REGENERATING DEGRADED LANDS IN FLORIDA THROUGH PONGAMIA

Document Prepared by Cultivo Land PBC and Terviva

Project Title	Regenerating degraded lands in Florida through pongamia
Version	2.0
Date of Issue	20-May-2022 this version of the document issued
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1. Project Details

1.1 Summary Description of the Project

The proposed project under the VCS-approved *CDM A/R Small-scale Methodology: Afforestation and reforestation project activities implemented on lands other than wetlands* aims to sequester carbon emissions through the implementation of sustainable agroforestry practices in degraded lands. The objective of this project is to sequester carbon and to obtain internationally verified carbon credits derived from these practices over 20 years, improve the quality of degraded agricultural lands, and improve farmer income through the implementation of sustainable agroforestry practices and the planting and cultivation of pongamia trees on private lands in St Lucie County, Indian River County, and Charlotte County in Florida, USA. This is a grouped project, aggregating land from different landowners who have owned and worked the land for decades. As a grouped project, it is intended for additional land to be included in future years, with the project size starting at 510 hectares and increasing to approximately 1,000 hectares in the following years.

Currently, the 510 hectares of land parcels are degraded due to intensive agricultural production of citrus and its subsequent collapse from vector-borne disease. Huanglongbing (HLB or Citrus Greening) (USDA, 2021c) has required farmers to intensify common practices such as high pesticide and fertilizer use, as well as the removal of trees to avoid the spread of the disease. This has resulted in a decrease in citrus production yield and, in most cases, the death of trees. Consequently, farmers have ceased growing citrus in the past decade, shifting to cattle grazing or leaving the land fallow.

Agroforestry presents an opportunity to recover the land through the reforestation of permanent, resilient crops, maintained using sustainable agroforestry practices such as reduced fertilization and pesticide use. Reforestation started in 2018, through the planting of 100 to 145 pongamia trees per acre (250 to 360 trees per hectare, approximately).

Pongamia (*Millettia pinnata*), also known as pongamia oil tree, is a non-GMO legume tree crop that produces three to four times the yield of protein and oil-rich beans per acre as soybeans. Pongamia's natural adaptations to a harsh, monsoonal climate – pest resistance, drought and salt tolerance, and nitrogen fixation – reduce the need for inputs like pesticides and fertilizers that can negatively impact water quality and biodiversity, and maximize its potential to restore the productivity of degraded agricultural lands.

The Project will be developed by multiple Project Proponents: the Florida Regenerative Pongamia Fund 1 (FRPF1), Terviva, and Cultivo Land PBC (Cultivo). FRPF1 is a fund created specifically for this endeavor, owned and managed by Terviva, an agricultural technology company that produces pongamia trees. Terviva provides patented high-yielding trees to growers and offers proprietary bean processing to create sustainable food ingredients. With operations in India, Hawaii and Australia, Terviva offers an alternative to local smallholder farmers of a product that is economically valuable and sustainable. Through pongamia production in agroforestry systems, Terviva and its partnering landowners are committed to restoring degraded farmlands for productive use in a sustainable way.

Terviva and FRPF1 will partner with local landowners to raise resilient, high-yielding pongamia trees on degraded land using minimal inputs and sustainable agroforestry practices for a period of 20 years, subject to renewal for another 10 years. This project will also create long-term social value and benefits for all project stakeholders through shared and equitable economic returns from carbon offsets and pongamia beans and products.

Cultivo is the project developer, in charge of Project Description (PD) preparation as well as Project Design Document and Monitoring Report delivery to the Validation/Verification body according to VCS guidelines and procedures. Cultivo will provide the necessary technology, experience and abilities to develop and monitor the natural capital of the project.

It is estimated that this project will capture 86,798 tCO2 eq in 20 years, or 4,133 tCO2 eq on average every year, for the initial 510 hectares accounted for through the implementation of the AR-AMS0007 methodology.

1.2 Sectoral Scope and Project Type

According to the VCS Standard v4.0 Section 3.2, the Project falls into the AFOLU afforestation, reforestation and revegetation (ARR) category. The Project activity is an eligible ARR activity as landowners will restore non-vegetative cover through the planting of pongamia trees. The Project area has not been cleared of native ecosystems within the 10-year period prior to the Project start date and does not lead to the violation of any law.

The Project has been designed as a Grouped Project, with plans to increase the number of project instances over time. The first phase of the project consists of the participation of five landowners in an initial Project Area of 510 ha to afforest fallow and pasture land through the plantation and harvest of pongamia trees.

1.3 Project Eligibility

The Project offers GHG emissions reduction through small-scale afforestation and reforestation activity of a non-forested, non-wetlands area. Thus, the Project falls under the AR-AMS0007 methodology, approved under the Clean Development Mechanism, and used under the VCS Standard. As such, the project falls within the scope of the VCS Program.

The Project complies with AFOLU eligibility criteria, pursuant to the VCS Standard v4.2, as project activities consist of restoring woody vegetation by planting trees in an area that has not been cleared of native ecosystems in the 10 years previous to the Project Start Date.

The Project complies with Section 3.17.16 of the VCS Standard v4.2, as it does not introduce invasive species or allow an invasive species to thrive through project implementation. Pongamia

(*Millettia pinnata*), formerly known as *Pongamia pinnata*, is a non-native species, permitted under the Florida Administrative Code (FAC). Landowners that join the Project will obtain the Non-Native Species Planting Permit, according to the FAC. In compliance with regulations, the Project has applied environmental mitigation measures to prevent plants and plant parts from spreading, as explained further in section 2.3 of this document.

1.4 Project Design

The Project was designed as a Grouped Project, that will comprise multiple plots of land in St Lucie County, Indian River County, and Charlotte County in Florida, USA. The initial stage of the project comprises 35 plots of land, owned by five different landowners, that total 510 hectares. It is anticipated that other landowners will join the project over time.

Eligibility Criteria

The eligibility of the project was assessed according to the A/R Methodological tool *"Demonstration of Eligibility of Lands for A/R CDM Project Activities"* and the *"VCS AFOLU Requirements Guidance"*.

Eligibility criteria for A/R CDM project activities

a) Demonstrate that the land at the start of the project activity does not contain forest, by providing transparent information confirming that:

    i) Vegetation on the land is below the forest threshold values applicable to the host party

According to the US Forest Service, forest land is defined as "land at least 10% stocked by forest trees of any size, including lands that formerly had such cover and will be naturally or artificially reforested" (USDA, 2021). The Project Area is characterized as primarily cropland or grassland formerly used for citrus production or pasture. As described in Section 1.14 Conditions Prior to Project Initiation, land cover in the Project Area prior to the Project Start Date is shown by satellite imagery as majorly shrubs[1], in a smaller extent by herbaceous vegetation[2] and other forest (open)[3].

Farmers participating in the project have predominantly owned the land for decades and have previously cultivated citrus. Currently, the 510 hectares of land parcels are in a high state of degradation due to former citrus production. Citrus greening pushed farmers to adopt intensive practices of high pesticide and fertilizer use to grow and maintain citrus pest-free. Despite these practices, citrus production still decreased and, ultimately, hundreds of thousands of trees died.

[1] "These are woody perennial plants with persistent and woody stems and without any defined main stem being less than 5m tall. The shrub foliage can be either evergreen or deciduous." (Buchhorn, et.al. 2021:28)

[2] "Plants without persistent stems or shoots above ground and lacking definite firm structure. Tree and shrub cover is less than 10%" (Ibid).

[3] "Open forest, not matching any of the other definitions" (Ibid).

Consequently, farmers have ceased growing citrus in the past decade and many landowners introduced cattle or left the land fallow, leaving the land degraded.

ii) The young natural stands and plantations on the land, if existing at the start of the project activity, are not expected to reach or exceed the forest threshold values applicable to the host party.

Due to current land management practices and the presence of livestock in most of the Project Area, it is most likely that young trees or any present vegetation will not reach or exceed the applicable forest threshold values.

Similarly, agricultural lands that have gone out of production are highly vulnerable to infestation by invasive plants, diseases and pests, as seen in Florida's abandoned citrus fields. According to the USDA, abandoned groves are a threat to the citrus industry as they can carry the bacterium that causes greening disease (USDA, 2016). In 2016, St. Lucie County had the largest amount of abandoned citrus lands, followed by Indian River County in Florida (ibid). The private and public funding needed to manage invasive species on lands that have been abandoned is often limited or non-existent, leaving these lands to become seed sources for invasive plants and breeding grounds for pests and diseases. Abandoned agricultural lands ultimately put nearby lands at risk, both public and private.

iii) The land is not a part of a forest area that is temporarily unstocked as a result of human intervention (e.g., harvesting) or natural causes, and the land is not expected to revert to forest.

For over 100 years, land cover and land use in North and Central Florida have mainly changed to agricultural activities (including citrus production) and the cattle industry (Volk et al, 2017).

Specifically, the lands within the Project Area have been owned and managed by private landowners for decades. As their lands will continue to be under productive management, land is not expected to revert to forest.

<u>Eligibility criteria for AFOLU AR project activities:</u>

a) The Project Area shall not be cleared of native ecosystems within the 10-year period prior to the project start date.

No native vegetation was removed in the Project Area during the past 10 years. In the decade prior to the Project Start Date, the main activities that took place on the Project Area were managing citrus orchards, cattle grazing and fallow land.

Satellite imagery from 2007, obtained from MODIS instrument of 500-meter spatial resolution (Sulla-Menashe et.al., 2019), shows that the land cover from agricultural activity in the Project Area classifies as savanna and grasslands. Savannas are defined by MODIS as land where tree cover is between 10% and 30% and tree canopy is more than 2 meters; grasslands are defined by land dominated by herbaceous annuals of less than 2 meters. Land cover satellite imagery of the Project Area from 2007 to 2017 (Figure 4) shows a significant increase in cropland and managed areas surrounding the Project Area.

All new project instances will comply with the above eligibility criteria. Additionally, all new Project Areas will be located within the geographical boundaries set out in section 1.12 Project Location.

1.5 Project Proponents

Organization name	Terviva
Contact person	Nathan Chan
Title	Sustainability Manager
Address	980 Atlantic Ave., Suite 105, Alameda, CA 94501
Telephone	(+1) 510 501 3707
Email	nathan.chan@terviva.com

Organization name	Florida Regenerative Pongamia Fund 1
Role in the project	Owner of the project natural capital and special purpose vehicle in charge of funding the carbon capture project.
Contact person	Marc Diaz
Title	Manager
Address	980 Atlantic Ave., Suite 105, Alameda, CA 94501

Organization name	Cultivo Land PBC
Role in the project	Project Manager, in charge of Project Description (PD) preparation as well as Project Design Document and Monitoring Report delivery to the Validation/Verification body according to VCS guidelines and procedures.
Contact person	Sofía Fernández Posada de la Mora
Title	Operations Manager
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Telephone	(+52) 55 80 33 26 33
Email	sofia.fernandez@cultivo.land

1.6 Other Entities Involved in the Project

Organization name	Alloporus Environmental
Role in the project	Methodology expert and advisor
Contact person	Dr J. Mark Dangerfield
Title	Consultant
Address	6 Banjo Place, Springwood, NSW 2777, Australia
Email	mark@alloporus.com

1.7 Ownership

Activities will be carried out by growers on privately-owned land. The project has all the required legal documentation to prove the property ownership and the lease agreement for right of usage for restoration activities.

Terviva, one for the Project Proponents, has entered into a tree purchase and oilseed purchase agreement with the landowners. Under the tree purchase agreement, landowners have agreed to purchase young pongamia trees at a fair cost (mostly lower than citrus trees), grown in nurseries owned by Terviva, plant those trees and cultivate them so they produce a crop of oilseeds. Under the oilseed purchase agreement, Terviva commits to offtake pongamia beans from farmers for 15 years at a mutually agreed price with an option to renew thereafter. Landowners have agreed to perform the project activities for a period of 20 years, subject to renewal for another 10 years.

Additionally, a second Project Proponent, FRPF1, a fund created specifically with the purpose of this Project, owned and managed by Terviva, has entered an agreement with the landowners to take ownership of environmental incentives (including carbon credits) produced on the landowners' land in exchange for financial compensation for a period of 20 years. FRPF1 was created to facilitate the investment to the Project and provide transparency on the use of funds.

1.8 Project Start Date

As set out in the VCS Standard, the project start date of an AFOLU project is the date on which activities that led to the generation of GHG emission reductions or removals are implemented (e.g., preparing land for seeding, planting, agroforestry practices, rewetting, restoring hydrological functions or implementing management or protection plans).

Hence, the Project Start date of July 16th, 2018, was the date on which the activities for the first plantings started, as evidenced by the first contract signed between the landowners and Terviva.

1.9 Project Crediting Period

The Crediting Period is from July 16th, 2018, and ends on July 15th, 2038. The length of the Crediting Period is 20 years, subject to renewal for another 10 years.

For AFOLU projects, other than Agricultural Land Management projects focusing exclusively on reducing N_2O, CH_4 and/or fossil-derived CO_2 emissions, the project crediting period shall be a minimum of 20 years up to a maximum of 100 years, which may be renewed, at most, four times with a total project crediting period not to exceed 100 years.

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

The estimated annual GHG emission reductions/removals of the project are:

- **<20,000 tCO2e/year**

Project Scale	
Project	X
Large project	

Table 1. Estimated GHG emission reductions or removals (tCO_2e)

Year	Area added under project activity (ha)	Estimated GHG emission reductions or removals (tCO_2e)
2018	38	0
2019	118	102
2020	246	489
2021	108	1,552
2022	0	2,936
2023	0	4,539
2024	0	5,519
2025	0	5,792
2026	0	5,798
2027	0	5,706
2028	0	5,576
2029	0	5,436
2030	0	5,295
2031	0	5,159
2032	0	5,030
2033	0	4,908
2034	0	4,794
2035	0	4,687

Year	Area added under project activity (ha)	Estimated GHG emission reductions or removals (tCO_2e)
2036	0	4,586
2037	0	4,492
2038	0	4,404
Total hectares	510	**-**
Total estimated ERs	-	**86,798**
Total number of crediting years	-	**20**
Average annual ERs	-	**4,133**

1.11 Description of the Project Activity

Description of Project Activity

The purpose of the Project is to sequester carbon, improve the quality of degraded agricultural lands and improve farmer income through the implementation of sustainable agroforestry practices and the planting and cultivation of pongamia trees on private lands in St Lucie County, Indian River County, and Charlotte County in Florida, USA. The United States is not part of the REDD+ program.

Landowners join the project on a voluntary basis and commit to implementing the project activities through agreements with Terviva for pongamia cultivation and as buyers of produce, and with FRPF1 as the entity receiving carbon credits. Farmers participate through the implementation and promotion of good agroforestry practices, the production of pongamia beans and through securing their land.

Over the past two decades, citrus greening has caused citrus cultivation to become increasingly expensive, requiring greater use of pesticides, antibiotics, and fertilizers. In many cases, citrus production ceases to be profitable and trees are removed or abandoned altogether. The adoption of pongamia agroforestry offers farmers a more profitable and sustainable option with material decreases in the use of pesticides and fertilizers when compared to citrus production with the presence of citrus greening. These less intensive practices will decrease greenhouse gas emissions, sequester carbon in the woody biomass of pongamia trees and soils, promote greater surrounding biodiversity and increase soil moisture.

Project changes common practice to improve sustainability and restore land because pongamia trees:

- Store carbon and produce nitrogen for healthy soils;
- Require minimal fertilizer and pesticides;
- Require relatively low water usage in sub-tropical areas;
- Adapt to climate extremes, particularly annual drought and flood cycles;
- Control soil erosion by creating a dense network of lateral roots.

Preparation of the land

Depending on the state of the land being used, various land preparation activities are required before pongamia can be planted. If the land was recently used for growing citrus, stumps and dead trees are removed. Citrus beds and water furrows may need to be regraded to accommodate low-clearance pongamia harvesting equipment. If the land has been left fallow for a long time, other bushes or trees that have grown may be removed. Additionally, depending on site conditions, earth-moving equipment may be required to move any large rocks or boulders, bed the groves, and create water furrows. Thick sod or heavy weed cover may require a pre-tillage herbicide application 4-6 weeks ahead of planting, and/or mowing 1-2 weeks ahead of planting. The disturbance of soil represents less than 10% of the total Project Area.

If irrigation is being used, new lines need to be laid down for drip or micro-jet irrigation. In some cases, new irrigation infrastructure, such as pumps and filters, may need to be installed. Water furrows are dug to a range from 30” to 40” aid and at a slight slope to encourage drainage through a drain tile.

Prior to planting, tree rows are staked out and tree locations are marked with paint or straws. Planting pongamia in Florida is typically accomplished with hand labor crews. Immediately prior to planting, 30cm x 30cm x 30cm holes are dug by hand or using a hydraulically driven auger. Trees are then planted by hand over the course of several days.

Planting pongamia. Source: Terviva

Planting

Pongamia trees are planted at a density of no less than 100 trees per acre and no greater than 145 trees per plantable acre, with 20' to 30' between tree rows and a minimum of 15' between trees within the row. Growers plant at different densities depending on the exact layout of their field. The configuration of the planting area is sited to maximize the length of the tree rows to an optimum ¼ mile (1,320') long. This configuration facilitates efficient harvesting, loading and hauling of the crop out of the field.

As with most orchard crops, it is typical to observe 0-5% mortality rates post-planting. In instances where pongamia trees do not survive, trees are replanted roughly 3-4 months after the initial planting event, as this allows enough time to determine with certainty that a questionable plant has not survived planting, as opposed to a plant that has dropped its leaves as a stress response and then recovers, which is also typical in pongamia.

Harvesting

Starting in year 5, pongamia trees are mechanically harvested using commercial nut crop shaking harvesting equipment that has been adapted for pongamia. Mechanical harvesting equipment requires a clear tree trunk from soil level to 3' up the trunk.

Harvested seeds in a pongamia orchard. Source: Terviva

<u>Caretaking</u>

Growers prune their trees as needed to maintain this branch-free base. In addition to pruning for clear trunks, growers deploy a variety of staking materials in their orchards to stake trees upright. Young trees are periodically shaped and balanced by cutting back excessively long branches. Hand staking, pruning and tying is necessary for approximately two years.

Hedging and topping is important for tree size containment as well as tree structure. The goal is to maximize fruiting wood with yield that can be captured with a shake and catch harvesting machine. The ability to collect harvest in the catchment frame is compromised if the trees grow too tall or wide. Hand pruning and topping through year 2 is often replaced with a light mechanical cut in year 3 to promote tree architecture. By year 4 and year 5 pongamia trees grow large enough that size containment is necessary. After year 5, hedging and topping is an annual occurrence.

Pongamia is very tolerant of a wide range of soil pH. Between 6.0 and 7.0 pH is optimal, with below 5.0 and above 8.5 pH potentially presenting a problem.

Pongamia trees planted in 2018 in the Project Area. Source: Terviva

<u>Residue management</u>

After planting, residues from deciduous tree litter, trimmed tree limbs and branches, and mowed weeds are left on the soil. The organic matter creates favorable microclimatic conditions that optimize decomposition and mineralization of organic matter ("surface composting") and protect soil from erosion.

Water use

Water management takes place to ensure tree growth, although water consumption is minimal due to pongamia's resilience to drought. Proper irrigation design ensures that sufficient pressure is available through irrigation lines, allowing for uniform application of irrigation water throughout the orchard. The overall capacity should provide 30 to 40 gallons of water per tree per day in order to replace evapotranspiration (ET) rates. Irrigation infrastructure from past citrus production that is still usable is kept. Drip emitters or microjets may be used. In Florida, the preferred drip option is factory installed 0.5 to 1.0 gph inline drippers every 3 ft in the poly. Microjets are used generally with a single 10 to 15 gph jet at each tree.

When planting pongamia, irrigation is critical at least three times per week during any week with less than 1" rainfall in the first two months. In following months and years, ET loss rates are replaced in the summer months (between May 1st and September 30th) with rainfall plus irrigation. As the tree growth is slower in the fall (between Oct 1st and Nov 30th), half of the ET loss rates are replaced.

Irrigation is typically not needed in winter months (between Dec 1st and Apr 30th), except for frost protection. Growers scout their orchards to verify that the emitter pattern is watering young trees and periodically check for emitter plugging and replacement. The point of irrigation is checked for placement and any damage to the lines is spliced with couplers and/or repaired for cuts and rips. Lines are also periodically flushed for any blockage or build-up.

Fertilizer use

Pre- and post-establishment fertilization practices will consist of some use of fertilizers to supplement pongamia trees with key macro and micronutrients to encourage maximal growth and high yields. Fertilizers will be applied through a mix of fertigation, individual tree applications and foliar sprays, depending on the nutrients being used and the equipment available to the grower.

Pre- and post-establishment practices will differ in the rate and concentration of fertilizers applied, with pre-establishment practices being more intensive. As trees mature into production, it is expected that a normal program based on crop removal replacement rates of nutrients minus soil availability will be utilized on all nutrients except Nitrogen (N). The application rates of N at tree maturity will be determined by ongoing research and grower experience. Spray nutritionals are also applied at year 5 onwards. Micronutrient foliar crop spray (B, Zn, Mn) is applied annually at peak bloom time. For mature trees, this is approximately during the early summer months of May to July.

Due to the less intensive practices in fertilizer use that are required for pongamia growth, the GHG emissions due to fertilizer use amounts to less than 5% of the total GHG benefit generated by the project for the total crediting period.

Young pongamia trees. Source: Terviva

Pesticide Use

Establishment practices consist of a small amount of broadleaf and grass herbicides applied to the base of trees for the first three years to help orchard establishment. Following establishment, no other herbicides or pesticides are used. Due to the minimum use of pesticide for project activities over the complete crediting period, GHG emissions are considered *de minimis.*

Cover crops

Growers include cover crops in their orchards so that the soil will remain covered by grass and other ground cover plants. Inter-rows and furrows will be mowed throughout the year, as needed, to allow access for maintenance and caretaking. All residues from mowing will be left on the field to compost.

Mechanical and/or chemical methods are used to control weeds in pongamia orchards. Growers typically mow bed top inter-rows with a tractor and 12’ - 15’ mower every 6 - 12 weeks, depending on grass/weed growth. When the pongamia trees are small, it often takes two passes per middle to fully mow the area. Water furrows are mowed as necessary to maintain sufficient drainage, typically an average of four times per year. In Florida, common cover crops are grass and weeds, or planting Millet and Bermuda or Bahia grass, to grow in between the tree rows. To control weeds in the planted tree row, growers maintain a weed-free buffer ~3-6’ wide on either side of the pongamia trees via chemical methods.

Implementation timeline

Project areas have been added to the Grouped Project according to the following timeline:

Table 4. Project timeline

Current areas		
Area ID	Total hectares	Year
B001, B002, B003, D001, D002	38	2018
A001, A002, B004, B005, B006, B007, B008 C001, C002	118	2019
A003, B009, B010, B011, D003, D004, D005, D006, D007, D008, D009, D010, D011, D012, D013, D014, D015	246	2020
C003, E001	108	2021
Total	**510**	

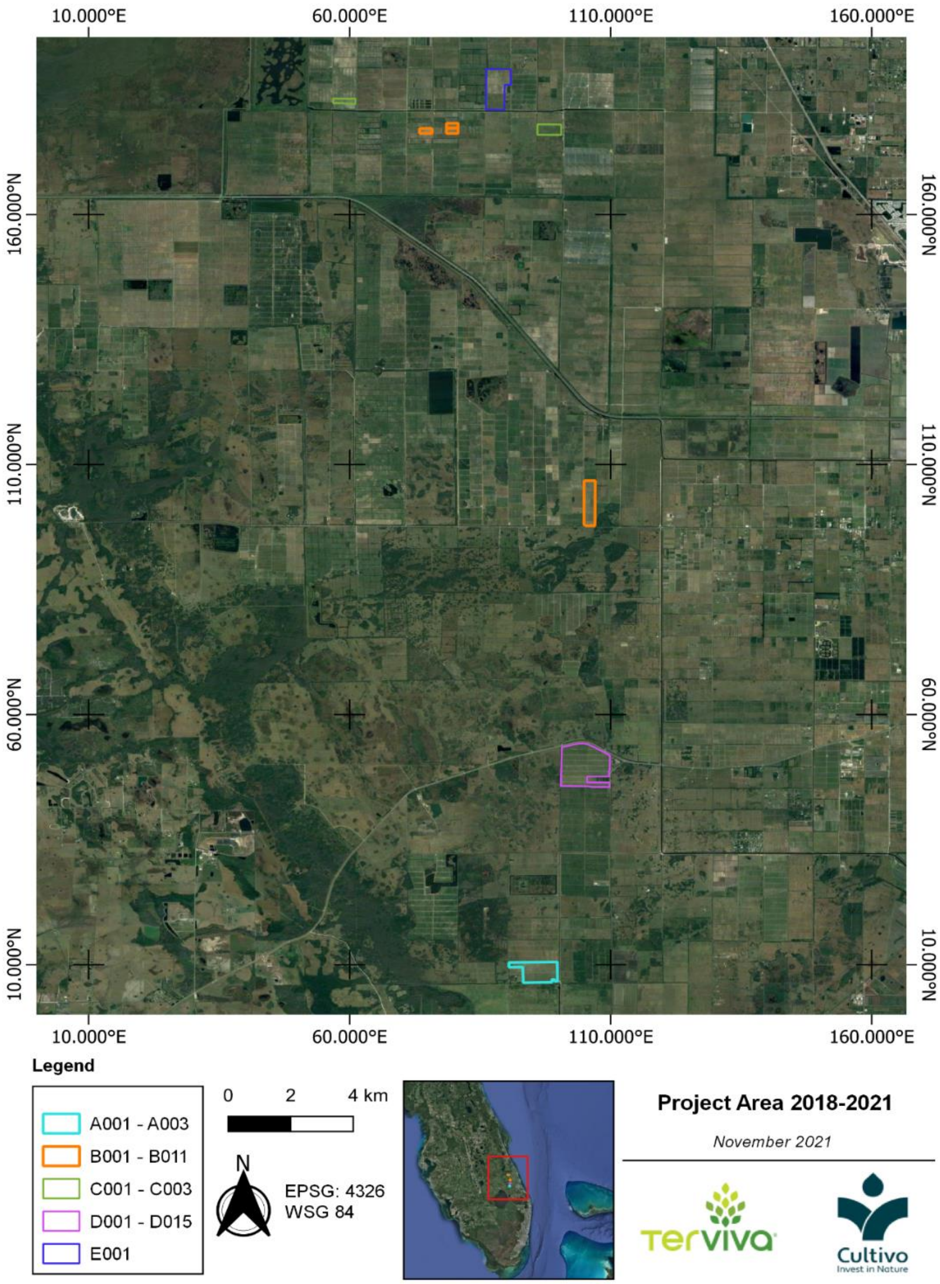
Source: Terviva

The Project Area is expected to increase as more landowners join the project, to a total of 1,000 hectares.

Project layout

The Project was designed as a Grouped Project, covering various plots of land across the Project Location. The initial stage of the project comprises different plots of land, owned by five different landowners, that total 510 hectares in St Lucie County and Indian River County, in Florida, USA.

Figure 1. Project Area

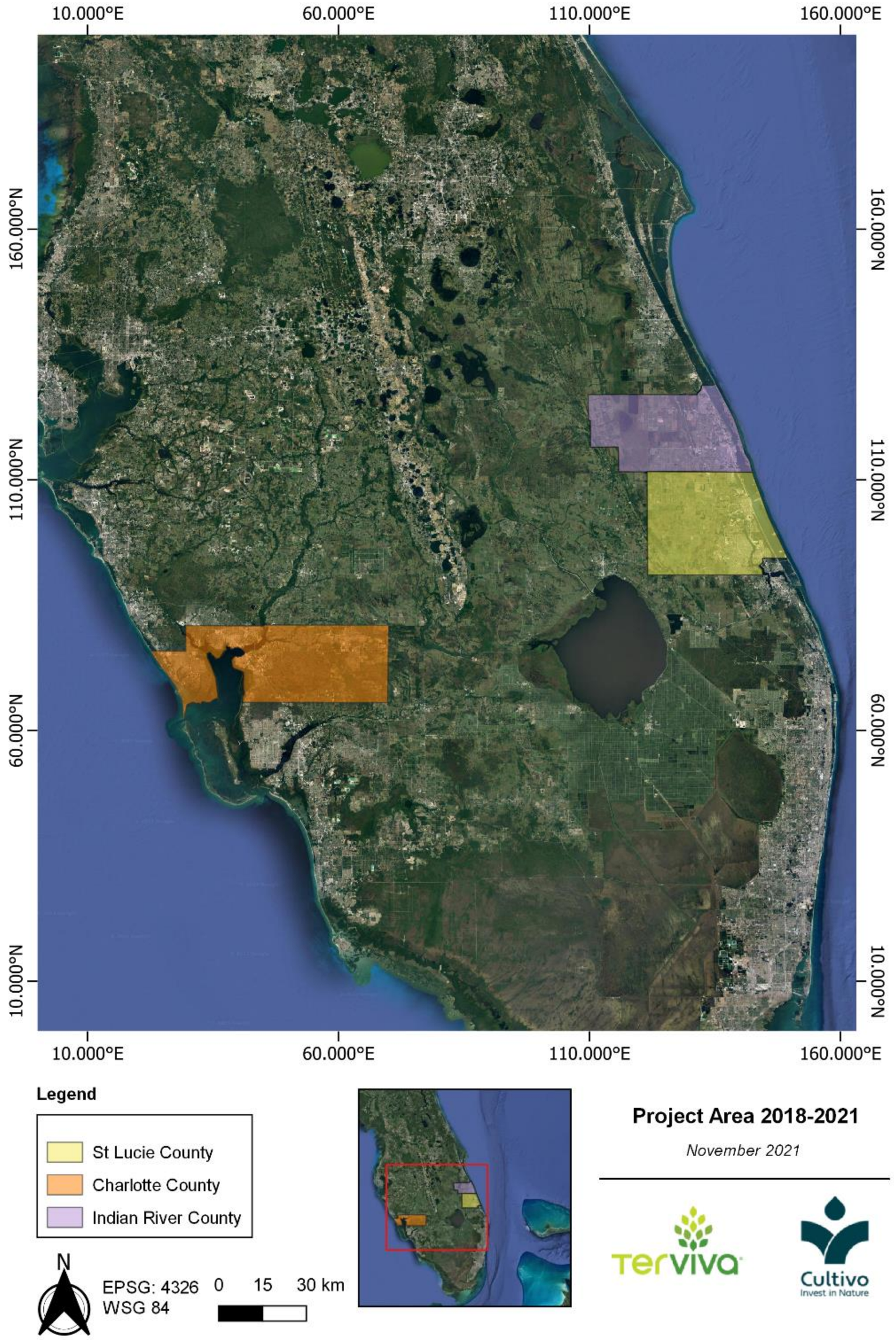


1.12 Project Location

The Project Area is located within St Lucie, Indian River and Charlotte counties in Florida, USA. Please refer to Annex 1 for Project Location boundaries in KML format.

As a Grouped Project, the complete Project Area is formed by a group of plots of land. See Table 4 and Figure 1 for reference.

Figure 2. Project Location



1.13 Conditions Prior to Project Initiation

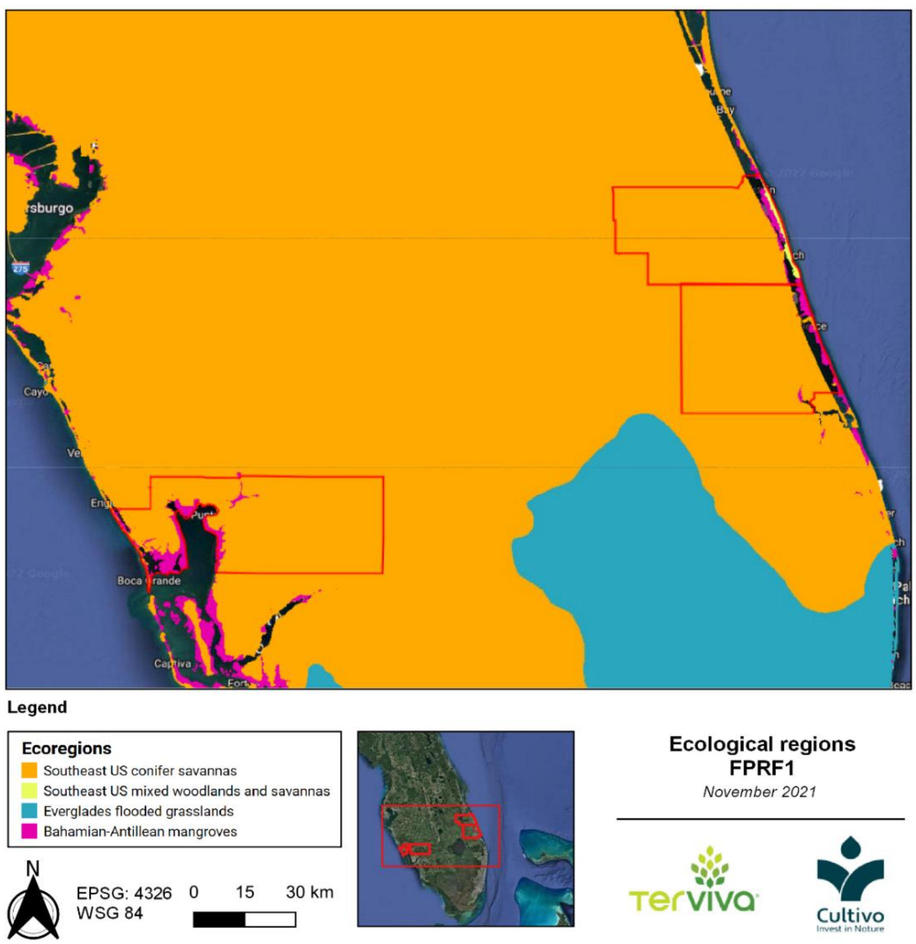
Climate

The project is located in a tropical moist Climatic Zone[4]. Based on the National Weather Service data from the Fort Pierce Station (2017), located at approximately 10 km from the Project Areas, the mean annual temperature is 74.5°F (23.6°C), the highest temperature is 95°F (35°C), and the lowest temperature 40°F (4.4°C). The mean annual precipitation is 66.03 in (1,303 mm). The Aridity Index for Florida is 0.90 (Humid).

Ecological region and biome

The Project Area is located in the Southeast US Conifer Savannas ecological region (RESOLVE Ecoregions dataset, 2017) that is mostly subtropical with temperate grasslands, savannas and shrublands.

Figure 3. Ecological regions in Project Location

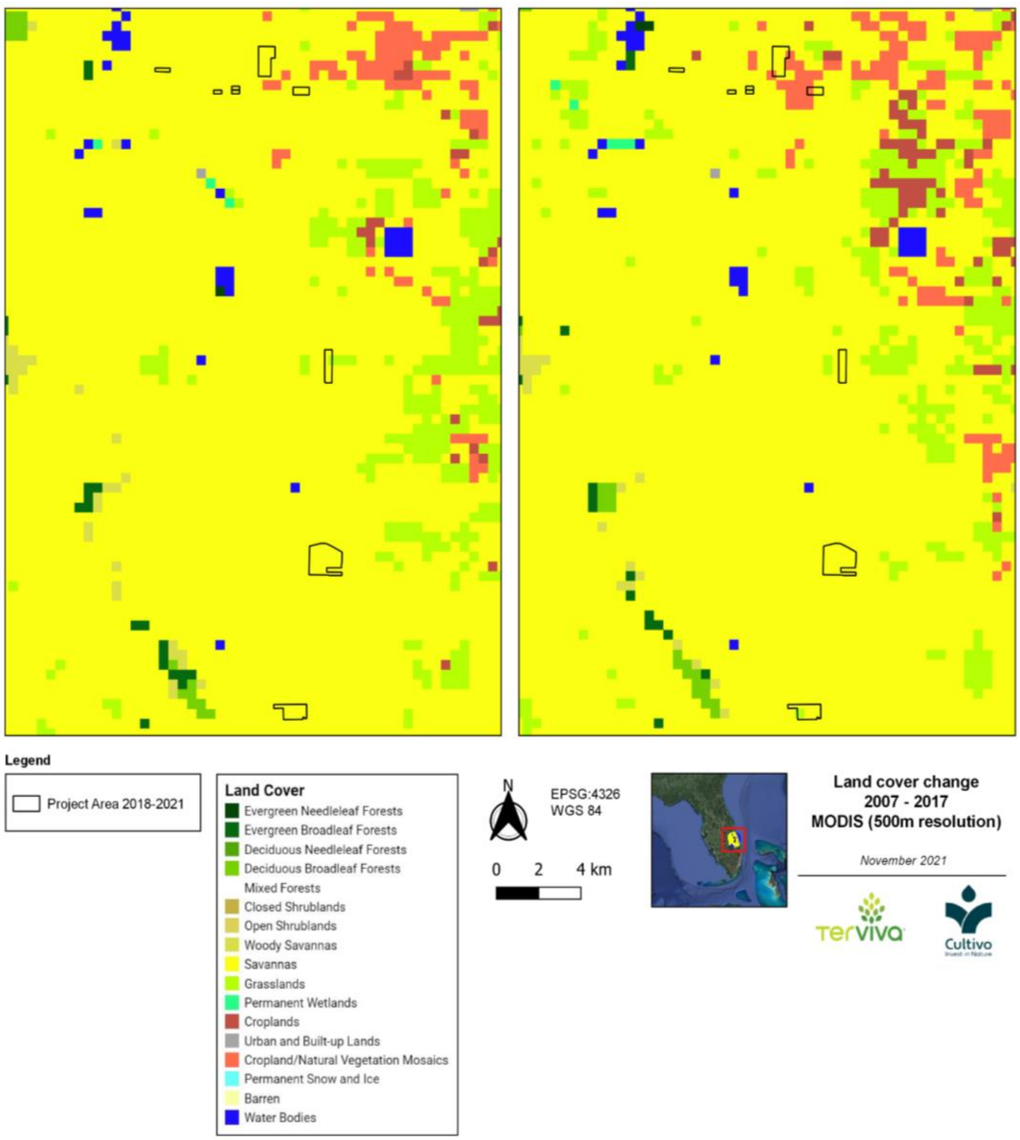


[4] Climatic Zone layer is defined based on the classification of IPCC (IPCC, 2006). Database taken from European Commission - Joint Research Centre, Institute for Environment and Sustainability (2014).

Land cover

Land currently dedicated to crops, groves and nurseries represents 7.9% of the land of the state of Florida (Volk et al., 2017). The 10-year land cover change analysis in Figure 5 of land cover change from 2007 to 2017 for the Project Area, according to the MODIS dataset of the corresponding years (Sulla-Menashe et.al, 2019), shows that in 2017 - prior to the project implementation - the land cover was dominated by herbaceous vegetation, i.e., a nearly continuous tree and shrubs cover of less than 10% (Figure 5). The change from 2007 to 2017 in the Project area is of savannas to grasslands land cover of approximately 25 ha[5].

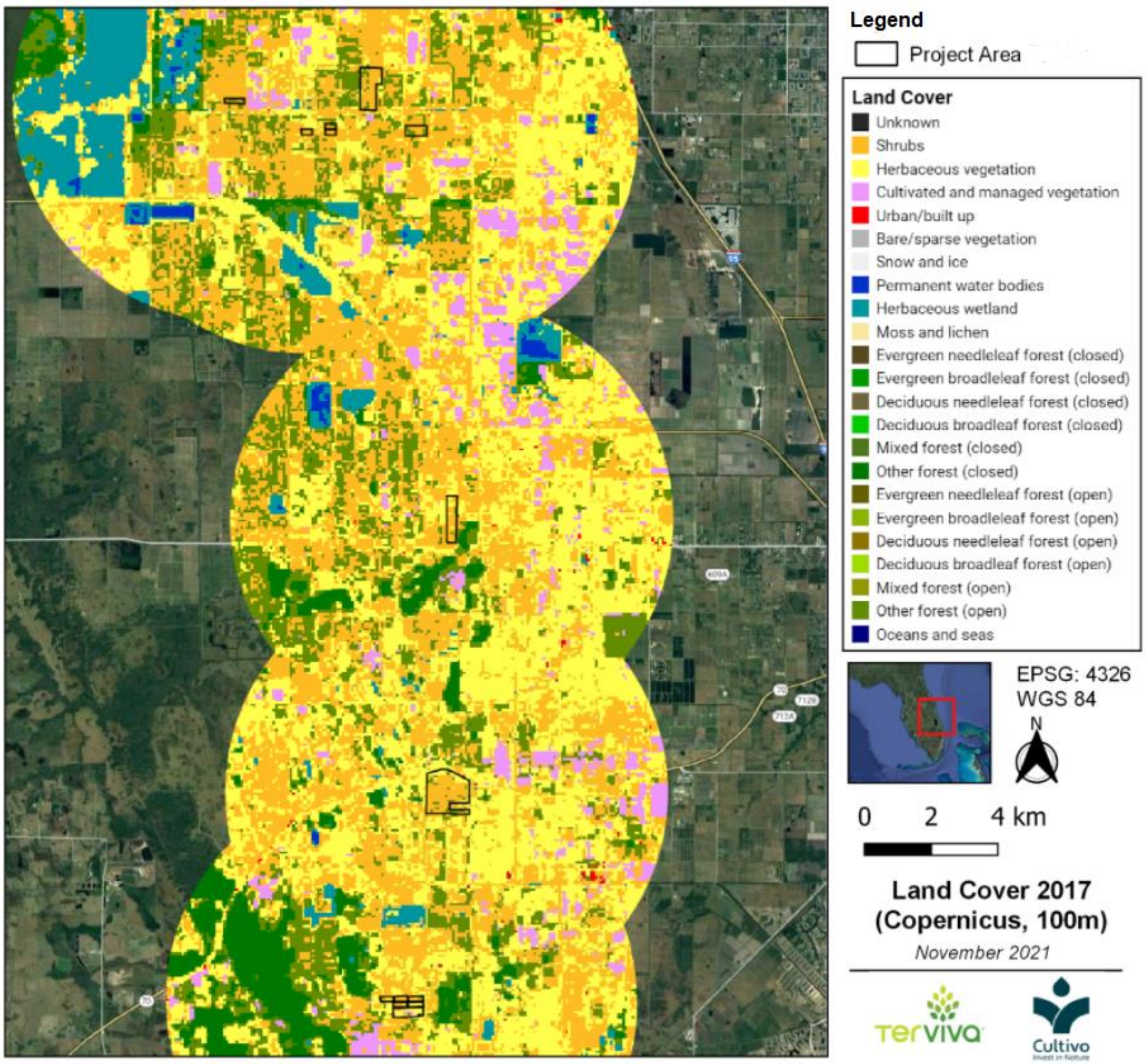
Figure 4. Land cover change in Project Area 2007-2017



[5] All land cover areas in hectares are estimations of simple subtraction of area for a certain land cover type for the study year, minus area for that same land cover type for a base year.

Satellite images of higher resolution (Figure 5) show land cover in the Project Area prior to the Project Start Date was categorized as majorly shrubs, to a smaller extent by herbaceous vegetation and other forest (open) (Buchhorn, et.al. 2021; Copernicus 2019).

Figure 5. Land cover 2017 (Copernicus, 100m resolution)

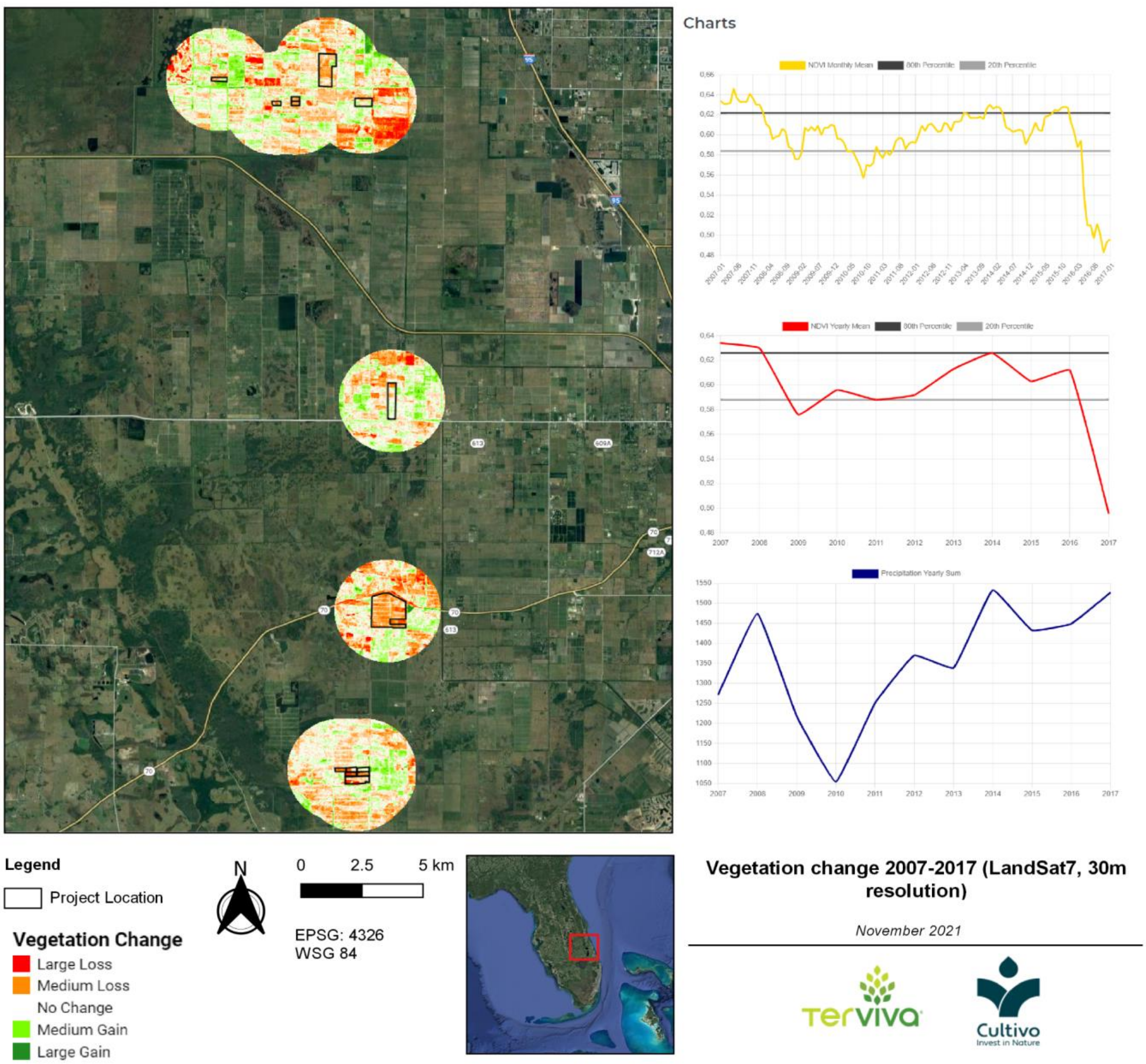


Vegetation cover

The vegetation cover changes in the project area from 2007 to 2017 were estimated using the average Normalized Difference Vegetation Index (NDVI) for the Project Area (Funk et.al, 2015) from LandSat7 (30 m resolution) (Figure 6). NDVI ranges from a scale of 0 (totally barren land) to 1 (densely vegetated) so that any change of NDVI between analyzed years in the order of 1.00 are considered large losses or gains of vegetation, while 0.1 changes are considered medium losses or gains.

As there has been a significant loss of citrus trees in the Project Area, and a shift to cattle grazing activities and land left fallow for the past two to seven years, most plots within the Project Area show a loss in vegetation from 2007 to 2017 with a decrease in vegetation in the past 10 years unrelated to precipitation levels in the area (Figure 6).

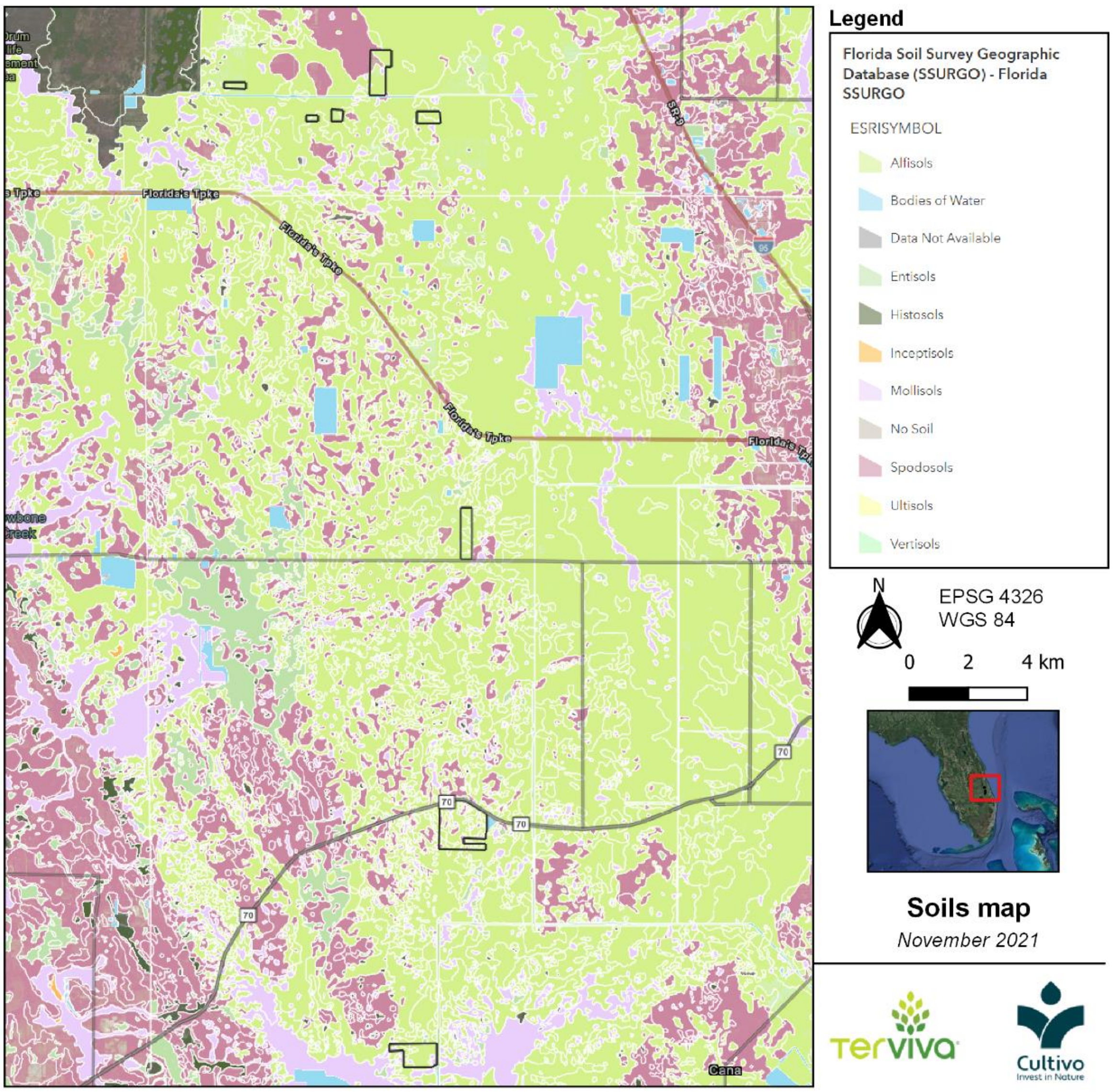
Figure 6. NDVI change 2007-2017 in Project Area



Soils

Soils in St Lucie County, Indian River County and Charlotte County have been extensively surveyed by the USDA - Natural Resource Natural Resources Conservation Service (2019). Soil mapping is available in the Florida Soil Survey Geographic Database (SSURGO). Soil data (Figure 7) shows that the soils within the Project Areas are predominantly Riviera Fine Sands and Pineda Sands — Aqualf soil types within the Alfisol soil order, with low organic matter and natural fertility content (USDA, 1980). The associated soil units, Wabasso and Floridana, are both Aqualfs very similar in form to Riviera Fine Sand and make up less than 10% of the Project Area. Complete results from SSURGO are found in Annex 2.

Figure 7. Soil Survey Map of the Project Area



Hydrology

Understanding the current distribution of water bodies can be useful both in terms of water availability and discharge, and from an ecological perspective (e.g., flora and fauna dependent on water bodies). As Figure 8 shows, there are no surface water bodies within the Project Area.

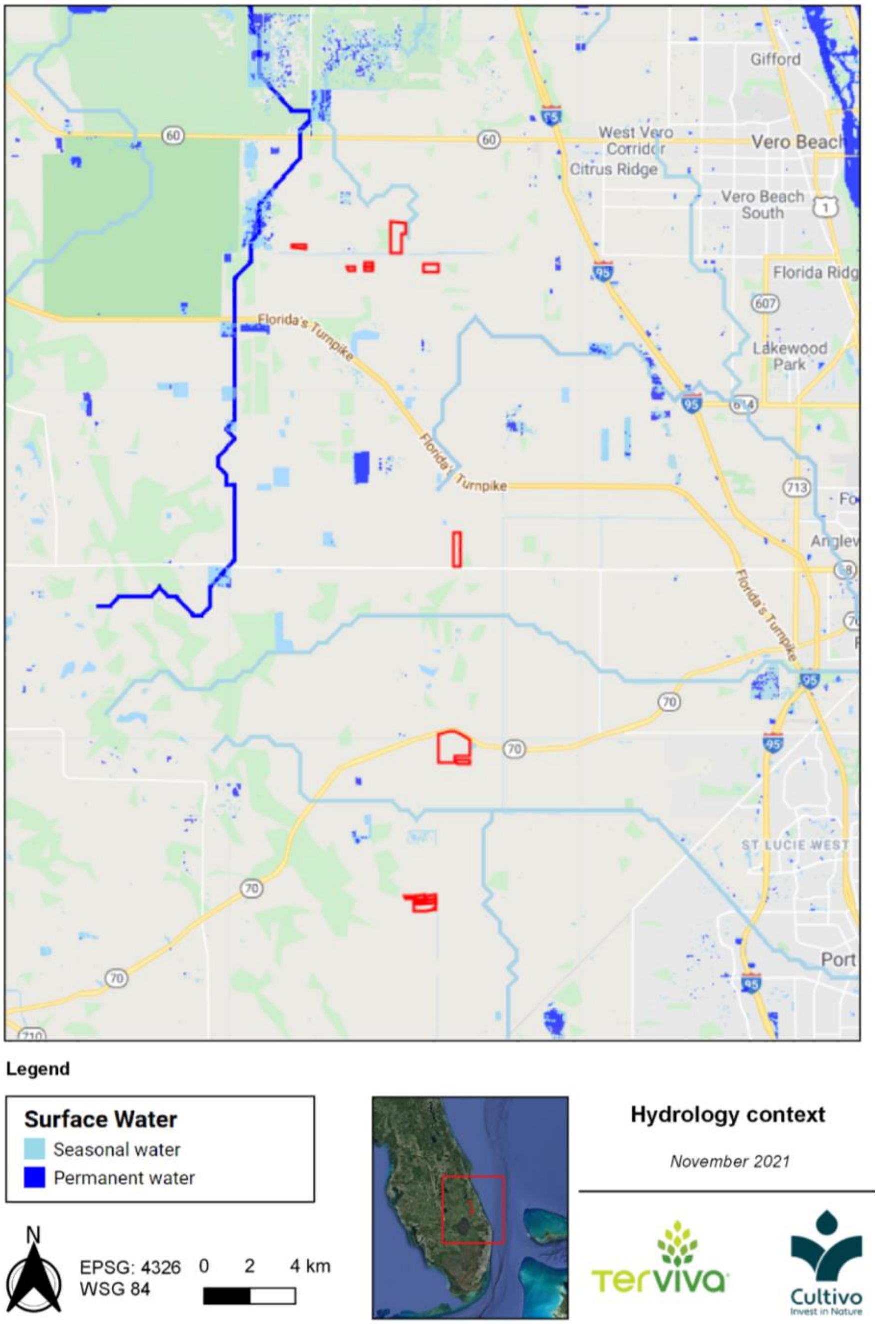
The initial Project Area is located between the Upper St Johns and St Lucie - Loxahatchee watersheds, South Florida basins. The former drains mainly into the St Johns River and the latter into the St Lucie River and forms part of the Everglades system (Florida Department of Environmental Protection, 2021; Shukla, 2004). Agricultural and urban development has increased in the region. Surface and groundwater quality varies from good to poor, although in the Upper St Johns watershed water quality has increased due to an improvement in management practices (Shukla, 2004). In the St Lucie watershed, increasing human population and agricultural activity - primarily citrus and pasture - have contributed to elevated nutrient concentrations (South Florida Water Management District, 2009).

Soil moisture

Soil moisture in the Project Area in 2017 was approximately 71.5 mm/yr. The TerraClimate dataset (2020) gives an indication of the mean baseline soil moisture, i.e., how much water the soil was storing on average for the Project Area, previous to the Project Start. While comparing local soil moisture levels to the range of soil moisture measured from similar land units (i.e., with the same soil taxonomy and land cover) across the neighboring area in the assessment year, Project activity has the potential to increase soil moisture equivalent an average of 5 mm/year. This is approximately a 7% increase in the soil moisture baseline of 2017, which represents 25,040 m^3/yr across the whole Project Area. This is a conservative assessment since it considers only the increase in soil moisture and does not consider the complex interplay between carbon storage, soil moisture and other elements of the water balance.

Biomass and crop health rely upon an adequate supply of moisture and soil nutrients, among other things. If moisture availability declines, the normal function and growth of plants are disrupted, and yields are reduced. Moreover, levels of soil moisture have a large influence on the land’s ability to store carbon. Researchers generally assume that soil response to moisture changes is linear and reversible (Patel et.al., 2021). Thus, the Project Area has the potential to increase its soil moisture and positively influence the dynamics of soil carbon.

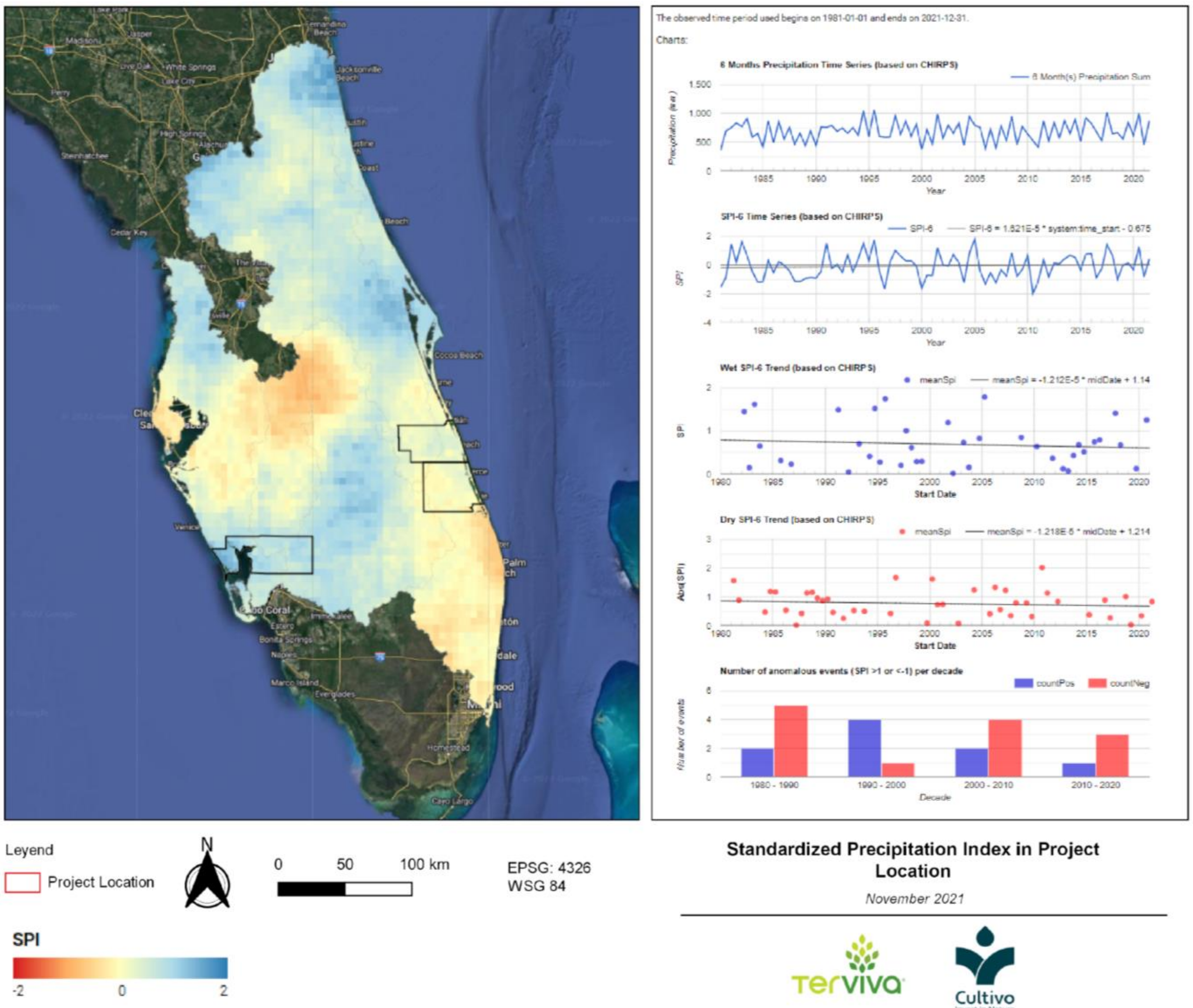
Figure 8. Surface water in the Project Area (WWF HydroSHEDS, 2021; Lehner et al, 2008)



Droughts and floods

The Standardized Precipitation Index (SPI) is based on the probability of precipitation for any timescale. SPI measures precipitation anomalies at a given location, based on a comparison of observed total precipitation amounts for an accumulation period of interest. Looking into the 6-month SPI graph in the Project Location and trends in event severity, there is a negligible decreasing trend in wet and dry events for the 6-month period, indicating there have not been any significant changes in the severity of dry and wet events. Further, SPI remained mostly between -1 and 1, which translates to normal precipitation rates.

Figure 9. The Standardized Precipitation Index (SPI) in the Project Location (Climate Hazards Group InfraRed Precipitation with Station Data; Funk et.al, 2015)



Land activity

The initial Project Area is located within the Indian River County and St Lucie County, a commercial citrus production area in Florida. Agriculture is Florida's second-largest industry, accounting for many land cover changes since the 20th century due to population growth and development (Volk et al, 2017; Workman et. al., 2014). Land currently dedicated to crops, groves and nurseries represents 7.9% of the state's land.

According to official data from the USDA's National Agricultural Statistics Service of citrus production in Florida, in 2017, the year before the Project start date, citrus production in Florida accounted for more than 40% of the county's production (USDA, 2019b).

The Project Area is characterized by cropland formerly used for citrus production, pasture, or fallow land. Farmers participating in the Project have predominantly owned the land for decades and have previously cultivated citrus. Due to the impacts of citrus greening, many of these farmers have ceased growing citrus in the past decade. In the interim period, the land was used for cattle grazing or farmers left the land fallow.

Orange tree with greening disease in Florida. Source: Sprague, 2019, University of Florida

The table below describes the land use management for each of the plots. The past land-use practices are looking backward from the Project Start Date. For example, "20+ yrs citrus, 5 years cattle" indicates that the site had cattle grazing practices for the 5 years before pongamia was planted, and citrus trees for more than 20 years prior to the Project Start Date.

Table 5. Past Land Activities in the Project Area

Area ID	Past land use practices	Total hectares
A001, A002	20+ yrs Citrus + 5 years cattle	51
A003	20+ yrs Citrus + 7 years cattle	39
B001, B002, B003	20+ yrs Citrus + 1 yr fallow	19
B004, B005, B006, B007, B008	20+ yrs Citrus + 2 yrs fallow	39
B009, B010, B011	20+ yrs citrus	20
C001, C002, C003	20+ yrs citrus	42
D001, D002, D003, D004, D005, D006, D007, D008, D009, D010, D011, D012, D013, D014, D015, D016	20+ yrs Citrus + 4 yrs fallow	207
E001	20+ yrs Citrus	94
	Total	**510**

Satellite pictures of each plot of land prior to the Project Start Date are shown in Annex 3.

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

The Project Activity is in compliance with applicable non-native species regulations as set by the USDA, and the Florida Department of Agriculture and Consumer Services, including Chapter 5B-57 and Chapter 5B-64. Additionally, landowners that join the Project will obtain the Non-Native Species Planting Permit, according to the Florida Administrative Code (F.A.C.), with support from Terviva throughout the process.

The Project Activity is in compliance with applicable wetland laws, specifically including Section 404 of the Clean Water Act. The Project Activity is also in compliance with Florida's Coastal Zone Protection Act and Florida Unified Wetland Delineation Methodology (Chapter 62-340, F.A.C.). No local laws regulating wetlands were identified.

Additionally, the Project Proponents have, to the best of their knowledge, complied with all relevant local, state and national laws, including labor and non-discrimination laws, in the course of project implementation. The following summary is based on the Project Proponent's review of applicable local, state and national laws.

The Project Proponents are duly organized corporations, validly existing, and in good standing under the laws of the State of Delaware and is qualified to do business in the State of Florida.

The Project Proponents maintain compliance with the following applicable anti-discrimination laws: Title VI of the Civil Rights Act of 1964 and Title VII of the Civil Rights Act of 1964, as amended by the Equal Employment Opportunity Act of 1972, Federal Executive Order 11246 as amended, the Rehabilitation Act of 1973, as amended, the Vietnam Era Veteran's Readjustment Assistance Act of 1974, Title IX of the Education Amendments of 1972, the Age Discrimination Act of 1975, the Fair Housing Act of 1968 as amended, and the Americans with Disabilities Act of 1990.

The Project Proponents are also in compliance with the Department of Labor Contract Work Hours and Safety Standards Act (40 U.S.C. 3701 et seq.), as supplemented by Department of Labor regulations (29 C.F.R. Part 5) and all applicable standards, orders or regulations issued pursuant to the Clean Air Act (42 U.S.C. 7401 et seq.) and the Federal Water Pollution Control Act as amended (33 U.S.C. 1251 et seq.).

1.15 Participation under Other GHG Programs

Projects Registered (or seeking registration) under Other GHG Program(s)

The Project has not been registered or is seeking registration in any other GHG programs.

Projects Rejected by Other GHG Programs

The Project has not been rejected by any other GHG programs.

1.16 Other Forms of Credit

Emissions Trading Programs and Other Binding Limits

The Project does not reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowance trading.

Other Forms of Environmental Credit

The Project has not sought or received another form of GHG-related environmental credit.

1.17 Sustainable Development Contributions

Project activities that result in sustainable development (SD) contributions

According to the Food and Agriculture Organization of the United Nations (FAO, 2017), agroforestry has the potential to restore degraded landscapes, as it can enhance physical, chemical and biological soil characteristics, thereby increasing soil fertility, controlling erosion and improving water availability. Pongamia is a permanent tree crop that has the potential to increase food and nutrition security, generate income and improve the livelihoods of farmers. Pongamia is a sustainable source of vegetable oil and plant protein. Additionally, the project addresses climate change mitigation through carbon sequestration in the trees.

Sustainable Development Contributions

The United States is aligned to the United Nations Sustainable Development Goals (SDG), and officially tracks US statistics for Sustainable Development Goal global indicators in order to measure its national contributions (US SDG, 2022). Within this framework, the project activities contribute to 3 of the SDGs, described as follows:

- SDG 2, Zero Hunger - Project activities will ensure sustainable food production systems, producing healthy and nutritious foods through regenerative agroforestry practices. The tree crop is permanent and a nitrogen-fixing species that are expected to contribute to increases in carbon biomass as well as soil carbon due to reduced fertilizer, pesticide, and water management use compared to alternative agricultural land use in the region.

  Additionally, the Project will create long-term social value and benefits for all stakeholders. As small-scale food producers, landowners' production and income will be positively benefited. At the core of Terviva's social sustainability strategy is the idea that the economic value it creates is shared and equitable among key stakeholders like employees, farmers, and landowners. Offtake agreements with farmers from their products are at a fair price based on revenue-sharing or a fixed-price offtake should growers prefer.

- SDG 13 Climate Action - The project contributes to GHG reductions and carbon capture. Cultivation of pongamia with sustainable agroforestry practices can produce a more sustainable and less carbon-intensive source of food.

  The project contributes also to increased environmental awareness in the region. As pongamia has proved to have a great potential to restore degraded lands and improve soil properties (Leksono B. et al, 2021), it is likely that the Project will increase the environmental awareness among the landowners within the Project Area, and potentially within the general Project Location.

  Project activities will also strengthen local capacities on sustainable practices. Project activities and the introduction of a new crop to landowners will represent an alternative to agroforestry common practice in the region (see Section 1.18). The capacities of landowners and growers in the Project Area to grow a permanent crop in a more sustainable and resilient way will continue to build over time. This will also be enhanced through inclusive participatory monitoring activities carried out with the landowners.

- SDG 15, Life on Land - The project will increase vegetation cover and reverse the degradation of lands in the Project Area. It contributes to achieving a land degradation-neutral world. Project activities will halt soil degradation caused by intensive land management practices and ecological imbalances due to HLB disease. Pongamia has multiple properties for agroforestry use to restore degraded land and biodiversity by improving soil quality, controlling erosion, and increasing vegetation cover. Pongamia has the capacity to restore soil organic content, soil pH, and overall soil nutrients and soil health (see section 2.3 for further details on pongamia).

Monitoring of Sustainable Development Contributions

SD monitored indicators will be defined according to the project's impacts and aligned to SDGs targets. The indicators of the SD contributions of the project activities to these SDGs will be included in the Monitoring Plan and monitored annually, through combined on-the-ground work and participatory techniques. An online survey will be sent out to the landowners with the objective to understand how land management activities have changed, and how the project has impacted the way they work, their productivity, and overall livelihoods.

1.18 Additional Information Relevant to the Project

Leakage Management

Displacement of cattle grazing is a potential source of leakage from project activity. However, the small area and low stocking rates make GHG emissions due to cattle grazing that could be displaced *de minimis* for the project scenario and with minimum impact to the regional production of cattle.

As lands in the Project Area are privately owned, any displacement of cattle would be within lands owned by the same owner where the continuation of pre-project practices occurs, such as lands with past citrus plantations, fallow lands or other lands used for cattle grazing.

Animals would be displaced to:

a) existing grazing land, with the total number of animals (both displaced and existing) in the receiving grazing land not exceeding the carrying capacity of the grazing land; or

b) cropland that has been abandoned within the last five years.

Agricultural activity by itself does not result in leakage emission.

As per the A/R Methodological tool *"Estimation of the increase in GHG emissions attributable to the displacement of pre-project agricultural activities in A/R CDM project activity" Version 2.0,* the applicable scenario for leakage caused by the proposed project activities would be accounted as zero. Thus, no leakage management plan is included.

Commercially Sensitive Information

Commercially sensitive information relating to exact agricultural practices such as the precise formulations of inputs like fertilizers and herbicides and methods for pruning and shaping trees to maximize yield and health have been omitted from this document as they are "trade secret."

Further information

No further information is included regarding relevant legislative, technical, economic, sectoral, social, environmental, geographic, site-specific, and/or temporal information that may have a bearing on the eligibility of the project, the net GHG emission reductions or removals, or the quantification of the project's net GHG emission reductions or removals.

2. SAFEGUARDS

2.1 No Net Harm

The Project provides a sustainable and resilient alternative for local landowners who have grown citrus trees in the past. Project activities represent a shift from past resource-intensive citrus orchards to pest-free, climate-resilient, and sustainable agricultural practices. The Project creates economic value for landowners and will positively impact their livelihoods in the long term. From an environmental perspective, the Project will restore degraded lands, bringing benefits to the environment in terms of carbon capture by planting pongamia trees, restoring the level of soil organic carbon in soils, and increasing soil moisture. As a result, this project is committed to achieving positive social and environmental outcomes without causing harm.

2.2 Local Stakeholder Consultation and AFOLU-Specific Safeguards

According to the VCS Standard, project proponents shall identify and address any negative environmental and socio-economic impacts of project activities, and shall engage with local stakeholders during the project development and implementation processes. As such, a process of identifying stakeholders and a stakeholder consultation process were carried out.

The following stakeholder map and consultation process was defined, based on the Inter-American Development Bank's "Meaningful Stakeholder Consultation" (IDB, 2017), Forest Trends' "Social Impact Guidance" and the International Association for Impact Assessment's "Social Impact Assessment: Guidance for assessing and managing social impacts of projects" (IAIA, 2015).

Stakeholder identification

Stakeholders are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively (IFC, 2007). The table below provides a list of stakeholder groups identified at this stage of the project. It also includes a brief description of each stakeholder group, whether they are being directly or indirectly impacted by the project and their respective level of influence and interest in the project.

Table 6. Stakeholder groups

Stakeholder	Description
Landowners	Landowners with proof of ownership of the land within the Project Area. They are directly impacted by the project activities as they are responsible to implement a change to new agroforestry practices. They will receive direct benefit from pongamia produce and carbon offsets for a minimum of a 20-year long-term impact, and provide a sustainable and permanent crop. Their level of interest and influence is high, as the Project will directly depend on them to successfully perform the necessary activities.
Employees and other jobs created for the project	Farmers and growers employed by the landowners to work on the Project Area. As the project looks for a minimum of a 20-year long-term impact and provides a sustainable and permanent crop, the Project will, directly and indirectly, impact their work activities and conditions.
Neighboring landowners	Communities neighboring the Project Area are, in most cases, farmers and growers within the agriculture, cattle, and agroforestry sector. They will be indirectly impacted by the Project activities. In addition, there are a few easements and areas under conservation, golf courses and parks. Managers of these areas might like to know more about new sustainable practices and pongamia.
Local, state and federal authorities	Main government agencies with a potential stake include a) at the federal level, United States Department of Agriculture (USDA); b) at the state level, the Florida Department of Agriculture and Consumer Services (FDACS), the Florida Department of Environmental Protection (DEP), and the Florida Department of Business and Professional Regulation (DBPR); c) at the local level, the County zoning boards. Government authorities at the federal level should have a favorable position towards nature restoration projects, and have a large influence given that these entities are in charge of laws and regulations as well as setting the country's overall policy direction. Entities at the state and county levels should have interest in the project helping local economic development and land restoration activities. Given their role, these entities have a crucial influence in the implementation of the project.
Local providers	Providers within the Project Location could be directly impacted as a number of services will be required for the lifetime of the project. These include: herbicide and fertilizer providers, vendors for irrigation microjets, soil sampling services and others.
Other companies in	Given their own inherent nature, this type of business should have a positive attitude towards agroforestry activities in the Project Location. They would

the agroforestry industry	have a medium degree of interest in the project as they might like to learn more about carbon offsets.
Academic Institutions	Academic institutions focused on environmental science could have a medium to high level of interest in the project. This project could be appealing for them from a research perspective as it will touch upon sustainable agroforestry practices, voluntary carbon markets and the impacts of cultivating a new crop in Florida such as pongamia. A relevant academic institution identified is the University of Florida, which has published research on pongamia and operates extension research and support activities in the area. Academic institutions could turn into valuable allies as it moves forward.

Social Impacts and Risks

The International Principles for Social Impact Assessment considers that social impacts include all the issues associated with a planned intervention (i.e., a project) that affect or concern people, whether directly or indirectly (IAIA, 2015).

Due to the nature of the project and the activities that will be carried out, primary and secondary sources will be used to complement the identification and characterization of the social impacts presented below. Moreover, information on-site will be gathered through a landowner survey. The results of this participatory approach will be included in this document to help assess the social impacts derived from this project.

Table 7. Impact Assessment

Impact	Description
Leakage	As mentioned in Section 1.18, following the A/R Methodological tool *"Estimation of the increase in GHG emissions attributable to the displacement of pre-project agricultural activities in A/R CDM project activity" Version 2.0*, the applicable scenario for leakage caused by the proposed Project activities would be accounted as zero.
Job creation and impact on local businesses	Jobs will be created indirectly through landowners hiring labor to complete agroforestry practices. The Project may also create additional demand for stationery items, provision of food, use of local hotels, as well as specific monitoring services and products, thereby contributing indirectly to the local economy.
Improved livelihoods	Terviva's social sustainability strategy is to create economic value which

for landowners	is shared and equitable. Despite financial barriers to uptake of the project activity, the project scenario is the most attractive financial option for landowners, compared to the alternative scenarios of cattle grazing and reforestation through government programs. It is therefore concluded that the Project would have a significant positive impact on the improvement of livelihoods through increased revenue for landowners and a range of ecosystem benefits associated with the implementation of sustainable agroforestry practices.
Increased environmental awareness	As pongamia has proved to have a great potential to restore degraded lands and improve soil properties (Leksono B. et al, 2021), it is likely that the Project will increase the environmental awareness in the landowners within the Project Area, and potentially within the general Project Location.
Strengthening local capacities on sustainable practices	Project activities and the introduction of a new crop to landowners will represent an alternative to agroforestry common practice in the region (see Section 1.18). The capacities of landowners and growers in the Project Area to grow a permanent crop in a more sustainable and resilient way will continue to build over time. This will also be enhanced through inclusive participatory monitoring activities carried out with the landowners.

Mitigation Measures

Following the identification and general characterization of social impacts, mitigation and enhancement measures are designed to minimize negative impacts and maximize positive ones. Although leakage is zero, leakage on surrounding areas will be monitored for the first two years of the activities and prior to validation and verification processes. Leakage will be monitored through a) a survey sent to landowners to verify the displacement of any grazing activities to other lands, and b) satellite imagery of vegetation levels in neighboring areas.

All other significant positive impacts will be monitored through annual surveys as well as with complementary materials provided by the Project Proponents.

Stakeholder Engagement and Communication Strategy

The stakeholder identification and analysis aim to inform the allocation of resources and time for the Project Proponents communication and engagement strategy in the following years. Table 8 describes the planned engagement activities for each stakeholder group:

Table 8. Engagement Plan and Communication Strategy

Stakeholder group	Engagement strategy	Communication strategy
Landowners	Regularly engage and monitor closely	● Clearly explaining to landowners how project activities, including carbon credits, will work in ways that are compatible with local practices. ● Ensure full and realistic understanding of the project risks and benefits when including landowners and signing legal agreements. ● Providing access to project documentation in the public comment stage. ● Monitoring impacts on a yearly basis through surveys. ● Involving landowners in leakage monitoring.
Employees and other jobs created for the project	Essential information and monitor regularly	● Providing access to all project documentation in the public comment stage. ● Monitoring indirect impacts on a yearly basis through surveys to growers and landowners.
Neighboring landowners	Essential information and minimum contact	● Providing access to public project documentation upon request.
Local, state and federal authorities	Monitor regularly and anticipate needs	● Establishing and maintaining good working relationships with all relevant government agencies, particularly with state and county agencies to ensure the successful development of the project. ● Anticipating any needs for environmental and other required permits. ● Providing information when needed and upon request.
Local providers	Essential information and regular contact	● Providing essential information on the Project for the required products and services. ● Maintaining regular contact for monitoring purposes to ensure the quality and timing of deliverables and services.
Other companies in the agroforestry industry	Essential information and minimum contact	● Communicate publicly available information on project documentation.
Academic institutions	Regularly engage	● Seeking potential research collaborations with relevant institutions.

2.3 Environmental Impact

Although no specific environmental impact assessments have been carried out for this project, there is available research on the effects of pongamia around the world. Research summarized below demonstrates environmental benefits of pongamia for agroforestry use to restore degraded land and reduce the risk of abandoned citrus fields, its benefits in nitrogen fixation, and oil-rich seeds. This section also includes a research review of potential environmental impacts from pongamia as a non-native species in Florida.

Land restoration

Pongamia (*pongamia pinnata*) has multiple properties for agroforestry use to restore degraded land and biodiversity by improving soil quality, controlling erosion and increasing vegetation cover. It is a fast-growing leguminous tree that can grow to a height of 15-20 meters, live up to 100 years and thrive in a range of harsh environmental conditions (Leksono et.al, 2021; Scott et.al, 2008). It can survive temperatures ranging 5 to 50°C and elevations up to 1,200 m; it can grow in most soil types from stony through sandy to clay (Agus et.al., 2017; Leksono et.al, 2021). Studies have found pongamia to have potential for growing as a restoration species in highly degraded forest areas in India (Ramachandran and Radhapriya, 2016), on land which has been degraded due to mining operations in Indonesia (Agus et.al., 2017), and withstand drought stress or low water input as shown in a trial of pongamia plantation in Bali (Arpiwi et.al., 2018). These studies highlight the properties of pongamia to restore soil organic content, soil pH, and overall soil nutrients and soil health. Studies also show the advantages of pongamia growth over similar trees in height, stem diameter, as well as yields, resistance to disease and oil content of the seeds.

Another distinctive advantage of pongamia is that it is a nitrogen-fixing species, meaning that it is capable of producing its own nitrogen. Nitrogen is one of the most important nutrients required by plants which control and enable their growth and reproduction (Calica, 2017). This characteristic reduces the cost of production and improves carbon efficiency.

Benefits of oil-rich seeds

Pongamia produces high yields of oil and protein-rich seeds makes it a source for food and biofuel production. Pongamia produces seeds which contain 40% oil which have historically been used for biofuel in many parts of the world (Scott et.al., 2008). Terviva's proprietary processes create pongamia oil that can be used as a cooking oil or in other formulated foods as well as high-protein flour and protein isolate. (Terviva, 2021). Pongamia oil has been calculated to be three times less carbon-intensive than soybean oil (Wylie et al, 2021).

Pongamia production yields increase as trees grow older and can range from 9 to more than 90 kg of seeds annually per adult tree (yields differ according to location), equivalent to a potential yield of between 900 kg and 9000 kg per hectare (Leksono et al, 2021).

Revitalizing fallow land

Agricultural lands that have gone out of production are highly vulnerable to infestation by invasive plants, diseases and pests, as seen in Florida's fallow citrus fields. Limited private and public funding to manage these invasive species make fallow lands potential seed sources for invasive plants and breeding grounds for pests and diseases. Fallow or unused agricultural lands ultimately put nearby public and private lands at risk.

Environmental stewardship has gained recognition as a positive aspect of Florida's agricultural sector, as exemplified by the Agricultural-Environmental Leadership Award (FDACS, 2021) and This Farm CARES (This Farm CARES, 2021). Farmers have been shown to be active stewards of the environment by buffering against the spread of invasive species between urban and natural areas through their daily land management activities.

Maintaining farmland in profitable agriculture ensures landowners can effectively manage agricultural land as well as Florida's natural resources.

Potential invasive risk

Available research was gathered to identify potential environmental impacts from pongamia as a non-native species in Florida. Although several predictive assessments have labeled pongamia as an invasive species, no empirical evidence of invasion risk was found in this review. Pongamia's native origins are uncertain, but research indicates a broad distribution from India, through central and south-eastern Asia, Indonesia and into northern Australia, in humid, tropical and subtropical areas, and in a wide range of soils (State of Queensland, 2016). It has been used for various purposes all around the world including indigenous medicine, biofuel and others. It was introduced to Florida in the 1960s as an ornamental tree and is currently recognized by the USDA as an "introduced" species in the state, native status L48[6] (USDA, 2021b). Currently, pongamia has not been listed by the IUCN in the Global Invasive Species Database (IUCN, 2021).

As a legume tree with biofuel and food production potential, several studies have been conducted to assess threats of human-assisted proliferation of pongamia. These studies have informed the environmental impact and the risk of invasiveness of pongamia in different locations in the world. Although predictive assessments have classified pongamia as an invasive risk due to its expansion beyond its native range and its biological characteristics, empirical studies in similar conditions for pongamia plantations in Hawaii have not been able to demonstrate these predictions. An invasive risk assessment conducted by the State of Queensland in 2016 stated that, although pongamia had been considered a 'weed' in Florida and other parts of the world, they were "unable to find evidence that pongamia has significant negative impacts as a weed anywhere in the world" (State of Queensland, 2016: 12). However, recommendations were drawn regarding preventing pongamia

[6] Native Status L48 means the species is introduced in the lower 48 states of the US (USDA, 2021).

plantings to occur close to environmentally sensitive areas. This study was based on both the historical introduction and spread as well as the currently observed distribution of pongamia to evaluate the potential impact of pongamia outside its native range in Queensland. Similarly, an observational study of seven pongamia sites in Oahu, Hawaii concluded that pongamia is not invasive or established outside of cultivation (Daehler, 2018). “Based on its current behavior in the field, pongamia is not invasive or established outside of cultivation” (Daehler, 2018 p.30).

As a non-native species, to prevent and minimize any risk of proliferation, management and monitoring measures are relevant when planting pongamia. Through a Monitoring Plan, environmental and social impacts will be monitored and evaluated for this project (refer to Section 5 on the monitoring of GHG emissions and reductions). Also, in addition to the compliance with all federal, state and local laws and regulations, landowners that join the Project will obtain the Non-Native Species Planting Permit, according to the Florida Administrative Code (F.A.C.). To comply with this permit, landowners must assert the following:

- A viable system to prevent plants and plant parts from spreading into ditches, natural waterways and any onsite drainage by maintaining a 20-25 foot buffer from site boundaries.
- Adequate measures to mitigate the spread of the permitted plant species from dispersal via seed such as eradicating any propagative material that occurs in buffer areas and natural areas.
- Adequate safeguarding measures are applied to border of the planting to prevent plant spread.
- Containment procedure for cleaning equipment used onsite.
- Adequate measures for wildfire mitigation
- Maintaining a surety bond for 150% to the cost eradicating the planting for the duration of the project.

Additionally, the Project has applied mitigation measures, such as properly cleaning equipment and vehicles that may carry pongamia seeds, properly covering harvesting bins and containers, and developing mitigation plans for any escaped seeds due to an inclement weather event to minimize any risk of uncontrolled spread of seedlings outside the Project Area.

2.4 Public Comments

To be developed, as defined in Section 3.1.3 of the VCS Procedural Document: Registration and Issuance Process v4.0.

3. APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

AR-AMS0007 A/R Small-scale Methodology Afforestation and reforestation project activities implemented on lands other than wetlands Version 3.1, approved under VCS. Further, the following tools are related to the referred approved baseline methodology and are applicable for the project activity:

- *"Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities", version 1.1.0.*
- *"Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities", version 4.1*
- *"Estimation of carbon stocks and change in carbon stocks in deadwood and litter in A/R CDM project activities", version 3.1*
- *VCS "Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities."*
- *A/R Methodological Tool "Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities", version 01.0.0.*
- *Demonstration of Eligibility of Lands for A/R CDM Project Activities*
- *Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*
- *Calculation of the number of sample plots for measurements within A/R CDM project activities, version 02.1.0.*

3.2 Applicability of Methodology

The Project activity meets the applicability conditions of the AR-AMS0007 methodology used by the project.

- **The land subject to the project activity does not fall in the wetland category:**

According to the definitions for terms used in the VCS Program document, a wetland is a "land that is inundated or saturated by water for all or part of the year (e.g., peatland), at such frequency and duration that under natural conditions they support organisms adapted to poorly aerated and/or saturated soil…". The Project Area does not fall into this category.

As described in Section 1.12, the Project Area is located within St Lucie and Indian River counties, a commercial citrus production area in Florida. The Project Area is characterized by cropland and grasslands formerly used for citrus production that turned to cattle grazing or land left fallow.

- **Soil disturbance attributable to the project activity does not cover more than 10% of the area in each of the following types of lands when these lands are included within the project boundary:**
    - Land containing organic soils;
    - Land which, in the baseline, is subjected to land-use and management practices and receives inputs listed in appendices 2 and 3 to this methodology.

The proposed project will not cover more than 10% of the area for both land containing organic soils and land which is subjected to land use and management practices. Immediately prior to planting, 30cm x 30cm x 30cm holes are dug by hand or using a hydraulically-driven auger. Trees are then planted by hand over the course of several days. Pongamia trees are planted at a density of no less than 100 trees per acre and no greater than 145 trees per plantable acre. Thus, soil disturbance in the Project Area will only cover a small fraction of the project area.

Depending on the state of the land being used, a number of practical land preparation activities are required before pongamia can be planted but will cause minimal disturbance of the land. If the land only recently stopped growing citrus, stumps and dead trees may need to be removed. Citrus beds and water furrows may need to be regraded to accommodate low-clearance pongamia harvesting equipment. If the land has been left fallow for a long time, other bushes or trees that have grown may be removed. Additionally, earth-moving equipment may be required to move any large rocks or boulders. If irrigation is being used, new lines need to be laid down for drip or micro-jet irrigation. In some cases, new irrigation infrastructure such as pumps and filters may need to be installed.

Regarding soil types, soil data (Figure 7) shows that the soils within the Project Area are predominantly Riviera Fine Sands and Pineda Sands — Aqualf soil types within the Alfisol soil order, with low organic matter and natural fertility content (USDA, 1980).

The project activity also meets the applicability conditions of the following tools:

- *"Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities", version 1.1.0.* The project activities meet the applicability conditions as described by the tool. The area does not contain wetlands, does not contain organic soils, and is not subject to the land management practices outlined in Tables 1 and 2 of the tool. Furthermore, litter will remain on site, and any soil disturbance will be in accordance with appropriate soil conservation practices and soil disturbance is limited to site preparation before planting.
- *"Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities", version 4.1.* This tool has no internal applicability conditions. The tool is

applicable for the project because biomass from the tree plantations is the principal carbon pool for the project activities.

- *"Estimation of carbon stocks and change in carbon stocks in deadwood and litter in A/R CDM project activities", version 3.1*. This tool has no internal applicability conditions. This tool is applicable for the project because this pool of carbon is expected to increase due to the project activities.
- *VCS "Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities."* All of the applicability conditions are met for this tool. The AFOLU activities will not lead to the violation of any laws, and this document outlines the most plausible baseline scenario.
- *A/R Methodological Tool "Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities", version 01.0.0.* This tool has no internal applicability conditions. This tool is appropriate for the project activities and all conditions of the tool have been met.
- *Demonstration of Eligibility of Lands for A/R CDM Project Activities.* This tool has no internal applicability conditions. This tool is appropriate for the project activities and all conditions of the tool have been met.
- *Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity.* This tool is applicable because the project activities will not cause, directly or indirectly, the drainage of wetlands or peat lands.
- *Calculation of the number of sample plots for measurements within A/R CDM project activities, version 02.1.0.* This tool has no internal applicability conditions. This tool is appropriate for the project activities and all conditions of the tool have been met.

3.3 Project Boundary

Due to the estimated changes in practices derived from the Project activities and according to the AR-AMS0007 methodology, the following carbon pools and GHG sources are included in the baseline and project scenarios.

Table 9. Project Boundary - Carbon Pools

Carbon pools		Included	Justification/Explanation
Baseline	Above ground	Yes	Assuming that past citrus trees would decline and die, this carbon pool is conservatively assumed to be equal to zero for the life of the project. The above ground biomass carbon pool is non-existent or in a steady state under a cattle grazing scenario.

	Below ground biomass	Yes	Assuming that past citrus trees would decline and die, this carbon pool is conservatively assumed to be equal to zero for the life of the project. The below ground biomass carbon pool is non-existent or in a steady state under a cattle grazing scenario.
	Deadwood and litter	Yes	Optional pools under AR-AMS0007. Past practices for citrus orchards consisted of removing dead or decaying trees. For the baseline scenario it is assumed that deadwood and litter carbon pools could result in a decline. It is therefore assumed to be zero.
	Soil organic carbon	Yes	Optional pools under AR-AMS0007. Soil organic carbon stocks are expected to remain at a steady state for pasture or decrease due to recurring soil disturbance from these practices. Thus, conservatively, this pool is assumed to be equal to zero.
Project	Above ground biomass	Yes	This is the principal carbon pool subject to the project activity.
	Below ground biomass	Yes	Carbon stocks in this pool are expected to increase due to the implementation of the project activities.
	Deadwood and litter	Yes	Optional pools under AR-AMS0007. This pool is expected to increase under the project activities.
	Soil organic carbon	Yes	Optional pool under AR-AMS0007. This pool is expected to increase under the project activities.

Table 10. Project Boundary - GHG Emissions

GHG emissions		Gas	Included	Justification/Explanation
Baseline	Burning of woody biomass	CO_2	No	GHG emissions in the baseline will be conservatively omitted.

		CH_4	No	GHG emissions in the baseline will be conservatively omitted.
		N_2O	No	Optional pools under AR-AMS0007.
Project	Burning of woody biomass	CO_2	No	There will be no burning of biomass as part of project activities.
		CH_4	No	There will be no burning of biomass as part of project activities.
		N_2O	No	There will be no burning of biomass as part of project activities.

Physical project boundaries are shown in Figure 2 and Annex 1.

3.4 Baseline Scenario

According to the CDM AR-AMS0007 Methodology, The baseline scenario of a small-scale A/R CDM project activity implemented under this methodology is the continuation of the pre-project land use: lands used for pasture or cattle grazing.

There is sufficient evidence in the Project Area and the region where the project is located, of the degradation of citrus orchards de to the citrus greening disease or huanglongbing (HLB). This together with economic reasons and other barriers, has led landowners to switch land activities to pasture. Pasture is also the most economically viable alternative for a landowner, without carbon finance, as detailed in the 3.5 Additionality section.

3.5 Additionality

According to the VCS Standard, Section 3.13, the simplified procedure to prove additionality is only applicable in a developing country context. Since this project is taking place in Florida in the US, the additionality demonstration is based on the approved VCS "*Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities", version 3.0* that requires greater detail from available information.

Step 1. Identification of alternative land-use scenarios to the proposed VCS AFOLU project activity

a) Sub-step 1a. Identify credible alternative land-use scenarios to the proposed AFOLU project activity.

Based on the specific context of the Project Location and economic activities in the region and pre-project land-use, four alternative land use scenarios are proposed: i) citrus orchards ii) land used for cattle ranching iii) abandoned and fallow land and iv) reforestation without registration of the A/R CDM project activity.

i) Citrus orchards

Lands within the Project Area have been used for citrus production for over two decades. Due to the increasing challenges of HLB most growers have ceased citrus production and land now lays fallow or has been converted to cattle grazing, though it is possible that growers may return to producing citrus. Additionally, citrus production remains common practice in the Project Location. The Project Area is located within the Indian River District, a commercial citrus production area in Florida. According to official data of the USDA's National Agricultural Statistics Service of citrus production in Florida in 2017-2018 (the year prior to the project start date), citrus production in Florida accounted for more than 40% of the country's production (USDA, 2019b).

ii) Lands used for cattle grazing

Past land activities in some areas within the project boundaries consisted of cattle grazing as an alternative to keep the land under production after the loss of citrus orchards to widespread disease. Cattle ranching is one of the most common agricultural activities in the region. In 2017, nearly half of Florida's agricultural land was involved in cattle production with half of all farms registering a cattle inventory (USDA, 2017c). Cattle production is considered a vital activity for the state's food security, so much so that Florida's Right to Farm Act, established in 1979, as well as the Rural and Family Lands Protection Act of December 2001, were designed to protect valuable agricultural lands and ranches to ensure sustainable land management practices and reasonable protection of the environment (FDACS, 2001).

iii) Abandoned and fallow land

Citrus groves that have died or become economically unfeasible to maintain due to HLB are cleared, replanted with new citrus trees, or are abandoned. Abandoned groves are a threat to the citrus industry in Florida, carrying the bacterium that causes the HLB disease. St. Lucie County has the largest amount of abandoned citrus at 32,605 acres, followed by Indian River County which had the largest gain, bringing its total to 16,599 acres (USDA, 2016).

iv) Reforestation of the land within the project boundary performed without being registered as the A/R CDM project activity.

The main land cover types and land use in Central Florida have been agriculture (including citrus production) and the cattle industry for over 100 years (Volk et al, 2017). Specifically, the lands within the Project Area have been owned and managed for citrus cultivation and grazing by private landowners for decades. As their lands will continue to be under management, land is not expected to revert to forest.

Afforestation and reforestation, through the adoption of conservation practices, is not a common practice in the region and represent a high investment and opportunity cost for landowners. However, existing federal subsidy programs such as the USDA Farm Service Agency (FSA), administered by the Conservation Reserve Program (CRP), the Wetlands Reserve Program (WRP), the National Resources Conservation Service (NRCS) Environmental Quality Incentive Program (EQIP), and the Conservation Stewardship Program (CSP) offer agricultural producers help with annual rental payments and cost-share assistance under the condition of conserving plant cover in the long-term to improve water quality, control soil erosion, and develop wildlife habitat.

CRP is the most important conservation program in the United States in terms of scale and budget (Wu, F. et al, 2013), but has modest enrollment, especially in Florida. In 2017 (the year prior to the Project Start Date), the number of cumulative acres in Florida enrolled in CRP initiatives was 29,841 across 597 farms (FSA and USDA, 2017). This represents 0.2% of the total CRP acreage and 0.3% of the total acreage of farms in Florida in that year (USDA, 2017). Enrolled acreage has continually decreased since 2007 (Oh J. and Guan Z., 2018). The main reasons for low enrollment levels in the state are because of the program entry barriers that limit the types of crops grown and other environmental conditions of lands to be eligible for enrollment. As there is a strong agricultural sector, vital to the economies of productive and rural communities, CRP becomes uncompetitive for markets and job opportunities of this sector (Oh J. and Guan Z., 2018; Wu, F. and Weber, B., 2012).

NRCS programs, such as CSP and EQIP, have been more successful for Florida farmers. CSP assists producers in protecting grazing land use; conserving and improving soil, water and wildlife resources; and achieving related conservation values by conserving eligible land through grassland conservation contracts (USDA - Natural Resources Conservation Service, 2021a). EQIP provides financial and technical assistance to agricultural and forestry producers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, ground and surface water conservation, reduced soil erosion and sedimentation, and improved or created wildlife habitat (USDA Natural Resources Conservation Service, 2021b). EQIP payments are one-time payments intended for small, one-off projects, whereas CSP is intended to provide annual payments for long-term, whole-farm projects for cropland soil health and sustainability, or water quality and grazing land conservation. Farmers often apply to both as complementary programs.

Specifically, the total financial assistance provided by the CSP program for all Florida farmers enrolled increased from $157 USD in 2009 to $9,214 USD in 2020 with a total of 43,885 acres and 38 active contracts (USDA – Natural Resources Conservation Service, 2021a). EQIP has better enrollment rates, as the total technical and financial assistance for the program in Florida was $30,256 in 2020, with 202,507 acres enrolled and 5,469 contracts (USDA Natural Resources Conservation Service, 2021b). Together with CSP, EQIP represents an alternative land-use scenario for afforestation and reforestation activities, while keeping the land under productive use.

Forestation of the land within the project boundary through one or more of these incentive programs for sustainable agricultural practices or conservation is an unlikely but potential land-use scenario.

b) Sub-step 1b. Consistency of credible alternative land-use scenarios with enforced mandatory applicable laws and regulations.

All four scenarios described above are consistent with enforced mandatory state and federal laws and regulations.

c) Sub-step 1c Selection of the baseline scenario.

According to the CDM AR-AMS0007 Methodology, The baseline scenario of a small-scale A/R CDM project activity implemented under this methodology is the continuation of the pre-project land use: lands used for pasture or cattle grazing.

There is sufficient evidence on the Project Area and the region where the project is located, of the degradation of citrus orchards de to the citrus greening disease or huanglongbing (HLB). This together with economic reasons and other barriers, have led landowners to switch land activities to pasture. Pasture is also the most economically viable alternative for a landowner, without carbon finance, as detailed in the 3.5 Additionality section.

Step 3. Barrier analysis

The barrier analysis is performed to identify barriers that a) Prevent the implementation of this type of proposed project activity without the revenue from the sale of GHG credits; and b) Do not prevent the implementation of at least one of the alternative land-use scenarios.

a) Sub-step 3a. Identify barriers that would prevent the implementation of the type of proposed project activity

Investment and financial barriers

Afforestation and reforestation activities represent a major investment for small landowners. Upfront investment costs for the establishment of a citrus orchard can start from $9,708 USD per acre ($23,978 USD per hectare) (IFAS, 2021), representing a significant investment of up to $1.7 million for a small landowner with typical farm size around 179 acres. Whilst the area cost for pongamia is lower at $4,618 USD per acre, initial investment of over $800,000 USD presents a significant financial barrier to implement sustainable agroforestry practices.

Reforestation through conservation actions also presents establishment and opportunity costs. The NRCS is the main entity through which individual farmers and ranchers currently gain access to financial capital to support their individual farm level conservation work (O'Connor, 2020). EQIP and CSP provide financial incentives and technical assistance to implement conservation practices and to improve systems through infrastructure upgrades. Although these subsidies from government programs are designed to generate environmental benefits and may increase land value, they can have a negative impact on agricultural production (Wu and Weber, 2012). Research suggests these programs are impractical for most farmers, especially for small landowners to financially justify investing in new practices (O'Connor, 2020). Payments received by landowners for the term of the servitude of the program are not competitive with returns from agriculture or cattle. As commodities prices increase, farmers will require higher rental payments to enroll their land into conservation programs (Miao et al, 2016).

Federal legislation has continuously reduced the maximum amount of land that can be kept in conservation programs as well as reduced the budget for conservation purposes (ibid), reducing the number of contracts and projects to be funded. Available funding has a direct impact on contract renewals and the sustainability of enrolled projects. EQIP payments are one-time only, assigned to specific activities, and CSP consists of annual payments, structured for five-year terms and can be renewed once. CSP renewals compete with new applicants on the merits of the environmental benefits, increasing the probability of a renewal request being rejected (Market Intel, 2019). Only 31% and 42% of farmers applying to the respective programs were awarded contracts between 2010 and 2020 (Happ, 2021).

Plans to transition to regenerative and sustainable farm practices are often difficult to implement for small landowners as they need additional capital beyond these government funds to help finance the operational, equipment, and/or infrastructure needs that are associated with the adoption of new crops and practices (O´Connor, 2020).

Institutional barriers

Agroforestry activities are possible through the funding of government programs, although there are various technical entry barriers for small landowners to participate. Available programs are neither designed nor funded sufficiently to deal with agroforestry. For instance, most of Florida's land is out of the range of traditional conservation programs such as the USDA's CRP program, due to the requirement of projects being under high erodible lands.

Other programs like the EQIP and CSP programs NCRS's Environmental Quality Incentive Program (EQIP) initiatives and the USDA's Conservation Stewardship Program (CSP), that range from specific soil types, requirements in the history of land management, size of the land, among others, that could prevent many landowners from enrolling.

Additionally, regarding EQIP and CSP programs, there are other barriers to entering these programs due to matters of race discrimination of farmers of color, and due to lack of funding for the CSP program specifically (Happ, 2021).

Technological barriers

Farmers and landowners in Florida face many challenges as they seek to make their farms and forestlands profitable, productive, and environmentally sustainable. Current and emerging agroforestry practices in the Southeast states in the USA, together with an increase in policy directed towards agricultural sustainability and alternative production systems focus on increasing food security while maintaining sufficient yields in sustainable production systems (Workman et al 2014). Despite these initiatives, competition between crops, trees and animals as the greatest constraint to use of agroforestry, lack of information and lack of markets, the expense of additional management and lack of familiarity with the practices, lack of technical assistance, water scarcity and lack of demonstrations are recorded constraints that prevent uptake (Workman et al 2014).

Specialty crops are considered high-risk, high reward, as growers face differing and larger risk exposure when compared to traditional row crops. The type of crops that can be grown in Florida are limited due to the climate and soil. This together with technology (including the efficiency of that technology), training to ensure proper field use of equipment, ability and capacity for on-farm storage/processing, produce form (fresh vs. frozen), timing and geography of harvest, etc., play interrelated roles in impacting the economic profitability of specialty crop growers (Neil and Morgan, 2021).

Pongamia is considered novel in the agroforestry sector. There is limited information around modern pongamia cultivation, long-term orchard management, and various other added-value plantation options that the Project activities entail. Pongamia has very limited use in the United States and there is limited evidence of pongamia supply chains and markets existing outside of the ones Terviva has created. Overall, there is no evidence that landowners would be able to access the knowledge, technical experience, plant genetics and cultivation expertise in pongamia elsewhere. This presents market barriers for landowners to gain access to the provision of pongamia trees and pongamia produce markets without the funding and partnership of Terviva.

Prevailing practices

Agricultural activities (including citrus production) and the cattle industry have persisted in North and Central Florida for over 100 years (Volk et al, 2017). Currently, citrus production in Florida accounts for more than 40% of the country's production (USDA, 2019b). Specifically, the lands under the Project Area have been under citrus production for over 20 years. Sustainable agroforestry practices as well as the adoption of a new crop represent a substantial change in the ways of working of owners who are familiar and specialized with the common practices of citrus production in the region.

Specialty crops that can be grown in Florida tend to have small and relatively mature markets that don't allow farmers to reach the same scale of operations that they once did with citrus. In Florida, the market for citrus produce is one of the biggest in the country. Considering Florida as one of the largest state producers of citrus in the US with over 80 thousand jobs (National Research Council, 2010), and that citrus fruit ranks first internationally in trade value among all fruits (ibid), the citrus markets remain one of the largest in the region. Entering new unknown crop markets represent a very high risk for farmers.

Ecological barriers

The largest barrier for landowners to continue growing citrus trees is the ecological conditions that allow for the spread of HLB disease, which results in increasing costs, and the decline of citrus production. Citrus production has suffered under the stresses brought on by these changing ecological and climatic conditions, thus jeopardizing its long-term future.

Florida's citrus production has declined around 80% from 2003-2004 to 2017-2018 (USDA, 2019a). This decline is mainly due to three factors: first, many trees and groves were culled in an effort by the State to eradicate citrus canker (*Xanthomonas axonopodis* pv. *citri*), followed by catastrophic hurricanes in 2004, 2005, and 2017, and by the devastating citrus greening disease or huanglongbing (HLB) (Ferrarezi et al., 2019).

Official data shows a constant decrease of yearly citrus production from almost 14 million tons in 1999-2000 to around 2 million tons in 2017-2018 (USDA, 2019a). While the economic data for the state's 2018-2019 citrus season improved from the prior season that was impacted by Hurricane Irma in 2017, the improvement lagged behind expectations. The state's citrus acreage has declined 4% since 2018 to 430,601 acres, according to the Commercial Citrus Inventory by the U.S. Department of Agriculture (2019a). This is the lowest total yearly acreage dedicated to citrus production since the USDA began the current inventory in 1966 (ibid). This trend has occurred across the whole state: the 2021/22 season is expected to reach a record low harvest and California's orange harvest is expected to be larger than Florida's for the first time ever (Buccholz, 2022).

Citrus greening or HLB is the most serious and devastating disease affecting citrus (FAO, 2013). The estimated damage of the disease from 2015 to 2020 amounts to over $1 billion per year, with nearly 5,000 jobs lost annually (Li et al, 2020). This has led growers to change and intensify their management practices, with a very high economic impact to production costs (ibid). The citrus greening disease impacts the health of citrus trees, as well as the quantity and quality of yields, and eventually kills trees. Trees affected by HLB can become unproductive in the first five years and their lifespan can be reduced significantly to only 7–10 years (ibid). Growers have turned to practices to prevent and control the spread and effect of citrus greening that include the increased use of pesticides, insecticides, fertilizers, as well as continuous monitoring and testing for the spread of the disease.

b) Sub-step 3b. Show that the identified barriers would not prevent the implementation of at least one of the alternative land-use scenarios (except the proposed project activity):

None of the identified barriers would prevent landowners continuing to operate pasture and cattle ranching activities.

The cattle grazing scenario assumes annual revenue of approximately $35 USD/acre (obtained from similar rental rates in the region), from leasing the land for cattle grazing purposes. This alternative land-use scenario does not entail upfront costs from the landowner and operational costs are considered minimal.

The identified barriers in the previous sub-step of this analysis, such as climate threats, together with implementation constraints, have actually pushed landowners to convert their land to other land-use activities such as pasture or ranching activities (Humphries, 2019; Workman et. al., 2014).

c) Sub-step 3c. Conclusion of barrier analysis

As result of the barrier analysis, scenario ii - Cattle grazing is identified as a land-use scenario not prevented by barriers and that presents an accessible alternative for landowners from a financial and investment perspective.

Step 4. Common Practice Analysis

The project activities consist of a series of sustainable agroforestry practices that are not common practice within the Project Location, located in a commercial citrus production area in Florida. This section explains the essential distinctions between common agroforestry practices in the region and the project activity.

4.1) Similar activities in the geographical area of the proposed VCS AFOLU project.

Agroforestry practices are common in the Project Location and Project Area. However, as mentioned in sub-step 3a, the adoption of pongamia as a new permanent crop for farmers represents a shift away from common intensive practices while improving yields. Citrus production practices in the region have increased their use of pesticide- and fertilizer-intensive farming practices to combat environmental and market pressures. Project activities for pongamia cultivation differ significantly from these.

4.2) Essential distinctions between common agroforestry practices and project activities.

Pongamia can thrive in a range of harsh environmental conditions – it can grow in a variety of soil types, withstand drought stress, grow on saline soils and needs little topsoil. It is also tolerant of soil sodicity, pH imbalances, high temperatures, heavy metal contamination, and poorly drained soils. Due to these properties, pongamia requires a moderate amount of maintenance, low use of chemicals, and reduced water input (Leksono et al, 2021). Nodulation and nitrogen fixation are also characteristic of pongamia trees. Biological Nitrogen Fixation (BNF) offers an economic and ecological significance by reducing the use of external nitrogen, such as fertilizers with high nitrogen content (Calica, 2017). Main distinctions to common agroforestry practices in the region are mentioned below.

Reduction of pesticides

The use of pesticides is widespread in citrus production for pre- and post-harvest protection and chemical substances are often applied in order to control undesirable molds or insects. In the Florida region specifically, Huanglongbing (HLB or Citrus Greening) (USDA, 2021c) has required farmers to intensify common practices of high-pesticide use in order to avoid the spread of the disease. In Florida, 90% of citrus acreage is affected by greening, requiring the use of pesticides such as

Glyphosate, paraquat, atrazine, and FOS as a part of agricultural management to control the spread of nematodes. Without intense practices and human intervention, citrus trees are likely to die and have a negative environmental impact on the region (Dala-Paula et al., 2019).

Based on the USDA chemical use survey (USDA, 2019e), the average use of chemicals for orange groves, including fungicide, herbicide, insecticide and other in 2019 was 1.85, 2.68, 3.79, and 6.31 lbs per acre per year, respectively. By assuming a mix of all chemicals is used for the production of citrus, the total use equals 14.63 lbs/acre/year (16.40 kg/ha/year). Project activities therefore represent a reduction of around 67% in total chemical use for the first three years and a complete elimination of pesticides from year 4 onwards.

Reduction of fertilizer use

Fertilizer use is considered common practice in the region. The 2017 Census of Agriculture in the US reported that the percentage of acres treated with commercial fertilizer, lime, and soil conditioners in St Lucie County was between 70% and 79% (USDA, 2019b), whereas in Florida the adoption rate is 85% in cropland areas (ibid).

Fertilizer use is an important component of citrus production and is considered common practice in the region to maintain tree productivity. Fertilizer programs and methods of delivery determine citrus tree growth, health, fruit production, and fruit quality (Boman et al., 2021). Additionally, in the past decade farmers have adopted more intense management practices such as high-fertilizer use to grow and maintain citrus due to HLB. The nutrient uptake efficiency of trees that are affected by greening is lower than that of healthy trees, so larger and more frequent doses of fertilizer are needed to grow and maintain the trees (Ferrarezi et al., 2021).

Studies of the relationship between nutrient uptake, tree growth, and yield production rates of citrus trees in central Florida have shown that minimum Nitrogen (N) rates required to reach optimal canopy volumes range from 182, 198 and 199 kg ha^{-1} for fertigation (30 times annually), control release fertilizer and fertigation (4 times annually), respectively (Kadyampakeni et.al, 2015). Other research suggests that a common rule between citrus growers in the past decades has been 0.4 lb (0.18 kg) of N 200 lb/acre (224 kg·ha^{-1}) of N fertilizer annually, split into three applications (Litvany and Ozores-Hampton, 2002). Project activities result in lower fertilizer use by at least 76% for years 1 and 2, 67% in years 3 and 4, and 64% in years 5 onwards.

Reduction of water use

Pongamia's resilience to drought and a variety of harsh climate conditions make it a suitable crop for reduced or no irrigation. Plantings of pongamia in hot, dry areas, with different soil conditions and water availability, showed high survivability (Leksono et.al., 2021). This represents a positive opportunity to reforest degraded lands as well as a change of water management in the Project Area, which is not considered common practice in the region.

Irrigation is an important component of citrus management and is common practice in the region. Citrus are subtropical plants and their optimal growth conditions are warm temperatures and high humidity. Citrus roots are shallow and are unable to mine deeper layers of soil, and thus irrigation is a critical component of citrus management. Due to low rainfall levels in from February to May, additional irrigation is necessary to reduce the negative effects of water stress and promote growth. Citrus greening has led to the increased frequency of irrigation, because water stress can negatively affect tree growth and crop production, and make trees more susceptible to infection (Ferrarezi et al., 2021b).

The implementation of project activities will impact water use significantly. The water needs for a citrus grove with 140 trees per acre are between 14 and 39 gallons per tree per day for the winter and summer months, respectively (Parsons and Morgan, 2017). For pongamia, irrigation is typically not needed in the winter months (except for frost protection). Therefore, the water use for pongamia plantations represents a reduction of 100% for winter months, and about 73% annually.

Cover crops

Cover crops are only included on a small portion of cropland in both the US and the region. According to the USDA, cover crops were used on just 1.7% of total farmland (USDA, 2019b). In Eastern Florida, specifically in the Indian River District, an adoption rate of cover crops is less than 5% of the total cropland acres (USDA, 2017a). While adoption of cover crops has increased for annual crops, there is less research on their impact on soil health and root growth for perennial crops such as citrus. The possibility of cover crops competing with citrus for nutrients or soil moisture has also not been well-examined and has possibly contributed to the low adoption rates of cover crops in the region (Strauss et al., 2019).

Project activity includes cover crops such as grass and weeds, or Millet and Bermuda or Bahia grass, to grow in between the tree rows.

Change in circumstances

One of the main essential distinctions between similar activities in the region and the project activities is the presence of Terviva and the Project Proponents in the region. Driven by a desire to combat climate change while helping farmers, Terviva aims to produce low-carbon-intensity food products from pongamia (Terviva, 2021). Carbon finance has allowed Terviva to reach this objective by being able to couple a new financial vehicle with trusted technical support to invest and partner with landowners in transitioning to sustainable agroforestry practices in their farms.

Terviva breaks the knowledge and technological barrier to access pongamia crops and sustainable agroforestry practices due to its decade-plus of agricultural technology and experience in the production of pongamia trees and pongamia production. The company provides patented high-yielding trees to growers and offers proprietary bean processing to create sustainable food ingredients. They are dedicated to training and supporting growers in adopting sustainable agroforestry practices and providing access to a new market through the purchase of pongamia produce.

3.6 Methodology Deviations

No methodology deviations were applied in this Grouped Project.

4. Quantification of GHG Emission Reductions and Removals

To be developed, as defined in Section 3.1.3 of the VCS Procedural Document: Registration and Issuance Process v4.0.

5. Monitoring

To be developed, as defined in Section 3.1.3 of the VCS Procedural Document: Registration and Issuance Process v4.0.

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ANNEX 1

Project Location and Project area in kml files.

ANNEX 2

Detailed soils map of the Project Area in a pdf file.

ANNEX 3

The following figures show satellite images taken from Google Earth of each plot of land of the Project Area, of the latest available year before Project Implementation.

Figure 1. Plots A-001, A-002, A-003, A-004 in 2018

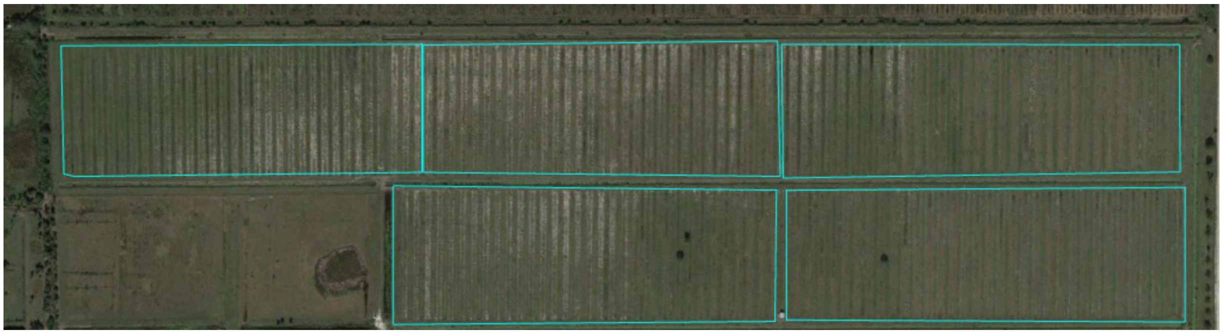

Figure 2. Plots A-005, A-006 in 2019

Figure 3. Plots B-001, B-002. B-003, B-004, B-005, B-006, B-007, B-008 in 2018

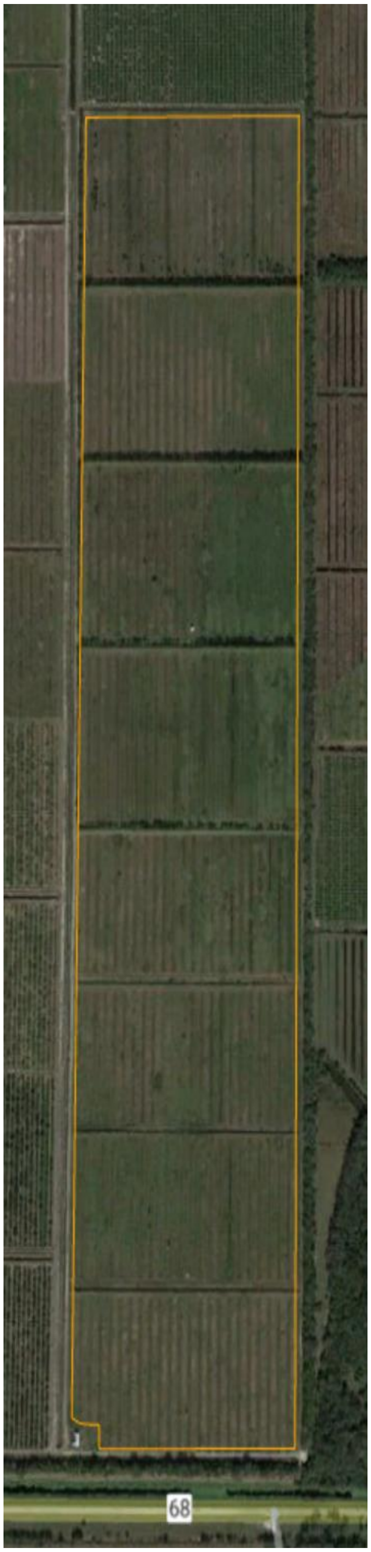

Figure 4. Blocks B-009, B-010, B-011 in 2019

Figure 5. Blocks C-001, C-002 in 2019

Figure 6. Block C-003 in 2021

Figure 7. Blocks D-001, D-002, D-003, D-004, D-005, D-006, D-007, D-008, D-009, D-010, D-011, D-012, D-013, D-014, D-015, D-016 in 2018

Figure 8. Block E-001 in 2019