2025

SATELLITE MONITORING REPORT

LT-012-MEX-210823 CHIHUAHUA, MÉXICO
Santa Isabel Water and Soil Credits

Life Terra

March, 2025

I. GENERAL INFORMATION

Project name	Santa Isabel Water and Soil Credits
aOCP Registered Project ID	LT-012-MEX-210823 CHIHUAHUA, MÉXICO
Name of the Project Proponent	Life Terra
Name of authorized representative of the Project Proponent	Sven Kallen
Email and Phone Number (with country code)	sven@lifeterra.eu
Project start date	July 2021
Project end date	September 2062
aOCP Scopes in which the project participates	☐ Greenhouse gases ☐ Biodiversity ☒ Water ☐ United Nations Sustainable Development Goals

II. MONITORING INFORMATION

Start of monitoring period	December 2024
End of monitoring period	March 2025
Duration of monitoring period (months)	4
Number of monitoring period (consecutive). Considers both onsite and remote monitoring campaigns.	1
Objective of this monitoring campaign	Generate the project baseline
Monitoring approach	☐ On-site (yearly)

	☒ Remote sensing (satellite images, acoustic sensors, etc) (quarterly)

III. METHODOLOGY

The quarterly remote sensing procedure forms a critical component of the monitoring framework for restoration and reforestation projects. This procedure aims to systematically evaluate changes in vegetation health and coverage over time, providing insights into the effectiveness of project interventions.

To establish baseline conditions, satellite imagery spanning six months prior to the project's implementation is acquired. These pre-project images are analyzed to calculate vegetation indices, which serve as reference points for assessing changes in vegetation cover and condition during subsequent monitoring phases.

After project implementation, satellite images are obtained quarterly to track and evaluate the progress of restoration or reforestation activities. This involves Randomly generated sampling points selected within the project area. The number of points is determined proportionally to the size of the project area to ensure representative coverage during assessments.

Sentinel-2 multi-spectral images, with a spatial resolution of 10 meters, are utilized due to their high-quality data, frequent revisit times, and suitability for vegetation analysis. Only images with cloud cover below 30% are selected to ensure accurate and reliable results.

The vegetation indices implemented for the purpose of this assessment are the Normalized Difference vegetation Index (NDVI) and the Green Normalized Difference Vegetation Index (GNDVI).

III.1. NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI).

The Normalized Difference Vegetation Index (NDVI) is a widely used indicator for assessing vegetation health, density, and photosynthetic activity. It is calculated using the formula:

$$NDVI = \frac{(NIR-RED}{(NIR+RED)},$$

where NIR is the near-infrared reflectance (band 8 in Sentinel-2 imagery), and RED is the red-light reflectance (band 4 in Sentinel-2 imagery).

NDVI leverages the contrast between strong near-infrared reflection (high in healthy vegetation) and low red-light reflectance (absorbed by chlorophyll during photosynthesis). Higher NDVI values indicate dense, healthy vegetation, while lower values suggest sparse or stressed vegetation. This index is instrumental in monitoring vegetation phenology, tracking land use and cover changes, and detecting natural events such as droughts. By analyzing NDVI time series, we

can gain insights into long-term trends and seasonal variations in vegetation, making it an essential tool for restoration monitoring.

III.2. Green Normalized Difference Vegetation Index (GNDVI).

The Green Normalized Difference Vegetation Index (GNDVI) complements NDVI by providing enhanced sensitivity to chlorophyll levels in vegetation. It is calculated using the formula:

$$GNDVI = \frac{(NIR - GREEN}{(NIR + GREEN)},$$

where NIR is the near-infrared reflectance (band 8 in Sentinel-2 imagery), and GREEN is the green-light reflectance (band 3 in Sentinel-2 imagery).

GNDVI measures "greenness" or the photosynthetic activity of vegetation. It is particularly useful for assessing nitrogen uptake and water content in the plant canopy, making it a valuable indicator for evaluating plant health and crop productivity. By combining GNDVI with NDVI, we gain a more comprehensive understanding of vegetation conditions, enabling more nuanced monitoring of restoration progress and ecosystem recovery.

Figure 1 illustrates the project area and the corresponding sampling points utilized for the current analysis. These points, along with the processed satellite imagery, facilitate an in-depth evaluation of vegetation dynamics, enabling the identification of progress and areas requiring further intervention.

Figure 1. Project area and sampling points used for the NDVI analysis.

IV. BASELINE (2021 BEFORE PROJECT IMPLEMENTATION)

During the baseline period (January to June 2021), the mean NDVI and GNDVI values were 0.16 and 0.32, respectively (Table 1). These values indicate low vegetation density and moderate photosynthetic activity, reflective of pre-project conditions with sparse or degraded vegetation cover.

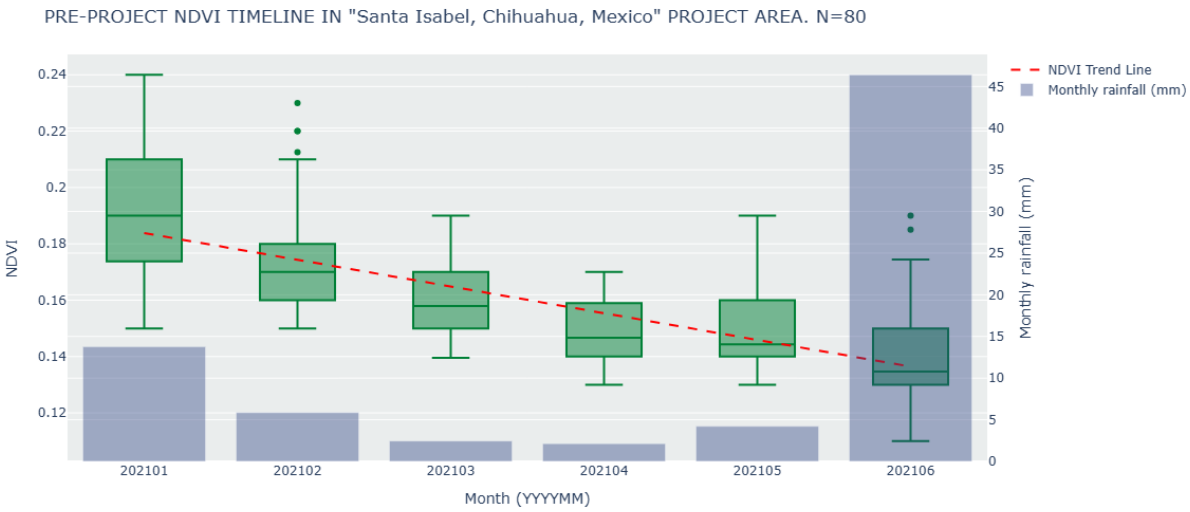

Figure 2. Pre-Project NDVI and Rainfall Trend within Project Area.

2021	January	February	March	April	May	June	Mean
NDVI	0.19	0.17	0.16	0.15	0.15	0.14	**0.16**
GNDVI	0.37	0.35	0.33	0.31	0.28	0.30	**0.32**

V. SECOND-QUARTER MONITORING (2024)

In the second quarter monitoring period (July to November 2024), both NDVI and GNDVI have shown significant improvement.

NDVI has increased to a mean value of 0.45, nearly tripling the 2021 baseline mean. Monthly values range from 0.30 in November to a peak of 0.62 in September, suggesting substantial greening and an improvement in vegetation density across the project area.

GNDVI has risen to a mean of 0.45, up from the 2021 baseline mean of 0.32. This indicates enhanced photosynthetic activity and healthier vegetation, likely driven by increased chlorophyll levels and improved vegetation vigor. The absence of data for November does not obscure the upward trend observed in prior months.

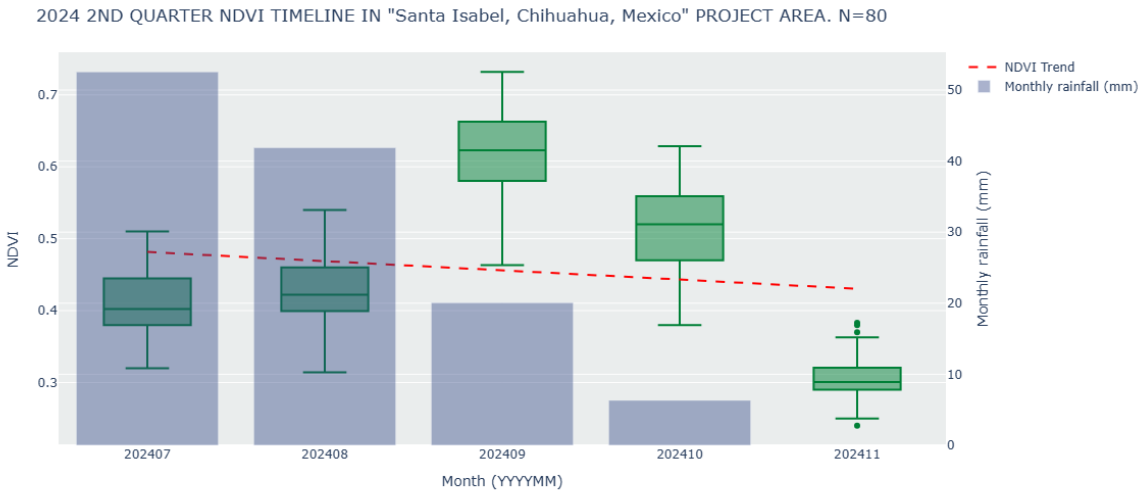

Figure 3. 2024 2nd Quarter NDVI and Rainfall Trend within Project Area.

2024	July	August	September	October	November	Mean
NDVI	0.40	0.42	0.62	0.52	0.30	**0.45**
GNDVI	0.42	0.42	0.49	0.45	-	**0.45**

VI. FIRST-QUARTER MONITORING (2025)

The NDVI and GNDVI values recorded during the first quarter of 2025 indicate a slight improvement compared to the 2021 baseline. NDVI increased from a baseline mean of 0.16 to 0.23, while GNDVI improved from 0.32 to 0.40, suggesting early stages of vegetation recovery and increased photosynthetic activity within the project area. These gains, although modest, reflect ongoing ecological improvements.

When compared to the previous quarter (July–November 2024), a seasonal decline in NDVI is evident from 0.45 to 0.23 likely due to winter dormancy or reduced vegetative growth in colder months. However, GNDVI remained relatively stable, declining only slightly from 0.45 to 0.40, which may indicate continued photosynthetic function despite seasonal stress.

These results suggest that while vegetation is still in the early growth phase, overall conditions are improving steadily from the pre-restoration baseline.

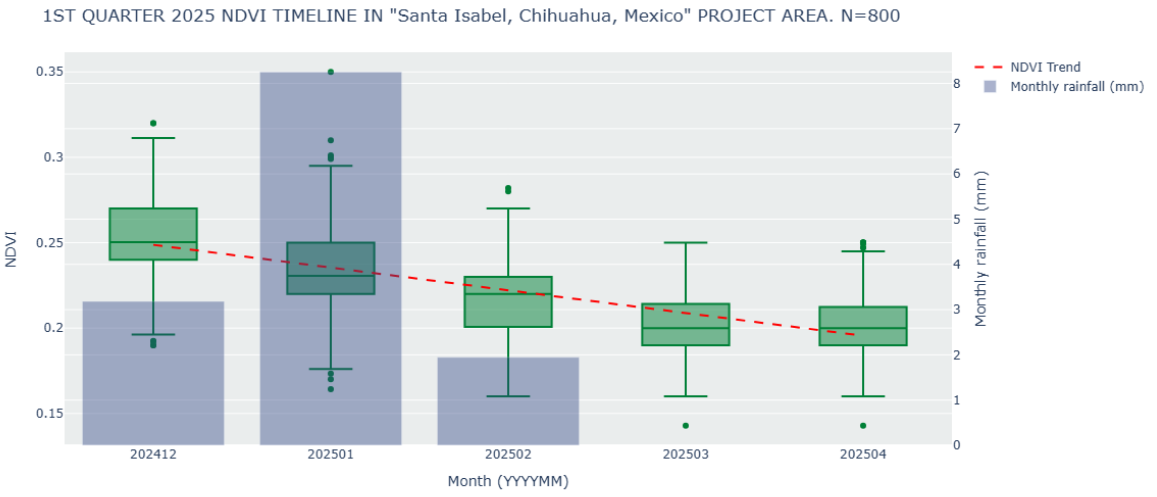

Figure 4. 2025 1st Quarter NDVI and Rainfall Trend within Project Area.

2024/2025	December	January	February	March	Mean
NDVI	0.25	0.23	0.22	0.20	**0.23**
GNDVI	0.46	0.38	0.39	0.35	**0.40**

VII. GLOBAL VARIATION

To accurately evaluate the evolution of NDVI within the project area, it is crucial to establish control areas in the vicinity. These control areas are selected within a defined buffer zone surrounding the project site, ensuring their environmental and ecological conditions are comparable to those of the project area. The selection of suitable control areas allows for a robust comparative analysis, distinguishing the effects of project interventions from natural or external factors influencing vegetation trends. This method ensures that observed changes in NDVI and vegetation health can be confidently attributed to the project activities rather than broader regional variations or unrelated environmental factors.

Figure 5 illustrates the control areas and sampling points strategically identified for this assessment. These sampling points within the control areas provide a representative dataset for tracking vegetation dynamics over time.

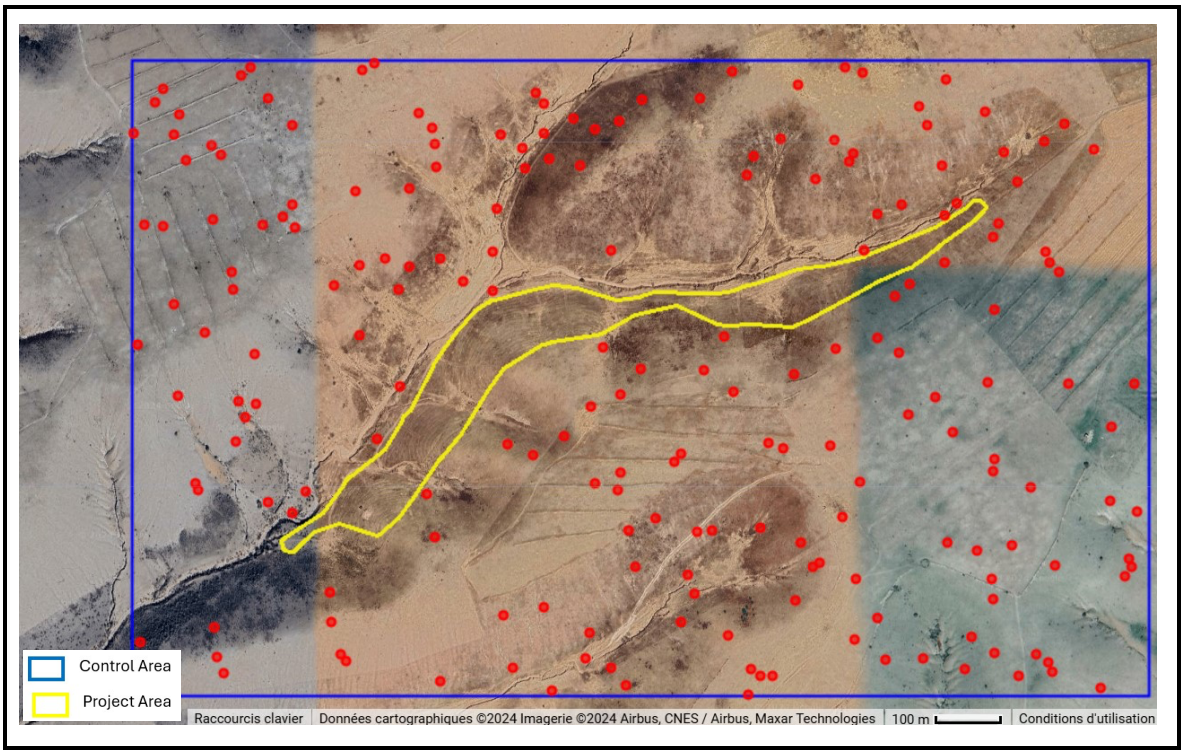

Figure 5. Selected Control Area and Sampling Points

Figure 6 presents a spatial distribution map of NDVI for two distinct assessment periods: the pre-project phase and the first quarter monitoring period of 2025. During the pre-project phase, the NDVI values across the project area and the surrounding adjacent areas were nearly homogenous, reflecting a uniformly low vegetation cover typical of degraded landscapes. This uniformity underscores the limited vegetation density and productivity across the region prior to intervention, with minimal distinction between the project and non-project areas.

In contrast, the first quarter of 2025 shows a significant shift in spatial variation. NDVI values within the project area have slightly increased compared to the adjacent, non-reforested areas. This demonstrates the impact of restoration efforts, with the project area showing some signs of vegetation recovery and enhanced greening. The surrounding areas, however, continue to exhibit lower NDVI values, emphasizing the stark difference resulting from targeted reforestation activities.

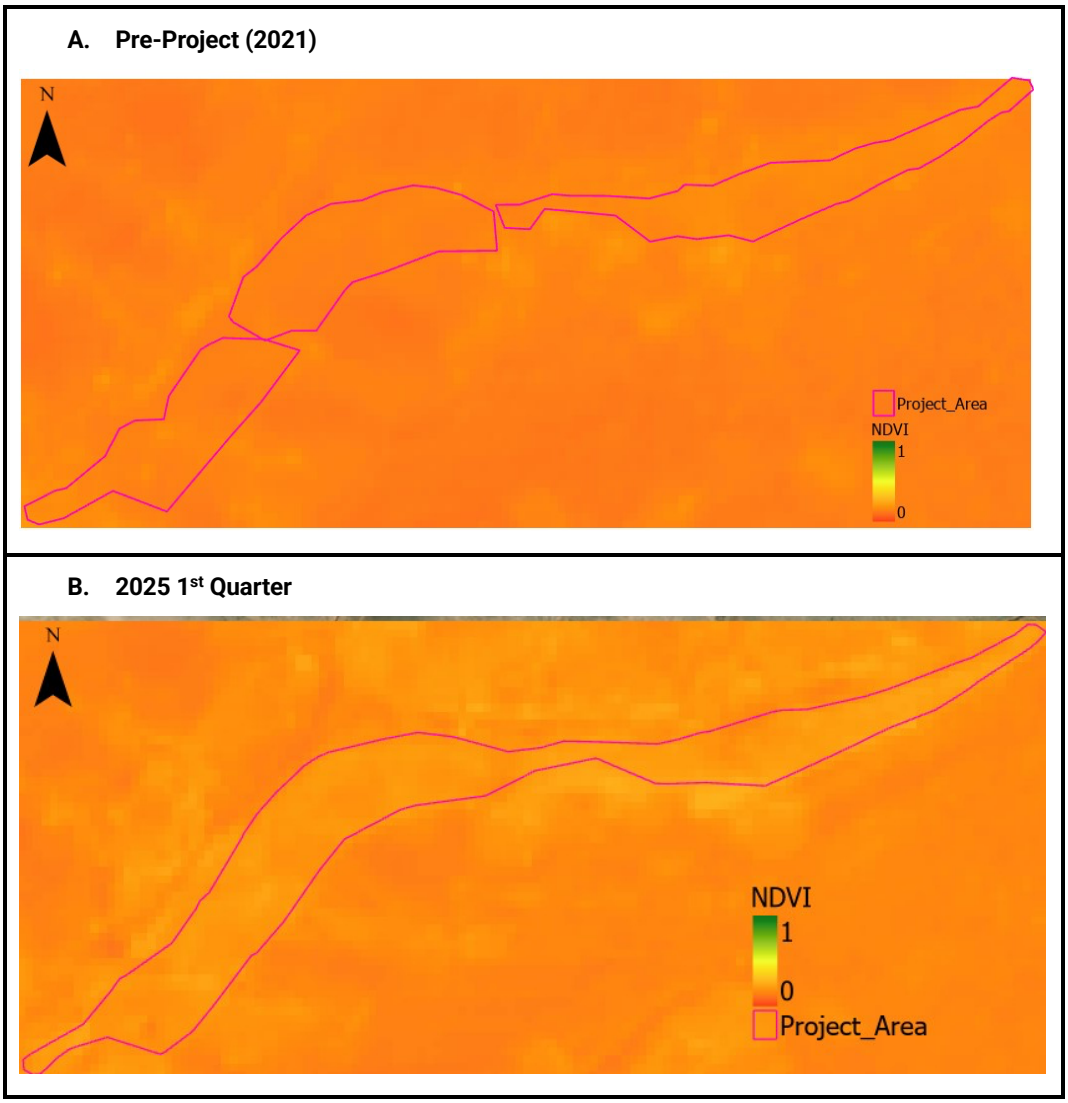

Figure 6. Spatial Evolution of NDVI Within Project area.

To enable a more detailed assessment and comparison of vegetation dynamics between the project and control areas, sampling points within both areas were analyzed. These comparisons provide a quantitative basis for understanding changes in vegetation cover over time.

The first quarter monitoring results for 2025 show a consistent pattern of higher NDVI and GNDVI values in the project area compared to the adjacent control area (Figure 7). Project area NDVI values range from 0.18 to 0.23, while GNDVI ranges from 0.35 to 0.45, both consistently outperforming the control area, which recorded lower NDVI values between 0.14 and 0.18 and GNDVI between 0.29 and 0.36.

Given that both areas had similarly low vegetation cover before the project implementation, this divergence indicates a positive impact of the restoration interventions. The slightly higher vegetation indices in the project area suggest improved vegetation cover and photosynthetic activity, potentially due to successful plant establishment and soil conservation measures.

While the overall values remain moderate, consistent improvements over the control area suggest that ecological recovery is progressing. Continued monitoring will be essential to verify the long-term sustainability of these gains, especially as the vegetation matures.

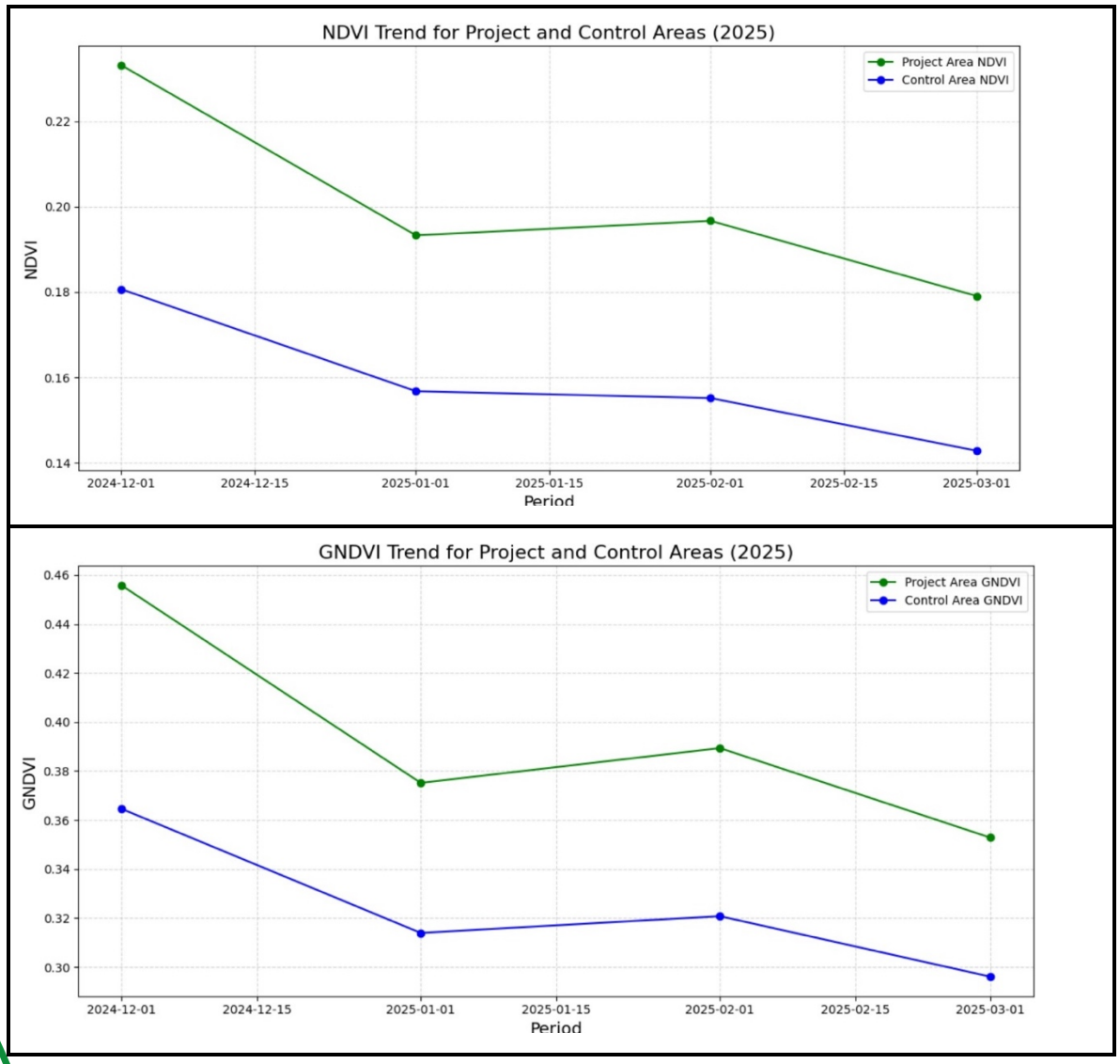

Figure 7. Comparison of NDVI and GNDVI trends between the project and control areas.

VIII. OBSERVATIONS AND COMMENTS

Date	Comments and observations
Pre-project (2021)	The values of the NDVI and GNDVI in the year 2021 were low (0.16 and 0.32 respectively). These values indicate low vegetation density and moderate photosynthetic activity, reflective of pre-project conditions with sparse or degraded vegetation cover.
March 2025	This quarter results suggest that while vegetation is still in the early growth phase, overall conditions are improving steadily from the pre-restoration baseline.

IX. CONCLUSIONS

The upward trajectory in both NDVI and GNDVI values demonstrates the effectiveness of the restoration interventions. Continued monitoring will be essential to ensure sustained progress and to identify any seasonal or spatial variations requiring adaptive management. This positive trend reinforces the project's contribution to ecological recovery and carbon sequestration objectives.