ASES ON-CHAIN PROTOCOL

QUATERLY SATELLITE MONITORING REPORT

Ecological Restoration in Santa Clara a Velha, Odemira (Portugal), Phase II

LT-015-POR-25012024 LUZIANES-GARE PHASE 2, PORTUGAL

Life Terra

Type B project

April 1, 2025

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On-Chain Protocol

I. GENERAL INFORMATION

Project name	Ecological Restoration in Santa Clara a Velha, Odemira (Portugal), Phase II
aOCP Registered Project ID	LT-015-POR-25012024 LUZIANES-GARE PHASE 2, PORTUGAL
Name of the Project Proponent	Life Terra
Name of authorized representative of the Project Proponent	Sven Kallen
Project start date	January 2024
Project end date	January 2064
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 four to 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.

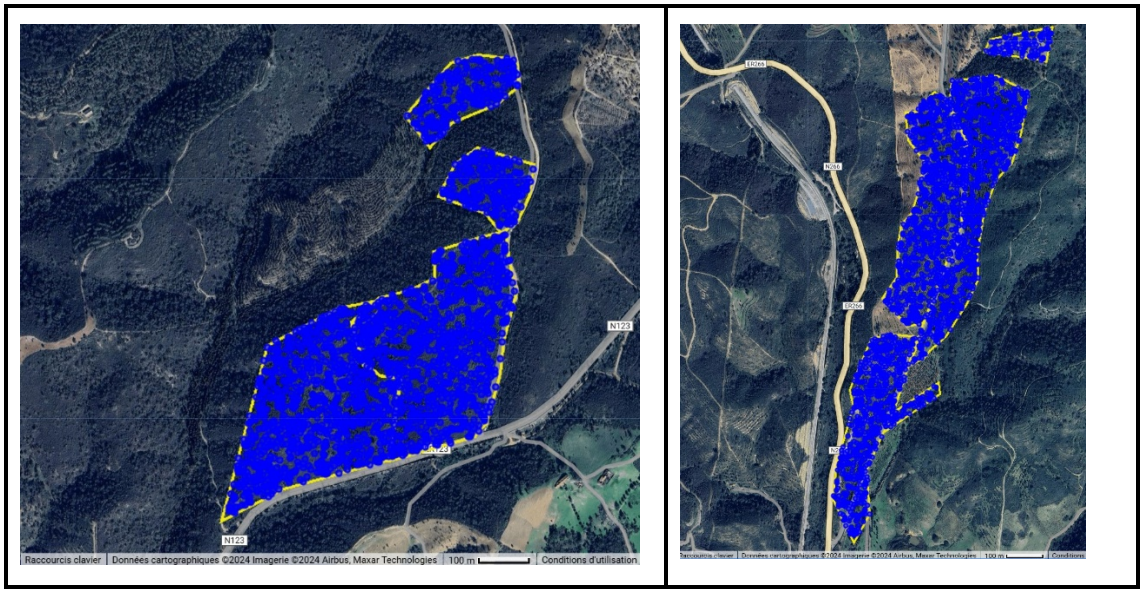

Figure 1. Project area and sampling points used for the NDVI analysis.

IV. BASELINE (2023 BEFORE PROJECT IMPLEMENTATION)

During the pre-project phase, the mean NDVI and GNDVI values for the project area were 0.38 and 0.41, respectively, indicating minimal vegetation cover and relatively low vegetation health. These values suggest a degraded landscape with sparse vegetation. The monthly progression shows slight improvement towards the end of the year, likely influenced by seasonal changes.

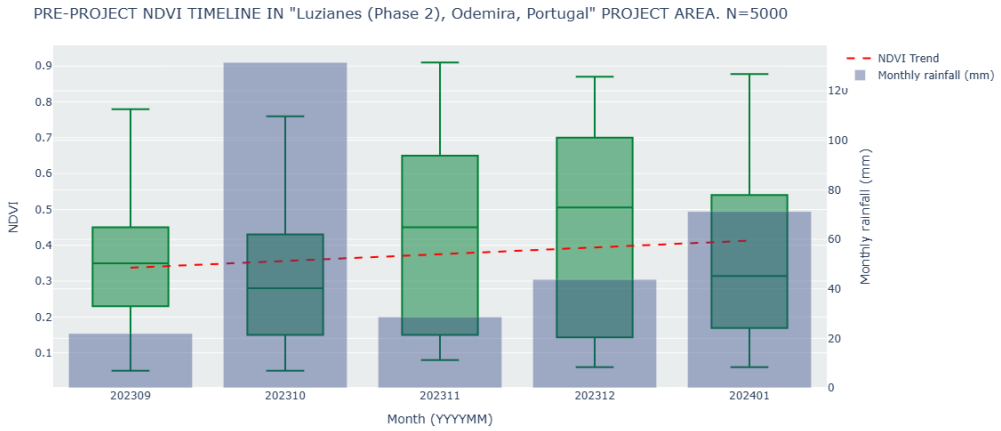

Figure 2. Pre-Project NDVI and Rainfall Trend within Project Area.

2023	September	October	November	December	Mean
NDVI	0.34	0.31	0.42	0.44	**0.38**
GNDVI	0.29	0.39	0.45	0.49	**0.41**

V. THIRD-QUARTER MONITORING (2024)

The third quarter monitoring results recorded further decline in NDVI values (mean 0.23) compared to earlier quarters, indicating that vegetation cover remained sparse. However, GNDVI values exhibited a slight reduction to 0.34, still reflecting stable vegetation health amidst challenging conditions.

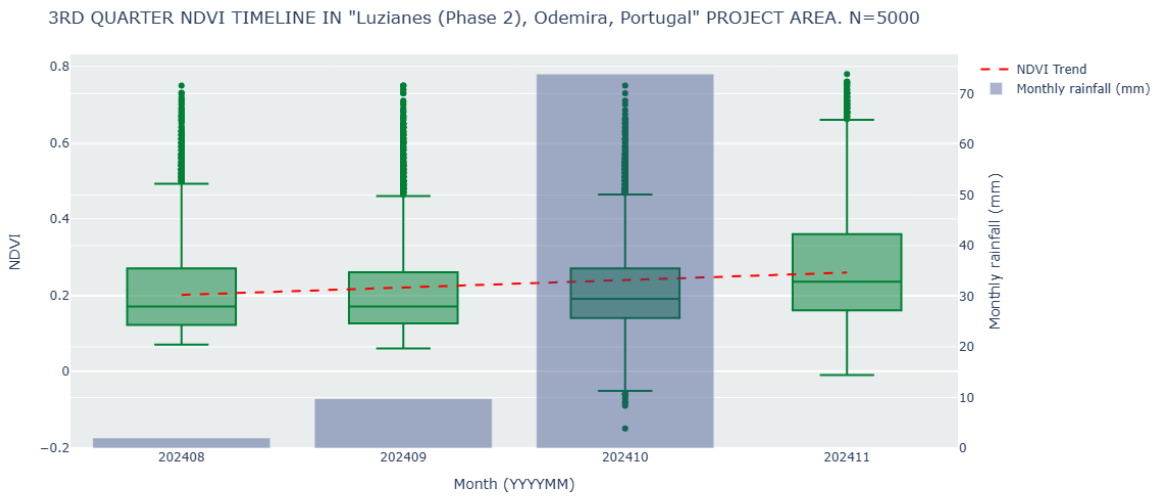

Figure 3. 2024 3rd Quarter NDVI and Rainfall Trend within Project Area.

2024	August	September	October	November	Mean
NDVI	0.21	0.21	0.22	0.28	**0.23**
GNDVI	0.35	0.35	0.32	-	**0.34**

VI. FIRST-QUARTER MONITORING (2025)

An assessment of NDVI and GNDVI values in the project area during the first quarter of 2025 indicates a continued recovery trend when compared to the previous quarter, and relatively stable conditions compared to the same period in the baseline year (2023). NDVI values averaged 0.37 in Q1 2025, a significant improvement over the previous quarter's mean of 0.23, indicating increased vegetation cover and photosynthetic activity.

GNDVI values, which are more sensitive to chlorophyll content, showed a Q1 2025 mean of 0.39, slightly below the 2023 baseline (0.41) but notably higher than the previous quarter's 0.34, suggesting recovery in vegetation health and greenness. The slight dip in February's GNDVI (0.28) could reflect seasonal stress or temporary climatic conditions, though the March rebound suggests this may be transitory.

The current quarter's vegetation indices remain relatively close to baseline conditions, which is concerning given that nearly 14 months have passed since project implementation. This limited improvement may suggest low plant survival rates, suboptimal establishment, or could potentially be attributed to seasonal environmental stressors affecting vegetation performance.

To better understand the underlying causes, continued monitoring in the upcoming quarters is essential. Additionally, a targeted on-site assessment is recommended to evaluate ground conditions, verify vegetation survival, and identify any biotic or abiotic stress factors. These steps will help inform any necessary adaptive management actions to support the recovery trajectory of the restoration site.

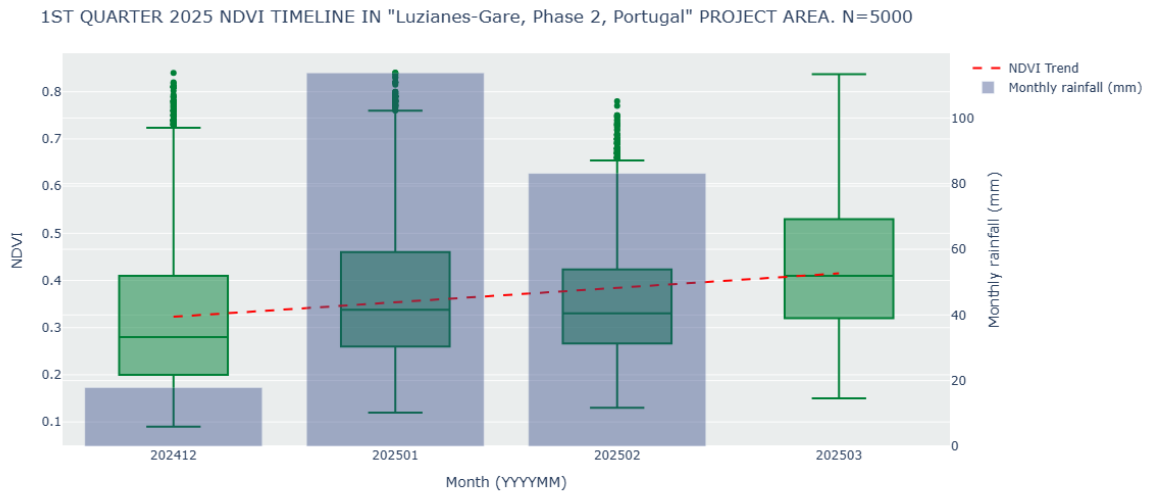

Figure 4. 2025 1st Quarter NDVI and Rainfall Trend within Project Area.

2024/ 2025	December	January	February	March	Mean
NDVI	0.32	0.37	0.35	0.43	**0.37**
GNDVI	0.43	0.45	0.28	0.41	**0.39**

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.

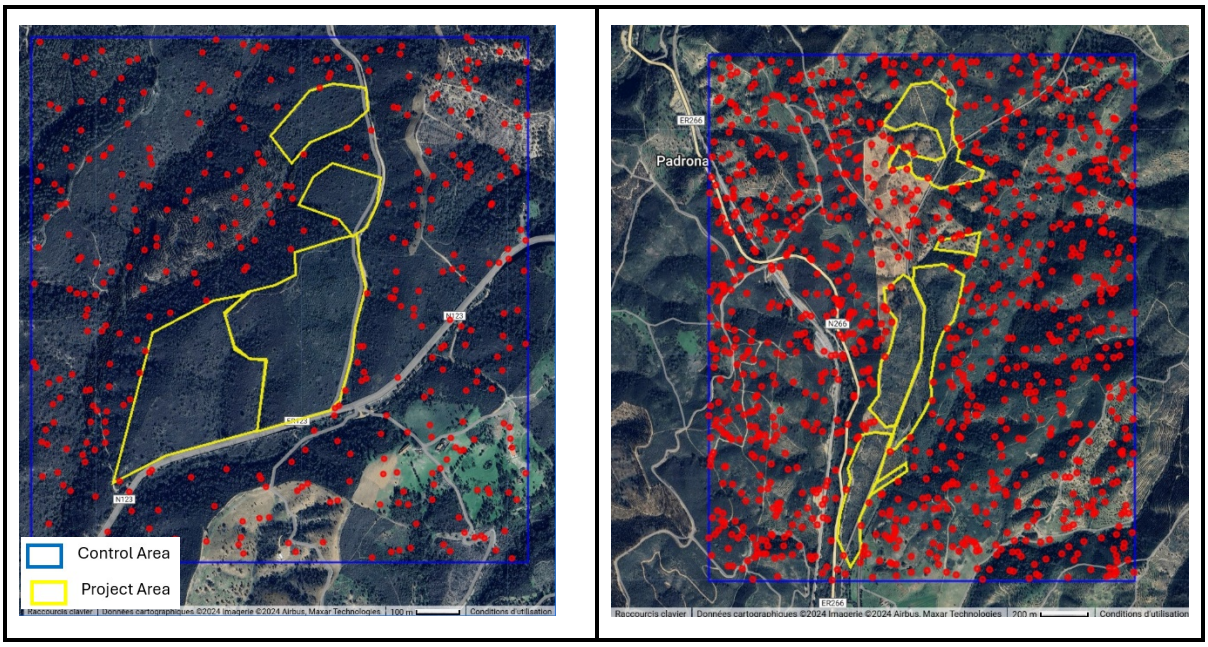

Figure 5. Selected Control Area and Sampling Points

Figure 6 presents the spatial distribution of NDVI across two key assessment periods: the pre-project phase and the first quarter of 2025. During the pre-project phase, NDVI values in the project area were significantly lower compared to the surrounding control areas, reflecting the sparse vegetation in the project area relative to the well-established vegetation in nearby regions. By the first quarter of 2025, the NDVI distribution shows early signs of vegetation growth in some areas within the project area. Though quite low, this may be due to the fact that the young plants may have not yet developed the canopy density needed to significantly influence NDVI.

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.

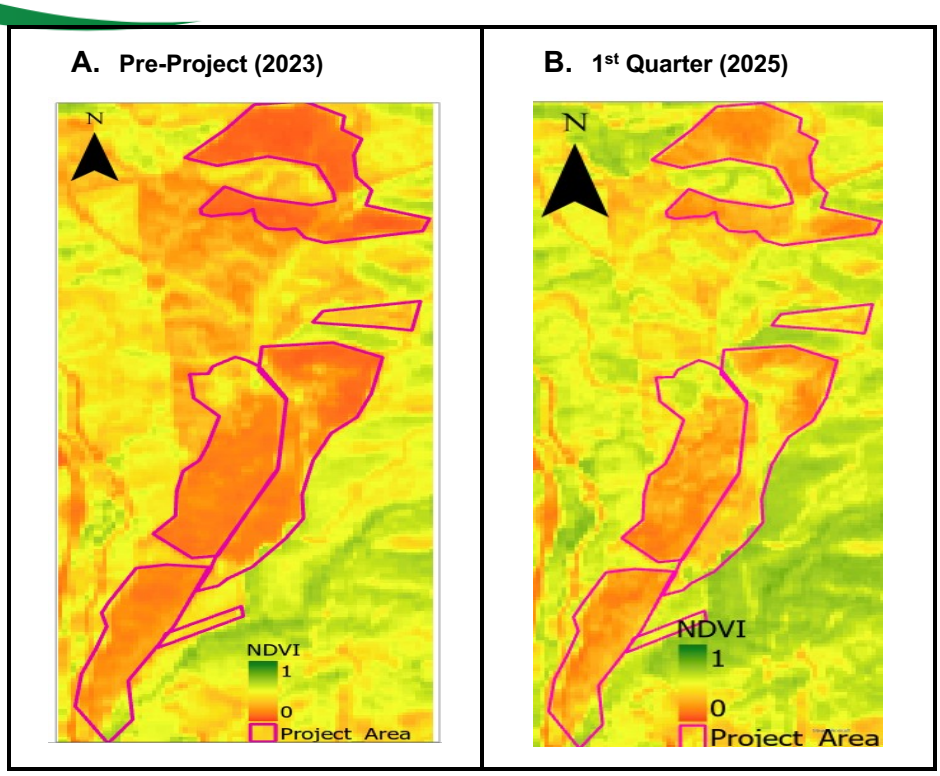

Figure 7. Spatial Evolution of NDVI Within Project area.

The vegetation indices (NDVI and GNDVI) for the project area during the first quarter of 2025 remain notably lower than those of the control area. While the control area maintains consistently high NDVI values (ranging from 0.33 to 0.59) and GNDVI values (0.32 to 0.62), the project area shows moderate to low values, with NDVI fluctuating between 0.25 and 0.37, and GNDVI between 0.28 and 0.45.

At 14 months post-implementation, the NDVI and GNDVI values in the project area remain consistently lower than those in the control areas. This is not unexpected, considering the control area had a pre-existing vegetation baseline, while the project area began from a nearly degraded state. The relatively modest vegetation indices in the project area can be attributed primarily to the early growth stage of the newly planted vegetation. At this stage, most seedlings and young plants have not yet developed the canopy density needed to significantly influence NDVI or GNDVI values. This is particularly true for tree and shrub species, which take time to establish roots, accumulate biomass, and increase leaf area index all of which drive up spectral vegetation signals.

However, the possibility of localized survival issues or environmental stress (e.g., drought, soil limitations, competition with weeds) cannot be ruled out, especially given the sharper declines observed in February. To distinguish between normal growth lag and potential survival or site challenges, a field visit to assess plant survival rates and vigor is advised. Also, continued quarterly monitoring, which will be key to identifying trends of improvement or stagnation over time will be carried out.

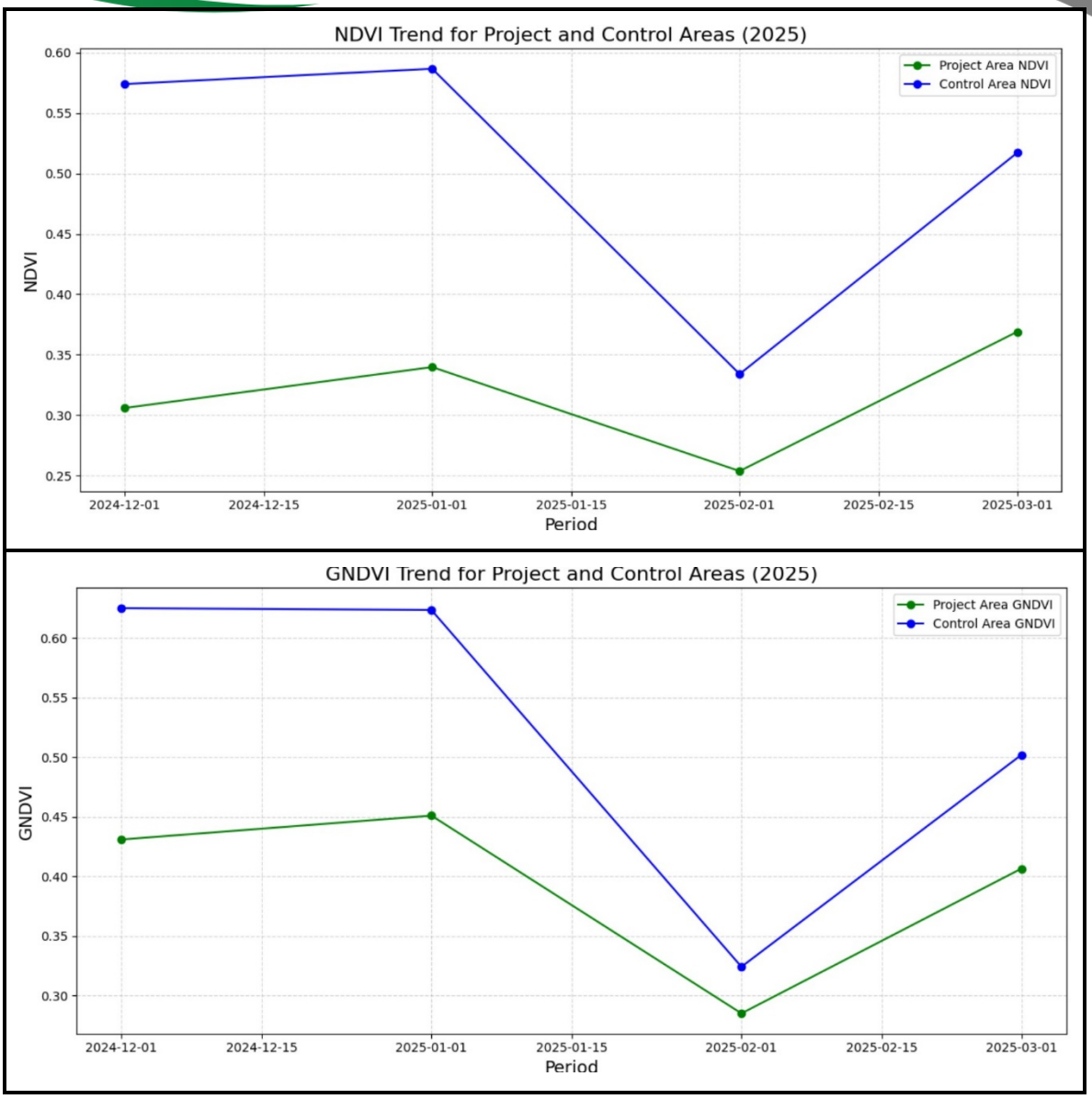

Figure 8. Comparison of NDVI and GNDVI trends between the project and control areas.

VIII. OBSERVATIONS AND COMMENTS

Date	Comments and observations
Pre-project (2023)	During the pre-project phase, NDVI and GNDVI values in the project area were significantly lower compared to the adjacent control areas, reflecting sparse or minimal vegetation. These baseline conditions highlight the degraded state of the project area prior to interventions.
March 2025	NDVI and GNDVI values within the project area remain lower than those observed in the control areas, which had a pre-existing vegetation cover prior to project implementation. Although the gap persists, the overall trend suggests early-stage vegetation establishment. The project area previously characterized by sparse or degraded vegetation shows gradual signs of recovery, though not yet at a significant level. This is consistent with the expected growth trajectory of young vegetation, which typically demonstrates limited canopy development within the first 1–2 years post-planting.

IX. CONCLUSIONS

The first-quarter (2025) monitoring results, 14 months after project implementation, reflect the early establishment phase of the restoration process. Although spectral indices in the project area remain below those of surrounding control areas, this is expected given the project's degraded baseline and the young age of the planted vegetation. Continued monitoring is essential to capture long-term trends and ensure adaptive management. On-the-ground verification will be important to confirm plant survival and identify any site-specific constraints. Overall, the project remains on a plausible recovery trajectory, with anticipated improvements expected in subsequent seasons as vegetation matures.