SPATIO-TEMPORAL ANALYSIS OF TURBIDITY IN THE PRAYAGRAJ REGION, UTTAR PRADESH USING NDTI FROM SENTINEL-2 IMAGERY

Presented by
Haripriya K R
(Register Number: 243308)

MSc Data Analytics And Geoinformatics
School of Digital Sciences

Final Project Presentation Semester II - Geospacial Programming

INTRODUCTION

TURBIDITY : cloudiness or haziness of water caused by suspended particles and organic matter

STUDY AREA & SIGNIFICANCE

- Triveni Sangam, Prayagraj (UP): Confluence of Ganga & Yamuna
- Area includes a 15 km buffer capturing core confluence and adjacent river stretches.
- Unique sediment mixing, flow dynamics, and seasonal variability shape turbidity patterns.

IMPORTANCE FOR TURBIDITY MONITORING

- Turbidity spikes linked to mass gatherings (e.g.Magh Mela) and monsoon rains.
- mass gathering , bathing and boat activities during this time makes water cloudy
- Site reflects both natural (monsoon-driven runoff) and human-induced turbidity.

STUDY FOCUS ON:

- **Pre-monsoon (May):** Low flow, high human activity mostly turbidity from Anthropogenic activity
- **Post-monsoon (October):** High flow, heavy runoff mostly turbidity driven by natural sediment transport
- Comparative analysis isolates human vs. natural turbidity influences from year 2019 to 2024

Figure 3.2-May month Sentinel-2 image

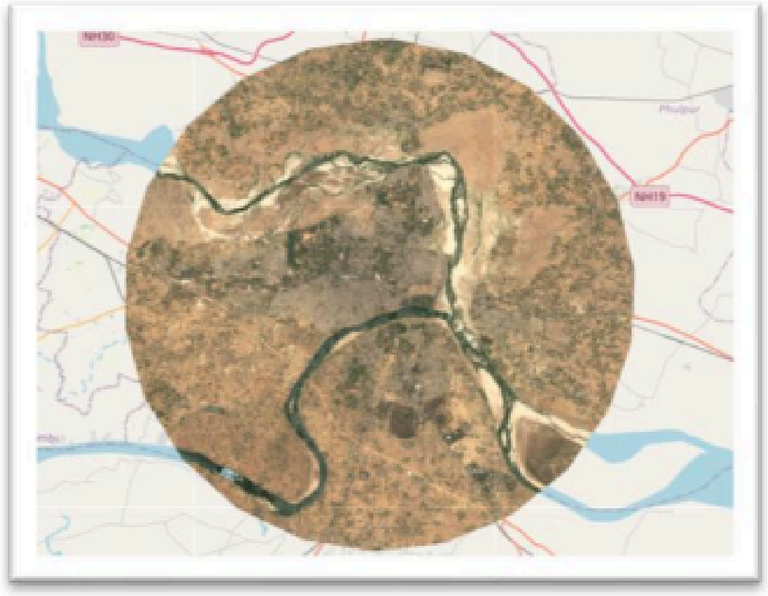


Figure 3.3-October month Sentinel-2 image

METHODOLOGY

Data Collection Tools and Environment

Data Sources

Sentinel-2 Surface Reflectance (SR) product accessed

through the Copernicus Open Access Hub via GEE (Monthly median)

Geospatial Programming Tools

- **Google Earth Engine (GEE):** compute indices such as NDTI and NDWI, Cloud masking etc.
- **Earth Engine Python API (ee):** Bridged GEE with Python environments

Development Environment

Google Colab: authentication and initialization of GEE, running Python scripts.

CALCULATIONS

NDTI Calculation: The Normalized Difference Turbidity Index (NDTI) was computed using the **red (B4)** and **green (B3)** bands of Sentinel-2 imagery used to generate monthly median composites for the study period

$$\mathrm{NDTI} = \frac{\mathrm{B4} - \mathrm{B3}}{\mathrm{B4} + \mathrm{B3}}$$

NDWI Calculation: The Normalized Difference Water Index (NDWI) was calculated using the green (B3) and near-infrared (B8) bands to identify and mask water bodies:

$$\mathrm{NDWI} = \frac{\mathrm{B3} - \mathrm{B8}}{\mathrm{B3} + \mathrm{B8}}$$

PREPROCESSING

Cloud Masking: Using the Scene Classification Layer (SCL) from Sentinel products cloud-affected pixels were masked out to ensure data quality.

- cloud shadows,
- medium-probability clouds,
- high-probability clouds

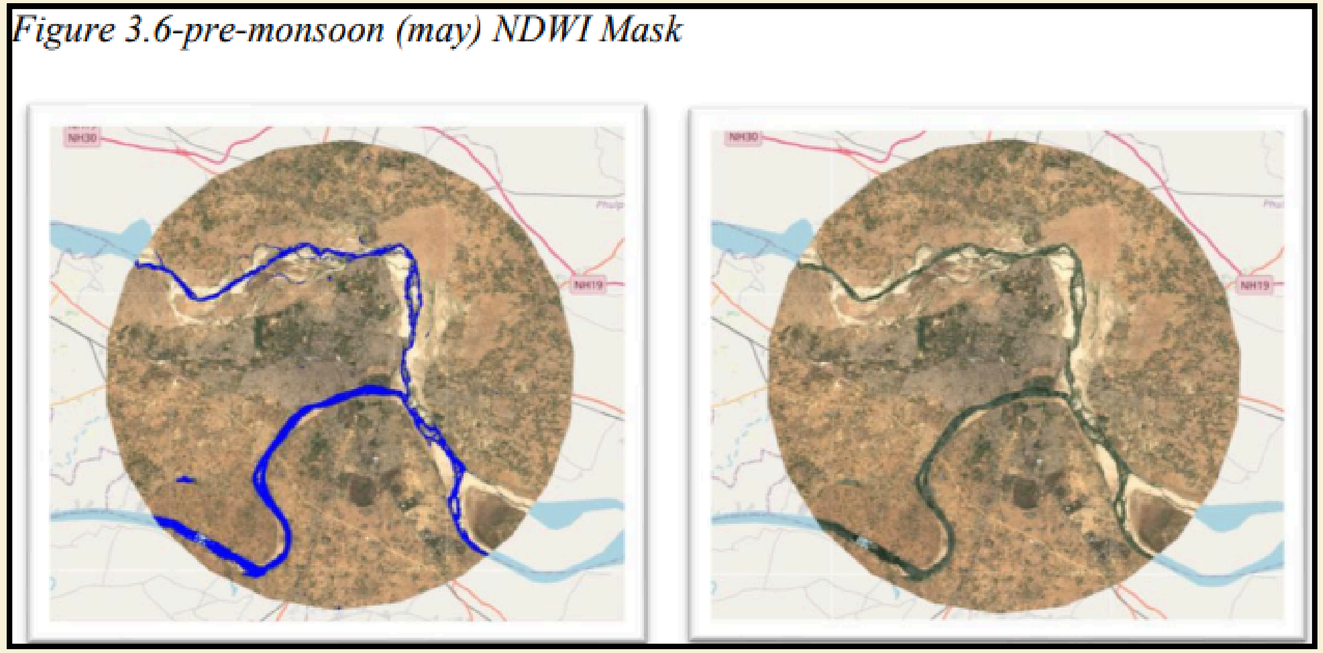
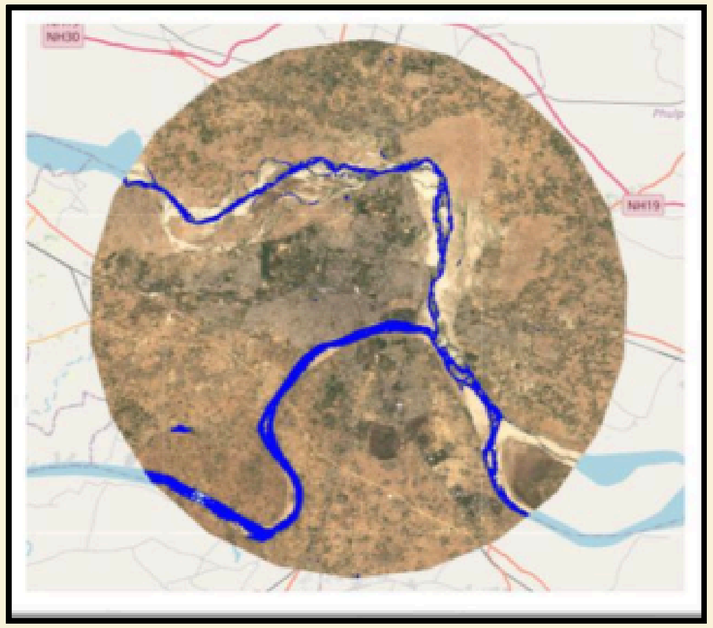
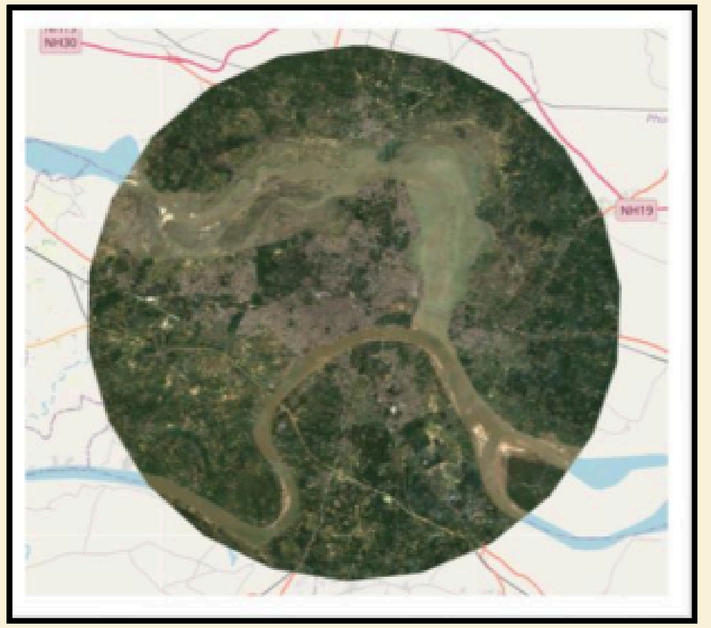


Figure 3.6-pre-monsoon (may) NDWI Mask

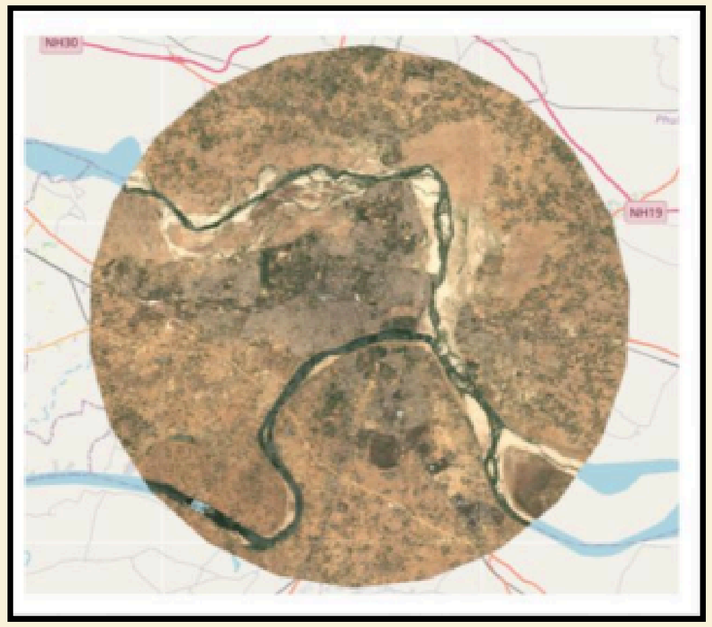
Water Masking: The **Normalized Difference Water Index** (NDWI) was computed using the green (B3) and near-infrared (B8) bands of Sentinel-2 imagery. A threshold value of **NDWI > 0** was applied to isolate water bodies and restrict the analysis to river pixels

WATER MASKING: NORMALIZED DIFFERENCE WATER INDEX (NDWI)

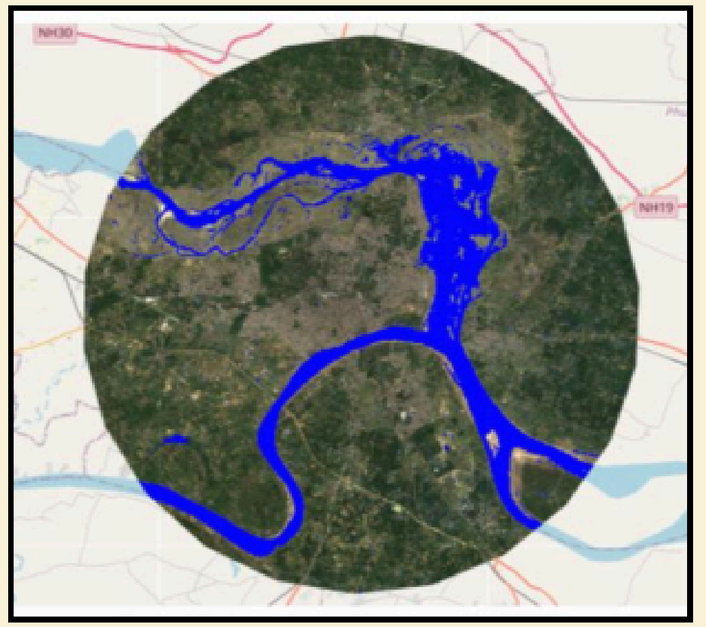




may



october



TEMPORAL AND SPATIAL ANALYSIS

NDTI Composites:

Monthly median NDTI composites were generated for each year to analyze seasonal turbidity variations. These composites capture the spatial distribution of turbidity across the study area.

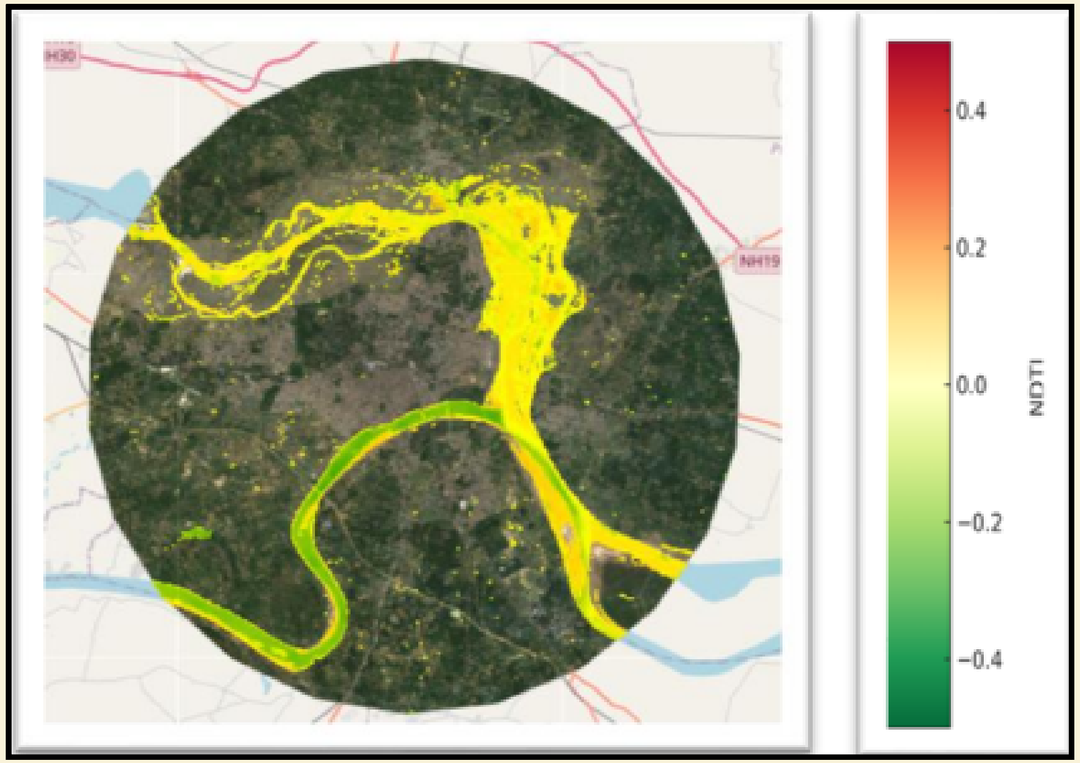


Figure 3.8 illustrates an NDTI map clipped exclusively to river pixels for October 2023, demonstrating the effectiveness of this masking approach.

TEMPORAL AND SPATIAL ANALYSIS

ΔNDTI Analysis:

Year-on-year changes in NDTI were calculated by subtracting the NDTI values of consecutive years using composite NDVI

$$\Delta NDTIyear(2) = NDTIyear(2) - NDTIyear(1)$$

Turbidity increased - positive values - RED

Turbidity stays same as before - WHITE

Turbidity decreased - negative values-BLUE

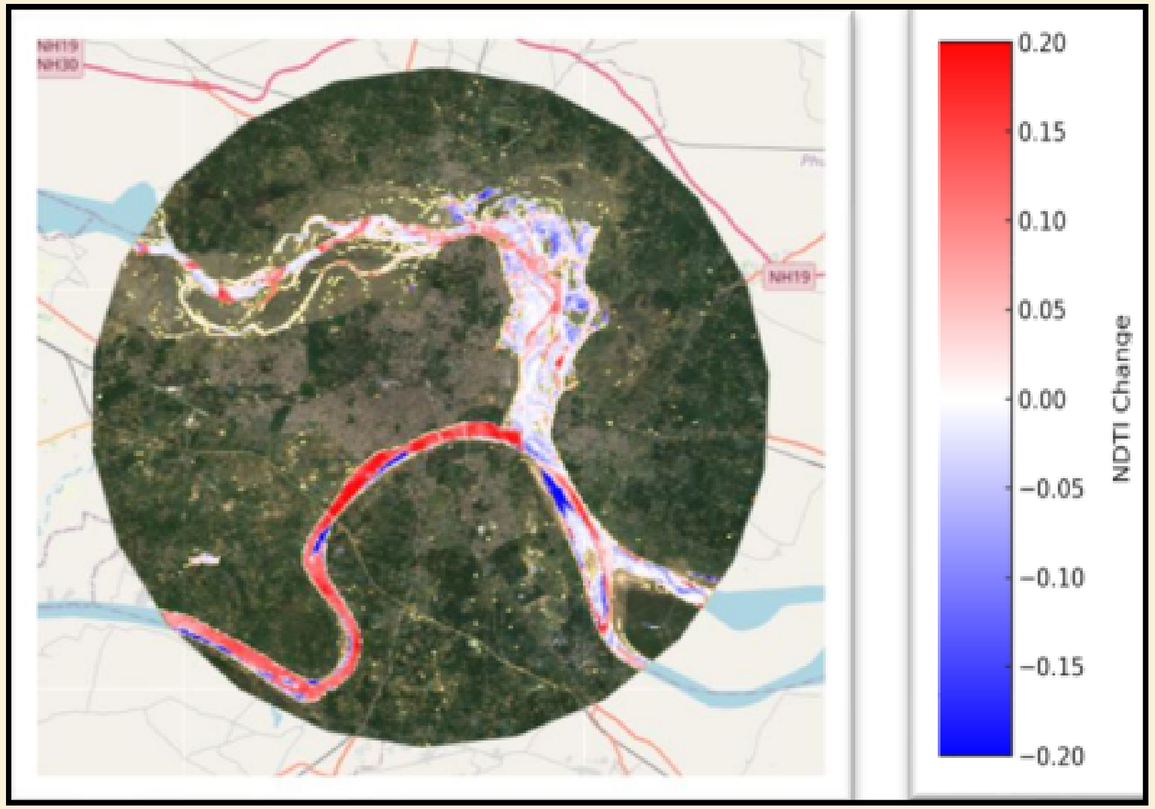
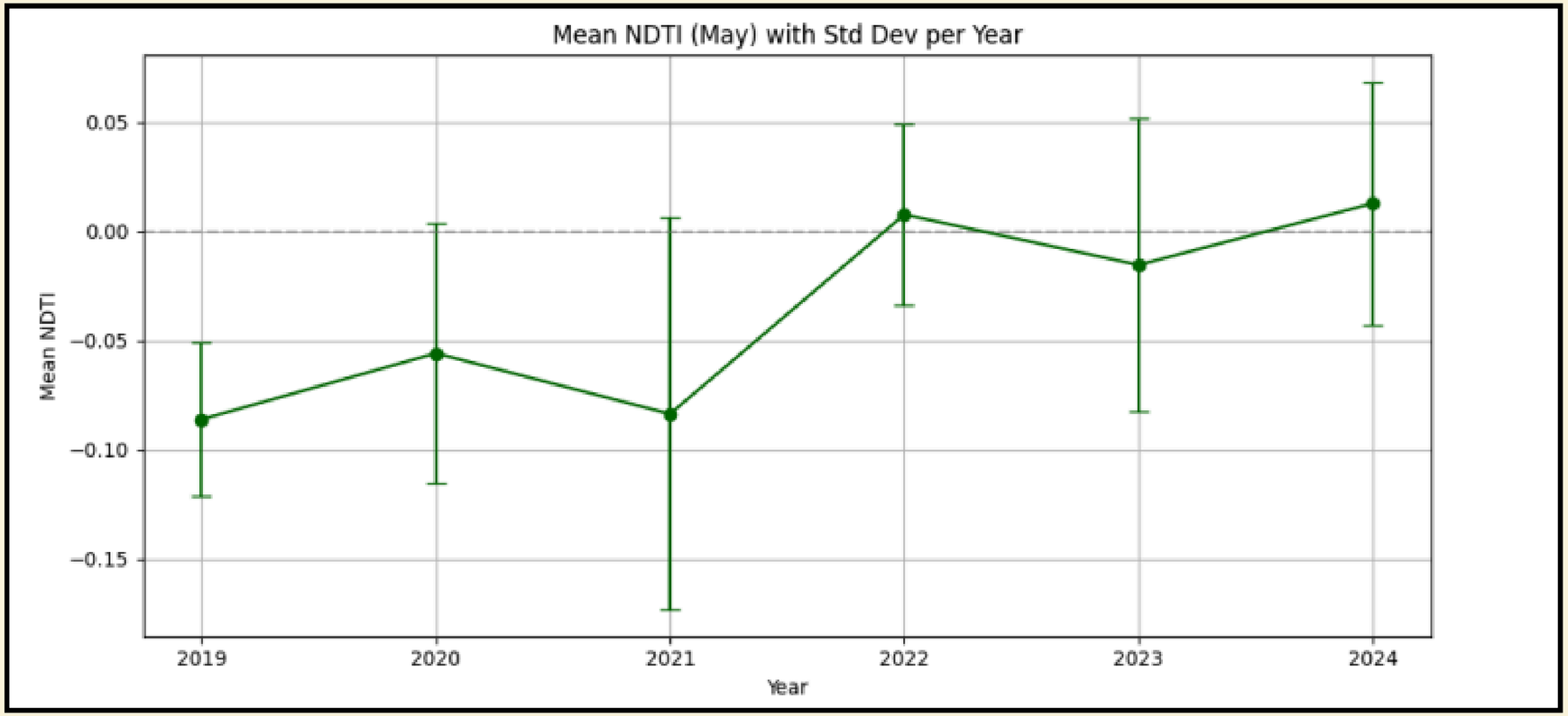


Figure 3.9 shows an example of compound NDTI change for October 2023 compared to October 2024

RESULTS:

PRE-MONSOON SEASON (MAY)

TEMPORAL TRENDS IN MEAN NDTI AND SPATIAL VARIABILITY (2019–2024)



A horizontal dashed grey line at NDTI = 0 served as a neutral reference point, where values above indicated higher turbidity and negative values indicated clearer water

SPATIAL DISTRIBUTION OF TURBIDITY – NDTI MAPS (MAY, 2019–2024)

Figure 4.4-NDTI Map 2019, May

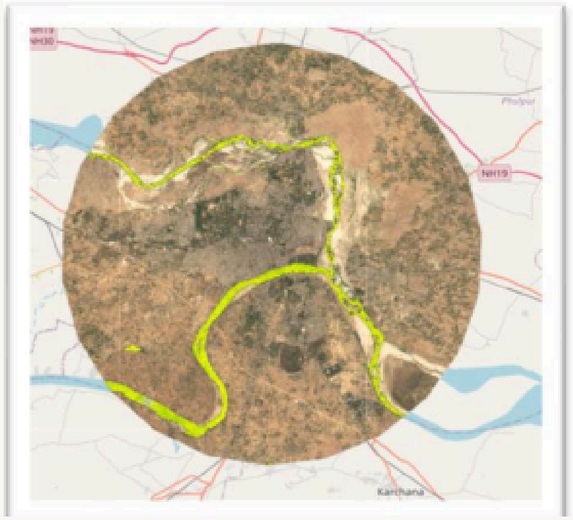


Figure 4.5-NDTI Map 2020, May

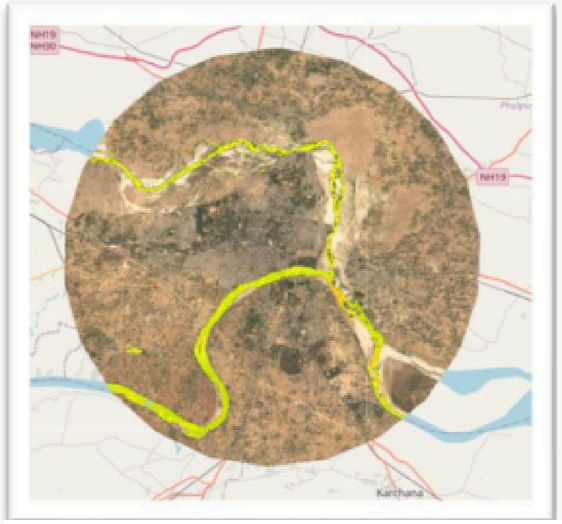


Figure 4.6-NDTI Map 2021, May

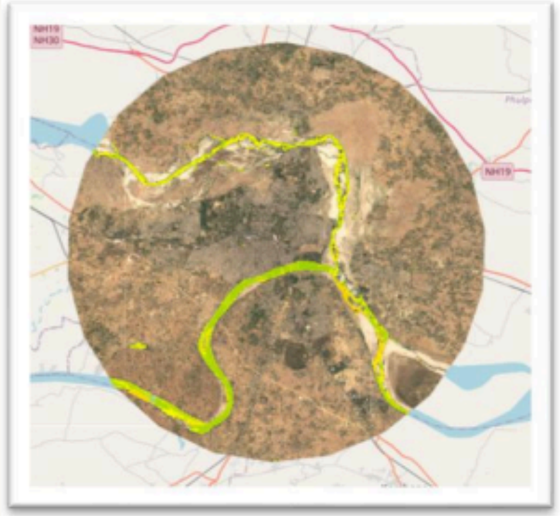


Figure 4.7-NDTI Map 2022, May

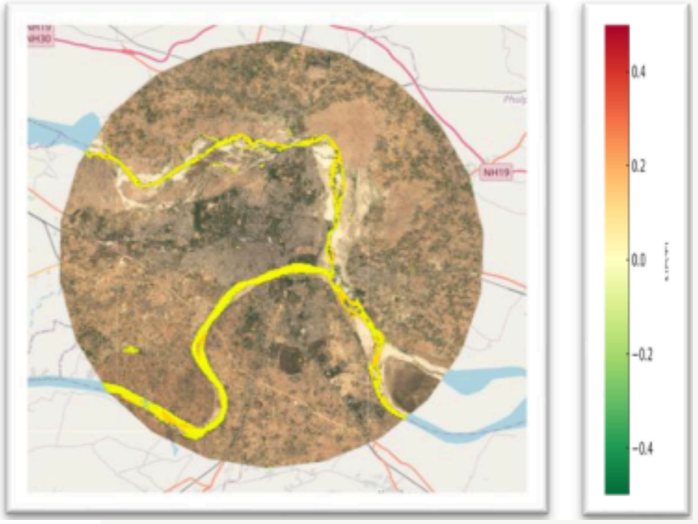


Figure 4.8-NDTI Map 2023, May

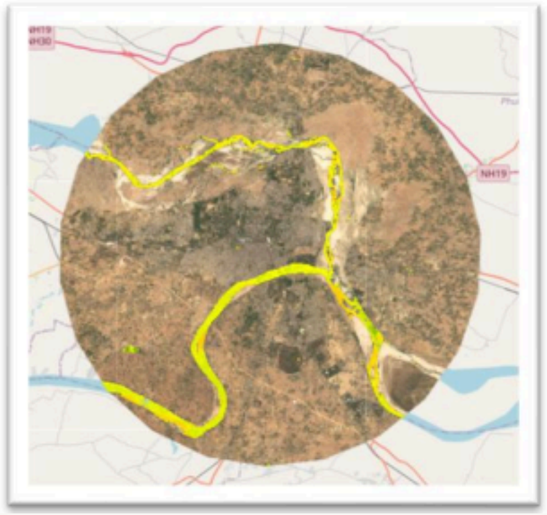
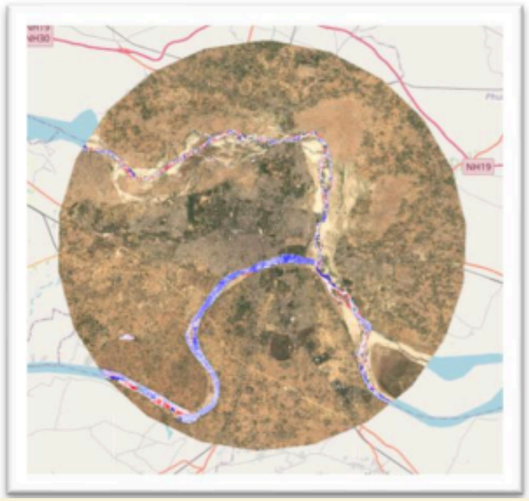


Figure 4.9-NDTI Map 2024, May

YEAR-TO-YEAR TURBIDITY VARIATIONS (ΔNDTI: 2019–2024)

Figure 4.10-ΔNDTI (2020–2019), May

Figure 4.11-ΔNDTI (2021–2020), May



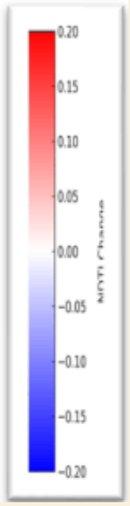


Figure 4.12-ΔNDTI (2022–2021), May

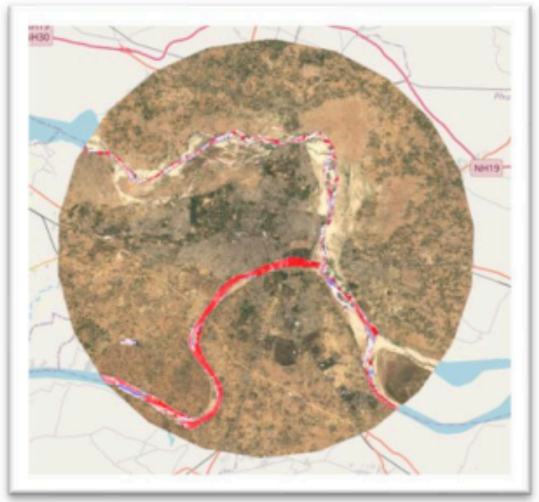
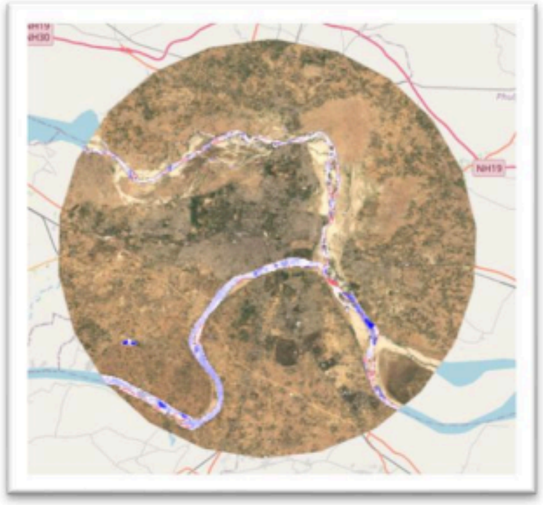


Figure 4.13-ΔNDTI (2023–2022), May



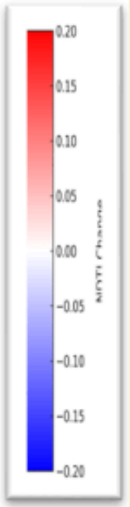
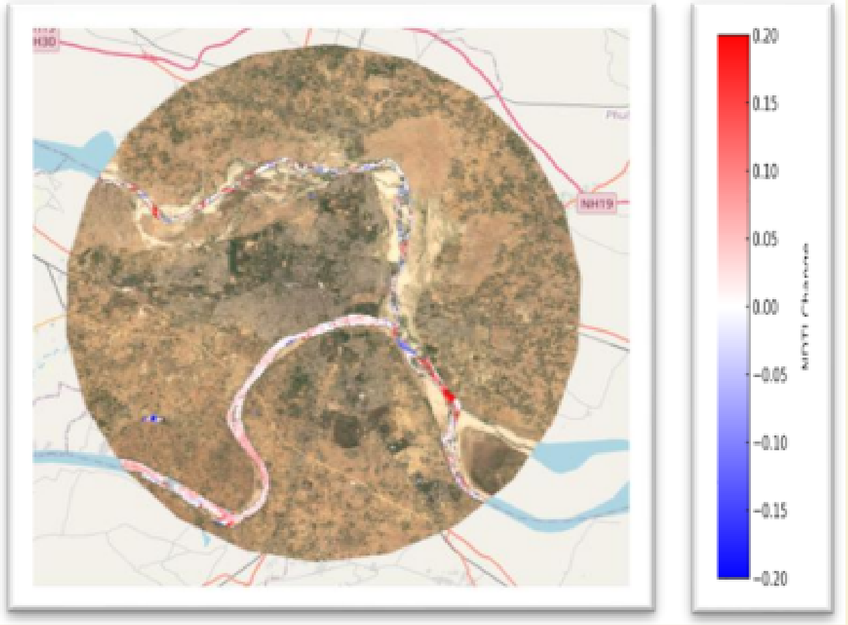


Figure 4.14-ΔNDTI (2024–2023), May



COMPOUND YEAR-ON-YEAR CHANGE IN NDTI WITH STANDARD DEVIATION (MAY)

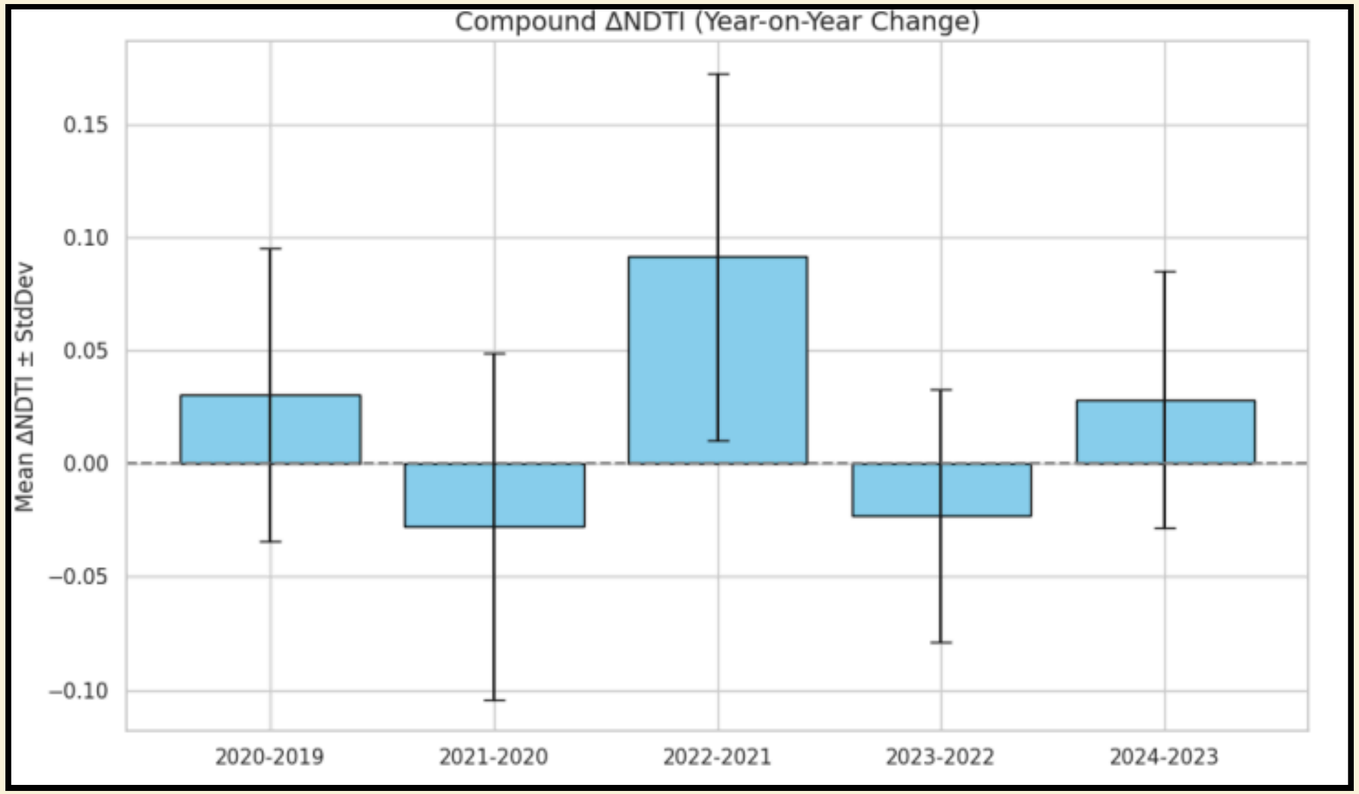


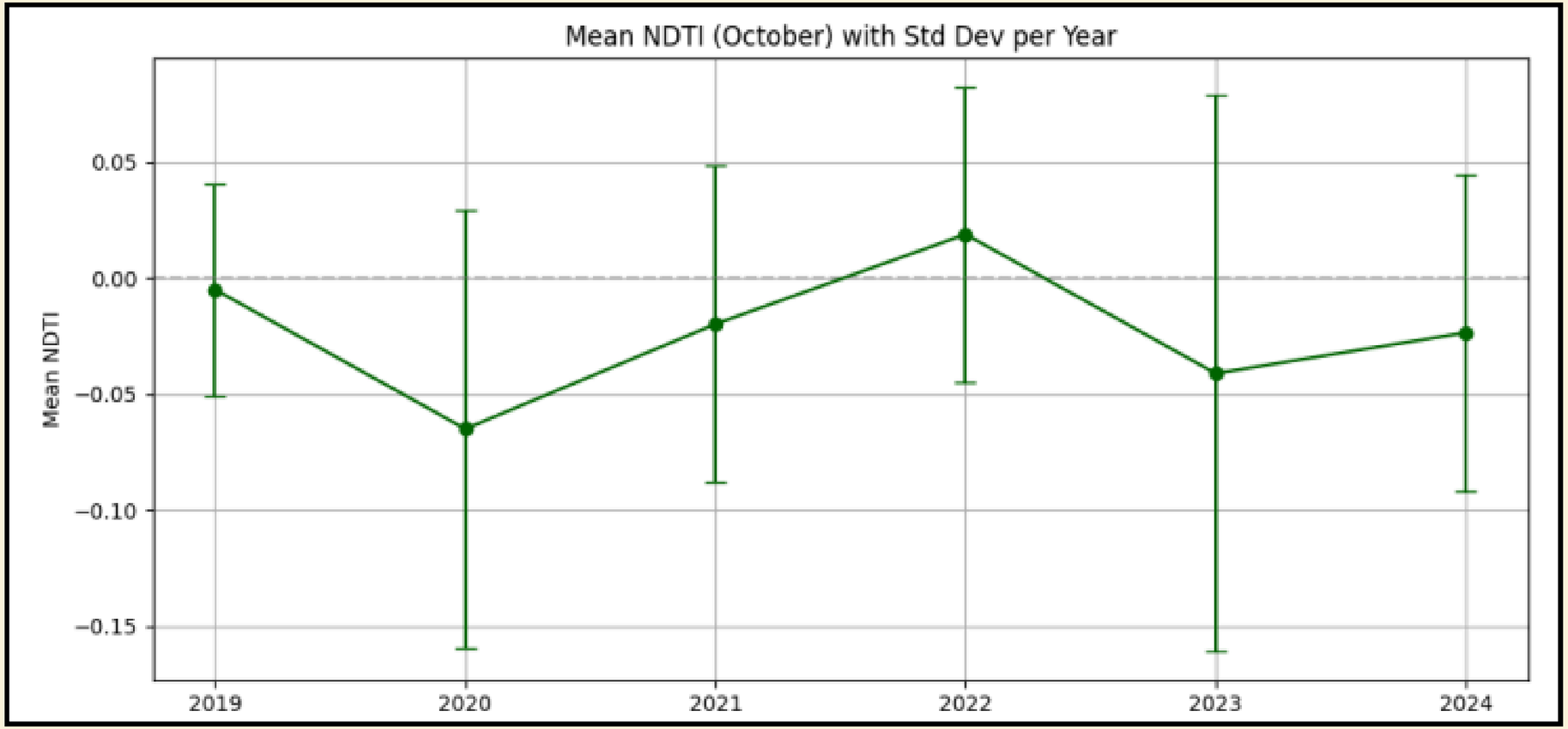
Figure displays the compound annual change in NDTI values (ΔNDTI) for May alongside the corresponding standard deviation for each year, capturing the net turbidity shift from the previous year.

Turbidity increased in 2020, 2022, and 2024 (positive ΔNDTI values).

Turbidity decreased in 2021 and 2023 (negative ΔNDTI values).

The most substantial increase occurred between 2021 and 2022, with ΔNDTI peaking at approximately +0.09

POST-MONSOON SEASON (OCTOBER)
TEMPORAL TRENDS IN MEAN NDTI AND SPATIAL VARIABILITY (2019–2024)



A horizontal dashed grey line at NDTI = 0 served as a neutral reference point, where values above indicated higher turbidity and negative values indicated clearer water

SPATIAL DISTRIBUTION OF TURBIDITY – NDTI MAPS (OCTOBER, 2019–2024)

Figure 4.19-NDTI Map 2019

Figure 4.20-NDTI Map 2020

Figure 4.21-NDTI Map 2021

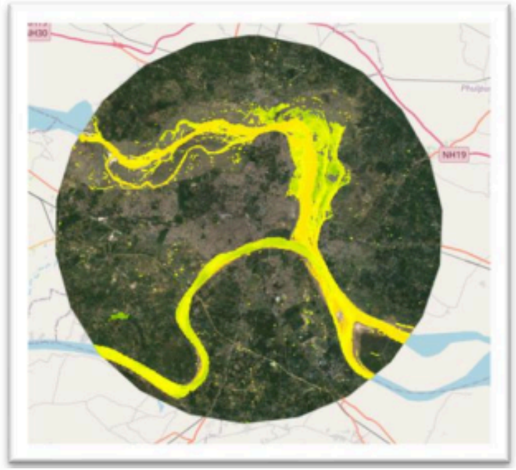


Figure 4.22-NDTI Map 2022

Figure 4.23-NDTI Map 2023

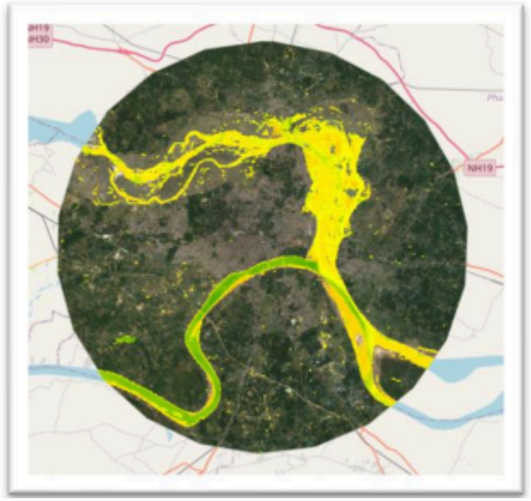
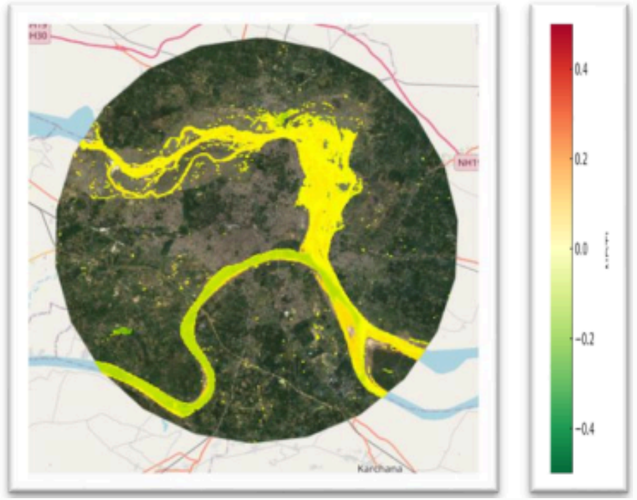


Figure 4.24-NDTI Map 2024



INTER-ANNUAL CHANGE IN TURBIDITY – ΔNDTI MAPS (OCTOBER, 2019–2024)

Figure 4.25-ΔNDTI (2020–2019)

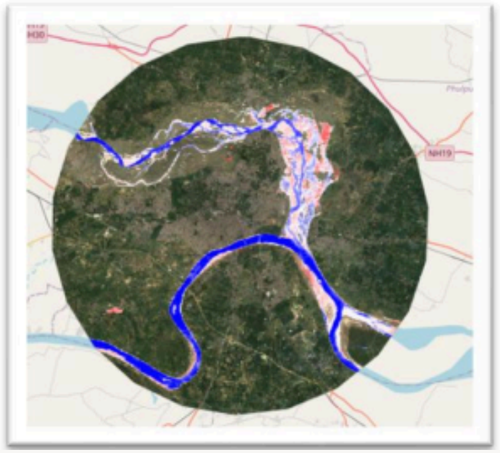


Figure 4.26-ΔNDTI (2021–2020)

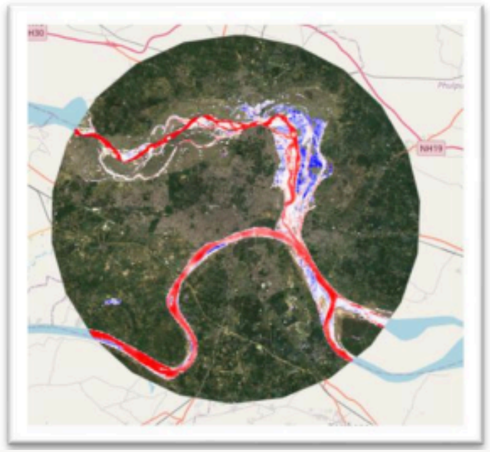


Figure 4.27-ΔNDTI (2022–2021)

Figure 4.28-ΔNDTI (2023–2022)

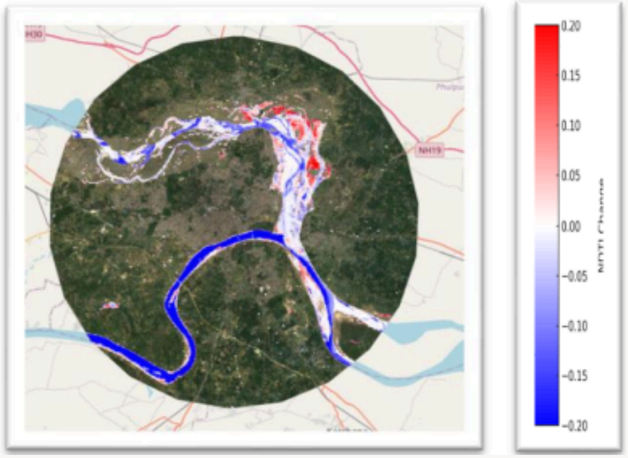
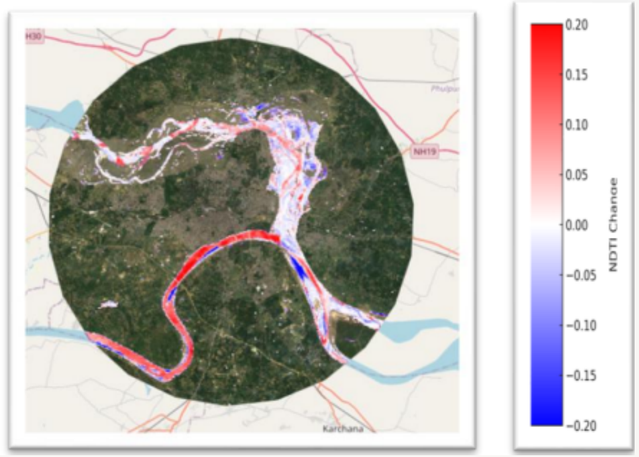


Figure 4.29-ΔNDTI (2024–2023)



COMPOUND YEAR-ON-YEAR CHANGE IN NDTI WITH STANDARD DEVIATION (OCT)

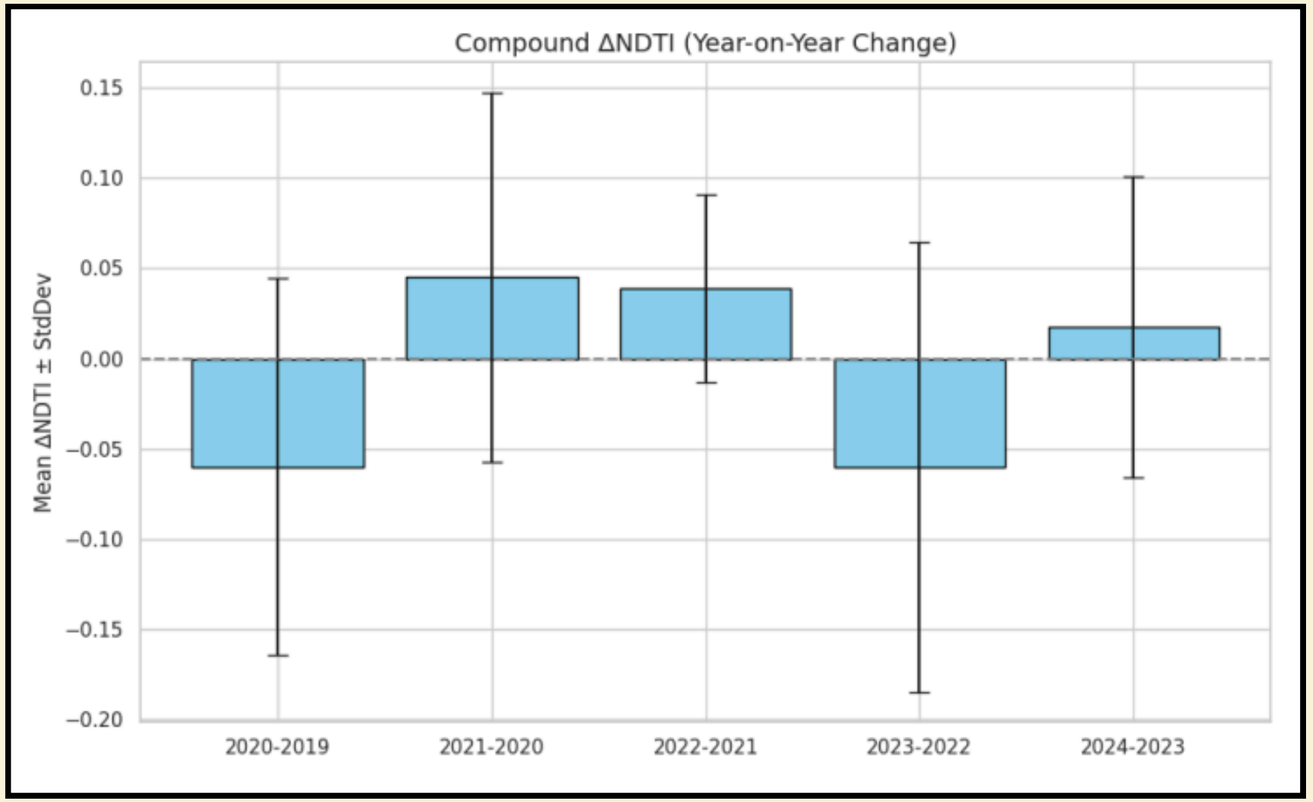
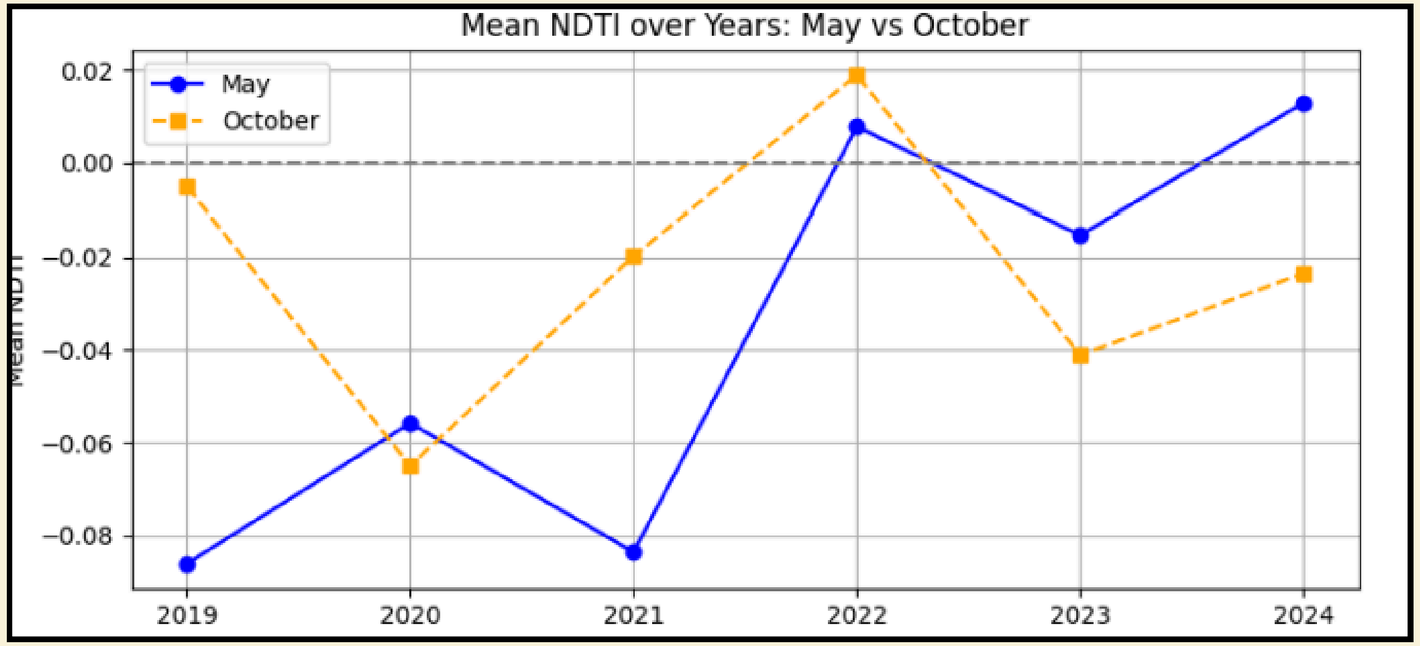
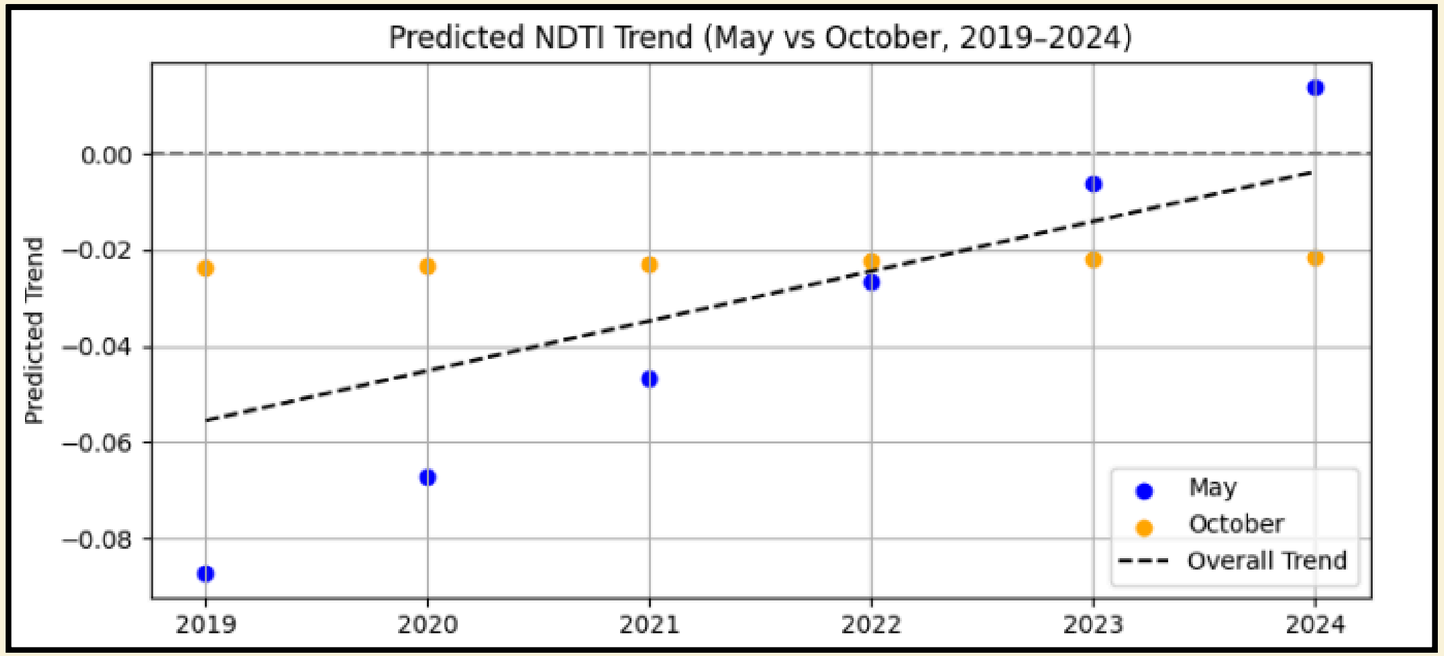


Figure Displays the compound year-on-year changes in NDTI (ΔNDTI) for October, accompanied by standard deviation bars to reflect spatial variability

- **Turbidity increased in 2021, 2022, and 2024 (positive ΔNDTI values).**
- The highest increase was in **2021–2020** (ΔNDTI ≈ +0.045).
- **Turbidity decreased in 2020 and 2023 (negative ΔNDTI values).**
- The most significant decreases occurred in **2020–2019** and **2023–2022** (ΔNDTI ≈ −0.06)



SEASONAL COMPARISON OF MEAN NDTI AND LINEAR TREND




thank you.