Productive agroforestry systems that turn CO_2 into stone:

a Tierra Foods & Playa Viva Project

Contents

Executive Summary

This project design document (PDD) has been written by Tierra Foods in partnership with Playa Viva and local communities for the following objectives: to create rigorously measured inorganic and organic carbon removal, to enable “demonstrator systems” for cacao, coffee, mango, sugarcane and turmeric to grow regeneratively, and cost-effectively with other regenerative ingredients, and to deliver overall financial, social, and environmental co-benefits which will be described in detail in this document.

The ultimate goal is to enable a landscape-approach to regenerative agroforestry systems, located in the Rio Tule watershed in Guerrero, México, and offers an opportunity to restore 353 hectares of degraded land.

The watershed is currently experiencing critical environmental and socio-economic challenges, which this project aims to alleviate during a multi-phased installation of agroforestry systems in collaboration with local, national and international partners. The project focuses on two distinct areas and microclimates along the lifegiving local Tule River (or “Rio Tule”): the upper watershed and the lower watershed. The *upper watershed* is located 15 kilometres inland from the Pacific Ocean at an elevation of 600-800 metres above sea level and is experiencing the expansive erosion of its hillsides due to 30 years of devastating deforestation and increased soil erosion in the micro-watershed. The *lower watershed* refers to the communities and coastal ecosystems at sea level (0-100 metres), which faces the threat of year-long droughts and a significant decrease in availability of clean water, among other effects of the misuse of land and natural resources. By implementing targeted interventions tailored to the unique conditions of each area, the project aims to restore the watershed's health, improve soil quality, and support the resilience of local communities.

This project aims to integrate social and environmental impact programs alongside scientific research to support the partner producers and landowners involved. Agroforestry systems will be co-designed with landowners and farming partners, to enhance the human, natural, built, social, and financial capitals in the watershed. Year-round farming opportunities based on agroecology principles and installed systems will invite new participants and community members to be engaged with the project and the productive reforestation of their own watershed. These agroforestry systems will be designed by the Tierra Foods team to maximise the powers of biomineralisation offered by the *Brosimum alicastrum* tree (locally known as “uje”, but also known as “ramón” or “capomo”). The uje tree offers a double advantage, due to its high agronomic potential, with the production of the highly nutritious but underused breadnut seed, while also storing large amounts of carbon in both organic and inorganic (biomineralised) form. Therefore, integrating uje trees can enhance the agroforestry potential yields, while providing additional financial returns for all stakeholders via Tierra’s new MRV methodology to quantify biomineralised carbon removal. Finally, biomineralisation is beneficial to soil health by improving soil pH, soil stability and soil water holding capacity.

Overall, the project aims to **restore 353 ha of land** and generate (conservatively) **92,063 tonnes of organic CO_2 and 3,627 tonnes of inorganic CO_2** during a 20-year period. Deployment will be in 3 phases, which will be followed by the expansion of the project within future subsequent phases:

1. Starting initially with **10 ha in Phase 1**,
2. Followed by an expansion to an additional **40 ha in Phase 2,** and
3. An opportunity for a series of future plantings across more than 303 hectares in the watershed in what can be called **Phase 3**.

There is strong interest from the local population, which means that with their support, we can potentially expand beyond 353 hectares within the watershed. For the purposes of this PDD, we will concentrate on Phase 1 and 2.

Due to the large natural range of the uje tree (present from México, throughout *Mesoamérica*, and as far south as Perú and Brazil), this project offers an exciting opportunity to act as a flagship for future deployment in México and all over LatAm. The collaboration between Tierra Foods and Playa Viva will revitalise the region by establishing a model that can be scaled to engage many more farmers and hectares in the local watershed; and in other coastal, agrarian towns, within and beyond Guerrero and México.

1. General Context

1.1 History of Place and Opportunities in the Watershed

The Juluchuca micro-watershed (part of the larger Rio Tule Watershed) is located in the Costa Grande Region of Guerrero in Southwest México (**Fig. 1**). It is characterised by semi-dry tropical forests in the Sierra Madre mountains, extensive coastal plains, lagoons, estuaries, mangrove forests, and a temperate oceanic environment, and is a designated “conservation priority site” by México’s CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad)[1] and CONANP (Comisión Nacional de Áreas Naturales Protegidas)[2]. Locals speak of jaguars still high in the mountains, crocodiles abound in coastal lagoons, and sea turtles nest by the thousands on the shores.

The region is distinguished by an arid, tropical climate with average temperatures ranging from 24 to 34 °C and distinct wet (July-October) and dry (November-June) seasons, with most of its annual precipitation of 355 mm occurring in July and September[3]. The soil type varies from sandy to sandy loam, shallow (25-30 cm), well-drained with rocky features, developed over granite and some limestone bedrock. The terrain ranges from flat along the coastline to rolling hills and valleys as it moves inland towards the Sierra Madre mountain range, with elevations from sea level up to 800 metres.

Figure 1. The Juluchuca micro-watershed is located in southeast México, in the state of Guerrero and within the Costa Grande region.

[1] Manages biodiversity information, supports research, and promotes the sustainable use and conservation of Mexico's biological resources.
[2] Manages and protects Mexico's natural protected areas, developing conservation strategies and promoting sustainable resource use and environmental education.
[3] https://weatherandclimate.com/mexico/guerrero/petatlan#t2

The Rio Tule Watershed is made up of six small communities (Juluchuca, Rancho Nuevo, La Ceiba, Las Placitas, La Barrita, and El Cayacal) with a population of about 1,000 people and the Playa Viva Hotel **(Fig. 2)**. More than 50 of the local community members are employed at Playa Viva, while others rely on agriculture, subsistence fishing, cattle ranching, and/or a few small cottage industries such as coconut candy factories and nearby salt flats (Arguedas et al., 2024). Agricultural production is deeply tied to the region's cultural traditions and values, and was historically practised by way of diverse plantations for subsistence production and economic gains for the household. The landscape has been changing dramatically, with increasing rates of deforestation along both coastal and highland forests, in order to allow for intensive monoculture farming focused on cash crops. The latter is coupled with unrestricted water use and chemical inputs, which remains the primary production method today. For instance, data from the past 20 years (from 2001 to 2023) show that, the Costa Grande region lost in total a net 5,530 ha of tree cover (data from GlobalForestWatch). Included within this number are 1,900 hectares of primary forest loss.

Many families rely on the annual harvests of a few commodity crops such as corn, coconut, sesame and mango, yet each year their fields and orchards require more intensive care as they increasingly turn to agrochemicals to try to guarantee their harvests. Unstable and unpredictable market prices such as the boom and bust of the coconut market or fluctuating mid-season prices for staple crops paired with insufficient rains and longer than average droughts are forcing farmers and producers to abandon agriculture production altogether. This shift is leading to heightened environmental degradation, an increasingly worrisome depletion of local resources, a lack of economic opportunities for the community, and a loss of diversity in the watershed. Despite this, local residents remain resilient and eager to write a new chapter of hope and prosperity for their communities. They value the immense beauty of the region, from the lush, threatened, forests at the top of the watershed, to the ocean environment once teeming with life; while at the same time recognizing the human pressure on these natural resources.

The landowners and farmers selected for participation in this project are part of the hope of the community, and they are key stakeholders in restoring the resilience of the local watershed. Their properties are the headwaters or some of the last terrestrial areas before rivershores meet the ocean; and offer a rare opportunity to study the ability of a native tree to restore a whole community and generate both food and income for many families.

Figure 2. Aerial image of the Rio Tule micro-watershed. The image depicts its four local communities (Juluchuca, Rancho Nuevo, La Ceiba, Las Placitas), two additional communities being engaged (La Barrita y El Cayacal); and Playa Viva.

1.2 Project Partners: Building on Success in Watershed Regeneration

The project partners are Playa Viva, Tierra Foods, local landowners, *ReSiMar*, a local Women's Cooperative, and the land stewards contracted for the installation and maintenance of the agroforestry systems. The project will rely on years of trust established between Playa Viva and local community members and will build on those relationships to continue to improve ecosystem health.

1.2.1 Rio Tule Producers and Farmers

Local landowners and producers in the Rio Tule Watershed are the largest stakeholder group in the project and selected participants have demonstrated multiple years of dedication to learning regenerative land management techniques and applying the knowledge and acquired skills on their properties. The farmers involved in this project are inspired by the multi-strata systems being developed, and have a collaborative role in the design, development and

Figure 4. Don Gabriel Garcia. Local landowner and project partner.

installation of the project sites. Don Gabriel **(Fig. 4)** is one of the older generation farmers in the community. He has managed his land organically for more than 20 years and leads a community of 27 local producers with the government supported program, *Sembrando Vida.* Juan Guitierrez, Ximena Rodriguez, Juan Carlos Vargas, Geovanny Peñaloza **(Fig. 5)**, Tomás Joven, Daniel Palacios, Rafa Arriaga Valdez, Trinidad Gomez and Pedro Armento Otero are some of the farmers, permaculture designers and landowners engaged in Phase 1 of the project.

Farmers engaged in the upper watershed are Juan Guitierrez and Ximena Rodriguez. Juan Guitierrez is the oldest son of a fourth generation family committed to protecting the forest of the upper watershed and active members in the Las Placitas community. Collectively, the family owns more than 1,000 hectares, and are regeneratively managing the forest for timber, coffee and cacao production. Ximena Rodriguez is an educator in the community and works closely with the Guitierrez family to leverage agroforestry and afforestation as economic drivers to restore the landscape.

Figure 5. Geovanny Peñaloza
Agroforestry designer and site manager.

The landowners and farmers from the lower watershed have worked with and been trained by Amanda Harris, a Permaculture Designer and Educator, for six years. Juan Carlos Vargas and Geovanny Peñaloza are young leaders in their respective communities and work together to create strong social cohesion and integration by engaging multiple generations, genders and community members in workshops, trainings, and producer cooperatives. Gabriel Garcia is one of the last active producers of large volumes of production in the lower watershed and supervisor of a farming program and plant nursery in Juluchuca. Don Gabriel works closely with Osmaira Hernández, the young lady responsible for facilitating the land management and value-adding activities of the local women's cooperative.

1.2.2 Playa Viva, ReSiMar, and the Rio Tule Women's Cooperative

Playa Viva opened in 2008 as a Regenerative Boutique Hotel and has since garnered significant international attention for its model, including recognition in the *NY Times* and in *Travel + Leisure* Magazine's Global Impact Award for Regenerative Travel Inc, the hotel collection founded on Playa Viva's principles.

Playa Viva's innovative and holistic model funds a Social and Environmental Impact team in the Rio Tule watershed known as *ReSiMar*[4]; through which it incubates regenerative programs such as a locally managed Permaculture Farm and Education Center; a budding regional Food Hub to support local agroecological producers; a Women's Cooperative focused on developing new value-add products for national and international markets; and the development of a regenerative education curriculum to include the installation and year-long programming required to develop Permaculture School Gardens with community leaders and educators in the watershed. The *ReSiMar* watershed development project covers 5 interconnected nodes: Education, Permaculture, Water, Marine Life, and Reforestation, where leaders work together to develop the potential of local people, engage them in regenerative practices, enhance cultural appreciation, and create sustainable economies within the watershed.

Since its inception in 2008, Playa Viva has remained committed to the restoration of their 80 hectare property along México's Pacific Coast. The Playa Viva Permaculture Team, made up of 12 local women and men, manage more than 600 metres of lagoons and estuaries to restore the hydrologic cycle and improve the carrying capacity of the property; and regeneratively farm 5 hectares using permaculture methods and agroecological practices. With traditional hand tools and limited motorised equipment, the team plants an average of 1,000 trees each rainy season and produces more than 3,000 kilos of organic fruits and vegetables every year. The team is driven by the aim of transitioning agricultural production in the watershed to the agroforestry systems they have been developing for local conditions.

Two years ago, the Playa Viva Permaculture Team founded the Rio Tule Women's Cooperative, which works to facilitate capacity building in organic production; create avenues for women to participate in farm production roles traditionally reserved for men; strengthen farmer relationships in the watershed; and increase market access for producers through the development of a regional Food Hub and value-adding activities (**Fig. 3**). Today the cooperative focuses on filling the supply gap for local organic products such as ginger, turmeric, cinnamon, cacao and moringa.

Figure 3. Rio Tule Women's Cooperative. Members Mayra de la Cruz, Osmaira Hernández, Betty Nogueda and Gabina Sánchez Palacios.

[4] https://www.playaviva.com/resimar

1.2.3 Tierra Foods

Tierra Foods (TF) is a science-led company and project developer, specialised in creating food ingredients that derive from biomineralisation-capable plants with agronomic potential. The aim is to develop agroforestry projects for food production, while promoting high durability carbon removal through biomineralisation and multiple environmental, social and commercial co-benefits. TF's agroforestry solutions are co-designed with farmers and landowners and are adaptable for integration into the existing food supply chains of large corporations.

TF is harnessing the power of biomineralisation through plants that participate in the Oxalate-Carbonate Pathway (OCP), integrating them into pioneering regenerative biomineralisation-centric agroforestry food systems (mixed cropping systems). The OCP enables high permanence carbon dioxide removal (CDR) by converting atmospheric CO_2 into soil-based calcium carbonate ($CaCO_3$), a stable form of inorganic carbon in the soil (10^2 – 10^6 years), through natural mineralisation (biomineralisation) (Syed et al., 2020).

This process only occurs via specialised plants globally known as ‘oxalogenic’. Among these, our first oxalogenic enabler of focus is the “uje tree” (*Brosimum alicastrum*), indigenous to the Americas, and a local species in the Rio Tule watershed. Tierra Foods wants to focus on *B. alicastrum* because of it has been recognized as important keystone species in the Americas (Lander & Monro, 2015), that combines high agronomic potential with annual breadnut production that can be between 50-75 kg/tree (Miguel-Chavez et al., 2023), and high carbon dioxide removal (CDR) potential for both organic (10-20 tCDR/ha/yr for the first 20 years of life) and inorganic carbon (1.27 tCDR/ha/yr) (Rowley et al., 2017). At the same time, uje is a robust tree that can grow in various environments, with a native range that spans across multiple countries of Latin America; from México, down to Brazil (data from kew.org/science). Complementary to food, and carbon, plant biomineralization with uje trees, offers environmental co-benefits; e.g. soil health/stabilisation, water retention, heavy metal immobilisation (Syed et al., 2020). Biomineralisation-centric agroforestry using tree species like the uje tree, could help drive the transition towards nature-positive, carbon-negative food production.

TF is developing a pioneering methodology for quantifying durable soil carbon capture through OCP biomineralisation. Their agroforestry solutions will capture organic carbon in the growing trees and inorganic carbon, through biomineralisation, in the soil and once quantified, will enable the issuance of high integrity carbon credits. TF intends on pursuing a dual approach whereby the methodology will fit within the framing of both off-registry credits (with an ISO-compliant methodology) and on-registry credits (under an ICROA-certified standards body and registry). The former is the first step to success in creating a highly rigorous, category leading methodology. The latter marks the next necessary step post ISO compliance to secure large food corporate partners, in line with our insetting scaling strategy. To ensure alignment with our preferred Standards and registry bodies (e.g. Cercarbono, Plan Vivo, Gold Standard, Isometric), TF has initiated engagement with some of these partners to introduce our methodology creation.

1.2.4 External scientific collaborators

In addition to MRV carried out by local producers, we are committed to secure collaboration with a local scientific partner (e.g. **UME - Universidad del Medio Ambiente**) to co-direct the measurements of **carbon sequestration** as an external body. Furthermore, the latter partner will be responsible for **water quality measurements**, in order to monitor improvements of water quality in the watershed from our intervention. These external collaborators aim to enhance the transparency of carbon and environmental impacts. We are seeking to extend these collaborations with a partner that can assess **animal biodiversity (**e.g. **Pronatura)** with keystone species used as proxies, and monitored presence via bioacoustics (birds), and camera traps (jaguars).

2. Project Aims

The principal aim of the project is to create four healthy functioning agroforestry systems that yield food (primarily cacao, turmeric and uje seeds), timber (*Gliricidia sepium*), sequester carbon, offer environmental co-benefits, and generate local employment opportunities for communities in the Rio Tule Watershed. Each agroforestry system will be designed together with and according to the needs and environmental context of the local producers. A notable common feature is the inclusion of biomineralisation tree species with agronomic potential, as an innovation towards creating resilient and sustainable production systems.

Alongside the general aim of the project, the following areas are addressed by the project, with measurable targets expected respectively:

A. **Socio-economic:**

   a. **Sustainable food production and financial resilience:** Restore 50 ha of degraded land through our biomineralisation-centric agroforestry design. As a result, increase the food production potential of the Rio Tule watershed, providing at a minimum 7,000 tonnes of total agroforestry produce over 20 years.

   b. **Community engagement and education:** Engage local community members in educational workshops, training and demonstration plots, creating healthy functioning systems and promoting awareness and understanding of agroforestry, permaculture, and sustainable land management practices. Improve agroforestry skills and knowledge resulting from training provided as part of the project activities for 50+ local people.

   c. **Gender equality in supply chains.** Engage the Rio Tule Women's Cooperative in value-added production opportunities to convert raw production from the agroforestry systems into value-added food products for regional and global markets and supply chains.

B. **Climate change mitigation:**

   a. **Carbon sequestration (organic):** Enhance carbon sequestration capacity within the agroforestry system by planting a diverse mix of trees and shrubs, resulting in the sequestration of 13-19 tCO_2 / ha / year, over 20 years, contributing to climate change mitigation efforts.

b. **Carbon sequestration (inorganic):** Integrate biomineralisation plants, and include inorganic carbon additionality and permanence within the agroforestry system, resulting in 1.27 tCO_2/ ha / year (Rowley et al., 2017).

C. **Environmental co-benefits:**

a. **Soil quality:** Improve soil health and fertility by implementing permaculture techniques such as mulching, composting, and cover cropping, resulting in a c.3-5% increase in soil organic matter content over 20 years.

b. **Soil erosion**: Reduce soil erosion through the mixed-cropping system, with shallow and deep root systems, that improve soil structure.

c. **Biodiversity conservation:** Provide habitat for bird and insect populations, allowing for ecological connectivity within the natural system and increased pollination of key production species.

d. **Water conservation:** Encourage the implementation of passive and built water conservation measures such as swales and other earthworks, drip irrigation systems where necessary, and *planting water* through the selection and support of key species like tropical hardwoods, banana and nopal.

e. **Pollution reduction**. Guarantee the agroecological management of project sites and reduce or eliminate the use of synthetic fertilisers, herbicides, and pesticides throughout the watershed and during the length of the project.

3. Project Timeline

The project will last for a total of 20 years (with the intention to extend to 40 years), and will initiate with **two implementation phases** (Phase 1 and Phase 2), followed by a **monitoring phase** of 20 years, and the eventual **validation** of our approach in 2045. Specific milestones are expected within that timeline and identified in **Fig. 7** below. It is important to emphasise that the issued carbon credits will only pertain to organic carbon, with a 20-year crediting period. Credits will be claimed from all plant species that remain permanently on site (trees, shrubs and cacti), or trees that sequester carbon as timber; hence organic carbon credits are not exclusive to uje trees. Inorganic carbon credits specific to uje will be considered an additional benefit and are planned for inclusion two years after uje plantation, once our certified methodology is ready.

Implementation Phase

Phase 1 of implementation, is already and will continue to take place from July through October 2024, and includes the setup of the first four agroforestry systems spread out across four project sites (Gabriel Cooperativa, Placitas Cafetal, Placitas Original, La Campiña), covering a total of 10 ha of productive land. The agroforestry systems were developed, designed, and agreed upon by all stakeholders in May and June 2024. Upon successful implementation of **Phase 1**, an additional 40 hectares will be selected in collaboration with the farmers (**Phase 2**), which will take place between July and October 2025. Potential expansion areas have already been identified and are detailed in Section 4. Before the initiation of Phase 1, we are conducting field baseline measurements for carbon, which will hold as a reference value for the expansion areas. Also, we will run training workshops to demonstrate sampling methods for carbon. At the end of the implementation phase, we expect to have set up 50 ha of projects (with tree survival ≥80%), that have produced their yields for the 1st year (pidgeon pea, banana), and to have trained 50+ farmers in carbon monitoring. Finally, an ISO-compliant methodology for measuring inorganic carbon removal via plant biomineralization will be developed during the first two years of the project.

Monitoring Phase

The monitoring phase will be conducted through a combined effort of trained local producers, and external analytical labs, under the co-supervision and with the support of Tierra Foods, and our scientific partners. The project will conduct regular surveys to measure environmental and social impacts, assessing the agroforestry model's effects on local communities, including changes in income, employment, and levels of community engagement and participation. Additionally, the financial performance of the agroforestry model will be tracked, covering revenue generated from crops and costs associated with implementation and maintenance. Changes in soil quality and biodiversity will also be monitored to evaluate contributions to climate change mitigation. Carbon indicators will be monitored annually for the first five years and every five years thereafter, over a total period of 20 years. Field measurements will include soil and biomass sampling to verify carbon sequestration and ecosystem impacts.

At the end of the monitoring phase, we anticipate managing the full 50 ha of planted systems, continuing to facilitate workshops in the community, watershed, and with project partners, participating farmers, and new stakeholders. We also expect to successfully produce the first yields from uje trees starting in 2030, along with secondary species such as banana and yuca in 2026, coffee and cacao in 2030, and timber beginning in 2035. **A descriptive summary of the collected data** will be made publicly available on the [Earthtrust platform](#).

Validation Phase

After a total period of 20 years, we will analyse the acquired data, and demonstrate success stories from flagship farms within the 50 ha of productive land, and to have established workshops for farmers to train each other. During that time, we will be continuously exploring the expansion towards 300+ ha.

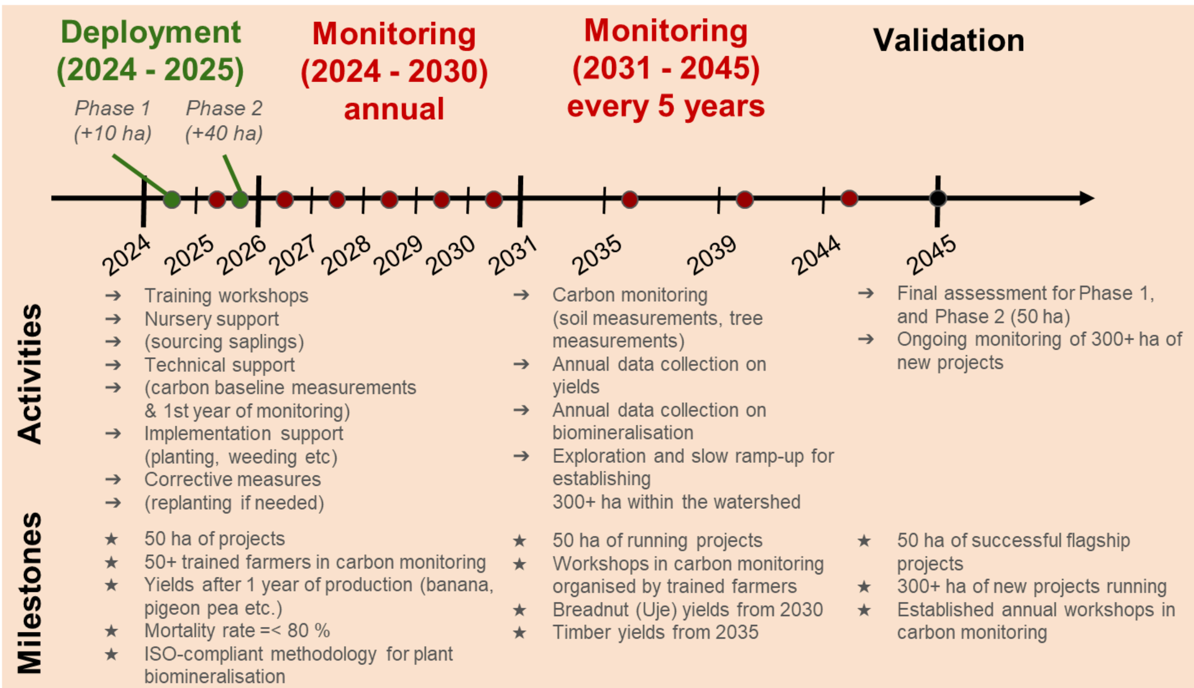

Figure 7. The Project Timeline, with associated activities and milestones. Starting from the initial deployment phases in years 2024-2025, followed by an intensive monitoring phase of 5 years (annual monitoring), and a monitoring phase of an additional 15 years (monitoring at 5-year intervals), before the final validations of the agroforestry models.

4. Description of the Watershed and Project Sites

4.1 Watershed

The project will be deployed in two key sections of the Rio Tule watershed (later referred to as the upper watershed and lower watershed), representative of two different ecosystems, land features, farmer typologies and accessibility for each of the areas and habitants. The upper watershed is located 15 km inland, at an elevation of approximately 600-800 m above sea level. This landscape has been shaped by over 30 years of deforestation, resulting in noticeable soil degradation and erosion. The lower watershed sites have experienced a notable decrease in water availability.

To better understand the totality of the project area and to identify sites of interest to regenerate, we collected soil samples and began engaging producers to discuss potential project sites in May 2024 (**Fig. 8A**). Our soil sampling and farm survey, pointed towards four sites (Gabriel Cooperativa, Placitas Cafetal, Placitas Original, La Campiña), which comprise a total of 10 ha. These sites will be the initial areas of intervention, with the potential to expand to a total of 353 ha around these areas (**Fig. 8B**).

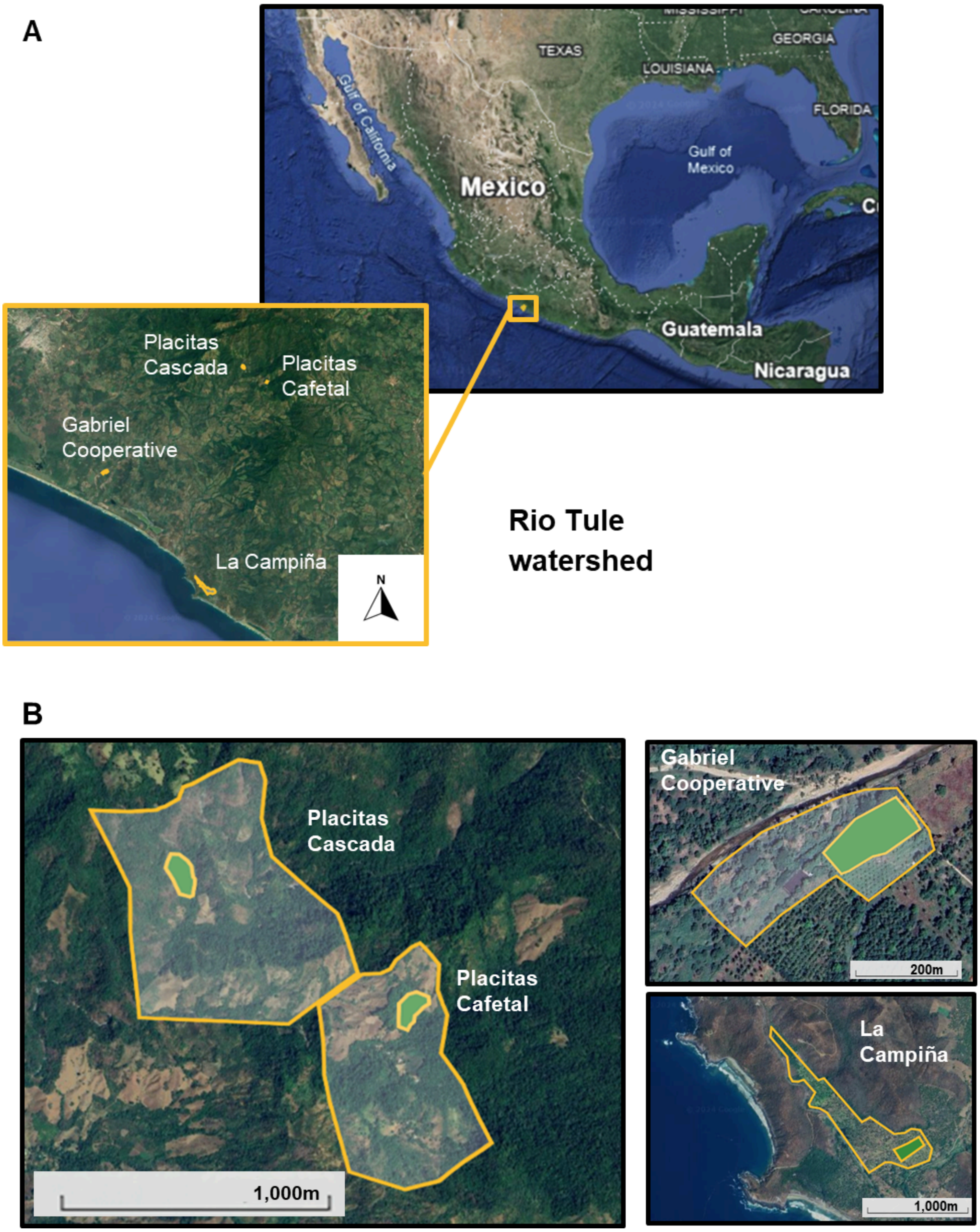

Figure 8. A map depicting the larger area of the Rio Tule watershed with points depicting the four site locations (A), as well as clearly delimited polygons for each site (B). In July 2024 (Phase 1), 10 ha will be installed with unique agroforestry designs (polygons filled with green). In June 2025 (Phase 2), we will expand to capture an additional 40 ha. The unfilled area within the yellow polygons, covers about 300 ha, and has been identified as a potential expansion zone within the watershed. Polygons were created on Google Earth.

4.2 Project Sites

Four distinct agroforestry sites will be managed (2 sites at the upper watershed, and 2 sites at the lower watershed), blending land restoration with unique designs for abundant, productive systems.

A. **Upper Watershed**

   a. **Placitas Cafetal.** The Cafetal site is at the top of the watershed (17°30'51"N, 101°07'51"W) on Juan Guitierrez's property, located on a moderately sloped hillside. The site was affected by a cyclone in 2023, whereby a change in canopy cover increased sunlight reaching the forest floor, and some coffee seeds are beginning to sprout naturally. Coffee trees used to be cultivated, 5-20 years ago. The soil has a balanced texture (sandy clay loam), with a slightly acidic pH (6), has moderate organic matter content (2.6%), and is free of carbonates. A total of 3 ha will be planted in Phase 1 and there is potential to expand to another 6 ha for Phase 2. For the expansion, there is an additional 108 ha to choose from.

   b. **Placitas Cascada** is also at the top of the watershed and is located 1.5 km west of the Placitas Cafetal site (17°31'15"N, 101°08'27"W). The land has occasionally been used as cattle pasture, but due to its steep slope and access to water, it is ideal for an alternative, more regenerative land use. Similar to the Cafetal site, the soil has a balanced texture (sandy loam), with a slightly acidic pH (6.1), has relatively low organic matter content (1.6%), and is free of carbonates. The site has 4 ha that can be planted in Phase 1, and an additional 10 ha for Phase 2.

B. **Lower Watershed**

   a. **Gabriel / Cooperative.** This site belongs to Don Gabriel Garcia and production is co-managed by him and a local women's cooperative, and it is located on a flat zone, at the bottom of the watershed, 2.3 km from the seaside (17°27'45"N, 101°13'36"W). The soil is sandy (91% sand), with a circumneutral pH (6.8), a relatively low organic matter content (1.6%), and is free of carbonates. The property comprises an existing mango plantation (5-15 years old), a seasonal river, and a young native forest which is beginning to grow at the edge of the property. No chemical inputs have been used on this site for the last 20+ years. The site offers 1 ha to be planted in Phase 1, and an additional 4 ha available for Phase 2.

b. **The La Campiña** site is located at the bottom of the watershed, and only 1 km from the seaside (17°23'36"N, 101°09'50"W). The land is flat, with very poor sandy soil (96% sand), with a relatively high soil pH (7.7), very low organic matter content (0.49%), but some carbonates (2.86% of $CaCO_3$). Currently, the site is littered with 30 year old mango trees of two local varieties, harvested but not managed by a community member. It is a recently acquired land with no present management model, and no agricultural inputs. The water resources in the form of wells tested clean in April 2024. The site offers a 2 ha planting of uje and cacao in Phase 1 of the project, and can accommodate another 20 ha of potential expansion for Phase 2.

5. Agroforestry Systems

Project sites are co-designed with the local producers, to include three to five species interplanted between the native and high-value, *Brosimum alicastrum* species and will include commercial crops like cacao, coffee, cinnamon, turmeric, and banana. Each design is tailored to the producer's needs, and to the respective environmental context of each site (soil/climate). The plant species selected for each project site are either indigenous or commonly grown in the dry tropics and in coastal Guerrero, ensuring their suitability and adaptability to the region. Below you may find the 4 different project sites, their associated Agroforestry systems, the annual profit/ ha, generated, and the additional annual carbon/ ha sequestered. The total profits and carbon sequestration are estimated for all plant species (including uje).

5.1 System 1: Placitas Cafetal

System 1, is a 3 ha planting focused on the layered production of uje, coffee, and turmeric in the upper watershed (**Fig. 9**). Support species like *gliricidia,* gandul and *leucaena* will be interplanted in service rows to increase water retention and humidity in the soil, create biomass for seasonal prunings and use as mulch, home consumption and some sales, and principally to support the production of uje and coffee (**Table 1**).

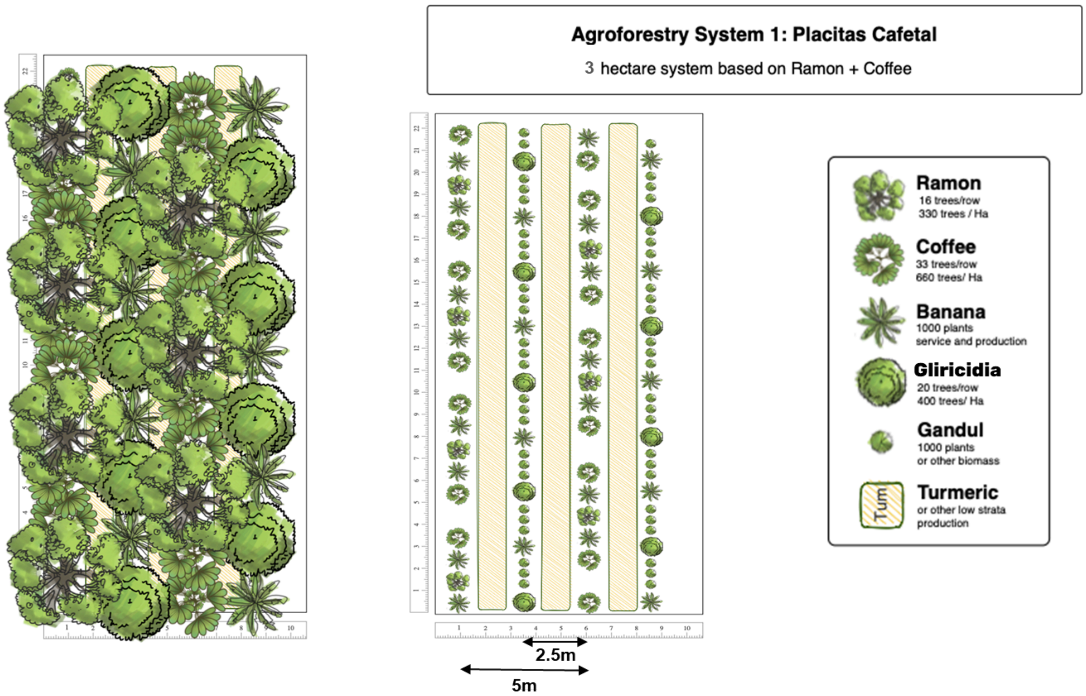

Figure 9. Agroforestry System 1 at year 5 on the left, and at the time of planting in the centre.

The leftmost image demonstrates the canopy development of long term perennial species in Agroforestry System 1 at year 5, and after some early stage species are already being harvested. The centre image is the planting scheme used by farmers at the time of planting, or year 0.

Table 1. Species Selection for System 1 in the upper watershed.

Species	Strata Layer	Functional Role	Residence (years)	Max. Height (metres)	Planting density (trees/ha or kg/ha)	Yield (ton/ha)
Brosimum alicastrum	Emergent	Crop	Long term (20 years)	>12m	330 trees/ha	1.65 tons/ha
Gliricidia sepium	Emergent	Timber	Medium term (5-10 years)	5m	100 trees/ha	--
Coffea arabica	Low	Crop	Long term (20 years)	2 - 4m	660 plants/ha	0.59 tons/ha
Curcuma longa	Low	Crop	Medium term (2-5 years)	1m	60 kg/ha	0.14 tons/ha
Zingiber officinale	Medium	Crop	Short term (0-3 years)	1m	60 kg/ha	0.14 tons/ha
Musa sp.	High	Crop	Short term (0-3 years)	3 - 4m	100 plants/ha	2.4 tons/ha
Cnidoscolus aconitifolius	High	Crop	Medium term (2-5 years)	2 - 3m	300 plants/ha	2.55 tons/ha
Cajanus cajan	Emergent	Crop	Short term (0-3 years)	2 - 3m	100 plants/ha	0.30 tons/ha

Key performance indicators:

Revenue (gross): $4,072 USD / ha / year

Carbon sequestration: 14 tCO_2 / ha / year

5.2 System 2: Placitas Cascada

Agroforestry System 2 (**Fig. 10**), is a 4 ha planting focused on multi-strata production from uje, cacao, *leucaena*, moringa and banana in the upper watershed. Support species like chaya, yuka, annatto and gandul will be interplanted between primary and secondary species in the production rows, in the service rows every 5 m, and maize or the traditional milpa, planted in the space between rows (**Table 2**).

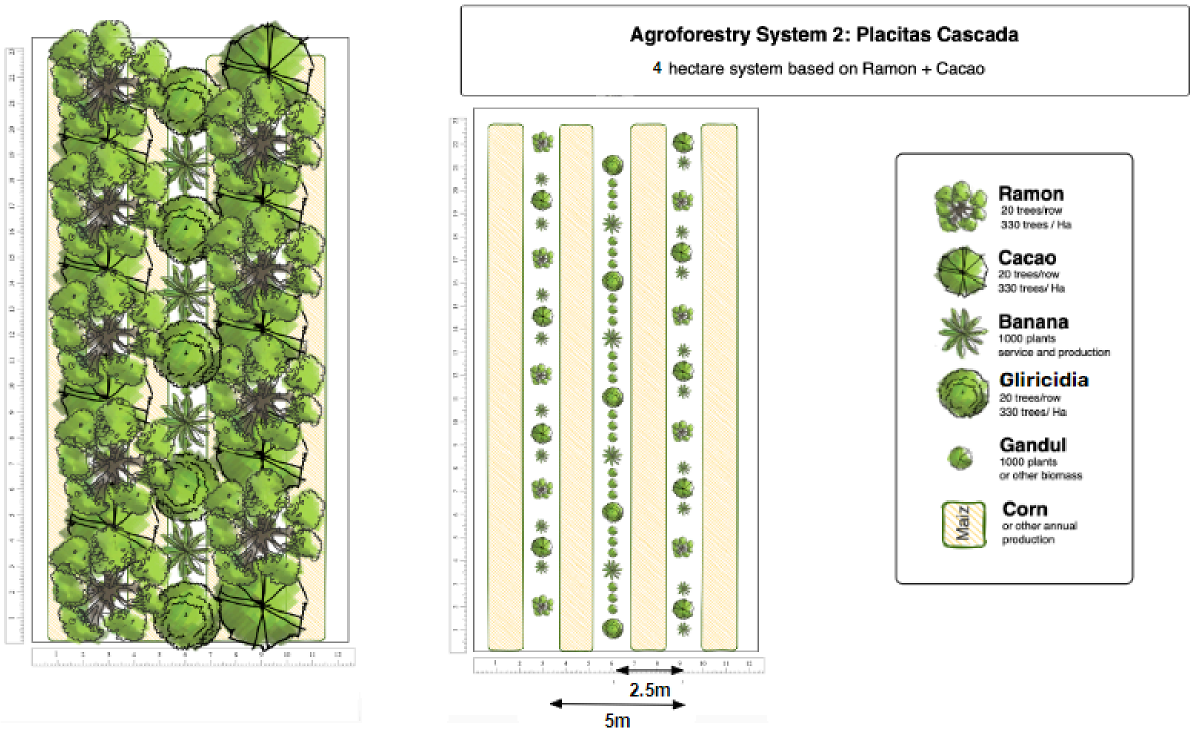

Figure 10. System 2 at planting and year five. Year 0 (centre image) shows the system design at the time of installation in 2024 and later in year 5 (on the left) showing system growth and representative of a few species having been fully harvested.

Table 2. Species Selection for System 2 in the upper watershed.

Species	Strata Layer	Functional Role	Residence (years)	Max. Height (metres)	Planting density (trees/ha or kg/ha)	Yield (ton/ha)
Brosimum alicastrum	Emergent	Crop	Long term (20 years)	>12m	330 trees/ha	1.65 tons/ha
Gliricidia sepium	Emergent	Timber	Medium term (5-10 years)	5m	100 trees/ha	--
Theobroma cacao	Low	Crop	Long term (20 years)	3 - 4m	330 trees/ha	0.40 tons/ha
Cajanus cajan	Emergent	Crop	Short term (0-3 years)	2 - 3m	330 plants/ha	1.0 tons/ha
Musa sp.	High	Crop	Short term (0-3 years)	3 - 4m	150 plants/ha	3.6 tons/ha
Cnidoscolus aconitifolius	High	Crop	Medium term (2-10 years)	2 - 3m	660 plants/ha	5.5 tons/ha
Manihot esculenta	Emergent	Crop	Short term (0-3 years)	2 - 3m	500 plants/ha	0.14 tons/ha (dry weight)
Moringa oleifera	Emergent	Crop	Short term (0-3 years)	3 - 10m	1000 plants/ha	3.3 tons/ha (seed crop)
Bixa orellana	High	Crop	Short term (0-3 years)	2 - 3m	150 plants/ha	0.12 tons/ha
Leucaena leucocephala	High	Crop	Short term (0-3 years)	2 - 3m	200 trees/ha	--
Chrysopogon zizanioides	Emergent	Crop	Long term (20 years)	1m	1000 plants/ha	--

Key performance indicators:

Revenue (gross): $4,125 USD / ha / year

Carbon sequestration: 19 tCO_2 / ha / year

5.3 System 3: Gabriel - Cooperative

Agroforestry System 3 (**Fig. 11**), in the lower watershed is a 1 ha plot managed by the women's cooperative and focused on the production of high value crops like turmeric, cinnamon and ginger under the canopy and shade of 330 uje trees in one of their natural habitats in the watershed. Supporting species like banana, chaya, nopal, *gliricidia* and hibiscus fruits will lead to additional harvests of food, fodder, biomass and timber from for many years (**Table 3**).

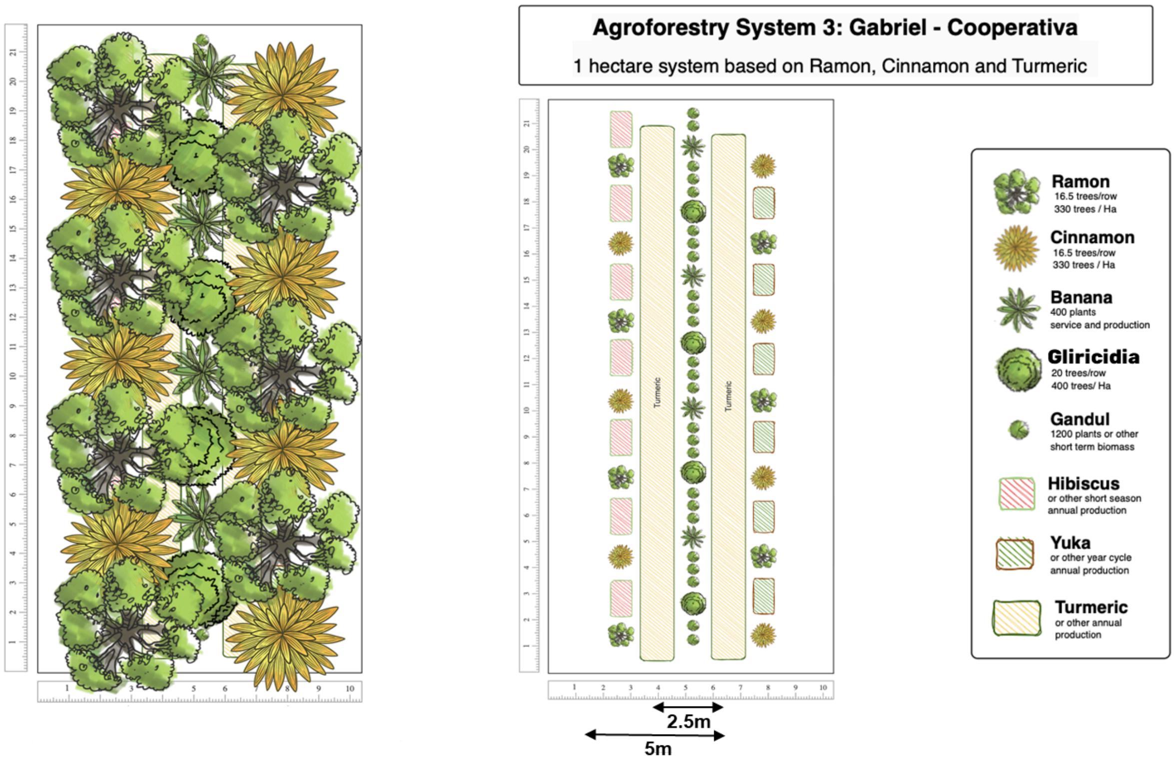

Figure 11. System 3 at planting and in year 5. Year 0 (centre image) shows the system design at the time of installation in 2024 and later in year 5 (on the left) showing system growth and representative of a few species having been fully harvested.

Table 3. Species Selection for System 3 in the lower watershed.

Species	Strata Layer	Functional Role	Residence (years)	Max. Height (metres)	Planting density (trees/ha or kg/ha)	Yield (ton/ha)
Brosimum alicastrum	Emergent	Crop	Long term (20 years)	>12m	330 trees/ha	1.65 tons/ha
Gliricidia sepium	Emergent	Timber	Medium term (5-10 years)	5m	100 trees/ha	--
Cinnamomum verum	Medium	Crop	Long term (20 years)	3 - 10m	330 trees/ha	0.013 tons/ha
Opuntia ficus-indica	High	Crop	Medium term (5-10 years)	2 - 3m	100 plants/ha	
Curcuma longa	Low	Crop	Medium term (2-5 years)	1m	60 kg/ha	0.14 tons/ha
Musa sp.	High	Crop	Short term (0-3 years)	3 - 4m	100 plants/ha	2.4 tons/ha
Cnidoscolus aconitifolius	High	Crop	Medium term (2-10 years)	2 - 3m	300 plants/ha	2.55 tons/ha
Moringa oleifera	Emergent	Crop	Medium term (2-10 years)	3 - 10m	1000 plants/ha	3.3 tons/ha (seed crop)
Hibiscus sabdariffa	Emergent	Crop	Short term (0-3 years)	1 - 2m	1000 plants/ha	0.033 tons/ha
Manihot esculenta	Emergent	Crop	Short term (0-3 years)	2 - 3m	200 plants/ha	0.056 tons/ha
Cymbopogon	Emergent	Crop	Short term (0-3 years)	1m	1000 plants/ha	0.600 tons/ha

Key performance indicators:

Revenue (gross): $4,171 USD / ha / year

Carbon sequestration: 18 tCO_2 / ha / year

5.4 System 4: La Campiña

System 4 in the lower watershed (**Fig. 12**) is the most diverse of the four planting sites and will incorporate 10-12 species in the 2 hectare production site. The primary species in production at La Campiña are uje and cacao in a multi-strata food forest layout, and sugarcane in the alleys between the production rows. Secondary species with known and predicted value for the landowner and the local women's cooperative are: yuka, banana, soursop, cinnamon, guava, and citrus; and support species to be planted in service rows are nopal, neem, *leucaena*, gandul, moringa and *gliricidia* (**Table 4**).

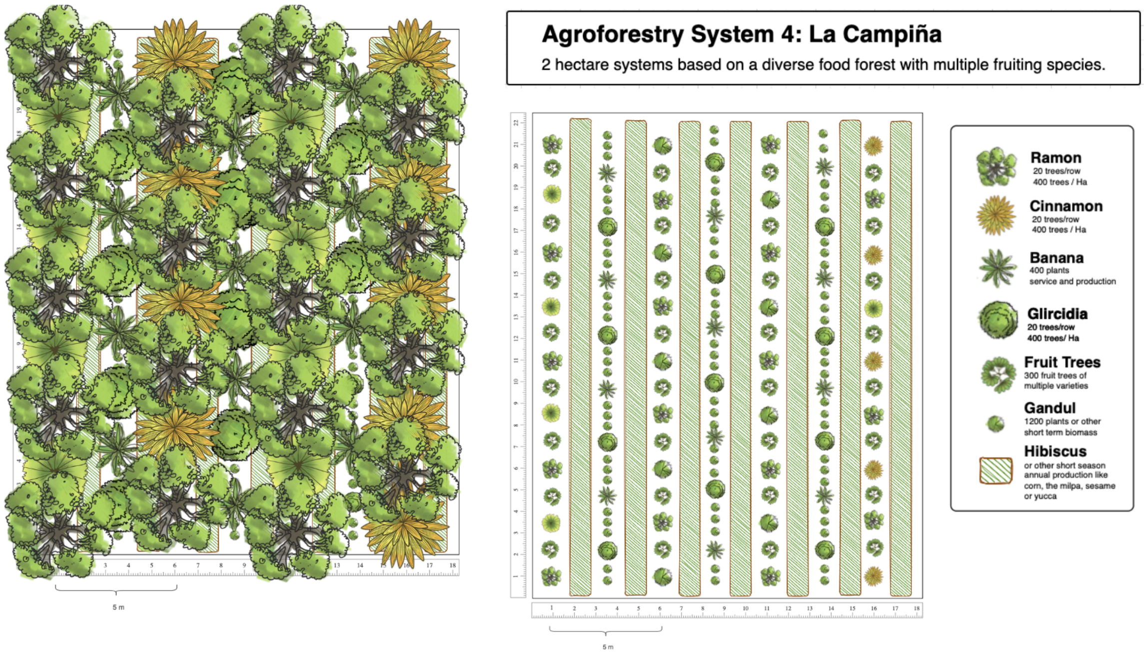

Figure 12. System 4 at planting and in year 5. Year 0 (centre image) shows the system design at the time of installation in 2024 and later in year 5 (on the left) showing system growth and representative of a few species having been fully harvested.

Table 4. Species Selection for System 4 in the lower watershed.

Species	Strata Layer	Functional Role	Residence (years)	Max. Height (metres)	Planting density (trees/ha or kg/ha)	Yield (ton/ha)
Brosimum alicastrum	Emergent	Crop	Long term (20 years)	>12m	330 trees/ha	1.65 tons/ha
Gliricidia sepium	Emergent	Timber	Medium term (5-10 years)	5m	200 plants/ha	--
Theobroma cacao	Low	Crop	Long term (20 years)	2 - 4m	100 trees/ha	0.12 tons/ha
Cinnamomum verum	Medium	Crop	Medium term (2-10 years)	2 - 4m	100 trees/ha	0.004 tons/ha
Musa sp.	High	Crop	Short term (0-3 years)	3 - 4m	250 plants/ha	6.00 tons/ha
Moringa oleifera	Emergent	Crop	Medium term (2-10 years)	3 - 10m	300 trees/ha	0.99 tons/ha
Manihot esculenta	Emergent	Crop	Short term (0-3 years)	2 - 3m	300 plants/ha	0.08 tons/ha
Cnidoscolus aconitifolius	High	Crop	Medium term (2-10 years)	2 - 3m	300 plants/ha	2.55 tons/ha
Zingiber officinale	Medium	Crop	Short term (0-3 years)	1m	60 kg/ha	0.14 tons/ha
Citrus × aurantiifolia	Medium	Crop	Long term (20 years)	3 - 4m	100 trees/ha	3.0 tons/ha
Annona muricata	Medium	Crop	Medium term (5-10 years)	3 - 4m	100 trees/ha	1.5 tons/ha
Psidium guajava	Medium	Crop	Short term (0-3 years)	3 - 4m	100 trees/ha	1.0 tons/ha

Key performance indicators:

Revenue (gross): $5,517 USD / ha / year

Carbon sequestration: 14 tCO_2 / ha / year

6. Intervention Strategy

6.1 Risk Management: Assessment

The strategic partnership with Playa Viva and ReSiMar ensured a comprehensive approach to risk identification, assessment, and the development of effective mitigation strategies; with the backing of 20+ years of developing relationships, trust and mutual respect with project participants and stakeholders in the region. Specific to the development of this project, we conducted stakeholder interviews and potential participant consultations, which involved engaging local community members, project partners, agroforestry experts, and relevant authorities and supply chain members to understand potential risks from their perspectives. Site visits and field assessments including soil sampling and species identification were conducted to identify potential environmental and operational risks specific to each project site; and participating landowners and farmers were selected based on the social cohesion evident and developed from years of already working together.

With regards to socio-economic risks, we identified the following:

- **Land tenure and resource access:** The 4 project sites are owned and titled to the participating farmer or landowner. Collaboration agreements (see section 6.3.2 below for details) have been executed with each landowner and formal contracts will be presented to and executed by the individuals hired to support the installation and maintenance of the agroforestry systems in Phase 1 and Phase 2. Access to the road and resources in the upper watershed can be limited between the months of August and October; however, this does not have to impact the plantings or the project if all inputs are secured and delivered to the participating farmers prior to the rainy and planting season. The transportation and delivery of harvests and production is in other seasons.
- **Community engagement risks:** Project participants are from families that have spent multiple generations in the same place, building relationships, trust, confidence, regulatory systems and community boundaries. This project is both farmer- and science-led, and depends on engagement from multiple stakeholders and many community members. It borrows on two decades of history between Playa Viva and the community, and six years of trust-building with the Head of Agroforestry at Tierra Foods.
- **Labour shortages:** Due to a large out migration of the local workforce and specifically men in the six communities there are fewer individuals dedicated to agriculture each

season. For this reason, Playa Viva began engaging women in the working, agrarian community and are training new pioneers of regenerative agriculture in the watershed.

- **Policy and regulatory changes:** There are few if any policy regulations in the Rio Tule watershed that will affect our project. Nonetheless, the project has the support of the local mayor, and project partners are in good standing with municipality leadership, and all interested programs and community members are informed of the collaboration.

Separately, we have identified the following environmental risks within the watershed:

- **Soil erosion:** Specific to the sites of the upper watershed and most prevalent on deforested lands over moderately steep slopes with visible soil erosion. As a result, the soil there is poor (with low organic matter), rocky, and shallow with transport of alluvials during heavy rainfall events. Ultimately, there is a risk of some crop failure and higher tree mortality due to the (current) poor soil conditions and shallow soil depth, which could hinder proper root system development.
- **Water availability:** Sites at the lower watershed suffer from low water availability because they receive less annual precipitation, with most water being used by producers higher up the watershed. Additionally, these sites are extremely sandy and lack organic matter, making them highly permeable and poor at retaining water.
- **Pests/diseases:** The weevil borer hatches its eggs within the cacao trunk, allowing larvae to feed from it. Coffee plantations can be prone to rust disease which is a global problem within coffee monoculture systems.

6.2 Risk Management: Mitigation Strategies

To ensure the project's success we developed a series of mitigation strategies with the project partners (**Table 5**). The key to our success will be active communication, monthly check ins in Phase 1 and Phase 2, and transparency; reporting on project issues as they arise, being resilient in our collective response, and responsible to ourselves, project participants and the project itself, by way of the strategies outlined below.

5. Overview of Risks and Mitigation strategies

Risk	Mitigation Strategies
Tree mortality	• Implementing best practices for seedling procurement, and planting. • Replanting if mortality exceeds a predetermined threshold (20%). • Weeding around seedlings in the first 3 years after planting
Soil erosion	• Use of vetiver grass on contour to create natural terraces and produce biomass. • Implementing soil conservation measures, such as green mulching. • Mixture of deep vs. shallow rooting plants for improved soil stability
Water availability	• Implementing water conservation measures, such as green mulching and planting water. • Selecting local species, adapted to the dry conditions of Guerrero. • Inclusion of shade trees to reduce evapotranspiration and water stress.
Pest and Disease	• Diversifying the production system (5-15 species per site) for natural biocontrol. • Using multiple varieties (for instance 4 different varieties of coffee and banana) • Regular monitoring, and established protocols for early detection and response.
Land Tenure and Resource Access	• Establishing legally binding Benefit Sharing Agreements with project participants. • Verify land tenure rights before project implementation.
Community Engagement Risks	• Ensuring transparent communication, participatory decision-making processes, and aligning incentives for community involvement.
Labour shortages	• Utilising Playa Viva's local network and established partnerships with local organisations to secure additional labour resources as needed
Policy and regulatory changes	• Staying informed about relevant policy developments, engaging with local authorities, and adapting project activities as needed to comply with new regulations.
Carbon permanence and leakage	• Verify whether the project area constitutes abandoned land, or land with agricultural activities . • If agricultural activity, then: ○ Leakage emissions within the project area will be calculated using the AR-Tool15 v2.0 (Cercarbono standard) ○ Leakage emissions from project activities will be assessed and calculated for a period of five years after the project start date, or project instance start date in the case of grouped projects.

6.3 Support for farmers tailored per site

6.3.1 Land Tenure and Project Management

All project areas are privately owned and titled to the landowner directly or indirectly; and it is only with their consent of the 20-year-use and study of the agroforestry sites and systems that this project can be implemented and verified. Participation Agreements will be executed by each participating landowner and farmer, and honoured for the duration of the project.

A dedicated project manager will oversee the technical and administrative components of the project and project sites in Guerrero, supporting individual farmers and landowners through the development of the project as well as Phase 1 and Phase 2. While project sites will principally be managed by the landowners and farmers themselves, the Head of Agroforestry at Tierra Foods will support each project site with monthly meetings and year round assessment.

To ensure effective coordination, decision-making, and accountability, the project will establish a governance structure (Appendix II). This structure will include a Project Steering Committee, composed of senior representatives from Tierra Foods, Playa Viva, and a representative on behalf of landowners. The committee will provide strategic oversight, guidance, and approval of major project decisions, ensuring a participatory approach. A project management team, led by the Agroforestry DIrector from Tierra Foods and the Playa Viva Permaculture Manager, will oversee management, coordination, and implementation of project activities, ensuring tasks are completed on schedule and resources are efficiently utilised. Additionally, a Technical Advisory Group, consisting of experts in agroforestry, biomineralization, community development, and environmental conservation, will offer technical guidance and support to the project team. The above governance structure will be shared, and quarterly project review meetings will be conducted. A central repository will be maintained for documentation and risk management.

6.3.2 Collaboration Agreement

All parties will sign a Collaboration Agreement (CA) derived from stakeholders' conversations at the onset of the project development stages from April to August 2024. The CA addresses land rights, harvest and production ownership and distribution, as well as carbon sequestered throughout the length of the project. A few key takeaways from the CA, found in Appendix III of this document, are:

- Tierra Foods, Playa Viva and partner farmers agree to share the benefits derived from the project in a fair and equitable manner, based on inputs invested by each participant and pursuant to this signed agreement by all parties.
- Participating landowners and partnering farmers will retain title and ownership of their land throughout the length of the project. They will also accumulate co-benefits and new ecosystem services on their property as a result of the installed agroforestry systems, including but not limited to: improved soil health, enhanced biodiversity, accumulated organic matter and new microclimates.
- Participating landowners and our partner farmers will own both the production and the distribution rights to the production from the agroforestry systems on their land.
- Tierra Foods will own the inorganic and organic carbon generated during Phase 1 of the project as part of the scientific research being conducted and the accreditation process for testing the methodologies of this multi-stakeholder project. As we progress into Phase 2 and 3, collaboration agreements will be developed with the participating farmers, guided by the insights gained from Phase 1.

6.3.3 Nursery Support

In Phase 1, the tree saplings for the primary and secondary species of each agroforestry system (see **tables 1-4** in Section 4 for the full species list) were procured and provided by Tierra Foods from reputable plant nurseries in regions with similar climates to the project sites. Any saplings injured during delivery will be replaced by the providing nursery; while tree loss after planting is insured by Tierra Foods. Playa Viva will produce and provide the seeds, cuttings or in some cases, the tree saplings for the support species designed into each unique project site. Farmers are responsible for any other plants added to the system for their own production, use or sale.

In the procuring of plants for the four project sites in Phase 1, we recognized an opportunity for the development of a nursery in the Rio Tule watershed to support the plantings in Phase 2 of this project; and to be considered a new revenue stream for a local farmer or the women's cooperative. As such, 40 kilograms of uje seeds were collected in the upper watershed in May 2024 and 2,000 new uje seedlings have been planted to support Phase 2 of the project. Playa Viva will begin the production of new tree seedlings in September 2024 for all secondary and supporting species such as cacao, *gliricidia*, *leucaena*, *annatto* and more.

6.3.4 Technical Support

Amanda Harris, from Tierra Foods, has already harvested baseline soil samples for carbon prior to Phase 1. Moreover, a first series of training workshops (three workshops) have been conducted and more are scheduled, to engage landowners and farmers on the scientific processes required for 1) taking baseline measurements and 2) monitoring carbon stocks evolution over time. These sessions cover the sampling method, sampling scheme, and how to sort/store samples after collection, for soils, trees, and herbaceous plants (for sampling methods see **Table I.1** in Appendix I). The soil samples will be sent to an independent certified lab for analyses. Since the sampling approach can vary greatly per location, a carbon monitoring expert from Tierra Foods will be available for support throughout the first 5 years of the project.

Project participants received a four-day intensive workshop, moving creatively between theory and practice, with renowned Syntropic Agriculture teacher, Namaste Messerschmidt this August, 2024. The 40-hour course highlighted design techniques and agroforestry systems that mimic natural patterns, teached how to prune in a timely manner to stimulate growth in the whole system, and how to plant for a site's own fertility and water inputs. Participants, as well as other community members invited and participating in the workshop, can join an international Syntropic Agriculture WhatsApp group to stay abreast of other agroforestry systems around the world; to ask questions and advice; for access to resources; and to build connections and capacity through sharing stories.

With funding from the World Research Institute (WRI), we delivered three workshops to support female farmers and other landowners during Phase 1 in July-August 2024. The workshops are designed to provide active and future women farmers with essential skills to obtain soil samples so these can be used to generate the soil data required to verify the carbon sequestration, as well as to expand on their knowledge of the project’s objectives and offering opportunities for networking. Participants engaged in hands-on training sessions and learned about regenerative farming practices. The objective is to foster a community of knowledgeable and resilient women farmers, contributing to the growth and sustainability of rural agriculture within the Rio Tule watershed.

6.4 Project Deployment

This deployment plan has been set up based on the existing track record of Playa Viva in the Rio Tule watershed, confirming their capacity to achieve the outlined ramp-up. Moreover, the willingness of the local producers to allow intervention on their land (up to 50 ha for the moment), as well as their labour capacity has been assessed during the design phase to ensure that smallholders can effectively implement this deployment plan. The ultimate goal is to expand throughout the watershed, and transform a total of potentially 353 ha of productive land (**Table 6**). This would result in ~80,000 trees planted within the first 2 years of implementation, and potential of ~600,000 trees within the totality of the watershed (**Table 7**).

Total count of permanently planted trees calculated with the following equation:

$$Number\ of\ trees\ =\ Planting\ density\ (trees/ha)\ *\ Project\ area\ (ha)$$

Table 6. Total area (ha) of project intervention.

		System 1 Placitas Cafetal	System 2 Placitas Cascada	System 3 Gabriel Cooperative	System 4 La Campiña	Total (ha)
Phase 1	**Year 1 (Q3 2024)**	3	4	1	2	10
Phase 2	**Year 2 (Q4 2024-Q1 2025)**	6	10	4	20	40
Phase 3	**Year N***	102	171	-	30	303
	Total	**110**	**185**	**5**	**52**	**353**

* Following Phase 2, our objective is to expand the project area to a total of 353 ha within the watershed. The year N of expansion is not predetermined but a slow ramp-up will take place within the first 20 years of the project.

Table 7. Total count of permanently planted trees (timber trees are excluded).

	System 1 Placitas Cafetal	System 2 Placitas Cascada	System 3 Gabriel Cooperative	System 4 La Campiña	
Planting density (trees/ ha)	1,090	2,140	1,860	1,430	
					Total
Phase 1 (number of trees)	3,270	8,560	1,860	2,860	16,550
Phase 2	6,540	21,400	7,812	28,600	64,352

(number of trees)					
Phase 3 (number of trees)	111,180	365,940	0	42,900	520,020
Total (number of trees)	**120,990**	**394,830**	**9,672**	**74,360**	**600,922**

7. Carbon stock estimates

7.1 Plant biomass

The carbon ex-ante estimates were calculated for trees, shrubs and cacti that remain permanently on-site, and for those that are harvested for timber (CDR plants). Any plants that are cut down and returned to the soil as mulch (such as banana or herbaceous plants) are not considered to result in CDR (non-CDR plant species) (see **table 8 for CDR and non-CDR plants**).

Table 8. List of plant species, divided into plants that result in additional CDR and plants that do not result in additional CDR (non-CDR).

CDR plant species	non-CDR plant species
Brosimum alicastrum	*Musa sp.*
Theobroma Cacao	*Cajanus cajan*
Moringa oleifera	*Zingiber officinale*
Gliricidia sepium	*Cnidoscolus aconitifolius (Mill.)*
Coffea arabica	*Curcuma longa*
Bixa orellana	*Manihot esculenta*
Leucaena leucocephala (Lam) De Wit	*Cymbopogon*
Cinnamomum verum	*Hibiscus sabdariffa*
Citrus × aurantiifolia	*Mentha spicata*
Annona muricata	*Aloysia citrodora*
Camellia sinensis	*Mentha piperita*
Opuntia ficus-indica	*Matricaria chamomilla*
Azadirachta indica	*Zea mays*

Data on annual DBH growth, as well as Height, and/or volume data for 20-year-old trees were not available for all CDR plant species. For these species, we developed in-house regression models for Height and DBH by selecting the best curve fits using Excel, based on data sourced from existing literature. Afterwards, Height and DBH were converted to aboveground tree biomass using allometric equations specific to dry tropical biomes (equation 1). Root:shoot ratios per plant species were used to include root biomass (equation 2). Total tree biomass was then calculated by summing aboveground and belowground biomass (equation 3). For the rest of the plant species, for which annual growth data were available, we used annual DBH as an annual growth step, followed by allometric equations and root:shoot ratios to estimate dry biomass. For the tree species that are sold as timber, a conversion factor of 0.65 was multiplied to the aboveground biomass (equation 4), in order to exclude the branches that are not sold as timber (de Miguel-Díez et al., 2023). For above four equations see **table 9**. The annual DBH, as well as the proposed regressions, the allometric equations used, and the root:shoot ratios, are in **table 10**. All respective literature is listed in the Appendix I, **table I.2**. Finally, the estimated biomass was multiplied by 0.47 to convert to carbon (IPCC, 2006a), which was then multiplied by 3.67 (Mol CO_2/Mol C = 44/12), to convert to CO_2.

Table 9. Equations for tree biomass calculations

$$f(H,\ DBH)\ =\ AGB \qquad (eq.\ 1)$$

$$BGB\ =\ AGB\ x\ R{:}S \qquad (eq.\ 2)$$

$$Total\ tree\ biomass\ =\ AGB\ +\ BGB \qquad (eq.\ 3)$$

$$Timber\ biomass\ =\ AGB\ x\ 0.65 \qquad (eq.\ 4)$$

H = height (m)

DBH = diameter at breast height (130 cm) (cm)

AGB = aboveground biomass (kg/tree)

BGB = belowground biomass (kg/tree)

R:S = root to shoot ratio

Table 10. In-house regressions, allometric equations, and R:S per tree species

Plant species	Growth regressions	Allometric equations	R:S
Brosimum alicastrum	$H\ =\ 0.5536\ *\ AGE\ +\ 0.8036$ $DBH\ =\ 1.4286\ *\ AGE\ -\ 1.5714$	$AGB\ =\ 0.0336\ *\ DBH\text{^}2\ *\ H$	0.26
Theobroma cacao	$H\ =\ 2.518\ *\ ln(AGE)\ +\ 0.319$ $DBH\ =\ 1.717\ *\ AGE\ -\ 2.933$	$AGB\ =\ e^{(-4.2\ +\ 1.19\ *\ ln(DBH) +\ 2.34\ *\ ln(H))}$	0.26
Gliricidia sepium	Due to insufficient data, the growth regression was modelled similarly to that of Theobroma cacao (as previously cited). However, to reflect realistic tree sizes, the annual growth increment was adjusted upward by 58%.	In the absence of specific allometric equations, and given the similar growth morphologies of Gliricidia sepium and Theobroma cacao, we used the same allometric equation as previously cited.	0.26
Leucaena leucocephala	In a similar fashion, and based on field observations from our agroforestry lead (Amanda Harris) in Guerrero (unpublished data) we assumed that *Leucaena leucocephala* would grow 20% less than *Gliricidia sepium*.		0.26

Bixa orellana	Due to insufficient data, we assumed two growth phases, assigning a growth step to each phase. Based on *Elias* et al. (2002), and; *Fern*, (2014), we made an assumption that the shrub would reach a height of 3 metres at 6 years of age and achieve its maximum size at 12 years old (height = 3m, DBH = 11cm). This resulted in the following polynomial equations: $H = -0.0403 * AGE^2 + 0.7711\ AGE - 0.5594$ $DBH = -0.0133 * AGE^3 + 0.2962 * AGE^2 - 0.8917 * AGE + 2.291$	$AGB = 0.2385 + 0.058 * (DBH^2) * H$	0.26
Cinammomm verum	Annual DBH growth assumed at 0.75 cm/ tree/ year (Orwa et al. 2009). A linear regression from Nepal for *Cinammomum tamala* was borrowed to estimate annual AGB.	$AGB = -73.4210 + 13.8525 * DBH$	0.26
	Annual DBH or H growth (cm/ year)	**Allometric equations**	**R:S**
Moringa oleifera	DBH: 2 cm/ year	$AGB = e^{(-3.916+2.982*LN(DBH))}$	0.26
Citrus × aurantiifolia	Based on Parsons et al. (2001) DBH: 1.4 cm/ year	Assumed equation from Costa rica (Andrade et al., 2022) $AGB = e^{(-2.57 + 2.65*LN(DBH))}$	0.26
Annona muricata	Assumed to be identical to *Citrus x aurantiifolia* DBH: 1.4 cm/ year	Assumed to be identical to *Citrus x aurantiifolia* $AGB = e^{(-2.57 + 2.65*LN(DBH))}$	0.26
Psidium guajava	Assumed to be identical to *Citrus x aurantiifolia* DBH: 1.4 cm/ year	Assumed to be identical to *Citrus x aurantiifolia* $AGB = e^{(-2.57 + 2.65*LN(DBH))}$	0.26
Azadirachta indica	Based on data from Ghana (Nanang et al., 1997) DBH: 1.03 cm/ year H: 0.89 cm/ year	-	0.26
	Annual AGB growth (kg /plant / year)		
Coffea arabica	Estimate based on 50-year-old projections per ha (Ruiz-García et al., 2020). And assuming a planting density of 2000 coffee trees/ha (Ruiz-García et al., 2021). 0.31 kg/ tree/ year	-	0.26
Saccharum officinarum	Assuming a planting density of 5 stems / m^2, and a productivity of 150 tons / ha / year (Desalegn et al., 2023). 0.85 kg/ stem/ year	-	0.17
Camellia sinensis	(Eitzinger & Anandacoomaraswamy, 1997) 2.3 kg/ plant/ year	-	0.18

Opuntia ficus-indica	Assumption based on total biomass for a planting density of 16 cacti plants / m^2 (Almaguer-Sierra et al., 2009) 0.014 kg/ plant/ year	-	-

7.2 Soil carbon

7.2.1 Soil organic carbon

Soil organic carbon (SOC) additionality was estimated following applicability requirements from Cercarbono's A/R-MethodologicalTool-v1.1. The Cercarbono tool uses a LU-change approach, with default LU-change factors that do not necessarily correspond to our context at the Juluchuca watershed. To estimate additionality, we calculated using the A/R-MethodologicalTool-v1.1, and alternatively using the exponential decay function for humic soil fraction from the RothC model. Both for the generally accepted "steady-state" period of 20 years for soil organic carbon. **To represent forestry reference values based on the Juluchuca watershed context, and because the Cercarbono approach gives very generalised results, we chose to keep the result based on the RothC model approach.**

Cercarbono approach

The **initial SOC stock at the start of the project** is estimated as follows:

$$SOC\ (initial)\ =\ SOC\ (Reference)\ *\ f_{LU}\ *\ f_{MG}\ *\ f_{IN}$$

SOC (Reference) = Reference SOC stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation - normally forest) by climate region and soil type applicable to stratum i of the areas of land; t C ha-1

f_{LU} = Relative stock change factor for baseline land-use in stratum i of the areas of land; dimensionless

f_{MG} = Relative stock change factor for baseline management regime in stratum i of the areas of land; dimensionless

f_{IN} = Relative stock change factor for baseline input regime (e.g. crop residue returns, manure) in stratum i of the areas of land; dimensionless

Since, our project area of land which is not subjected to soil disturbance attributable to project activity and for which the total area disturbed, **no SOC carbon loss is accounted for**.

$$SOC\ (loss)\ =\ 0$$

To calculate the additional soil organic carbon (tC/ ha/ yr), hereby mentioned as dSOC:

$$dSOC = \frac{SOC_{REF} - (SOC_{INITIAL} - SOC_{LOSS})}{20\ years}$$

The additional carbon stock after 20 years for a soil depth of 15cm is demonstrated in **table 11** below.

Table 11. Results for additional annual SOC following the Cercarbono approach

Agroforestry system	SOC [1] (Initial)	SOC [1] (Reference)	fLU	fMG	fIN	SOC loss	dSOC [2] (tC/ ha/ yr)	dSOC (tCO_2/ha/yr)
Placitas Cafetal	24.738	38	0.93	0.7	1	0	0.33155	1.2167885
Placitas Cascada	24.738	38	0.93	0.7	1	0	0.33155	1.2167885
Gabriel Cooperative	12.369	19	0.93	0.7	1	0	0.165775	0.60839425
La Campiña	12.369	19	0.93	0.7	1	0	0.165775	0.60839425

[1] SOC default values for 30 cm soil depth

[2] SOC converted from 30 cm soil depth down to 15 cm of soil depth; dividing by 2

RothC approach

The data used are a combination of site soil analyses from Tierra Foods (soil bulk density, soil organic matter, soil depth), soil map data from INEGI (rock fraction) (SNIB, 2024) (**table 12**), and the available median land-use reference values of soil carbon stocks in Mexico (Aryal et al., 2018) (see reference values for forestry and pasture land-use in **table 13;** we could not find reference soil carbon stocks for croplands, or barren lands). The soil organic matter was converted to soil organic carbon, by multiplying with 0.58 according to the van Bemmelen factor (IPCC, 2006b). Organic carbon was converted to CO_2, by multiplying with 3.67. Since our soils are rather shallow, and in order to match our soil depth of 15 cm, the land-use reference values for Mexico were adjusted from a depth of 30 cm to 15 cm by halving the original values. We understand that the depth distribution of soil organic matter is not linear, and that this calculation probably underestimates the C stock values for 15 cm soil depth in Mexico. However, we had to make adjustments to account for the shallowness of our soils. Soil additionally is presented in **table 14**.

Table 12. Soil descriptive data, and baseline soil carbon stocks per Agroforestry system for a depth of 15 cm.

Agroforestry system	Soil bulk density (tonnes /m^3)	Soil organic matter (%)	SOC (%)	Rock fraction (%)	Soil depth (cm)	SOC stock (tC/ha)	SOC stock (tCO_2/ha)
Placitas Cafetal	0.84	2.60%	1.51%	11.46%	15	17	62
Placitas Cascada	0.86	1.60%	0.93%	11.46%	15	11	39
Gabriel Cooperative	0.93	1.60%	0.93%	0.00%	15	13	48
La Campiña	1.3	0.49%	0.28%	0.00%	15	6	20

Table 13. Median values of soil organic carbon stock at a depth of 15 cm, for Forestry, and Pasture lands.

Land-use	SOC stock (tCO_2/ ha)
Forestry	109
Pasture	52

The additionality of the soil organic carbon stock from the initiation of the project (baseline) to 20 years later, was calculated using the exponential decay function for humic soil fraction from the RothC model, for a period of 20 years.

$$S(n) - S(0) = (C_{forestry} - C_{baseline}) * (1 - e^{-0,02 * n})$$

$C_{forestry}$ = reference carbon stock for a forestry land-use scenario

$C_{baseline}$ = baseline carbon stock for “Placitas Cafetal”

S (0) = carbon storage at 0 years

S (n) = carbon storage at n years

Taking “Placitas Cafetal” as an example, the organic carbon stock after 20 years will be:

$$S(20) = 62 + (109 - 62) * (1 - e^{-0,02 * 20}) = 77\ tCO_2 / ha$$

$$Additionality = S(20) - S(0) = 77 - 62 = 16\, tCO_2 / ha$$

Table 14. Soil organic carbon stocks after 20 years, and additional soil organic carbon at a depth of 15 cm.

Agroforestry system	SOC stock after 20 years (tCO$_2$/ha)	Additional SOC dSOC (tCO$_2$/ha)	Additional SOC dSOC (tCO$_2$/ha/year)
Placitas Cafetal	77	16	0.78
Placitas Cascada	62	23	1.16
Gabriel Cooperative	68	20	1.02
La Campiña	50	29	1.47

7.2.2 Soil inorganic carbon

According to Rowley et al. (2017), the annual soil sequestration rate of $CaCO_3$ for large centennial *Brosimum alicastrum* trees, is on average 1.27 tCO_2/ ha/ year. The latter value corresponds to ~1% of the estimated annual sequestration of organic carbon as biomass for these large trees (105.7 tCO_2/ ha/ year). Our goal is to reach a higher sequestration rate corresponding to 5% of biomass stocks from *B. alicastrum*, through increased litter and oxalate inputs (pruning, green mulching).

Hence the soil inorganic carbon (SIC) stock is estimated as follows:

$$SIC\ stock = Organic\ carbon\ stock\ as\ tree\ biomass * 0.05$$

7.3 Leaf litter layer

Since this project is an agroforestry project that involves green mulching, which entails collecting and returning organic residues to the soil as ground mulch, we assume that a layer of leaf litter will not be present in these systems. Therefore, **the carbon stocks for leaf litter are not included** in these estimates.

7.4 Dead wood

Given that the duration of the agroforestry project is 20 years, and that the first few years' maintenance work (clearing) must be carried out, existing dead wood on the ground, standing wood or windfall, will be neglected for both the project and reference scenario. As long as any significant amounts of dead wood resulting from tree mortality (such as large logs) is removed from the site, then it is not considered part of the additional carbon stock. As such, **dead wood is excluded from our carbon stock estimates**.

8. MRV approach

This **MRV (Monitoring, Reporting, and Verification)** section outlines the assessment of **socio-economic impacts**, **climate change mitigation,** and **environmental co-benefits** within the project area. It evaluates how the project monitors and verifies the enhancement of natural ecosystems, improves local socio-economic conditions, and mitigates negative environmental impacts (**table 15**), ensuring a comprehensive understanding of the project's overall benefits and challenges.

Table 15. Overview of impact categories, objectives, variables to monitor, chosen methodologies, and frequency of measurement and reporting.

Category	Objective	Monitored Variables	Methodology	Frequency and reporting
Socio-economic[1]	Sustainable food production and financial resilience	Yields/ ha/ year, selling price at farmgate, costs, net income	Conducting interviews from representative farms	On the first year and every year after project implementation till year 20.
	Community engagement and education	Number of families, farms, and community members engaged in workshops		
	Gender equality in supply chains	Women to men ratio, of engaged community members		
Climate change mitigation[2]	Carbon sequestration (organic)	Soil organic carbon (%)	Soil harvests, and analyses from a certified external soil laboratory	Before project initiation, annual for the first 5 years of the project, and every 5 years thereafter till year 20.
		Tree biomass	DBH measurements with a tape, and height measurements with a stick or clinometer	Annual monitoring for the first 5 years of the project, and every 5 years thereafter till year 20.

		Number of alive trees	Tree count, and recording of unhealthy/diseased trees per ha	
	Carbon sequestration (inorganic)	Soil $CaCO_3$ (%)	Soil harvests, and analyses from a certified external soil laboratory	Before project initiation, annual starting from year 1, and for the first 5 years of the project, and every 5 years thereafter till year 20.
Environmental co-benefits[3]	Improved soil quality	Soil pH, soil organic matter (%), NPK content (mg/g)	Soil harvests, and analyses from a certified external soil laboratory	Before project initiation, annual for the first 5 years of the project, and every 5 years thereafter till year 20.
	Reduced soil erosion	Erosion pin height (cm)	Erosion pin method, and photographic documentation of rills, gullies, or sediment accumulation.	Installing pins after project implementation, and annual monitoring for the first 5 years of the project, and every 5 years thereafter till year 20.
	Biodiversity conservation	Presence of keynote species	Bioacoustics combined with Camera traps	**Tbd with pending collaborator**
	Water conservation	Irrigation m^3/ ha/ year	Conducting interviews from representative farms	On the first year and every year after project implementation till year 20.
	Reduced water pollution	**Tbd with pending collaborator**	Water quality tests	**Tbd with pending collaborator**

[1] The socio-economic variables will be monitored, via community interviews conducted by **Ximena Rodriguez**, and in coordination with **Osmaira Hernández** from the **women's cooperative**.

[2] The climate change mitigation variables will be monitored, via soil harvests from local producers, in co-supervision with a pending external academic collaborator with **Tierra Foods**. The analyses will be performed by a certified soil laboratory.

[3] Soil quality will be monitored through samples from local producers, co-supervised by **Tierra Foods** and an external academic collaborator, with analysis by a certified lab. On-field soil erosion observations, and water irrigation needs will be provided by the local producers. Biodiversity

conservation assessments will be conducted by **a scientific collaborator** and water pollution assessment by **a scientific collaborator.**

8.1 Carbon monitoring protocol

8.1.1 Monitoring Subplots - Area based approach

To monitor carbon removal we are using an **area-based approach**, using **subplots** (1 subplot of 100 m^2/ha; i.e. 1% of the project area) that scale biomass and soil carbon measurements per unit area to the project level using project area as the multiplier (i.e., the area within the project boundary). Field measurements consist of soil harvests, and dendrometric, and herbaceous biomass measurements; a list can be found in **table I.1 in Appendix I**. Subplots are measured every year for the first 5 years, and every 5 years thereafter, for a total period of 20 years. It is important to note that the sampling method will be adapted to the most recent/ science-aligned practices available.

8.1.2 Control plots - Counterfactual

According to the additionality guidelines from Cercarbonos-Additionality-Tool-V2.0.1, climate change mitigation initiatives focused on removing GHG must demonstrate that the net anthropogenic removals of GHG by carbon pools resulting from the CCMP activity must exceed the sum of the changes in carbon pools that would have occurred in the absence of the activity.

To abide with these requirements, we will designate an adjacent area of 500 m^2 (per site) to serve as a **Counterfactual**. This area will be left untouched, and will be monitored at the same intervals as the subplots.

8.1.3 Additionality calculation

The additionality is then calculated, off a carbon stock baseline, which depends on the land use history:

1. **Abandoned land**

   If the project area consists of land that has been abandoned for more than 10 years, then the baseline is fixed as the current organic carbon (woody biomass, non-woody biomass, soil organic carbon), to be measured prior to the project's intervention.

2. **Land with agricultural activities**

   If the project area consists of an existing cropland or grazing land, then this constitutes a regeneration practice which necessitates a counterfactual for comparison. Effectively, control plots will be selected based on their similarity to project plots, outside the project area. The control plots will be left untouched and visibly marked, and their evolution will be monitored annually during the first 5 years, and every year thereafter together with the project subplots.

The additionality calculation is as follows:

$$Net\ GHG\ removal\ =\ (Removal_{with\ project\ activity}\ -\ Removal_{without\ project\ activity})$$

Removal $_{with\ project\ activity}$ = cumulative CO_2 stocks obtained from subplots after 20 years of project activity

Removal without project activity = cumulative CO_2 stocks obtained from control-counterfactual plots after 20 years of project activity

9. Carbon credits

The following ex-ante estimates incorporate a **15% non-permanence buffer** in the form of reserved non-tradable organic carbon removals. These reserves serve to compensate for unexpected declines in carbon stocks. The latter buffer accounts for the risk of plant mortality and surface losses possible within the watershed that suffers from landslides (upper watershed), low water availability (Lower Watershed). On the other hand, inorganic carbon once stored in soil is highly permanent, hence a lower **1.5% non-permanence buffer** is applied.

Phase 1 & Phase 2 (50 ha), will be registered under the **Cercarbono** standard using a Forest and Woody Crops Methodology (**Methodology M/UT/F-A01**) and is expected to generate a combined total of **13,092 tCO_2 (organic carbon) and 516 tCO_2 (inorganic carbon) over 20 years (Table 16).**

Within future expansion of the project to 353 ha, a total of 95,690 tCO_2 may be sequestered.

Since there are no explicit studies on the carbon sequestration for the tree species involved within the Juluchuca micro-watershed, or within the state of Guerrero, we used studies from similar ecosystems, borrowing results from México, but also from other countries and continents. To be conservative and considering the challenging growing conditions within our sites, we used the lower range of values within the existing literature. Soil organic carbon was included in these estimates, but using conservative approaches.

The **gross ex-ante CO_2** estimates after 20 years, are calculated as follows for organic and inorganic CDR respectively:

$$Gross\ Organic\ CO_2 = (ABG + BGB + SOC) * 20\ years * Project\ area$$

$$Gross\ Inorganic\ CO_2 = (ABG + BGB) * 20\ years * Project\ area * 0.05$$

ABG = CO_2 sequestered annually as aboveground biomass; t CO_2 ha^{-1} $year^{-1}$

BGB = CO_2 sequestered annually as belowground biomass; t CO_2 ha^{-1} $year^{-1}$

SOC = CO_2 sequestered annually as soil organic matter; t CO_2 ha^{-1} $year^{-1}$

Project area = Surface area to be planted with our agroforestry systems for each Phase; ha

The **conservative ex-ante CO_2** estimates, are calculated as follows for organic and inorganic CDR respectively:

$$Conservative\ Organic\ CO_2 = Gross\ Organic\ CO_2 - Gross\ organic\ CO_2 * NPB_{Org}$$

$$Conservative\ Inorganic\ CO_2 = Gross\ Inorganic\ CO_2 - Gross\ Inorganic\ CO_2 * NPB_{Inorg}$$

NPB_{Org} = Non-permanence buffer for organic carbon stocks; 15%

NPB_{Inorg} = Non-permanence buffer for inorganic carbon stocks; 1.5%

Table 16. Ex-ante estimates of the total amount of CO_2 sequestered as organic and inorganic carbon for 353 ha for the three Phases 1, 2 and 3 over a 20-year period.

Carbon estimates	**Organic carbon stocks as plant biomass (aboveground + belowground parts) and in soil** **tCO_2 for 20 years**	**Inorganic soil carbon stocks as calcium carbonate [1]** **tCO_2 for 20 years**
Phase 1 (10 HA)	3,157 tCO_2	104 tCO_2
Phase 2 (40 HA)	12,245 tCO_2	419 tCO_2
Phase 3 (303 HA)	92,907 tCO_2	3,159 tCO_2
Gross ex-ante estimate total for 353 HA *(AA)*	108,309 tCO_2	3,682 tCO_2
Non-permanence buffer (NPB%)	**15%**	**1.5%**
Conservative ex-ante estimate for Phase 1 (10 HA)	2,684 tCO_2	103 tCO_2

Conservative ex-ante estimate for Phase 2 (40 HA)	10,408 tCO_2	413 tCO_2
Conservative ex-ante estimate for Phase 3 (303 HA)	78,971 tCO_2	3,111 tCO_2
Conservative ex-ante estimate total for 353 HA *(AA - AA * NPB% = BB)*	**92,063 tCO_2**	**3,627 tCO_2**

[1] Figure with potential for optimisation.

10. Financial budget

This financial overview outlines the key budgetary elements for the Phase One of the project, which has a total cost of $**97,791 USD**. As a first-of-a-kind (FOAK) project, one-off costs have been incurred to get the project up and running. Some examples of one-off costs are: purchasing of equipment and new tools and trees bought from nurseries from other regions.

Funding of various types has been secured, including a $**4,000 USD** capital injection from WRI to run workshops with communities, **$10,000 USD** funding from in-kind services from Playa Viva, and **$50,000** USD catalytic loan from Tierra Foods' reserves, totaling **$64,000 USD**, of which $50,000 USD loan will be repaid in order to re-invest in Phase 2 of this project. Therefore, a funding gap of **$83,791 USD** remains, which we aim to address through projected net income from selling Carbon Reduction Credits (CRCs) for *organic carbon*, estimated at **$119,966 USD,** with an upside of **$20,800 USD** for *inorganic carbon***.** Inorganic carbon is considered an upside because its credits cannot be claimed or sold until a certified biomineralization methodology is available. If this certification is obtained within the project's crediting period, it will unlock additional carbon credits, increasing the project's value.

The **remainder of the sales** will be utilised for **initialising Phase 2** of the project. **Table 17,** below, provides a detailed summary of the budget, secured financing, and projected revenues for Phase 1 of the project.

Table 17. Financial overview - Phase 1

Category	**Description**	**Amount ($USD)**
Total Project Cost	Total budget for the Phase 1	**$97,791 USD**
Secured Financing		
• Playa Viva	Funding from Playa Viva	**$10,000 USD**
• WRI	Payment to run workshops	**$ 4,000 USD**
• Internal funding from Tierra Foods	Allocated from Tierra Foods as catalytic investment	**$50,000 USD**
Total Financing to start		**$64,000 USD**
Funding Gap	Amount still needed	**$33,791 USD**
Projected CRC revenue (incl. the non-performance buffer)	Expected from selling Organic CRC[1]	**3,157 tCO_2 x 38 USD/tCO_2 =$119,966 USD**
	Expected from selling Inorganic CRC[2]	**104 tCO_2 x 237 USD/tCO_2 = $20,800 USD**

[1] Calculation for Organic carbon made based on a **selling price** of *38 USD / tCO_2*, - which will then be increased by adding a **selling fee** of *7 USD / tCO_2* , resulting in a total of *45 USD / tCO_2*
[2] Calculation made for Inorganic carbon based on a **selling price** of of *200 USD / tCO_2*, with a **selling fee** of *37 USD / tCO_2* , resulting in a total of *237 USD / tCO_2*

11. Conclusion

This collaboration and project values the deep relationships and trust between the community members, participating partner farmers, and members of the Playa Viva, ReSiMar and Tierra Foods teams. It prioritises science-backed soil health and social impact as drivers for the high value, multi-species production to be harvested from the agroforestry systems planted at each project site, and intercrops local and native species for both water and fertility inside the future forests. As the dynamic team of producers, scientists, designers, teachers, and students come together to study and realise the true biomineralization abilities and impact of the *Brosimum alicastrum* tree, we will also be engaging an entire community and multiple generations in the regeneration of their own watershed, social cohesion and economic systems, for a more resilient future for men and women. We are excited for this pioneering collaboration to enable the first methodology of its kind for agroforestry-based biomineralization, co-developed with the communities and landowners for the prosperity of future generations of our human and non-human co-habitants, and the organisations involved in its inception, sharing the holistic benefits of this approach to landscape restoration.

Team Profiles

Amanda Harris is a Permaculture Designer and Educator with more than a decade of experience living and working in the dry tropics of Latin America. She uses Permaculture Design principles to develop resilient landscapes, to lead agroforestry and restoration projects in the public and private sectors, and to build capacity in a new generation of permaculture designers. Amanda has an MA in Global Environmental Politics from American University and an MA in Natural Resource Management and Sustainable Development from United Nations mandated *Universidad para La Paz* in Costa Rica.

Andreas Altinalmazis-Kondylis is an environmental scientist, with 10 years' experience on the conception of nature-based solutions for the support of agricultural and environmental projects. Andreas holds an M.Sc. in Agroecology and Organic Agriculture from Wageningen University & Research, and a PhD in biogeochemistry and ecosystems from the University of Bordeaux. He has built experience on mineralisation in nature-based solutions and is an expert on biomineralisation (via the Oxalate to Carbonate pathway).

Marcela Flores (CEO and founder) is a food entrepreneur from Mexico, with a Master's in Sustainability Leadership from Cambridge University. Prior to Tierra Foods, she founded a multi-award winning food brand and has experience across Unilever, Quorn and Divine Chocolate. Marcela's entrepreneurial experience, deep understanding of local indigenous communities and strong credibility with CPG companies provides excellent grounding to build a harmonious solution that creates wins for all.

Ximena Rodriguez is a Mexican sociologist from Universidad Autónoma de México (UNAM) She has been researching and working in different learning spaces in urban and rural contexts. Now, along with a multidisciplinary and specialised team, she is developing a regenerative education in the communities of the Rio Tule watershed, encouraging children and teenagers to be young leaders of their territory, by valuing their natural richness, the strength of the social relations, and the multigenerational wisdom.

Osmaira Hernandez is a Mexican environmental scientist from the Universidad Iberoamericana Puebla (IBERO). She has over five years of experience in community work, particularly in rural areas, focusing on educational projects and water conservation. Over the past two years, she has led the development of a women's cooperative in the Río Tule watershed, where she has promoted women's empowerment and social fabric reconstruction through the cultivation and processing of value-added products using regenerative techniques and collaboration with local producers.

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Appendix I

Table I.1. Carbon pool and sampling methods

Carbon Pool	Sampling Method
Soil carbon (organic)	soil sampling with a shovel (0-15 cm deep)
Soil carbon ($CaCO_3$)	soil sampling with a shovel (0-10 cm deep)
Non-woody biomass	clippings of alive and dead herbs (1 m^2 quadrant)
Woody biomass	tape measurements of diameter at breast height (allometry, and root:shoot ratios)

Table I.2. Literature per plant species

Plant species	Average annual DBH (cm) & Height (cm)	Allometric equations	Root : shoot
Brosimum alicastrum	Hernández-González et al. (2018)	Cairns et al. (2003)	Cairns et al. (1997)
Theobroma Cacao	Morán-Villa et al. (2024)	Morán-Villa et al. (2024)	Cairns et al. (1997)
Moringa oleifera	Benedicte Priscile et al. (2022)	Benedicte Priscile et al. (2022)	Cairns et al. (1997)
Gliricidia sepium	-	Villanueva-López et al. (2015)	Cairns et al. (1997)
Coffea arabica	Ruiz-García et al. (2020, 2021)	-	Cairns et al. (1997)
Bixa orellana	Elias et al. (2002); Fern, (2014)	Cairns et al. (2003)	Cairns et al. (1997)
Cinamomum verum	Orwa et al. (2009)	-	Cairns et al. (1997)
Citrus × aurantiifolia	Parsons et al. (2001)	Andrade et al. (2022)	Cairns et al. (1997)
Annona muricata	*Same as citrus x aurontiifolia*	*Same as citrus x aurontiifolia*	*Same as citrus x aurontiifolia*
Saccharum officinarum	Desalegn et al. (2023)		Smith et al., 2005
Camellia sinensis	Eitzinger & Anandacoomaraswamy (1997)	-	Eitzinger & Anandacoomaraswamy (1997)
Opuntia ficus-indica	Almaguer-Sierra et al. (2009)	-	-
Azadirachta indica	Nanang et al. (1997)	-	Cairns et al. (1997)
Psidium guajava	*Same as citrus x aurontiifolia*	*Same as citrus x aurontiifolia*	*Same as citrus x aurontiifolia*

Appendix II

Project Governance Structure document

tierra

PLAYA VIVA

PROJECT GOVERNANCE STRUCTURE

JULY 2024

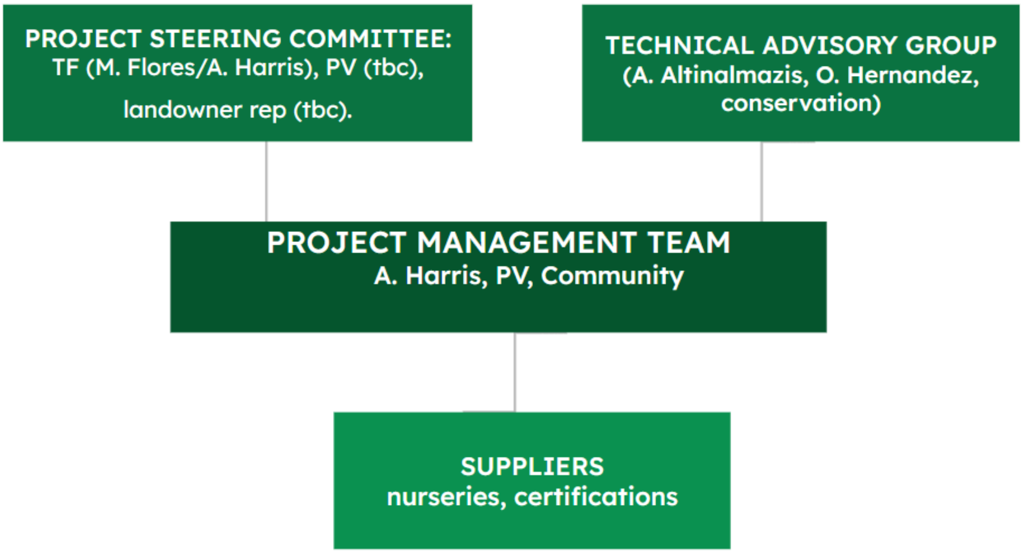
ABOUT THIS DOCUMENT

To ensure coordination, decision-making, and accountability, the Phase 1 of the PV<>TF project has a governance structure. The objective of this document is to set out this structure::

- **Project Steering Committee,** comprised of a TF (M. Flores/ A. Harris), a PV (tbc) representative, and a representative on behalf of landowners (tbc). The aim is to provide oversight, guidance, and approval of major decisions, ensuring a participatory approach.
- **Project management team**, led by a project manager from Tierra Foods (Amanda Harris) will provide oversight, and a named Playa Viva member (tbc), will be responsible for the day-to-day management, coordination, and implementation of project activities.
- **Technical Advisory Group**, consisting of (A. Altinalmazis/ O. Hernández) experts in agroforestry, biomineralization, community development, and environmental conservation, for technical guidance to the project team.

The above governance structure **will be shared**, and quarterly project review meetings will be conducted. A central repository will be maintained for documentation and risk management.

GOVERNANCE STRUCTURE



QUARTERLY REPORT

DATE	PROGRESS	RISK	MITIGATION	ACTION
ABC	ABC	ABC	AABC	ABC

Appendix III

Pending signature by stakeholders.