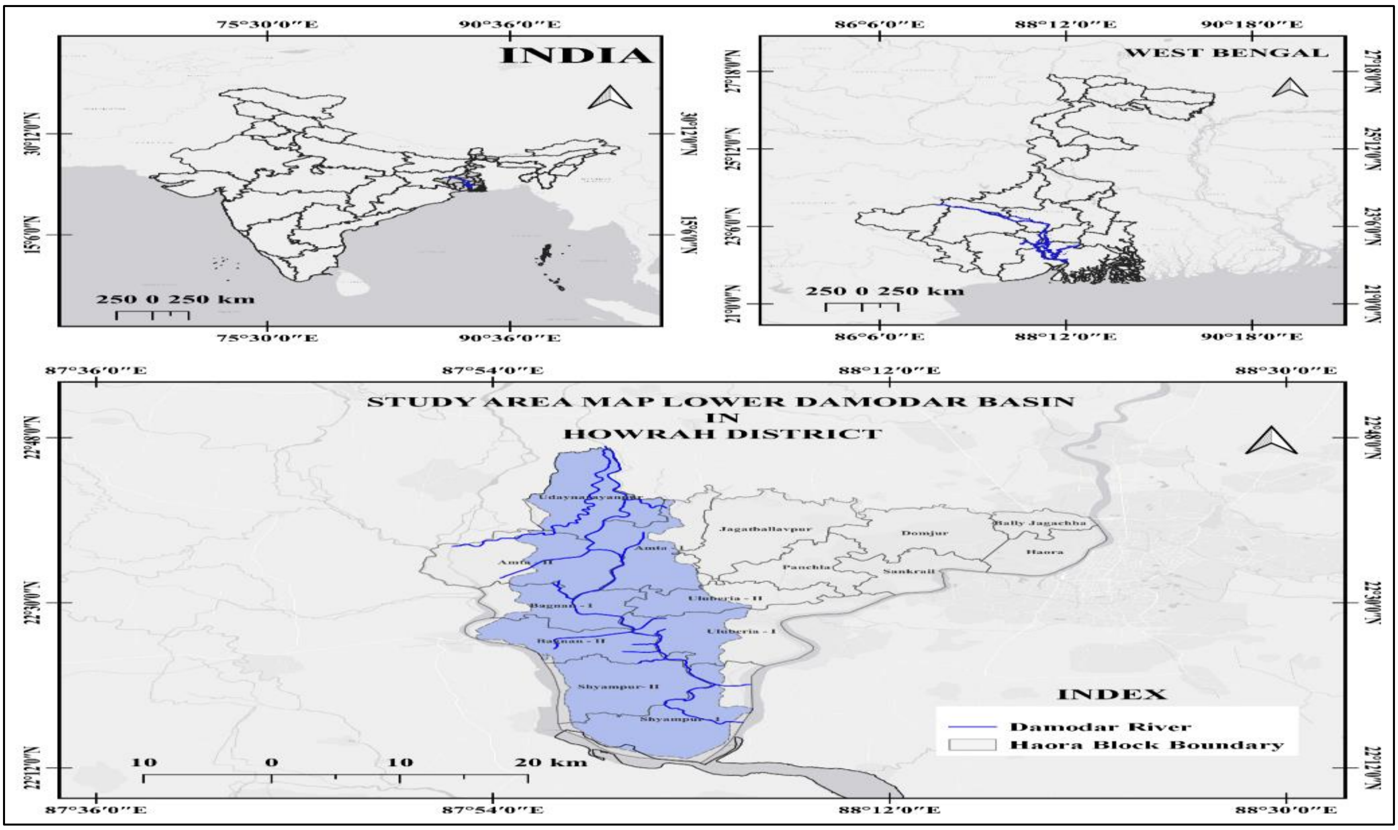

Fig 1 Location Map of the Study Area

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➢ *Factors Behind the Selection of Study Area:*

The course of any river changes due to hydrological and geological factors. However, for my research paper, I have focused on the Lower Basin area of the Damodar River (Howrah District). This choice stems from the notable characteristics of this region, which is covered with fertile alluvial soil. These plains are particularly susceptible to the detrimental effects of unrestricted sand mining, a prevalent practice in the area.

Several literature reviews indicate that this area used to get flooded due to excess rain during monsoon. As a result, it is prone to flooding. The main purpose of this research paper is to examine the current situation in this area and highlight the steps taken by the government and how much it has benefited the people of that area.

➢ *Problems of the Study Area:*

The Damodar River is known as the Sorrow of Bengal due to its historical propensity for destructive floods. Several CD blocks and municipality areas of Howrah district belong to the Lower Damodar Basin area and belong to the Damodar River. All the problems that have been observed in this particular study area are discussed below.

- **Floods:** During the monsoons, the Damodar River tends to flood at a great rate. The impact caused extensive damage to property, infrastructure, and agriculture in the lower Damodar basin.
- **Sedimentation:** Damodar is transported downstream at a high rate due to the large amount of erosion in the upper reaches of the river. This results in sediment accumulation in river basins that reduces the water-carrying capacity of the river, contributing to increased flood risk.
- **Water Pollution:** Industrial and domestic discharge of lightning leads to water pollution in the Lower Damodar Basin area adjacent to rivers. Due to continuous population and industrial growth over a long period, the amount of river water pollution is also increasing due to consumption.
- **Impact on Agriculture:** Floods, erosion, and water pollution affect agricultural productivity in the lower Damodar basin, resulting in crop losses and farmers' livelihoods.
- **Infrastructural Damage:** Floods and erosion often damage roads, bridges, dams, and other infrastructure, which disrupts transport and communication networks, especially in the Lower Damodar Basin area.

➢ *Objectives:*

- To find out the temporal changes in landforms within the lower Damodar basin.
- To examine the causes of sedimentation in the lower Damodar Basin area and identify the associated problems caused by sedimentation.
- To investigate the current effects of floods on the lives and livelihoods of people in the basin area.

➢ *Limitation:*

This passage outlines the challenges faced in a research project, particularly regarding spatial data limitations. The primary constraints highlighted include:

- *Limited Availability of Satellite Data:*

The limited availability of satellite data from the years 2000-2024, particularly from Landsat 8 and Landsat 4-5, Sentinal-2, posed significant challenges for my research. This scarcity made it difficult to perform comprehensive temporal analyses and hindered the accuracy of historical trend assessments.

- *Methodological Challenges:*

Variations in terrain and river conditions, combined with the limited scope and sample size of perception surveys, posed challenges in ensuring uniform and comprehensive data collection, particularly in flood-prone areas like Udaynarayanpur and Bagnan.

➢ *Structures of Research:*

To carry out my research work, I have followed certain methods, keeping in mind the complete research guidelines. It is divided into the following three parts. Respectively:

- *Pre-Field:*

✓ I studied the different research papers on the Damodar River basin in detail, which motivated me to do my work.
✓ Secondly, I have chosen a specific location within the entire Damodar River, and the rationale behind choosing the study area has been discussed earlier.
✓ Thirdly, apart from the help of Remote Sensing and GIS, various published articles and research works related to the Damodar River have been of particular help in keeping my objective intact.
✓ Fourthly, various official websites helped me get geological, Average temperature, rainfall, and agriculture Production data, making my work easier.

- *Field:*

✓ I have collected some pictures and conducted a perception survey in the Bagnan and Udaynarayanpur blocks.

- *Post-Field:*

✓ Firstly, I have prepared the Study area map of the Damodar River in the Howrah district the basin area reveals that the dire condition of the Damodar River is impacting some block divisions of the Howrah district the most.
✓ Secondly, analysis of temperature and rainfall variability (2000-2023) highlights extreme fluctuations, with notable excess rainfall years.
✓ Thirdly, I prepared a land-use land cover map based on the study area map and field visit. I tried to highlight the changes between 1990 and the current map of 2024.

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- ✓ Fourthly, I calculated the Damodar River's sinuosity index, which revealed changes in the river's channel morphology over 34 years.
- ✓ Fifthly, Prepared Cross-sectional profiles from transects AB, CD, EF, GH, and IJ highlighted slope and elevation variations, identifying erosion-prone zones and sediment deposition areas vital for designing effective flood mitigation strategies.
- ✓ Sixthly, a Survey has been done in Udaynarayanpur and Bagnan areas to find out revealed localized challenges, with Udaynarayanpur facing persistent siltation and prolonged floods impacting livelihoods, while Bagnan showed mixed perceptions of siltation, shorter floods, and heightened concerns over drinking water scarcity.

IV. GEOMORPHOLOGICAL CHARACTERISTICS OF THE STUDY AREA

➢ *Topography:*

The lower Damodar basin is highly fertile due to its flat soil and fertile alluvial soil, resulting in dense settlement and agricultural activities in the areas adjacent to the river. Earthen embankments were built in the past on both river banks to protect the area from flooding, but these were not strong enough to deal with the massive monsoon floods. According to 20-30 years of data, major floods with peak flows greater than 12000 cubic meters per second have occurred several times. As a result, the course of the river has also changed. Efforts to control the floods that were taken in the past such as diverting the flood water through the 'Eden Canal' to the Bhagirathi-Hooghly River were mostly ineffective (**Ghosh, S., 2011**).

➢ *Geology and Soil:*

The lower Damodar River basin is characterized by metamorphic, sedimentary, and igneous rocks found in the Damodar basin. The geology of the basin primarily consists of Granites and granitic gneisses from the Archaean Period, along with sandstones and shales of the Gondwana's, and the recent alluvial are the major litho-units constituting the geology of the basin. The geological features of the lower catchment are distinctly from the middle and upper parts of the basin. The thick veneer of alluvium over the solid rocks of Tertiary age is dominating in the lower part of the basin (**Mondal, G.C., Singh, A.K. and Singh, T.B., 2018**).

➢ *Climate:*

The Damodar River basin area of the Howrah district experiences unbearable summers due to high humidity. The winter season is observed from the middle of November to the end of February. Summer is from March to May, mainly during this time the effect of Luu (hot air) is noticed. The area adjacent to this river basin experiences a rainy season from June to the end of September due to the southwest monsoon.

- *Temperature:*

In the lower basin area of the Damodar River, mainly the summer effect is more noticeable throughout the year. From the middle of November, the temperature gradually decreases and the effects of winter are steadily noticed. January is the coldest month with average daily maximum and minimum temperatures of 26°C and 16°C respectively (**Table: 1, Figure: 2)**. Temperatures start to rise from the end of February and May is the hottest month of the year with an average daily high of 36ºC-39°C and an average low of 25ºC-28°C.

Table 1 Average Month-Wise Temperature Data In the Lower Damodar Basin Area Howrah (2000-2024)

Month	**Day**	**Night**
January	26°c	16°c
February	30°c	19°c
March	35°c	23°c
April	37°c	26°c
May	39°c	28°c
June	36°c	29°c
July	34°c	27°c
August	32°c	27°c
September	32°c	26°c
October	31°c	24°c
November	29°c	21°c
December	27°c	17°c

Source: WorldWesatherOnline.Com

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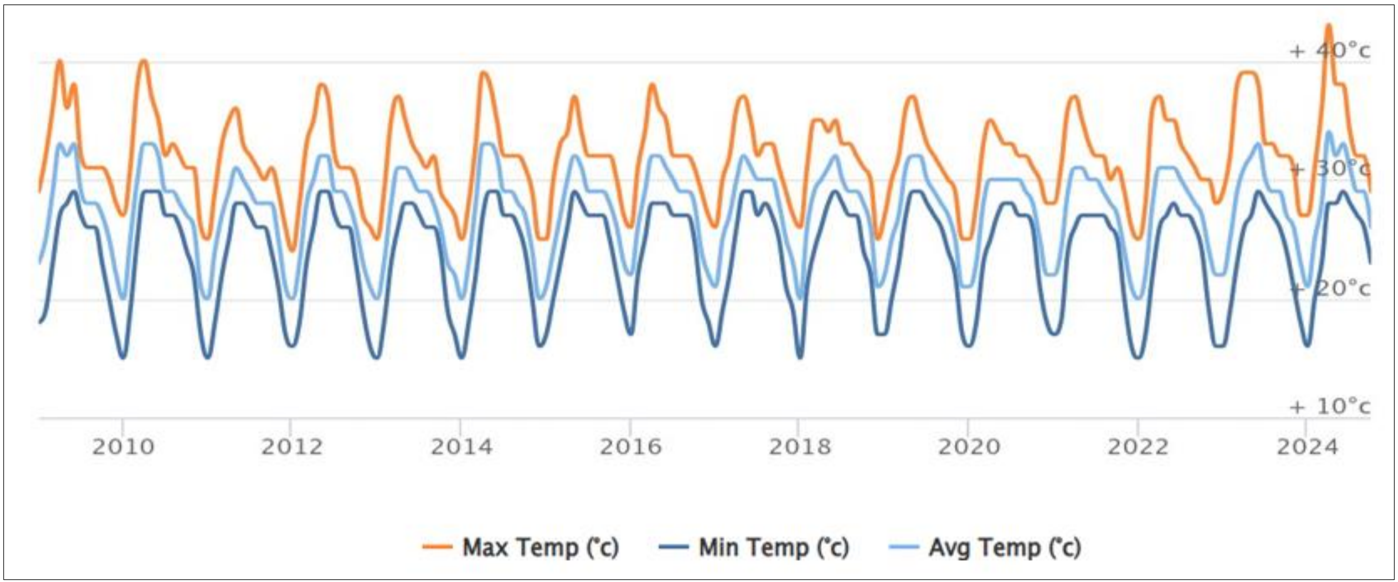

Fig 2 Assessing Seasonal Temperature Dynamics in Howrah: Insights from 14 Years of Data (2010-24)
Source: WorldWesatherOnline.Com

- *Rainfall:*

Based on the rainfall data for the Lower Damodar Basin Area in Howrah District from 2000 to 2024 experienced significant year-to-year variability in rainfall. While the normal annual rainfall is consistently recorded as 1603.9 mm actual rainfall fluctuates considerably. In the years of excess rainfall, such as 2002 (1897.84 mm) and 2021 (2173.82 mm), this may have led to flooding issues in the district. Conversely, there have been years of severe deficit, notably in 2012 only 545.48 mm, potentially causing drought conditions.

Recent years show continued variability, with 2021 being an exceptionally wet climate, followed by a sharp decline in 2022 (1215.78 mm) and a slight recovery in 2023 (1496.5 mm) (**Table: 2, Figure 4),** though still below normal. This inconsistency in rainfall patterns poses challenges for agriculture, water resource management, and other planning in Howrah District.

Table 2 Yearly Rainfall Data in Lower Damodar Basin Area, Howrah District (2000-2023)

Years	NORMAL (mm)	ACTUAL (mm)
2000	1603.9	1523.63
2001	1603.9	1575.75
2002	1603.9	1897.84
2003	1603.9	1712.14
2004	1603.9	1497.88
2005	1603.9	1691.16
2006	1603.9	1580.39
2007	1603.9	1635.64
2008	1603.9	1457.66
2009	1603.9	1465.26
2010	1603.9	1310.73
2011	1603.9	1236.68
2012	1603.9	545.48
2013	1603.9	2164.28
2014	1603.9	1370.45
2015	1603.9	1873.46
2016	1603.9	1524.13
2017	1603.9	1786.29
2018	1603.9	1397.87
2019	1603.9	1701.11
2020	1603.9	1756.52
2021	1603.9	2173.82
2022	1603.9	1215.78
2023	1603.9	1496.5

Source: Indiawris.gov.in

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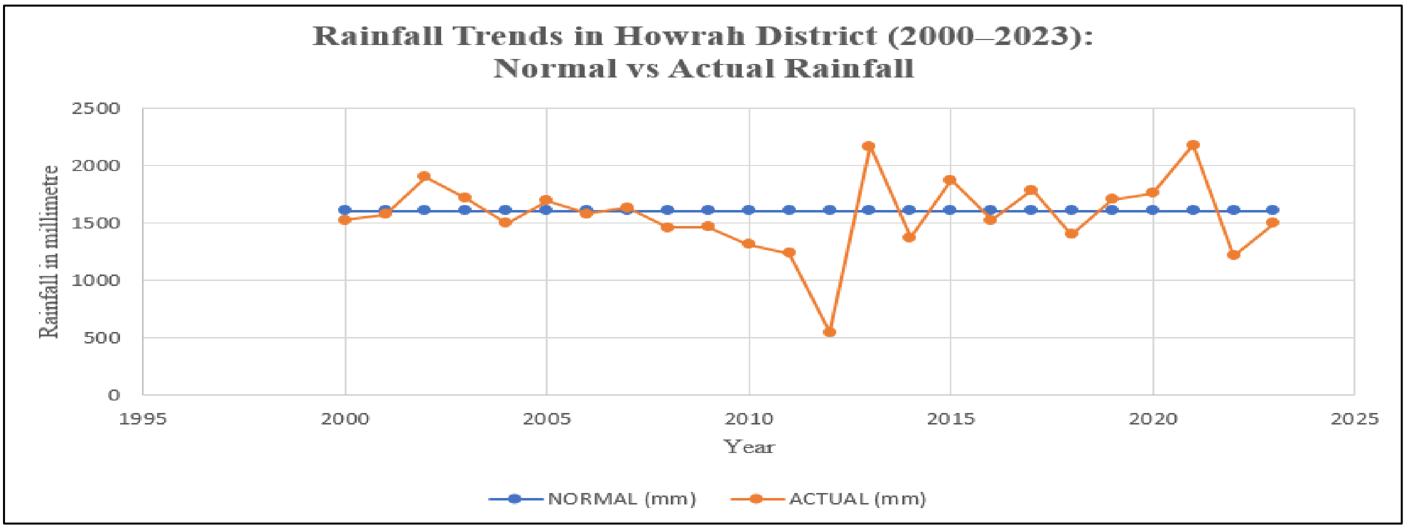

Fig 3 Rainfall Trends in Howrah District (2000-2023)

- *Land use Landcover Pattern:*

The Lower Damodar River Basin which comprises parts of the Howrah district of West Bengal is an agriculturally productive region. Howrah district consists of 727 habitable villages. Which is divided into two sub-divisions with 165 villages in the urban Howrah Sadar respectively and 562 villages in the relatively rural Uluberia sub-division. According to the Land Use and Land Cover Map 2024, agricultural land played a major role across the district which is spread over an area of 488.43 square kilometers indicating its suitability for agriculture. Natural forest is the second largest category which is 164.80 square kilometers. Which has preserved some natural areas. The built-up area is 61.63 sq km which reflects the development of the city and the water body is 26.93 sq km which includes river ponds and wetlands. The smallest category is the open-scrub area which is 11.68 sq km. This distribution highlights the region's strong agricultural base with limited urbanization and protected natural areas that characterize the Lower Damodar Basin.

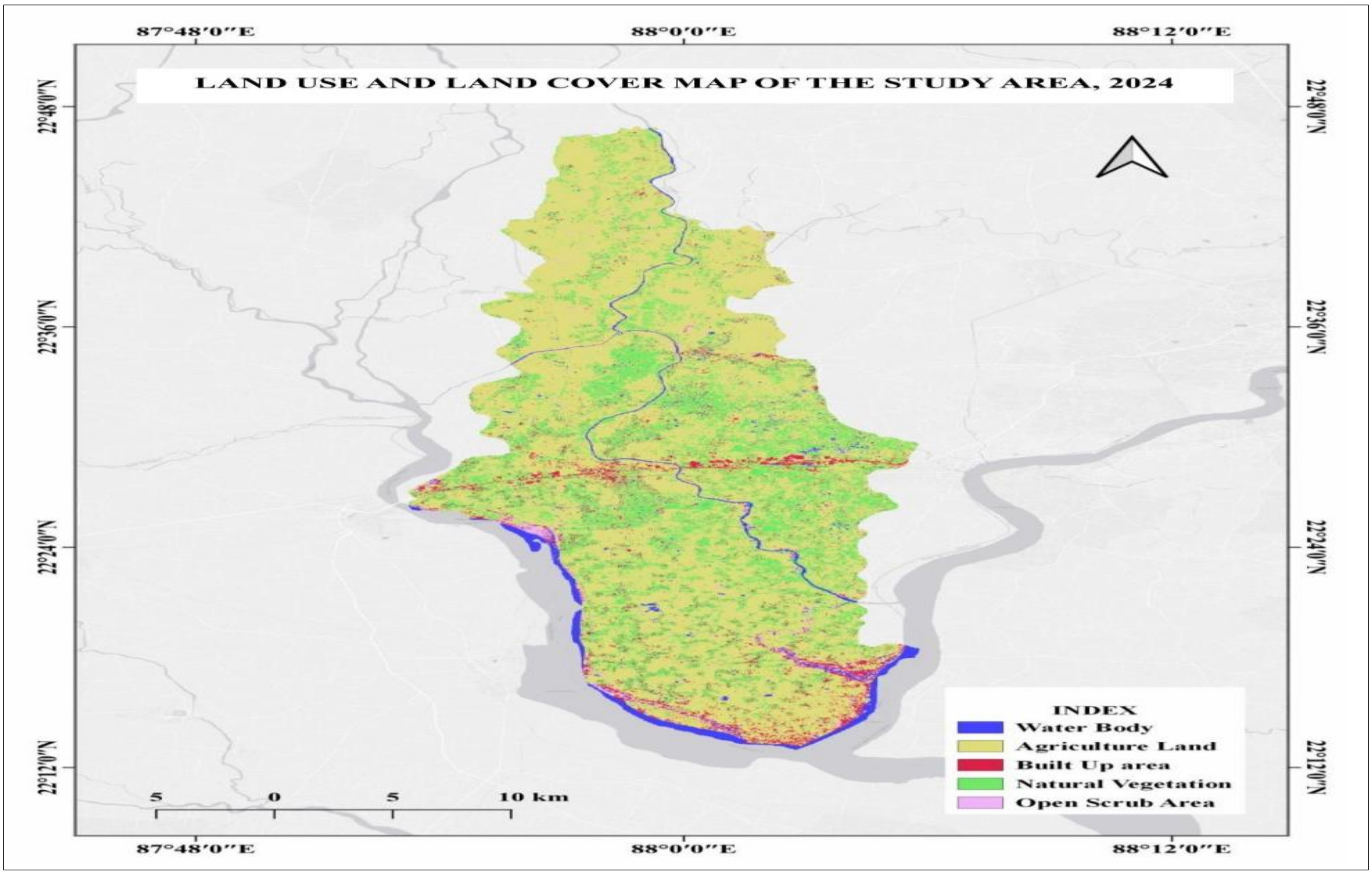

Fig 4 Land Use Land Cover Map of Study Area 2024
Based On SENTINAL-2 Satellite Image

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- *Agriculture Pattern:*

In the area adjacent to the Damodar River (Lower Damodar Region, Howrah), the amount of alluvial soil is relatively high, so the amount of cultivation in these areas is also good **(Table 3)**. The cultivators here divide the land into different sections, such that the land below the water table is called JALA (usually paddy land). If the land is above the water level, then it is called SUNA and when the land is much higher than the water level it is called DANGA. Mainly JALA and SUNA land are important land in terms of Agricultural yield. In terms of crop yields, these lands have special classifications such as Awal, Doyam, Seyam, and Chaharam (**Census, 2011**).

Table 3 Distribution of Villages according to Agricultural Land Use. Census, 2011

SL NO	Name of C.D. Block	Total area (in Hectares)	Percentage of cultivable area to total area	Percentage of Irrigated area to total cultivable area
1	Udaynarayanpur	10961.05	73.74	56.65
2	Amta-II	12545.78	67.2	69.83
3	Amta-I	10052.18	62.36	15.47
9	Uluberia-II	3849.24	75.65	86.2
10	Uluberia-I	8699.26	67.02	72.48
11	Bagnan-I	5395.27	81.94	84.49
12	Bagnan-II	5646.95	75.65	42.14
13	Shyampur-I	10515.65	79.51	88.1
14	Shyampur-II	9233.47	77.23	37.32
	Total	76898.85	660.3	552.68

Source: Census of India, 2011

V. RESULT AND DISCUSSION

- *Sinuosity Index:*

The Sinuosity Index is a measure of how much a river or stream meanders. It is calculated by dividing the channel length and the straight-line distance between two points along the river. A perfect straight river would have a Sinuosity Index of 1. Generally, a river with Less than 1.1 is considered almost a straight channel, Between the values of 1.1 and 1.5 is considered sinuous, and Greater than 1.5 is considered meandering. This index is useful in geomorphology, hydrology, and also environmental studies to characterize river channels and understand the behavior of channels.

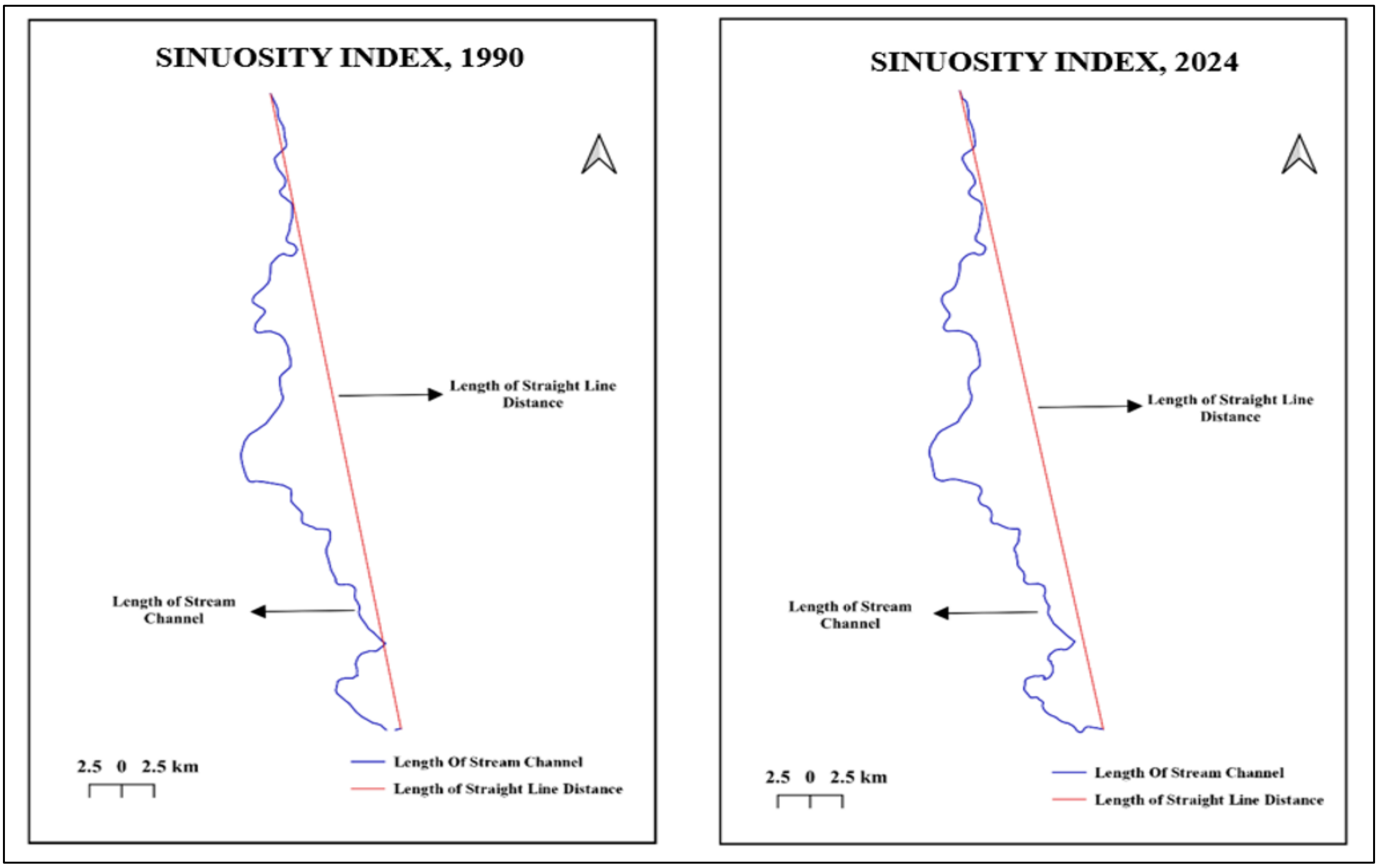

Fig 5 The Sinuosity Index illustrating a segment of the lower Damodar River in 1990 and 2024

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Table 4 Results of the Sinuosity Index in 1990 and 2024

Year	Sinuosity Index
1990	1.356407741
2024	1.401480618

- According to the above information, River was 'sinuous' in 1990
- According to the above information, in 2024 river also played slightly more sinuous over this 34-year duration.

Based on the calculated data, the changes in the Sinuosity Index for the Lower Damodar basin area between 1990 and 2024 can be explained (**Table 4, Figure 5**). The Sinuosity Index increased from 1.356 in 1990 to 1.401 in 2024, indicating that the river became slightly more sinuous over these 34 years. Additionally, the stream channel length increased from 76.047 km to 79.321 km, suggesting that the river's path became longer and more winding. In both 1990 and 2024, the Sinuosity Index falls between 1.1 and 1.5, classifying the river as 'sinuous' rather than straight or highly meandering. The increase in sinuosity could be attributed to natural processes such as erosion and deposition, or human interventions in the river basin. This data suggests that the Lower Damodar basin experienced a modest increase in river meandering over the 30-year period, which could have implications for flooding, increased sediment transport, and local ecology.

➢ *Cross-Sectional Profile:*

Creating cross-section profiles for a river basin is essential for understanding the river's morphology, analyzing water flow, and managing sediment transport. These profiles aid in flood prediction, ecological studies, and designing hydraulic structures, ensuring effective river basin management and conservation.

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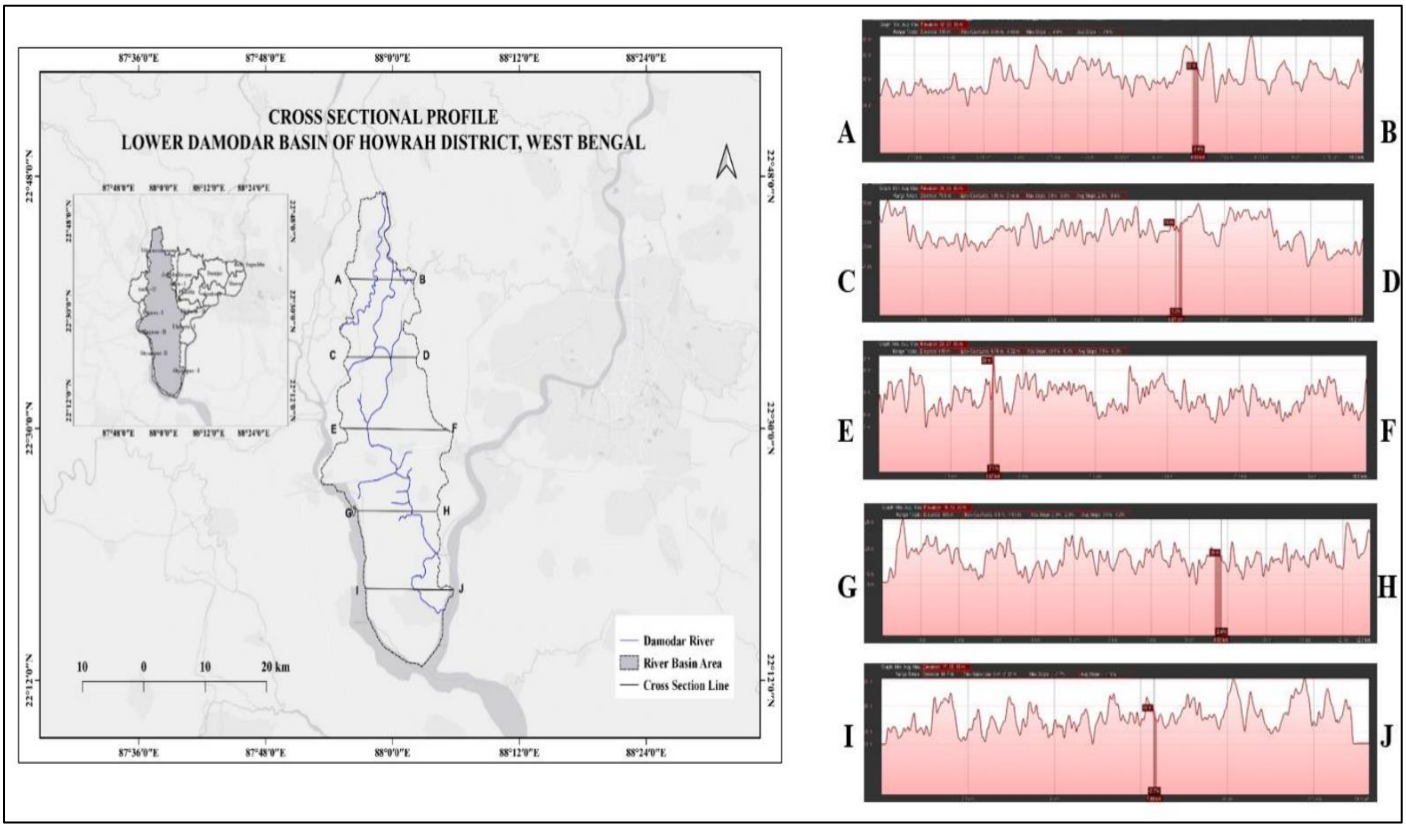

Fig 6 Cross Sectional Profile along with the Damodar River Basin

The cross-sectional profiles of the river basin along lines AB, CD, EF, GH, and IJ (**Figure 6**) reveal significant variations in elevation and slope. These profiles indicate areas of steep gradients and flatter sections, which suggest varying flow velocities and potential zones of erosion and deposition. The profiles show that certain sections of the river basin, such as those around the midpoint of each profile, experience abrupt elevation changes, which could correspond to rapid water flow and increased sediment transport. In contrast, flatter sections might indicate slower flow and potential sediment accumulation. Understanding these variations is crucial for effective river management and planning for flood mitigation and infrastructure development.

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➢ *Land use Land Cover Changes:*

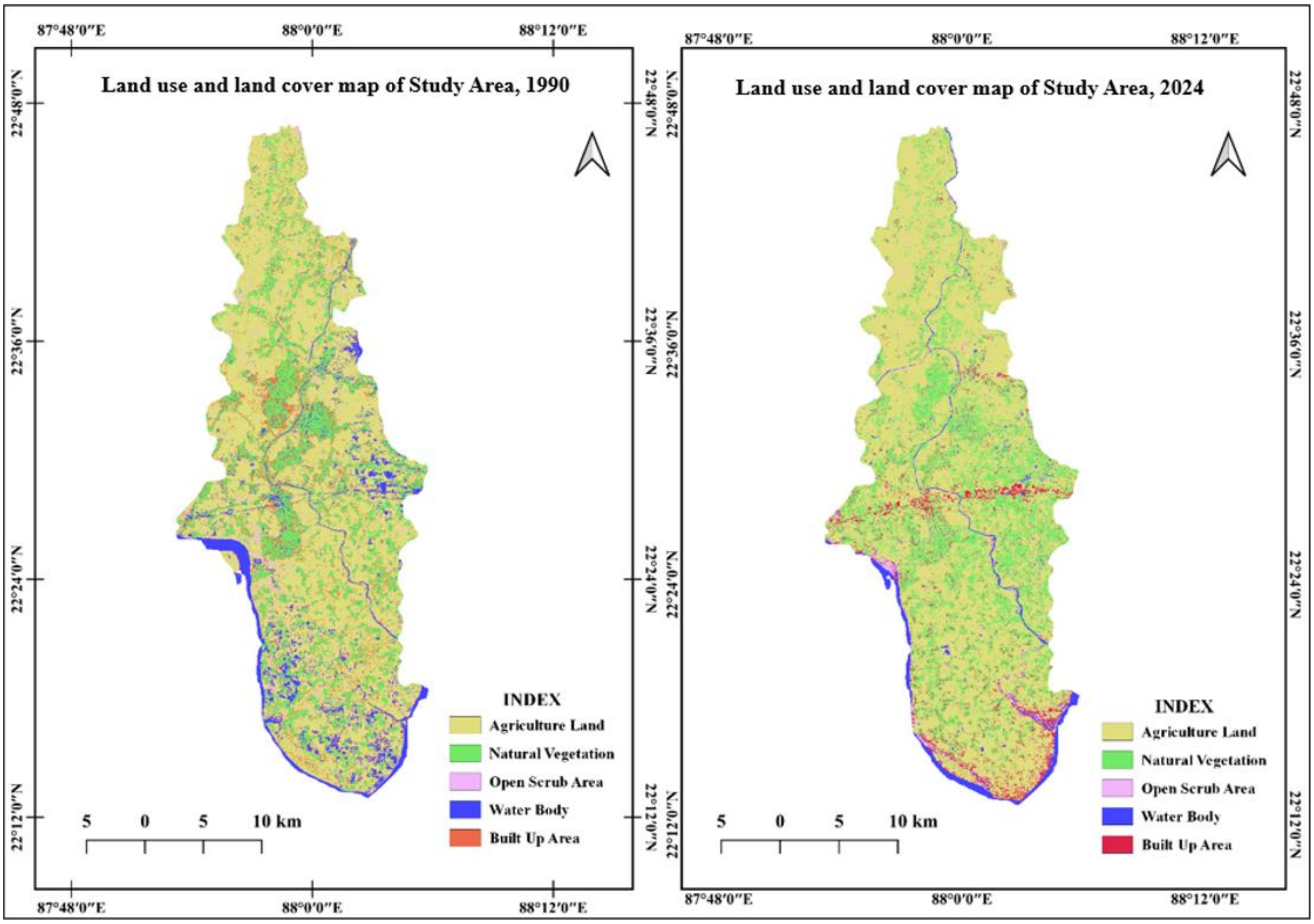

Fig 7 Land use and Land Cover Maps for Two Different Years: 1990 and 2024

Table 5 Land use Land Cover Classification Report

SL NO.	CLASSIFICATION OF LAND	AREA IN Sq. km (1990)	AREA IN Sq. km (2020)
1	Agriculture land	439.53	488.43
2	Natural vegetation	151.37	164.8
3	Open Scrub area	12.15	11.68
4	Water Bodies	63.12	26.93
5	Built up area	34.58	61.37

According to the land use and land cover classification report (**Figure 7, Table 5**) for the Lower Damodar basin, various land changes were analyzed between 1990 and 2020. Agriculture land increased from 439.53 sq. km in 1990 to 488.43 sq. km in 2020, indicating an expansion of agricultural activities in the region. This expansion could be attributed to increased demand for food and economic incentives for agricultural development. The increase in agricultural land has likely led to more intensive farming practices and higher yields, but it may also have caused habitat fragmentation and loss of biodiversity.

Natural vegetation also increased from 151.37 sq. km to 164.80 sq. km, suggesting some recovery or growth of natural vegetation cover in the Lower Damodar Basin area. This growth could be due to reforestation efforts, natural regrowth after disturbances, or conservation policies aimed at preserving natural habitats. The increase in natural vegetation is a positive development for the local ecosystem, as it can enhance biodiversity, improve soil quality, and provide essential ecosystem services such as carbon sequestration and water regulation.

Conversely, the open scrub area slightly decreased from 12.15 sq. km to 11.68 sq. km over the same period. The reduction in open scrub land might be due to its conversion into agricultural land or natural vegetation. While the decrease is not substantial, it indicates a shift in land use priorities and the dynamic nature of land cover changes in the basin.

The most significant change was observed in water bodies, which decreased from 63.12 sq. km to 26.93 sq. km, likely due to factors such as land reclamation, drought, or

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conversion to other land uses. The reduction in water bodies is concerning as it can impact local water availability, aquatic habitats, and the overall hydrological balance of the region. This decline might also exacerbate water scarcity issues, affect agricultural irrigation, and increase the vulnerability of the area to droughts and climate change impacts.

The built-up area almost doubled from 34.58 sq. km to 61.37 sq. km, indicating significant urban expansion and development in the region. The rapid growth of built-up areas reflects the increasing population and economic development pressures in the Lower Damodar basin. Urban expansion can lead to several challenges, including increased demand for infrastructure, higher levels of pollution, and greater pressure on natural resources. It also highlights the need for sustainable urban planning and development strategies to manage growth without compromising environmental quality.

These changes reflect complex interactions between human activities and natural resources in the Lower Damodar basin, with clear trends towards urbanization and agricultural intensification, potentially at the expense of water resources. The study underscores the importance of balancing development needs with environmental conservation to ensure the long-term sustainability of the region. Effective land use planning, water resource management, and conservation efforts are crucial to address the challenges posed by these changes and to promote a harmonious coexistence between human activities and the natural environment in the Lower Damodar basin.

➢ *Perception Survey:*

Table 6 Assessment of Community Dependence and Challenges Related to the Damodar River in Udaynarayanpur

SL NO.	DEPENDENCY ON THE DAMODAR RIVER	SILTATION IN RIVER	FLOOD PERIOD IN RIVER	FLOOD AFFECTED LIVELIHOOD	DRINKABLE WATER	POPULATION GROWTH
1	YES	YES	AUG-OCT	YES	NO	MODARATE
2	YES	YES	AUG-SEP	YES	YES	MODARATE
3	YES	YES	JULY-SEP	NO	NO	LOW
4	YES	YES	AUG-OCT	YES	NO	LOW
5	YES	YES	AUG-OCT	YES	YES	LOW
6	YES	YES	JULY-SEP	NO	NO	MODERATE
7	YES	YES	AUG-SEP	YES	NO	MODARATE
8	YES	YES	AUG-SEP	YES	NO	LOW
9	YES	YES	JULY-SEP	NO	YES	MODERATE
10	YES	YES	AUG-SEP	YES	NO	MODARATE

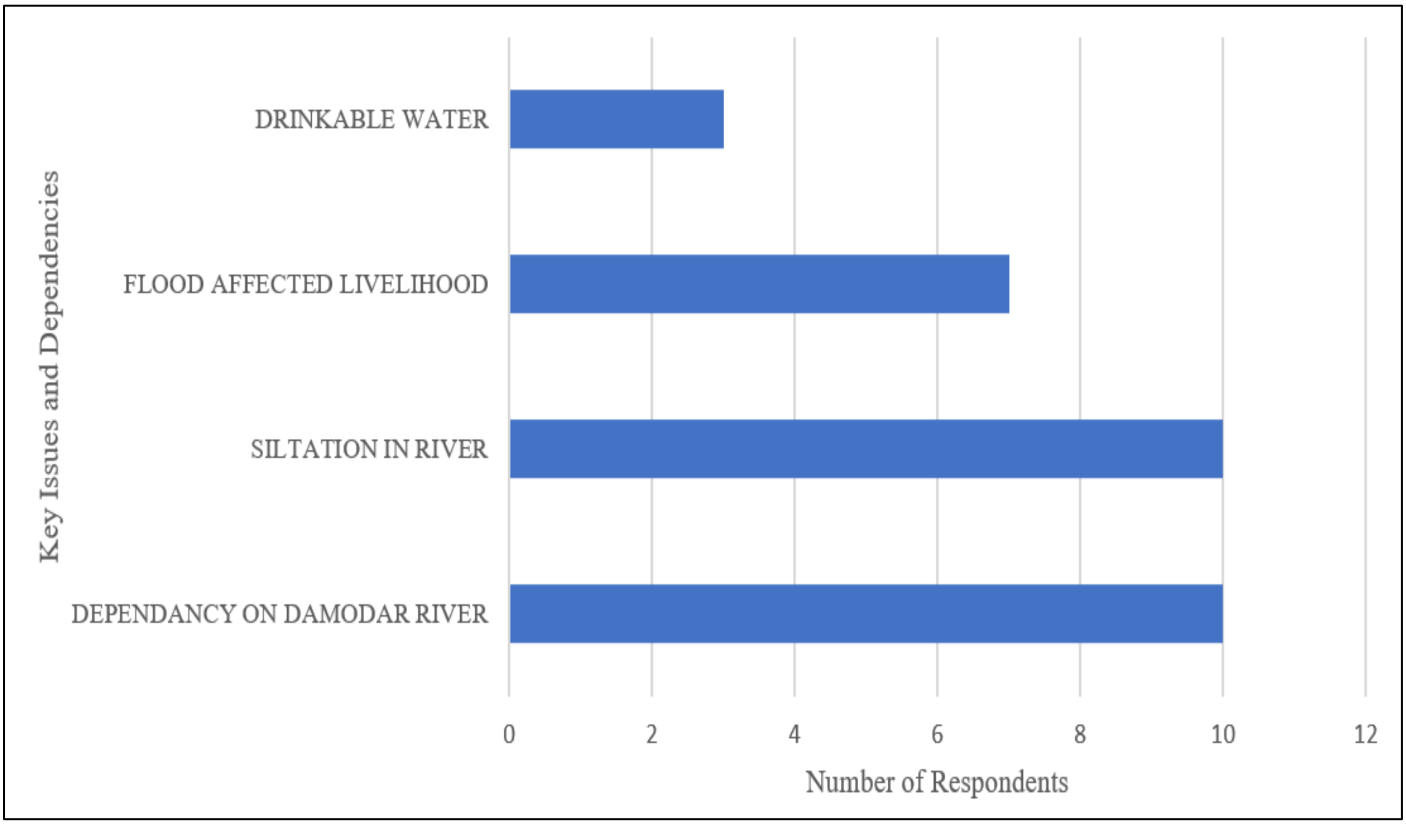

Fig 8 Community Challenges and Dependency on the Damodar River in Udaynarayanpur

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Table 7 Assessment of Community Dependence and Challenges Related to the Damodar River in Bagnan

SL NO.	DEPENDENCY ON THE DAMODAR RIVER	SILTATION IN RIVER	FLOOD PERIOD IN RIVER	FLOOD AFFECTED LIVELIHOOD	DRINKABLE WATER	POPULATION GROWTH
1	YES	NO	AUG-SEP	YES	YES	MODARATE
2	YES	NO	AUG-SEP	YES	NO	LOW
3	NO	YES	JULY-SEP	YES	YES	LOW
4	YES	NO	AUG-OCT	YES	NO	MODERATE
5	YES	NO	JULY-SEP	NO	YES	MODERATE
6	NO	YES	AUG-OCT	NO	NO	LOW
7	YES	NO	AUG-SEP	YES	YES	MODARATE
8	NO	YES	AUG-SEP	NO	YES	MODARATE
9	YES	NO	JULY-SEP	YES	NO	LOW
10	YES	NO	AUG-SEP	YES	YES	MODARATE

Source: Primary Data

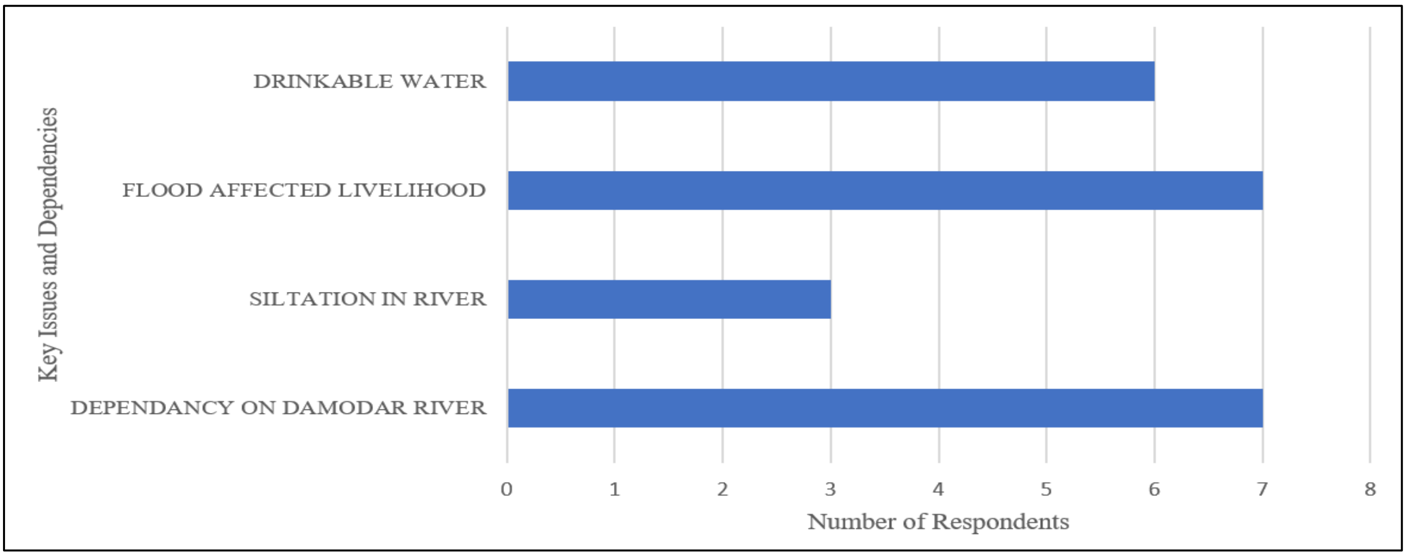

Fig 9 Community Challenges and Dependency on the Damodar River in Bagnan

➢ *Report of Comparative Perceptions: Udaynarayanpur and Bagnan:*

The key emerging issues are discussed below based on the information obtained through the perception survey of the above two blocks. Where siltation problems flood problems and how floods affect people's lives are highlighted.

- *Siltation in River:*

✓ **Udaynarayanpur**: Most respondents agreed siltation was an issue.

✓ **Bagnan:** Responses varied; fewer people considered siltation as a significant concern.

Fig 10 Siltation in Damodar. Field Survey, 2024

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- *Flood Period:*

✓ **Udaynarayanpur:** Floods were reported mainly from August to October.
✓ **Bagnan:** Floods occurred between July and September with some respondents citing an extended period into October.

Fig 11 Flood Situation in Monsoon Season, 2024

- *Flood-Affected Livelihood:*

✓ **Udaynarayanpur:** Higher agreement on the impact of floods on livelihoods.
✓ **Bagnan:** Responses were mixed; some denied livelihood impact.

Based on the comparative perception survey of Udaynarayanpur and Bagnan, a conclusion was reached that the people of both blocks are heavily dependent on the Damodar River. But in some cases, their challenges differ in intensity and nature. In Udayanarayanpur siltation in the river and its impact on livelihoods were consistently recognized as critical issues, with a prolonged flood period (August to October) exacerbating the situation. Conversely, Bagnan exhibited mixed responses regarding siltation and flood impacts, though concerns over drinkable water were more prominent. The variation in perceptions highlights localized challenges, underscoring the need for tailored mitigation strategies to address the specific needs of each block effectively.

➢ *Problem Identification:*

- *Increased Siltation and Flood Risk:*

According to the information obtained from the sinuosity index mentioned in the report, it is known that the river has become slightly more sinuous in the last 34 years i.e. from 1990 to 2024. Also, the length of the river has increased slightly. This indicates favorable conditions for the accumulation of silt and sand in the riverbed and surrounding areas. It is also known through the profile that in the northern part of Howrah district i.e. in the area adjacent to Udaynarayanpur, the amount of sediment transport is higher due to a steeper slope compared to Bagnan. Also, through the field visit, it has been seen that the amount of siltation in the Dihibhursut area of the Udayanarayanpur block is much higher than that in Bagnan, where siltation is considerably lower.

Siltation exacerbates the impact of flooding on rivers. Since siltation is relatively high in the area adjacent to Udaynarayanpur, there are also frequent occurrences of floods. However, the construction of concrete embankments along the riverbanks has provided some protection to the local population from these floods. In contrast, despite the low level of siltation in the Bagnan block, people have to suffer from floods due to the lack of construction of embankments in the area adjacent to the river. Also, excessive filtration pollutes river water, making it unfit for drinking. The perception survey showed that most of the people said that the water in the Udayanarayanpur block is not very drinkable due to the high filtration rate.

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- *Increased Flood Incidence in the Study Area:*

The various data obtained through the Perception survey and the secondary data; it is known that till now the blocks adjacent to Damodar in Howrah district have to face floods. Especially from July to October every year, with the peak occurring in August and September. In that case, according to the information obtained through the perception survey, it has been seen that the incidence of flooding in Bagnan is somewhat higher than in Udaynarayanpur block. Although the amount of siltation in Bagnan is relatively less as compared to Udayanarayanpur. But due to lack of proper management i.e. lack of permanent embankment on both sides of the river, floods are often faced.

- *Land Use Changes and River Alterations:*

Analysis of the land cover map obtained from satellite images (Landsat & Sentinal-2), it has been found that there have been several changes in land in 34 years from 1990 to 2024. Naturally, there has been a massive increase in population especially in the riverine areas. Apart from this, the Damodar Basin area of Howrah District is very popular for agricultural activities due to its fertile alluvial associated areas in the Lower Damodar Basin area. As a result, one of the main livelihoods of the people here is agriculture. A review of the sinuosity index shows a slight increase in both the sinuosity and length of the river over this period. Furthermore, sand mining in the lower Damodar Basin has significantly altered the morphology and hydrology of the river, such as the narrowing of river bed incision channels, bar instability, and shifting thalwegs. Uncontrolled and excessive extraction, driven by urbanization and industrialization, has caused severe environmental degradation, including pollution, depletion of groundwater levels, and threats to agriculture and local livelihoods. Illegal mining is rampant, exceeding the permissible limits thereby greatly affecting the natural course of the river. (**Ghosh, P.K. and Jana, N.C., 2021**)

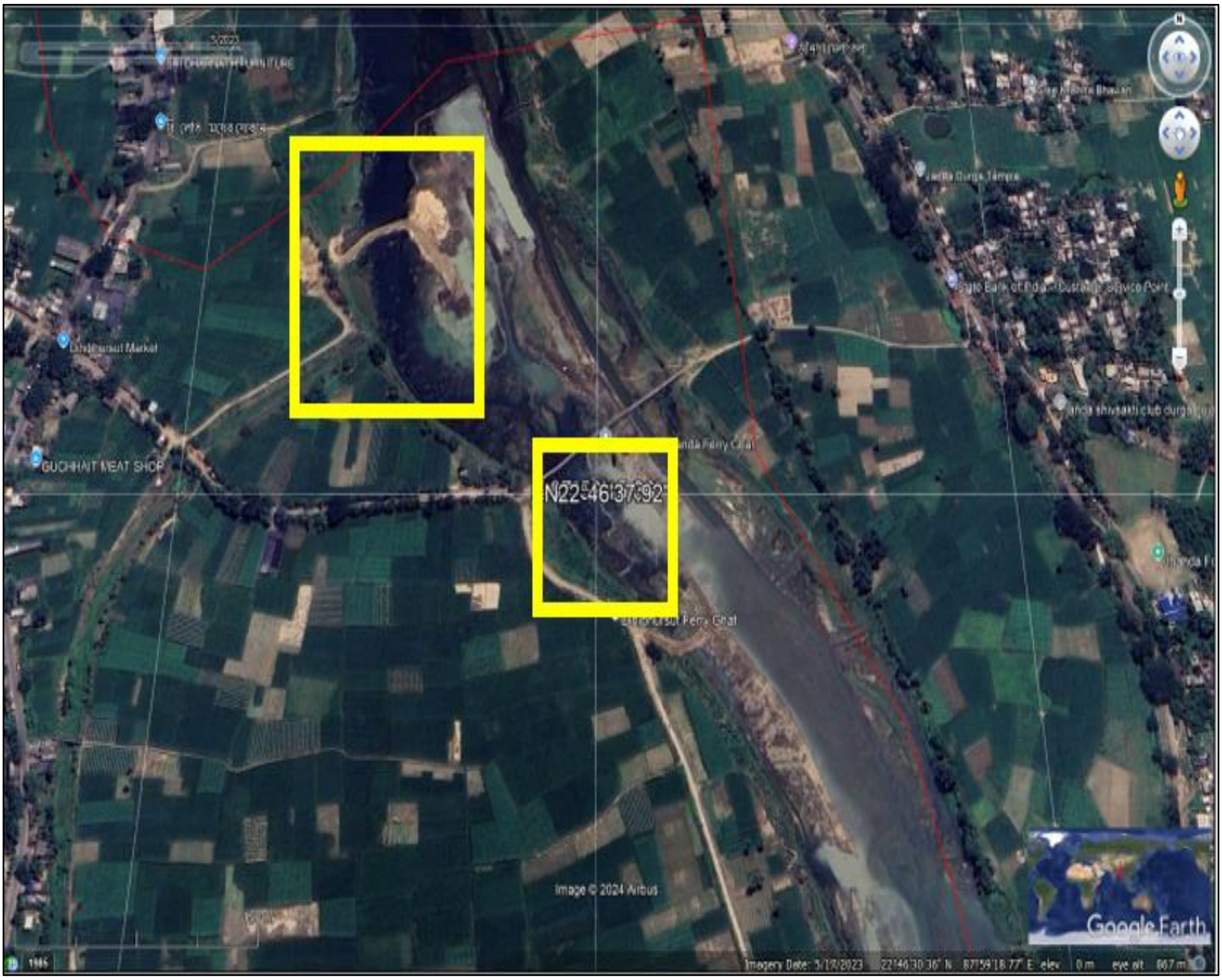

Fig 12 The Previous Instance of Sand Mining in 2023

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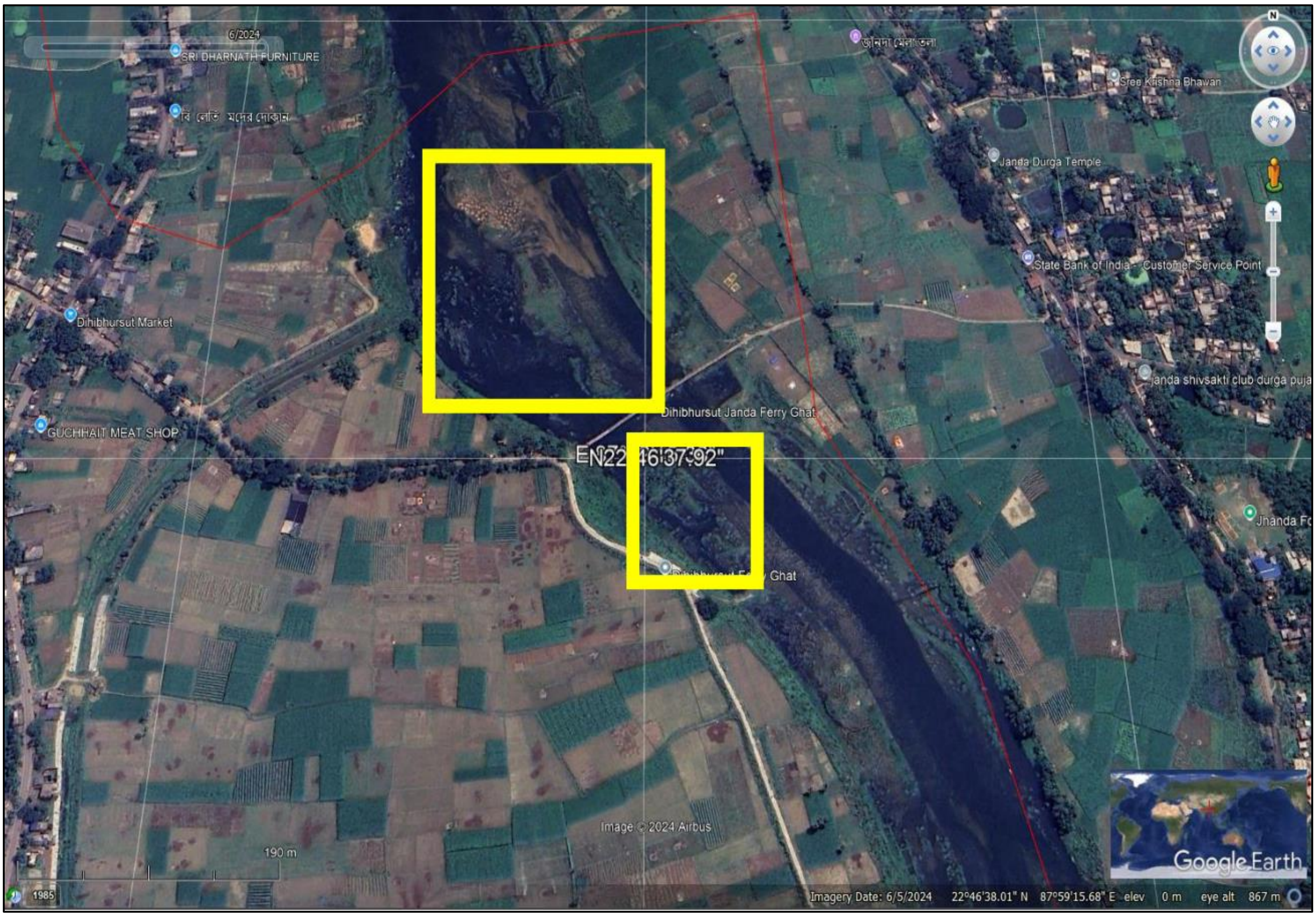

Fig 13 Unregulated Sand Mining in Rivers throughout 2024

VI. GOVERNMENT INITIATIVES AND RECOMMENDATIONS FOR FUTURE POTENTIAL

Government initiatives for the Damodar River Basin System have evolved to address the region's flood and water resource challenges. Early 18th-century efforts focused on building dams to protect agricultural land from frequent flooding, although these proved inadequate as floods increased in intensity. The Damodar Valley Corporation was established after the disastrous floods in 1948 to implement a multi-purpose river basin management plan for flood control, irrigation, hydropower, and industrial water supply. Major projects included the construction of large dams such as Tilaiya, Konar, Maithon, and Panchet which significantly reduced flood peaks, provided irrigation, and supported industrial growth. The National Commission on Floods, formed in 1980, introduced a comprehensive flood management approach with an emphasis on flood-prone area modification and the use of uplifted land and livestock. In 1999 the focus shifted to sustainable people-centred flood management rather than non-structural measures such as floodplain zoning, forecasting, and insurance. The Flood Forecasting Network established by the Central Water Commission in 1986 has improved disaster preparedness by providing early warning. Additionally, the Damodar Valley Reservoir Regulation Committee i.e. DVRRC coordinated watershed activities for flood control irrigation and optimizing water use for industrial needs. These initiatives emphasize the need for a balanced approach combining structural and non-structural measures for sustainable flood control and resource management and replication of the DVC model in river basins. Research in the Damodar basin provides insights into integrated river basin management that demonstrates the evolution of strategies from early flood control to modern holistic water management practices (**Chandra, S., 2003**).

➢ *Recommendations for Future Potential:*

Government agencies, stakeholders, and local people must collaborate to address issues related to geological changes and environmental degradation in the Lower Damodar Basin. In addition, GIS technology should be used to monitor activities and promote sustainable mining practices in less sensitive areas while restoring degraded ecosystems. Stakeholders, including industry and agencies, should also support alternative livelihoods, invest in community-based flood resilience projects, and promote sustainable land use practices. Local people should actively participate in monitoring illegal activities, adopt environmentally friendly agricultural practices, and raise awareness about the adverse effects of unregulated sand mining. Together these efforts can ensure environmental conservation and sustainable development in the region.

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VII. CONCLUSION

Geomorphological studies in the lower Damodar basin highlight important interrelationships between natural processes and human activities that shape the river basin and affect local livelihoods. Over the past several decades, the Damodar River has undergone significant geomorphic transformations due to excessive sedimentation, sand mining, and flood-induced erosion. These changes have exacerbated the risk of flooding and have also changed land use patterns.

This research emphasizes the importance of sustainable management practices to mitigate these challenges. This Study has Successfully land use change studies using tools such as GIS and remote sensing have analysed variations in sinuosity index and sediment transport processes. Through this research, it is clear that effective flood management, sand mining control, and community-based conservation efforts are critical to ensure the ecological and socio-economic stability of the region.

Collaboration among government agencies, stakeholders i.e. various administrative bodies and local communities is essential to achieve sustainable development. Adoption of an integrated river basin management approach along with strict monitoring and enforcement of environmental regulations will help tackle the critical problems of siltation, flooding, and erosion. In addition, promoting alternative livelihoods and increasing awareness of the consequences of uncontrolled human intervention can increase resilience among affected populations.

Finally, the findings of this study not only contribute to the understanding of the fluvial dynamics of the Lower Damodar Basin but Rather, provides useful insights for policymakers and planners to balance development with environmental conservation.

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