2025

BASELINE REPORT

VERIFIED CARBON CREDITS (VCC)

SB-001-14072025 PROVINCE DE GUARCIF, ORIENTAL, MAROC

Samir Benhalima
Guercif, Morocco

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Executive summary

The baseline report for the Guercif plantation project is a critical component of its certification process, as it establishes reference metrics for biomass production and future carbon sequestration potential. This report will include the calculation of NDVI and biomass indices using satellite imagery and high-resolution ortho-mosaics, providing a scientifically grounded baseline. Located in Guercif, Morocco, the project encompasses 10 hectares—9 hectares allocated for reforestation and one hectare for seasonal vegetable cultivation. A total of 3,520 trees has been planted across six fruit and nut-bearing species, including two varieties of olive trees. These species were selected to encourage biodiversity rather than monoculture, reflecting a regenerative agriculture approach. The project applies a moderate planting density of approximately 400 trees per hectare and integrates efficient water-saving systems such as drip irrigation and rainwater harvesting. The initiative aims to enhance local biodiversity, improve agricultural productivity, and support sustainable livelihoods for participating landowners and farmers.

The total CO_2 capture for the project area was calculated to be between 1,830.99 and 2,046.03 TCO_2-eq considering survival scenarios of 89.49% and 100% respectively at the end of the 40 years of the project's lifetime. These figures underscore the project's significant contribution to carbon sequestration and overall environmental restoration. The successful reforestation endeavor in Pichucalco demonstrates the positive impact of strategically selecting native species to reclaim and revitalize degraded landscapes, providing ecological, economic, and social benefits for the region and its communities.

I. Project Design

This section is based on the information compiled in the PSF Format - Project Submission Form prepared by the project developer.

I.1. Project location

The project is located in Guercif, Morocco, covering a total area of 10 hectares. Of this, 9 hectares are designated as active reforestation zones, while the remaining hectare is allocated for the cultivation of seasonal vegetables and herbs. A map of the project location is presented in Figure 1, and Table 1 provides the central coordinates of the site.

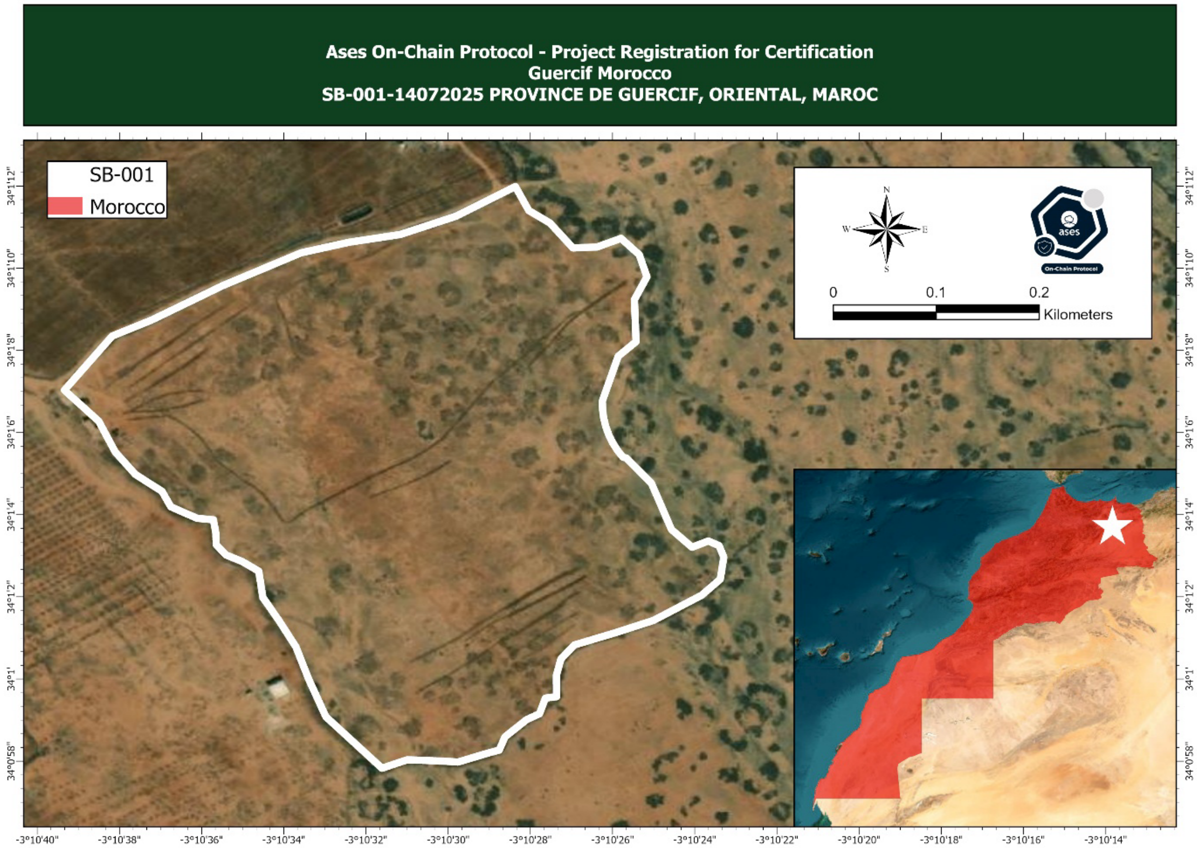


FIGURE 1. PROJECT LOCATION

TABLE 1. CENTRAL COORDINATES OF PROJECT PLOT

Coordinates (decimal degrees)	
Latitude	**Longitude**
34.0180583°N	**3.1750787°W**

I.2. ADMINISTRATIVE SPECIFICATIONS

This section introduces the project developer and provides a clear understanding of the roles and responsibilities assigned to each party involved. It also addresses the status of land ownership, ensuring transparency and certainty regarding the agreements made with the landowners.

I.2.1. Project developer

Key project	SB-001-14072025 PROVINCE DE GUERCIF, ORIENTAL, MAROC
Title of the project activity	Regenerative agriculture in Guercif, Morocco
Company	Samir Benhalima
Person responsible	Samir Benhalima

I.2.2. Type of project

Project registration year	2025
Project duration	40 years
Issuance of credits	Annual
Methodology applied	Methodology for estimating carbon removal capacity of projects V2.0[1]
Type	☐ Forest management ☒ Regenerative agriculture ☐ Silvopastoral management ☐ Individual tree-based climate action / urban forest ☐ Water flow restoration ☐ Biochar

I.2.3. VNPCs the project is applying to

Type of VNPCs the project is applying for	☒ Carbon Removals (VCC) ☐ Biodiversity Based Credit (VBBC) ☐ Water Credits (VWC) ☐ Soil Credits (VSC)

1 https://www.nat5.bio/wp-content/uploads/2024/03/aOCP-Methodology-for-estimating-the-carbon-removal-capacity-of-projects-V2.0.pdf

II. PROJECT AREA BASELINE

The project area is located in an arid region of northern Morocco, characterized by low and irregular rainfall, high evapotranspiration, and generally poor soil fertility. Despite these challenging conditions, agriculture remains a key livelihood activity in the region. Traditional practices, particularly the cultivation of olive trees, are commonly observed around the project site, alongside other small-scale agricultural activities such as almond, fig, and citrus farming. These crops are typically chosen for their resilience to dry conditions and their economic importance to local farmers. Livestock grazing and seasonal vegetable cultivation are also practiced in surrounding areas, often relying on limited water resources. The implementation of this project aligns with regional agricultural traditions while introducing regenerative practices and improved water management systems, such as drip irrigation and rainwater harvesting, to enhance land productivity and climate resilience.

II.1. SPECTRAL RESPONSE

When solar radiation interacts with an object, one of three situations can occur, either individually or in combination:

Reflection: The radiation can bounce off the object partially or entirely, resulting in reflection.

Absorption: The object can absorb the radiation, taking in its energy.

Transmission: Radiation can pass through one object and reach another, known as transmission.

The extent to which radiation is reflected, absorbed, or transmitted depends on the specific physicochemical characteristics of the objects involved. However, for object identification purposes, our primary interest lies in the reflected light or radiation at different wavelengths. For instance, vegetation exhibits low reflectance in the visible range, but the presence of chlorophyll in plants increases reflectance in the green channel. On the other hand, plants demonstrate the highest reflectance in the near infrared region of the electromagnetic spectrum.

II.1.1. INDEX

Vegetation indices (VI) are extensively employed for monitoring and detecting changes in vegetation and land cover. These indices are created by considering the contrasting absorption, transmittance, and reflectance of energy by vegetation across the red and near-infrared portions of the electromagnetic spectrum. Numerous studies have demonstrated that the Normalized Difference Vegetation Index (NDVI) is particularly resilient against the influence of topographic factors. NDVI is commonly utilized as a broad indicator of photosynthetic activity in plants and the corresponding aboveground primary production. It provides information on the quantity and quality of vegetation in a given area. It varies from -1 to +1, where values closer to +1 indicate dense and healthy vegetation, while values close to -1 suggest a lack of vegetation or presence of artificial surfaces.

The calculation of NDVI was performed using Sentinel-2 satellite images in the Google Earth Engine platform. Images with less than 20% cloud cover were selected for each month. Additionally, random control points were created within the reforestation area, and the monthly NDVI and rainfall values at each point were extracted. Google Colab was then used to generate a box plot showing the distribution of NDVI values at the control points. The assessment focused on the average monthly NDVI time series spanning from January 2019 to June 2025. The NDVI analysis (Figure 2) indicates generally stable but low NDVI values from 2019 through late 2023, with most values fluctuating around 0.2 and showing little evidence of a long-term upward trend. A notable increase begins in early 2024, suggesting an improvement in vegetation health or coverage. This rise in NDVI corresponds with the reported start of planting activities during the same period (January 2024). Although monthly rainfall has varied over the years, NDVI remained relatively steady until this recent increase, implying that the observed improvement is likely attributable to project interventions.

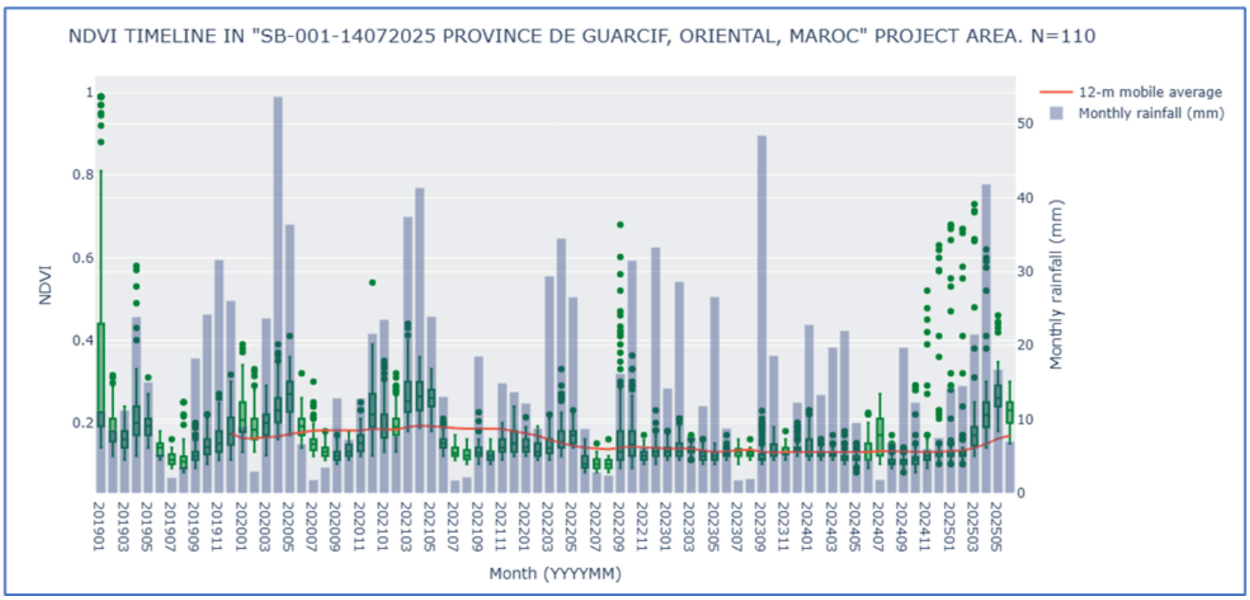


FIGURE 2. NDVI TIME SERIES IN THE AREA OF INTEREST

II.2. IMPACT ON THE LANDSCAPE

The primary objective of the Guercif project in Morocco is to implement regenerative agriculture practices by cultivating olive trees alongside a variety of other fruit-bearing species, with a strong emphasis on promoting biodiversity over monoculture. As shown in Figure 3, satellite imagery of the project area from 2019 to 2023 captures notable changes in land use and management, despite being taken prior to the official project launch in early 2024. Evidence of early site development is visible as early as 2023, including the construction of additional buildings, improved road infrastructure, and the establishment of clearly defined planting zones in the southeastern portion of the project site. Within the project boundaries, signs of land preparations, such as vegetation clearing and site organization, suggest proactive management efforts in anticipation of project implementation.

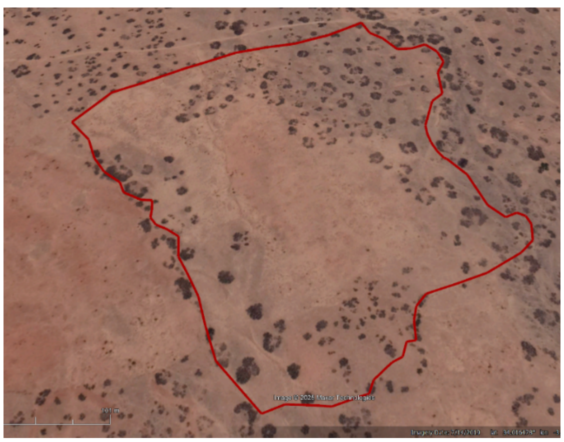
2019	2023
	

FIGURE 3. SATELLITE AERIAL VIEW OF PROJECT AREA

III. Technical specifications

III.1. Carbon removal

This section analyzes the carbon sequestration expected by the project from the reforestation.

III.1.1. Reforested area

The project covers a plot with a total area measuring 9 hectares situated in Guercif, Oriental, Morocco.

III.1.2. Species

The reforestation project successfully planted a total of 3,520 trees of six different species. The number of individuals of each species is shown in Table 2. The selection of species was based on a preliminary assessment of the region, considering available bibliographic information, as well as the prevailing climatic, vegetative, and meteorological conditions. All species chosen are indigenous to the area and well-suited to the local climate and environmental conditions. Out of the total number of trees planted (3,520), the percentage by species and origin is presented in Table 2.

Table 2. Number and Origin of Trees by Species

Species	Number of trees	Percentage (%)	Origin
Prunus dulcis	300	9.2	Native
Citrus limon	200	6.2	Native
Ficus carica	200	6.2	Native
Olea europaea var. picholine marocaine	1,400	43.1	Native
Olea europaea picual	1,400	43.1	Native
Punica granatum	20	0.6	Introduced
Total	**3,520**	**100%**	

The assessment revealed an average planting density of one tree per 12.78 square meters, equivalent to an average of 391 trees per hectare in the plot. This moderate density approach offers several ecological, environmental, and economic advantages. The moderate tree density, combined with the implementation of various tree species, will foster biodiversity and enhance ecological resilience within the restored ecosystem. Moreover, the density will expedite canopy closure, creating a continuous cover as the tree canopies interlock. This canopy closure plays a crucial role in weed suppression, creating improved microclimates, moisture retention and reducing soil erosion.

It is important to note, however, that high planting densities may lead to competition for resources among trees, which may result in stunted growth, reduced health, and increased mortality of some trees. In addition, the proximity between trees can facilitate the rapid spread of diseases and pests, therefore, controlling and managing these issues can become more complex in densely planted areas.

From this moderate density with "wide spacing" planting strategy, the reforestation project is well-positioned to maximize carbon sequestration potential, promote wildlife habitat, and provide essential ecosystem services. The management of this densely planted plot will be critical to ensure the continued success and long-term sustainability of the reforestation efforts.

III.1.2.1. Distribution/Origin of the species selected for reforestation

The distribution of plant species is influenced by a variety of abiotic and biotic factors, including:

- Climate
- Soil
- Topography
- Hydrology
- Competition between plants for resources
- Seed dispersal

These factors interact in complex ways to determine the distribution of plant species across a landscape.

Understanding and knowing the distribution of the flora species that have been selected for reforestation is important to ensure the adaptation of the new trees and their survival, to secure the long-term benefits of the project, and to avoid altering the ecosystem balance by introducing non-adapted species.

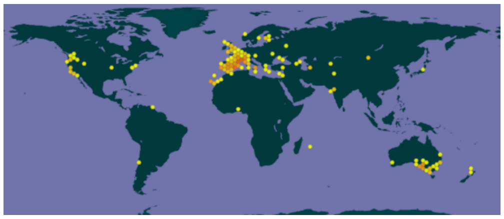
To achieve this, each species was consulted in the Global Biodiversity Information Facility GBIF (https://www.gbif.org). This database allows you to know the species classified as introduced in each country, their EUNIS habitat, their native range, and observation records.

The Global Register of Introduced and Invasive Species (GRIIS) presents validated lists of introduced (alien) and invasive alien species at the country, territory, and associated island level. The International Union for Conservation of Nature (IUCN) describes an introduced/alien and invasive alien species as follows:

- **Introduced/alien species:** A species, subspecies, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e., outside the area, it could occupy without human intervention) and which has been transported by human activity; this includes any parts, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.
- **Invasive alien species**: A species that becomes established in natural or semi-natural ecosystems or habitats, is an agent of change, and threatens native biological diversity. This includes widespread species, rapidly expanding, or present in high abundance and that hurt biodiversity.

According to the aOCP's eligibility criteria, species classified as invasive alien species cannot be counted towards the project's benefits.

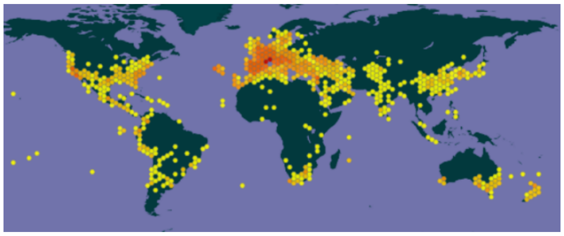
- *Prunus dulcis*

Recorded as introduced in Morocco	☐ Yes ☒ No
Habitat EUNIS	• Arable land and market gardens (I1 level 2) • Broadleaved deciduous woodland (G1 level 2) • Buildings of cities, towns and villages (J1 level 2) • Constructed, industrial and other artificial habitats (J level 1) • Domestic gardens of city and town centers (X24 level 2) • Dry grasslands (E1 level 2) • Cultivated areas of gardens and parks (I2 level 2)
Native range	• Arabian Peninsula • Asia- Temperate • Europe • Middle Asia • Northern Africa • Southeastern Europe • Southwestern Europe
Georeferenced records	

- *Citrus limon*

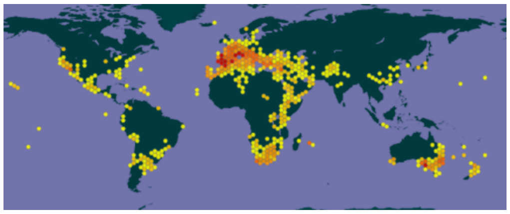
Recorded as introduced in Morocco	☐ Yes ☒ No
Habitat EUNIS	Not specified
Native range	Not specified
Georeferenced records	

- *Ficus carica*

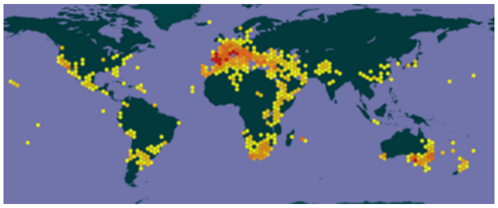
Recorded as introduced in Morocco	☐ Yes ☒ No
Habitat EUNIS	Not specified
Native range	Not specified
Georeferenced records	

- *Olea eurpaea var. picholine marocaine*

Recorded as introduced in Morocco	☐ Yes ☒ No
Habitat EUNIS	Not specified
Native range	• Europe • Northern Africa

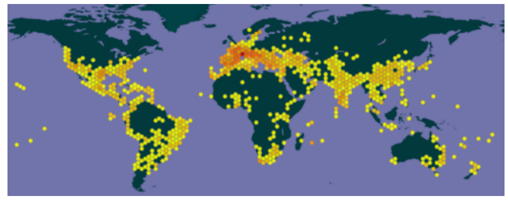
Georeferenced records	

- *Olea europaea picual*

Recorded as introduced in Morocco	☐ Yes ☒ No
Habitat EUNIS	Not specified
Native range	• Europe • Northern Africa
Georeferenced records	

- *Punica granatum*

Recorded as introduced in Morocco	☒Yes ☐No
Habitat EUNIS	Constructed, industrial and other artificial habitats (J level 1) Regularly or recently cultivated agricultural, horticultural and domestic habitats (I level 1)
Native range	• Arabian Peninsula • Asia- Temperate • Caucasus • Europe • Western Asia

Georeferenced records	

Punica granatum is considered an introduced species in Morocco (https://www.gbif.org/fr/species/160942786/verbatim). No negative impact has been reported from the species, therefore, it will be included in any calculations relevant to this project and is considered *noninvasive*.

From the 6 implemented plants species, one species is considered introduced in Morocco, however, no species are considered invasive; therefore, all species can be considered for biodiversity or carbon credit generation for the project.

The technical data sheets providing detailed information about each of the species utilized for the reforestation project are included below, in Table 3. These sheets offer insights into the characteristics, growth patterns, environmental requirements, and other relevant details of the selected plant species. These data sheets serve as valuable references for understanding the specific attributes and suitability of each species for the reforestation efforts.

TABLE 3. TECHNICAL DATA SHEETS FOR SPECIES USED IN REFORESTATION EFFORT

Prunus dulcis • **Native Habitat:** Native to the Middle East and South Asia, particularly Iran and surrounding regions. It thrives in Mediterranean climates with hot, dry summers and mild, wet winters. • **Primary Use:** Cultivated primarily for its edible seeds (almonds), used in food products, oils, and cosmetics. • **Growth Characteristics:** Almond trees typically grow 4–10 meters in height. They require well-drained soils and full sun and are deciduous with early spring blossoms. • **Ecological Role:** While often grown in monocultures, almond orchards can support pollinators, especially bees, during blooming. • **Economic Importance:** A significant global crop, especially in Spain, the U.S. (California), and Morocco, almonds are a key export and high-value nut commodity.	

Citrus limon • **Native Habitat:** Believed to have originated in Northeast India and spread through Asia and the Mediterranean. Prefers subtropical to Mediterranean climates. • **Primary Use:** Cultivated for its fruit, used for juice, zest, and essential oils in food, beverages, and cleaning products. • **Growth Characteristics:** Lemon trees grow up to 3–6 meters tall, are evergreen, and can fruit year-round under the right conditions. • **Ecological Role:** Supports pollinators and beneficial insects. When grown in polycultures, contributes to agroecosystem diversity. • **Economic Importance:** A widely cultivated citrus crop, lemons are economically valuable for both fresh consumption and industrial uses.	
Ficus carica • **Native Habitat:** Native to the Middle East and Western Asia; naturalized throughout the Mediterranean and other warm regions. • **Primary Use:** Grown for its edible fruit (figs), consumed fresh or dried and used in cooking and baking. • **Growth Characteristics:** Deciduous tree reaching 3–10 meters. Thrives in warm, dry climates and tolerates poor soils. • **Ecological Role:** Supports bird and insect biodiversity and often grows in marginal lands, contributing to soil stabilization. • **Economic Importance:** Figs are a culturally and economically important fruit in Mediterranean agriculture, with high value in local and export markets.	

Olea europaea var. picholine marocaine • **Native Habitat:** Originates from the Mediterranean region; the Moroccan variety is adapted to semi-arid conditions. • **Primary Use:** Cultivated for dual purposes: oil production and table olives, known for their firm texture and rich flavor. • **Growth Characteristics:** Slow-growing evergreen tree that can reach up to 6–12 meters. Drought-tolerant and long-lived. • **Ecological Role:** Promotes biodiversity in traditional agroforestry systems and stabilizes soil in arid areas. • **Economic Importance:** A major olive cultivar in Morocco, supporting local economies through oil cooperatives and olive markets.	
Olea europaea picual • **Native Habitat:** Native to Spain, particularly Andalusia. Thrives in Mediterranean climates with dry summers and mild winters. • **Primary Use:** Primarily used for high-yield olive oil production, known for its stability and high oleic acid content. • **Growth Characteristics:** Evergreen tree growing up to 10–12 meters. Highly productive and drought tolerant. • **Ecological Role:** Offers erosion control and shade in Mediterranean agroecosystems and supports some wildlife. • **Economic Importance:** One of the most widely cultivated olive cultivars globally, it dominates Spanish olive oil production and export.	

Punica granatum	
• **Native Habitat:** Native to the region extending from Iran to Northern India and widely cultivated throughout the Mediterranean. • **Primary Use:** Grown for its nutrient-rich fruits used in juices, cooking, and cosmetics. • **Growth Characteristics:** Deciduous shrub or small tree, typically 2–5 meters tall. Drought-tolerant and well-suited to arid and semi-arid climates. • **Ecological Role:** Flowers attract pollinators, and the plant can be used in hedgerows or erosion-control systems. • **Economic Importance:** Increasingly valued for its health benefits and antioxidant-rich juice, pomegranates are an important commercial fruit in dryland farming.	

III.1.3. Reforestation technique

The reforestation technique implemented is the wide spacing or moderate-density planting technique. Wide spacing or moderate density planting is a reforestation technique where tree seedlings are planted with relatively larger gaps between them. This approach contrasts with high-density planting, where seedlings are placed closer together. The wide spacing technique aims to provide individual trees with more access to essential resources such as sunlight, water, and nutrients, allowing them to grow with reduced competition. The goal of this technique is to optimize the use of available resources, such as sunlight, water, and nutrients by creating a more efficient growing environment as trees have ample room to establish strong root systems and develop healthier canopies, potentially leading to better long-term growth. Additionally, with wider spacing, there's a reduced risk of disease transmission between trees compared to denser plantings.

Nevertheless, it is important to note that the suitability of wide spacing depends on factors like soil type, climate, and water availability. In addition, choosing tree species adaptable to wider spacing is crucial for successful establishment. It is a balance between optimizing individual tree growth and considering the overall ecosystem dynamics.

III.1.3.1. Methodological process

The operational phase is divided into three steps shown in Figure 4.

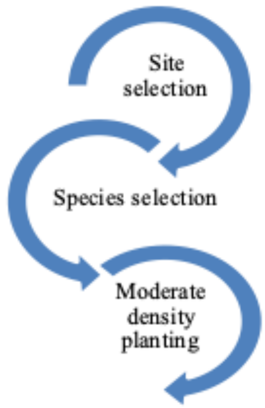


FIGURE 4. METHODOLOGICAL PROCESS

The reforestation process involved a well-defined series of steps. Firstly, a thorough evaluation was conducted to select the most suitable reforestation area, considering restoration needs, climatic and soil feasibility, permit requirements, and cost considerations. It ensured that the chosen location was conducive to successful reforestation. To preserve the ecological integrity of the region, reforestation was not carried out on scarified ground. This approach aimed to leverage the existing ecosystem to facilitate the growth and development of the newly planted trees, promoting biodiversity and increasing the chances of successful reforestation. Local community stakeholders were actively involved in the process, fostering a sense of ownership and sustainability in the reforestation initiative.

III.1.4. PROJECT CAPACITY

This section determines the project's and the area's capacity to absorb CO_2 using Net Primary Productivity (NPP) as a reference parameter. Three approaches are used to arrive to a sound result considering various ecological aspects and data sources:

A. Species-specific allometric equations, survival/mortality defined by tree density according to mean DBH of trees and latitude, according to (Madrigal-González et al., 2023).
B. Species-specific allometric equations, survival/mortality defined by tree density according to regional timber plantation tables,
C. Carbon stocks derived through a machine learning model trained with the Global Forest Aboveground Carbon Stocks and Fluxes from GEDI and icesat-2, a global carbon dataset.

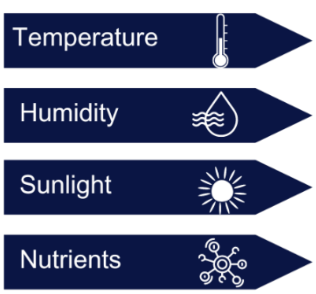
For all three approaches, Net Primary Productivity (NPP) is regarded as the upper limit, representing the maximum achievable carbon sequestration potential based on biophysical considerations.

Using Net Primary Productivity (NPP) as a reference parameter. The amount of CO_2 that can be captured is then estimated with allometric equations considering the age and height of individual species. Subsequently, the estimation of survival rates is derived from tree density projections published in the study by Madrigal-González et al. (2023).

III.1.4.1. Net Primary Productivity (NPP)

Net Primary Productivity (NPP) is the result of organic matter production through the process of photosynthesis. However, primary productivity involves more than photosynthesis; it also encompasses the uptake of inorganic nutrients and the assimilation of diverse organic compounds into protoplasm, which are vital for all photosynthetic organisms. Among various ecosystem processes, NPP is extensively measured due to its ability to reflect carbon accumulation in ecosystems. The calculation of NPP is based on the increase in biomass per unit area over a specified period.

NPP is influenced by several factors, including:



Hence, the net primary productivity (NPP) can be expressed as the difference between the carbon absorbed by vegetation through photosynthesis (referred to as Gross Primary Production or GPP) and the carbon lost through respiration. Temperature and precipitation are key limiting factors for NPP, and it is generally assumed that NPP increases with both temperature and precipitation. However, it is important to note that the NPP cannot exceed the saturation value of 3000 gDM/m^2/year (DM stands for dry matter) in either case.

For the calculation of NPP in the Murcia Ecological Restoration project, present and future NPP were computed to take into consideration ecosystem's vulnerability to climate change and to define the threshold for carbon sequestration. Both were computed on Google Earth Engine using the resources available in the catalog. Present NPP was calculated for 2024 from 2 data sources: a) precipitation data from the "CHIRPS Daily: Climate Hazards Group Infrared Precipitation with

Station Data (Version 2.0 Final)" dataset (Funk et al., 2015) and b) temperature data from the MODIS/Terra Land Surface Temperature/Emissivity Daily L3 Global 1km SIN Grid V061 [Dataset] (Wan et al., 2021). Future NPP was computed using precipitation and temperature data for the year 2064, from the NEX-GDDP-CMIP6 dataset (Thrasher et al. 2022). This dataset, comprised of global downscaled climate scenarios derived from the General Circulation Model (GCM), runs conducted under the Coupled Model Intercomparison Project Phase 6; the CMIP6 GCM runs were developed in support of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6).

This methodology incorporates the following equations to determine NPP:

$$\mathbf{NPP} = \mathbf{min}\ (\mathbf{NPP_T}, \mathbf{NPP_P})$$

Where:

$$NPP_T = 3000(1 + exp(1.315 - 0.119 * T))^{-1}$$

$$NPP_P = 3000(1 - \mathrm{Exp}(-0.000664 * P))$$

Where:

T: average annual temperature

P: accumulated precipitation

Carbon capture capacity was calculated using the conversion factor 0.47 (IPCC, 2006), using the following equation:

$$NPP_c = NPP_{dm} \times 0.47$$

Where:

Npp_c: Net primary productivity, gc m-2 yr-1

Npp_{dm}: Net primary productivity, gdm m-2 yr-1

Then, the equivalence to carbon dioxide was calculated using the conversion factor of 3.67. This factor represents the molar mass ratio of CO_2: C. CO_2 molar mass is 44 and C is 12, therefore, 44/12 = 3.67. The conversion was done using the following equation:

$$CO_2 \text{ capture capacity} = 3.67(npp_c)$$

Finally, the maximal CO_2 capture capacity for the Project area was computed by multiplying the previous result by the Project area surface. The calculation was repeated for each scenario (present with real data, present with CMIP data and future with CMIP data). Real data is privileged over modelled data for the present scenario. To estimate future NPP, the percent change was calculated between present and future estimates done with CMIP6 data. This percent change was then applied to the present estimate done with real data, this way we obtain a future NPP estimate based on present real data.

The results (Table 4) indicate that the project area currently has an NPP of 272.06 gDM m^{-2} yr^{-1}, which, due to the climatic conditions, will decrease to 225.91 gDM m^{-2} yr^{-1} in 2064. This change, of -46.15 gDM m^{-2} yr^{-1}, represents a decrease of -16.96%. In terms of CO_2, **the Project restoration area (9 ha) is currently capable of capturing 47,486.14 kgCO_2 yr^{-1} and is expected to capture around 39,431.54 kgCO_2 yr^{-1} by 2064**.

Based on these results, it has been determined that **39.43 TCO_2-eq/year** will serve as the base parameter for the estimation of maximum achievable annual CO_2 capture. For the 40 years of the project, it equals **1,577.26 TCO_2-eq.**

TABLE 4. NPP AND BIOMASS POTENTIAL BY ALL PLOTS WITHIN THE PROJECT SITE.

NPP	Present Real Data	Present CMIP	2064 CIMP	CMIP Change	CMIP % Change	2064 Based on Real Data	Real Data Change
gDM/m^2/yr	272.06	613.51	509.45	-104.06	-16.96	225.91	-46.15
gCO_2/m^2/yr	469.27	1058.24	878.75	-179.50	-16.96	389.67	-79.60
gC/m^2/yr	127.87	288.35	239.44	-48.91	-16.96	106.18	-21.69
KgCO_2/plot/yr	47,486.14	107,085.69	88,921.82	-18,163.87	-16.96	39,431.54	-8,054.60

III.1.4.2. Allometric Equations

Allometric equations are mathematical formulas used to estimate the amount of CO_2 that can Be captured and stored in certain types of vegetation, such as trees or shrubs, depending on Their morphometry. Table 5 shows the allometric equations used for each species planted.

TABLE 5. SPECIES-SPECIFIC ALLOMETRIC EQUATIONS

Species	Allometric Equation CO_2 absorbed (Kg)	Reference
Prunus dulcis	Biomass=20.48931-1.67602*(DBH)+1.07958*((DBH)^(2))	Wiant, H. V., Jr.; Sheetz, C.; Colaninno, A.; Moss, J.; Castaneda, F. 1977. Tables and procedures for estimating weights of some Appalachian hardwoods. Bull.

Species	Allometric Equation CO_2 absorbed (Kg)	Reference
		659T. Morgantown, WV: West Virginia University Agricultural and Forestry Experiment Station
Citrus limon	Biomass=0.1245*(DBH)^(2.4163)	Hung, D.N., Son, N.V., Hung, N.P. (2012) Tree allometric equation development for estimation of forest above-ground biomass in Viet Nam - Evergreen broadleaf forests in Quang Binh Province in (Eds) Inoguchi, A., Henry, M. Birigazzi, L. Sola, G. Tree allometric equation development for estimation of forest above-ground biomass in Viet Nam, UN-REDD Programme, Hanoi, Viet Nam
Ficus carica	Biomass=0.1245*(DBH)^(2.4163)	Hung, D.N., Son, N.V., Hung, N.P. (2012) Tree allometric equation development for estimation of forest above-ground biomass in Viet Nam - Evergreen broadleaf forests in Quang Binh Province in (Eds) Inoguchi, A., Henry, M. Birigazzi, L. Sola, G. Tree allometric equation development for estimation of forest above-ground biomass in Viet Nam, UN-REDD Programme, Hanoi, Viet Nam
Olea eurpaea var. picholine marocaine	Biomass=-359.11+50.19*(DBH)-0.44*(DBH)^(2)	Abbas, M., Nizami, S. M, Saleem, A., Gulzar, S.& Khan, I.A. 2011. Biomass expansion factors of Olea ferruginea (Royle) in sub tropical forests of Pakistan. African Journal of Biotechnology, 10(9): 1586?1592.
Olea europaea picual	Biomass=-359.11+50.19*(DBH)-0.44*(DBH)^(2)	Abbas, M., Nizami, S. M, Saleem, A., Gulzar, S.& Khan, I.A. 2011. Biomass expansion factors of Olea ferruginea (Royle) in sub tropical forests of

Species	Allometric Equation CO_2 absorbed (Kg)	Reference
		Pakistan. African Journal of Biotechnology, 10(9): 1586?1592.
Punica granatum	Biomass=0.1245*(DBH)^(2.4163)	Hung, D.N., Son, N.V., Hung, N.P. (2012) Tree allometric equation development for estimation of forest above-ground biomass in Viet Nam - Evergreen broadleaf forests in Quang Binh Province in (Eds) Inoguchi, A., Henry, M. Birigazzi, L. Sola, G. Tree allometric equation development for estimation of forest above-ground biomass in Viet Nam, UN-REDD Programme, Hanoi, Viet Nam

Carbon stocks in planted trees and shrubs at year 40 was calculated applying these allometric equations to the tree dimensions expected at age 40. The total carbon storage at year 40 for the 3,520 trees and shrubs is estimated to be 2,046.03 Tons CO_2.

Due to natural ecological processes, a fraction of the planted trees and shrubs will die. The survival/mortality percentages were computed with two different approaches, as described in the following subsection.

III.1.5. CO_2 CAPTURE

In reforestations carried out in degraded areas, a planting density of 1 tree every four meters is

considered, since distributing the trees in this way allows each tree to have enough space to grow

And develop adequately, avoiding excessive competition for resources such as sunlight, water,

And soil nutrients. The reference density for this scenario is 16 square meters per tree. At present, the project has achieved a density of 12.78 square meters per tree, which is more dense than the targeted reference density.

Planting density can have significant implications for the success of reforestation efforts. By providing adequate space for individual tree growth, the chances of survival and healthy development are increased. Proper management practices will be essential to ensure the optimal utilization of resources, especially as the trees grow and compete for sunlight, water, and nutrients. Maintaining the appropriate balance between tree density and resource availability will be crucial to sustaining the health and productivity of the reforested ecosystem over time.

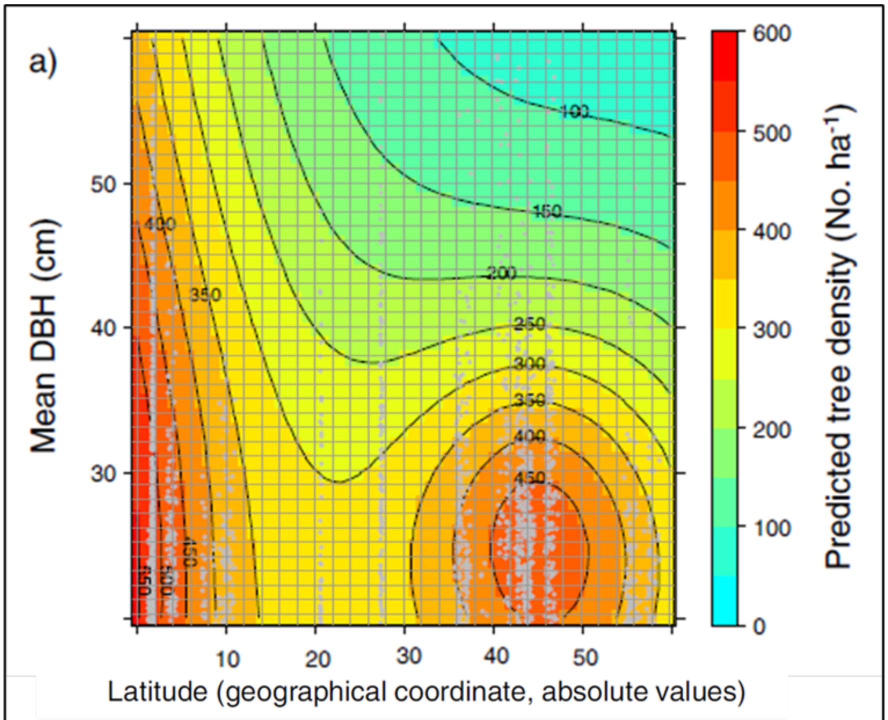
The avoidance of resource competition promotes optimal access to sunlight for photosynthesis, sufficient water uptake, and efficient nutrient absorption from the soil as defined by the Net Primary Productivity (NPP). These factors are crucial for the establishment of a sustainable and resilient forest ecosystem.

III.1.5.1 Survival rate based on forest tree density.

Tree density as a function of mean DBH and latitude.

One estimation of survival rate is based on the results from Madrigal-González et al. (2023). These authors established the relationship between mean Diameter at Breast Height (DBH) and latitude in determining forests' tree density (Figure 5).

According to this reference, predicted tree density for an area located at latitude 34.01°N, and with a mean tree diameter of 21.96 cm is around 350 trees per hectare. Considering that 3,520 trees and shrubs were planted in the restoration area (9 ha), i.e. 391 trees per hectare, a survival of 89.49% would lead to the density of 350 trees ha-1, proposed by Madrigal-González et al. (2023).



Source: Madrigal-González et al. (2023), figure 2a.

FIGURE 5. PREDICTED TREE DENSITY AS A FUNCTION OF MEAN DBH AND LATITUDE. SOURCE: MADRIGAL-GONZÁLEZ ET AL. (2023).

Tree density according to timber plantation tables.

Cienciala et al. (2022) elaborated a list of estimated survival rate due to tree mortality and management interventions by biogeographic regions and species group types. For Mediterranean conifers and broadleaves, they report a stand density at year 40 from plantation, of 1169 trees per hectare. Since the plantation in the restoration area has a density of 391 trees ha-1, a survival of 298.89% would lead to the final density reported by the authors.

In conclusion, currently the project has a density of 391 trees and shrubs per hectare, which will generate an initial competition for resources. However, due to the expected mortality that occurs in each reforestation project, the planting density will progressively decrease and the trees that manage to adapt and survive will have increasing access to the available resources (water, sunlight, and nutrients) and will be able to continue growing.

Based on the 2 density references, there are 2 scenarios for survival rate of the project at year 40. One estimates survival at 89.49% and the other at over 100%.

III.1.5.3.2. Carbon capture in vegetation

The carbon removal potential, calculated using the allometric equations, was adjusted to account for survival/mortality, as follows. Survival scenario 1, calculated from tree density predicted by Madrigal-González et al. (2023), results in a survival of 89.49% of planted trees and shrubs. Therefore, 89.49% of the carbon removal potential equals 1,830.99 T CO_2-eq along the 40 years of the project. Survival scenario 2, calculated from tree density predicted by Cienciala et al. (2022), results in a survival of 100% of planted trees and shrubs. Therefore, 100% of the carbon removal potential equals 2,046.03 T CO_2-eq along the 40 years of the project.

Considering these 2 scenarios, the amount of carbon removals the project can generate attributable to the planted trees and shrubs lies between 1,830.99 and 2,046.03 T CO_2-eq. However, it is important to note that this ex-ante estimation excludes carbon removals from vegetation that develops in the project area natural regeneration, triggered by Project activities. As the reforestation matures, it is expected that monitoring campaigns reveal carbon stocks higher than those estimated ex-ante. These estimates were and will continue to be cross-referenced with the maximum carbon removal determined through Net Primary Productivity (NPP), which for this project equals 1,577.26 T CO_2-eq, to ensure adherence to biophysical ecological limits, thus avoiding overestimates.

III.1.5.2. Carbon Credits

According to *aOCP Methodology for carbon removal and storage in vegetation V2.0,* this ecological restoration project in Guercif, Morocco, spanning an area of 9 hectares with 3,520 trees and shrubs planted, has the potential to generate between 1,831 and 2,046 Verified Carbon Credits (VCC) from removals. This range considers survival scenarios of 89.49% and 100%, as elaborated above. However, the inclusion of carbon capture calculations conducted by the project developers will further refine these estimates and provide a more comprehensive assessment of the project's environmental impact.

The project developers did not indicate a predicted carbon capture for the project; however, they did state that they expected a 82.5% survival of the reforested individuals at the completion of the project period. By applying this survival rate to the initially aOCP determined carbon capture, this rate yields 1,687.98 T CO_2-eq. Table 6 presents a summary of the of the considerations.

TABLE 6. ESTIMATED CARBON CAPTURE OF ECOLOGICAL RESTORATION PROJECT AT YEAR 40.

	Survival Scenarios		Carbon Capture (TCO_2-eq)	Carbon credits (VCC)
aOCP Determined	Total Derived	100%	2,046.03	2,046
	Madrigal-González et al. (2023).	89.49%	1,830.99	1,831
	Plantation Tables	100%	2,046.03	2,046
	Project Developer expected survival	82.5%	1,687.98	1,688

Based on the survival scenarios presented above and the species resilience analysis, a conservative approach will be maintained for the allocation of carbon credits. This means that the VCCs will be granted based on 90% of the survival rate estimated by the aOCP, given the land's vocation and the project's activity, which corresponds to 1,841 VCCs.

It is important to note that carbon credits will be calculated annually in the dynamic baseline. This baseline will be adjusted based on the results of audits, monitoring, and the action plan implemented by the project developer.

As established in section III.1.5 of the Project Procedures document, version 2.3, for project classified as Type "A" according to the Nat5 Scoring, **25% of the credits generated will be allocated to the buffer reserve** as a measure to ensure the permanence of the project's benefits. This corresponds to 460 Verified Carbon Credits, resulting in a total of **1,381 Verified Carbon Credits (VCC)** issued over the lifetime of the project.

A 30% after-project emission will be made, corresponding to **414 VCC.** Annually, the capture will be calculated based on the Dynamic review baseline, adjusting the number of credits as necessary and issuing the corresponding credits.

IV. Relevant Sustainable Development Goals

The 17 Sustainable Development Goals (SDGs), established by the United Nations in 2015, are essential in guiding restoration projects toward meaningful and enduring outcomes by addressing the interconnected nature of global challenges such as biodiversity loss, climate change, poverty, and social inequalities (https://sdgs.un.org/goals). Acting as a comprehensive framework, the SDGs enable project activities and their associated restoration and conservation efforts to align environmental, social, and economic objectives, ensuring that projects contribute not only to ecological recovery but also to broader sustainable development. By embedding these principles into restoration efforts, projects contribute not only to ecological recovery but also to the broader pursuit of sustainable development envisioned by the UN. Project initiatives can foster ecosystem resilience, support climate adaptation, enhance community livelihoods, and promote responsible resource use. This holistic approach acknowledges the intricate linkages between healthy ecosystems and human well-being, emphasizing that environmental restoration is also a pathway to achieving social equity and economic stability.

Moreover, aligning restoration projects with specific SDGs facilitates measurable progress, enhances accountability, and ensures the initiatives' relevance within a global context. It also opens pathways to partnerships with stakeholders who share a commitment to these goals, from local communities and governments to international organizations and private entities. By adopting this approach, restoration projects can amplify their impact, making meaningful contributions to global sustainability targets. The following table (Table 8) highlights the SDGs most relevant to the project initiatives, illustrating how each goal serves as a guiding principle in shaping the strategies and ensuring the long-term success of the project.

TABLE 7 SUSTAINABLE DEVELOPMENT GOALS APPLICABLE TO THE PROJECT

SDG #	Goal	Positive Benefits / Indicator
	***Ensure availability and sustainable management of water and sanitation for all***	Improves soil water retention through reforestation and drip irrigation systems. Enhances infiltration and supports the recovery of local hydrological cycles in arid zones. Reduces surface runoff and soil erosion, helping stabilize local water availability.
	***Use of sustainable techniques and selection of adapted native species***	Improve soil health through the implementation of sustainable agricultural practices, increasing water retention and reducing the need for chemical inputs, while selecting and cultivating adapted native species that are resilient to local climatic conditions.
	***Take urgent action to combat climate change and its impacts***	Increases long-term carbon sequestration through tree planting and vegetation cover. Supports climate adaptation in semi-arid regions through regenerative land use practices. Reduces greenhouse gas emissions via sustainable agriculture and low-impact irrigation.

SDG #	Goal	Positive Benefits / Indicator
	***Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss***	Restores degraded land through biodiverse agroforestry rather than monoculture. Enhances local biodiversity by introducing multiple native and climate-resilient species. Promotes sustainable land use and prevents desertification in vulnerable areas.

This project showcases a nature-based solution to environmental degradation, demonstrating how targeted reforestation and regenerative agriculture practices can drive climate resilience, biodiversity restoration, and sustainable land use. By sequestering carbon and improving local ecosystems, it supports global sustainability efforts while delivering long-term ecological and community benefits.

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