Executive Summary:

Title of the Project: "**Tapi River Sustainability: Surat's Lifeline and Beyond**

Project group: Students of M.Sc. (Applied Statistics) semester-4

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Introduction:

Our research investigates the complex relationship between urban river sustainability and development, with a focus on the Tapi River in Surat City. Aligned with Sustainable Development Goal (SDG) 14, which aims to conserve and sustainably use marine resources, our study examines water turbidity levels to address marine pollution and ecosystem protection. By employing satellite imagery and calculating the Normalized Difference Turbidity Index (NDTI), we analyze river health and stressors, while also monitoring changes in river width to guide development and conservation efforts. Although our primary focus is SDG 14, our research also intersects with SDGs 11, 15, 6, 3, and 13, contributing to urban planning, ecosystem conservation, clean water access, public health, and climate action.

Study Area: Tapi River, Surat City

Location: Surat, Gujarat, India.

Length in Surat: Approximately 20 kilometers.

Importance:

- Economic: Supports agriculture, industry, and trade.
- Urban Development: Influences city growth and infrastructure.
- Water Supply: Provides essential water for drinking and irrigation.

Environmental Concern: Pollution and flood risk management are key issues.

Remote sensing is crucial for this study as it provides comprehensive satellite data to monitor water quality, assess turbidity levels, and track changes in river dynamics. By using satellite imagery and data analysis, we can effectively evaluate the river's health, identify pollution sources, and support sustainable management practices, thus enhancing local conservation and development efforts.

Key Findings:

Turbidity Trends and Spatial Analysis of the Tapi River in Surat City

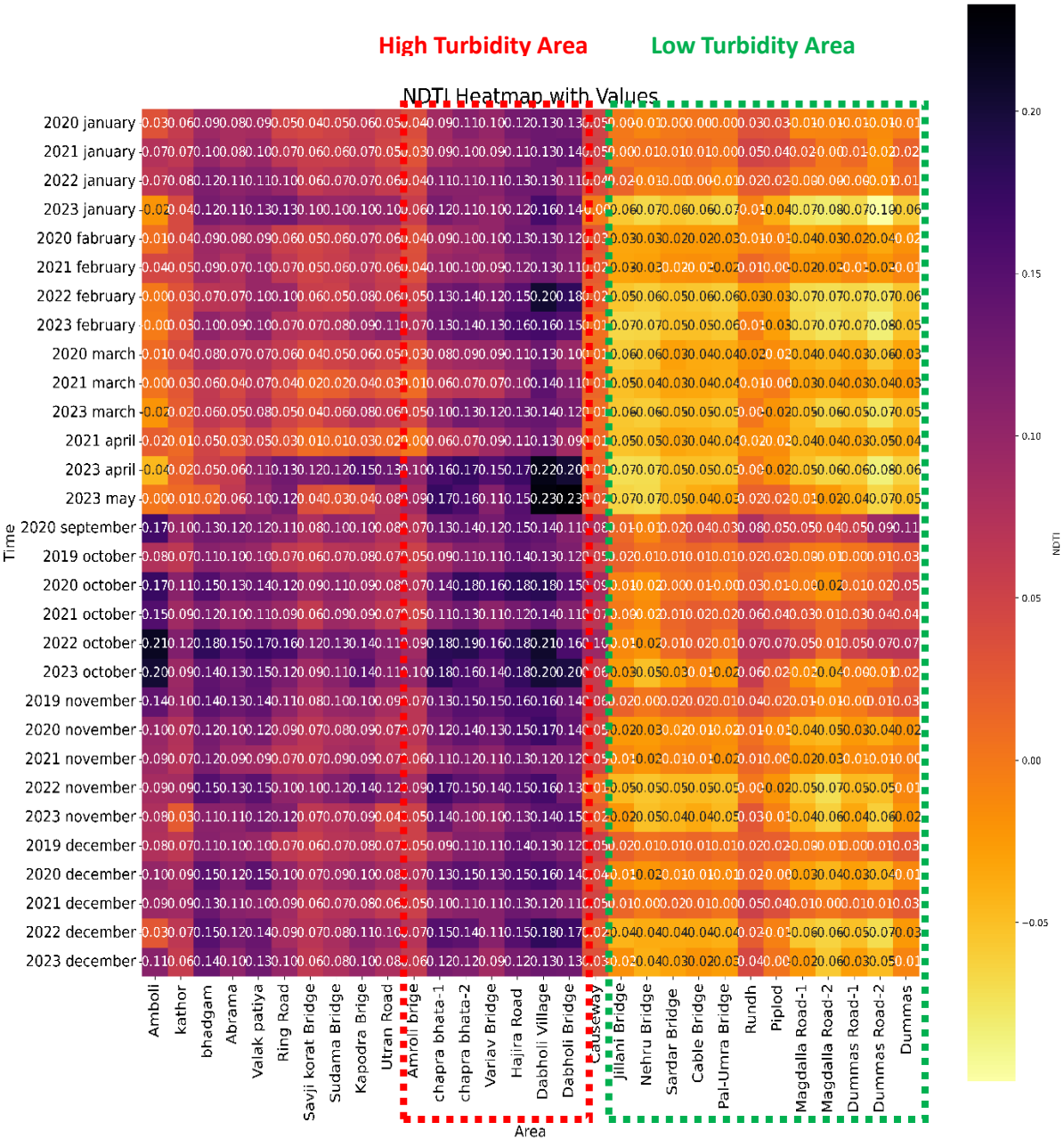

Figure 1.0: Heatmap Representation of Tapi River NDTI (Oct 2019 - Dec 2023 : Clean Image Only)

This heatmap illustrates the NDTI (Normalized Difference Turbidity Index) variations of the Tapi River across 30 areas from October 2019 to December 2023. The image is divided into two sections:

- **Red**: High turbidity area
- **Green**: Low turbidity area

The heatmap uses the **Inferno color scheme**, where higher values are represented by darker colors and lower values by lighter colors.

Data Collection for NDTI

Used Sentinel-2 imagery to compute NDWI and NDTI, applying cloud masking and compositing for monthly analysis in 30 buffer zones along the Tapi River to monitor water quality and turbidity.

Turbidity Trends:

- Highest turbidity was observed at Dabholi Bridge in May 2023 and lowest at Dummas Road-2 in January 2023.
- Areas with low variance, such as Kathor and Savji Korat Bridge, show stable turbidity levels, while high variance at Amboli indicates more fluctuations.
- Generally, turbidity peaks in post-monsoon months (October to December) and is lower during winter and summer (March to April).

Temporal Changes:

- October 2022 was the most turbid month, and January 2023 had the least turbidity.
- Turbidity consistently peaks in post-monsoon and drops during winter to summer.

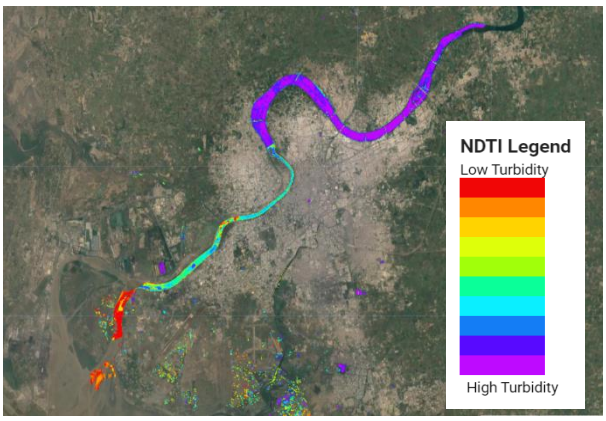

Figure 2.0: Image before causeway of High Turbidity October-2022

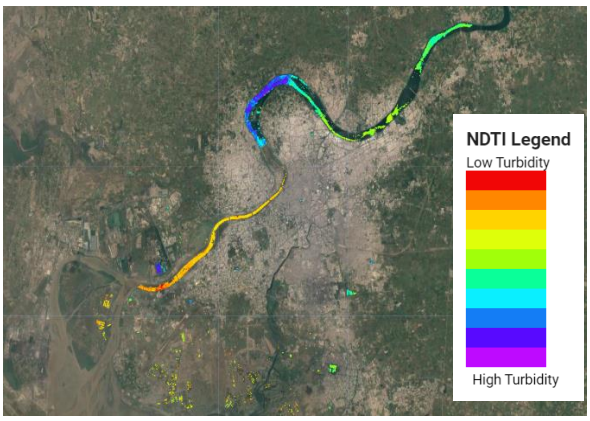

Figure 2.1: Image before causeway of Low Turbidity April-2021

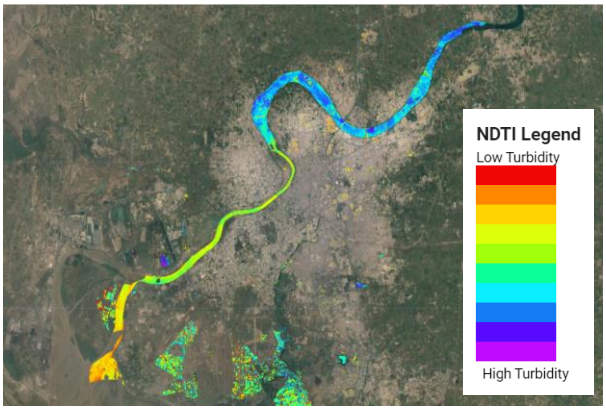

Figure 2.2: Image after causeway of High Turbidity September-2020

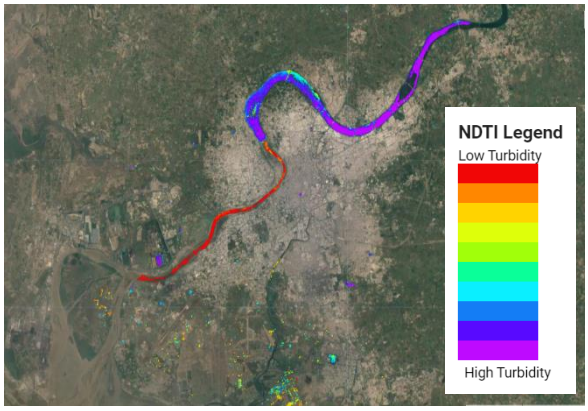

Figure 2.3: Image after causeway of Low Turbidity January-2023

Width Variability of the Tapi River in Surat City (1987-2021)

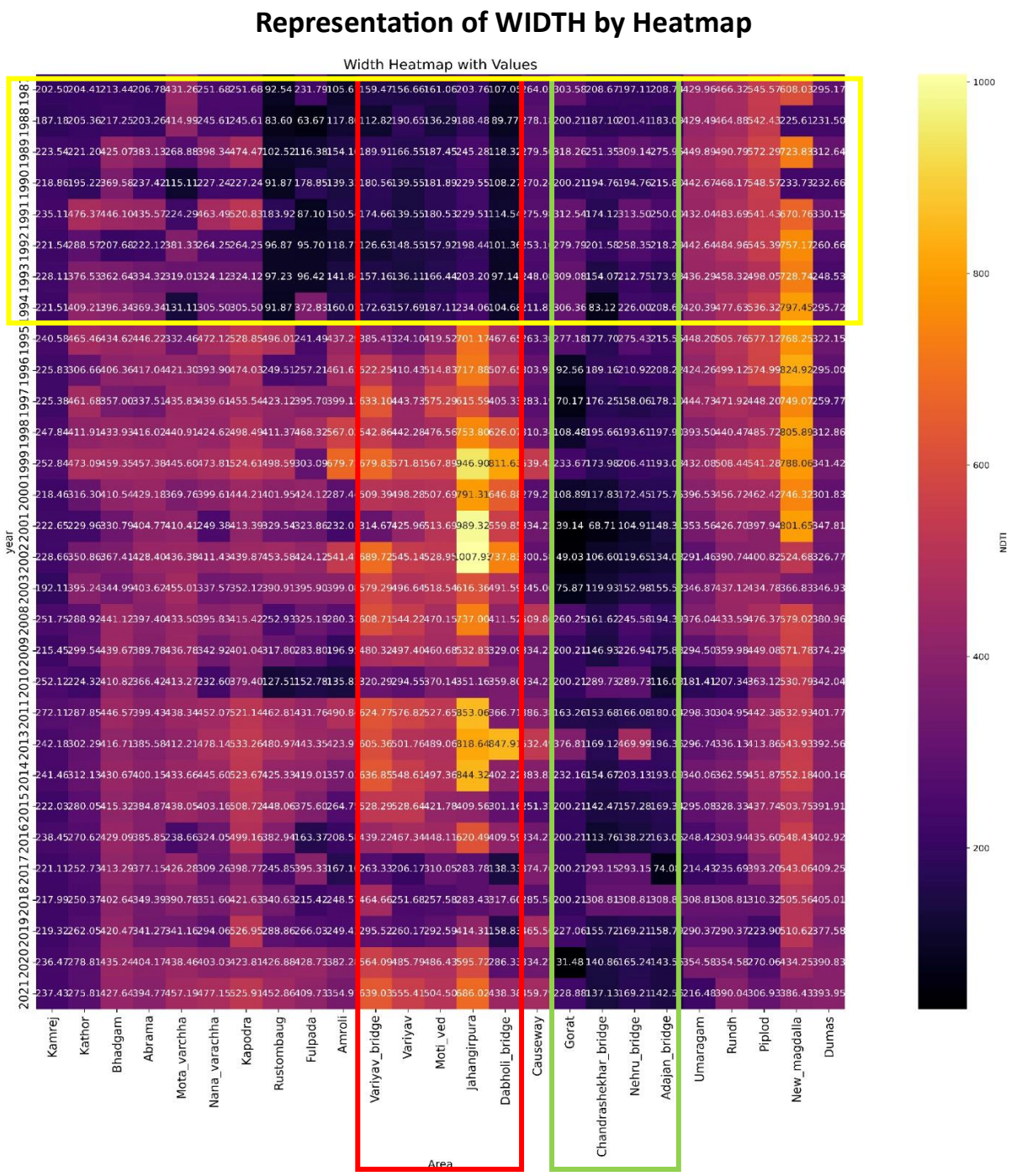

Figure 3.0: Heatmap Representation of Tapi River Width (1987-2021)

This heatmap illustrates the width variations of the Tapi River across 25 areas from 1987 to 2021. The image is divided into three sections: (The heatmap uses the **Inferno color scheme**, where higher values are represented by lighter colors and lower values by darker colors.)

- **Yellow**: Before Causeway build.
- **Green**: Gorat to Adajan Bridge. (Low fluctuations Area) (Average 200m)
- **Red**: Variyav Bridge to Dabholi. Bridge (High fluctuations Area) (Average 350m to 550m)

- **Historical Changes**: From 1987 to 2021, the width of the Tapi River varied significantly. The widest point was at Jahangirpura in 2002, while the narrowest was at Gorat in 2020.
- **Temporal Trends**: Jahangirpura exhibited the greatest width fluctuations, while Kamrej remained stable with minimal changes.
- **Spatial Variability**: The Gorat to Adajan Bridge area showed minor changes, Kamrej had consistent width, and Rustombaug to Adajan Bridge had no changes between 1987 and 1994.
- **Variance Analysis**: Jahangirpura had the highest variance in width, whereas Kamrej had the lowest.

Recent Observations

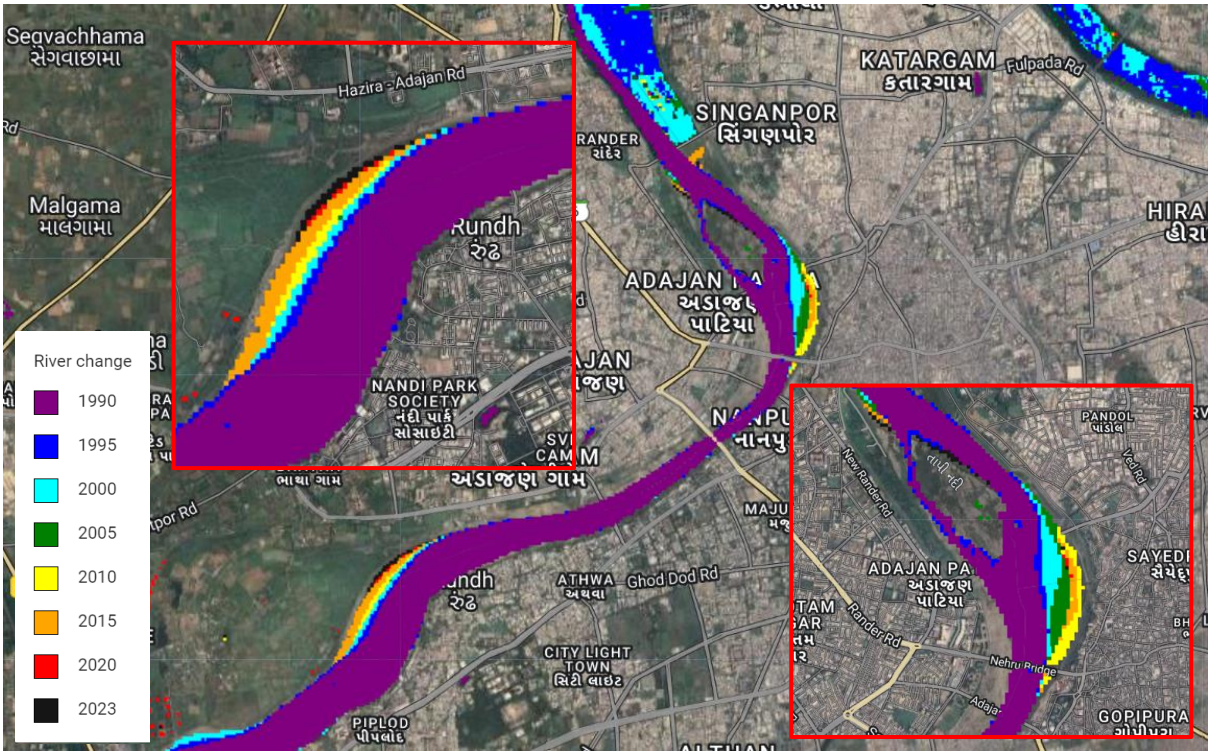

Figure 4.0: Satellite Image Depicting River Change Trends from 1990 to 2023

Recent Observations: The Rundh area has seen a steady increase in width since 1987, whereas the Chowk-Bazar area has fluctuated but remained relatively constant.

These insights into the width changes of the Tapi River highlight areas of stability and significant fluctuation, crucial for river management and development planning.

Importance of the Study with Respect to Sustainable Development Goals (SDGs):

1. **SDG 14: Life Below Water**
    - **Marine Pollution Control:** The study aligns with SDG 14 by addressing water turbidity levels, which are directly linked to marine pollution. By identifying and monitoring pollution hotspots along the Tapi River, effective strategies can be implemented to mitigate contamination and protect aquatic ecosystems.
    - **Ecosystem Protection:** Continuous monitoring of turbidity and river width supports the conservation of aquatic habitats, ensuring the sustainability of the riverine ecosystem in Surat City. This contributes to the broader goal of conserving and sustainably using marine and freshwater resources.
2. **SDG 11: Sustainable Cities and Communities**
    - **Urban Planning and Infrastructure:** The findings offer valuable insights for urban planning, particularly in managing the riverfront and surrounding areas. By understanding the dynamics of river width and turbidity, city planners can prioritize sustainable development that balances urban growth with environmental preservation.
3. **SDG 15: Life on Land**
    - **Biodiversity Conservation:** The study's focus on water quality and river dynamics contributes to the protection of terrestrial and aquatic ecosystems. By mitigating pollution and managing land use around the river, the study supports efforts to maintain biodiversity and restore degraded ecosystems.
4. **SDG 6: Clean Water and Sanitation**
    - **Water Quality Improvement:** By assessing and monitoring water turbidity, the study directly contributes to SDG 6, which emphasizes the importance of clean water for all. The findings can guide the implementation of policies to improve water quality, ensuring that communities have access to safe and clean water.
    - **Wastewater Management:** The identification of pollution sources enables the development of targeted wastewater management strategies, reducing the discharge of untreated water into the Tapi River and improving overall water sanitation.
5. **SDG 3: Good Health and Well-being**
    - **Public Health Protection:** Clean water is crucial for public health. By addressing water pollution and turbidity, the study helps reduce the prevalence of waterborne diseases, contributing to better health outcomes for the population of Surat City.
6. **SDG 13: Climate Action**
    - **Climate Resilience:** The study's analysis of river dynamics and climate-related changes supports SDG 13 by informing climate adaptation strategies. Understanding how climate change impacts the river's width and turbidity helps Surat City develop resilient infrastructure and adaptive management practices.

Policy Implications:

1. **Integrated River Management Policy:**
    - Establish a comprehensive policy that integrates river health monitoring, pollution control, and urban development along the Tapi River. This policy should prioritize sustainable management practices that balance environmental conservation with urban growth.
2. **Water Quality Standards and Enforcement:**
    - Develop stringent water quality standards based on the findings of turbidity levels and pollution sources. Implement regular monitoring and enforcement mechanisms to ensure compliance, reducing the risk of contamination and protecting public health.
3. **Sustainable Urban Development Guidelines:**
    - Create guidelines for sustainable urban development along the riverfront, emphasizing green infrastructure, flood resilience, and the preservation of natural habitats. These guidelines should inform zoning laws, construction permits, and land use planning.
4. **Public Health and Environmental Education Campaigns:**
    - Launch public health campaigns that raise awareness about the importance of clean water and the risks associated with water pollution. Educate communities about sustainable practices that protect the river and promote overall well-being.
5. **Remote Sensing and Data-Driven Policies:**
    - **Evidence-Based Decision Making:** Utilize remote sensing data to inform and develop policies that are grounded in real-time and historical data. This approach ensures that policies are responsive to current environmental conditions and trends, leading to more effective and adaptive management strategies.
    - **Continuous Monitoring Framework:** Establish a framework that incorporates regular satellite-based monitoring of the Tapi River. This would involve setting up a centralized data repository where satellite imagery and related data are continuously analyzed to track changes in river health, turbidity, and width, providing a solid foundation for ongoing policy adjustments.
    - **Predictive Analytics for Resource Management:** Implement predictive analytics tools to forecast future changes in the Tapi River's dynamics, such as potential turbidity spikes or shifts in river width. These insights can guide proactive resource management and urban planning decisions, reducing the risk of environmental degradation.
    - **Incorporation into Urban Planning Tools**: Integrate remote sensing data into urban planning tools and Geographic Information Systems (GIS) used by the city planners of Surat. This ensures that every aspect of urban development, from infrastructure projects to land use decisions, is informed by accurate, up-to-date environmental data.

Recommendations:

Long-Term Monitoring: Continue using satellite imagery to track changes in the width of the Tapi River, providing insights into long-term patterns and impacts from human activities and climate change.

Water Quality Assessment: Expand the use of satellite images to assess river cleanliness, identify pollution hotspots, and prioritize conservation efforts.

Enhanced Measurements and Management: Install sensors at 25 locations to continuously monitor river width and integrate this data with water flow information for comprehensive management and sustainable river health.

Development Focus: Prioritize development along the riverfront between Gorat and Adajan Bridge for amenities such as eco-parks, public spaces, and market upgrades, leveraging its consistent width for effective planning

Conclusion:

Our study on the Tapi River in Surat City reveals critical insights into water turbidity and river width trends from 1987 to 2023. Utilizing Sentinel-2 imagery and Landsat data, we observed significant turbidity fluctuations, with the highest levels recorded at Dabholi Bridge in May 2023 and the lowest at Dummas Road-2 in January 2023. Turbidity generally peaks in the post-monsoon months and is lower during winter and summer. Spatial analysis shows persistent high turbidity from Amboli to Dabholi Bridge and varying impacts from the causeway.

Width measurements from 1987 to 2021 indicate substantial variability, with Jahangirpura experiencing the widest fluctuations and Kamrej remaining stable. Recent data shows the Rundh area widening steadily, while the Chowk-Bazar area fluctuates.

These findings underscore the importance of ongoing satellite-based monitoring to track river dynamics and guide sustainable development. Recommendations include enhancing water quality assessments, installing sensors for precise width measurements, and focusing development efforts on the stable riverfront between Gorat and Adajan Bridge.