Food and Agriculture Organization of the United Nations

FUNDING PROPOSAL TO THE GREEN CLIMATE FUND

-IRES-CUBA-
INCREASED CLIMATE RESILIENCE OF RURAL HOUSEHOLDS AND COMMUNITIES THROUGH THE REHABILITATION OF PRODUCTIVE AGROFORESTRY LANDSCAPES IN SELECTED LOCALITIES OF THE REPUBLIC OF CUBA

APPENDIX 2.6 AGROFORESTRY MODULES FOR LANDSCAPE RESTORATION

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Republic of Cuba

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1. Glossary

EBA	Ecosystem-based adaptation
AIP	Project implementation area
Azcuba	Sugar Business Group of Cuba
BMSM	Model Forest of Sabanas de Manacas
BP	Planted Fores
CAP	Allowable annual cut
CC	Climate Change
CCS	Cooperative of Credit and Services
CGB	Cuba Ranger Corps
CITMA	Ministry of Science, Technology and Environment
CPA	Cooperative of Agricultural Production
DFFFS	Forestry, Wildlife and Wildlife Management
EAF	Agroforestry Company
FFI	Integral Forestry Farm
GCF	Green Climate Fund
GAF	Agroforestry Group
GHG	Greenhouse gases
Ib	Forestry index
ICA	Institute of Animal Science
IES	Institute of Ecology and Systematics
IIPF	Pasture and Forage Research Institute
IMA	Annual Average Increase
INAF	Institute of Agroforestry Research
MFS	Sustainable Forest Management
MINAG	Ministry of Agriculture
MS	Dry Mass
MV	Green Mass
NTFP	Non-Timber Forest Products
GDP	Gross domestic product
SEF	Forest State Service
Tabacuba	Tobacco Business Group
UBPC	Basic Unit of Cooperative Production
UEB	Base Business Unit
UEBIST	Integral Managerial Base Units of Technical Services

2. Summary

For a small country island such as Cuba, one of the priorities closely linked to the food security of its population is the implementation of good practices in the agricultural sector, to mitigate and adapt to climate change.

The agricultural sector is strategic and decisive for the country's economy due to multiple reasons, including its high participation percentage in the Gross Domestic Product (GDP), and its role as one of the main sources of employment. In it rests the food security of the country, one of the main pillars of the Cuban social system, as well as education and health, among others.

In order to implement good sustainable agroforestry management practices in the Project Implementation Area (AIP), six productive modules have been identified based on the principles of Ecosystem Based Adaptation (EBA), all linked to agricultural, livestock and forestry systems,. Which will entail changes in the rationalization and actions of farmers, technicians and managers involved in these activities.

In principle these productive modules can be implemented by any of the non-state productive forms existing in the country such as the Agricultural Production Cooperative (CPA), Credit and Services Cooperative (CCS), Basic Unit of Cooperative Production (UBPC), usufructuaries of lands benefited by Decree Laws No. 259 first and No. 300 afterwards, as well as by state companies. The productive modules have been designed on the basis of practical experiences complemented with research results.

The productive modules summarized in this document, have not been highly promoted in the country due to diverse considerations, among which are the scarcity of essential resources to implement them; the governmental inefficiency of the extension units and other entities, the training that is carried out in the agricultural and forestry sector and the resistance to change by managers, technicians, farmers and land managers in general.

The areas in which these modules will be implemented are characterized by showing high vulnerability to climate change (CC) as expressed in the "Adaptation and vulnerability Analysis" report prepared for this project.

Starting from depressed scenarios from the social and economic points of view and of very low productivity, especially in the agricultural sector, which is due, among other reasons, to water scarcity (more frequent and prolonged droughts), extreme weather events such as hurricanes, saltwater intrusion and underground watersheds.

These factors, along with low rates of forest coverage reported in the territories and the scarce presence of isolated trees in the rural setting, threaten the resilience of the homes and communities in the AIP.

The implementation of these modules will result in a novel experience in relation to the practices currently carried out within the agricultural and forestry activity, and its main objective is to improve adaptation in the rural households more vulnerable to climate change impacts through the rehabilitation of productive agroforestry landscapes.

To ensure this objective, the project designed modules that operate under sustainable systems, which fulfill relevant functions in the scenario in which they are developed and also focus on ensuring greater resilience of vulnerable people, households and ecosystems. These functions are summarized in:

- Protect and improve surface and underground water resources to achieve greater water availability, in quantity and quality.

- Decrease or stop saltwater intrusion, hence the salinization of soils and aquifers.

- Improve the quality of life of people and households that currently live in economically depressed areas.
- Increase carbon sequestration in the Cuban agrarian system through sustainable practices.
- Protect and improve agricultural and livestock soil against erosion and other degrading factors.
- Create new habitat and contribute to the conservation of the terrestrial biodiversity existing in the AIP.

As a consequence of the implementation of these modules, the following results would be achieved:

- Restore areas invaded by marabou and its conversion to biodiverse, more productive and resilient systems.
- Increase the Forest Index (Ib) / forestry coverage in the AIP by reconverting idle and unproductive areas in sustainable agroforestry systems.
- Establish biodiverse forest plantations, including those of a commercial nature, in such a way that they are more resilient to climate change and improve the ecosystem services they provide.
- Diversify the rural landscape with different productive modalities that adjust and benefit both small producers and state companies.
- Increase the presence of trees in the landscape of AIP.
- Promote and improve the creation of habitats and reduce the fragmentation of forests to improve connectivity between ecosystems.
- Increase the productivity of crops, livestock systems and forests.
- Protect, improve and establish gallery forests as a water regulation factor.
- Expand knowledge within the rural population on the benefits of applying good practices in the agricultural sector and their importance in confronting climate change.

This document summarizes the technical and implementation aspects of the six selected agroforestry production modules, as well as arrangements for their implementation within the Cuban Government structure.

3. Introduction

This document is part of a proposal prepared by FAO in support of the Republic of Cuba to access the financing of the Green Climate Fund (GCF), called: "Increasing the climate resilience of rural households and communities through the rehabilitation of production landscapes in selected localities of the Republic of Cuba"- IRES-Cuba Project, which aims to bring forth benefits in environmental, social and economic terms through an innovative approach that integrates the adaptation and mitigation elements for the sustenance of environmental functions at the agro-landscape level, as well as enhancing the application of better agricultural practices, as well as the management of water resources in the most vulnerable populations in the project implementation areas (AIP).

The agroforestry activities on the selected areas and their communities are the central point of the project, as they represent one of the most hazardous and vulnerable scenarios to the impacts of climate change; responding to these challenges requires adjustments in policies, programs and management practices. It becomes necessary to adopt new productive modules that integrate agricultural, livestock and forestry production in the short term, bringing forth a true paradigm shift that leads to a sustainable, resilient and low carbon agroforestry sector. Additionally, the project appropriates one of the central objectives of the State Plan to Confront Climate Change, known as “Task Life”, which encompasses "Effectively implementing the programs and actions for confronting Climate Change (CC), with emphasis on adaptation, reducing vulnerability, mitigating its causes and introducing systemic and cross-sectorial strategies".

The agricultural sector in Cuba (agriculture, livestock and forestry) is developing in a changing climate environment as well as increasingly adverse, due to rising temperatures, decrease in rainfall, increase in mean sea level, intensification and greater frequency of tropical cyclones, decrease of water resources in quantity and quality, and the loss of biological diversity (See Report on "Baseline adaptation and vulnerability for the implementation of the project, FAO 2018).

According to the study cited above, it is considered that with the scenarios foreseen for the next 100 years, as a result of current climate trends, a deterioration in the overall environmental quality is to be expected, highlighting water resources, which will be one of the most severely affected, resulting in critical repercussions for other resources and sectors.

The territories where the project will be implemented (AIP) have faced during the last three years, the most intense and prolonged drought periods for the last 115 years, which has led, on the one hand, to the proliferation of diseases in people, and on the other, to a drop in productivity for crops and livestock production, including the death of thousands of heads of cattle.

Population vulnerable to drought amounts to a total of 237 014, comprising 79 005 vulnerable households (FAO, 2018).

Water scarcity affected more women (see Supplementary Material 8) for whom the access and storage of water for washing, cooking and cleaning, among other reproductive tasks, is one of their basic needs directly linked to the aim of improving the quality of life they have today.

According to the Cuban Second National Communication to the United Nations Framework Convention on CC (Álvarez, 2011), research carried out in 29 crops show that 65% of them are affected by diverse elements, hence the potential yield is below 50%; the net primary productivity will likely decline because the span of the phenological phases of crops will progressively be shortened. The agricultural areas will be reduced due to soil erosion and salinization, the volumes of available water will decrease in quantity and quality and the surface of the mangrove ecosystem will be affected, all of which will result in growing rural exodus towards urban areas (Álvarez and Mercadet, 2012).

4. Project Implementation Area (AIP)

The AIP comprises two well defined areas as shown in Fig 1; one in the north-central region of the country, considering two provinces and four municipalities: Los Arabos in the province of Matanzas and Santo Domingo, Corralillo and Quemado de Güines in the province of Villa Clara (Villa Clara - Los Arabos) with a extension of 281 586 ha. The second zone is located in the eastern region, encompassing three municipalities in the southern area of Las Tunas province: Jobabo, Colombia and Amancio Rodríguez (Las Tunas area), which altogether cover 229 876 ha. The total geographic area of the AIP is 511 462 ha.

The main economic activity in the seven municipalities of the AIP is based on agricultural and sugarcane production, in spite of very low yields as it happens in most of the country. Food production in this area is basically based on grains, meats, fruit and vegetables as well as milk and eggs.

The sugar industry has undergone a significant deterioration in the last two decades, resulting from the low yields of cane cultivation and the low prices of sugar in the world market. It is noteworthy that the municipality of Santo Domingo is the only site in Cuba where organic sugar is produced in limited quantities, which has a good demand in the international market.

The livestock sector is the main administrator of lands in the territory under different productive forms: state, cooperative and private, who altogether have around 154 800 ha., equivalent to 30% of the geographical area of the AIP (Table 1). It is comprised of natural pastures, mostly of very low productivity and a notorious absence of trees, which turns this important activity into one of the most vulnerable to climate change.

Additionally, that there is a significant area of land that is idle, mostly colonized by marabou, which turns it into highly unproductive; a relative situation in other areas of the country, which constitutes a concern at the highest level of the country's agenda.

It is estimated that by 2019, there are about 158,300 ha. covered by this invasive species in the AIP, which represents 30.9% of the total geographic area of the AIP (see Table 1 and Table 3).

Forest coverage as expressed through the Forestry Index (Ib) is only 11.7%, a value below the national average, which at the end of 2016 was 31.2% (Table 4).

Table 1: Area covered with natural pastures and declared idle lands in the municipalities of the Central region, year 2016.

Municipality	Total Area (km^2)	Natural Pastures (a)	Idle Land (b)	Total (a + b)	% Land within the municipalities		
		(km^2)			Natural Pastures (c)	Idle (d)	Total (c + d)
Central Region	2 815,86	953	608	1561	33,84	21,59	55,44
Los Arabos	757,61	276	176	452	36,43	23,23	59,66
Corralillo	839,89	296	189	484	35,24	22,50	57,63
Quemado de Güines	333,26	92	47	140	27,61	14,10	42,01
Santo Domingo	885,10	289	196	485	32,65	22,14	54,80

Source: Gonzáles R and Remond R. 2019, elaborated from the balance of land use, MINAG (2015).

Table 2: Area covered with natural pastures and declared idle lands in the municipalities of the Eastern region, year 2015

Municipality	Total Area (km^2)	Natural Pastures (a)	Idle Land (b)	Total (a + b)	% Land within the municipalities		
		(km^2)			Natural Pastures (c)	Idle (d)	Total (c + d)
Eastern Region	2 298,77	596	680	1 276	25,96	29,60	55,56
Colombia	561,33	117	98	215	20,85	17,60	38,45
Jobabo	888,48	281	300	581	31,71	33,77	65,48
Amancio	848,95	197	281	478	23,31	33,17	56,48

Source: Gonzáles R and Remond R. 2019, elaborated from the balance of land use, MINAG (2015).

Fig 1: Municipalities in the project implementation area

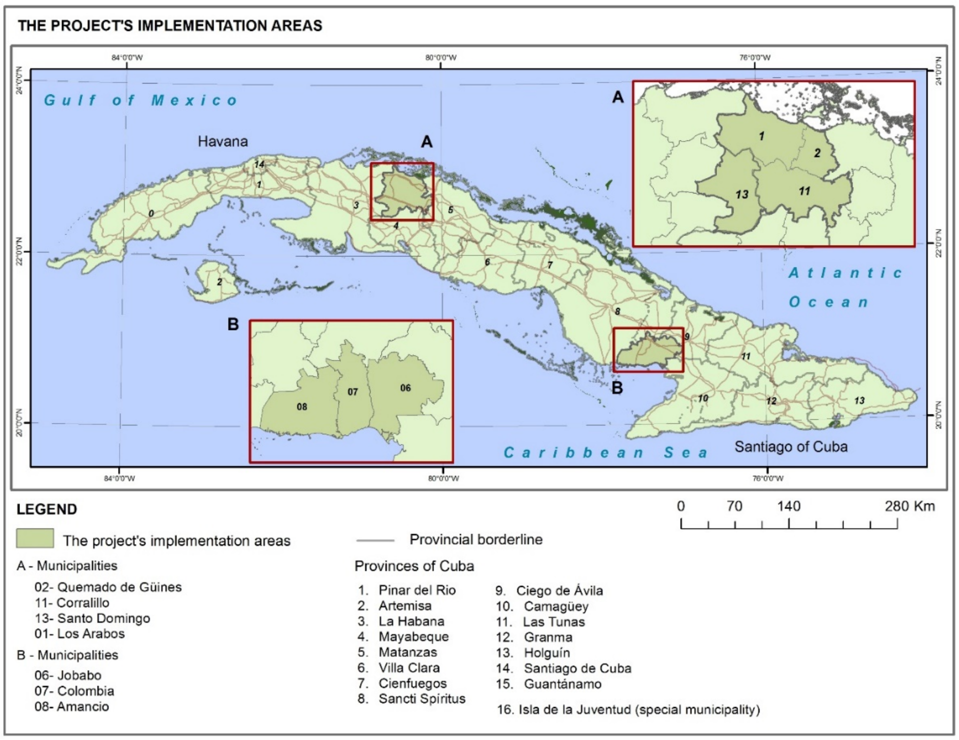


Table 4 shows that the Forest Index (Ib) is low all the municipalities, compared to the national average value. Municipalities with the lowest Ib are: Jobabo, Colombia, Santo Domingo and Los Arabos; so the project aims to increase this important indicator linked to the confrontation of CC impacts and the preservation and conservation of the environment.

The natural forests present in the AIP are broad-leaved formations, dominated by semi-deciduous forests (semi-deciduous) on limestone, acid and poorly drained soil, as well as mangroves and coastal manigua (coastal xerophytic forests).

Table 3: Marabou covered area in each municipality of the AIP - years 2015 and 2019.

MUNICIPALITY	Municipal Area (in km²)	Areas with Marabou, 2015 (%)	Areas with Marabou 2019 (%)
Central Region	2 815,86	10,07	40,40
Los Arabos	757,61	12,01	35,93
Santo Domingo	885,10	10,51	24,24
Quemado de Güines	333.26	0,63	5,49
Corralillo	839,89	10,60	31,50
Eastern Region	2 298,77	25,69	31,44
Jobabo	888,48	39,89	35,93
Colombia	561,33	13,40	24,24
Amancio	848,95	19,14	31,50
Total	5 114.63	17,09	71,9

Source: Gonzáles R and Remond R. 2019 based on the balance of use and land tenure of the MINAG (several years); images of the Sentinel 2ª satellite.

Planted forests represent a third of the total existing forests in the AIP, which demonstrates the great effort made in recovering the depleted forest heritage for hundreds of years. Among the species used, the autochthonous ones stand out, such as: *Pinus caribaea* (male pine), only in the area of Villa Clara - Matanzas, *Caesalpinea violácea (yarúa), Colubrina ferruginosa (bijáguara), Tabebuia angustata (white oak), Swetewnia macrophyla* (Honduras mahogany) and some exotic species such as *Eucaliptus* sp, *Khaya niásica* (African mahogany), *Acacia mangium* (acacia), *Albizia procera (carob tree from India) and Tectona grandis (teak),* among others.

In recent years, the annual proportion of forest plantations in the AIP has declined considerably, as shown in Fig 2; as a consequence of: a) the reduction of clean deforested areas without marabou, which do not require heavy equipment for their preparation, and b) the shortage of heavy machinery (bulldozers) to clear the areas to be reforested, which are mostly covered by marabou. This situation is similar for the rest of the municipalities in the AIP.

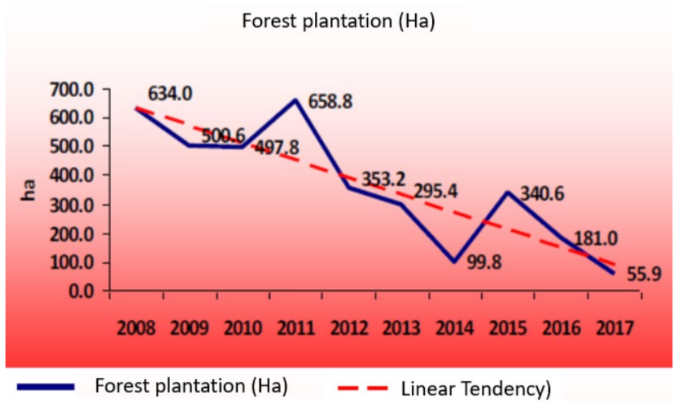
Despite this, an experience is taken as an example: It is the only Model Forest case existing in Cuba and whose potential forest area covers more than 20,000 ha., located between the Santo Domingo and Corralillo municipalities in the province of Villa Clara.

Table 4: Forest coverage in the municipalities that make up the AIP (2016)

Region	Province	Municipality	Geographical Area (ha)	Area covered by forests (ha)			Forestry Index (%)
				Natural Forests	Planted Forests	Total	
North-Central	Matanzas	Los Arabos	76,282	3,284	4,328	7,612	10.0
	Villa Clara	Santo Domingo	88,060	4,395	3,902	8,297	9.4
		Corralillo	83,730	8,847	6,906	15,753	18.8
		Quemado de Güines	33,282	6,613	1,322	7,935	23.8
Sub total			281,354	23,139	16,458	39,597	14.1
Eastern	Las Tunas	Jobabo	88,540	2,286	474	2,760	3.1
		Colombia	55,997	2,301	1,668	3,969	7.1
		Amancio	85,643	13,239	262	13,501	15.8
Sub total			230,180	17,826	2,404	20,230	8.8
Total AIP			511,534	40,965	18,862	59,827	11.7

Source: Forest Directorate, Wild Flora and Fauna, DFFFS (2016) – MINAG

Fig 2 Annual rate of plantations carried out in two municipalities of the AIP



Note: The Fig. correspond to the municipalities of Santo Domingo and Corralillo. Province Villa Clara. Taken from Vidal (2017).

5. General information on the natural and socioeconomic conditions of the AIP

5.1 Current socio-economic situation - Migration and rooting

Total population inhabiting the two geographical areas comprising the AIP is 240 117 people. According to the Statistical Yearbook of 2015, there were 132 046 working-age people in the AIP. The population that will be constituted as direct beneficiary of the project is 51 098 people, of which 23 550 are women, representing 46%.

Both territories have been classified as advanced-age, which is closely related to the low birth rate. Although the percentage values of aging may seem low (between 17% and 22% with respect to the total population), in terms of low birth rates, these territories face a vulnerable position concerning the deficit in labor force and/or agricultural workers aged to assume productive tasks with very few technologies.

From the process known as Energy Revolution, carried out throughout the country with the aim of seeking greater efficiency and savings in the use of energy carriers (mostly imported), the proportion of households that cook with firewood has decreased considerably in the province of Villa Clara (between 3 and 7%).

The housing fund of the AIP faces an unfavorable situation given that more than half of the houses are classified as below average or inadequate. Predominating housing typologies in rural areas are type III and IV, which according to their building materials, are the most vulnerable to natural disasters, especially hurricanes, strong winds and heavy rains.

In times of drought, more than 40,000 people are supplied with water through pipes; women are the most affected and have expressed feeling stressed due to the lack of water, since they carry the burden of household chores. This situation of extreme vulnerability will be one of the highest priorities addressed by the project, considering the foreseen fact that water resources will be one of the major impacts of climate change, strongly affecting all socioeconomic sectors.

The productive forms existing in the rural scenario of the AIP are multiple and diverse, such as: institutions and state entities belonging to the Ministry of Agriculture (MINAG) such as the Sugar Business Group of Cuba (AZCUBA) and the Agroforestry Business Group (GAF); as well as, cooperatives of the non-state sector, in all its modalities, Agricultural Production Cooperative, (CPA), Cooperative of Credit and Services (CCS) and Basic Unit of Cooperative Production (UBPC); and the state ones as the Base Business Units (UEB) at the municipal level. There are also small farmers not associated with cooperatives, with private lands and usufructuaries who have received land in accordance with Decree Laws 259 of 2007 and 300 of 2012, promoting the delivery of idle state lands to natural and legal persons.

In economic terms for the AIP, additional to agricultural activities; that is, livestock and various crops (primary sector), food production is based mainly on grains, meats, fruit, citrus, vegetables, milk and eggs; the industry (secondary sector), in the case of Las Tunas comprises 40% of the population while in Villa Clara it accounts for 12.6%; an economic activity that does not reach 10% of the population employed; it is complemented by other economic activities that also play a significant role in the occupation of the AIP population. As of the case of Villa Clara: commerce, hotels and restaurants (tertiary sector) with 14.3% of the population, while for Las Tunas 11.8% of the population is engaged in electricity, gas and water supply.

Being a socialist and planned economy country, the interrelation in Cuba between population and development, its conditioning factors and impacts, are all part of the policies that govern the economic and social model of the nation, as well as the sectoral actions it develops. There are policies for external and internal migration, attention to territorial and urban development, Territorial and Urban Planning plans, attention to precarious neighborhoods and urbanization, among others. (ECLAC-CELADE, 2014-2016, Technical Secretariat of the Regional Conference on Population and Development, ECLAC, 2018).

Based on the socioeconomic study carried out in 2018 for the AIP, and the documentary review and group interviews carried out in the territories, the topic of internal and external migration among the different variables show similar characteristics and behaviors in both regions.

External migration is significant, especially among young people who emigrate to the United States, with the perception that almost all urban population have at least one family member in this country. Regarding internal migration, people go to the tourist poles and to the municipal and provincial capitals. There is also a population movement from the most rural areas to the urban areas within each municipality.

Historically, certain economic, social, environmental and political attributes inherent to the areas involved have been considered factors of attraction and expulsion. (Elizaga, J and Macisco, J, 1975: 107, cited by ONEI, 2010). Undoubtedly, the beginning of the 90s and the appearance on stage of the so-called *Special Period*, set a change in the outstanding direction of the currents, which is summarized in the increase of immigration to Havana, capital of the republic.

Table 5, constructed from the information provided on the basis of continuous migration statistics, includes the indicators and international migration rates in Cuba and allows appreciating the significant difference in the intensity of emigration with respect to immigration, as well as the changes from the new legislation of 2012, and the participation of the territories in these events. This information records the situation for Cuba in general, Havana, and for the three provinces of the AIP in particular.

Between 2015 and 2016 the same negative migratory balance rate is retaken, but the numbers of immigration show a rate of more than 8 thousand on average for the 2013-2016 four-year period, which aids to compensate the effect of the emigrations. It is verified that the external migrations, especially the emigrations, show a very accentuated territorial differentiation, since the capital of the country, where 19 percent of the country's population resides, let off 45 percent of the emigrations within such four-year period.

The territory constitutes the scenario where, in a special way, the differences that local development processes assume and their respective impacts on the welfare of the population and access to basic services are expressed. The population-development-territory relationship has distinctive features about the processes of human mobility and implantation that become, in turn, a condition and consequence of the socioeconomic development process itself.

Table 5: Immigration rates, migration and balances of net external migration, 2013-2016

Cuba and provinces	Immigration Rates				Migration Rates				Total Net balance			
	Years											
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Cuba	0,45	0,93	0.48	1,22	0,16	0,76	2,68	2,75	0,30	0,17	-2,20	-1,53
Havana	1,26	2,41	1,21	2,44	0,43	3,14	5,91	5,63	0,83	-0,74	-4,70	-3,19
Matanzas	0,28	0,77	0,43	1,28	0,12	0,19	2,38	2,54	0,16	0,58	-1,95	-1,25
Villa Clara	0,32	0,70	0,31	1,13	0,13	0,24	2,74	2,95	0,19	0,46	-2,42	-1,83
Las Tunas	0,26	0,62	0,25	1,27	0,07	0,12	1,43	1,60	0,20	0,51	-1,18	-0,33

Source: Cuba: Report to the Third Meeting of the Regional Conference on Population and Development of Latin America and the Caribbean. Lima Peru, August 2018

5.2 Market and Marketing Circuit

5.2.1 Analysis of current demand and supply of forest products

The demand for forest products in Cuba is wide and unsatisfied. Products of forest origin are imported annually for a value exceeding 100 million dollars. Imports of sawn wood have reached around 30,000 m^3 in recent years, valuated in 8.3 million dollars.

According to the Development Program up to 2030 of the Agroforestry Group (GAF), by 2020 a demand of more than 400 000 m^3 of sawn timber is estimated, to cover only 40% according to the calculation of the annual allowable cut (CAP) conducted and under the principles of sustainable forest management.

On the other hand, the occurrence of intense hurricanes in the recent years, consequently impacting forest resources and the overall construction background, has prompted a markedly increased demand for wood while the CAP has declined.

Even though the demand for firewood and coal for domestic use has decreased considerably in recent years due to the positive results of the Energy Revolution, the demand for wood, not only sawn but also for direct use in construction and other activities, increases and it is not being fullfiled.

As for timber, several species are used in the country; One of the most sought-after is the cedar, for which there is high demand in Cuba, the Caribbean and Central America for its acknowledged properties, which make it irreplaceable for innumerable uses, such as in the chain of production of Cuban tobacco (one of the most important), in the furniture industry and fine woodwork in general.

Nonetheless, the supply of this wood has been noticeably diminished due to:

- The regulations for commercialization that as of the year 2010 have been instrumented in the region
- The attack of the Hypsipyla grandella to young plantations
- The diminishing timber stocks due to the indiscriminate felling of the natural populations of this species for many years.

Currently only covers between 35 and 45% of the demand of the tobacco industry so this sector has to spend between 2.4 and 3 million USD for the acquisition of sheets and interspersed abroad, while producing them in the country costs four times less along with better organoleptic quality.

The main organization that produces wood in all its forms and assortments is the GAF of the MINAG, which, according to our economic - social system, structures its annual production plans taking into account the demands of the main state entities and other sectors of the company but subject to the Annual Allowable Fee, (CAP) based on the Forest Management Project.

These productions are delivered directly to the entities through an act of purchase - sale; but the market and offer of different assortments of wood with commercial character to the population, is limited.

5.2.2 Analysis of the current demand and supply of agricultural products

The demand for agricultural products is conditional on the values reported by the indicators related to population growth, tourism growth and economic growth.

Consequently, the demand for agricultural products is concentrated in at least four sectors, involving different levels of participation:

The sector produces the monthly basic food basket demand of the population, an element of the food security chain; through the monthly distribution of products through the "Supply Book", which has an approximate price of 15 CUP per person and the products demanded are the following: agricultural products (rice, black beans), livestock products (fish) , chicken and meat, (only for pregnant women and children with disabilities); agro-industrial products (sausages, minced beef or chicken, poultry mortadella, white sugar, brown sugar and coffee).

The agricultural products not included in the list that makes up the distribution through the "Supply Book", are demanded by the population through the different marketplaces operating in Cuba (MAE State Agricultural Markets, Supply and Demand Markets, MOD , Self-employed workers, TPC-“Barrow Boys”. The main products are: food (sweet potato, taro, yucca/cassava, banana/plantain), fruits, milk, honey, eggs, meats.

The food industry, organized through the Business Group for the Food Industry (GEIA), concentrates around 70% of the production and transformation of the food industry. The GEIA is composed of 94 companies that have 767 productive establishments. It also covers 23 different activities of industrial food processing and the productive chain of the fishing sector. It is also present in companies and factories throughout the national territory.

The industries organized in the GEIA annually produce around one million 500 thousand tons of different products from the agricultural and fishing sector, the main ones being: meat, milk, fruit, coffee, and corn. The GEIA, points out that in all cases, the demand of the population is higher than the current production and the real capacities the industry has. Acknowledging the fact that the industry faces major problems, although they are not the only ones; that is, agricultural production is not sufficient in any of the assortments to ensure the demand of the population and other markets; the scarce diversity of products and formats to meet consumer demand.

In terms of the Tourism Sector, Cuba as a tourist destination reached on November 10, 2018, four million international visitors, which occured only four days after the date it reached the same number in the year 2017. This situation constitutes a demonstration of the confidence towards Cuba as tourist destination, due to its natural and cultural attributes, as well as for the preservation and beauty of its beaches.

This implies that the variety, stability and large volumes of products needed to meet the demands of the tourism sector must be met. Numerous products are essential and the one that stands out is food. The Frutas Selectas company is the main responsible for marketing agricultural products. Villa Clara’s Base Business Unit (UEB) sells around 150 products, including seasonal fruits (guava, mango, banana, carambola, medlar, passion fruit, etc.), vegetables, viands, honey and processed products (tomato paste, fruit pulp, jams and condiments). Chaining has been the best contribution that the province has made. Boosting Villa Clara along with various tourist destinations does not only have to do with agriculture or with the work of each of the suppliers, it also has to do with participation from the community and consolidating local development so that it can multiply later ». (Ministry of Tourism, MINTUR, 2018).

In relation to the response to the demand of agricultural products of the sectors indicated above, necessary for economic and social development in Cuba; the Cuban agricultural sector faces a series of limitations to be able to offer in a systematic way the quantity, quality and periodically the products demanded. The limitations in the supply, forces those responsible for the management of the sectors to be supplied by means of importation of such agricultural products; raising their cost.

The production of food in the AIP is concentrated in grains, meats, fruit, citrus, honey, milk, and eggs; all of them complemented with the development of the program of urban and sub urban agriculture (AUSU) dedicated mainly to the cultivation of vegetables and legumes; representing 12% of the country's production areas.

When it comes to the access and availability of food, it is recognized that in this Zone you see what is produced, although also in other provinces some products for the basic basket. Livestock production in the private sector stands out. As in the whole country these foods are available in state markets and non-state sites or squares, highlighting the proliferation of the so-called "carretilleros" (informal street vendor of Agricultural Products).

Cuba has approximately 11 million hectares of available land; of them, about 6 million dedicated mainly to various crops and livestock. In addition, another 3.5 million to forest development. 80 percent of the land is owned by the State. However, 70 percent manages and produces through cooperatives and farmers.

As to the main recipients of the sector, they are focused on “producing food for the people, supplying industry and tourism, replacing exports and generating exportable funds that serve as a financial source for development”. In the field, there are about 30 companies organized in 10 groups with the main responsibility of producing the land they have and implementing development programs. (MINAG, 2018).

5.3 Edaphoclimatic characteristics

The climate of the AIP is classified as Tropical Semi-Humid of Savannah with two fundamental periods of rain in the year: little rainy (November-April) and heavy rain (May-October).

The climatic conditions of the Cuban archipelago are determined by its geographical position in the northern hemisphere. Cuba receives high levels of solar radiation throughout the year, which conditions the warm character of its climate; in turn, the proximity to the Tropic of Cancer presupposes the seasonal influence of organisms of both the tropical and extra tropical atmospheric circulation.

When analyzing the historical records of annual variations of maximum and minimum temperatures, the rate of decrease of rainfall and the predominance of long periods of drought, it can be said that the climate in these regions at present, is drier and hotter that several decades ago, resulting in noticeable negative impacts on the vegetative cycle of crops and agriculture where rained agricultural production predominates; in the thermal comfort of livestock, in the systems of supply to the population and in the occurrence of fires forest, more frequent and intense.

According to the reference scenarios for 2050 and 2100, a progressive increase in the degree of aridity of the soil and an evolution towards drier life zones of the forests of the region are estimated. This evolution is caused by a sustained increase in temperatures and potential evapotranspiration, in combination with the progressive decrease in rainfall.

Meanwhile the climate and the zones of life become increasingly dry, the episodes of drought will increase considerably, as well as the frequency of years with moderate and severe droughts. Both the evolution of aridity and the frequency of droughts will make the occurrence of forest fires more frequent and intense, which will increase the vulnerability of forests to these disasters.

The occurrence of eight intense hurricanes from 2001 to 2016 constitutes one of the most dangerous variations observed in Cuba's climate in recent years, as reported in Cuba's Second National Communication (SCN) to the United Nations Framework Convention on CC (UNFCCC) (Álvarez, 2011).

Erosion is not an aspect of much relevance in the AIP, taking into account that the non-eroded soils occupy a little more than 50% and the highly eroded ones do not reach 1%. However, in terms of the levels of agro productivity in these areas, the situation is completely different. Around 54% of the soil classify as poor or medium productive and only 9% classify as very productive, a situation that indicates the need and importance of implementing systems of good practices in these areas that make it possible to improve the yields of the different agro ecosystems present.

The types of soil that predominate within the AIP are detailed below in Table 6. The Yellowish Ferralitics occupy a quarter and are followed by brownish and Reddish Fersialitics.

6. Technical Considerations

Increasing the resilience of homes, communities and ecosystems is an objective that can only be achieved by reducing social, economic and environmental vulnerabilities; in this sense, implementing sustainable systems in agricultural and forestry activities constitutes a substantial contribution to these purposes and is a key objective. Under the principles of Adaptation based on Ecosystems (EbA), the technical feasibility of resilient agroforestry production systems is supported; which include the combination of agricultural, livestock and forestry activities; with adaptation and mitigation measures for the impact of climate change, which will be established in the AIP.

Table 6: Main Types of Soil

Type of Soil	Total AIP		Central Region		Eastern Region	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Yellow Ferralitic	124,587	25	83,155	31	41,432	18
Brown with Carbonate	81,870	17	58,989	22	22,881	10
Fersialitic reddish brown	56,151	11	8,391	3	47,760	21
Dark Plastic Gleyed	40,446	8	13,667	5	26,779	12
Gley Ferralitic	35,400	7	12,649	5	22,751	10
Brown without Carbonate	31,408	6	2,479	1	28,929	13
Humic carbonate	21,040	4	21,040	8	0	0
Ferralitic Quartziferous, yellowish reddish Lixiv	19,461	4	19,461	7	0	0
Swampy	14,326	3	72	0	14,254	6
Sub total	424,689	86	219,903	83	204,786	89
Other types of soil	71,096	14	46,461	17	24,635	11
Total	495,785	100	266,364	100	229,421	100

Source: Baseline study of adaptation and vulnerability for the implementation of the project. IRES - FAO (2018).

The AIP can become ideal spaces for the application of various forms of agroforestry management systems and integral technologies that require these management systems, to steadily produce food and other products necessary for the life of humans in harmony with the natural resources of water, soils and forests; as well as reducing the risk to environmental vulnerability due to the exposure of fragile ecosystems.

The Integrated Forest Farms[1] (FFI), which add up to around 1 500 in the country, is a modality of management of the forest resources that has been created fundamentally within the system of the MINAG and of the AZCUBA Sugar Group, with the objective of managing forest resources and protecting them against forest fires; they are also a guarantee to avoid illicit actions within the forest estate. It is a modality to keep in mind in the implementation of the current project.

The Decree Law-300 of 2012 "On the delivery of idle state lands in usufruct, a legal instrument that encourages agroforestry development in all its modalities stating that: "delivery of idle state lands is authorized in the form of free usufruct and for a determined period of time, to legal or natural persons, so that they can rationally and sustainably exploit them according to the capacity of the soils, depending on the agricultural, forestry and fruit production. A forestry and fruit production can be mixed in different crops as well as animal husbandry, as appropriate and feasible, and in accordance with established regulations".

This Decree-Law, in relation to its predecessor, Decree-Law 259 of 2007, incorporates new issues, among which can be mentioned the delivery of land for forest use, the obligation to protect water sources, and as established in Article 6: "the delivery of the lands that make up the forest belts of the dams and rivers is prohibited, except when they are delivered for reforestation."

The supplementation of trees in agricultural and livestock production systems must be preceded by a rigorous selection of agricultural, forestry and fruit species based on their adaptation properties to CC and the main characteristics of the soils that make up the agricultural scenario of these regions in which agro-productive categories III and IV predominate.

In the design of the modules, care has been taken that the crop, grass and legume species for livestock and forestry activities are resistant to drought. In relation to the latter, the reasons taken into account for the selection, according to criteria of experts from the Institute of Agroforestry Research (INAF), GAF and the Forest, Wildlife and Wildlife Directorate (DFFFS), were:

- That naturally belongs to the forest formation of "semi-deciduous forests on limestone soil" in which there are skeletal soils with very poor moisture retention

- Having a pivoting and deep root system

- Having resisted the events of drought that have occurred in the country for the last ten years

6.1 Influence of different vegetation cover on the operation of river basins

According to FAO (2009), the protection of watersheds is one of the most important environmental services provided by forests, a criterion that Kalenda and Rield (1966) support when expressing that: "the knowledge that the forest has a favorable influence on the water economy is in general, from day to day more recognized and studied experimentally ".

Bearing in mind that in Cuba, water resources are scarce and have a deficient temporal and spatial distribution according to Renda et al. (2012), the statement of Bergkamp et al. (2003) is of great importance when it concluded: "before the CC, the relationship between forests and water is a critical issue that should be given priority attention".

[1] The Integral Forest Farms: they constitute a coherent answer to the solution of diverse global environmental problems. It is recognized worldwide that deforestation, soil erosion, loss of biodiversity, desertification, water pollution, and other environmental deterioration substantially threaten the food security of the rural population and, above all, the sustainability of the agrarian scenario of the watersheds. IDEASS Cuba, Innovation for Development and South-South Cooperation. *www.ideassonline.org*

Research carried out in Cuba at the Experimental Hydrological - Forest Station "Amistad" in the province of Pinar del Río, as well as in studies carried out in 81 nonpermanent plots to which artificial rain was applied, have shown that the coefficient of surface runoff in soil variations in different edaphoclimatic and physical-geographical conditions (see Supplementary material 1) is on average 3.4, 4.2 and 6.2 times lower than in permanent agricultural crops (fruit trees), pastures and temporary agricultural crops, respectively. In the latter case, it can reach 1:90 (Herrero, 1993).

According to Ortega (1979): "in the forest tapestry favors the infiltration; in the tropics, forest soils can receive up to 250 t / ha annually of organic remains and remain as a mulch on the A01 horizon, up to 10 t / ha."

This assertion is reinforced by the fact that subsurface and underground runoff in the forests, moves at a very slow speed, at a rate of 8 m / day and it takes time to reach the riverbed or stream, between 18 and 37 days according to the existing length between the water part and the channel that in Cuba oscillates between 150 and 300 meters. On the other hand, if the soil is being used for crops or pastures, the delay is shorter (between 6 and 14 days). This means that the forest vegetation lengthens the hydrological cycle in its terrestrial phase and therefore there is greater availability of water in the period of drought (Mora and Melchanov, 1995).

By favoring the infiltration potential of rainwater, as is common in all proposed modules, there will be a positive impact not only on the improvement of the farm's own soils and greater water availability, but also affect in the lower sector of the basin, which is the most vulnerable area. This increase of the infiltration could contribute to the first attention and to the retrogression afterwards, of the wedge of saltwater intrusion.

The root system of the trees that make up the module plays a relevant role in this phenomenon. According to Sagué (1978) and Lastres (1987): "the deep, branched and dense root system of trees which can weigh 23 t / ha and where up to 1715 roots can be found per linear meter in the first 50 cm deep, allows the transfer of considerable volumes of water to the lower horizons ".

The establishment of hydro regulatory forest strips on the vicinity of fresh water sources, where gallery forests do not exist, is a consubstantial action in the management of each of the modules since Law 85 of 1998, Forestry Law defines them as "areas of obligatory reforestation ". These forests ensure that water from the areas cultivated or dedicated to livestock is retained and purified before reaching the river or the dam.

On the other hand, live fences, green belts and other green infrastructure modalities inherent to the agroforestry systems, constitute techniques that protect crops and facilities against strong winds and hurricanes and reduce the evapotranspiration rates in pastures and agricultural crops with the consequent benefits.

6.2 Production of vegetative material of forest, fruit and agricultural species

The supplementation of trees in agricultural and livestock production systems must be preceded by a rigorous selection and production of forest and fruit species based on their adaptation properties to the CC and the main characteristics of the soils that make up the agricultural scenario of these regions. In which agro-productive categories III and IV predominate.

In the design of the modules, care has been taken that the crop, grass and legume species for livestock and forestry activities are resistant to drought. In relation to the latter, the reasons taken into account for the selection, according to criteria of experts from the Institute of Agroforestry Research (INAF), GAF and the Forest - Wildlife and Wildlife Directorate (DFFFS), were:

- That naturally belongs to the forest formation of "semi-deciduous forests on limestone soil" in which there are skeletal soils with very poor moisture retention.
- They have a pivoting and deep root system.
- That they have resisted the drought events that have occurred in the country for the last ten years.

In order to guarantee the quality, quantity required and delivery according to the established schedule; the production and reproduction of the vegetative material, will be through the Business Base Units, UEB, located in municipalities of the AIP, companies specialized in the production of goods and support service to the forestry sector, members of the Agroforestry Group GAF); with whom the productive forms (UBPC, CPA or CCS) will establish a contract for the provision of seedlings; that allow the delivery of the material, reducing the risk factors.

Through the support of the specialized institutions participating in the implementation of the project, the technical and economic conditions for the production and delivery of the recommended vegetative material in the agroforestry production systems resilient to CC will be established between the parties (Nurseries and Cooperatives).

Table 7 shows the detail of the Base Business Units, UEB, responsible for the administration and management of the production centers, and commercialization of the vegetative material (Nurseries) that will be used in the modules to be implemented; which are organizations subordinated to forestry companies (EAF), supported by the Ministry of Agriculture, MINAG.

Table 7: Business Base Units, UEB, by municipality in the project intervention areas

Province	Municipality	Entity to which it belongs	Subordinate Entity	Expected Production Capacity (Unidat / Year)
Central Region				**3,750,000**
Matanzas	Los Arabos	UEB Agroforestry	Matanzas Agroforestry Company	1,000,000
Villa Clara	Santo Domingo	UEB Agroforestry	Villa Clara Agroforestry Company	1,000,000
	Quemado de Güines	UEB Agroforestry		750,000
	Corralillo	UEB Agroforestry		1,000,000
Eastern Region				**2,500,000**
Las Tunas	Jobabo	UEB Agroforestry	Las Tunas Agroforestry Company	500,000
	Colombia	UEB Agroforestry		1,000,000
	Amancio	UEB Agroforestry		1,000,000
Total				**6,250,000**

Source: Directorate of Forests, Wildlife and Wildlife (DFFFS) –MINAG

6.3 Agricultural Mechanization

Mechanization covers all levels of agricultural production and process technologies, from simple hand tools to the most sophisticated motorized equipment.

Mechanization facilitates and reduces heavy work; It relieves the lack of labor, improves productivity and timeliness of agricultural operations, while improving the efficient use of resources, strengthens access to markets and contributes to the mitigation of threats derived from climate. Sustainable mechanization considers aspects of the technological, social, environmental and cultural fields to contribute to the sustainable development of the agricultural and food sectors.

Sustainable mechanization is that type of mechanization that assummes the principles of conservation agriculture and the “save to grow” paradigm, in which, FAO proposed a new paradigm of intensive agricultural production, which is both productive and profitable for farmers and is also environmentally sustainable (FAO 2011).

As the effects of climate change and depletion of natural resources become more visible, large-scale adoption of conservation agriculture practices will be essential, such as practices that protect the soil, conserve water, use less energy and use inputs more efficiently and accurately, with the goal of maintaining and substantially improving food production and distribution.

Farmers who have access to improved agricultural tools and mechanized technologies can shift from subsistence agriculture to a climate-resilient and sustainable market agriculture, making the agricultural sector more attractive to rural youth. Sustainable mechanization supports the development of food supply chains through improved agricultural practices to increase production and improve food security.

Sustainable mechanization is used for tillage, sowing and timely planting assistance, weed control, integrated pest management, precise application of fertilizers, harvesting, storage preparation and operations to add value along the food chain in terms of processing on the farm, transport or marketing.

The analysis of what agricultural mechanization is, has to take into account not only the technical, economic and engineering aspects, but also the connections and interdependencies with other sectors and their role in the production chain of agricultural tools and machinery. The need to increase agricultural production overcoming today's environmental and social challenges is not achieved through isolated actions, but with a holistic vision of agriculture.

It is a part of a very complex set of interactions between the many parties concerned, ranging from large scale (such as governments or large manufacturers), to small scale, such as small farmers and service providers. The nature and interests of these parties is also varied (E.g. business, non-profit, government, etc.). (FAO, Sustainable Agricultural Mechanization)[2].

6.3.1 Situation of agricultural mechanization in Cuba, 2016

Among the actions taken in terms of agricultural mechanization, since 1990 in Cuba, keeping an indispensable number of tractors active by repairing and recovering obsolete equipment, saving fuel, increasing animal traction as complementary energy source, organizational work for a better use of machinery, and credit management and collaboration agreements for the introduction of a number of tractors and implements, among others. (Suarez & Ríos, 2017). However (cited in Ríos, 2016 a and b), in spite of this, the situation of the farm fleet of agricultural machinery is far from satisfactory, so strategies were designed for each of the units served by the Ministry of Agriculture, among such, agricultural mechanization, in correspondence with the guidelines and other management documents, as well as the development perspectives.

The most important aspects considered in the evaluation made in 2016 (Suarez & Ríos, 2017) were: the number of tractors by stages, ownership, density per unit area and their comparison with other countries, age of equipment, technical status, ranges of power in different activities, problems of repair and

[2] http://www.fao.org/sustainable-agricultural-mechanization/overview/es/

maintenance, availability of spare parts, technical services of machinery provided to agricultural producers, use of animal traction and legal regulatory aspects on the subject.

Among the main elements that allow us to have an idea of the situation of agricultural mechanization in Cuba today, there are:

a) Number of tractors: In 1998, the year in which the registration of self-propelled tractors and combines was made, there were 105 thousand tractors. This number decreased in subsequent years as a result of the "Special Period". By 2016, the country had 63,433 tractors; of them, 32,404 (51%) belong to legal persons and 31,029 (49%) to natural persons.

b) Obsolescence. The lack of foreign exchange has influenced the little renovation of the machinery fleet. More than 60% of tractors and other agricultural machines exceed 30 years of exploitation. This is even more acute in the non-state sector, since 80% of its tractors are obsolete. (cited in Ríos, 2017).

c) Working capacity. The fleet of tractors and implements; as well as other agricultural equipment has a high level of deterioration; 21% of the tractors on tires and 35% of the ones on mats are not suitable for agricultural work, mainly due to breakage or lack of fundamental parts such as batteries, tires, hydraulic system, lights, etc. Some of these tractors are only used for auxiliary internal transport work. Of the total fleet of self-propelled tractors and combines, 13% are completely inactive, of such 18% belonging to legal persons and 7% to natural persons.

d) Mechanization services: The provision of agricultural mechanization, technical assistance, maintenance and repair services to producers is very insufficient due to lack of equipment and infrastructure for this activity. Although the Mechanization Services Units have been created, managed and operated by the UEB, with a wide range of services to be provided. Only mechanized services (especially land preparation) constitute their main activity and source of income. This is mainly due to the limited availability of machinery, so the provision of services in the rest of the activities for which they were created is not met, or only in exceptional cases. (cited in Fernández and Shkiliova, 2006; Suárez et al., 2011; Fernández et al., 2013).

e) Animal traction. Animals (oxen, horse and mules) are widely used as energy sources, but the necessary quantity is not available and the number of implements, carts and other attachments is deficient.

It is important to highlight that the diagnosis made in 2016 reflects the use of agricultural implements that do not respond to soil conservation measures, examples are the use of plows and disc harrows, which cause high soil compaction.

6.3.2 The Agricultural Mechanization Policy in Cuba

In updating the guidelines of the economic and social policy of the Party and the Revolution, for the period 2016-2021; guideline No. 161, which is to be implemented by the Ministry of Agriculture, establishes "Continue the reorganization and development of irrigation, drainage, water supply to animals and agricultural machinery services, with the objective of achieving a rational use of water, hydraulic infrastructure and agricultural equipment, contributing to increased productivity and saving labor power, combining the use of animal traction with advanced technologies. Guarantee maintenance and repair services "; directly linked to other guidelines and complies with the Specific State Function No. 10, which is responsible for: "Promoting the development of mechanization, irrigation and agricultural drainage systems, validating the introduction of new technologies and its efficient use, and establish regulations for its technical assistance "(cited by Ríos, 2015).

Based on the results of the diagnosis and taking into account the national policies, plans and guidelines for the development of this activity, the following policies were developed regarding motorized energy sources and other mechanization means for agriculture (Suarez & Ríos , 2017).

a) Tractor replacement. Overcome the shortage of agricultural machines and pieces of equipment in order to achieve greater use of the tractor fleet. Execute replacement plans, not based on the growth of number of equipment, but on its quality, and guaranteeing an adequate proportion of low, medium and high-power tractors. Guarantee the standardization of brands and models in newly acquired equipment, to avoid diversity of brands, which then hinders the supply of spare parts. Guarantee the Agricultural Engineering Research Institute, IAgric of the MINAG validation for all new mechanization technologies, both of national and imported production, prior to their generalization in production or services.

b) Rehabilitation and modernization: Execute, from the different agricultural development programs, rehabilitation and modernization plans for tractors, machines, agricultural implements and harvesters in order to reach a technical availability of 85% in all types of equipment. Rehabilitation of at least 500 tractors will be required per year.

c) Organization of use: Concentrate medium and high-power tractors, self-propelled harvesters and other agricultural machines in the state units providing services to the productive base and a part of the low power tractors in the most efficient smallholder and producing units. Improve technical conditions, availability of spare parts and components, condition of machine tools and facilities of repair and maintenance workshops. Facilitate the access of the productive base through the wholesale market, for the purchase of parts, pieces and accessories with the purpose of recovering the agricultural machinery, ensuring compliance with the maintenance policy. In machinery, purchase contracts include 15% of the investment for the initial acquisition of spare parts, pieces and aggregates.

d) Mechanization services: Expand and improve mechanization services and technical assistance to mechanization, irrigation, agricultural drainage and water supply equipment in business units and cooperatives, providing them with the necessary equipment.

e) Animal traction: Use animal traction under conditions whose employment is economically justified, guaranteeing the availability of animals and conditions for their use; promote the national production of implements and accessories for this activity. Ensure the supply of oxen, horses and mules, properly trained to meet the needs.

f) Training and working conditions of personnel: Increase training and recruitment of personnel for the tasks related to mechanization, repair, maintenance and technical services activities, as well as achieve adequate working conditions of the personnel associated with these activities.

The implementation of the proposed policies, established for compliance since 2017, that each policy is specified, the actions related to it, dates or periods of execution, responsible and participants. In some tasks, the compliance date is not specified, since they are permanently carried out and verified as of the beginning of implementation. (Suarez & Ríos, 2017).

6.3.3 Agricultural mechanization in the implementation of sustainable agroforestry modules

In the context of the Agricultural Mechanization Policy in Cuba, the government has considered all different stages included in the IRES Project: from the design, implementation and replication of the activities; that is, adaptation and rehabilitation of land, soil preparation, establishment, maintenance (cultural work), harvesting and transportation of products generated by the agroforestry and silvopastoral systems; the conservationist approach is guaranteed, with criteria of water and soil resources management; as well as the social and economic aspects; therefore, in Table 8, the agricultural and forestry mechanization is presented in a summary way according to the phase, activity, equipment, implements and mechanized work; applied in the modules proposed by the project.

It is important to note that the project considers the recovery and rehabilitation of 15,544 hectares of Marabou, for which two mechanized tasks will be carried out, due to the high level of infestation. The first work to be done is clearing by removing the marabou using the BMH 480 brushcutter; activity that is complemented with the crushing and incorporation of marabou material using the Rotavator RT 400; work that allows the enlistment of the soil for the development of agroforestry activities.

This financing proposal includes aspects that justify the request for financial resources; likewise, the co-financing funds of the Government of Cuba are quantified, to ensure the implementation of the mechanized activities within the six modules designed.

An element to highlight is the incorporation of activities and the use of implements for the development of a conservation agricultural approach combined with sustainable mechanization; elements that are based on the experiences developed and the institutional commitment for the research and from the leadership and other personnel involved in the agricultural mechanization in Cuba; which is aimed to be expanded and replicated in other regions of the country.

The proposal for the mechanization of the activities to be developed in the implementation of sustainable agroforestry systems, includes the acquisition of agricultural machinery of different power ranges and equipment (implements), for the restoration of lands invaded by Marabou; low impact technology in soil preparation, application of cultural practices that allow the development of agroforestry systems and harvesting. Based on the design of the agroforestry modules, the necessary implements to combine with the machinery have been established; considering the minimum tillage with benefits for the soil, humanize work and increase productivity; a combination that contributes to the reduction of carbon to atmosphere.

In Table 8, the equipment and implements to be used are summarized; and the implements related with conservation agriculture are as well included.

Table 8: *Use of agricultural machinery in the implementation and development of agroforestry modules. (Source: Technical file by module. IRES_Cuba)*

Phase	Activity	Task	Objective	Equipment	Tools	Modules					
						1	2	3	4	5	6
ADAPTATION OF LAND	**Land Clean-up Operation**	**Clearing**	Clean and recover potentially productive land invaded by Marabou; using mechanical methods.	Biomass harvester (Marabou) BMH - 480	n/a						
		Crashing and incorporation of stubble	Incorporate organic matter into the soil, through the removal and chopping of marabou remains.	220 hp tractor	Rotavator TR - 400						
		Transportation of removed waste	Remove material that is not incorporated into the ground because of its texture and size.	90 hp tractor	14t. trailer						
	Land Preparation	**Subsoiled**	Oxygenate the soil while allowing better water circulation into the deep layers of the land.	120 hp tractor	Subsoiler -3 bodies						
		Broken	Develop different forms of tillage to improve water storage and soil airing-out.	120 hp tractor	Multiple plow						
		Preparation	Sponge and air the soil; as well as preparation of the planting bed.	90 hp tractor	Cultivator						

Source: IAgric-MINAG, Cuba 2019

Table 8 (Continuation): *Use of agricultural machinery in the implementation and development of agroforestry modules. (Source: Technical file by module. IRES_Cuba)*

Phase	Activity	Task	Objective	Equipment	Tools	Modules 1	2	3	4	5	6
SETTING	**Plantation**	**Plough**	Draw parallel grooves within a batch spaced at the same distance where the seed or vegetative material is sown.	90 hp tractor	Ridger/Furrow opener – 3 bodies						
		Drilling	Opening of cylindrical holes, intended for planting trees and posts.	90 hp tractor	Drilling machine						
				n/a	Manual Drilling Machine - gas motor						
		Transfer of supplies and materials	Transport the supplies and materials necessary for the establishment of the modules to the growing area.	90 hp tractor	7t. trailer						
MAINTENANCE	**Development of cultural chores**	**Construction and maintenance of fire trails**	Protection against forest fires through the control and management of vegetation that could cause the spread of fire	120 hp tractor	Rotovator Multiplow 6 in 1						
		Sowing, fertilization, control of pests and weeds.	Perform mechanized or manual planting, fertilization, pest control; weed control; Humanizing work and increasing productivity.	90 hp tractor	Seeder, Sprinkler, Fertilizer						
				Seeder - fertilizer, sprinkler, manual brush-cutter							
		Thinning and pruning	Tree formation and mechanical sanitary control.	Chainsaw for thinning and pruning							
HARVEST MANAGEMENT	**Recall**	**Harvest**	Collection of grains, food and fruits, Non-Wood Forest Products (M2)	n / a	n/a						
		Felling	Definitive logging of forest species	Chainsaw with extension	n/a						
	Transportation of agricultural crops	**Transportation**	Facilitate the availability of inputs in the production areas and the collection of agricultural and livestock products.	120 hp tractor	Trailer						

6.3.4 Operational mechanism for the administration and uses of agricultural machinery and equipment

The equipment included in the proposal to implement agricultural mechanization in the project are: agricultural machinery (wheel tractors of different powers, brush cutter and belt excavator); conventional implements to be integrated into tractors; parts to couple low power tractors and hand tools in order to perform conservation agriculture work.

The machinery and the respective tools to be acquired will be distributed between two of the participating stakeholders of the project; in such a way that it allows to expand and improve the mechanization and technical assistance services, use of the machinery according to the power required for the development of mechanized work and guarantee maintenance and repair activities.

The stakeholders involved in the implementation of agricultural mechanization have been selected considering the experience developed in Cuba; hence, the two key stakeholders in the implementation process are identified.

The productive forms considered in the project are: Credit and Services Cooperatives, CCS, Agricultural Production Cooperatives, CPA, Basic Units of Cooperative Production, UBPC and State Farms; directly responsible for the implementation of agroforestry and silvopastoral production systems.

The Integral Base Business Units of Technical Services (UEBIST), specialized units; whose role will be the provision of machinery, maintenance and repair services to agricultural machinery, irrigation and transport equipment; who operate throughout the different municipalities, including those included in the project.

The Agricultural Engineering Research Institute, IAgric. An institution of MINAG, is an organization that has participated in the process of formulating the proposal and will be responsible for providing advice for the harmonious implementation of mechanization technologies, based on the sustainable use of natural resources, to contribute to the food security of the country.

The operational mechanism for the implementation of agricultural mechanization in the project includes the following activities:

- Assignment and distribution of goods acquired between the two key stakeholders, UEBIST and Productive Forms. The assignment will respond to the role of each in the execution of the activities for the implementation of mechanization.

- Agricultural machinery and conventional implements will become assets for the agricultural work, including: wheel tractors of different powers, brush-cutter and belt excavator are included. Such implements will be assigned, managed and operated by the Integral Base Business Units of Technical Services, UEBIST. In the project area, seven UEBISTs have been identified, one for each municipality.

- These UEBISTs, in addition to the activities indicated, will be responsible for providing machinery services to the Productive Forms included in the project; for this, a service contract will be established between the parties. Details related to this activity are described in the following section.

- Equipment and implements acquired to impulse and enhance conservation agriculture; this includes manual implements, minor equipment operated by fuel (chainsaws, manual operation equipment) and those that are coupled to low-power tractors (40-45 hp). These assets will be assigned, managed and operated by the Productive Forms benefiting from the project.

- These Productive Forms will be assigned as a loan, all goods received for administration, according to the demand established in the planning of the production systems developed by each of the producers organized in the Productive Form.

Additionally, the project will provide a tool kit necessary for the development of complementary activities in the installation of the modules; which will be administered by the Productive Forms. These tool kits will be delivered as a loan to the producers, according to the planning of crops and activities. Technical assistance services and training for mechanization.

These activities will be carried out by the MINAG IAgric, in order to strengthen and guarantee the execution of the agricultural mechanization and sustainability approach and replicate the expected results related to conservation agriculture and sustainable development in the project. Section 10 of this document amplifies the information related to UEBIST as a strategic aspect in the implementation of the project and the strengthening of the value chain approach.

The list of machinery and implementations assigned to UEBIST is detailed in the following tables; as well as the equipment and implements assigned to the Productive Forms.

Table 9: Machinery assigned to the Integral Base Business Units of Technical Services, UEBIST

Equipment	Quantity
Brush cutter BMH 480	4
120 hp rim/tire tractor	14
90 hp rim/tire tractor	14
45 hp rim/tire tractor	7
Hydraulic band excavator	4

Source: IAgric.-MINAG, Cuba 2019.

Table 10: Implements assigned to the Integral Base Business Units of Technical Services, UEBIST

Implements	Labor	Quantity
Rotovator RT 400	Crushing	2
Subsoiler - 3 bodies	Subsoil	8
Multiplow	Turn over	7
Cultivator	Preparation	6
Ridger - 3 bodies	Plowing	8
14 ton. Tribasculante trailer	Assorted Transport	13
7 ton. Trailer	Assorted Transport	9
Drilling Machine	Drilling / Hole Digging	7
Coarse grains precision sowing machine / 4 rows	Planting	6
Multiplow 6 in 1	Various Tasks	8
800 L Sprinkler	Application	7
Electrical Forage Chopper	Chop forage	5
Silo harvester	Chop and harvest	5
Hay baler	Collect and pack	5
Windrower	Collect and form cord	5
Grass mower	Mow grass	5

Source: IAgric.-MINAG, Cuba 2019.

Table 11: Equipment assigned to the Productive Forms

Equipment	Labor	Quantity
Manual tillage equipment	Land preparation, cultural work and harvest.	100
Manual crusher with set of cutting discs		300
Manual grain seeder		300
Manual borer - gasoline engine		400
Manual granular fertilizer applicator		300
Backpack sprayer with 20-25-liter gasoline engine		150
20-25-liter backpack sprinkler		150
Manual Brush cutter		200
Chainsaw for thinning, pruning and felling		400
Battery telescopic chainsaw		300
Electric fence systems	Amplify milk production and commercialization leche	3371
Mechanical milking equipment		20
Milk tank with a capacity of 1000 liters		20

Source: IAgric.-MINAG, Cuba 2019

Technical description of the machinery and equipment to be purchased is found in supplementary material 2.6.5.

6.4 Water resources in the AIP

Taking the "Adaptation and vulnerability baseline study for project implementation", FAO, 2018 as a reference; this document records the situation of adaptation and vulnerability to Climate Change for the AIP, integrating the exposure, sensitivity, adaptive capacity of the population according to the impacts of climate change on their environment for their homes and productive units. The context of Climate Change in Cuba is taken as a starting point, emphasizing the variables of water resources, coastal areas, forests, agriculture, human settlements and land use and impact on the yields of selected agricultural productions.

In relation to water resources, the hydrological study carried out in the reservoirs in the area, for 34 years period, found that only in 8 of these, the filling volumes have behaved close to the nominal ones, the other years have displayed below 50% filling, evidencing that the rain parameters for which these dams have been designed have had a decreasing trend, not to forget that the only source of water in the country comes from rainfall. In this area, there is also a tendency to an increase in the average values of positive anomalies, particularly in the period 1980-2007, with a reduction in the variation of the average precipitation values.

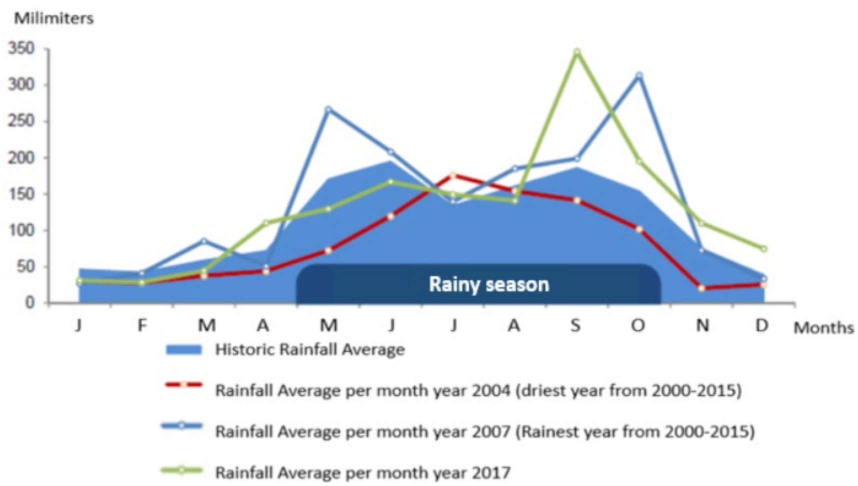
The spatial zoning of the current uses in the areas in process and / or prone to the phenomena of desertification, degradation and salinization in the AIP shows that the Central area has more cultivated area (cane and various crops) and natural pastures in the very exposed category; while in the Eastern zone, the most exposed land use are those occupied by forestry and idle lands. There is therefore a significant difference between the Central and Eastern zones in relation to current land use and their spatial distribution in the areas most prone and exposed to desertification, degradation and salinization, an important aspect that has been taken into account in the implementation of the agroforestry modules promoted by the project.

In the AIP, reservoir-filling levels, availability and access are affected by recurring periods of moderate and severe drought, and the tendency to decrease rainfall due to the progressive effects of Climate Change. The hyper annual behavior of the reservoirs is evidenced in correspondence with the decrease in rainfall and the affectation by intense droughts experienced by the AIP, which in their historical behavior have extended for periods longer than 12 months in the Central Zone and 24 months in the Eastern zone.

As for the rainy season, the distribution of precipitation anomalies reveals a change in average values during recent decades, but contrary to the trend described for the non-rainy season, in this case there is a tendency to the prevalence of negative anomalies. This behavior implies a reduction in the range of variation of the average rainfall values, particularly in the Eastern Zone. Most notable in this rainy period, is the sharp decrease in average values and variation in this area. The reduction of accumulated rainfall in the East is largely due to the more frequent occurrence of meteorological drought processes in recent years in that region.

Fig 3, shows the distribution of the monthly average rainfall in relation to the historical average during the Period 2000-2017.

Fig 3 Distribution of the monthly average rainfall in relation to the historical average. Period 2000-2017



Despite the fact that the average rainfall is 1335 mm / year for all of Cuba, there are recurring drought events that can last for several years. In the decade of the 90's, the most notable intense drought events occurred in the Caribbean, Central America, Mexico and the southeastern United States (period from April to July 1998), generated by the influence of ENSO 1997-1998. The event was noticeably manifested throughout the country and particularly in some municipalities in the eastern region. On the other hand, in the years after 2000 there have been significant drought processes in the Caribbean region, highlighting the event of 2004 (listed as the most critical event for Cuba in the last 100 years) and 2009, which has been the most acute for the western region in the last 50 years.

The Second National Communication, Republic of Cuba, 2015; cited in the Baseline Study of the IRES Cuba Project, (FAO 2018); indicates that the current climate trends and the scenarios considered (A2 and B2 of the Intergovernmental Panel on Climate Change, IPCC) for the next 100 years, will cause a deterioration of the overall environmental quality, as a consequence of the reduction of water potential, the loss of land in low coastal areas, soil impoverishment, reduction of agricultural yields, loss of biodiversity (mainly in coastal areas), effects on coastal settlements, the increase in communicable diseases and the consequent negative impact on economic activity.

Cuba's climate future can be described as more arid and extreme, characterized by prolonged and intense processes of drought and severe water deficit. The dry landscapes of the eastern zone will intensify and progressively progress towards the west, producing a transformation from the current climate (tropical humid) to dry sub-humid with threats of occurrence of desertification processes.

On the other hand, national rainfall scenarios estimate drastic reductions for 2050-2100, between 15 and 63% of current averages. In this sense, according to this scenario, the accumulated rainfall in the AIP would be around between 975-481 millimeters in the Central zone and 750-370 millimeters in the Eastern zone, which would lead to water crisis with repercussions on yields of crops and people's health.

6.4.1 Annual water balance

The total volume of water that enters through surface runoff and the infiltration of the rainwater that falls directly into the territory, as well as the amounts of water flowing from neighboring territories and / or aquifers, is recognized as the Potential Water Resources in the AIP. These resources have been evaluated for more than a decade and are estimated to total 835 million m³ annually. Of these, 490 million are underground and distributed in nine hydrogeological units, and the remaining 345 are superficial, distributed in 21 river basins. However, the results of the pluvial study for the elaboration of the current Isoietic Map of Cuba 1961-2000 (INRH, 2005), indicate that these potential resources are probably lower.

Changes in rainfall behavior patterns and their reduction, the increase in evaporation, together with the increase in saline intrusion because of the rise in the mean sea level, will affect the availability and quality of the water resources of the AIP.

The situation of the water balance in the AIP and in the Central and Eastern zones is consistent with the results of the baseline studies of the country and with the projected scenarios at 2050 and 2100 at the national level and regional disaggregation in Cuba. (Gutiérrez, 2012, cited in the Baseline Study of the IRES Cuba Project, (FAO 2018). Tabe 12, summarize the average of rainfall of the stations in the provinces of the AIP, from period 2013 to 2017, the average and the projection to year 2050, taking in consideration an decrease of 17% according with the IPCC reports.

Table 12: Average annual rainfall (in mm) of the stations in the provinces of Matanzas, Villa Clara and Las Tunas, 2013-2017 period

Provinces	2013	2014	2015	2016	2017	Average (1)	Average (2)
Matanzas	780.10	1,108.20	1,195.10	1,325.70	1,572.60	**1,196.34**	**1,040.82**
Villa Clara	1,519.40	1,349.70	1,290.90	1,073.70	1,452.40	**1,337.22**	**1,163.38**
Las Tunas	1,033.30	998.20	761.00	946.10	1,221.00	**991.92**	**862.97**
Project intervention Area						**1,175.16**	**1,022.39**

Average rainfall is 1335 mm / year for all of Cuba
(1) Current average scenario
(2) Average scenario A2 of the IPCC (With a decrease of 17%) - Year 2050
Source: Baseline study of adaptation and vulnerability for the implementation of the IRES Project, Cuba, FAO 2018

According to the water balance of the AIP, the potential volume of water in 2050 (IPCC Scenario A2) is reduced to 695 million m³ (17%) and in 2100 to 398 million m³, reducing by 52% in relation to the average volume currently registered In 2100 the Central AIP area will experience the greatest impact on the reduction of the potential water volume (66 hm^3), followed by the reduction in the Eastern AIP area with

332 hm^3, respectively (it is the sum of the subtotal of the surface basins of the Eastern zone, 136 hm^3 and the 196 hm^3 of the underground basins), which indicates that in this baseline scenario the water shortage in the AIP will be a critical element.

The national water balance registers that the potential volume of water is almost halved between 2050 and 2100 according to the climatic scenarios used in the projection (A2 of the IPCC), about 13.1 thousand hm3, 40% in relation to the volume average recorded between 1961 and 1990. The Central region of Cuba reports the greatest impact on the reduction of the potential water volume (4426 hm^3), followed by the reduction in the Eastern region with 4278 hm3, which indicates that in the baseline scenario, the water deficit will be critical, particularly for human and agricultural use.

In table 13, the potential volume of water to be captured, considering the current scenario and the scenario A2 of the IPCC in 2015, is presented. Here it is clear to notice that even with the A2 escenario with a reduction of 17%, the requierements of water for 1 Ha will be sufficient to cover the needs.

Tabla 13: Potential volume of water to be captured, considering Current Scenario and Scenario A2 of the IPCC in 2050.

Province	*Runoff Efficiency (E in%)*	Scenario Actual			Scenario A2 - IPCC/2050			
		Average annual rainfall (Average in m)	*Catchment area (A in m2)*	*Volumen (Vol. in m3)*	*Average annual rainfall (Average in m)*	*Catchment area (A in m2)*	*Volumen (Vol. in m3)*	Under this scenario, the potential volume to be captured decreases by 17% by 2050. However, the potential volume remains sufficient to meet the demand for crops and animal consumption, established in the different modules*.
Matanzas	60	1.19634	10,000	**7,178.04**	1.04082	10,000	**6,244.89**	
Villa Clara	60	1.33722	10,000	**8,023.32**	1.16338	10,000	**6,980.29**	
Las Tunas	60	0.99192	10,000	**5,951.52**	0.86297	10,000	**5,177.82**	

Source: Technical specifications Manual - SCALL, CEDEME -U. National, Costa Rica, 2010
*The demand of water for crops and animal consumption is summarized in the Suplementary material 16.3 and 16.4 and 16.5.

6.4.2 Water management, policies and legislation related to the use of water in agriculture

The National Institute of Hydraulic Resources (INRH) is the state agency whose mission is to direct, execute and control the application of State and Government policy regarding planning, control and protection of water resources. This institution administers the hydraulic infrastructure belonging to the state and regulates the use of that belonging as property or usufruct of other state entities. It receives the annual water demands of the different users and depending on the availability, authorizes under contract, its distribution through the Provincial Hydraulic Utilization Companies, which in that geographical environment (the province) manage, together with the Provincial Directorates of the Agency, water and measurement networks (quantity and quality) in the watersheds under its jurisdiction.

The development, operation and maintenance of irrigation and drainage systems are technically carried out mainly by MINAG and the AZCUBA Business Group (for sugarcane agriculture), whom, through Municipal Companies, provide technical assistance services, both to private and state users. The IAgric-MINAG (created in 2009 by the merger of the Irrigation and Drainage Research Institute (1976-2009) and the Agricultural Machinery Research Institute) is the scientific-technical support for these activities.

Each year, each user prepares a water demand adjusted to their requirements, which in the case of irrigation responds to the area to be irrigated by crop, the demand for crop irrigation and the irrigation technique to be used. These aspects are adequately legislated (resolution 21 / 99 of the INRH), and according to the availability of water, this demand is accepted without changes or is modified, which is then reaffirmed by means of a contract between the user and the Distribution Companies (entities for provincial state governed by the INRH). For the control of water deliveries and the operation of the sources there is a network of 700 hydrometric points that measure 85 percent of deliveries to users.

As noted above, once the water consumption plan has been established and approved, its planning and control process is carried out by the Provincial Hydraulic Utilization Companies, the core business structures of the INRH. These companies administer and maintain the hydraulic works of capture, conduction and protection against floods, recharge of aquifers and networks of observation of the hydrological cycle. Through them, the hydrological planning is carried out, as well as the water supply to the aqueducts and the electricity generation.

The payment of water supply services is mandatory for all consumers, and is based on the volume consumed (for irrigation at a rate of 0.2 Cuban pesos per 1000 m3 consumed).

In 2013, the National Assembly of Popular Power approved the National Water Policy presented by the INRH and prepared in collaboration with of all the water user organizations. This policy establishes 22 principles and four priorities for the sustainable management of water resources, these are: (i) the rational and productive use of available water; (ii) the efficient use of the built infrastructure; (iii) the management of risks associated to water quality; (iv) the management of risks related to extreme weather events. Since the approval of this policy, an institutional change has begun, which includes the development of policies adapted to each water user, the revision of Decree-Law 138 on Terrestrial waters (Water Law, which dates from 1993) and the resulting resolutions, such as the revision of the fees for the right to use water, as well as the annual water balance as part of the economy plan.

The legislation related to the conservation of water and soil resources gathers different laws and resolutions on terrestrial waters (1993), the cost of water for irrigation (1999), Environment (1997), Protection, Use and Conservation of Soils and its Contraventions (1995) and regulations for the protection and rational use of hydraulic resources (1995). All these legal documents are in force and are strictly enforced, and there is a tax system through inspector bodies accredited for these purposes[3].

6.4.3 The implementation of agroforestry modules and the hydrological cycle

6.4.3.1 Practices and measures to consider in the implementation of the modules

As indicated at the beginning of this section 6.1, regarding the influence of different plant coverings on the functioning of river basins; citing FAO (2009), the protection of river basins is one of the most important environmental services provided by forests, criteria supported by Kalenda and Rield (1966); in expressing that: "*the knowledge that the forest has a favorable influence on the economy of water is in general, more validated experimentally and researched day by day* ".

Considering that water resources in Cuba are scarce and have a poor temporal and spatial distribution, according to Renda et al. (2012), the statement of Bergkamp et al. (2003) becomes highly relevant by concluding: “In the face of climate change, the relationship between forests and water is a critical issue that should be given priority attention”.

[3] http://www.fao.org/nr/water/aquastat/countries_regions/CUB/indexesp.stm.

In Table 14, practices and measures to be considered in the implementation of the proposed agroforestry modules are summarized; indicating the problem to solve and the benefits related to the management of water and soil resources; as well as the practices to implement agriculture of low volume irrigation.

Supplementary Material 2.6.6, includes the description of irrigation by aspersion systems and reservoirs to be constructed.

Table 14: Practices and measures to consider in the implementation of the modules with agroforestry systems, linked to the hydrological cycle.

MODULE	PROBLEM	PRACTICES	BENEFITS
CEDPAL: Agroforestry system with Cedrela odorata (common cedar) interspersed with other forest species and agricultural crops with perimeter live fences.	Degraded soils with low levels of water infiltration and fertility	• Planting deciduous trees, drought resistant, with deep roots; combined in rows with semi-permanent agricultural cultivation. • Cleaning and soil preparation, by eliminating and clearing the marabou, incorporating the chips into the soil as organic matter, contributing to improve the agro-productive capacity of the soil; as well as the subsoiling, for greater aeration, fertility, water filtration and drainage; without inverting the soil profile. • Drip irrigation, using only accumulated rainwater and water product of surface runoff, operated with electric energy pumps; as well as the construction of excavated reservoirs to store rainwater during winter and use it during drought and in the dry season.	• Restore ecosystem functions in areas covered with Marabou and in high risk of desertification and degradation • Reduce rainfall runoff. • Reduce soil erosion. • Groundwater recharge. • Reduction of wind speed and evapotranspiration. • Increase the cycle of water and nutrients.
MARREG: Forest establishment through assisted natural regeneration in areas invaded by marabou.		• Establishment of forests through assisted natural regeneration in areas infested with marabou. • Identification and selection of young trees and natural regeneration of native tree species, additional management of the succession to a natural forest through liberation cuts and enrichment planting.	
MARFOM E establishment and management of polyfunctional forest plantations in areas invaded by marabou.		• Plant multifunctional forests achieving a combination of forest species where natives predominate over exotic species and offer important ecosystem services so that communities and inhabitants in general benefit from them.	
FRUAGR: Agroforestry system with fruit trees, agricultural crops and live fences.		• Agroforestry system with fruit trees, combined with agricultural crops, crop rotation and live fences. • Drip irrigation, using only accumulated rainwater and water product of surface runoff, operated with electric energy pumps; as well as the construction of excavated reservoirs to store rainwater during winter and use it during drought and in the dry season.	

Table 11 (continuation): Practices and measures to consider in the implementation of the modules with agroforestry systems, linked to the hydrological cycle.

<table>
<tr><th>MODULE</th><th>PROBLEM</th><th>PRACTICES</th><th>BENEFITS</th></tr>
<tr><td>SILLEC: Silvopastoral system with legumes</td><td rowspan="2">The scenario in which livestock is in degraded natural savannas with low rainfall, lack of waterlogging, prolonged drought, natural grasslands degraded by continuous grazing, lack of free grazing, prolonged drought and high animal load.</td><td rowspan="2">• Silvopastoral systems as an imperative need for livestock activity in the face of the effects of Climate Change to improve the low yields of animal production (milk and meat), low birth rates and high mortality.
• Progressive introduction of improved pasture varieties, more resistant to drought.
• Implement green contour fencing with forest trees.
• Introduction of drinking troughs for livestock, using only accumulated rainwater and water product of surface runoff, operated with electric power pumps; as well as the construction of excavated tanks to store rainwater during winter and be used during drought and in the dry season.
• Internal electric fence to regulate grazing of livestock and allow pasture recovery and soil conservation.</td><td rowspan="2">• Restoration of ecosystem functions, in areas with high risk of desertification and degradation really covered with natural degraded grasslands.
• Increase soil organic matter (increased retention of nutrients and water).
• Runoff reduction.
• Increased rainfall infiltration.
• Reduction of soil erosion.</td></tr>
<tr><td>SILSOM: Grazing with shade trees, living fences and protein and energy bank</td></tr>
</table>

6.4.3.2 Promotion of agriculture under irrigation

When designing the modules, specifically those related to irrigation systems, the IAgric-MINAG technical team established, after verifying the alternatives of water sources for irrigation and for animal consumption, that accumulated rainwater sources would be used, product of shallow runoff.

To implement agriculture under irrigation, the installation of drip irrigation systems is proposed, the availability of rainwater due to surface runoff; using irrigation units with coverage of 6.0 ha. per unit, for CEDPLA and FRUAGR modules; as well as the construction and equipment of reservoirs with capacity to cover 1.0 ha. of crops. In the case of livestock, 500-liter drinking fountains will be installed per productive unit of 2.5 cows, depending on the availability of rainwater surface runoff and the construction of 1,000 reservoirs of 63 m3, to supply and store water for the summer, according to the design of the SILLEC and SILSOM modules. More details about the crops requierements of water are summarized in supplementary material 2.6.

6.4.3.3 Rainwater harvesting

Water storage allows the agricultural producer to have a water supply in the summer or during droughts that occur in the winter.

Rainwater harvesting is defined according to FAO, 2000, cited by Salinas et al (2010) as "the collection of surface runoff water for productive use, and that can be achieved from roof surfaces, as well as intermittent or ephemeral water currents."

For the design of rainwater collection structures, the following parameters were considered:

- **Average annual total rainfall (in mm):** considers the amount of rainfall fallen at each weather station, divided by the amount of them, throughout the year. For the AIP, the following annual average rainfall values in the period from 2000 to 2017 are considered; Matanzas 1,196.34; Villa Clara 1,337.22 and Las Tunas 991.92; according to the National Institute of Water Resources, reported in the Environmental Panorama, 2017 - ONEI.

- **Runoff influence area in (m2)**: An area of 10,000 m2 of water collection is established to lead it towards the accumulation of water and the reservoir.

- **Efficiency of runoff (in%),** taking as reference, 60%, for treated soils.

With the indicated parameters, it is established that the potential volume to be collected for the different provinces of the AIP is 7,178.04 m3 in Matanzas; 8,023.32 m3 in Villa Clara, and 5,951.52 m3 in Las Tunas.

To determine the need for rainwater harvesting, through runoff, the following variables, calculated for each crop and animal consumption were considered (see supplementary material 2.6.8 for more details):

• Evapotranspiration (ETo)

• Vegetative crop cycle (CV)

• Days of operation irrigation system (OSR)

• Crop coefficient (Kc)

• Consumption Use (UC)

• Area in meters (A)

• Evaporation of accumulated water (Evap).

For each module using irrigation or water supply, the consumption and the needs of water to be harvested were calculated. Tabla 15 and Tabla 16 summarize the needs of water to be harvested per module.

Tabla 15: Summary of water consumption per agroforestry modules

Water requierement by module	Comsuption/ha (m3)	Area under irrigation (ha)	Comsumption (Liters)
AGROFORESTRY			
CEDPLA			
Plantain	3,675	1,754	**6,445,950**
FRUAGR			
Beans	4,900	1,338	**6,556,200**
Sweet potato			
Cassava			
Corn			
Tangerine			
Orange			

Fuente:
IAgric-MINAG, Y Cuba. 2019 and Instituto Nacional de Recursos Hidráulicos, Cuba, 2019

Tabla 16: Summary of water consumption per silvopastoral modules

Water requierement by module	Consumption/2.5 cows (m3)	Area with fountains (ha)	Consumption (liters)
SILVOPASTORAL			
SILLEC			
Livestock for milk production	63	7,500	**468,750.00**
SILSOM			
Livestock for milk production	63	3,862	**241,375.00**
Total		**14,454**	**13,712,275.00**

Fuente:
IAgric-MINAG, Y Cuba. 2019 and Instituto Nacional de Recursos Hidráulicos, Cuba, 2019

In the supplementary material 2.6.8, more information about the calculations of the water consumption for module are summarized.

6.4.3.4 Technology for the use of water in agricultural and livestock production systems.

Within the design framework of the agroforestry and silvopastoral modules included in the IRES Project, the concept of agriculture under irrigation is incorporated, for the production of bananas, annual crops (grains and food), and fruit species (citrus) included in modules CEDPLA and FRUAGR; as well as milk production, which demands water resources for animal consumption, modules SILLEC and SILSOM.

The technology for the use of water in the production systems considers as a source of this resource the rain of surface runoff, stored, in two different structures; on the one hand, the capture of surface runoff waters, taking advantage of the soil profile and the harvesting of runoff water in excavated reservoirs. Water is conducted through pipes, using pumping equipment operated by electric power, for drip irrigation systems.

With the installation of rainwater collection structures, complemented with drip irrigation systems, 1,754 ha will be established, under irrigation; using 267 units of 6.0 ha, which will cover 1,602 ha, and 152 units of 1.0 ha, which will cover 152 ha; covering 100% of the platain crop area included in the CEDPLA module. In the case of the FRUAGR module, 173 units of 6.0 ha will be installed that will cover 1,038 ha, and 300 units of 1.0ha, covering a total of 1,338 ha, of fruit crops (orange and tangerine) and various crops (beans, sweet potatoes, cassava and corn); which represents 53% of the module area; totaling 3,092 ha, under drip irrigation for the two modules indicated.

Regarding water consumption, in Cuba Resolution 287/2015 of the National Institute of Hydraulic Resources in its Annex 2. CONSUMPTION INDICES: Total Net Irrigation Standards for Agricultural Crops establishes the norms that will be applicable in these cases:

- CEDPLA module: Platain with 625 plants / ha. The norm of crop consumption is 6mm / day.
- FRUAGR module: Sweet orange with 32 plants / ha, Tangerine with 24 plants / ha ,; crop rotation, using half a hectare of beans, cassava or cassava, sweet potato or sweet potato and corn. In this case, the consumption standard to be used must be 4 mm / day.

The use of water in Silvopastoral Systems (SP), will be destined for animal consumption, by supplying drinking fountains with a capacity of 500 liters. The source of water for the drinking fountains considers the rain water of surface runoff, stored, in two different structures; on the one hand, the capture of surface runoff waters, taking advantage of the soil profile; whereby 11,012 drinking fountains and the runoff water harvest in excavated reservoirs will be installed, supplying a total of 700 drinking fountains; for a total of 11,712 drinkers, equivalent to 58% of the total fountains.

In Cuba, water consumption per animal is regulated by Resolution 287 / 2015. National Institute of Hydraulic Resources. Annex 1. WATER CONSUMPTION INDICES FOR LIVESTOCK SUPPLY. For the conditions of the SP provided for in the project in modules 6. SILLEG and 7. SILSOM, considering 2.5 cows / ha; with an average milk production of 6 liters / cow / day and a total of 230 days in milking. According to the Cuban standard, the demand is 0.18 m3 / head / day (equivalent to 180 liters / head / day).

In Table 17 Information related to the source of water for drip irrigation systems and for the supply of 500-liter drinkers is presented; as well as the information related to the excavated reservoirs, the area under irrigation and the total number of drinking fountains to be installed.

Table 17: Summary of technology for water use on agricultural production systems

Module	Productive activity	Drip irrigation system, with pumping equipment and conduit pipe - Rainwater			Rainwater reservoir		
		Type	Coverage	Quantity	Type	Volumen capacity (in m3)	Quantity
CEDPLA	Platain	Drip irrigation system, with pumping equipment and conduit pipe	Unit to cover 6.0 ha.	267	Excavated with geomembrane, drip irrigation system (1.0 ha unit), pumping and driving equipment.	3,675	152
FRUAGR	Annual and fruit crops (Citrus)			173		4,900	300
Module	**Productive activity**	**Pumping and conduction - Rainwater**			**Rainwater reservoir**		
		Type	**Coverage**	**Quantity**	**Type**	**Volumen capacity (in m3)**	**Quantity**
SILLEC	Milk production	conduction system to supply the drinking fountain	500 liter drinking fountain	7,150	Excavated with geomembrane and conduction system to supply the drinking fountain.	63	350
SILSOM				3,512			350

6.4.4 Integral management of soil fertility

Integrated nutrient management is a technique that seeks to increase agricultural production and protect agroecosystems. It consists of incorporating nutrients and organic matter into the plants through the balanced use of organic and green fertilizers, as well as mineral fertilizers. This avoids the excessive application of synthetic fertilizers and the consequent contamination of aquifers, as well as soil impoverishment (Muñiz, O, Febles, Balmaceda, and others (2007).

Gutiérrez Castorena, E, Gutiérrez Castorena, M, and Ortiz A. (2015), state that this integrated nutrient management approach considers four interrelated strategies as main axes: a) conservation and efficient use of nutrients in the native soil, through conservation practices and loss reduction in agro-ecosystems; b) recycling of the flow of organic nutrients, through the incorporation of plant waste; c) access to alternative sources of nitrogen by biological activity; and d) addition of inorganic fertilizers only in those soils with low fertility.

In Cuba, by agreement of the National Council of Watersheds in 2001 and within the framework of the Program to Combat Desertification and Drought, taking into account the problem that arose in soils regarding its degradation and its relationship with the low crop productivity, the National Soil Improvement and Conservation Program (PNMCS) is created, under the auspices of MINAG and CITMA, with the participation of other organizations and institutions linked to the activity (Riverol and Aguilar, 2015).

The PNCMS, contemplates the execution of a set of measures to stop the degradative processes of the soil and begin its gradual recovery, they are contained in an action plan that contemplates temporary and permanent measures; conditioning and soil improvement. It also includes monitoring water for irrigation, as well as training and technical assistance. This Program supports the implementation of soil conservation and improvement actions, with producers being the main beneficiaries. (Riverol and Aguilar, 2015).

The FAO´s, International Code of Conduct for the Use and Management of Fertilizers” will be as well taken inconsideration for the proposes of the project proposal.

The plant nutrition plan used in the implementation of agroforestry and silvopastoral modules considers the relationship between plants, soils and the environment.

The use of different sources to provide nutrients to the soil and plant has been included in the design of the nutrition plan; with a focus on sustainable management of soil and water resources.

Table 18 summarizes the nutritional plan by module and by plant species; including the product to be used, the proposed dose, volume and method of application of the product.

Table 18: Summary of the plant nutrition plan for agroforestry and silvopastoral systems. IRES / Cuba

AGROFORESTRY MODULES					
Module	**specie**	**Product**	**Dose**	**Quantity**	**Application**
CEDPLA	Timber trees	Organic material	5.0 Kg/plant	5,701 kg.	Apply at planting time.
	Platain	NPK	1.0 kg/plant	3,289 kg.	Apply the first three years..
		Biofertilizer	10.0 kg/ha/year	123 kg.	Apply the first seven years..
MARFON	Fruit trees	Biofertilizer	3.75 kg/ha/year	215 kg.	Apply the first seven years.
FRUAGR	Fruit trees	NPK	0.30 kg/plant/year	273 kg.	Apply the first three years..
		Organic material	5.0 Kg/planta	1,517 kg.	Aplicar al momento de la siembra.
		Biofertilizer	3.75 kg/ha/year	67 kg.	Apply the first seven years.
	Various crops (Beans, Sweet potatoes and Corn)	Biofertilizer	8.7 kg/ha/year	154 kg.	Apply the first seven years.
SILVOPASTURE MODULES					
Module	**specie**	**Product**		**Dose**	**Application**
SILSOM	Grass	NPK	35.0 kg/ha.	339 kg.	Apply at planting time.

Source: Ministry of Agriculture, MINAG. Cuba, 2019.

In the nutrition plan defined, the use of biofertilizers requires special attention. Biofertilizers are preparations that contain beneficial microorganisms that are used in agriculture for application to seeds, plant or soil, with the aim of increasing the productive yield of agricultural crops. The use of biofertilizers in Cuba dates back to the early twentieth century, with Rhizobium inoculation of strains from the United States of America for the cultivation of legumes at the time, Central Agronomic Station of Cuba, current National Institute of Fundamental Research in Tropical Agriculture (INIFAT), where the history of the emergence of the application of biofertilizers in Cuba was widely addressed.

Several Cuban authors have discussed the potential of using biofertilizers. However, the results of science and innovation on biofertilizers are not widely applied by agricultural producers in Cuba, nor in most of the underdeveloped countries. This situation prompted the creation of the Government Program of Biofertilizers, Biopesticides and Biostimulants in Cuba, in order to increase the research, production and availability of these products at the service of agriculture with sustainable bases, through the accumulated capacities in the country since the emergence and development of the biofertilizer and biostimulator production network, in the 90s

The biofertilizing microorganisms of the highest level of study in the period were Glomus, Rhizobium, Bradyrhizobium, Azotobacter, Gluconoacetobacter and Pseudomonas2). The following table shows the biofertilizer alternatives in Cuba for the different crops. (Peña B, Maida D, by Zayas Pérez M, and Rodríguez R. 2015).

7. *Dychostachys Cinerea* (Marabou), Exotic Invasive Species

Invasive species (EI) and CC are two of the greatest threats to the natural world. Their combined effects are not only devastating for the environment, but can also cost countries up to 10% of their GDP. A scientific report published in Nagoya, Japan, urges states to take immediate action against this "deadly duo"[4].

EI species have different characteristics that make them highly competitive, among which we can mention their tolerance to wide ranges of edaphoclimatic characteristics, high efficiency in the use of water, high reproductive rates, short maturation times and effective dispersion mechanisms[5].

Dychostachys cinerea is a shrub of the family of the Mimosaceae, native to South Africa introduced in Cuba at the end of the 19th century for ornamental purposes. It has spread alarmingly throughout the country's geography invading and rendering useless large areas of land since the beginning of the last century; the Agricultural Census of Cuba of 1946 reported an area of 268 151 ha; definitely, this species has become a real plague. It has very good colonizing ability, an action that it carries out through its extensive root system and its seeds that it produces abundantly with an admirable germinative capacity that the cattle eats and disseminates through the excreta.

Its wood is hard and used mainly in the manufacture of high-quality coal that has been exported to countries in Europe and more recently to the United States. In addition, peasants and rural dwellers use it as firewood and for fence posts spontaneously but in much smaller amounts than to make coal. According to INAF and GAF experts' criteria for these objectives, an average of no more than 3% of the total biomass is used.

[4] https://www.ecoticias.com/cambio-climatico/188200/Plantas-invasoras-contra-cambio-climatico

[5] Nature Ecology and Evolution and Mexican Congress of Ecology, Mérida, Yucatán, November 2008

Tabla 19: Biofertilizer alternatives in Cuba, per species and crops included in agroforestry modules.

Species/Crop	Biofertizer (Options)
Fruts	Fosforina
	Azotobacter
	Ecomic
	Fitomas E
Beens	Rhizobium
	Biobras-16
	Fitomas E
	Fosforina
	Azotobacter
	Ecomic
Sweet potato	Fosforina
	Azotobacter
	Fitomas E
	Ecomic
	Nitrofix
Platain	Fosforina
	Azotobacter
	Ecomic
	Fitomas E
Corn	Fosforina
	Azotobacter
	Fitomas E
	Ecomic
	Nitrofix

Source: Ministry of Agriculture, MINAG. Cuba, 2019.

The studies carried out by Rivero et al. (2004); show that in Cuba the potential agricultural yields of all crops will progressively decrease throughout the 21st century, between 10 and 25% and although the total evapotranspiration of the crops will generally decrease, the needs of irrigated water would rise progressively (40-55%, for short-cycle crops and 15-30% for long-cycle and perennial crops). The effect of CC would also be exerted on pastures in livestock areas, which in the case of Cuba are predominantly of grasses and could benefit the expansion of invasive alien species such as marabou, which has a high capacity for adaptation, recovery and growth.

Thus, the most vulnerable crops, yields, production and sowing are affected by climatic anomalies, as well as forests and pastures are giving way to the horizontal expansion of marabou and the area of traditional commercial crops is reduced.

In this way, the food and livelihood vulnerability (in particular jobs and income) of the communities and rural households increase in the first place, but of the whole population in general, which is reflected in a constant migratory flow to other jobs and other regions.

On the other hand, it is evident that it is economically untenable to maintain approximately 1/6 of the agricultural area covered by marabou at the country level, at the expense of areas of sugarcane, various crops and pastures.

The comparison of the income that would be obtained from the commercialization of marabou wood for the production of coal or chips for bioelectric power plants with those that would be obtained from any other use of the land such as sugarcane, temporary and permanent agricultural crops, pastures or forests, does not offer any doubt regarding the economic superiority of the latter.

The lands colonized by this exotic plant are unable to provide, or do so limited, ecosystem services such as provisioning, regulation, cultural and support. Regarding the protection and conservation of biodiversity, the marabou is rather a factor of imbalance and risk, both for the plant kingdom and for the animal and has become a factor of poverty and emigration of people who do not find those areas sustainable and human ways of life.

It is known that as a legume species, the marabou improves the soils and gives them a certain level of nitrogen and it is a real fact that, compared to uncultivated land, the marabou cover is more effective in terms of protection and improvement of the soils, but It has become a transforming species forming thorny and impenetrable thickets that leave unused lands for agricultural crops, livestock and forestry.

From the climatic and hydrological point of view, the replacement of marabou areas by planted forests (BP), has the following advantages:

- They provide a greater volume of biomass (litter, branches, fruits, etc.) to the soil which, when decomposed, constitutes a fundamental factor in the improvement of the hydro physical properties of the soils (structure and porosity, among others). In addition, the root system of the BP is deeper and expanded than when penetrating into the ground it opens tunnels through which the water penetrates towards the lower horizons. These are factors that decisively influence the ability of infiltration and retention of rainfall aspects of great importance in the water economy to be able to have greater volumes of this precious liquid in times of drought.

- If sub soiling is carried out, the beneficial effect is reinforced.

- In the absence of hydrological investigations in marabou areas, we homologate their influence on the water regime with a permanent crop such as fruit trees (mango or citrus) which is the use of soil more similar to the marabuzal of which we have research data. In this case, the forest-covered soil has an average 3.4 times lower runoff coefficient and an erosion 13 times lower than the marabuzal, a result that was achieved in investigations carried out in non-permanent water balance plots (See Supplementary Material1).

- The effect of decreasing the speed of the winds and the greater distance, in which this influence takes place, is another aspect of singular importance for the subject of the economy of the water (losses by evaporation in pastures and in agricultural crops). The BP, even if they were not designed as windbreak curtains, fulfill these functions, which is due to the fact that: a) they can reach up to three times and more the height of the marabuzal and thereby extend the distance of influence of the winds and b) in the BP there is a complete vertical structure, composed of the herbaceous, shrub and strata that serve as an obstacle and barrier to the prevailing winds in the area. These characteristics are absent in the marabuzal.

- Additionally, they are superior in the provision of other services, such as:

- CO_2 sequestration: in marabuzal it is much lower than in planted forests, which is due to the low increase in biomass, as summarized in Table 20.

Table 20: Performance indicators of marabou and energetic forests

Indicator	U/M	Marabou med (*)	Energetic Forests
Total Biomass	t/ha	40	155
Turn	Years	25	8
IMA	m3/ha/year	1,6	19

Note: (*) The definition of the degree of density of the marabou is as follows:

- Fine or light: average diameter less than 3.0 cm

- Medium: average diameter between 3,1cm - 8,0 cm

- Thickness: average diameter greater than 8.0 cm

Source: Prepared by Vidal et al. (2015).

- It is noted that the increase in biomass in the BP is 12 times higher than in the marabuzal; which demonstrates that the conversion of marabuzal to planted forests, constitutes a notable contribution to the topic of CC mitigation.

- Biodiversity: in the ecological field, the main impact of biological invasions is the loss of biodiversity, unlike forests, which are habitat for most of the terrestrial biodiversity of Cuba and the world.

- Socio-economic: the elimination of this species and its conversion to agroforestry use has a positive effect in reducing the levels of vulnerability of households, communities and the population in general; There will be more and more varied offers of jobs with net benefits for the inhabitants and especially for women, improvement of the quality of life and in general, greater resilience to the effects of CC.

- Ecosystem services: supply services (production of wood and other non-timber forest products) and regulation services provided by marabuzal are restricted in relation to the PRs and practically nil in relation to cultural and spiritual services.

The invasion of large areas of land by the marabou has various causes and in this sense the incidence of CC can not be underestimated, an effect associated with the increase in solar radiation that benefits the development of this plant due to its heliophilic qualities and, on the other hand, the prolonged and strong periods of drought that affected the country in the last decade

The surface invaded by marabou in the AIP (17%) is similar to that in the rest of the country. Of the approximately 86 961 hectares, about 60,000 ha correspond to the province of Las Tunas and just over 26 961 hectares to Villa Clara - Matanzas. It is the main obstacle to the execution of prosperous agricultural and forestry activities, which threatens the food security of the AIP residents.

In order to achieve the least possible impact to the soil and vegetation that occurs in the process of reconversion of marabou-infested areas, the clearing and subsequent preparation of the land, will be done avoiding the least possible removal of the soil (no employment of harrows or of plow of disks or others) and especially, the work without turning the prism of earth what will contribute to the contribution of organic matter to the floor and in addition, the increase of the levels of infiltration. It will consist of the following:

- Clearing the aerial part of the marabou using the brush cutter / chipper machine, spreading the chips to the ground to increase the content of organic matter and respecting the natural regeneration of individuals of promising tree species.

- Sub soiling at 40 - 50 cm depth to break the impermeable layer and increase water infiltration and root development.

For all the reasons given and the importance, transcendence and complexity of the Marabou issue for the country, the Cuban Government is making enormous efforts in the search for effective and diverse solutions to put back into production the lands colonized by this invasive species, by taking advantage of existing biomass as much as possible before turning it for agricultural and forestry use. This issue is a political one of high priority for the country because it is consubstantial with the effort that is being made in order to guarantee food security (sustainability) of the population and the confrontation with the CC.

8. Approach to rural territorial development

8.1 Territorial development approach concept

The challenges linked to the fight against poverty and inequality, to climate change, to globalization and competitiveness, have established in Latin America and the Caribbean the conviction that it is necessary to review the principles on which development strategies are based. The rural territorial development approach, although installed in the public debate of the region since the beginning of the century, has been generalized with the conviction that it is essential to reinforce and operationalize territorial policies and, at the same time, to provide sectorial policies with a territorial. At the same time, a rethinking of the need to strengthen institutional capacities to face new strategic approaches in the territory is taking place.

The concept of "territory", given its complexity, did not have a universal or consensual definition until now. In what exists a generalized agreement is in the idea that the territory is the result of a process "of social construction". Its delimitation is made from very different approaches (administrative limits, watersheds, ethnic and cultural identity, the existence of economic poles of development, social criteria), and is the responsibility of public authorities. Sometimes private agents may be the ones who, through the location of their investments, also delimit the territory; and social movements and non-governmental organizations can also do so through their actions.

What is certain is that the territorial dimension exceeds the most traditional definition of administrative region, and integrates all kinds of spaces. The territory becomes under this new paradigm, in the new public management unit (Echeverri, 2009, cited by FAO-Platform for Smart Territories / Territorial Development).

The definition of a territorial system includes, in addition to the dynamics of agrarian systems, the interrelations between rural and urban areas, as well as the existence of poles of attraction linked to the market, production and technology, new information systems and those resulting changes in the social, economic, environmental and cultural dimensions. Territorial systems are open to influences from national and supranational contexts as well as inter-territorial relations.

8.2 The Agrarian System and the forms of production in Cuba

Important changes took place in Cuba during the decade of the 90s, in the agrarian relations, the institutions of the sector and in the relations with the local Governments and the territory, from the restructuring and readjustment of the economy and the Cuban society, caused by two factors triggering the changes: the exhaustion of the current economic model in the second half of the 1980s, and the crisis and liquidation of the world socialist system. The combination of both, a historical and a conjunctural one (known as the Special Period in Times of Peace), led to a profound crisis in the Cuban economy and society, from which the country has not yet fully recovered; the very process of restructuring the economy, the reforms undertaken and the indispensable international reintegration of the Cuban economy and society in today's world, point to the complexity of the process and its prolongation over time.

It is not just a temporary response to a conjectural crisis; the situation requires profound changes in the way of conceiving the economy and society, in the forms of organization of the productive sector, in property relations, in the role of local governments, in the management model and social participation, in national strategies and priorities, among other important issues.

The confrontation with the agri-food crisis was the most immediate objective of a new agrarian reform, (Third Agrarian Reform, 1993) elaborated to create the conditions that reactivated agricultural and agro industrial production. It was essential to achieve an adjustment of the conflict between productive forces, forms of land exploitation and the functioning of the agricultural system, that is, a formula for the destatisation of agriculture. The changes were made in the midst of the economic crisis and the breakdown of the pattern of conventional agriculture, at a time when an intensification of manual labor was necessary to guarantee survival and overcome the agri-food crisis.

The new agricultural economy implied a substantial modification of the planning mechanism, which now had to be oriented towards the market. The opening of the agricultural free market in 1994 was followed by other measures such as financing schemes and foreign exchange incentives for certain sectors related to exports; the reduction of food imports; and the contributions of foreign capital to reactivate national production, stabilize and subsequently expand the labor force employed in agriculture. (Albelo and Averhoff 2000).

It was also necessary to focus on changes in the organization of the national agricultural sector, the creation of research and teaching institutions, the training of technicians, and knowledgeable specialists to carry out the transformations required in agriculture and in the Cuban rural environment. This situation generated actions and changes, among which the following stand out:

- Development of urban agriculture through organoponics and urban integrated gardens for the production of vegetables, rice and other crops in and around cities and towns.

- Introduction of technological-productive systems of low inputs and high labor density, with the purpose of more rationally combining the conventional or classic production model with a sustainable production model.

- Strengthening of agricultural research centers with the aim of introducing new substitute technologies for agrochemical inputs and mechanization. (Albelo and Averhoff 2000).

The Cuban State promoted the need to organize, in higher forms, individual farmers production, encouraging cooperativism in the agricultural sector. The first Agricultural Production Cooperatives (CPA) was created, stimulating the development of the (already existing) Credit and Service Cooperatives (CSS). In this way, at the end of the sixties, and the beginning of the eighties, the vast majority of CPAs are made up in the country. These are cooperatives of associated work created mainly by farmers benefiting from the 1st and 2nd agrarian reforms, carried out in 1959 and 1963 respectively, which sold their land to the cooperatives to constitute them as collective property. For its part, the Credit and Services Cooperatives (CCS) is the voluntary association of small farmers who have the property or usufruct of their respective lands and other means of production, as well as the production they obtain. It is a form of agrarian cooperation through which the technical, financial and material assistance that the State provides to increase the production of farmers is processed and made viable.

This process (of agricultural cooperativism) was developed in a stable way until the end of the 90s. During that period the agricultural cooperativism coexisted together with the large state enterprise, characterized by the high degree of centralization of its management. (Recompensa Joseph, 2017).

Among the transformations carried out, we find: the creation of village farms or state farms organized in large land holdings, the profound reform of land tenure, promoting cooperative forms; Fig that had been promoted between 1976 and 1983 as a socialist alternative to small peasant production, with broad support from the State. Taking as reference the CPA and the transformation process, the Basic Units of Cooperative Production (UBPC) are created. The UBPC, were created with the groups of workers who previously worked in state companies, which are given land in permanent usufruct, receive the means of production of the company in a set period, to become owners of the means of production and productions in process. In this way, the cooperative sector became the most important and decisive of Cuban agriculture as an alternative to decentralization. The UBPC constitute the central core of the collective-cooperative sector.

The National Association of Small Farmers (ANAP) was set up as the governing body for the work of the farmers movement, which was in charge of supporting the development and strengthening of this movement, with different forms of cooperation in farmers production.

In 1998, just over 50 percent of the national agricultural fund corresponded to the cooperative sector, while the State had one third of that fund: one part was exploited according to the traditional scheme, and another was in transition to integrated farms again kind. Military farms, contingent groups, Popular Power entities, scientific institutions and other institutions exploited the rest of the land. Finally, the peasant and farmer private sector had just over 16 percent of the national agricultural area (72.1 percent of the private land fund in CCS, equivalent to 12 percent of the national agricultural land). The remaining private farmers were small farmers not associated with CCS.

The Base Business Units (UEB) was created by the companies and the Superior Organization of Business Management (OSDE) under the protection of Decree-Law 252 of August 7, 2007. They had the purpose of achieving greater efficiency in the process of production of goods and services, but their task is very difficult, since they do not enjoy independence or have legal personality; since they are directly linked to business groups. (E.g. Agroforestry Group, GAF, of the forestry sector, created by the Ministry of Agriculture, MINAG, and the Business Group of the Food Industry, GEIA, created by the Ministry of the Food Industry, MINAL).

8.3 Decentralization, territorial and local development

The implementation of decentralization policies has a history dating back to 1959, without the crystallization of a decentralization strategy integrated to profound changes in the functioning of the State and society; rather, they respond to specific situations and temporary conjunctures.

Four programs that have played a decisive role in shaping the interest for the territorial-local space can be identified: the transformation of agricultural production, industrialization, the territorial distribution of social services and the constitution of the Organs of the Popular Power in the limits of a new Administrative Political Division, which meant ¨The intention of the decentralization in all instances of the state apparatus, the concentration of the absolute majority of the economic and social activities under the administration of the lower instances of the state apparatus, that is to say of the municipal instances¨. (R. Castro, 1974, cited by cited by González, 2017).

In the last twenty years, the effort of the State and the Government has gone in favor of the strengthening of these territorial links, developing, in particular, the provincial level in the industrial branches and of the superior services and the municipal level in the provision of the intermediate and basic services.

In this sense, the V Congress of the Communist Party of Cuba agreed, in the "Resolution on the Guidelines of Economic and Social Development, which the territorial economy should assume an increasingly active role in the search and implementation of related to local development, particularly from the resources, culture and tradition of each territory. Likewise, it will complement national activities based on the same premises. These policies, despite their limitations, allowed the implementation of decentralized strategies, at the territory and municipality level, as in rural areas and in the agricultural sector; for its importance in the contribution to the Gross Domestic Product (GDP) of the nation. Hence, at present, appropriate steps are taken to grant the territory (municipality) the role that corresponds to decision-making, especially to producers. To this end, Municipal Agricultural Delegations were created, whose purpose is the territorial management of agricultural production, with emphasis, at this level, on the guarantee of food security.

8.4 Institutional and regulatory framework to strengthen the territorial development approach

Cuba has two public policy instruments that define its economic and social actions:

- The Conceptualization of the Cuban Social and Economic Development Model
- The National Economic and Social Development Plan until 2030

The elements contained in the mentioned instruments are implemented through the 274 Guidelines of the Economic and Social Policy of the Party and the Revolution for the period 2016-2021; updated and approved by the National Assembly of People's Power, on June 1, 2017.

Related to the focus of the "IRES - Cuba" project; in the main policy guidelines in execution and linked to the IRES project are detailed, as well as the basis for strengthening the territorial development approach, in the execution and results of the design of the Sustainable Agroforestry Modules, included in the project.

Table 21: Economic and Social Policy Guideline 2016-2021, to strengthen the territorial development approach.

AREA	GUIDELINE
ECONOMIC MANAGEMENT MODEL	12. Companies and cooperatives will pay to the councils of the municipal administration where their establishments operate a territorial tribute, defined centrally, taking into account the particularities of each municipality, to contribute to their development and constitutes a source to finance current and capital expenditures.
	17. Promote the development of the territories based on the country's strategy, so that the municipalities are strengthened as a fundamental instance, with the necessary autonomy, sustainable, with a solid economic-productive base, and the main disproportions among these are reduced, taking advantage of its potential
SCIENCE, TECHNOLOGY, INNOVATION AND ENVIRONMENT POLICY	107. Accelerate the implementation of directives and programs of science, technology and innovation, aimed at confronting climate change, by all agencies and entities, integrating all this into territorial and sectorial policies, with priority in the agricultural sectors, hydraulic and health.
SOCIAL POLICY	121. To train with quality and rigor the teaching staff required in each province and municipality to respond to the needs of the educational centers of the different levels of education.

Source: Own elaboration based on the Documents of the 7th. Congress of the Party approved by the III Plenum of the Central Committee of the PCC on May 18, 2017 and endorsed by the National Assembly of the People's Power on June 1, 2017.

9. Value Chain Approach

9.1 Territorial development approach concept

*Trad*itionally, interventions that seek to support the development of the agricultural sector have focused on increasing the productivity of production systems through programs of land reform, credit, research, and technical assistance, among others. This type of interventions, in general, has resulted in an increase in the production and productivity of the sector measured in kilograms produced by cultivated area allowing substantial improvements in the supply of agricultural commodities.

However, these increases in production have generated significant reductions in the prices paid for these products, as a result of the law of supply and demand. A clear example of this trend can be seen in the average prices of commodity products, which have been declining for the last 50 years. Although, the productive increases have 'cheapened' the cost of food for important segments of the urban population, they have not generated sustainable improvements in the incomes of the producers or the rural populations nor have they contributed to reduce the levels of rural poverty. (CIAT, 2004)

Moreover, the global trend towards globalization and free trade requires a shift from the "productivity" approach to a "competitiveness" approach. For the achievement of this competitiveness, the business organization both at the level of the company and its forward and backward links and access to information and technology are becoming increasingly necessary.

During the last decade, the concept of the value chain (CV) has become one of the main paradigms of the theory and practice of development. This has been coupled with a rapid increase in literature devoted to all aspects of VC. In particular, the analysis of value chains has received great attention and has focused on specific aspects of the approach, for example, the selection of CVs, the elaboration of strategies, the execution plans, the instruments to analyze the favorable environment; highlighting the most recent key issue, the three-dimensional sustainability approach; that is, the approach that combines economic, social and environmental aspects. (FAO, 2015)

In this context, the Food and Agriculture Organization of the United Nations (FAO) has generated and disseminated information on the Development of Sustainable Food Value Chains (DCVAS), facilitating the dissemination of innovative solutions arising on the ground to an audience Recipient formed by policy makers responsible for the formulation of projects and professionals in the field, given that their recipients belong to the public sector, the information adopts a perspective mainly oriented to development, which addresses the question of how it can be use the VC approach to reduce poverty and eradicate hunger on a large scale.

A Sustainable Food Value Chain (CVAS) is defined as follows: All those agricultural holdings and companies, as well as the subsequent activities that add value in a coordinated way, that produce certain agricultural raw materials and transform them into specific food products. They sell to final consumers and are discarded after use, so that it is profitable at all times, provides broad benefits for society and does not permanently consume natural resources.

According to FAO (2015), this definition refers to the different actors (individuals and / or legal entities); characterized in: i) direct owners, responsible for the functions of production, storage, transformation and distribution; and ii) suppliers of goods necessary services to generate value in each function or link of the CV, which, as well as those responsible for the development of the different activities

The expression "all those farms and enterprises" refers to both the CV stakeholders that are the direct owners of the product and the various business service providers (for example, banks, transporters, extension agents, input merchants and processors that charge a fee). Their behavior and performance are strongly influenced by the specific business environment in which they operate.

9.2 Value Chain Approach in Cuba

The production chain approach has been used since the 70s to improve the competitiveness of agri-food systems as it helps to have a broad and comprehensive view of the evolution and performance of a product, from production to consumption; contributes to a better understanding of the dynamics of the chain, its internal processes and the external factors that affect it. In Cuba, the development of production chains began a few years ago due to agricultural production, giving rise to agro industrial complexes in sugar and rice production.

In a context of a centrally planned economy, with little market participation and certain external constraints (economic blockade, difficult access to credit and currency, energy dependence and external inputs), all this depends on a complex planning process that not only identifies the necessary resources and services, but to set certain priorities, since the State can never meet all the needs at once.

There are two aspects of the Cuban context that make the application of the chain approach to planning more complex:

- The direct and indirect actors of the chains respond to different sectorial and central administrative structures (ministries and business groups) that are responsible for the planning of their resources and investments.

- The administrative structures make the plans (sectorial / national) feasible, but not necessarily integrating and articulating actions and priorities between different sectors or at a territorial level. This generates that the priorities are established according to the strategies of the ministries and companies and not of the territorial chains in which their entities participate.

- The plans are built more with the purpose of taking advantage of the existing productive potential and not always based on the needs and requirements of the market. This can generate distortions and inefficiencies when implementing and managing plans and creating new bottlenecks in the functioning of some productive linkages.

- If it is considered that the productive potential of each link is different and that the market has limited physical and economic capacity to absorb production, there is a risk that the production increases will not reach the final market or that it will not be able to absorb them. For example, if the production of the fresh product exceeds market demand and there are no warehouses to conserve or industries to process, part of the production will be lost.

The application of a chain approach to planning and management can overcome or reduce these risks and bottlenecks since it differs from the traditional model by the following aspects:

- It is based on what the market demands and can absorb, regardless of the productive capacity of the system.

- It is built on a territorial scale, to allow the integration of the different actors and institutions (including the indirect actors that provide services and inputs) that make up the chain, under the coordination of local governments or other mechanisms of agreement that the chain itself build.

- Responds to a strategy based on collective and consensual needs (as a chain) and not on the specific needs of the actors that compose it.

- Seek equity and sustainability (economic, environmental, institutional and social) of the chain as a system, and not of each of its members.

For all the characteristics described above, achieving a territorial planning and management process that incorporates the chain approach in the Cuban agri-food sector requires deepening some innovations in the culture and practice of managing the sector and its institutions. It needs, therefore, a strategy of action and a methodological accompaniment that allows creating the basic conditions for its understanding and use.

9.2.1 Regulatory framework of the value chain approach

As indicated above, Cuba promotes a model of Economic and Social Development until 2030. In Table 22, the guidelines of the economic policy that laid the foundations for the development of a value chain approach in Cuban productive activities, related to the agricultural and forestry sector are shown.

Table 22: Economic and Social Policy Guideline 2016-2021, to strengthen the value chain approach.

AREA	GUIDELINE
ECONOMIC MANAGEMENT MODEL	9. Advance in the improvement of the business system, gradually granting the entities' new powers, defining their limits with precision, in order to achieve companies with greater autonomy, effectiveness and competitiveness.
	13. Prioritize and continue advancing in the achievement of the complete production cycle through productive linkages between organizations that develop productive activities, services and science, technology and innovation, including universities, to ensure the rapid and effective development of new products and services.
MACROECONOMIC POLICIES OF SCIENCE, TECHNOLOGY, INNOVATION AND THE ENVIRONMENT	37. To perfect the necessary banking services for the sector that operates under non-state management forms, to contribute to its proper functioning, particularly those aimed at the development of the agricultural sector.
	99. Continue developing the legal and regulatory framework that promotes the systematic and accelerated introduction of the results of science, innovation and technology in production and service processes, and compliance with established social and environmental responsibility standards.
	107. Accelerate the implementation of directives and programs of science, technology and innovation, aimed at confronting climate change, by all agencies and entities, integrating all this into territorial and sectorial policies, with priority in the agricultural, hydraulic and health sectors.
AGROINDUSTRY	165. Organize the production in the agricultural productive poles in charge of supplying the big cities and the food industry, achieve an effective substitution of imports and increase exports, applying a productive chain approach of all the links that are articulated around the agro-industrial complex, with independence of the business organization to which they are linked.
	172. Develop a comprehensive program of maintenance, conservation and promotion of forest plantations that prioritizes the protection of watersheds, in particular dams, hydro-regulatory fringes, mountains and coasts; as well as to increase the plantations in the plain and the pre-mountain, to increase the production of wood and other products of the forest.
	174. Develop the food and beverage industry, including local activity, in order to achieve greater use of raw materials, diversification of production and increased supply to the domestic market and exports.

Source: Own elaboration based on the Documents of the 7th. Congress of the Party approved by the III Plenum of the Central Committee of the PCC on May 18, 2017 and endorsed by the National Assembly of the People's Power on June 1, 2017.

The process of updating the Cuban economic and social model proposes a set of transformations that aspire to contribute to greater efficiency and sustainability of the national economy to continue guaranteeing the satisfaction of the basic needs of the population. Among those needs, since 2008, the highest government leadership as a national priority has declared food security.

These transformations aim to achieve a better complementarity between the market and planning in the Cuban development model, giving greater importance to the monetary-mercantile relations, improving and better distinguishing the role of the State and the business system, and introducing, expanding and strengthening forms of non-state management, such as cooperatives and self-employed workers.

Achieving this systemic, territorial approach and oriented to demand or market, constitutes an important challenge for the process of updating the Cuban economic model, especially for the agri-food sector. Moving from a productive chain approach to a value chain approach can be a very useful analytical and management tool for the construction of this new management model that is to be achieved. (PALMA-AGROCADENAS, 2014).

9.2.2 Actions carried out related to the development of value chains

It is necessary to recognize the actions that the authorities of the Government of Cuba; With their own resources through the MINAG or international cooperation they have made with the aim of implementing the Economic and Social Policy Guidelines 2016-2021, to strengthen the value chain approach in agricultural and agro industrial activities. A brief summary of some actions developed, is presented below:

A. Local Support Program for Agricultural Modernization in Cuba, Project PALMA, (2009-2014).

- Support: European Union and from 2012 with the contribution of the Government of Canada.
- Although a chain approach was not systematically developed, this initiated a first pilot of application to diagnose milk and grain chains in Sancti Spíritus and fruit trees in Santiago, carrying the first learnings and approaches.

B. Co-innovation in agrarian processes to strengthen food sovereignty in Cuba, (03 / 2011- 2014).

- Objective: Increase productivity and strengthen the value chain through a pilot research-production integration experience in six municipalities in the provinces of Matanzas and Villa Clara.
- Specific objective: Increase production and strengthen the value chain of agricultural products through a pilot experience of research-production integration in six municipalities of the aforementioned provinces.
- Coordinating entity: OIKOS - Cooperação e Desenvolvimento
- Participating entities: National Association of Small Farmers (ANAP) Experimental Station of Pastures and Forages "Indio Hatuey" (EEPFIH)
- Amount: € 1 224 476. (81.67% financed by the EU).

C. Strengthening of the milk value chain in Sancti Spíritus and Camagüey, FOCAL. (03/2011 - 02/2014)

- Objective: Improve the availability and quality of milk and milk products in four municipalities through the implementation of a sustainable pilot model of closed-cycle integration of the production chain, which incorporates a strategy of adaptation to local conditions of climatic variability in 20 cooperatives from the selected territories.
- Coordinating entity: CARE France
- Participating entities: OIKOS - Cooperação e Desenvolvimento Cuban Association of Animal Production (ACPA) Meteorological Society of Cuba (SOMETCUBA).
- Amount: € 1 199 943 (83.34% financed by the EU).

D. Support to small producers of cooperatives for the improvement of food security in the coastal municipalities of Manzanillo and Amancio, Tierra Viva Project. (10/2011 - 12/2015).

- Objective: Increase the level and quality of the productive and economic chain of suburban agriculture in 15 agricultural cooperatives located in the beneficiary municipalities.

- Coordinating entity: Cooperazione per lo Sviluppo dei Paesi Emergenti (COSPE)

- Participating entities: Center for Rural Studies and International Agriculture (CERAI) National Small Farmers Association (ANAP) Antonio Núñez Jiménez Foundation for Nature and Man (FANJ).

- Amount: € 1 122 529 77. (61% financed by the EU).

E. Cooperative Rural Development Project in the Eastern Region, PRODECOR, (2013 - 2019).

- Objective: Increase the production and productivity of strategic crops, mainly corn and beans, two essential components of the diet of the Cuban population.

- Financing: International Fund for Agricultural Development, IFAD and the Agence française de développement.

- Focus: Strengthening cooperative organizations of small farmers, increasing their capacity for sustainable production, business management; actions that complement the strengthening of agricultural service providers; promoting the provision of services to cooperatives and their members by governmental and non-governmental suppliers.

F. Program to support the strengthening of agrifood chains at the local level, AGROCADENAS, (2014-2018)

- Objective: To improve the food security of the country's population by strengthening selected agrifood chains (grains, milk, and beef) in pilot municipalities of the country.

- Support: European Union and the Swiss Cooperation Agency for Development (COSUDE).

- Participating entities: Since its conception the chain approach, promoting the joint work of MINAG, the Ministry of Domestic Trade (MINCIN) and the Ministry of the Food Industry (MINAL) for the chains of beans, corn, meat and milk in 13 municipalities, grouped in two regions with similar productive vocation.

- Focus: Strengthen the management and performance of agrifood chains at the local level, in correspondence with the strategy of integral development of the selected municipalities; as well as, strengthen the capacities of producers, agricultural cooperatives, forms of non-state management linked to the other links and local support services, to integrate more effectively and sustainably into the selected chains.

- Coordinating entity: The United Nations Development Program (UNDP) and the Ministry of Agriculture (MINAG), to support the country in boosting the agricultural sector, have implemented The PALMA and AGROCADENAS projects.

G. Support for the cocoa production chain in Eastern-Guantánamo. (03/2014 -02/2019).

- Objective: Improve food security in Cuba, strengthening the decentralized management of the cocoa value chain in the municipalities of Baracoa and San Antonio del Sur, and the province of Guantánamo.

- Coordinating entity: Spanish Agency for International Cooperation for Development (AECID)

- Participating entities: Council of the Provincial Administration of Guantánamo (CAP - Guantánamo) Ministry of Agriculture (MINAG).

9.2.3. *Current situation of the development of the value chain in Cuba*

When analyzing the actions and projects developed, in the Cuban agricultural sector, the interest and the support received can be observed; as well as the tendency to deepen this approach, as a strategy to respond to the problem of agricultural supply and the reduction of food imports.

Some elements extracted from the actions presented are:

- The linkage of the value chain approach with the territorial development approach, a key element for the sustainability of the results of the intervention.
- The level and diversity of international and local cooperation institutions in the efforts made.
- The orientation of the efforts to agri-food production chains, which reflects the imperative of the need to improve the competitiveness of agricultural activity, to respond to demand and food security.
- Without going into the details of lessons learned and results obtained; it can be seen that the focus is on improving the capacities of the main actors to build the value chain; exposing in some projects elements of sustainable production.
- In the framework of the implementation of the mentioned projects, a study has been made of the following value chains: grains, vaccine, bovine meat, and cocoa.
- There are no actions to promote agroforestry and silvopastoral activities.

9.3 The IRES project and the value chain approach in Cuba

The need to consider a chain approach for the study of production processes in general and for agricultural production in particular is currently recognized in Cuba as an effective way to develop these processes in a harmonious and sustainable manner. In spite of this, it is necessary to deepen on this approach, which has been applied from a perspective of development of competitiveness of a product and not of the actors.

To ensure that a productive chain reaches a level of organization, articulation and integration that allows it to move towards a value chain, it is necessary that sectorial and territorial public policies and business strategies (of the state and non-state sector incorporate the chain approach in all the components that guide its action: analysis, planning and management.

The application of the chain approach to public and business management (of the state and non-state sector) requires the following basic conditions: (AGROCADENAS Project, 2014).

Have the ability to recognize and analyze a productive sector as a complex and interdependent system of processes (production, transportation, transformation, etc.), actors (companies, cooperatives, etc.) and relationships (contractual, administrative, etc.).

Promote actions and comprehensive policies aimed at improving the functioning of this system (the chain), rather than specific policies for the actors and processes that comprise itself

The IRES project, with resources from the requested co-financing to the Green Climate Fund and the resources of the Government of Cuba, will promote the development of agroforestry and silvopastoral systems that are resilient to climate change (including agricultural, livestock and forestry production).

It is an initiative that seeks to promote the integration of the efforts of governmental actors (regional and local level), the cooperative sector and market players; to achieve the sustainability of the results generated by the investment; that is, the generation of income and jobs in the Project Intervention Area, thus increasing the climatic resilience of the beneficiary population; to carry out studies of strengthening and competitive development of the value chain, aimed at satisfying local demand and import substitution.

A fundamental element to achieve sustainability is that the productive activities promoted by the IRES Project, reach the competitiveness to access the markets and ensure their permanence; to do so, it will promote coordination and cooperation actions to deepen the value chain approach, which Cuba has been promoting.

It is important to point out, as indicated in the previous paragraphs, that efforts have been made in Cuba, capacities developed, tools created and resources managed, which allow deepening this approach; for this, the IRES Project, through the facilitation of institutional efforts, will promote three key actions towards competitiveness:

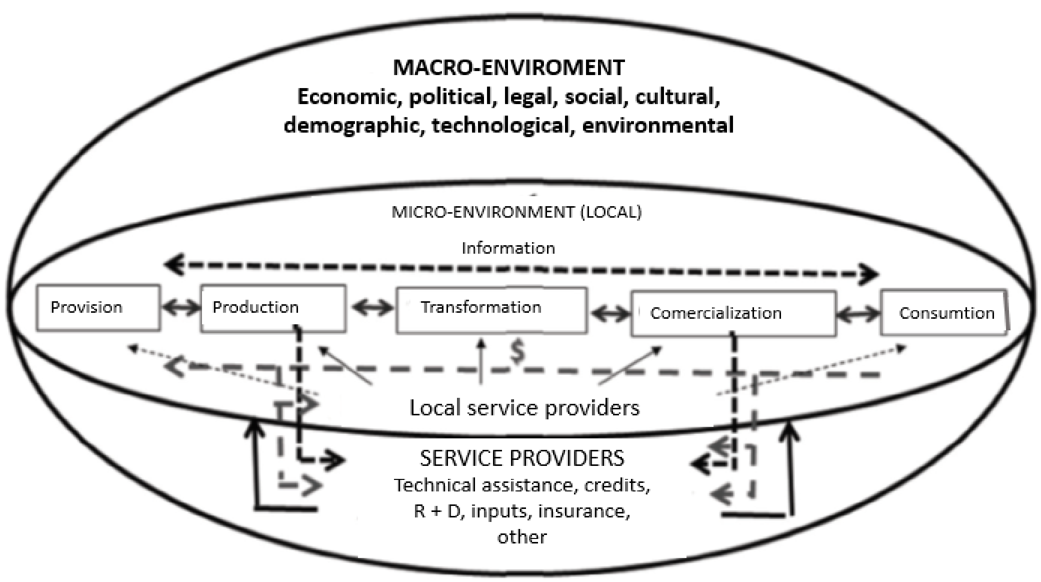
Strengthen the capacity of business management in the different productive and service forms, supported by the Project.

Improve productivity levels, promoting good sustainable agroforestry management practices, based on the principles of Adaptation Based on Ecosystems (EbA).

Improve market access; through, the already established instances that allow to generate climate, market and other information in support of competitive development, among other aspects.

Fig 4 expresses what Cuba is developing with its action. This Fig somehow tends to outline the Interrelationships among the various actors, support institutions, relations, policy instruments and perspectives of the IRES Project, with the co-financing of the Green Climate Fund and the Government of Cuba.

Fig 4: Representation of the Value Chain



Source: From Castellá Miguel. 2016. Value chains of agricultural products in six municipalities of Cuba. (Adapted from Methodology Guide for string analysis). P. 59

10. Integral Base Business Units of Technical Services (UEBIST)

Agriculture in Cuba faces a challenge to achieve the establishment of a sustainable agricultural system capable of meeting the food needs of the population. It is of paramount importance to solve the problems that affect or limit the production of food both in quantity and quality, given the increase in population and the need to guarantee future demands.

In the context of the implementation of the Value Chain approach as a key element of the strategy of implementation and sustainability of the results projected in the IRES Project, the existence of a timely and efficient provision of services that contributes to the strengthening of the actors that intervene along the agricultural and forestry value chain, with emphasis on the productive link; on which the actions of adaptation and mitigation against the effects of climate change in the Cuban agroforestry sector are based; as well as the ability to face the limitations of food production are vital. These actions are supported by the country's vision of the importance of the agroforestry sector for Cuba's economy, structured in the Economic and Social Policy Guidelines, Cuba, 2016.

As stated in Section 6.3, Cuba has an Agricultural Mechanization Policy; which starts from the situational diagnosis of the activity and the entities responsible for the provision of mechanization services to the agricultural and forestry sector; taking advantage of the proposal of the economic management model, in the business sphere of policy guidelines, by expressing that progress must be made in improving the business system, by granting it new powers for its operation, in order to achieve companies with greater autonomy and competitiveness.

The Business Groups, promoted and supported by the MINAG, execute their activities through the creation of the Business Base Units (UEB for its name in spanish), based on article 15 of Decree-Law No. 252 of 2007, specializing in the provision of services for Productive Forms of Agriculture (CCS, CPA, and UBPC, cooperative organizations responsible for agricultural and forestry production); proposing the operating scheme described in this section.

In all state enterprises, cooperatives, farms of family producers and other productive units and services of the Ministry of Agriculture and other ministries, agricultural machinery, workshops and other means are available to meet the needs of these productive entities. However, the means available in the entities do not always meet the productive needs, especially in the so-called "machinery needs peaks", which limits the exploitation to the maximum of the land available. It would be vital to have the technologies, technical means and knowledge that allow them to operate efficiently and economically through a system in which they can have their own means as well as those obtainable through technical services provided by other entities at convenient prices. (. (Suárez, Ríos y Linares, 2011).

The Integral Base Business Units of Technical Services (UEBIST), constitute a new form of organization within the agricultural sector.

The Integral Base Business Units of Technical Services (UEBIST), constitute a new form of organization within the agricultural sector; which are governed by Decree-Law no. 252 on the continuity and strengthening of the Cuban business management and management system, dated August 7, 2007; and Decree No. 281 of August 16, 2007; which contains the Regulation on the main rules of action and technical procedures of the Management and Management System; both, agreed and noted, in accordance with the provisions of the Third Final Provision of Decree-Law No. 320 of January 30, 2014. These units, in addition to providing mechanization services to the production units of your municipality, will also offer maintenance and repair services to agricultural machinery, irrigation and transport equipment. This last task turns the technical service activity into a strong link in the new organization, so the establishment and strategic management actions will be the key to the success of the mission of these units. (Sánchez, Shkiliova, Nores, y Ríos, 2011)

In each Cuban municipality, the creation of these centers responsible for providing agricultural mechanization services and technical assistance to producers has begun. For this they must have agricultural equipment and their own implements, as well as workshops for repair and maintenance. Each of these centers will be an Integral Unit of Technical Services (UIST) with the character of the Base Business Unit (UEB) subordinated to the Municipal Agricultural Company. (Suárez, et al, 2011)

The direct beneficiaries of the results obtained will be first of all farmers and other individual producers or small-scale entities of MINAG and the National Association of Small Farmers, ANAP, a social organization that represents the interests of the Cuban farmers, and in general all the people who are related to this productive activity from the municipality to the nation.

At the moment, the agricultural machinery and the infrastructure of factories are very affected by obsolescence and deficient technical state. This influences the low yields of production and production costs. It is not possible to replace all this machinery in a short period of time, so it is necessary to find organizational procedures that increase the efficiency of the available means.

The aim is to achieve an organizational structure for the management of agricultural machinery and its workshop and equipment facilities that will increase its effectiveness and scope, also linked with a plan for the reordering of technical resources and personnel involved in the activity. The main advantages are centered on the possibility of having more effective organizational systems, as well as the orientations and strategies for their development.

The main services that will be provided are the following:

- Mechanization services to the production units served by the Municipal Agricultural Company in the different agricultural tasks.

    - Maintenance services for irrigation and drainage systems, agricultural roads and other infrastructure works.

    - Technical assistance and repair services for the tractor park, agricultural machines and implements, irrigation equipment, transportation means and other specialized equipment.

    - Technical consultancy services related to the organization and proper use of machinery, irrigation and transport.

The UEBIST provides the mechanization services according to the Balances of Machinery and Irrigation prepared in the production units from the planting plans, as well as technical assistance to agricultural machinery equipment, irrigation and means of transport, making both services through a Single Contract signed between the producing units and the Municipal Agricultural Company. It is part of the Single Contract signed between the Production Unit and the Municipal Agricultural Company, the description of the work to be carried out (tasks, area, technical and agronomic parameters), period of completion, quality of the work, cost of work, collection procedure, payment method and penalties for breach of the parties. (Suárez, et al, 2011)

In present-day agriculture, there is a tendency to reduce operating costs and avoid costly depreciation of machinery that, in some cases, would be impossible to amortize during its entire useful lifespan. There are many farmers who carry out the most common tasks in their crops with their own means, such as cultural care, irrigation and fertilization, but they have contracts with companies that provide agricultural services for some tasks that they can not perform, such as soil preparation, harvesting, packing, crushing, pruning, etc. These companies work not only in the provision of agricultural services to producers, but also in technical advice and training, for which it is important that the provider has adequate training and continually develop their skills, knowledge and entrepreneurial skills to ensure thus, the correct execution of services in rural areas. (cited in Figueroa et al, 2010)

This form of organization took a new impulse in Cuba from the year 2009 when the first Integral Business Units of Technical Services were created, a process that later became generalized to the rest of the country (cited in Figueroa et al, 2010). They were created on the basis of the facilities of the old workshops and have not experienced significant structural and technological changes in the last 20 years. This being one of the causes of their low level of development compared to the new quality standards, construction design showing the new agricultural machines, tractors and agricultural implements that have been introduced in the agricultural sector through different programs for the development of mechanization in Cuba and some international projects. (Fernández, Suárez, ShkiliovaIII y Urgelles, 2017)- The process of providing services is shown in Fig 5.

In order to successfully implement this new organizational form, it is necessary in advance to objectively identify those internal and external aspects that may limit the fulfillment of the mission of the future business units of mechanization services, technical assistance.

The framework of the proposal of financing to the Green Climate Fund (GCF), the Government of Cuba with the support of the FAO, has considered including the request of resources that allow to strengthen the management capacity, improve its productivity and access to the services market of machinery, contributing to the formation and development of the value chain of the provision of agricultural machinery services, at a territorial level; as well as, the development of the agricultural sector.

In order to ensure the sustainability of the results of the administration and management of the resources allocated or acquired by the UEB; it is in common agreement with the management and its members that it is necessary to develop and implement a sustainability strategy for the business model to be strengthened. One of the key elements in this process is to promote the capitalization of the UEBIST, by having a fund to meet the demand for services and the needs of equipment maintenance and replacement; For this, it is necessary to create a "revolving fund" or "revolving fund", a fund that arises in kind but is subsequently monetized in order to achieve sustainability for investments aimed at acquiring inputs, replacement or acquisition of equipment to strengthen or expand its access and sustained growth in the market of agricultural machinery services, in this very particular case.

11. Forest and agricultural species to be used in the agroforestry modules for landscape restoration

In the next section, the agroforestry modules within the IRES project will be introduced; however, before the modules are described, it is important to make a brief description and discussion about the trees, crops and forage species selected for these modules.

The selection of the species has been made in consultation with different stakeholders (national and international experts, Cuban government officials and FAO staff) and an effort was made to keep the number of alien species to a minimum. The alien species included, were selected due to the fact that there are not native species that could perform as well as those alien species, they are already existing in the implementation areas, and they show a low potential of invasiveness.

It is importante to mention that the Project formulation Team, has been always aware of the risks to work with Alien Species, and all the recomendations have been done based on the IFC ESS policy on invasive species[6] and the FAO Enviromental and social management guideline[7], and as well the Cuban normative regarding the use of Alien species (Law 81 regarding the Environment. July 1997).

From the earlie stages of the project formulation, there were different discussions with national and international experts, about the use of alien species in the project. After a deep analysis with national/international experts and Cuban government authorities, species such as neem (Azadirachta indica), Acacia (Acacia mangium), Guinea grass (Megathyrsus maximus), with a high potential profile to be invasive species, where excluded from the first modules design. In the same context it was agreed to keep some alien species with lower potential level of invasiveness risks, but providing control management measures that will be implemented in order to develop more diversified production alternatives, including agricultural and cattle diversity, which will be more viable when facing the effects of climate change.

In these modules, a total of 26 different species were selected. Native and naturalized species account for 54% of the total, while alien species total 15% (4 species). The rest are crop species (such as Maize [*Zea Mays* L.]) which are widely cultivated elsewhere. The species were arranged following classification enclosed in Table 23.

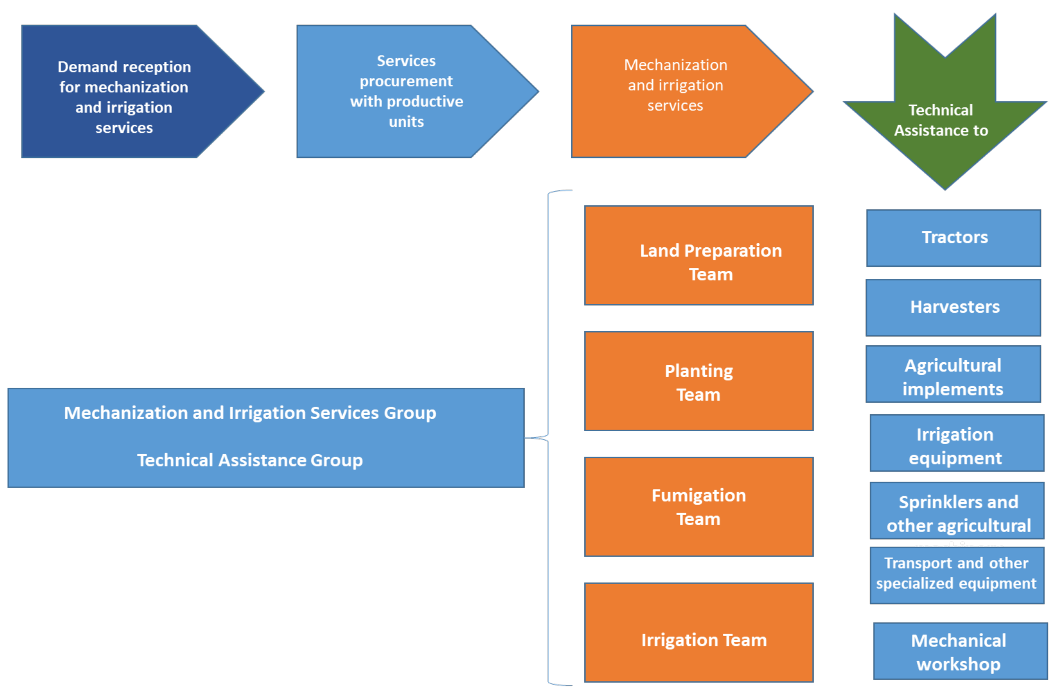


Fig 5: Design proposal of the U.E.B Integral of Technical Services (Adapted from Suarez et al 2011*)*

Table 25, summarizes the description of all the species to be used in the agroforestry modules in the IRES-Cuba project, and the proposed management measures in the case of the three alien species with a low potential risk of invasiveness. The 4 alien species considered are: Brachiaria brizantha, Arachis pintoi, Morus alba and Moringa oleifera, which are well known by farmers and the scientific community, with a long history in Cuba, and without a report of an invasiveness behavior in the country.

[6]https://www.ifc.org/wps/wcm/connect/c02c2e86-e6cd-4b55-95a2-b3395d204279/IFC_Performance_Standards.pdf?MOD=AJPERES&CVID=kTjHBzk
[7] http://www.fao.org/3/a-i4413e.pdf

The project´s modules that manage alien species are those of silvopastoralism. It is noteworthy that, for the effects of climate change, they notably favor carbon capture capacity and the balance of emissions, contribute to improving the water balance, reduce vulnerability to drought and prevent soil erosion, while at the same time it make possible the thermal regulation, help the animal welfare before the increase of the temperature and the evapotranspiration. In this way, sufficient feed is guaranteed to the cattle throughout the year, including the dry period, eliminating the dependence on imported grains, which results in an increase in income and better livelihoods for the producers. The Cuban herbaceous species due to characteristics such as their size, speed of growth, protein intake and usable mass, are not capable of sustaining efficient livestock systems.

Table 23: Recommended terminology in plant invasion ecology

Alien plants	**Plant taxa in a given area whose presence there is due to intentional or accidental introduction as a result of human activity (synonyms: exotic plants, non-native plants; nonindigenous plants).**
Casual alien plants	Alien plants that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions for their persistence (includes taxa labelled in the literature as *waifs*, *transients*, *occasional escapes* and *persisting after cultivation*, and corresponds to De Candolle's (1855, p. 643) usage of the term *adventive*).
Naturalized plants	Alien plants that reproduce consistently (cf. *casual alien plants*) and sustain populations over many life cycles without direct intervention by humans (or in spite of human intervention); they often recruit offspring freely, usually close to adult plants, and do not necessarily invade natural, semi-natural or human-made ecosystems.
Invasive plants	Naturalized plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants (approximate scales: > 100 m; < 50 years for taxa spreading by seeds and other propagules; > 6 m/3 years for taxa spreading by roots, rhizomes, stolons, or creeping stems), and thus have the potential to spread over a considerable area.
Weeds	Plants (not necessarily alien) that grow in sites where they are not wanted and which usually have detectable economic or environmental effects (synonyms: *plant pests*, *harmful species*, *problem plants*). *Environmental weeds* are alien plant taxa that invade natural vegetation, usually adversely affecting native biodiversity and/or ecosystem functioning (Humphries et al., 1991; Randall, 1997).
Transformers	A subset of invasive plants which change the character, condition, form or nature of ecosystems over a substantial area relative to the extent of that ecosystem.
Source: Richardson *et al.*, 2000	

The silvopastoral modules have been designed on the basis of the research (more than 25 years) of the Institute of Animal Sciences (ICA) belonging to the Ministry of Higher Education, and of the Pastures and Forages Research Institute of the Ministry of Agriculture, incorporating also experiences of the Pastures and Forages Station of the Ministry of Science, Technology and Environment (CITMA).

The four alien species included are listed below, with an additional rational:

Manicillo (*Arachis pintoi*): Species not reported as invasive, widely cultivated. CABI (2019a)

Bread grass (cv Marandu) (*Brachiaria brizantha* [Hochst. ex A. Rich.] Stapf): These species has not been reported as invasive (CABI, 2019b); additionally, its caespitose habit might hinders the dispersal of the species.

Morus (*Morus alba*): Multipurpose tree widely planted in tropical, subtropical and mild temperate regions of the world for fodder and silkworm rearing, and for fruit and timber production. According with CABI (2019c) is a species widely cultivated and with low invasive reports.

Moringa (*Moringa oleifera* Lam.): Moringa is regarded at present by CABI (2019d) as a widely cultivated species and with low invasive potential.

Some of the management measures to take in consideration to reduce or mitigate the risk of the invasive effect of the low potential alien species are :

- The modules should include green shade barriers that will help contain their spread of non-native grasses. These barriers should be planted with indigenous trees that provide dense shade.

- Species to be use for forage, should be used for cutting and racing at short cycles.

- Include capacity building for rural populations who will benefit from the project to provide training on control techniques and practices for marabou and other invasive species.

- Rural populations involved should not only receive benefits, but also endure the responsibility over the land they receive for their use, mainly to avoid reinvasion by marabou, but also to prevent the spread of other invasive species if maintained in the production modules. The project must also include provision for tools and materials for follow up control of marabou and other invasive species.

- An early detection and rapid response system for biological invasions is desirable so that the Ministry of Agriculture can take immediate action upon alerts sent by rural populations on new invasion foci by marabou and other invasive species derived from this project in the future. This could be part of a contingency plan developed by the project to reduce the risk of using certain invasive species as currently proposed.

- Even the project knows there is a risk with the use of those invasive alien species, it is expected that with the right measures, it will not be a problem, and the risk can be managed.

In the case of Moringa oleífera, special attention should be given, as it appears on the list of invasive species in Cuba, and according to the attached risk analysis in supplementary material X is a kind of moderate risk. Because of this, the following species-specific measures are recommended:

- To limit the possibilities of dispersion, planting near rivers and streams should be avoided.

- It is also recommended to ensure that the remains of pruning activities and any other action that involves cutting the stems of the species are burned, composted or disposed of in some other way to ensure that they lose their ability to establish.

- Early pruning of the specimens (before flowering) will reduce the risk of dispersion through the inhibition of seed production.

- It is recommended to establish a safe area around the plantations where the eventual spontaneous recruitment of plants of the species is monitored. This area should be reviewed with a periodicity not less than one semester to allow the detection of possible leaks before the specimens produce seeds. The individuals detected should be safely disposed of (see above).

- The plants have a high regrowth capacity so ensuring the extraction of specimens from the root is necessary, or otherwise be complemented with chemical control techniques.

- It is recommended that the actions be complemented with spontaneous nucleus control tasks at the level of the work area, if any, even if they were not associated with the crop. It is very important to inform the population that beyond its positive attributes, the species must be kept in cultivation, eliminating concentrations of spontaneous establishment. Therefore, a communication strategy must be developed that conveys the risks associated with the expansion of the species.

- Regardless of the measures taken at the level of the enterprise in which the cultivation of the species is developed, the risk that people carry propagules of the species to other places where they are used for other purposes and/or without the aforementioned controls should be considered.

Table 24**:** List of species to be used in the Agroforestry modules in the IRES-Cuba project, including the risk of invasive alien species and the type of management measures to reduce the risk of invasinveness

SCIENTIFIC NAME COMMON NAME	DESCRIPTION	STATUS	SELECTION CRITERIA	INVASIVENESS RISK	INVASIVENESS RISK REDUCTION MEASURES
***Brachiaria brizantha* (Hochst. ex A. Rich.) Stapf** (Bread grass / Marandu)	Perennial gramineae that develops in humid and sub-humid regions. It adapts to well drained soils of medium fertility with pH> 4.5; It is resistant to prolonged droughts, with good production of forage in critical season.	Alien	The species can tolerate frequent defoliation under grazing or cutting and withstand drought periods of up to 6 months (Cook *et al*., 2005) Had been included due low productivity of indigenous forage grasses Native pasture species are not sufficient to sustaining efficient livestock systems	This species has not been reported as invasive (CABI, 2019a)	Monitor established areas for signs of invasiveness Create green shade barriers to contain possible spreading Implement capacity building programs for rural populations who will benefit from the project to provide training on control techniques and practices of invasive species
***Bursera simaruba* (L.) Sarg.** (Almacigo-Indio desnudo**)**	Native tree of high size that can reach up to 25 m in height, perennial foliage and wood that despite being white and of low hardness, has varied uses. Tolerates drought and is medicinal, with leaves used to make tea and wood for furniture and indoor use	Native	-	-	-
***Caesalpinia violacea* (Mill.) Standl.** (Yarúa)	Medium-to-large native legume tree that can reach heights up to 40 m and diameter of more than 30 cm.	Native	-	-	-
***Cedrela odorata* L.** (Cedro)	It is a tree of the Meliaceae family, slender, of medium to large size that can reach 30 m and more in height and a saw-toothed trunk of 10 or 12 m long with a diameter of up to 60 cm.	Native	-	-	-
Citrus reticulata (Mandarina)	There are different varieties; the pulp of the fruit is sweet and sour very pleasant and demanded by the population and tourism.	Alien (cultivated)	-	Not reported	-
***Citrus sinensis* (L.) Osbeck** (Naranja dulce)	Tree widely cultivated throughout Cuba of which numerous varieties are known; fruit very desired by the population and that has great demand for tourism.	Alien (cultivated)	-	Not reported	-

Table 24. List of species to be used in the Agroforestry modules in the IRES-Cuba project, including the risk of invasive alien species and the type of management measures to reduce the risk of invasinveness

(Continuation)

SCIENTIFIC NAME COMMON NAME	DESCRIPTION	STATUS	SELECTION CRITERIA	INVASIVENESS RISK	INVASIVENESS RISK REDUCTION MEASURES
***Colubrina arborescens* (Mill.) Sarg.** (Bijaguara)	Belongs to the ramnaceae family, can reach a height of 25 meters, grows rapidly, can be used in rural buildings, poles, sleepers, bridge wood and turned objects	Native	-	-	-
***Cordia gerascanthus* L.** (Baria prieta)	Species belonging to the family borraginaceae, large tree with a remarkably tall stem, grows rapidly and has deep roots. Tree of medium size, straight and clean bolus that can reach 15 m in height and up to 50 cm in diameter	Native	-	-	-
***Guazuma ulmifolia* Lam.** (Guácima)	Tree of the family Esterculiaceae. It grows in all kinds of terrain, reaches 12 m in height and up to 0.80 m in diameter, widely distributed grows wild throughout the island.	Native	-	-	-
***Ipomoea batatas* (L.) Lam.** (Camote boniato)	Perennial tree from 3 to 10 m in height and pivoting roots, although some timber varieties reach up to 20 m. It adapts to a wide range of soils with pH 5.5-8.0; tolerate prolonged droughts	Naturalized	-	Not reported	-
***Lysiloma latisiliquum* (L.) Benth.** (Soplillo)	Native perennial tree of the family mimosácea, reaches 7-10 meters high, blooms from April to May, is able to develop on poor and skeletal soils even of high stoniness	Native	-	-	-
***Mangifera indica* L.** (Mango)	Tree widely cultivated in Cuba of which there are many varieties; It has a great demand for population, tourism and industry. Its introduction in Cuba dates back around 100 years and has been naturalized throughout the country	Alien (Cultivated) More than 100 years in the country	-	-Not reported	-
***Manihot esculenta* Crantz** (Yuca)	Widely cultivated in most of the tropical and subtropical areas of the American continent	Naturalized (Cultivated) (Cuba is center of origin and dispersion of the specie)	-	-Not reported	-

Table 24.. List of species to be used in the Agroforestry modules in the IRES-Cuba project, including the risk of invasive alien species and the type of management measures to reduce the risk of invasinveness (Continuation)

SCIENTIFIC NAME COMMON NAME	DESCRIPTION	STATUS	SELECTION CRITERIA	INVASIVENESS RISK	RISK REDUCTION OPTIONS
***Moringa oleifera* Lam.** (Moringa)	It grows in poor soils, resistant to drought, grows well in arid and semi-arid conditions. Fast growing, can reach up to 4 m / year. It is a forage plant with a high percentage of crude protein, the waste from oil extraction is used as a food supplement for poultry and livestock	Alien	Multipurpose tree use for food and forage, among other uses (Oyeyinka and Oyeyinka, 2018)	This species did not report an invasive history in Cuba's environment. However, it is included in the list of Alien species in Cuba González-Oliva et al. 2015 The risk analysis done in the framework of this project formulation (see suplementary material 16.6) suggest the specie in Cuba has a moderate risk	Monitored and controlled to avoid possible invasion in the future. Implement capacity building programs for rural populations who will benefit from the project to provide training on control techniques and practices of invasive species It will be used for cutting and racing at short cycles. It has been included due to the lack of native forage species. The proposed management constitute scientific results validated in practice. Planting near rivers and streams should be avoided (see supplementary material 2.6.7 for more details)
***Morus alba* L.** (Morera)	The adult tree has 20 m or more in height. It grows well in soils of medium texture, good drainage, pH of 6 to 7. with good biomass production, high palatability and high nutritional value (proteins, minerals, and energy), due to its digestibility it is recommended for monogastric	Alien (Cultivated)	-	-Not reported González-Oliva et al. 2015	Monitored and controlled to avoid possible invasion in the future. Implement capacity building programs for rural populations who will benefit from the project to provide training on control techniques and practices of invasive species It will be used for cutting and racing at short cycles.
***Musa paradisiaca* L** (Plantain)	Rustic species with high productivity and resistance to pests, diseases and drought; its fruit is very common in Cuban cuisine	Alien (cultivated)	-	Not reported	-

Table 24. List of species to be used in the Agroforestry modules in the IRES-Cuba project, including the risk of invasive alien species and the type of management measures to reduce the risk of invasinveness (Continuation)

SCIENTIFIC NAME COMMON NAME	DESCRIPTION	STATUS	SELECTION CRITERIA	INVASIVENESS RISK	RISK REDUCTION OPTIONS
***Petitia domingensis* Jacq.** (Roble guayo)	Tree very common in all the Island, it develops in calcareous and stony lands. With thick trunk and smooth bark, it reaches up to 22 m in height.	Native	-	-	-
***Phaseolus vulgaris* L.** (Frijo común)	It admits a wide range of soils, the most indicated being the light soils, siliceous-silty texture, with good drainage and rich in organic matter. The optimum pH values range between 6 and 7.5	Alien (cultivated)	-	-Not reported	-
***Pinus caribaea* Morelet** (Pino macho)	It can reach up to 25 m in height, with a straight and cylindrical trunk; Its wood is very versatile and has multiple uses. It is a pine resistant to drought	Native	-	-	-
***Saccharum officinarum* L.** (Caña de azúcar)	The cultivation of sugar cane as cattle feed is well known and used in Cuba, especially in the dry period, functioning as an energy bank	Alien (cultivated)	-	-Not reported	Monitored and controlled to avoid possible invasion in the future. Implement capacity building programs for rural populations who will benefit from the project to provide training on control techniques and practices of invasive species
***Albizia saman* (Jacq.) Merr.** (Algarrobo del país)	Tree that in fertile soil conditions can reach large dimensions, very beneficial in soils due to the symbiotic fixation of Nitrogen and the contribution of leaf litter;	Naturalized	-	It did not express invasive history in Cuba's environment. González-Oliva et al. 2015	Monitored and controlled to avoid possible invasion in the future. Implement capacity building programs for rural populations who will benefit from the project to provide training on control techniques and practices of invasive species
***Spondias purpurea* L.** (Ciruela común)	Highly demand tree due its fruits, and to be used on living fences	Native	-	-	-

Table 24. List of species to be used in the Agroforestry modules in the IRES-Cuba project, including the risk of invasive alien species and the type of management measures to reduce the risk of invasinveness (Continuation)

SCIENTIFIC NAME COMMON NAME	DESCRIPTION	STATUS	SELECTION CRITERIA	INVASIVENESS RISK	RISK REDUCTION OPTIONS
***Tabebuia angustata* Britton** (Roble blanco)	Medium-sized tree, reaches about 20 m in height and up to 75 cm in diameter. Flowers from April to June, pink flowers. It is naturally associated with júcaro in high coastal soils, it is not demanding to soil conditions. It occupies margins of rivers, stream and high banks of swamp	Native	-	-	-
***Vigna unguiculata* (L.) Walp.** (Frijol carita)	Climbing plant; the grain is consumed abundantly by the population but it is less desired than the typical black and red beans. It is a fodder plant and is also used as green manure.	Alien (cultivated)	-	Not reported	-
***Zea mays* L.** (Maíz)	Gramineae with a production cycle of three months, native and domesticated by indigenous peoples in central Mexico for about 10,000 years	Naturalized (Cultivated)	-	-	-
Arachis pintoi (Manicillo)	Introduced perennial herbaceous creeping and stoloniferous growth, yellow flower, bare stem, dark green leaf, underground seed, forms a dense mat. It adapts well in acidic to alkaline soils, with medium-high fertility. The potential for animal production of pastures associated with Arachis is 150 to 180 kg / an and 400 to 600 kg / ha per year	Alien	It has been included due to the lack of native forage species. The proposed management constitute scientific results validated in practice.	Specie not reported as as invasive specie, widely cultivated. CABI (2019a)	Monitored and controlled to avoid possible invasion in the future. Implement capacity building programs for rural populations who will benefit from the project to provide training on control techniques and practices of invasive species

12. Modules of selected good agribusiness practices

In order to select successful experiences of good agroforestry management practices that can be implemented in the AIP, an analysis was carried out and various agroforestry, silvopastoral and forest systems existing in the country were documented. Initially local authorities and technicians, government officials, and the general public were contacted in order to collect information and then locate a list of possible successful experiences that were visited. After having carried out the on-site visits, seven potential modules were identified, which were evaluated and validated by expert criteria in two workshops held with authorities, academia, and the general public (See Supplementary Material 2.6.4 and Supplementary Material 2.6.5).

Premises indispensable for the selection of the modules were the contribution to the reduction of the vulnerabilities of homes and people and the sustainable nature of the practices. Table 25 shows the name of the modules and the experiences that gave rise to them.

Table 25: Name of the modules and experiences that gave rise to them

No.	Short Name	Name	Experience
1	CEDPLA	Agroforestry system with *Cedrela odorata* (common cedar) interspersed with other forest species and agricultural crops with perimeter live fences	Business group "Tabacuba"
2	MARREG	Establishment of forests through natural regeneration assisted in marabuzales	Model Forest Sabanas de Manacas (BMSM)
3	MARFOM	Establishment and management of multifunctional forest plantations in areas invaded by marabou	Model Forest Sabanas de Manacas (BMSM) and in Agroforestry Company (EAF) Las Tunas.
4	FRUAGR	Agroforestry system with fruit trees, agricultural crops and live fences	Farm Los Velásquez. Las Tunas and El Aguacate, Santo Domingo.
5	SILLEC	Silvopastoral system with legumes	Animal Science Institute (ICA)
6	SILSOM	Grazing with shade trees, live fences and protein bank with Morera and Moringa	Institute of Pastures and Forages Research (IIPF)

Source: Self made

Similarly, the application of the Adaptation based on Ecosystems (EbA), which involves both natural systems and households and communities, implies a paradigm shift in the rural scenario of the AIP since it includes conservation, sustainable management, and the restoration of natural ecosystems.

The selected area in which the modules will be implemented in the seven municipalities during the project execution period total 35 734 ha (supplementary material 2) distributed in 252 productive forms: 61 UBPC, 44 CPA; 98 CCS, 48 UEB and 1 Farm / Company, in addition to usufructuaries of lands favored by the Decrees Law 259 and 300.

Of this surface, around 15,545 hectares correspond to the implementation surface of four of the six modules, which are covered with marabou, which constitutes the baseline of the same. In this sense suffice to say that, discounting the income generated by the production of coal, the economic contribution of the marabuzales is very little and is limited to the extraction of firewood and fence posts fundamentally what is done spontaneously and without arrangement No handling or authorizations.

Fig 6 and Fig 7, show the distribution of the different productive agroforestry modules in the project implementation area (Santa Clara-Region A, Las Tunas-Region B).

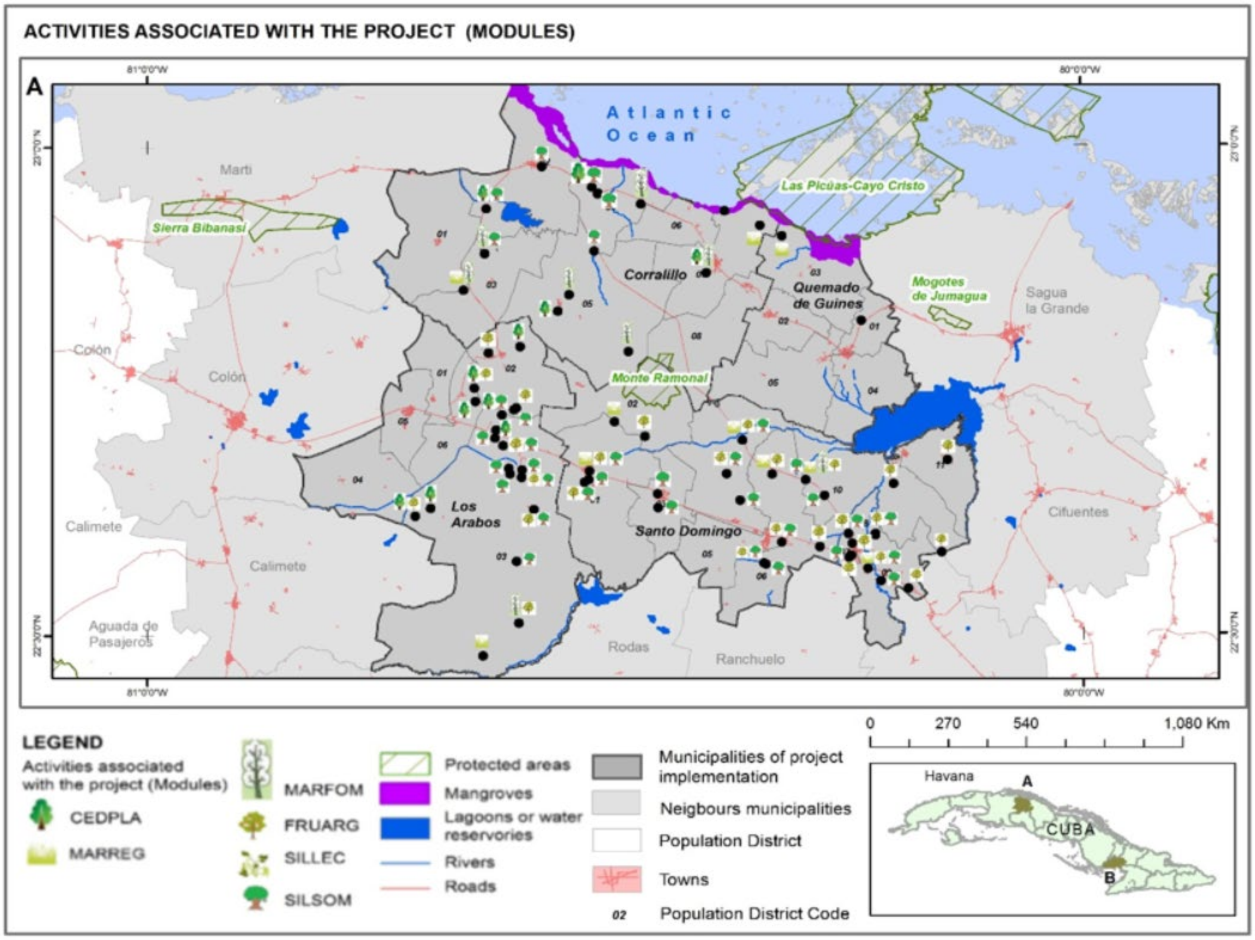


Fig 6: Distribution of production modules in the Santa Clara region (A)

The implementation surface of the different modules was taken from the Soils report and later specified by field trips made by specialists from the Delegations of Agriculture of the municipalities involved in the project: State Forestry Service, Department of Land Control and Units Businesses of Base (Forestry, Agricultural and Livestock) along with each of the productive forms (state, non-state and usufructuaries).

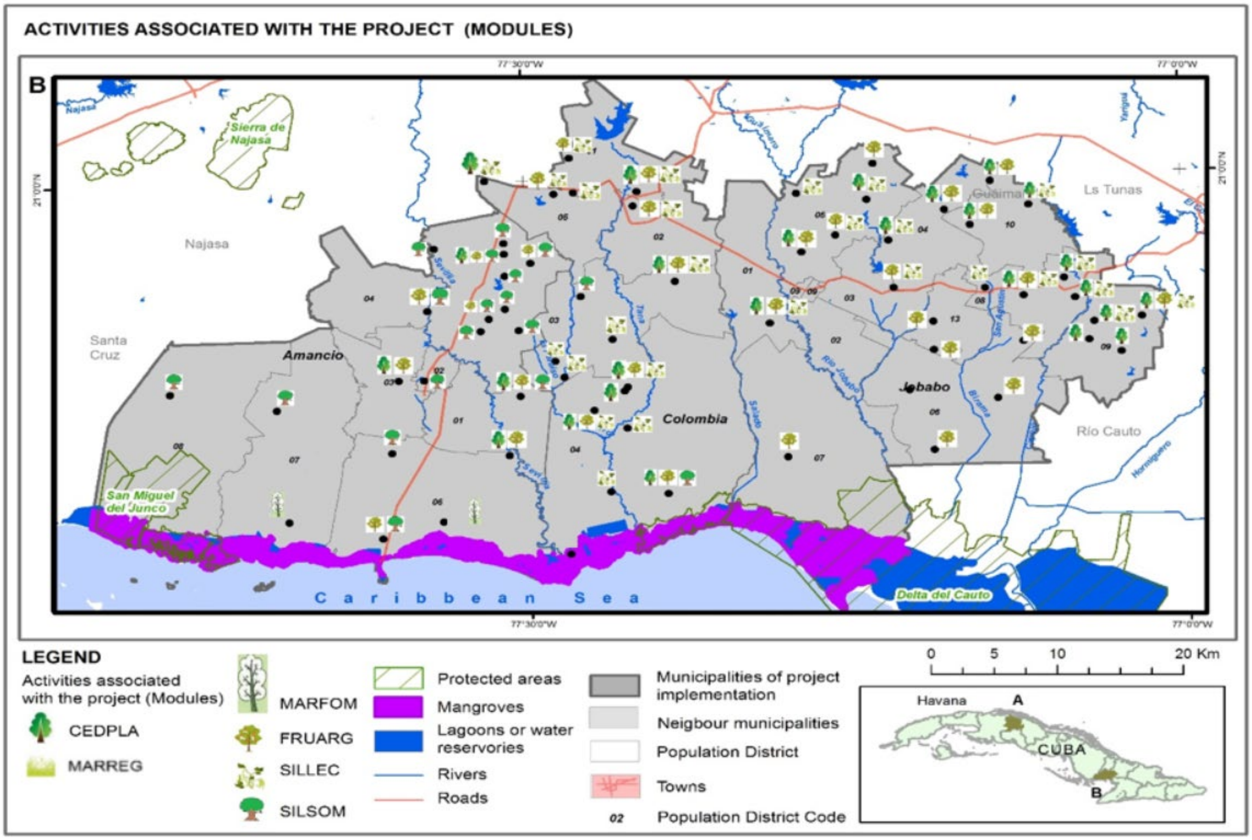


Fig 7: Distribution of production modules in the Las Tunas region (b)

The selected areas are located in areas near populated centers with certain levels of risk and vulnerability; it was also taken into account that the characteristics of the soils were compatible with the proposed use and availability of labor force.

The current development of commercial forest plantations and the experience developed determines agroforestry combinations as a viable technical option (López, 2007). The trees of these agroforestry systems fulfill many purposes such as production of (wood, firewood, fodder, fruits, medicines, etc.) as well as services (shade for crops and / or animals, protection as in the case of windbreaks, etc.).), Increase the biological diversity of the agro ecosystem by creating in its branches, in its roots and in the litter, homes for other organisms.

In order to standardize the modules, a structure was designed to characterize them from the technical, environmental, social and economic - financial point of view, which appears in (Supplementary material 3).

CEDPLA MODULE

12.1 Agroforestry system with Cedrela odorata (cedar) intercaled with other forest species and agricultural crops with live perimeter fences. (CEDPLA)

12.1.1 Description of current situation and baseline

For Cuba, cedar wood has a significant importance because in addition to the high appreciation it deserves for the population and for being the main base for the manufacture of furniture and carpentry objects in general, it is an important element for the commercialization of Cuban cigars.

In the tobacco industry, cedar wood has great importance in the export market of cigars (cigars), for this reason, the TABACUBA Business Group has decided to initiate the promotion of Cedar plantations to guarantee their future needs and not depend on an uncertain and insufficient market.

On the other hand, the unsatisfied demand for cedar wood and its high cost, as well as the limitations for its commercial production make the cultivation of this species very attractive to the Cuban population in general and to the farmers in particular.

However, attempts to establish commercial monkey plantations specific to this species have failed, not only in Cuba, but in Latin America, due to the attack of Hypsipyla grandella, whose presence in young plantations causes malformations in all trees and sometimes causes their death, limits their growth and development and make them unusable from the commercial point of view.

In Cuba there are experiences to produce cedar in association with plantain (Musa paradisiac) using narrow spacing of 4m x 4m (625 plants / ha) of culture; which allows an increase of wood of this species up to 7m3 / ha / year but with the disadvantage from the ecological point of view that requires the application of insecticides to eliminate or mitigate the effect of the aforementioned pest until two or three years after age. To avoid the application of insecticides, in this module, the spacing of the cedar plants has been greatly expanded so that they are hidden in the agroforestry arrangement with plantain and the other forest species included in the module. It is expected to minimize the risk of damage caused by the Hypsipyla.

In the AIP, the average annual increment (IMA) of the other species included in this module, such as the yarúa, baría and bijáguara, is low, in the order of 3 - 4 m3 / ha / year (Forest Management Projects) of the business system) although its potential is greater.

It should be noted that the current food production in general does not satisfy the demand nor the per capita consumption requirements of food, grains, fruit and vegetables; considering the productive history of these territories, the banana is one of the crops highly demanded by the population for its multiple uses; which is why the inclusion of plantain in the forest arrangement in this module is considered.

12.1.1.1 Agro ecological description: site quality, soils, precipitation and humidity

The cedar grows naturally and preferably in brown soils on calcareous rocks, deep, fertile and of good drainage, of alkaline pH to slightly acidic. However, it is also forming the arboreal stratum in the "semi-deciduous forests on limestone soil" which, in large areas, develop on very shallow soils with low moisture retention. The flat or slightly undulating topography without flooding probability, it prefers the tropical

Semi-Humid climate of Sabana with two periods of rain well differentiated during the year: little rainy (November-April) and rainy (May-October).

Betancourt (1987) states that in Cuba this species has been observed growing in areas with annual rainfall of 757 mm, well below the national average and even places where these are high, greater than 2000 mm. In terms of temperatures, this species tolerates maximums greater than 360 ºC and absolute minimums of up to 5ºC. These characteristics make it a suitable species to be used in places where changes are foreseen in the main climatic variables that are also present in the AIP where specimens that grow naturally are also observed.

12.1.1.2 Area and productive forms for the implementation of the module

This module is planned to be implemented in areas invaded by marabou. In the selection of the sites, it was taken into account that the cultivation of cedar and banana requires well-drained and deep soils with Ph between 6.8 and 7.2. Due to the particularities of its management, this system offers better results when it is implemented in small areas, no larger than 50 ha. (Personal communication of specialist of the Business Group Tabacuba). As a criterion for the final definition of the CEDPLA module, the proximity to water sources will be considered because the module needs to have this resource 12 months of the year.

Taking into account the characteristics of soil and climate, the total area of the arrangement for this module is 1 754 hectares, distributed in five municipalities of the seven participants in the project; since it will not be implemented in the municipalities of Santo Domingo y Quemado de Guines (See Table 26), in 39 productive forms, which will be responsible for the execution of the activities; which represents an average of 44.9 ha per productive way.

Table 26: Area in Hectares proposed for the implementation of the module by municipalities

CEDPLA MODULE									
	Las Tunas				Matanzas		Villa Clara		**TOTAL**
ENTITY	Amancio	Colombia	Jobabo	**TOTAL**	Los Arabos	**TOTAL**	Corralillo	**Total**	
CCS	164	33	170	**367**	13.42	**13.42**			**380.4**
CPA	63	1	211	**275**	46.97	**46.97**	41.8	**41.8**	**363.8**
UBPC		27	172	**199**	33.55	**33.55**	36.84	**36.84**	**269.4**
UEF	240		500	**740**					**740**
TOTAL	467	61	1053	**1581**	93.94	**93.94**	78.64	**78.64**	**1754**

12.1.2 Objective and justification of the proposed module

12.1.2.1 Impact on the resilience of the population

With the implementation of this module, of which there are no experiences in the AIP, the aim is to increase the resilience of communities and households to the CC through a sustainable agroforestry system that will provide sufficient financial resources to achieve adequate levels of quality of life. The people and families.

The mixture of cedar with the yarúa, bijaguara and the baría, drought-resistant species with pivoting and deep root systems increase the infiltration levels of rainwater (see Supplementary Material1) and are also less susceptible to the effects of forest fires; this, together with the wide range of uses that wood has, of these species, provide greater income to the people linked to this module; On the other hand, the use of irrigation systems with low water consumption as expected, puts the population in better conditions with respect to the availability of water and food even in periods of drought.

The plantain can become a food and economic guarantee for people who dedicate themselves to it and thus place them in better conditions to recover from extreme events that affect their homes and production (ability to invest again).

12.1.3 Description of the species that make up the module

a. ***Cedrela odorata*** *(cedar)*: a tree of the meliaceae family, slender, medium to large in size that can reach 30 m and more in height and a hardwood trunk of 10 or 12 m in length with a diameter of up to 60 cm. It is a kind of deciduous foliage very common in the Cuban landscape but not abundant, heliophilous when young (brinjal stage) requires to be intensely lit in its glass and at the same time to have lateral shade. Cedrela species are widely distributed in Latin America and the Caribbean.

b. ***Musa paradisiaca*** (Donkey plantain): this species includes some varieties, among which is the CEMSA donkey banana, which is a rustic species with high productivity and resistance to pests, diseases and drought; its fruit is very common in Cuban cuisine and also, in the first years of establishment of the module, it is practically the only source of monetary income to the farm.

c. ***Caesalpinea violácea*** (yarúa): medium to large autochthonous leguminous tree that can reach heights up to 40 m and diameter of more than 30 cm. It manifests an average growth and its wood, resistant in exteriors, is used as fence posts, sleepers, wood slats, and rural constructions in general; for these reasons it is a very useful tree and appreciated by peasants and rural people. It provides nitrogen and a large amount of biomass to the soil due to its abundant litter production.

d. ***Cordia gerascanthus*** (baria prieta): Cuban native species of the Boraginaceae family. Tree of medium size, straight and clean bolus that can reach 15 m in height and up to 50 cm in diameter, belonging to the formation of semi-deciduous forests on limestone soil. The plant has a deep root and grows rapidly and can reach 1 meter per year. It is heliophilous, grows in different types of soils from brownish to ferralitic, stony, tall and drying. It can be planted associated with cedar. Hard and heavy wood of 800 - 970 kg / m3.

e. ***Ferruginous colubrina*** *(bijáguara):* belongs to the family ramnaceae, can reach a height of 25 meters, grows rapidly, can be used in rural buildings, poles, sleepers, bridge wood and Wood lathe.

f. ***Spondias purpurea*** (common or yellow plum): it is frequent throughout the island and suitable for use in live fences because of the ease with which it is achieved and desired for its fruit that is eaten directly or prepared soft drinks and sweets.

Having completed the arrangements of the module and selected the forest and agricultural species, it is established that the participation of cedar in this module is only 10 % looking to reduce the attack of the Hypsipyla. The detail of the plantation framework of the species included in this module is presented in Table 27.

Table 27: Plantation Framework by Species

Species	Plantation Framework (m)	Plant Number/ha	% Total Plants
Cedar	12 x 12	64	10
Baría	12 X 4	184	28
Yarúa	12 X 4	184	28
Bijaguara	Variable	120	19
Common or yellow plum	4 m between plants	98	15
Donkey Plantain	4 X 4	625	100

12.1.4 Agro-ecological practices and tasks for the implementation and management of the module.

12.1.4.1 Technical description of tasks

a) **Plantation of forest species**

- **Recruitment and acquisition of seedlings of forest species**: The seedlings needed to establish forest plantations will be produced through the Business Base Units (UEB) located in municipalities of the AIP, companies specializing in the production of goods and support service to the forestry sector, members of the GAF Agroforestry Group); with whom the productive forms (UEPC, CPA or CCS) will establish a contract for the provision of seedlings.

- For forest species the acquisition of 5% additional to the number of plants / ha indicated in which the frame of planting by species is defined in Table 23.

- **Land preparation**: As described above (Technical considerations); the conditions of the site should be evaluated; considering factors such as climate, geology, soil fertility and texture, vegetation, management and previous use of the soil (covered with marabou); activity carried out in mechanical forms (see description of machinery in supplementary material No.2.6.5).

- **Establishment of the living fence**: Seedlings of the species that will be substituted for the live fence tree produced in nursery and planted 4 m apart from each other. Live fences play the role of producing firewood, timber and promoting biodiversity.

- **Postures and plantation framework**: Defined the arrangement of the module and selected the forest and agricultural species, it is established that the participation of the cedar in this module is only 10% looking with them to reduce the attack of the Hypsipyla. The detail of the plantation framework of the species included in this module is presented in Table 23.

- **Planting and replacement of faults**: Stroke, staking and hole digging, ensuring a deep ahoyado of 40 cm with application of 5 kg of organic matter. Planting will take place in the months of June to October, where there is adequate soil moisture; and replenishment of faults: it is carried out in the first and second year in the rainy season.

- **Fire protection**: Construction of firebreaks. Mineralized strip (4m wide) to the contour of the area. It will be done before planting.

- **Pruning**: periodic from the second year of planting.

- **Stinging**: do not apply to cedar. To the rest of the species, the first at 10 years (intensity 10%, production of 8 m3 of round wood): the second at 16 years (20% intensity produces 30 m3 of wood, mainly round) to finally leave 400 trees, of which 340 are of the other three species and 60 of cedar.

- **Control of Hypsipyla grandella**: the proposed plantation framework for cedar and also the intercalation of three other species of trees and banana plus biological and mechanical control, will enable the infestation index to remain below 3% and not be necessary the application of pesticides. As of 2.5 - 3 years of age, the cedar plantation does not require control activities for that pest because the plants have already reached a development that makes them less vulnerable to that insect.

- **Annual maintenance**: end of the rainy season until five years of age.

- Selective individual felling: from 20 years.

b.) Associated Crops (Donkey Plantain)

- Hiring and Acquisition of seedlings.

- **Land preparation**: As described above (Technical considerations).

- **Assembly and operation of the irrigation system:** in order to make efficient use of water, the drip irrigation system will be used, which will be buried**.** Two irrigations per week are scheduled.

- **Plantation:** Establish one year before planting cedar and other forest species. Plantation framework: 4m x 4m interspersed between the trees (625 plants/ha).

- **Clusters**: One meter in diameter at least.

- **Fertilization**: 1.0 kg de NPK/plant durante los primeros tres años; y 10.0 kg/ha. de Biofertilizante durante los primeros siete años.

- **Cultural attention**: Defoliation, carry out a systematic pruning on collapsed, yellow, dry leaves and those with Sigatoka affectations.

- **Sucker Removal**: Consists in selecting the sprouts that will be left by production unit, eliminating the rest.

- **Harvest:** Bananas should be harvested green, but at a point very close to physiological maturity.

12.1.5 Chronological diagram of the module's implementation. CEDPLA

12.1.5.1 Calendar of Activities of the module's implementation CEDPLA

The activities described in the previous section, consider the activities for the period of preparation and establishment; as well as those related to the period of maintenance and use (forest species); and harvest (banana donkey); summarizing the planning for year 1 per month; and per year, until year 20. In Table 28 are the activities to be carried out for months for the CEDPLA module.

Table 28: Calendar of Activities of the module's implementation. CEDPLA.

No	Activities	Period (Years)		Months											
		Start	End	J	F	M	A	M	J	J	A	S	O	N	D
Forest Plantation															
I	Hiring and Acquisition of seedlings	1	1												
II	Preparation of lands	1	1												
III	Live fence establishment	1	1												
IV	Construction of firebreads	1	1												
V	Forest Plantation	1	1												
VI	Replacement replanting	1	2												
VII	Maintenance of trails against fire	1	20												
VIII	Chemical fertilization	1	3												
IX	Pest control and sanitation	1	3												
X	Periodic pruning	2	7												
XI	Slit	2	7												
XII	Individual selective felling	20+													
Associates crops (Plantain)															
I	Hiring and Acquisition of seedlings	1	1												
II	Preparation of lands	1	1												
III	Installation of drip irrigation system	1	1												
IV	Banana plantation	1	1												
V	Watering banana	1	10												
VI	Maintenance, manual street-to-street masonry	1	5												
VII	Clusters	1	3												
VIII	Chemical fertilization	1	10												
IX	Cultural services	1	10												
X	Harvest	1	10												

Source: Prepared by the authors with information from Business group "Tabacuba", Cuba, 2018.

12.1.5.2. Graphic diagram of the module's implementation CEDPLA.

Fig 8 and Fig 9 show a top view with the distribution and spacing of the species that make up the CEDPLA module, based on 0.25 Ha and the lateral view of the module respectively

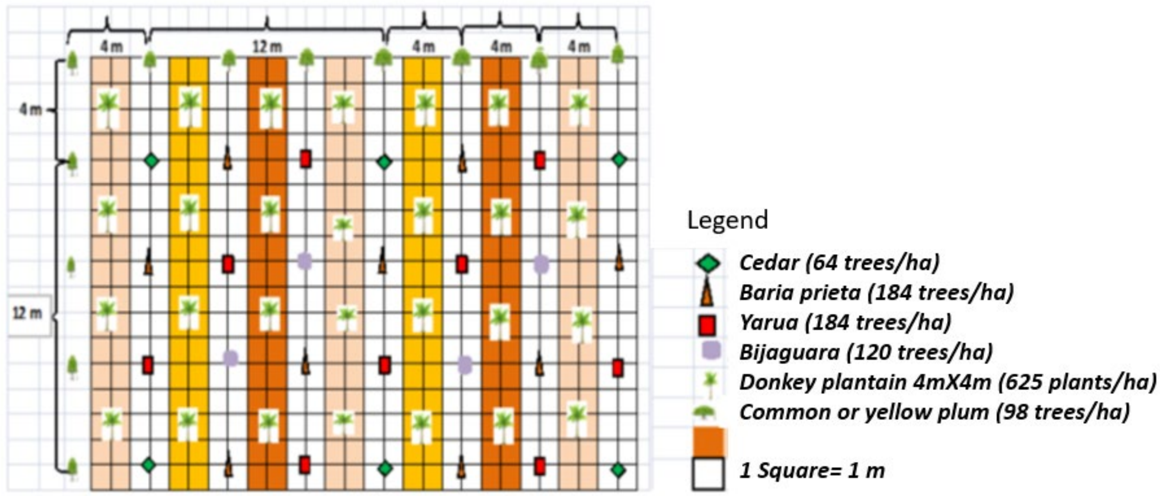


Fig 8: Top view of the spatial arrangement of the CEDPLA module (representation based for 0.25Ha)

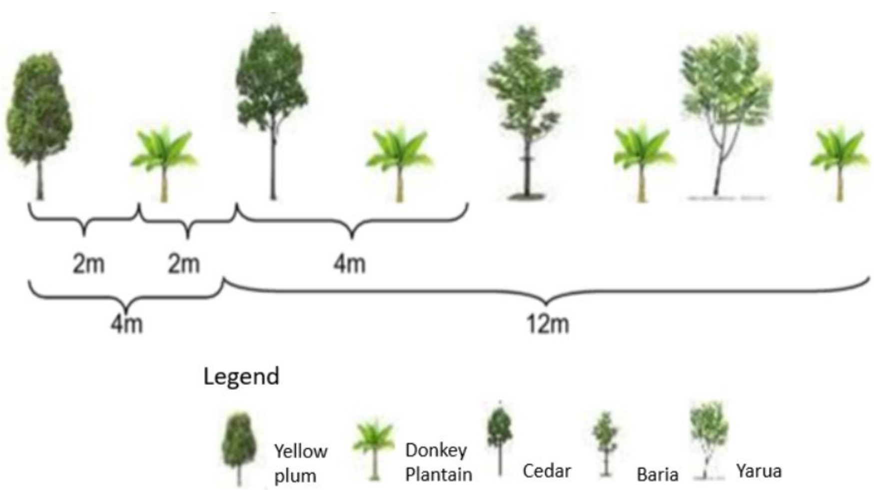


Fig 9: Profile view of the spatial arrangement of the CEDPLA module.

12.1.6. *Expected outputs and outcomes*

The expected IMA of the four species that make up the forest plantation is estimated at 11 m3 / ha / year. In the specific case of cedar, according to studies carried out in demonstration plots of cedar associated with plantain and eucalyptus in 11 localities of the country, it is evident that, on average, the diameter of the cedar was increased by 1.9 cm / year and the height in 1.3 m / year which allows to estimate trees with an average diameter of 32 cm and a height of 20 m. This increase doubles the current ones which, on average, are estimated at 3.5 m3 / ha / year (MINAG 1986).

At 20, there should be 60 cedar trees with an average volume of 0.57 m3 / tree and usable 0.40, which in total represents around 24 m3 / ha of bolus wood that is currently marketed at 805.00 pesos / m3.

Of the thinning's I and II applied to the other three species, approximately 38 m3 will be produced which, added to the 150 m3 left at the end of the 20-year shift and to the volume of the cedar, total 212 m3 which is equivalent to the IMA indicated above (11 m3 / ha / year).

In the case of plantain, its production is estimated to yield 4.11 (Metric tons / ha / year); likewise, it is estimated that the useful life of the plantation is 10 years.

12.1.7. *Technologies to be promoted through the CEDPLA module*

The technological proposal of this module consists of executing agricultural and forestry activities in a sustainable system under a systemic and integrating vision; that is conceived from the security of having the technical and financial resources; as well as the participation of the producers; Considering different types of forest species and a semi-permanent crop like plantain, generating economic, social and environmental benefits.

For the implementation of the module, drip irrigation is promoted, with pumps operated by solar energy, as well as the construction of small reservoirs of water, which will store the water during the winter and will be used during the dry season (the design of the reservoirs are based Salinas et al 2010-Supplementary material 6). It is also expected that an important (but not limiting) criterion is that producers wishing to implement the module are close to surface water sources.

The use of the brush cutter and other equipment for the preparation of land will be an important point within the module, since this technology is not available in Cuba (see supplementary material 5 for more detail of the machinery).

12.1.8. *Environmental benefits and Adaptation Scenario*

12.1.8.1. ***Carbon sequestered and avoided***

Table 29 shows a summary of the avoided and sequestered carbon estimates with the CEDPLA module

Table 29: Avoided and sequestered carbon estimates with the CEDPLA module

Module	Area (ha) Result	Balance C (tCO2-eq) Year-1	Balance C tCO2-eq. in 7 years of implementation	Balance C tCO2-eq. in 20 years
CEDPLA Agroforestry system of cedar and plantain	1753.58	-6,188	-43,319	-123,719

12.1.8.2. ***Land and Water Conservation (sediment retention decreased runoff and increased infiltration)***

The proposed system is primarily aimed at the protection of water and soil resources; the multifunctional character of the module that entails the presence of 5 species of trees with ideal characteristics for these purposes, the type of preparation of the land and its design in general, presupposes an improvement in the hydro physical characteristics of the soils and an IMA that can be achieved in the case of cedar up to 7 m3 / ha / year (Batista, 2017).

Regarding hydrological functions, similar results to those obtained in investigations corresponding to forest cover and permanent agricultural crops are expected (Supplementary material in which the runoff coefficient was notoriously low, between 0.05 and 0.17% (Herrero, 1993) The application of this module will therefore mean an increase in underground water reserves in relation to the situation of the baseline.

Likewise, it has been demonstrated that the degree of erosion decreases to more than half of the losses that occur in soils dedicated to agricultural crops and the quality of the water increases. These subjects have been studied in Research Stations such as the "Amistad" Hydrological-Forest Station in Galalón, province of Pinar del Río and in the Tobacco Research Station in the same province.

12.1.9. **Social Profile**

12.1.9.1. ***Benefits to Women and Families (employment, food, income)***

With the expansion of these systems, the sources of employment that will be more stable and better remunerated will increase and diversify, with a greater diversification of productive activities. This new situation will contribute to the satisfaction of the needs of the family nucleus and have different products for their commercialization and will result in an improvement of the family's food security and in general of their quality of life.

Women will be able to join agricultural work with better working conditions in terms of spaces on farms, in cooperatives or on farms, which respond to their specific needs, all of which will allow them to obtain high incomes by linking to direct production and production. This way guarantee their economic independence and therefore, improve their quality of life.

The implementation of the module will allow the development of skills and the acquisition of new knowledge on suitable and sustainable methods for the use and management of the land, in the face of scenarios damaged by CC. Likewise, it enables the socialization of good agro ecological practices, the participation of the family in exchanges of experiences with other producers and, in summary, a greater permanence of the inhabitants in these areas.

12.2 Establishment of forests through natural regeneration assisted in marabou affected areas. (MARREG)

12.2.1 Description of the current situation and baseline

In the country there are regions in which it has been observed that the marabou has been gradually replaced by the natural regeneration of native trees that develop spontaneously under the canopy of marabou canopies; There is no doubt that this process is economically more attractive and the degree of resilience of the forests achieved under this system is much greater since it is closer to the original forest, but has the disadvantage of the delay in the complete reconversion of the area and in the structure and composition of species that is not always what is desired.

These lands that were used decades ago in the cattle activity were abandoned due to the loss and impoverishment of the pastures caused by the notorious shortage of water and the gradual degradation of their soils which caused a low production of milk and meat and high mortality of animals. When they were unused for other uses, they were finally transferred to the forestry sector.

Currently, the forest plantations that are made as successors of marabuzales are more than 90%, nonspecific, very little resilient to CC and generally susceptible to pests and forest fires to which is added that in many cases exotic species are used mostly, high consumers of water such as eucalyptus, albizia, casuarina, etc.

The "cleaning" of these areas that is still done with heavy machinery, which causes great impacts if we take into account that the use of "bulldoze" affects the surface horizons of the soils and eliminates the natural regeneration of native tree species that have been competing with the marabou and that can constitute, in the future, the multispecific natural forest in a natural process of "ecological succession" that has the disadvantage of being very late.

12.2.1.1 Agro ecological description: site quality, soils, precipitation and humidity

The areas infested by marabou, which constitute the starting point of this module, can be found anywhere in the AIP occupying different types of soil. The only limiting factor that does not tolerate is poor drainage (prolonged waterlogging).

This module is characterized by being supported by soils of a very low agro productivity (category IV) and with severe limiting factors (low effective depth, high stoniness, low content of organic matter, etc.). In addition to these factors, the selection criteria to define if this module is used will take as a basis the density in the understanding that it will be calculated in the following way:

Density (D): is the percentage ratio of the number of individuals of natural regeneration of appropriate species present in the area and the number of desirable seedlings in the area that is a variable number; but that in our conditions we assume 2500, equivalent to a plantation frame of 2 m X 2 m; this amount is assumed for two reasons; 1) to achieve a faster closing of cups and with it the control of the marabou and 2) to have the possibility of making a more rigorous selection of the individuals and the species through later handling (clean and thinning).

In this way it would be:

- D <20% (less than 500 plants / ha): the MARREG module would be applied.
- D> 20% and <of 80% (between 500 and 2000 plants / ha), the present MARREG module is applied.
- D> 80% (more than 2000 plants / ha): it is recommended to leave only the Natural Regeneration (RN) conversion to marabuzal forests.

To define the existing density of the RN and the application of one or another module, as well as the way of cleaning the area, manual or mechanized, among other elements, it is required to carry out a simple inventory as an activity to start the work.

12.2.1.2 Potential area for the implementation of the module in the project area

The proposed areas for the implementation of the module are specified in Table 30

Table 30: proposed areas for the implementation of the MARREG module

MARREG MODULE											
	Las Tunas				Matanzas		Villa Clara				TOTAL
ENTITY	Amancio	Colombia	Jobabo	TOTAL	Los Arabos	TOTAL	Corralillo	Quemado de Güines	Sto Domingo	Total	
CCS			650.5	**650.5**					90	90	740.5
UBPC									60	60	60
UBF		200		**200**	724.2	**724.2**	650	510	210	1370	2294.2
TOTAL		**200**	**650.5**	**850.5**	**724.2**	**724.2**	**650**	**510**	**360**	**1520**	**3094.7**

12.2.2 Objective and justification of the proposed module

The conversion of areas affected by marabou in forests through assisted natural regeneration is a novel technique with the potential to scale throughout the country due to the multiple advantages it exhibits in relation to other forms of rehabilitation of these areas, among which are:

- Shortening of the time when the marabou is eliminated and replaced by a semi-natural, more resilient and productive forest;
- Decrease in the initial environmental impact;
- Lower implementation costs;
- Humanization of this task

12.2.3 Impact on the resilience of the population

Currently in the AIP there are numerous communities with a high deficit of job offers, which brings with it a deterioration of the quality of life of its inhabitants and a migration of these towards other communities and towards urban areas.

In some of these communities, forestry is the main source of employment and in others; it is the only one, a situation that could be improved with a more accelerated and broader development of forestry in general. The implementation of the module provides stable sources of employment that generate income taxed to improve the quality of life of families, while putting them in a less vulnerable or rapid recovery before extreme weather events that affect their homes.

Among the proposed areas (Table 26), in addition to being the most extreme edaphoclimatically, it is more difficult to implement other agroforestry systems that require greater availability of labor, which is not always possible due to the remoteness of human settlements.

It is important to highlight the obtaining of Non-Timber Forest Products (NTFP) as guano (leaves of different species of palms) with which artisanal and other rural objects are made that are an important source of family economic support. In many rural communities, these products are, to a large extent, the sole economic support of their inhabitants. In addition, these forests are a source of seeds and honey, among other non-timber forest products that contribute to the quality of life of the population.

As mentioned above, the gains from the hydrological, social, economic and environmental point of view of the proposed system in relation to the areas invaded by marabou, are defining. The forest to which this module aspires will promote a variety of ecosystem services that, in general, will favor and make more pleasant and pleasant the lives of the people who will feel less burdened economically and environmentally; they will have more water in periods of drought and obtain more diversified and stable income, especially for the use of NTFPs. All of these are factors that reduce the vulnerability of families and people.

The care and management of the natural regeneration and tree plantations carried out will provide improvements in the biophysical environment and especially in the biodiversity of the place.

12.2.4 Description of the species that make up the module

In principle, all species that have spontaneously regenerated under the marabou canopy, more than 40, are potentially usable; However, taking into account its economic, biological and cultural importance, among other aspects, Table 31 proposes the most promising species that will have priority in its establishment.

Although any of the species listed in Table 31, can be potentially usable, the most promising and which have greater experience and knowledge in the country are the following: soplillo, guácima, baría, white oak and the bijáguara, all of them of fast growth and adequate development of glasses, ideal characteristics to stop the development of the marabou by the effect of shade. Below, a brief summary of its characteristics.

- ***Cordia gerascanthus*** (baria prieta): native species of the Boraginaceae family. Tree of medium size, straight and clean bolus that can reach 15 m in height and up to 50 cm in diameter, belonging to the formation of semi-deciduous forests on limestone soil. The plant has a deep root and grows rapidly and can reach 1 meter per year. It is heliophilous, grows in different types of soils from brownish to ferralitic, stony, tall and drying. It can be planted associated with cedar. Hard and heavy wood of 800 - 970 kg / m3.

- ***Tabebuia angustata*** *(white oak or yoke oak):* medium-sized tree, reaches around 20 m in height and up to 75 cm in diameter. Flowers from April to June, pink flowers. It is naturally associated with júcaro in high coastal soils, it is not demanding to soil conditions. It occupies margins of rivers, stream and elevated banks of swamp. It has good natural regeneration. It can be established by direct sowing.

- ***Guazuma ulmifolia*** *(guásima):* tree of the family Esculculiaceae. It grows in all kinds of terrain, reaches 12 m in height and up to 0.80 m in diameter, widely distributed grows wild throughout the island. The pigs eat its fruit and larger and smaller cattle consume the foliage. It is part of the semi-deciduous forest on limestone soils. In the secondary forests it is one of the pioneer species, capable of sprouting after felling. Its wood has multiple uses and is appreciated for its dimensional stability, which is why it is used in the construction of shoe lasts, stools, etc.

- ***Petitia dominguensis*** *(guayo oak):* berbenaceae family. Tree very common in all the Island, it develops in calcareous and stony lands. With thick trunk and smooth bark, it reaches up to 22 m in height. Very good wood, hard and heavy. It is very used in horconadura, piloting and naval constructions. The seedlings are reproduced in containers.

- ***Lysiloma bahamensis*** *(soplillo)*: fast-growing tree, blooms in April and seeds ripen in May. Tree that reaches up to 35 m in height and diameter of 0.40 m., Characteristic of semi-deciduous formation on limestone soils. Wild tree of the mimosaceae widespread throughout the country. Its reddish wood is used for railway sleepers, in rustic buildings, furniture, charcoal, tool handles, etc.

- ***Ferruginous Colubrina*** *(bijáguara):* belongs to the family ramnaceae, can reach a height of 25 meters, grows rapidly, can be used in rural buildings, poles, sleepers, bridge wood and Wood lathe.

Table 31: Promising Native Species currently present in Marabou areas

Scientific name	Common name	Description
Brya ebenus	Granadillo	Timber/precious
Bursera simaruba	Almácigo	Timber
Busida buseras	Yellow Júcaro	Timber
Busida espinosa	Black Júcaro	Timber
Byrsonima crassifolia	Peralejo	Bush / undergrowth
Cecropia peltata	Yagruma	Pioneer species
Chrysophyllum oliviforme	Caimitillo	Timber / fruit
Colubrina ferruginosa	Bijáguara *	Timber
Cordia gerascanthus	Baría *	Timber
Dipholis salicifolia	Almond or cuya	Timber
Erythroxylum sp	Arabo	Timber
Guazuma ulmifolia	Common Guásima *	Timber
Luchea platipetala	Guásima baría	Timber
Lysiloma bahamensis	Soplillo *	Timber
Metopium toxiferum	Guao de costa	Timber
Roystonea regia	Royal Palm	Cuba National Tree
Saval parviflora	Guano cana	Palm
Swietenia mahagoni	Mahogany West Indian	Timber/precious
Tabebuía angustata	White Oak *	Timber
Petitia dominguensis	Guayo oak *	Timber

Source: Vidal and Llerena (2018).

12.2.5 Agro ecological Practices for the Implementation and Management of the Module

12.2.5.1 Technical Description of the Tasks

Inventory or evaluation of the area: An inventory of the area will be carried out to evaluate the present species, the density and the state of the natural regeneration, among other indicators for later, define the species that will be used in the plantation and the subsequent management.

Recruitment and acquisition of seedlings of forniture species: The seedlings needed to establish forest plantations will be produced through the Business Base Units (UEB) located in municipalities of the AIP, companies specializing in the production of goods and support service to the forestry sector, members of the GAF Agroforestry Group); with whom the productive forms (UEPC, CPA or CCS) will establish a contract for the provision of seedlings.

For forest species, the acquisition of 15% additional to the number of plants / ha indicated in Table 23: Plantation Framework by Species.

Preparation of the Site: for the cleaning of the area two alternatives can be used depending on the prevailing conditions:

Clear the marabou manually with a machete, chainsaw and brush cutter, always respecting the existing natural vegetation and just removing trees "wolves" (usually exotic and large trees that hinder the development of the RN), the malformed or those that have excessive density; They will also eliminate the lianas and vines and other undesirable to reduce competition for light and nutrients and promote further development of promising species. The disadvantage of this method, is that it is more expensive and requires a greater amount of labor.

Cleaning in a mechanized way with the brush cutter/wood shredder machine taking care not to affect the NR of small trees greater than 0.5 m in height. It has the disadvantage that there will always be affectation to the RN if it is taken into account that this practice has an irregular distribution within the marabuzal.

Cut trees of more than 5 cm in diameter, can be used in the manufacture of coal and the finest, will be chopped and scattered in the soil as a contribution of organic matter.

After the area has been cleaned and when the regrowth of the marabou occurs, a systemic herbicide (for example glyphosate) will be applied, broad-spectrum and innocuous, which is absorbed by the leaves.

Coal processing: It is made in traditional coal cellars, the branches and trunks of the bush are used.

Plantation: In open spaces will be made the opening of individual holes or terraces where the seedlings will be placed between the months of June and October. The plantation will try to achieve a total density of 2 500 plants / ha, respecting the vital area of each individual without following a defined framework in function of the future forest closing its cups as soon as possible and progressively weakening the marabou, until its elimination due to lack of light.

If we start with an estimated natural regeneration of 50%, approximately 1250 plants / ha, we will need to plant an amount similar to that which, of course, is a variable number depending on the density of the NR from which it is split. A good survival is expected if one considers that in those places there are better conditions of humidity, temperature, exposure to the winds, etc.

Maintenance: Will consist of rings around the planted positions and the quantity will be according to the needs; if required, herbicides will be applied to definitively control the marabou.

Protection Measures Against Fire: At the time of land preparation, the construction of trails will be carried out, which will be maintained in the following years by mechanized means. The width of the master trails, which are those along high-circulation and dangerous roads, is 12 m and the interiors, separating stands, are six meters wide.

In addition to the trails, pruned strips with a width between 20 and 100 m wide will be executed along the most dangerous and communication routes, measured from the edge of the road into the forests.

The green strips shall be made of no less than four rows separated 1.5 m from each other and with trees and bushes of fire-resistant fruit species.

Cleansing and thinning: These will be carried out periodically, every three years from the age that the plantation is established, which normally happens at that same time. This activity is carried out with the objective of improving the composition of species as well as the quality of the plantation by eliminating trees that are badly formed, sick or too close to each other.

Thinning: taking into account that the objective of this module is not only the production of wood but also the rehabilitation of the forest and the increase of the provision of environmental services, this type of management will be carried out discretionally to eliminate undesirable trees that are not useful to meet these objectives (for example exotic species with high water consumption).

Use of Non-Timber Forest Products (NTFP): It is common to find in these areas different types of palms called vernacular with the generic name of "Guanos" that have multiple applications such as roof blankets (guano cana), hats and other fabrics (guano yuragua) and fiber producers (guano spiny) which have a wide domestic and artisanal use.

Taking the example of these three palms at a density of 50 palms / ha, a year could produce approximately 500 stalks that are traded at 53.00 pesos / 100 stalks which would occur from the fifth year of the module. The greatest value of this type of production lies in the use value of these products. The order of execution of the activities appears in Table 28.

12.2.6 Calendar and Graphic diagram of the module's implementation. MARREG.

12.2.6.1 Calendar of Activities of the module's implementation MARREG

The activities described in the previous section, consider the activities for the period of preparation and establishment; as well as those related to the period of maintenance and use (forest species); and use of Non-Timber Forest Products (NTFP); summarizing the planning for year 1 per month; and per year, until year 20. In Table 32 are the activities to be carried out for months for the MARREG module.

Table 32: Calendar of Activities for the MARREG Module

No.	Activities	Period (years)		Months											
		Start	End	J	F	M	A	M	J	J	A	S	O	N	D
Establishment of forests by natural regeneration															
i	Inventory or evaluation of the area	1	1												
ii	Recruitment and acquisition of plants (*)	1	1												
iii	Preparation of marabou invaded sites	1	1												
iv	Coal processing from marabou	1	1												
v	Forestry Plantation	1	1												
vi	Maintenance:	1	3												
vii	Protection Measures against fire	1	20												
viii	Cleansing and Thinning	1	5												
ix	Thinning's:	1	20												
x	Use of non-timber forest products (NTFP)	5	20												

Note: (*) All activities are included from the collection and processing of seeds

Source: Prepared by the authors with information from Model Forest Sabanas de Manacas (BMSM). Cuba, 2018.

12.2.6.2 Graphic diagram of the module's implementation

Fig 9 and Fig 10 reflect approximately the location of the individuals that make up the natural regeneration and the possible location of the trees to be planted

Fig 10: Top view of the MARREG module

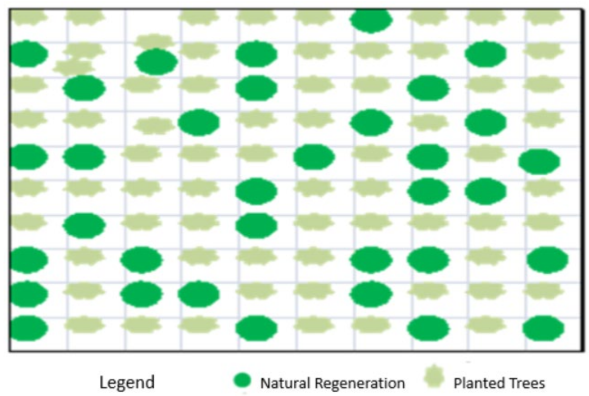
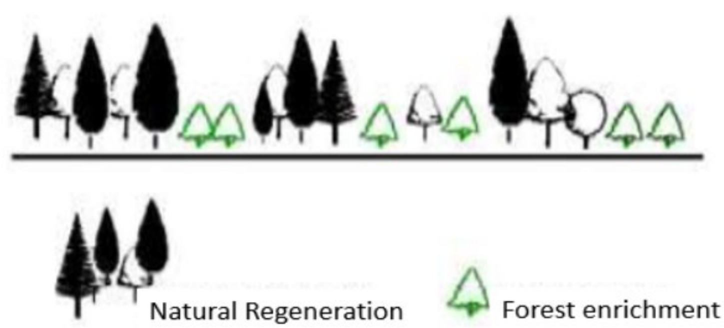


Fig 11: Profile view of the MARREG module



Note: The spacing and the vertical and horizontal structure are irregular. Prepared by Vidal (2018).

12.2.7 Expected outputs and outcomes

The forest resulting from this type of management has the objective of rehabilitating the area with the highest representativeness of species native to the area and towards that goal, point out the planned management. The production of wood with commercial character is a secondary objective, which does not prevent that different assortments of wood, can be extracted by means of thinning and cutting of selective use.

The production of coal from marabou at the beginning of the module is an additional income for people, but it is emphasized that the volume of production in this module is lower than in others because part of the area does not have marabou when it is occupied by natural regeneration.

12.2.8 Technologies to be promoted through the MARREG module

The starting point to implement the technology that allows the reconversion of marabuzales in forests through assisted natural regeneration, besides being a novel technique with the potential to scale throughout the country due to the multiple advantages it presents, is based on an inventory of the area to evaluate the species present, the density and the state of natural regeneration; Among other indicators that allow to later define the species that will be used in the plantation and the corresponding management.

This technique places great emphasis on the production of seedlings of the promising tree species present in the area. The seeds will be harvested from trees that show a better phenotype, selected in the same areas, in protected areas or in nearby seed stands. These seeds will be revived with tube technologies that increase the quality of the plantable material at a lower cost.

12.2.9 Environmental benefits and adaptation scenario

Achieving forests with a high diversity of species in all its strata, is a benefit of this module compared to the traditional method used to mechanically clear and perform a nonspecific plantation. The mere fact of not clearing bulldozer, eliminates the negative impact that this activity causes on soils and achieving a target forest with no less than 30 tree species in its composition, gives this new ecosystem greater resilience in addition to saving human and financial resources in its establishment.

It is to be understood that the hydrological response of the forests in terms of the water economy is generally more effective, as has been previously analyzed; in this case, when the forest consists of multiple native forest species, which, compared to exotic ones, are less water consuming, this aspect is even more relevant.

The ecosystem services for the protection of biodiversity, culture and landscape that this ecosystem will provide, with more than 30 arboreal, shrub and herbaceous species, give these new forests superior qualities to those of the marabuzal. Likewise, resistance to fire and the delay it causes in the speed of propagation of these phenomena, give greater security to the inhabitants and communities. In addition, the forests achieved by this method become corridors of biological connectivity, which gives this module a special importance.

12.2.9.1 Carbon sequestered and avoided

Table 33, summarizes the avoided and sequestered carbon estimates with the MARREG module

Table 33: Avoided and sequestered carbon estimates with the MARREG module

Module	Area (ha) Result	Balance C(tCO2-eq) year-1	Balance C tCO2-eq. in 7 years of implementation	Balance C tCO2-eq. in 20 years
MARREG Management of natural regeneration of native tree species.	3094.7	-19,878	-139,146	-397,566

12.2.9.2 Soil and water conservation (retention, runoff and infiltration)

The conversion of marabuzales to forests through assisted natural regeneration brings with it a series of advantages to the ecosystem and to the communities linked to them, which Lopez (1977) has confirmed, which concluded that "the transformations that take place in the vegetable cover can have a significant impact on water availability. "

In the forest ecosystems the hydrological services are more effective but also, the forests provide other services, absent in the marabuzales.

The protection of water bodies (rivers, streams and reservoirs) through the establishment of Hidroregulatory Forestry Belts in the places where the gallery forests are missing is an action contemplated in the module and endorsed as mandatory in Law 85, Forest Law.

On the other hand, in the area of implementation of the project there are numerous basins of territorial and national importance such as Sagua la Grande, one of the 11 basins of national interest, the Cañas River in the province of Villa Clara and the Jobabo River from the province of Las Tunas, which will benefit from the establishment of the proposed plantations taking into account what has been expressed by several authors, among them López (1988) who concluded that "forest cover reduces erosion to minimum levels and consequently The sediment rate of the waters that drain through the forest spaces is also minimal, thus prolonging the lifespan of the reservoirs ".

Melchanov and Herrero (1973) stated, in relation to the quality of the waters, that "the bacteriological indicators of the waters that drain through forest plantations are significantly better compared to those of deforested areas and for example the concentration of Bacillus subtilis and Escherichia coli species can be 11: 1 ".

12.2.10 Social Profile

Benefits to women and the family (employment, food, income), because the expansion of these systems will generate new sources of employment, more stable, better conditions and better paid, which will contribute to the satisfaction of the needs of the family nucleus and the quality of life will be increased in a general way.

Of the new sources of employment generated by the implementation of the module, women will benefit in tasks such as seed processing, technician nurseries, forest plantations, in the use and preparation of NTFPs and in areas of self-consumption, among other activities, which they will be made with better conditions.

Likewise, new spaces for women's work will be opened in any entity where this module is developed that will respond to their specific needs, all of which will allow them to obtain higher incomes when linked to direct production and thus guarantee their economic independence, and therefore, improve their quality of life.

The implementation of the module will allow the development of skills and the acquisition of new knowledge on suitable and sustainable methods for the use and management of the land, in the face of scenarios damaged by CC.

12.3 Establishment and management of polifunctional forest plantations in zones invaded by marabou. (MARFOM).

12.3.1 Description of the current situation and baseline

The reforestation activities in Cuba that began on a massive scale in 1959 have had a significant impact on the country's economy, on the protection of the environment and on society in general.

The diversity of species used in the annual reforestation plans is considerable, around 100, of which 80 are forest, between native and exotic and 20 of fruit trees.

Of the 535 000 ha that existed of forests planted at the end of 2016, 117 species are represented, of which just over 90% are native. In terms of surface area, they cover 343,423 ha, which is 64% of the total area planted; exotic species cover 177,676 ha, 33% of the total, those that are planted in almost all cases for productive purposes and the fruit trees that are promoted in the non-commercial reforestation process, which occupy 13,901 ha (3%). (DFFFS, 2017).

Without exception, all the native species that are being proposed in the present project are represented on the surface of planted forests of which there are experiences of their management.

Analyzed at the country level, this situation could be seen as satisfactory, but when analyzing the issue of the diversity of species that are used in reforestation at the grassroots level, the reality is different; It is generalized that in the same area, only one species is used, even in those plantations that have protection and conservation objectives. The species of fruit trees have not had a significant representation in these plans.

In light of the problems linked to the effects of CC, a conceptual change in current Cuban silviculture is required, which will have to be governed by the principles of the EBA, even in plantations of a commercial nature.

The establishment of mixed planted forests, the care of natural regeneration, propitiates and maintains the vertical structure of the forest (herbaceous, shrub and tree strata) and the effective protection against forest fires, including fire management, is among others. That also allow that the planted forests with commercial character, assure the numerous and varied Eco systemic services that provide the forest systems.

As previously stated, in recent years the rate of reforestation has decreased, among other reasons due to the lack of heavy equipment that responds to the "bulldozed" cleaning of areas invaded by marabou. However, these techniques have shown their aggressiveness to soils and vegetation, which should be replaced by other less aggressive systems that have less impact on the environment. Likewise, the practice of preparing the soil using sub soiling is not widespread even though its wide advantages are known from the silvicultural and hydrological point of view.

The execution of nonspecific plantations, as is usual practice nowadays, constitutes a serious problem from the point of view of increasing the resilience of households, people and ecosystems.

Aspect of relevant importance is the quality of the plantable material (seedlings). It should be noted at this point that there still persist in the AIP forest and fruit nurseries of outdated technology that use plastic containers that do not encourage adequate development of seedlings which show a high mortality when they are taken to the field. The few tube nurseries existing in the AIP, which is a technology far superior to that of polyethylene containers, have not generally been assembled with the complete system and, therefore, are not always as effective as they could be.

From these concepts derives the proposal of this module that has its starting point in soils invaded by the marabou in different degrees and its elimination by low impact methods that include mechanical, silvicultural and chemical means.

12.3.1.1 Agro ecological description: site quality, soils, precipitation and humidity.

As a result of the effects of the CC that among other affectations prolonged the duration of the dry period with the consequent shortage of water and the gradual degradation of the soils, there was a growing and accelerated, the abandonment of land surfaces that stopped being used for agricultural and livestock use and were invaded by the Dichrostachys cinerea (marabou).

Thus, in the Santo Domingo, Corralillo and Quemado de Güines municipalities of Villa Clara province there are more than 20,000 ha invaded by this species and in the municipality of Los Arabos over 5 000 ha. A similar situation is found in the municipalities of Las Tunas (Jobabo, Colombia and Amancio Rodríguez) where the marabou extends over 70,000 ha.

12.3.1.2 Potential area for the implementation of the module in the project area.

For the implementation of the module in the Northern Zone of Villa Clara, the area occupied by idle lands covered by marabou was assessed, which have remained stable in areas of agro-productive categories III and IV where the soils predominate: Ferralitic Yellowish, Ferralitic Gley and Yellowish Quartz Ferralitic Reddish leachate These areas are linked to 10 rural communities that are: La Piedra, Gavilanes, San Pedro, La Sierra, Salvadora and Guayabo in Corralillo and Espinal, Jiqui, Triangulo and Punta Felipe in Santo Domingo. In Los Arabos, the soils are similar to those in the northern area of Villa Clara and the implementation area is linked to the community of San Pedro de Mayabón.

For the implementation of the module in the South Zone of Las Tunas, the areas covered by marabou were also defined, where the soils predominate: Gley Ferralitic, Ferralitic Yellow and Glendidic Dark Plastic. All these areas are linked to the communities of Sabalo, Aguacate and Palo Seco, in the municipality of Jobabo; Tana, Santa Rosalía and Puerta Prieta, in Colombia and El Indio, Guayabal, Santa Amalia and Vicente Pérez, in Amancio. Table 34 details the proposed areas to implement this module in the AIP.

Table 34: Proposed area for the implementation of the MARFOM module

MARFOM MODULE										
	Las Tunas				**Matanzas**		**Villa Clara**			**TOTAL**
ENTITY	Amancio	Colombia	Jobabo	**TOTAL**	Los Arabos	**TOTAL**	Corralillo	Sto Domingo	**Total**	
CPA							30		30	**30**
UBPC							1127.02		1127.02	**1127.02**
UEB	900			**900**	509.5	**509.5**	3600	2000	5600	**7009.5**
TOTAL	**900**			**850.5**	**509.5**	**509.5**	**4757.02**	**2000**	**6757.02**	**8166.52**

As can be seen, it corresponds to the Villa Clara area to implement 82% of the total area of the module.

This module is one of the largest in extension, due to the following reasons:

- Areas close to Forest Based Business Units (UEB) were selected, usually with better access roads and infrastructure (facilities, observation towers for forest fires, nurseries, among others).

- Despite the innovations of the module in relation to traditional plantations, these entities have experiences that make the execution of different activities more viable, such as: the collection and processing of seeds, the management of nurseries and plantations, among others.

- It is the most attractive module from the point of view of economic sustainability for the forestry sector from the point of view of wood production.

12.3.2 Objective and foundation of the proposed module

In general terms, it can be said that, in the rural communities of the seven municipalities that make up the AIP, job opportunities have been affected due to the decrease or disappearance of agricultural and livestock activities, which constituted the main source of work and sustenance of its inhabitants for many years, leading to a deterioration of their quality of life and their migration to urban areas.

Based on the above, the implementation of this module will have positive effects as it will encourage the opening of new sources of employment with better working conditions and higher remuneration.

On the other hand, the country needs to continue increasing its forest cover, but on a sustainable basis and in accordance with the new concepts and principles of modern forestry. The production of wood and other goods produced by the forest cannot prevail over the aspects of adaptation to CC or the protection of the environment.

12.3.2.1 Impact on the resilience of the population

The implementation of multifunctional forest plantations on a large scale and with an optimal level of mechanization will reverse this situation and will constitute a secure and stable source of employment, which generates income, improving the quality of life of families, while putting them in less vulnerable situation or rapid recovery before extreme weather events that affect their homes.

Achieving greater availability and better quality of water by filtering potential contaminants and strengthening the recharge of aquifers, are factors that will increase the resilience of the population in general and farmer families in particular, to which is added the improvement of the microclimate in those areas and the improvement of the soils.

The establishment of forests also contributes to the fact that in the event of extreme events that affect the housing stock of the territories, sufficient wood is available for the recovery of the houses.

The implementation of the module will provide more and varied job offers, particularly for women if taken into account that there are 29 458 housewives who are a potential workforce.

Fruit trees play an important role in the general context of this module for several reasons:

- They constitute a permanent source of income from the first years of implementation,

- They are a factor in delay and deterrence of forest fires; and

- They are a source of food for wildlife.

As soon as the reforestation work begins, the inhabitants of many of the small communities surrounding or close to the forests will become "Forest Dwellers".

12.3.3 Description of the species that make up the module

This module plans to use several species, according to their adaptability to the existing soils in each place and to the objectives of the plantations taking into account that they are resistant to drought and fire and that their wood is of economic value. The IMA and the expected yields by species appear in Table 35.

Table 35: Species to be used in the module

Species	Objective	Logging Term /years	Increment (m^3/ha/year)	Wood Production (m^3/ha)			
				Timber Total	Wood Pieces	Wood Rolling	Firewood
Male Pine	Timber/Pine	20	18	360	216	108	36
Baría(*)	Timber/Pine	25	15	375	225	113	38
Bijáguara(*)	Round wood	15	15	225	135	68	23
Yarúa	Round wood	15	15	225	135	68	23
Soplillo(*)	Firewood	7	20	140	84	42	14

(*). Melliferous Species

- ***Pinus caribaea*** (male pine): tree of the pinaceae family, can reach up to 25 m in height, with a straight and cylindrical trunk; Its wood is very versatile and has multiple uses. It is a pine resistant to drought (Barret & Golfari, 1962).

- ***Cordia gerascantus*** *(baría*):* species belonging to the family borraginaceae, large tree with a remarkably tall shaft, grows rapidly and has deep roots, is used in the manufacture of furniture, buildings, round objects, sleepers, etc.

- ***Colubrina ferruginosa*** *(bijáguara*):* belongs to the rhamnaceae family, can reach a height of 25 meters, grows rapidly, can be used in rural constructions, poles, sleepers, and wooden bridges and round objects.

- ***Caesalpinea violacea*** *(yarúa):* family tree cesalpinaceae, legume, medium tree that can reach up to 18 m, the plant is vigorous and grows rapidly, is a valuable wood of variable color, is used in works of great resistance to the exterior, such as a fence post, wooden posts, handicrafts , sleepers and cart masses.

- ***Lysiloma bahamensis*** (soplillo): family tree mimosaceae, leguminous, medium height, 15 meters, grows rapidly, is used in the manufacture of furniture, frames, doors, such as firewood and charcoal making, etc.

12.3.4 Agro ecological practices and tasks for the implementation and management of the module.

12.3.4.1 Technical Description of Tasks

Multifunctional-planted forests are established by achieving a combination of forest species where native species predominate over exotic ones and which offer important ecosystem services so that communities and residents in general can benefit from them.

The maximum area (block) to be cleaned for planting is 60 ha, leaving the same area without clearing alternately. The blocks of 60 ha are composed of six 6 nonspecific stands that can have a ha minimum and 10 ha maximum. When the plantation has been established, which usually happens within two or three years, it will proceed to clean and plant the adjoining areas that remain with marabou.

The stands are square or rectangular, but without rigid designs respecting the troughs, fluvial currents and any other type of geographical accident and separated by internal firebreaks; the blocks will be separated by master tracks and green strips. The design of the module is not rigid and allows adapting it to the specific conditions of each place.

Recruitment and acquisition of seedlings of species: the seedlings needed to establish the forest and fruit plantations will be produced through the Business Base Units (UEB) located in municipalities of the AIP, companies specialized in the production of goods and support service to the forestry sector, members of the AGF Agroforestry Group); with whom the productive forms (UBPC, CPA or CCS) will establish a contract for the provision of seedlings.

For forest and fruit species the acquisition of an additional 5% is considered as the number of plants / hectare indicated in Table 27.

Preparation of the site: will be carried out in accordance with what is stated in chapter 5, "Technical Considerations". After the sub soiling and before planting, when the sprouts of the marabou are between 20 - 30 cm high, at least two applications of herbicide will be made to reduce the incidence of this species which will be further affected by the shadow of the trees.

Forest plantation: in the case of the forest plantation, it will be executed in the sub soiling line in the place where the planting holes are opened. The Planting Framework: 3m X 3m (1 100 plants / ha).

Fruit tree plantation: It will be carried out in the green belt, in the protection zones of water bodies and in areas close to communities and homes, mainly. Green girdles: they will be 6 m wide, using the fruit species indicated in Table 36.

Table 36: List of fruit and timber species to be used in the MARFOM module

Scientific name	Common name	Use
Anacardium occidentale	Cashew	Fruit bush
Chysobalanus icaco	Hicaco	Fruit bush
Mangifera indica	Mango	Fruit tree
Manmea americana	Mamey of santo domingo	Fruit tree
Calophyllum antillanun	Ocuje	Timber tree

Fault replacement: the first year of the plantation.

Fertilization fruit tree: application of 3,75 Kg/ha of biofertilizer during the first seven years.

Maintenance: the amount of maintenance will depend on the conditions of the place, but normally they should take place between 3-5 in the first three years of the plantation combining the manual and mechanized method. If necessary, new passes of biodegradable herbicides will be applied to control the regrowth of marabou.

Fire protection measures: at the time of land preparation, during the marking of the stands, the construction of 12 m wide master trails will be carried out around each block and on both sides of these, the green strips will be planted. Between the stands will be established internal trails of 6m. As additional measures, pruned belts and burned strips parallel to the trails will be made up to a distance, within the forest, of no less than 20 m from the trail. These actions are carried out with the objective of reducing fuel material within the forest.

Cleansing: will take place after 3 years of age of the plantation and consists of eliminating the malformed or sick trees.

Thinning: plantations are made from 8 to 10 years and as a rule produce assortments of usable wood (round wood and firewood). 2 or 3 interventions will be made up to 5 years before felling.

Trimming: in the plantations whose objective is the production of bolus wood for sawing and depending on the characteristics of the species and their growth pattern. They are made after the first thinning.

Fruit harvest: The fruit will be harvested depending on its date of production by type of fruit species.

Forest Harvesting: it will be carried out between 20 and 21 years of age by individual selective logging with the objective of permanently maintaining the tree cover of the area. The exploitation must be carried out on the basis of the "Handbook of exploitation of reduced impact of forests in Cuba" in effect for the whole country. The order of execution of the activities appears in Table 21

12.3.5 Calendar and Graphic diagram of the module's implementation. MARFOM

12.3.5.1 Calendar of Activities of the module's implementation MARFOM

The activities described in the previous section, consider the activities for the period of preparation and establishment; as well as those related to the period of maintenance and use (fruit harvest and forest Harvesting); summarizing the planning for year 1 per month; and per year, until year 20. In Table 37 are the activities to be carried out for months for the MARFOM module

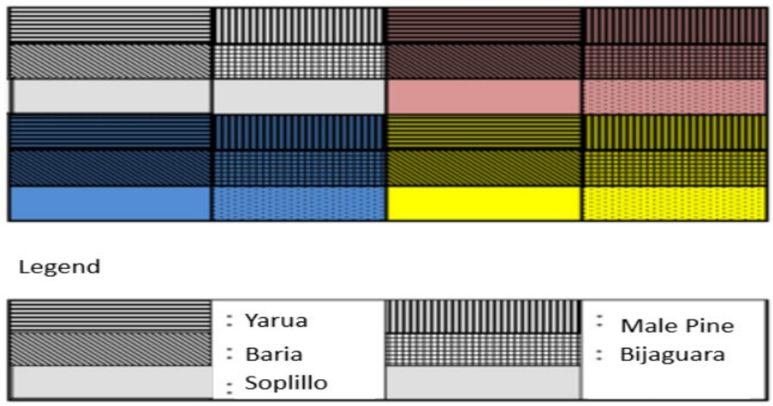
Table 37: Calendar of activities for the MARFOM module

No.	Activities	Period (years)		Months											
		Start	End	J	F	M	A	M	J	J	A	S	O	N	D
Establishment of forests by natural regeneration															
i	Recruitment and acquisition of plants	1	1												
ii	Land preparation	1	1												
iii	Construction of trails against fire	1	1												
iv	Forest plantation	1	1												
v	Replenishment of faults	1	1												
vi	Forest chemical fertilization	1	2												
vii	Maintenance of trails against fire	1	20												
viii	Pest control and sanitation	1	3												
ix	Periodic trimming	1	3												
x	Thinning	2	7												
xi	Individual selective felling	2	7												
Management of green strips (fruit species)															
i	Recruitment and acquisition of plants	1	1												
ii	Land preparation	1	1												
iii	Fruit plantation	1	1												
iv	Replenishment of faults	1	2												
v	Fruits chemical fertilization	1	5												
vi	Pest control and sanitation	1	3												
vii	Maintenance	3	5												
viii	Harvest	4	20												

Source: Prepared by the authors with information from Model Forest Sabanas de Manacas (BMSM) and in Agroforestry Company (EAF) Las Tunas. Cuba, 2018.

12.3.5.2 Graphic diagram of module implementation

In Fig 11 and 12 the structure of the plantation is observed considering the arrangement of firebreaks and green strips.



Note: each color is a block composed of six stands of variable size but minimum of one ha.

Fig 12: Top view of the MARFOM module

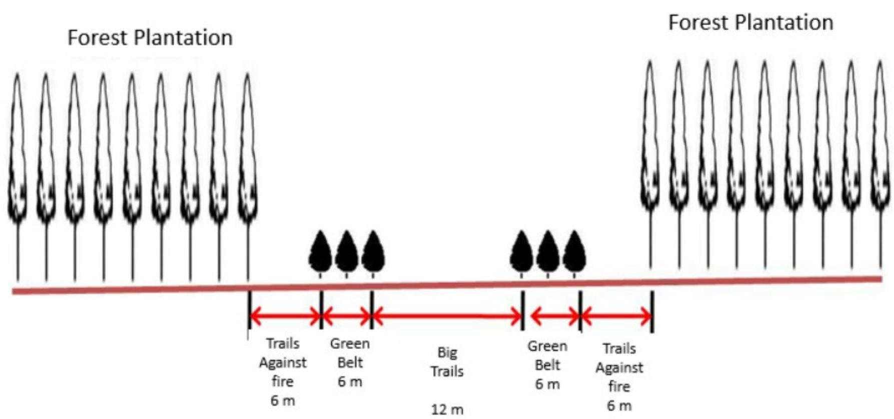


Fig 13: Profile view of the MARFOM module

12.3.6 Expected outputs and outcomes

It is expected to produce with the implementation of this module: bolus wood for the production of sawn timber, round wood (for direct use) such as rods, wooden posts, beach chairs, etc. and wood for the production of coal or for direct use as seen in Table 38.

Table 38: Expected yields from wood assortments of selected species

Species	Objective	Logging term (years)	Timber Production (m^3/ha)			
			Timber total	Wood Pieces	Wood Rolling	Firewood
Pino macho	Wood/bolus	20	360	216	108	36
Baría	Wood/bolus	25	375	225	113	38
Bijáguara	Wood/round	15	225	135	68	23
Yarúa	Wood/round	15	225	135	68	23
Soplillo	Firewood	7	140	84	42	14

12.3.7 Technologies to be promoted through the MARFOM module

The technology defines that the maximum area (block) that must be cleared to carry out the plantation is 60 hectares (Ha.), Leaving the same area without clearing alternately. The blocks of 60 ha. They consist of six 6 nonspecific stands that can have one hectare. At least 10 ha. at the most.

When the plantation has been established, which generally occurs within two or three years, the adjacent areas that remain with marabou will be cleaned and planted.

The stands without rigid designs respecting the channels, fluvial currents and any other type of geographical accident, will be separators by interior firewalls; In addition, the internal blocks will be separated by masterful paths and green stripes.

These multifunctional-planted forests are established by achieving a combination of forest species where native species predominate over exotic species and offer important ecosystem services for communities and residents in general.

As in the CEDPLA module, the use of machinery for clearing and preparation of the land will be of the utmost importance. The detail of the machinery and equipment is noted in supplementary material 2.6.5.

12.3.8 Environmental Benefits and Adaptation Scenario

12.3.8.1 Carbon sequestered and avoided

Table 39, summarizes the avoided and sequestered carbon estimates with the MARFOM module.

Table 39: Avoided and sequestered carbon estimates with the MARFOM module

Module	Area (ha) Result	Balance C(tCO2-eq) year-1	Balance C tCO2-eq. in 7 years implementation	Balance C tCO2-eq. in 20 years
MARFOM Establishment of forest plantations	8166.52	-31,711	-221,977	-634,220

12.3.8.2 Soil and water conservation (retention, runoff and infiltration)

Polifunctional plantations have been designed to provide a wide range of ecosystem services. The sub soiling of the land to break the impermeable layer and the own action of the roots can triple the infiltration of the water coming from the rains in relation to the current uses, including the marabou, until reaching infiltration rates higher than 90%. This could mean that the underground water reserves are increased by more than 4000 m3 ha-1 year-1 considering an annual average rainfall of 1000 mm. Herrero, 1993

On the other hand, Herrero (1993) and Plasencia (2010) show that these conditions are reached when the plantations reach the age of latizal and have closed the canopy flight and the content of organic matter is greater than 3%.

12.3.9 Social Profile

Benefits to women and the family (employment, food, income). With the expansion of these systems, the quality of life of the families will be increased, new sources of employment will be generated, more stable and better remunerated, which will contribute to the satisfaction of the needs of the family nucleus.

Many of these new sources of employment will benefit women in tasks such as seed processing, in the whole cycle of seedling production (nursing), in forest plantations and self-consumption areas, among other activities, which will be made with better conditions. For example, the new nurseries with tube technology make the work easier and more human.

Likewise, new spaces will be opened for the work of women, both in the farms, as in cooperatives and in any other entity where this module is developed, that will respond to their specific needs, all of which will allow them to obtain high incomes by joining to direct production and in this way guarantee their economic independence and therefore improve their quality of life.

FRUAGR MODULE

12.4 Agroforestry system with fruit trees, agricultural crops and living fences (FRUAGR).

12.4.1 Description of the current situation and baseline

Generally, in Cuba and particularly in the AIP, agroforestry systems mixing fruit trees with agricultural crops and live fences have not spread widely even though there are numerous examples in the country that demonstrate the multiple benefits of these systems. The misconception but deeply rooted in the rural environment of the advantages of monocultures and consider the trees as competitors (enemies) of the "sowing", are aspects that have prevented the development of systems like the one proposed in this project . However, in recent years there has been a change in the attitude of peasants, usufructuaries, technicians and officials to these systems, which should facilitate the implementation of this module.

The starting situation for the implementation of the module is marabou-infested areas with different intensities, which has been referred to before.

12.4.2 Agro ecological description: site quality, soils, precipitation, and humidity

The soils of the area where the module is developed are of the Ferralitic yellow, brownish and brown grayish of flat topography to undulated, with agro productive category III and IV.

Trees give agroforestry systems ecological stability by preventing erosion and recycling nutrients through the contribution of litter: they help to conserve soil moisture and increase resistance to pests and diseases. These systems are recognized as a factor of importance for watershed management (Calzadilla, 2013).

Due to the particularities of this module, rather of a family nature, its implementation is not recommended in large areas, but it can be applied by any of the forms of production that exist today in the Cuban agricultural sector such as CCS; CPA; UBPC; usufructuaries and any other type of land holder, whether state or private. The Integrated Forest Farms are in some cases, suitable structures to implement this module.

12.4.2.1 Potential area for the implementation of the module in the project area

The surface of implementation in the municipality of Santo Domingo represents 50% of the total due, among other reasons to the existence in the territory of the Research Institute of Tropical Food (INIVIT) institution that develops an extensive program of extension and promotion of these systems and the strong existing cooperative movement; in the rest of the municipality it ranges from 100 to 150 ha, except Corralillo, where its implementation is not expected (Table 40).

12.4.3 Objective and justification of the proposed module

As described in the socioeconomic report and in the baseline of adaptation and vulnerability, the scenario that is currently presented and facing the CC is complex throughout the AIP. In this sense, the module aims to reduce environmental and socioeconomic vulnerabilities.

It should be noted that the current food production does not meet the demand or the per capita consumption requirements of food, grains, fruit and vegetables; the module takes into account that, in the productive history of these territories, these crops are highly demanded by the population.

Table 40: Proposed area for the implementation of the FRUAGR module

FRUAGR MODULE										
	Las Tunas				Matanzas		Villa Clara			TOTAL
ENTITY	Amancio	Colombia	Jobabo	TOTAL	Los Arabos	TOTAL	Corralillo	Sto Domingo	Total	
CCS	344	33	283	660	13.42	**13.42**		605	**605**	**1278.42**
CPA	112		44	156	33.54	**33.54**		80	**80**	**269.54**
UBPC			221	221				35	**35**	**256**
UEB					180.52	**180.52**	514.88	30	**544.88**	**725.4**
Total	**456**	**33**	**548**	**1037**	**227.48**	**227.48**	**514.88**	**750**	**1264.88**	**2529.36**

On the other hand, these territories are characterized by having difficulties in water supply and storage which is motivated not only by the droughts that have occurred in the country in recent years, but also by the insufficient infiltration of the waters of the country. Rain does not favor the recharging of underground layers.

With the implementation of this module, an improvement is expected in the supply of this precious liquid, especially in the dry season or in the occurrence of prolonged droughts that tend to become cyclical.

12.4.3.1 Impact on the resilience of the population

This module focuses on households and farmers so that families achieve greater resilience to CC. Achieving greater stability and guarantee in the supply of agricultural products produced by themselves and that, in addition, can market the surplus of their productions would result in higher monetary income and increased quality of life. Achieving greater availability of water of better quality by recycling potential contaminants, strengthening the recharge of aquifers and reducing potential evapotranspiration, are factors that influence the increase in the resilience of the population in general, of families peasants and women in particular to which is added the improvement of the microclimate in the environment of the farm and the conservation of their soils.

The tree-planting of these lands according to the proposed design increases, as has already been stated, the infiltration capacity of the soils, which can be doubled; Likewise, moisture retention is more durable due to the shade provided by the trees which also decrease the speed of the winds within the farm.

The crop residues scattered on the surface of the land and the contribution of organic matter are factors that contribute to the improvement of the water balance, strengthened by the fact of the application of some regulations related to conservation agriculture, mainly the minimum tillage and the diversification and crop rotation.

The protection offered by trees to houses and infrastructure against strong winds, provide families and crops with greater security in the face of extreme events.

In short, the environment created by these more welcoming and pleasant systems and, above all, the sustainability character that they have intrinsic, diminish the vulnerabilities of families and agro ecosystems.

12.4.4 Description of the species that make up the module

The module is composed of fruit species, various crops and for live fences.

12.4.4.1 Fruit Species:

- ***Citrus sinenis***. (sweet orange or Chinese orange): tree cultivated extensively in all Cuba of which numerous varieties are known; fruit very desired by the population and that has great demand for tourism.

- ***Citrus* reticulata** (tangerine): there are several varieties; the pulp of the fruit is sweet and sour very pleasant and demanded by the population and tourism. It differs from other citrus fruits that the skin or epicarp easily separates from the pulp without the use of a knife.

- ***Manguifera indica*** (mango): tree widely cultivated in Cuba of which there are many varieties; it has a great demand for population, tourism and industry. Its introduction in Cuba dates back around 100 years and has been naturalized throughout the country and in some localities it is more common than the native species themselves. It is planned to establish the varieties adapted to these localities and of greater economic value.

12.4.4.2 Species of various crops:

- ***Phaseolus vulgaris*** (common bean): beans have a high content of protein and fiber, being also an excellent source of minerals. It is a traditional crop and diet of Cubans. It is cultivated in soils not very saline, with average rainfall. Although it admits a wide range of soils, the most indicated are the light soils, siliceous-silky texture, with good drainage and rich in organic matter. The optimum pH values range between 6 and 7.5.

- ***Vigna sp.*** (bean face): climbing plant; the grain is consumed abundantly by the population but it is less desired than the typical black and red beans. It is a fodder plant and is also used as green manure.

- ***Ipomoea batatas*** (sweet potato or sweet potato): it is a plant cultivated in a large part of the world. It prefers tropical and subtropical climates with mild temperatures (14-26ºC), deep and well-drained soils, although with some humidity. 3-month crop cycle.

- ***Manihot esculenta*** (cassava or manioc): it is a plant widely cultivated in most of the tropical and subtropical areas of the American continent. The cultivation cycle is between 9 months and a year. As it is highly resistant to drought, it is a promising species in this module.

- ***Zea mays*** (maize): grass with a production cycle of three months, native and domesticated by indigenous peoples in central Mexico for about 10,000 years.

12.4.4.3 Species for live fences:

- ***Bursera simaruba*** (seedbed or naked Indian in Central America): large tree that can reach up to 25 m in height, perennial foliage and wood that despite being white and of low hardness, has many uses.

- ***Spondias purpurea*** (common or yellow plum): it is frequent throughout the island and suitable for use in live fences because of the ease with which it is achieved and desired for its fruit that is eaten directly or prepared soft drinks and sweets.

12.4.5 Agro ecological practices and tasks to implement and manage the module

The proposed system is based on agro ecological practices such as polyculture and crop rotation to increase their resilience and, at the same time, to maintain and increase soil fertility and reduce the incidence of pests and diseases.

This module may have numerous variants, which will depend on the interests of the inhabitants, the local demand for products, the market prices and the soil conditions of the farm.

12.4.5.1 Technical Description of the Tasks

Cleaning and conditioning: will be done with the use of the brush cutter-chipper prior to the manufacture of coal from the biomass of the marabou.

Seedlings: will be acquired by purchasing fruit seedlings (mango, sweet orange and tangerine) grafted of good quality. Gammic seeds and agasics of agricultural crops will be used seeds of the best genetic quality and varieties resistant to drought and salinity.

The seedlings needed to establish forest plantations will be produced through the Business Base Units (UEB) located in municipalities of the AIP, companies specializing in the production of goods and support service to the forestry sector, members of the GAF Agroforestry Group); with whom the productive forms (UEPC, CPA or CCS) will establish a contract for the provision of seedlings.

For forest species the acquisition of 5% additional to the number of plants / ha indicated in Table 23 in which the frame of planting by species is defined.

Land preparation: minimum tillage for agricultural crops through the use of multiplow that breaks the ground, but does not invert the prism of land**.**

Sub solation: crossed at 0.50 m depth to favor the establishment of fruit trees.

Assembly of the irrigation system: once the farm design has been defined, the irrigation system will be assembled, which will be dripping in order to reduce the water consumption levels.

Fencing and establishment of live fences: will be established in the perimeter of the area with live poles preferably of the indicated species**.**

Fruit plantation: manually and the agro technical norms of each fruit species (mango, orange and tangerine) will be taken into account, in terms of planting framework, dimensions of the hole, application of organic fertilizers, cultural attention, among other.

Fertilization of fruit trees: aplicar 0.30 kg de NPK/planta a la siembra y por los dos años siguientes; 5.0 kg de materia organica/planta a la siembra; y 3.75 kg de biofertilizante/ha, manteniendo su aplicación por 7 años.

Sowing of various crops: manual form complying with the agro-technical standards of each crop species: sowing frame, number of seeds per planting point, and others.

The crops will be established between the lines of fruit trees, tracing the first furrow at least 1.0 to 2.0 m from the trunk of each fruit tree. In the case of beans and tubers, the preparation tasks are carried out according to the conditions and with the use of multiplow to make the soil well fluffy, as explained above. In general crop rotations should be made alternating the planting of depleting plants such as cassava with beans; the cultivation of sweet potato with corn, etc.

In the sowing calendar the year will begin with the cultivation of bean carita (Vigna, sp), which is harvested in April; as of May, sweet potato associated with maize is planted, whose harvest is carried out in September and the year is closed with the cultivation of Phaseolus vulgaris bean. The following year, land use alternates: where the beans were planted cassava; where the sweet potato was, the corn is sown; the yucca area is rotated with beans, and where corn was planted it can be rotated with another crop, or a green manure can be planted to incorporate it into the soil.

In addition, polycultures can be established with: beans + corn; sweet potato + corn and yucca + beans, with which synergies are created to control the attack of harmful insects.

Cultural attention: in the case of the fruit trees, the plantation line will be kept clean, as well as the floor per plant; Pruning, irrigation, pest control and application of bio fertilizers will be practiced.

Fertilizacion de cultivos: aplicar 8,7 Kg de biofertilizante/ha por ciclo de cultivo.

Crop Harvest: in the case of intercropped agricultural crops, the harvest will be made at the end of the vegetative cycle of each species, when it has reached the maximum development.

Fruit Harvest: Considering that the system starts with grafted postures of fruit trees, it is estimated that the first harvests will be made after five years. The collection of the harvest will be manually and its extraction from the field mechanized or by animal traction.

12.4.6 Calendar and Graphic diagram of the module's implementation. FRUAGR

12.4.6.1 Calendar of Activities of the module's implementation FRUAGR.

The activities described in the previous section, consider the activities for the period of preparation and establishment; as well as those related to the period of maintenance and use (fruit harvest and forest arvesting); summarizing the planning for year 1 per month; and per year, until year 20. In Table 21 are the activities to be carried out for months for the MARFOM module

The sequence of activities for the implementation of the module appears in Table 41.

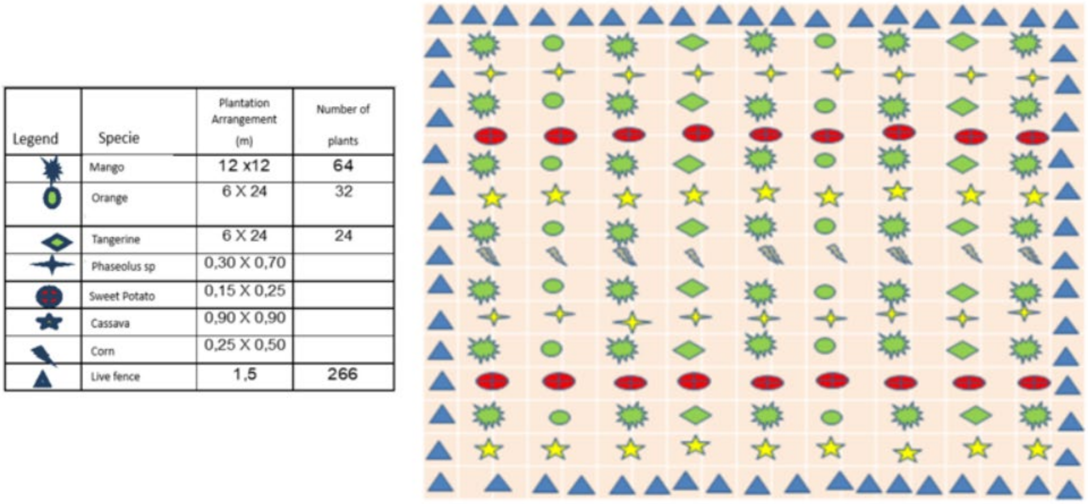
Table 41: Calendar of Activities for the FRUAGR Module

No.	Activities	Period (years)		Months											
		Start	End	J	F	M	A	M	J	J	A	S	O	N	D
Management of fruit species and agricultural crops															
i	Recruitment and acquisition of fruit plants	1	1	■	■	■	■	■							
ii	Land preparation	1	1		■	■	■	■							
iii	Live fence establishment	1	1				■	■	■						
iv	Installation of drip irrigation system				■	■									
v	Fruit plantation	1	1				■	■	■	■	■				
vi	Organic fruit fertilization	1	1				■	■	■						
vii	Fruits chemical fertilization	1	2					■	■	■					
viii	Pest control and sanitation	1	20				■	■	■	■	■	■	■		
ix	Fruit watering	1	3	■	■	■	■	■						■	■
x	Fruit harvest	4	20	■	■	■	■					■	■	■	■
Various crops (beans, sweet potatoes, cassava and corn)															
i	Recruitment and acquisition of plants	1	1	■	■	■									
ii	Land preparation	1	1		■	■									
iii	Installation of drip irrigation system	1	1		■	■									
iv	Sow several crops (3 cycles per year)	1	5	■	■	■		■	■	■		■	■	■	
v	Watering various crops	1	5	■	■	■		■	■	■		■	■	■	
vi	Maintenance, manual cleaning between streets	1	5	■	■	■		■	■	■		■	■	■	
vii	Chemical fertilization	1	5	■		■		■		■		■		■	
viii	Pest control and sanitation	1	5		■	■			■	■			■	■	
ix	Harvest	1	5				■				■				■

Source: Prepared by the authors with information from Farm Los Velázquez. Las Tunas and El Aguacate, Santo Domingo, Cuba, 2018.

12.4.6.2 Graphic diagram of module implementation

Fig 13 and Fig 14 show the structure of the plantation considering the disposition of the three species.



Legend	Specie	Plantation Arrangement (m)	Number of plants
	Mango	12 x12	64
	Orange	6 X 24	32
	Tangerine	6 X 24	24
	Phaseolus sp	0,30 X 0,70	
	Sweet Potato	0,15 X 0,25	
	Cassava	0,90 X 0,90	
	Corn	0,25 X 0,50	
	Live fence	1,5	266

Fig 14: Top view of the FRUAGR module

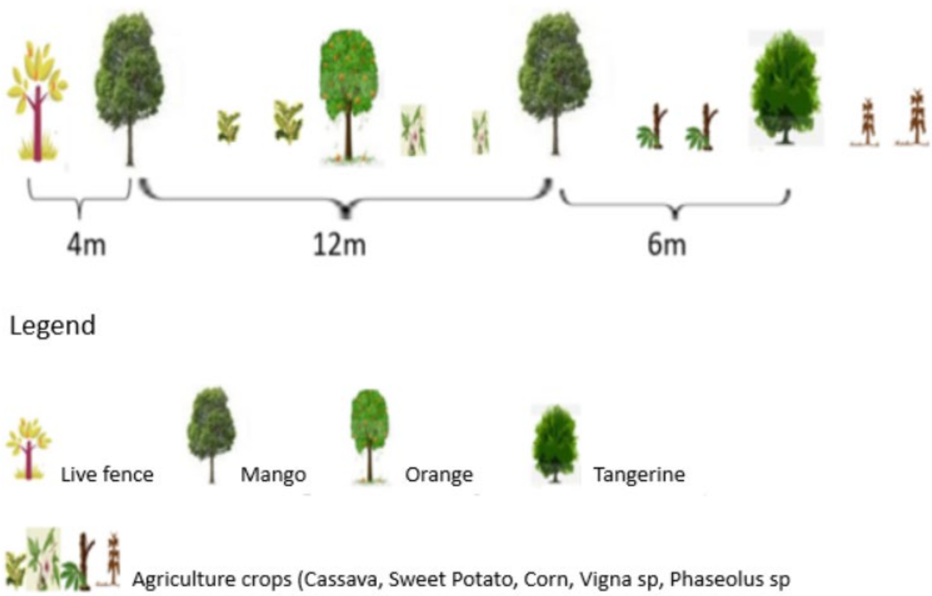


Fig 15: Cross section of the FRUAGR module

12.4.7 Expected outputs and outcomes

Bearing in mind that the main objective of this module is to increase the resilience of households and people from the social and environmental point of view, but without neglecting production, homologated performances can be expected as means shown below in Table 42.

Table 42: Yields by crops in the module

Fruit	Yield (t/ha)
Mango	16.0
Orange	5.0
Tangerine	3.0
Agricultural Crops	
Cassava	5.0
Sweet Potato	3.0
Corn	0.5
Vigna sp	1.0
Phaseolus sp	0.5

Source: Calzadilla,E. INAF, 2018

12.4.8 Technologies to be promoted through the FRUAGR module

The proposed system is based on agro ecological practices such as polyculture and crop rotation to increase their capacity for recovery and, at the same time, maintain and increase soil fertility and reduce the incidence of pests and diseases: promote food and nutrition security .

For the implementation of the module, drip irrigation is promoted, with pumps operated by solar energy, as well as the construction of small water reservoirs (Salinas et al 2010 - supplementary material 6), which will store the water during the winter and will be used during the dry season It is also expected that an important (but not limiting) criterion is that producers who wish to implement the module are close to surface water sources.

The use of the brush cutter and other equipment for the preparation of land, will be an important point within the module, since this technology is not available in Cuba (see supplementary material 2.6.5 for more detail of the machinery).

12.4.9 Environmental benefits and adaptation scenario.

12.4.9.1 Carbon sequestered and avoided

Table 43, summarizes the avoided and sequestered carbon estimates with the FRUAGR module

Table 43: Avoided and sequestered carbon estimates with the FRUAGR module

Module	Area (ha) Result	Balance C(tCO2-eq) year-1	Balance C tCO2-eq. in 7 years implementation	Balance C tCO2-eq. in 20 years
FRUAGR Fruit trees, agroforestry agricultural systems	2529.36	-1,870	-13,090	-37,405

12.4.9.2 Soil and water conservation (retention, runoff and infiltration).

The scaling of the proposed agroforestry system entails the execution of good agricultural practices such as the application of organic matter, the construction of terraces and the rotation of crops, among others. These measurements substantially improve the hydro physical properties of the soils, with which dramatically lower runoff coefficients can be expected, between 0.07 and 0.23, as shown in Supplementary Material 1.

If we take into account these results and that therefore the infiltration rate of soils in these systems can range between 93% and 77%, the application of this module would mean that the underground water reserves are favored in not less than 6 000 m3 / ha / year, which represents an increase in relation to previous uses, considering an annual rainfall average of 1000 mm.

These results indicate the positive of incorporating trees in the rural environment in general and in the areas of cultivation in particular by means of agroforestry and silvopastoral systems because, in addition, they contribute a considerable amount of organic matter in the form of leaf litter and branches (up to 9 kg / tree / year) which contributes to the positive balance of nutrients (Plascencia, 2010).

12.4.10 Social Profile

Benefits to women and the family (employment, food, income). The implementation of the module will decrease the negative incidence of CC in the territories through the productive increase and per capita income per family and, consequently, in the improvement of their quality of life. These factors, together with the possibility of accessing usufruct lands through Decree Law 300, will favor the permanence of these people in rural areas, including especially young people, as well as the possible return of those who migrated in search of economic improvements.

With the expansion of these systems, the quality of life of the family will increase markedly, new sources of employment will be generated, more stable and better remunerated, with a greater diversification of the productive activities which will contribute to the satisfaction of the needs of the nucleus family and have different products for marketing. All this will result in the significant improvement of the family's food security.

The implementation of the module will allow the development of skills and the acquisition of new knowledge on suitable and sustainable methods for the use and management of the land, in the face of scenarios damaged by CC. It also allows the socialization of good agro ecological practices, the participation of the family in exchanges of experiences with other producers and phylogenetic resources (seeds) with other communities, among others.

SILLEC MODULE

12.5 Silvopastoril system with arbustive leguminous (SILLEC)

12.5.1 Description of the current situation and baseline

The scenario in which livestock is developed in the AIP is on pastures or pastures degraded by the continuous grazing, sparsely populated and composed of spontaneous grass species of poor yields and quality, based mainly on species introduced mainly in the 19th and 20th centuries. the genera Paspalum and Dichanthium, with lack of free grazing, prolonged drought and high load encourages, l without the presence of legumes, little or no presence of trees and low level of mineral or organic fertilization and generally low birth rates and high of mortality .. It is supported by soils in general of very low agro productivity (category IV), with the presence of numerous limiting factors such as: compaction, low content of organic matter, stoniness, low effective depth, among others.

The productivity of livestock is an indicator of notorious variability in the country, but, in general, with low levels; on average 4.5 liters of milk / cow / day are produced and a gain in weight of 200 g / animal / day is obtained.

12.5.1.1 Agro ecological description: site quality, soils, precipitation, and humidity.

The module will be developed in degraded pastures with low precipitation, lack of quartering, prolonged drought, high animal charge and escarpment trees. Soils of low agro productivity.

12.5.1.2 Potential area for the implementation of the module in the project area

To estimate the potential area for the implementation of the module in the northern zones of Villa Clara and Sur de Las Tunas, the results of the evaluation of the trend and change in coverage and land use carried out in the "Baseline Report" were considered. of vulnerability and adaptation "(FAO 2018) in which pasture areas were identified that remain stable and can be assumed as established spontaneous pasture areas. The module is oriented to soils of agro-productive categories III.

In the central zone it rises to 3318.6 ha, soils predominate: Yellowish Ferralitic, Dark Gleyzoso Plastic, Ferralitic Gley and Brown with Carbonates. In the South Zone, Las Tunas rises to 7180 ha, with a predominance of soils: Brown without Carb, Fersialitic, Brown reddish, Plastic Dark Gleyzoso and Yellowish Ferralitic. The surface to be implemented in the project period appears in Table 44.

12.5.2 Objective and justification of the proposed module.

In these areas the shortage of labor force is a problem; the people who work in this sector are mostly elderly and their replacement by young people is not always guaranteed. The improvement of the efficiency of livestock systems, of working conditions, including income in the first place, and improving the inputs and tools used in the activity, could reverse this situation and thus stimulate the participation of women and young people, who currently do not get involved in this type of role.

Table 44: Proposed surface for the implementation of the SILLEC module

SILLEC MODULE										
	Las Tunas			Matanzas		Villa Clara				TOTAL
ENTITY	Colombia	Jobabo	TOTAL	Los Arabos	TOTAL	Corralillo	Quemado de Güines	Sto Domingo	Total	
CCS	348	2208	**2556**			33.12	200		**233.12**	**2789.12**
CPA	27	180	**207**	40.26	**40.26**	398.5			**398.5**	**645.76**
UBPC	107	860	**967**	161.04	**161.04**	1548.58		150	**1698.58**	**2826.62**
UEB	1500	1950	**3450**	288.4	**288.4**	484.7	14		**498.7**	**4237.1**
	1982	**5198**	**7180**	**489.7**	**489.7**	**2464.9**	**214**	**150**	**2828.9**	**10498.6**

12.5.2.1 Impact on the resilience of the population

The application of this module will make it possible to face extreme events of drought and high temperatures, maintaining acceptable levels of food and milk production, as well as facilitating and humanizing work on the farm, increasing job offers, better paid and with greater stability.

On the other hand, it would allow women to work in better conditions on the farms, with greater availability and access to water and better quality of life in general.

12.5.3 Description of the species that make up the module

- ***Lysiloma bahamensis*** (soplillo) native perennial tree of the family mimosácea, reaches 7-10 meters high, blooms from April to May, is able to develop on poor and skeletal soils even high stoniness. It has beneficial effects on the soil due to its contribution to the fixation of nitrogen and the contribution of organic matter. It has an erect trunk of usable hardwood. Its leaves composed of small leaflets let in light. It will be used as a shade tree (100 trees per hectare).

- ***Guazuma tomentosa*** (Guasima): árbol nativo de la familia Esterculiaceae, puede alcanzar de 8-12 metros de altura, es una de las especies más ampliamente distribuidas en Cuba, aparece entre la vegetación emergente de las formaciones secundarias, es de rápido crecimiento, hojas perennes, copa amplia(más de 10 m) y copiosa , su fruto es comestible por el ganado, los caballos y cerdos. Se desarrolla en todo tipo de suelos, incluyendo los áridos y de mal drenaje. Su madera es dura y es aprovechable para la carpintería rústica y para confeccionar útiles ganaderos como los yugos para las yuntas de bueyes.

- ***Bursera simaruba*** (seedbed or nude Indian in Central America): native tree of high size that can reach up to 25 m in height, perennial foliage and wood that despite being white and of low hardness, has many uses**.**

- ***Brachiaria brizantha*** (marandu): excellent forage plant dry land, stems erect 1.20 m high. It is propagated both by seeds and by cuttings. Tolerates soils from very acidic to neutral, but not saline. In tropical climate it reaches a yield of up to 80 t / ha. It adapts well in poorly drained soils. Pastures will be established from botanical seeds as it is safer and cheaper. It is multiplied by cuttings and will be managed for rotating grazing (every 21 days).

- ***Arachis pintoi:*** introduced perennial herbaceous creeping and stoloniferous growth, yellow flower, bare stem, dark green leaf, underground seed, forms a dense mat. It adapts well in acidic to alkaline soils, with medium-high fertility. Its adaptation range goes from humid forests to sub-humid forests (> 1200 mm - 3500 mm per year), survives for 4 - 5 dry months, height up to 1800 m.s.n.m., tolerates shade and is suitable for slopes. It improves the physical and chemical conditions of the soil; high protein and calcium contents are manifested in animal production. The potential for animal production of pastures associated with Arachis is 150 to 180 kg / an and 400 to 600 kg / ha per year.

12.5.4 Agro ecological practices and tasks for the implementation and management of the module.

This module is more effective when it is carried out in pasture lands and therefore, in a first stage it is not advisable to execute it in areas covered with marabou since after the clearing of this species, the enormous quantity of dormant seeds that remain in the soil and the renewal by the roots, make very expensive and lengthens the period of establishment.

In the first year of intervention, an area of Arachis pintoi is planted to produce forage according to the conditions of the site. The plantation of live poles to fence the perimeter of the system is made from the beginning of the transformation of the farm at a distance of 2 or 4 m. In the same way, the shadow for the shade will be sown.

In the second year of intervention, the sowing of Guazuma ulmifolia and grazing grasses is carried out in 25% of the double furrow area, separated by 4 or 5m, and in that space the grazing grass (and brachiaria, among others) will be sown. In the following years, this operation is repeated until the system is established in the whole area in the fourth year.

12.5.4.1 Technical description of the tasks

Preparation of the soil**:** Start the preparation of soil from the second tenth of March, preparing the conditions to start the sowing from the rainy season.

Forage Plantation

i. ***Guazuma ulmifolia:*** when the rainy season is established at a rate of 1.5 kg / ha of seeds in double rows separated 1.0 m apart and spaced at least 3m apart. When the plants have 8 - 10 cm. of height, to plant three grooves interspersed C. The right time to start grazing with adult animals is when the plant reaches around 1.2 m.

ii. **Arachis pintoi***,* will be established by seeds, 11-30 kilos of seed per hectare at a depth of 3-5 centimeters. It has rapid coverage, helps to protect the soil due to its prostrate growth habit and rooted stolons. This characteristic and underground seed production guarantees its persistence in the meadow.

iii. **Establishment of live fences**, the plantation of live poles *Bursera simaruba* and *Spondias purpurea* to fence the perimeter of the system is made from the beginning of the transformation of the farm at a distance of 2 or 4m as a whole with the planting of the 100 plants of shadow for the shade.

12.5.5 Calendar and Graphic diagram of the module's implementation. SILLEC.

12.5.5.1 Calendar of Activities of the module's implementation SILLEC.

The activities described in the previous section, consider the activities for the period of preparation and establishment; as well as those related to the period of maintenance and use (forest species); and use of Non-Timber Forest Products (NTFP); summarizing the planning for year 1 per month; and per year, until year 20. In Table 16 are the activities to be carried out for months for the SILLEC module.

Table 45 describes the order of the activities to be carried out and the months of execution.

Table 45: List of activities to be carried out and the months of execution for the SILLEC Module

No.	Activities	Period (years)		Months											
		Start	End	J	F	M	A	M	J	J	A	S	O	N	D
Forage plantation and forest species															
i	Land preparation	1	1												
ii	Guazuma ulmifolia plantation	1	1												
iii	Forage plantation (Arachis pintoi)	1	1												
iv	Live fence establishment (Lysiloma)	1	1												
v	Sowing of Soplillo for shade														
vi	Cultural services (AC) to the planted area for forage	1	1												
Viii	AC to live close plantation	1	1												
ix	Start cut in forage area (planted year 1)	2													
x	Promotion and cultural attention of 25% of the area (first planting)														

Note: Activities iii, iv, v, vi, vii and viii are repeated through the years

Source: Prepared by the authors with information from Animal Science Institute (ICA), Cuba, 2018

12.5.5.2 Graphic diagram of module implementation

Fig 15 shows the sequence of implantation and disposition of the perimeter and internal fences and Fig 16 shows the distance between the elements that make up the module.

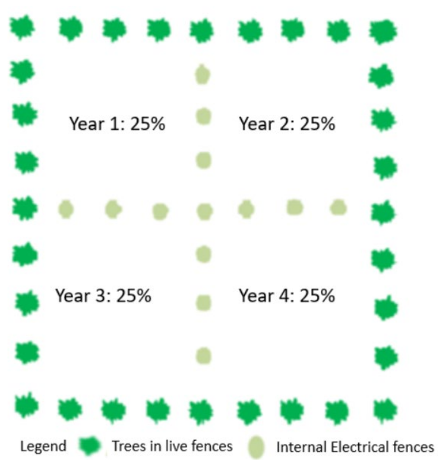


Fig 16: Top view of the SILLEC module

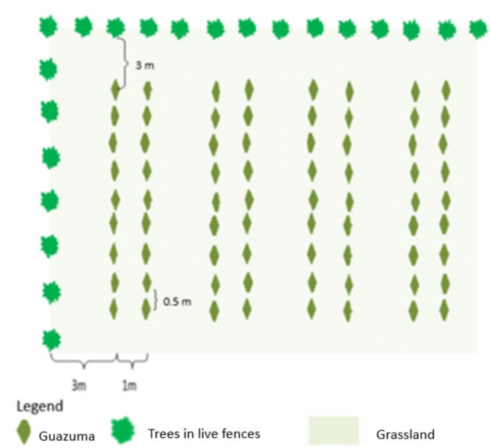


Fig 17: Top view of the SILLEC module (distance between elements)

12.5.6 Expected outputs and outcomes

The association of trees such as Guazuma ulmifolia with Arachis pintoi and improved grass in the entire grazing area will allow a load from 2 to 2.7 animals / ha, depending on the type of soil and should be rotated in 27 paddocks. Production / ha / year may increase from 2925 l / ha / year to 4550 l / ha / year (Ruiz et al., 2015).

In the fattening of animals, the association introduced in this module, in the entire grazing area might allow loads of 2 - 2.5 animals / ha, depending on the type of soil and rotation between 6-8 paddocks as a minimum, with the use of improved grasses whose population does not is less than 70%, without fertilization or supplementation.

12.5.7 Technologies to be promoted through the SILLEC module

The technology proposed in this module is more effective when carried out in degraded natural pastures and proposes the development of actions that combine species to produce fodder (Arachis), the sowing of Guazuma and grazing grass. These components interact within the system with a different dynamic than that which would only have the interaction of the animals with the grass, because the trees will have an effect on the pastures, the animals and the soil; and in turn, the soil will have an effect on the pastures and animals.

Additionally, the construction of small reservoirs of water is envisaged to work as drinking troughs, as well as the introduction of electric fences based on photovoltaic panels. These electric fences combined with live fences, will come to give a new way of managing livestock, with the promotion of items for the management of pasture and livestock. At the same time, the introduction of electric fences has a novel aspect and improves the resilience of producers to CC, especially in the possibility of better managing livestock distribution and pasture growth, and decreasing the use of conventional wire on the which is also difficult and expensive to use in Cuba. Electric fences will allow them to be easily installed and rotated if necessary.

Producers have also considered it the improvement of milking systems, as well as the maintenance of cold milk.

The description of the equipment to be procured, as well as the machinery to be used, is detailed in the supplementary material 2.6.5.

12.5.8 Environmental Benefits and Adaption Scenario

12.5.8.1 Carbon sequestered and avoided

Table 46, summarizes the avoided and sequestered carbon estimates with the SILLEC module

Table 46: Avoided and sequestered carbon estimates with the SILLEC module

Module	Area (ha) Result	Balance C(tCO2-eq) year-1	Balance C tCO2-eq. in 7 years implementation	Balance C tCO2-eq. in 20 years
5. SILLEC Silvipastoral system with shrub legumes	10498.6	-39,307	-275150	-786,142

12.5.8.2 Soil and water conservation (retention, runoff and infiltration)

It has been scientifically proven that the use of trees such as Guazuma ulmifolia, with legumes such as Arachis, contributes favorably to the increase of litter and Nitrogen accumulation in the soil and to the recycling of nutrients in general, as well as to the structural stability of the soil shows increase with the time of exploitation of the system. These results were obtained through studies conducted for more than 25 years (Ruiz, 1999).

All these improvements that are observed in the chemical and microphysical properties of the soils have another important effect and it is the increase of the porosity of the soils and the improvement and stability of their structure, properties that favor considerably the infiltration rates of the waters of rain with which the underground water mantles are recharged with greater force with the consequent benefits for the water economy (Lok, 2005 and Ruiz et al., 2016).

According to the results of research carried out in three watersheds in Cuba, the pastures, when they are well preserved, with a coverage of more than 80% and without overgrazing, are efficient hydro-regulatory and anti-erosive coverings through which only 13% of the total of rain (see Supplementary Material 1). Should be expected, in the case of the proposed system, more effective results, if you take into account the presence of the tree in it and that the predominant topography is flat.

These results have, in addition, an effect in the lower sector of the basin if it is considered that, greater volumes of water infiltrated in the upper and middle part of the basin move towards the sea or stop, with greater force, the salt water interface - sweet water; that is, the transfer of the saline intrusion inland slows down at first and accelerates its displacement towards the coastal line, later.

Additionally, it is recommended to establish Hydro-Regulatory Forestry Belts in the places where the gallery forests are lacking in accordance with current legislation.

SILSOM MODULE

12.6 Silvopasture with shadow trees and protein Banks. (SILSOM)

12.6.1 Description of the current situation and baseline

The scenario in which livestock is developed in the AIP is on pastures or pastures degraded by the continuous grazing, sparsely populated and composed of spontaneous grass species of poor yields and quality, based mainly on species introduced mainly in the 19th and 20th centuries. the Paspalum and Dichanthium genera, with lack of watering or free grazing, prolonged drought and high animal load without presence of legumes, little or no presence of trees and low level of mineral or organic fertilization and generally low birth rates and high mortality .. It is supported by soils in general of very low agro productivity (category IV), with the presence of numerous limiting factors such as: compaction, low content of organic matter, stoniness, low effective depth, among others.

The productivity of livestock is an indicator of notorious variability in the country, but, in general, with low levels; on average 4.5 liters of milk / cow / day are produced and a gain in weight of 200 g / animal / day is obtained.

12.6.1.1 Agro ecological description: site quality, soils, precipitation, and humidity.

The system is planned to be implemented in pastures degraded by continued management with low rainfall, lack of watering or free grazing, prolonged drought and high animal load. Soils, in general, have very low agro productivity (category IV), with severe limitations.

Overgrazing and insufficient stocking of pastures with pastures accelerate erosion processes. The compaction of the surface leads to a decrease in infiltration capacity.

12.6.1.2 Potential area for the implementation of the module in the project areas

The land area occupied by pasture constitutes 50% of the AIP, it is areas with low agro productivity soils, however, for the implementation of the module an area of 9691.2 ha is estimated (Table 47).

Table 47: Proposed area for the implementation of the SILSOM module

SILSOM module									
	Las Tunas		**Matanzas**		**Villa Clara**				**TOTAL**
ENTITY	Amancio	TOTAL	Los Arabos	**TOTAL**	Corralillo	Quemado de Güines	Sto Domingo	**Total**	
CCS	1180	**1180**	67.1	**67.1**	147.62	200	784	1131.62	**2378.72**
CPA	248	**248**			447.5		720	1167.5	**1415.5**
Granja							100	100	**100**
UBPC	134	**134**	187.94	**187.94**			610	610	**931.94**
UEB	565	**565**	281.84	**281.84**	4008.2	10		4018.2	**4865.04**
TOTAL	**2127**	**2127**	**536.88**	**536.88**	**4603.32**	**210**	**2214**	**7027.32**	**9691.2**

Almost 90% of the proposed areas are concentrated in the Santo Domingo and Corralillo municipalities in Villa Clara and Amancio in Las Tunas

12.6.2 *Objective and justification of the proposed module*

The implementation of the module would improve the supply of jobs and working conditions, as well as the availability of inputs and work tools. The incorporation of women, who normally do not involve themselves in this type of role, can be an important factor in the family economy.

On the other hand, the improvement of the feeding and the management of the herd would favor the elevation of the yields in meat and milk, notoriously low at present (4 l / cow / day in spring and half in the dry period). The increase in birth rates and the decrease in mortality rates will have an impact on an increase in economic income and consequently, an increase in the standard of living of farmers in general and of women in particular.

Likewise, the implementation of these systems is contemplated in the regulations for the delivery of land, which constitutes a good opportunity to support this process and incorporate more areas to livestock production.

12.6.2.1 *Impact on the resilience of the population*

The multiple use of the land, as well as the presence of the arboreal component at a rate of 100 trees / ha (*Samanea saman*) (to finally leave 50) in the grasslands in the initial phase, allows facing in better biophysical and socio-economic conditions, extreme events such as prolonged and frequent droughts, increased temperatures and strong winds. Thanks to the agro ecosystem created, it will be possible to continue producing food in a sustainable manner due, among other reasons, to the fact that there will be a greater availability of water and an appreciable increase in soil fertility levels.

It facilitates and humanizes work on the farm and what stimulates a greater presence of women and increased income are aspects, among others, that would encourage the permanence of the family and women especially in rural areas.

From the economic point of view with the implementation of this technology, you can expect productions of up to 7 liters of milk / cow / day.

12.6.3 *Description of the species that make up the module*

12.6.3.1 *For live fences:*

- ***Guazuma ulmifolia*** (guásima): native tree of the Esterculiaceae family, can reach 8-12 meters high, is one of the most widely distributed species in Cuba, appears among the emerging vegetation of the secondary formations, is a fast growing and evergreen specie with wide canopy (more 10 m) and copious, its fruit is edible by cattle, horses and pigs. It develops in all types of soils, including arid and poor drainage. Its wood is hard and can be used for rustic carpentry and for making livestock tools such as yokes for oxen yuntas.

- ***Bursera simaruba*** (seedbed or nude Indian in Central America): native tree of high size that can reach up to 25 m in height, perennial foliage and wood that despite being white and of low hardness, has many uses.

- ***Spondias purpurea*** (common or yellow plum): introduced tree, frequent throughout the island and highly demanded to be used in live fences for the ease with which it is established and what is desired of its fruit that is eaten directly or from which soft drinks and sweets are prepared.

12.6.3.2 *Shadow trees:*

- ***Samanea saman*** *(Algarrobo del país):* leafy tree that in conditions of fertile land can reach large dimensions. Because it is a legume species, it has very beneficial impacts on soils due to the symbiotic fixation of nitrogen and the contribution of leaf litter; its fruits are an excellent source of protein for livestock feed (a mature tree can produce between 150 and 200 kg of fruit / tree / year) and for its regulatory effects of climatic conditions associated with the circular pattern of its cups mitigating the effect of high temperatures on animals and pastures.

12.6.3.3 Herbaceous stratum:

The successive substitution of spontaneous pastures with improved grasses is expected to be carried out at an annual rate between 20-25% of the total grazing area of each fattening or milk production farm using the following species:

- ***Brachiaria brizantha*** *(marandu):* excellent forage plant dry land, stems erect 1.20 m high. It is propagated both by seeds and by cuttings. Tolerates soils from very acidic to neutral, but not saline. In tropical climate it reaches a yield of up to 80 t / ha. It adapts well in poorly drained soils. Pastures will be established from botanical seeds as it is safer and cheaper. It is multiplied by cuttings and will be managed for rotating grazing (every 21 days).

12.6.3.4 Fodder bank of protein species

- **Morus** ***sp.*** *(mulberry):* it is a plant of the family of the moraceae, with good production of biomass, high palatability and high nutritional value (proteins, minerals, and energy), for its digestibility is recommended for monogastric. The adult tree has 20 m or more in height. It grows well in soils of average texture, good drainage, pH of 6 to 7, good level of organic matter and does not support waterlogging, rainfall between 1000-3000 mm, and temperature of 14-30 ° C. In Cuba, it develops well in Ferralitic, Fersialitic and Pardo with Carbonate soils, with good drainage. Stakes that must have a length of 15 to 20 cm with a diameter of 2 cm approximately sows it, mature stems of trees of more than 3 years of age must be used. It will be used for cutting and racing at short cycles.

- ***Moringa oleifera*** (Moringa): Moringaceae family, easy to reproduce by seeds and stakes. It grows in poor soils, resistant to drought, grows well in arid and semi-arid conditions. Fast growing, can reach up to 4 m / year. It is a forage plant with a high percentage of crude protein, the waste from oil extraction is used as a food supplement for poultry and livestock, or as an organic fertilizer. The litter can be used as "mulch" or clothe. The yield can range from 0.9 to 4.7 t / ha. In the yield, the sowing density and the pruning frequency influence, which ranges between 35 and 45 days, from a first one that will be 60 days after planting. It will be used for cutting and racing at short cycles.

12.6.3.5 Fodder bank with energy species

In each farm an area equivalent to 15% of the total area with the best quality soils will be selected to be planted with forage species of cut and carry necessary to supplement the energy balance of the ration during the dry period fundamentally.

- ***Saccharum officinarum*** (sugarcane): the cultivation of sugarcane as cattle feed is well known and used in Cuba, especially in the dry period, functioning as an energy bank. It uses the bud, green leaves and stems ground and chopped for cattle, horses, sheep, and the guarapo for fattening pigs. It is sown in stems of 50 to 60 cm, a chorriillo and a meter of ridge, the first cut can be made after 10 months of established. It will be used for cutting and racing at short cycles.

12.6.4 Agro-ecological practices for the implementation and management of the module

12.6.4.1 Technical Description of the Tasks

The rotational grazing method will be used. In dairy farms, twelve subdivisions or paddocks are projected for each subgroup of the herd (eg, high production, low, dry, etc. groups), while in the fattening farms, 6 - 8 cortones are projected for each subgroup or category. old. The appropriate animal load for each farm will be decided taking into account the agro productive category of the predominant soil, the water regime of the region, the botanical composition of the grassland, the availabilities of cutting forages and the level of watering reached in accordance with the results of the Institute of Pastures and Forages Research.

- ***Land preparation****:* the establishment of pastures will be done through minimum tillage systems in a mechanized way, starting work in March. The planting of trees will be done through 40x40X40 cm planting holes manually opened. The postures will be tall (1- 2 m high) and will be protected rudimentarily to prevent livestock from damaging them.

- ***Acquisition of gásmicas and agámicas seeds****:* they will buy grass seeds gásmicas; forest seedlings and stakes for live fences and forage species.

- ***Establishment of live fences*** through live poles, seed and plum, in the perimeter areas of the paddocks and interior divisions, generally at a distance of 1.50 m, alternating in the first stage of establishment with dry poles. It starts from the beginning of the project.

- **Sowing:** the sowing of the pastures will be done with the beginning of spring (May) manually, in furrows by seeds or stolons, with a frame of 0.20m x 0.80m. The establishment rate will be 25% of the annual area.

- ***Sandwiching****:* by the rotational grazing method to subdivide the areas. In the dairy farms twelve subdivisions or paddocks are projected for each subgroup of the herd.

- ***Tree planting of pastures****:* The forest plantation will be made in holes for which preferably high-postures (1 m in height, approximately) produced in nursery will be used. It is estimated a density of 25 to 30 trees / ha that could cover approximately 25% of the land considering a stem diameter of 10 m. The planting of trees implies protection against trampling or browsing of animals for which there are two alternatives: 1) adjust the rotation of livestock taking into account that trees can survive grazing when they reach at least two to three meters in height and 2) protect the small trees with rustic methods or small fences which allows to maintain the grazing from the beginning of the implementation of the module.

- ***Protein bank establishment****:* with protein forage species defined, according to the agro technical information of each species, in an area equivalent to 5% (500 m2 / ha) for which a site with good soil conditions close to the dairy.

- ***Establishment of an energy bank****:* preferably with agasic seeds of sugarcane, according to the agro technics of each species, to be used in mixture with the protein forage species. The area to be planted will be 1500 m2 / ha for sugarcane.

- ***Cultural services****:* once the sowing of the grass is established, cultural attention will be made, mainly weeding and fertilizacion quimica al establecimiento de 35 kg/ha. In the plantation of forestry trees will be carried out hedges and pruning's if it were necessary. According to the development of the trees, the thinning will be carried out in such a way that the shade does not exceed 30% of the total area.

- **Beginning of grazing of the herd**: the year of establishment of the plantation and adequately pasting the land, the herd is introduced, whose load will be calculated taking into account the agro productive category of the predominant soil, the water regime of the region, the botanical composition of the pastureland, the availabilities of cutting forages and the level of watering reached.

- **Management of grasslands and forage banks**: to ensure good productivity of the pastures, proper management must be done, which is achieved by rotation of the herd in the paddocks (every 21 days), adequate time of stay and rest. The calendar of activities to be carried out is in Table 44

12.6.5 Calendar and Graphic diagram of the module's implementation. SILSOM.

12.6.5.1 Calendar of Activities of the module's implementation SILSOM

The activities described in the previous section, consider those for the period of preparation and establishment; as well as those related to the period of maintenance and use (forest species); per year, until year 20. In Table 48 are the activities to be carried out for months for the SILSOM module.

Table 48: Calendar of Activities for the SILSOM module

No.	Activities	Period (years)		Months											
		Start	End	J	F	M	A	M	J	J	A	S	O	N	D
i	Cleaning the area	1	7												
ii	Establishment of live fences	1	7												
iii	Isolation	1	7												
iv	Arborization of grassland (at the rate of 25% each year)	1	4												
v	Seeding of the pasture (at the rate of 25% each year)	1	4												
vi	Establishment of a protein bank	1	7												
vii	Establishment of an energy bank	1	7												
viii	Cultural Attention:	1	7												
ix	Start of herd grazing: management and veterinary attention (continuous activity)														
x	Management of pastures and forage banks: (continuous activity)														

Source: Prepared by the authors with information from Pastures and Forages Research Institute, Cuba, 2018.

12.6.5.2 Graphic diagram of module implementation (horizontal sketch and cross section) with distance and height

Fig 17, shows a horizontal outline of the SILSOM module, and the photography in Fig 18, shows a front view of the module, showing some Samanea saman trees (algarrobo del país) with non-uniform distribution within the paddock and covering approximately 30% of the area.

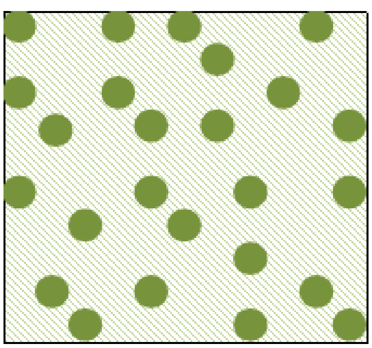


Fig 18: Top view of the SILSOM module

Fig 19: Front view of the SILSOM Module

12.6.6 Expected outputs and outcomes

Convincing with an improved pasture in the entire grazing area allows a load of 2 to 2.5 animals / ha, depending on the type of soil and should be rotated in 27 pastures. Production / ha / year can increase from 2790 l / ha / year to 6344 l / ha / year (Ruiz et al., 2015).

12.6.7 Technologies to be promoted through the SILEC module

The multiple use of the land, as well as the presence of the arboreal component in the grasslands in the initial phase, allows facing in better biophysical and socioeconomic conditions, extreme events such as prolonged and frequent droughts, the increase of temperatures and strong winds. Thanks to the agroecosystem created, it will be possible to continue producing food in a sustainable manner due, among other reasons, to the fact that there will be a greater availability of water and an appreciable increase in soil fertility levels.

The grazing of a plantation is gradual and, as the trees grow and receive a silvicultural management, they tolerate the presence of the cattle better.

Additionally, the construction of small reservoirs of water is envisaged to work as drinking troughs, as well as the introduction of electric fences based on photovoltaic panels. These electric fences combined with live fences, will come to give a new way of managing livestock, with the promotion of items for the management of pasture and livestock. At the same time, the introduction of electric fences has a novel aspect and improves the resilience of producers to CC, especially in the possibility of better managing livestock distribution and pasture growth, and decreasing the use of conventional wire on the which is also difficult and expensive to use in Cuba. Electric fences will allow them to be easily installed and rotated if necessary.

Producers have also considered it the improvement of milking systems, as well as the maintenance of cold milk.

The description of the equipment to be procured, as well as the machinery to be used, is detailed in the supplementary material 5.

12.6.8 Environmental Benefits and Adaptation Scenarios

12.6.8.1 Carbon sequestered and avoided

Table 49, summarizes the estimated avoided and sequestered carbon for the SILSOM module.

Table 49: Avoided and sequestered carbon estimates with the SILSOM module

Module	Area (ha) Result	Balance C(tCO2-eq) year-1	Balance C tCO2-eq. in 7 years implementation	Balance C tCO2-eq. in 20 years
6. SILSOM Silvopasture with shading and protein banks	9691.2	-61,154	-428075.3	-1,223,072

12.6.8.2 Soil and water conservation (sediment retention, runoff and infiltration)

The integration of multipurpose trees with pastures and the animal mass, forms a production system that combines silviculture and livestock with significant beneficial impacts, in the recycling of nutrients, the improvement of soil fertility and the production of forage, as well as environmental services that have to do with the reduction of wind speed and unproductive evaporation that decreases the capacity of moisture retention in the superficial layers of the land dedicated to grasslands.

The trees deposit around 2500 kg / ha of dry litter that increases the organic matter content of the soil and at the same time improves the structural stability of the soil (porosity and other physical-mechanical properties) which favors the increase of the infiltration index of the soil. soil from 0.26 to 0.79 and the erosion decrease from 70 t / ha / year to less than 8 t / ha / year (See Supplementary Material 1).

In terms of water management, it has been shown that poor arborization in pasturelands results in less water availability (4 times) in the soil due to evapotranspiration effects caused by wind speed (9 m / sec on average), and the amount of sun-hours and abrupt temperature changes between night and day. It is indicated the obligatory nature of the establishment of Hydro-Regulatory Forestry Belts in the places where the gallery forests are lacking according to the current legislation.

13. Transfer of productive modules to agricultural and cooperative producers:

To carry out the transfer of the productive modules described in this document, several strategies will be available, including the establishment of field schools for small farmers, exchanges from farmer to farmer and technical advice and specialized training by trainers of the Department of agriculture.

The efficiency and effectiveness of institutional and regulatory systems to help farmers develop the resilience of their agroecosystems will be improved through awareness and technical training regarding ecosystem services and agroforestry systems, business planning agricultural and the development of the value chain to generate the income that small farmers require to continuously invest in practices and equipment that improve resilience, and in improved monitoring and evaluation instruments and technologies.

A. Field schools:

In coordination with the technicians of the Ministry of Agriculture and the different producer cooperatives, at least 17 pilot demonstration farms will be used as areas for training and demonstration of the establishment of the modules.

Additionally, these pilot sites will be used under the concept of Field Schools. A Field School is an innovative, participatory and interactive learning approach that emphasizes problem solving and discovery-based learning. FFS aims to build farmers' capacity to analyze their production systems, identify problems, test possible solutions, and eventually encourage the participants to adopt the practices most suitable to their farming systems (FAO 2016), FFS can also provide an opportunity for farmers to practice and test / evaluate sustainable land use technologies, and introduce new technologies through comparing their conventional technologies developed with their own tradition and culture.

The Farmer Field Schools (FFS) approach was developed by FAO and its partners over 20 years ago as an alternative to the then prevailing top-down extension method of the Green Revolution, which failed to work in situations where more complex and counter-intuitive problems existed (see http://www.fao.org/3/a-i5296e.pdf for more details).

The Ministry of Agriculture will strengthen and intensify training and field visits system, combining off-site instruction and participatory research through Farmer Field Schools (FFS) with farm field visits as to provide technical assistance. MINAG extension workers and "champion farmers" (see Activity 2.2, below) will receive training to help producer organizations and small farmers to acquire the skills needed to establish, maintain and operate agroforestry, silvopastoral and forestry systems that improve resilience in production landscapes.

The project will train MINAG extension workers who will then train farmers in Farmer Field Schools (FFS) in the seven municipalities, according to the type of agroforestry, silvopastoral or forestry system that will be implemented, and will also provide technical expertise to help groups of small farmers in order to maintain agroforestry, silvopastoral and forestry systems established in Product 1, above. Extension trainers will be identified from an internal list of qualified MINAG experts. The extensionists will also promote exchanges from farmer to farmer in the ECA and through agricultural markets and agricultural fairs.

At the same time, extension agents will receive the logistical and technological support they need from MINAG to monitor agroforestry, silvopastoral and forestry systems in the field, collect data and store them properly, provide advice and training on the site, and build an interactive network of professionals agroforestry / silvopastoral / forestry.

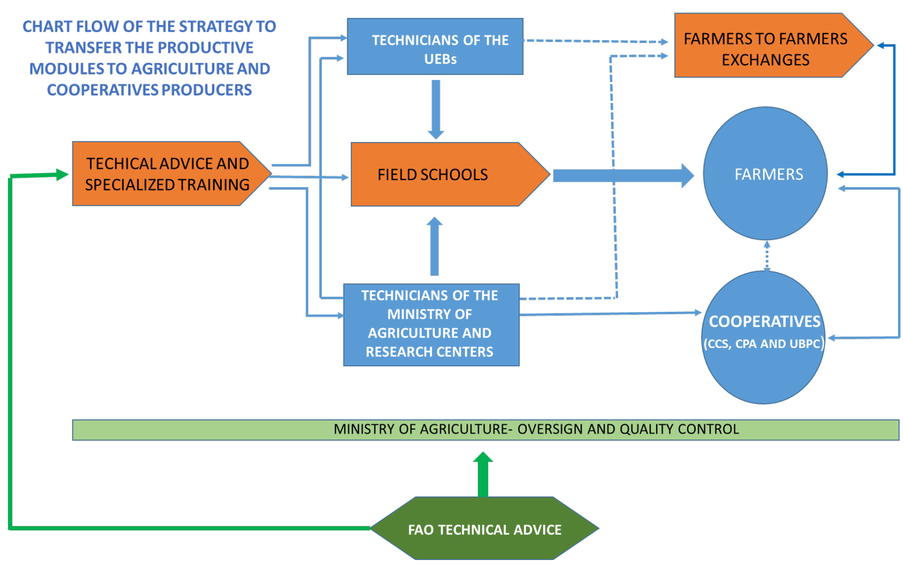
B. Farmer to Farmer Exchanges

An excellent strategy for transferring knowledge is that farmers learn with other farmers, so in addition to the FFS, exchange between farmers will be promoted, so that the transfer is direct, having the opportunity to learn by doing.

C. Technical Advice and Specialized Training

The technicians of the Ministry of Agriculture, as well as the extensionists of the cooperatives and the experts in the research centers, will play an important role in the transfer of technology. For this purpose, technical advice is expected to be carried out farm by farm, as well as group training and dissemination workshops on various topics. Additionally, it is expected to have the visit of international experts to address specific issues of importance to the project.

Fig 20: Chart flow of the strategy to transfer the productive modules to agriculture and cooperatives producers



14. Consulted Bibliography

Albelo and Averhoff 2000. Agrarian revolution and evolution of the Cuban agrarian system in the period 1959-1989. Cooperativism and social economy, ISSN 1130-2682, Nº 21-22, 2000, p. 53-106

Altieri, M.A. and Nicholls, C.I. Agroecology and resilience to climate change:

Álvarez, A. (2011) Second National Communication to the United Nations Framework Convention on Climate Change. Reanalysis of the impacts of climate change in the agricultural sector: 2nd approach. Havana.

Álvarez, A. and Mercadet, A. (2012). The Cuban Forest Sector and Climate Change. Institute of Agroforestry Research, Ministry of Agriculture. ISBN 978-959-721-500-4. Havana, Cuba, 248 pp.

Ávila, J, García, I, González, E., Rodríguez, J. and Duran, A. (1979). Ecology and Forestry. Havana, Editorial Scientific - Technical, 289 p.

Barret, W.H.G. & L. Golfari. 1962. Description of two new varieties of Caribbean pine. Carib For. 23: 59-71.

Batista, C. and Morales, F. (2017). Results of two demonstration plots of cedar associated with plantain and eucalyptus of 11 and 16 years in Mantua, Pinar del Rio. Havana, 7th Forestry Congress.

Bergkamp, G., Orlando, B. and Burton, I. (2003). Change: adaptation of water resources management to climate change. Gland, Switzerland, World Conservation Union (IUCN).

Betancourt, A. (1987). Special Forestry of tropical timber trees. La Hababa: Editorial Científico Técnica, 427 pp.

Betancourt, A. (2000). Exotic timber trees in Cuba, Havana, Editorial Científico - Técnica 352 p.

Bisse, J. (1981). Trees of Cuba. Havana, Technical Scientific Editorial. 383 p.

CABI. 2019a. Invasive Species Compendium. Wallingford, United Kingdom: CAB International. www.cabi.org/isc

CABI. 2019b. Brachiaria brizantha. In: Invasive Species Compendium. Wallingford, United Kingdom: CAB International. www.cabi.org/isc

CABI. 2019c. Morus alba. In: Invasive Species Compendium. Wallingford, United Kingdom: CAB International. www.cabi.org/isc

CABI. 2019d. Moringa oleifera. In: Invasive Species Compendium. Wallingford, United Kingdom: CAB International. www.cabi.org/iscCalzadilla, E. 2013. Agroforestry Systems in Cuba. Havana, Institute of Agroforestry Research. ISBN: 978-959-7210-59-7. 107 p

Cardona, J (2004). Multilingual Glossary of Forest Terminology (Spanish, Japanese, English, French and Portuguese). Colombia, Silvano Ltda, 350 p.

CIAT 2004. Design Strategies to Increase the Competitiveness of Productive Chains. Field Manual. Agro-Business Development Project. Cali, Colombia.

Cook, B.G., Pengelly, B.C., Brown, S.D., Donnelly, J.L., Eagles, D.A., Franco, M.A., Hanson, J., Mullen, B.F., Partridge, I.J., Peters, M. and Schultze-Kraft, R. 2005. Tropical Forages: An interactive selection tool [website]. Brisbane, Australia: Commonwealth Scientific and Industrial Research Organisation (CSIRO), Department of Primary Industries and Fisheries (DPI&F Queensland), Centro Internacional de Agricultura Tropical (CIAT) and International Livestock Research Institute (ILRI).

Díaz, G. (2013). Method for the rehabilitation of the hydroregulating forestry belt: Sub-basin Santoyo (Cuenca Almendares - Vento). Havana, MES / Higher Institute of Technologies and Applied Sciences. Thesis in option to the Scientific Degree of Master of Science, 75 p.

Espinal, M. et al. (2005) Silvopastoral systems. Establishment and management. CIPAV. Editorial Fesiva S.A. Bogotá, 155 p.

FAO (Food and Agriculture Organization) 2015. Development of sustainable food value chains: Guiding principles. Compiled by David Nemen. Rome Italy.

FAO (Food and Agriculture Organization) 2018. Socioeconomic characterization of the implementation area of the IRES-Cuba project. Prepared by Ania Mirabal. Internal document not published. Havana Cuba.

FAO (Food and Agriculture Organization). 2009. Forests and water. Forestry Study 155. Compiled by: Hamilton, LS et al in the field of the evaluation of world forest resources 2005. Rome, Italy.

FAO (Organización para la Alimentación y la Agricultura). 2019. Recuperado de http://www.fao.org/sustainable-agricultural-mechanization/overview/es/

Fassbender, H.W (1993). Edaphological production modules of agroforestry systems, Turrialba, CATIE, 492 p.

FAO 2016. Farmer Field School: Guidance document planning for quality programmes. Food and Agriculture Organization of the United Nations. Italy.

Fernández M, Shkiliova, L, Nores Y, y Ríos A. (Enero-Marzo, 2011). Estudio para la implementación de acciones estratégicas en la Unidad Empresarial de Base Integral de Servicios Técnicos de la Empresa Agropecuaria Güira de Melena. Revista Ciencias Técnicas Agropecuarias. Vol. 20, No. 1, pp. 66-71. Universidad Agraria de La Habana Fructuoso Rodríguez Pérez. La Habana, Cuba.

Fernández M, Suárez J, Shkiliova, L, Urgelles C y Almaguer J. (Julio-Agosto-Septiembre, 2017). Identificación de los servicios prestados en cuatro Unidades Empresariales de Base Integrales de Servicios Técnicos. Revista Ciencias Técnicas Agropecuarias, Vol. 26. No. 3. pp. 84-93. Instituto de Investigaciones de Ingeniería Agrícola (IAgric)- Ministerio de la Agricultura (MINAG)- Universidad Técnica de Manabí/Ecuador. La Habana, Cuba.

Forest Directorate, Wild Flora and Fauna (2017) Status of the forests of Cuba, 2016.

Fors, A.J. (1965). Cuban woods. Havana: Editorial Mario Reguera Gómez, 162 pp.

Funes, F. and Vázquez, M. (2016) Advances of Agroecology in Cuba. Editorial Experimental Station of Pastures and Forages Indio Hatuey. 580 p.

Gómez, A. and Gómez C. (2013) References for an analysis of sustainable development. UAH Collective works of science 10, 200 p.

González Mayra. 2019. Non-native species useful for the rehabilitation of agroforestry landscapes in Cuba. FAO Consulting report. Cuba.

González-Oliva L, Palmarola Bejerano A, González-Torres LR 2015. Lista Nacional de Plantas Invasoras en Cuba – 2015. Bissea 9:2. 88p.

González-Torres LR, Rankin R, Palmarola A eds. 2012. Plantas invasoras en Cuba. Bissea 6(1). 135p.

Gutiérrez Castorena, E.V, Gutiérrez Castorena, M.C. y Ortiz Solorio, .A. (2015). Manejo integrado de nutrientes en sistemas agrícolas intensivos: revisión* Rev. Mex. Cienc. Agríc vol.6 no.1 Texcoco ene./feb

Hellmann JJ, Byers JE, Bierwagen BG, Dukes J 2008. Five potential consequences of climate change for invasive species. Conservation Biology 22(3): 534-543.

Herrero, J. A. (2003). Hydro-regulatory forest girdles. Havana, Agrinfor, 52 p.

Herrero, J.A. (1992). Hydro-regulatory and anti-erosive function of the forests of the mountainous and premontane areas of Cuba. Thesis in option to the Degree of Doctor in Agricultural Sciences. Havana, Ministry of Higher Education, 100 p.

Institute of Soils (1999). New Version of Genetic Classification of the Soils of Cuba. City of Havana, Agrinfor 64 p.

IPCC (InterGovernmental Panel on Climate Change) 2018. Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, Maycock, M. Tignor, and T. Waterfield (eds.)]. Geneva, Switzerland: World Meteorological Organization. 538p.

IUCN 2017. Invasive species and climate change. Disponible en: https://www.iucn.org/resources/issues-briefs/invasive-alien-species-and-climate-change

Olmsted JL 2011. The butterfly effect: conservation easements, climate change, and invasive species. Environmental Affairs 38(1).

Kalenda, J. and Rield, O. (1966). Other useful functions of the forest. In Czechoslovak Forestry.

Lastres, l. 1990. Dynamics of the organic and energy reserves of the leaf litter of a semideciduous tropical forest in Cuba. Thesis in option to the degree of Dr. In Biological Sciences. Havana, Institute of Ecology and Systematics. Academy of Sciences of Cuba.

Lhumeau, A. and Lamb, D. (2012). Adaptation based on Ecosystems; a response to climate change. IUCN, Quito, Ecuador. 17 pp.

Lok, S. 2005. Study and selection of indicators of the stability in the soil-plant system of pastures in exploitation. Thesis presented as an option to the Degree of Doctor of Agricultural Sciences. Institute of Animal Science. p-100

López, F. 1977. Influence of vegetation on the fundamental elements of the hydrological cycle. Technical Quarterly Newsletter - informative Nos. 26 and 27. Institute of Hydrology, Madrid. Pag 263,275.

Melchanov, V and Herrero, J. Methodology to calculate the width of the hydroregulatory forest belt in the tropical conditions of Cuba. Rev. Forestry No. 6. P 74-79

Minag, Havana. Bulletin No 1, s / p.

Ministry of Agriculture (Minag) (1986). General Project of Organization and Development of the Forest Economy of the Republic of Cuba 1986 - 1995. Havana. Forest Management Projects Unit. 457 p.

Ministry of Agriculture (Minag) (2014). Compendium of legal norms for the implementation of a single price for inputs of the agricultural sector, including fuel. Havana, Minag.

Mora, N. and Melchanov, V 1995. The movement of groundwater in different land uses.

Muñiz, O., Febles, J.M, Balmaceda, C y otros (2007). La Ciencia del Suelo en Cuba: Actualidad y futuro previsible. En: XVII Congreso Latinoamericano de la Ciencia del Suelo. Sociedad Latinoamericana de la Ciencia del Suelo, León Guanajuato, México.

National Assembly of Popular Power. (1998). Law No. 85. Forestry Law. Official Gazette of the Republic of Cuba Year XCVI: ISSN 0864-0793.La Habana. Cuba.26 pp.

Novo, M. and Colectivo de Autores (1999) The environmental challenges. Reflections and proposals for a sustainable future. Madrid, Unesco, Editorial Universitas, S.A., 365 p.

Ortega, F. (1979) The organic matter of soils and soil humus in Cuba. Soil Institute. Academy of Sciences of Cuba. 129 p.

Oviedo Prieto, R. and González-Oliva, L. 2015. Lista nacional de plantas invasoras y potencialmente invasoras en la República de Cuba – 2015. Bissea 9(2): 5–90.

Parry M et al. 2009. Assessing the costs of adaptation to climate change – a review of the UNFCCC and other recent estimates. London: International Institute for Environment and Development and Grantham Institute for Climate Change. 111p.

Pérez, A. and Pérez, J. (2008). The production of honey in the mangroves. Beekeeping Research Center. MINAG, Havana.

Plascencia, T. A. (2010). Hydrological characterization in the ecosystems of natural pine forests with and without management in the Hidrológica Forestal Amistad Alturas de Pizarra, Cuba. Thesis in option to the Degree of Doctor of Ecological Sciences. University of Pinar del Río / University of Alicante. 252 p.

Prague, State Agricultural Publishing House (131-162).

Principles and methodological considerations. Agroecology (8): 7-20.

Pysek P, Jarosik V, Hulme PE, Pergl J, Hejda M, Schaffner U, Vilà M 2012. A global assessment of invasive plant impacts on resident species, communities and ecosystems: the interaction of impact measures, invading species traits and environment. Global Change Biology 18: 1725-1737.

Renda, A., Rodriguez, Y., Plasencia, T., Herrero, J.A. (2012). Manual for the protection of the water resources of Cuba. Havana. ISBN-978-959-7210-36-8. 160 pp.

Riverol, M. y Aguilar, Y. (2015). Alternativas para reducir la degradación de los suelos en Cuba y el enfrentamiento al cambio climático en Libro “Sembrando en tierra viva. Manual de agroecología” 185pp La Habana.

Rodríguez, G. and Samón, R. (2014). Management of mangroves, technical instructions. Institute of Agro-Forestry Research 22 pp. ISBN 978-959-7215-11-0.

Roig, J. T. (1965). Botanical Dictionary of Cuban Vulgar Names. Havana, Editor of the National Council of Universities. 1142 pp. Vol. 1 and 2.

Ruiz, T. E., Febles, G. and Alonso, J. 2015. Studies with legumes, a contribution to science during the fifty years of the Institute of Animal Science. Cuban J.Agric.Sci.49: 233

Sagué, H and Hernández, M. 1979. Structure of the radical system fingers vegetal communities of mountainous soils. Department of Ecology Foerestal. Ciencais Academy of Cuba. Scientific-technical report No. 41. 1-.9 p

Salinas Adolfo, Rodriguez Rigoberto, Morales David. 2010. Manual de especificaciones técnicas para la elaboración de estructuras de captación de agua de lluvia (SCALL) en el sector agropecuario de Costa Rica y recomendaciones para su utilización. CEMEDE. Universidad Nacional de Costa Rica. Nicoya, Costa Rica.

Salinas Adolfo, Rodriguez Rigoberto, Morales Hidalgo David. 2010. Manual of basic technical specifications for the development of rainwater harvesting structures (CALL) in the agricultural sector of Costa Rica and recommendations for their use. Mesoamerican Center for Sustainable Development of the Dry Tropics. National University of Costa Rica. Nicoya 96p.

Samek, V. (1974). Elements of Forestry of the Latifolios Forests. Havana, Science and Technology, Cuban Book Institute. 291p.

Sardiñas, O.F. (2014) Environmental impacts of climate change on agriculture in Cuba. Havana, Institute of Tropical Geography. s / p.

Seo SN 2010. Is an integrated farm more resilient against climate change? A micro-econometric analysis of portfolio diversification in African agriculture. Food policy 35: 32-40.

Sgrò CM, Lowe AJ, Hoffmann AA 2011. Building evolutionary resilience for conserving biodiversity under climate change. Evolutionary Applications 4: 326-337.

Spalding, M., Kainuma, M. and Collins, L. (2011). World Atlas of Mangroves. Okinawa, ITTO / ISME. 320 p.

Suarez J, Ríos A. y Linares E. (2011). Unidades integrales de servicios técnicos de maquinaria agrícola. Revista Ciencias Técnicas Agropecuarias. Vol. 20, No. 2. pp. 15-19. Instituto de Investigaciones de Ingeniería Agrícola (IAgric)- Ministerio de la Agricultura (MINAG).La Habana, Cuba.

Suarez J, y Ríos A. (Enero, Febrero, Marzo, 2018). Políticas para el desarrollo de la mecanización Agropecuaria en Cuba. Revista Ingeniería Agrícola. Vol. 8, No. 1. ISSN-2306-1545, E-ISSN-2227-8761. pp 54-59. Instituto de Investigaciones de Ingeniería Agrícola (IAgric)- Ministerio de la Agricultura (MINAG). La Habana, Cuba.

Technical Report No. 12. 12 p. Havana, INAF.

Vidal, A. et al. (2015) Inventory for the use of the covered areas of the vegetation of Dichrostachys cinérea (marabou) belonging to the Carlos Manuel de Céspedes municipality, province of Camagüey. Institute of Agroforestry Research, Havana, Cuba, 33 p.

Yero-Valdés. L; Rosales, M (2011). The forest farms and their contribution to the mitigation of climate change. Havana, 5th. Forestry Congress of Cuba.

15. Supplementary material

15.1 Behavior of the variables runoff and erosion coefficient for different vegetation cover in three selected watersheds.

	Runoff coefficient (%) by basins				Erosion (kg/ha) by basins			
Type of cover	San Diego	Hanabanilla	Cauto	Media	San Diego	Hanabanilla	Cauto	Media
Forests	0,07	0,03	0,04	0,05	8,8	6,7	42,0	19,2
CAP	0,23	0,21	0,07	0,17	15,8	86,6	37,0	46,5
Grass	0,23	0,15	0,24	0,21	34,7	26,7	60,0	41,5
CAT	0,37	0,30	0,27	0,32	1241	5788	1418	2815
CAP: Permanent agricultural crops								
CAT: Temporary agricultural crops								

Source: Elaboration by the author on the basis of doctoral thesis, 1993.

15.2 Proposed area for modules implementation

UM: ha										
Modules	**Zone Villa Clara - Los Arabos**				**Sub Total**	**Zone Las Tunas**			**Sub Total**	**Total General**
	Los Arabos	Santo Domingo	Corralillo	Quemado de Güines		Jobabo	Colombia	Amancio Rodríguez		
CEDPLA	94	0	79	0	**173**	1053	61	467	**1581**	1754
MARREG	724	360	650	510	**2244**	651	200	0	**851**	3095
MARFOM	510	2000	4757	0	**7267**	0	0	900	**900**	8167
FRUAGR	227	750	515	0	**1492**	522	59	456	**1037**	2529
SILLEC	490	150	2465	214	**3319**	5198	1982	0	**7180**	10499
SILSOM	537	2214	4603	210	**7564**	0	0	2127	**2127**	9691
Total	**2582**	**5474**	**13069**	**934**	**22058**	**7424**	**2302**	**3950**	**13676**	**35734**

Source: Own elaboration with information of the provinces.

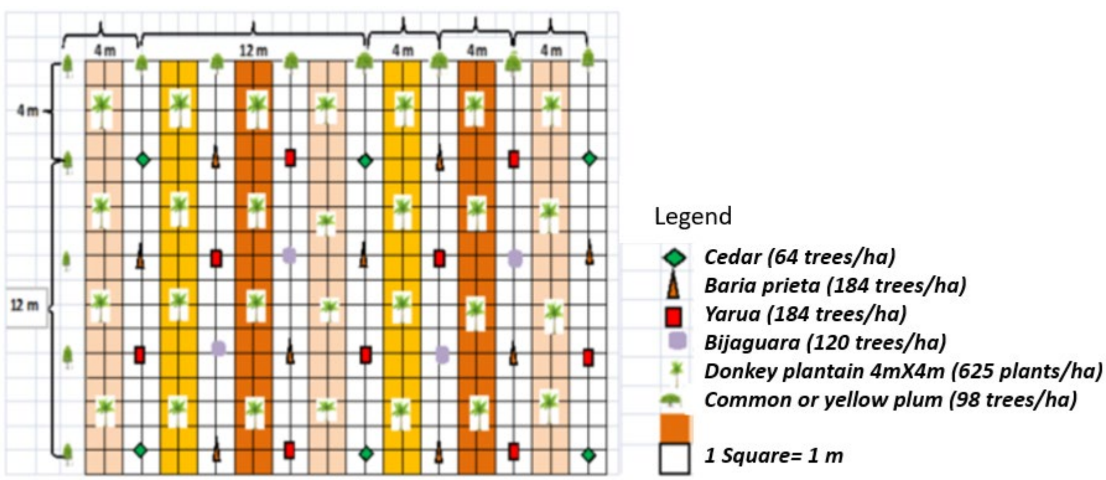
15.3 Technical summary per module

CEDPLA: **AGROFORESTRY SYSTEM WITH CEDAR / PLANTAIN**	
Objective	Increase the resistance of communities and households to Climate Change through a sustainable agroforestry system that will provide sufficient financial resources to achieve adequate levels in the quality of life of individuals and families.
Description	Sowing of deciduous trees, more resistant to drought, with deep roots and abundant litter production (552 trees / ha), including Cedrela odorata, Cordia gerascanthus, Caesalpinea violacea; Combined in rows with banana, Musa sp. (625 plants / ha).
Experiences in Cuba	In Cuba, through the "Tabacuba" Business Group, cedar production was promoted; considering the economic and environmental benefits of the activity; Recognizing the limitations that it faces.
Problem to be solved (current state):	- Water resources and degraded soils. - Attempts to establish nonspecific commercial plantations have failed in Cuba. - Reduction of the abundance of Cedar in Cuba due to overexploitation. - Unsatisfied demand for cedar wood. - High application of insecticides. - Lack of diversification of productive activities and income generation.
Benefits	- Restore the functions of ecosystems in areas with high risk of desertification and degradation covered with Marabou. - Reduce runoff from rainfall. - Groundwater recharge - Reduce soil erosion. - Increase in soil biomass. - Reduction of wind speed and - evapotranspiration - Increase the water and nutrients cycle. - Sequestration of CO2 by accumulation in biomass.

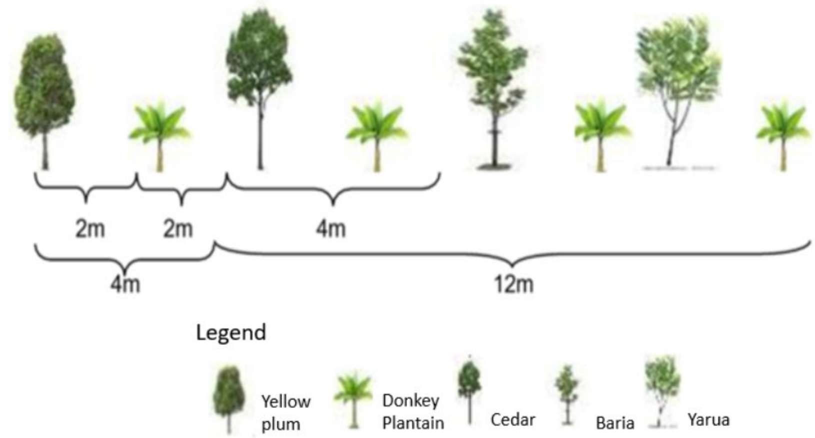
	- Employment for young people and women. - Development of capacities and knowledge about adequate and sustainable methods for the use and management of the land. - Increase and diversification of employment sources.
Potential area for implementation	Area Villa Clara - Los Arabos (Los Arabos, Coralillo, Quemado de Guiñes) and Area Las Tunas (Jobado, Colombia and Amancio Rodríguez), marabou affected areas (1754 ha).
Technological proposal	The technological proposal of this module consists of executing agricultural and forestry activities in a sustainable system under a systemic and integrating vision; that is conceived from the security of having the technical and financial resources; as well as the participation of the producers; Considering different types of forest species and a semi-permanent crop like plantain, generating economic, social and environmental benefits. For the implementation of the module, drip irrigation is promoted, with pumps operated by solar energy, as well as the construction of small reservoirs of water, which will store the water during the winter and will be used during the dry season. It is also expected that an important (but not limiting) criterion is that producers wishing to implement the module are close to surface water sources. The use of the brush cutter and other equipment for the preparation of land will be an important point within the module, since this technology is not available in Cuba.

GRAPHIC REPRESENTATION

AERIAL VIEW



Side View


2m
2m
4m
4m
12m
Legend
Yellow plum
Donkey Plantain
Cedar
Baria
Yarua

MARREG: MANAGEMENT OF THE NATURAL REGENERATION OF NATIVE ARBOREAL SPECIES

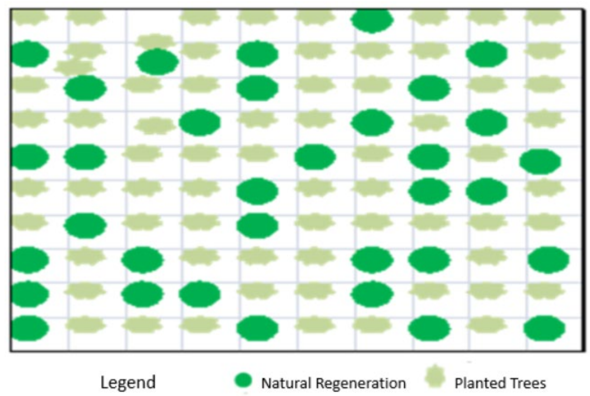
Objective	Increase the resilience of communities and ecosystems to Climate Change through the establishment of forests through assisted natural regeneration that will guarantee the reestablishment and provision of ecosystem services, diversification of livelihoods and generate a stable source of employment to achieve adequate levels of the quality of life of individuals and families.
Description	Establishment of forests through assisted natural regeneration in areas infested with marabuzales. Identification and selection of saplings and natural regeneration of native tree species, further management of the succession towards a natural forest through liberation cuts and enrichment planting. This module is characterized by being supported by soils of a very low agro productivity and with severe limiting factors (low effective depth, high stoniness, low content of organic matter, etc.). In addition to these factors, the selection criterion to define if this module is used will take as a basis the density (percentage ratio of the number of individuals of natural regeneration of appropriate species present in the area and the number of desirable seedlings in the area). The conversion of marabuzales into forests through assisted natural regeneration is a novel technique with the potential to scale throughout the country due to the multiple advantages it exhibits in relation to other forms of rehabilitation in these areas, among which are: a) shortening of the time in which the marabou is eliminated and replaced by a semi-natural, more resilient and productive forest; b) reduction of the initial environmental impact; c) lower implementation costs and d) humanization of this task. Taking into account its economic, biological and cultural importance, among other aspects, 20 more promising natives species are proposed for the module, which will have priority in their establishment. Achieving forests with a high diversity of species in all strata, is a benefit of this module compared to the traditional method used to mechanically clear and perform a nonspecific plantation, providing greater resilience to the ecosystem. besides the saving of human and financial resources in its establishment.
Experiences in Cuba	Model forest Sabanas de Manacas (BMSM)
Problem to be solved (current state):	In the country there are regions in which it has been observed that the marabou has been gradually replaced by the natural regeneration of native trees that develop spontaneously under the canopy of the marabou canopies; there is no doubt that this process is economically more attractive and the degree of resilience of the forests reached under this system is much greater since it is closer to the original forest, but has the disadvantage of the delay in the complete reconversion of the area and the structure and composition of the species that is not always what is desired. These lands that were used decades ago in the cattle activity were abandoned due to the loss and impoverishment of the pastures due to the notorious lack of water and the gradual

	degradation of their soils, which caused a low production of milk and meat and a high mortality the animals When they were not used for other uses, they were finally transferred to the forestry sector. At present, the forest plantations that are realized as successors of marabuzales are in more than 90%, nonspecific, very little resistant to the CC and in general susceptible to pests and forest fires to which it is added that in many occasions' exotic species are used mostly. , high water consumers such as eucalyptus, albizia, casuarina, etc. The "cleaning" of these areas that is still carried out with heavy machinery causes great impacts if we consider that the use of "excavation" affects the superficial horizons of the soils and eliminates the natural regeneration of the native tree species that have been competing with El marabou and that may constitute, in the future, the multispecific natural forest in a natural process of "ecological succession" that has the disadvantage of its delay.
Benefits	- Restore the functions of ecosystems in areas with high risk of desertification and degradation covered with Marabou. - Reduce runoff from rainfall. - Groundwater recharge - Reduce soil erosion. - Increase in soil biomass. - Reduction of wind speed and evapotranspiration. - Increase the water and nutrients cycle. - Sequestration of CO_2 by accumulation in biomass. - Employment for young people and women. - Increase and diversification of employment sources.
Potential area for implementation	Area Villa Clara - Los Arabos (Los Arabos, Santo Domingo, Corralillo, Quemado de Guines) and Area Las Tunas (Jobado, Colombia y Amancio Rodríguez), marabou affected areas (3095 ha).
Technological proposal	The starting point to implement the technology that allows the reconversion of marabuzales in forests through assisted natural regeneration, besides being a novel technique with the potential to scale throughout the country due to the multiple advantages it presents; it is based on an inventory of the area to evaluate the species present, the density and the state of natural regeneration; Among other indicators that allow, later, define the species that will be used in the plantation and the corresponding management. This technique places great emphasis on the production of seedlings of the promising tree species present in the area. The seeds will be harvested from trees that show a better phenotype, selected in the same areas, in protected areas or in nearby seed stands. These

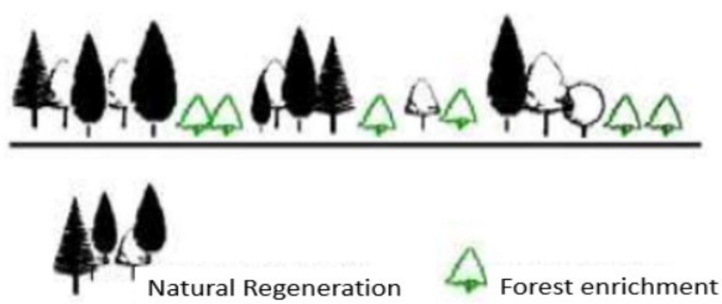
	seeds will be revived with tube technologies that increase the quality of the plantable material at a lower cost.

GRAPHIC REPRESENTATION

AERIAL VIEW



SIDE VIEW



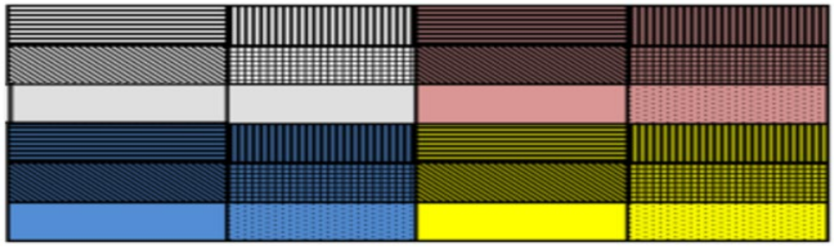
MARFOM: ESTABLISHMENT OF PLANTED FORESTS CLOSE TO NATURE

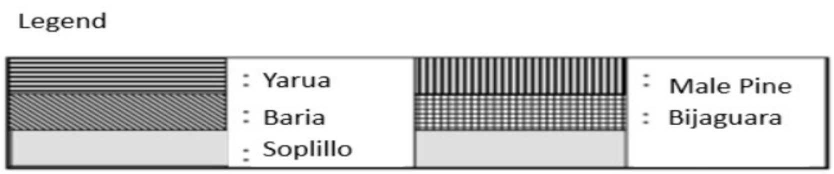
Objective	Increase the resilience of communities and households to Climate Change through the establishment of a Close-to-nature Planted Forests that will guarantee the reestablishment and provision of ecosystem services and generate a stable source of employment to achieve adequate levels of the quality of life of individuals and families.
Description	The multifunctional-planted forests are established by achieving a combination of forest species where the natives predominate over the exotic ones and offer important ecosystem services so that the communities and the inhabitants in general benefit from them. The objective of this module is to achieve the establishment of planted forests close to nature by planting mixtures of native and exotic species, such as pines, cordia, colubrina, caesalpinea and lysiloma sp in the places where Marabou has been mechanically removed. It is planned to use these species, according to their adaptability to existing soils and to the objectives of the plantations, taking into account that they are resistant to drought, to fires and that their wood is of economic value.
Experiences in Cuba	Experiences in the Model Forest Sabanas de Manacas and the Agroforestry Las Tunas Company
Problem to be solved (current state):	Massive reforestation activities in Cuba began in 1959, with a significant impact on the country's economy, on the protection of the environment and on society in general. For 2016, 64% of the forests planted correspond to forests of native species, 33% of forests with exotic species and 3% of fruit trees without commercial character. Without exception, all the native species proposed in the present project are represented on the surface of planted forests, of which there are experiences of their management. Analyzed at the country level, this situation could be considered satisfactory, but when the problem of the diversity of species used in reforestation at the grassroots level is analyzed, the reality is different; It is generalized that only one species is used in the same area, even in those plantations that have protection and conservation objectives. In light of the problems related to the effects of CC, a conceptual change is required in current Cuban forestry, which must necessarily be governed by the principles of adaptation based on ecosystems. The establishment of mixed forests, the care of natural regeneration, propitiate and maintain the vertical structure of the forest and the effective protection against forest fires are aspects that allow that the planted forests with commercial character assure the numerous and varied Eco systemic services that the forests offer. In recent years, the reforestation rate has decreased, mainly due to the lack of heavy equipment that responds to the "bulldozed" cleaning of the areas invaded by marabou. However, these techniques have shown their aggressiveness in soils and vegetation, so they must be replaced by other less aggressive systems that have less impact on the environment.

	The implementation of nonspecific plantations, as is common practice today, is a serious problem from the point of view of increasing the resilience of households, people and ecosystems. In the intervention area there are tree nurseries and fruit trees with obsolete technology, where plastic containers are used that do not encourage the adequate development of seedlings that show high mortality when they are taken to the field. The few nurseries of existing pipe plants, which is a technology far superior to that of polyethylene containers, have not generally been assembled with the complete system, so they are not as effective.
Benefits	- Restore the functions of ecosystems in areas with high risk of desertification and degradation covered with Marabou. - Reduce runoff from rainfall. - Groundwater recharge - Reduce soil erosion. - Increase in soil biomass. - Reduction of wind speed and evapotranspiration. - Increase the water and nutrients cycle. - Sequestration of CO2 by accumulation in biomass. - Employment for young people and women. - Increase and diversification of employment sources.
Potential area for implementation	Area Villa Clara - Los Arabos (Los Arabos, Santo Domingo, Corralillo) and Area of Las Tunas (Jobado, Colombia y Amancio Rodríguez), marabou affected areas (8167 ha).
Technological proposal	Technology defines that the maximum area (block) that must be cleared to carry out the plantation is 60 hectares (Ha.), Leaving the same area without clearing alternately. The blocks of 60 ha. They consist of six 6 nonspecific stands that can have one hectare. At least 10 ha. at the most. When the plantation has been established, which generally occurs within two or three years, the adjacent areas that remain with marabou will be cleaned and planted. The stands without rigid designs respecting the channels, fluvial currents and any other type of geographical accident, will be separators by interior firewalls; In addition, the internal blocks will be separated by masterful paths and green stripes. These multifunctional-planted forests are established by achieving a combination of forest species where native species predominate over exotic species and offer important ecosystem services for communities and residents in general. Like the other modules mentioned above, the use of the machinery for clearing and preparation of the land will be of the utmost importance.

GRAPHIC REPRESENTATION

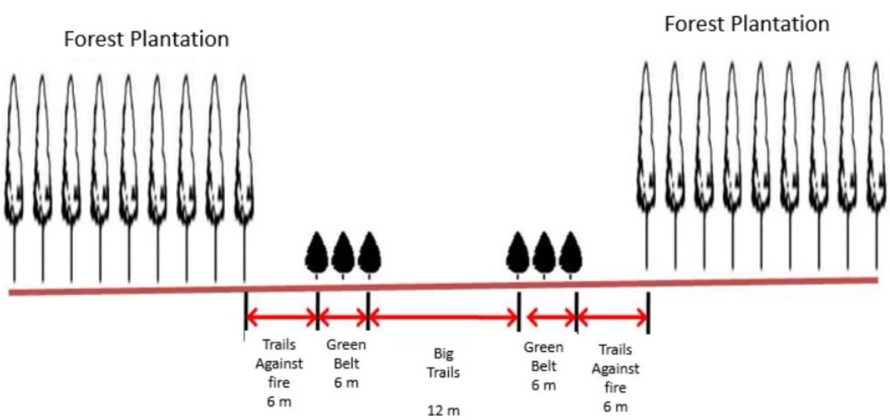
AERIAL VIEW





Note: each color is a block composed of six stands of variable size but minimum of one ha.

SIDE VIEW



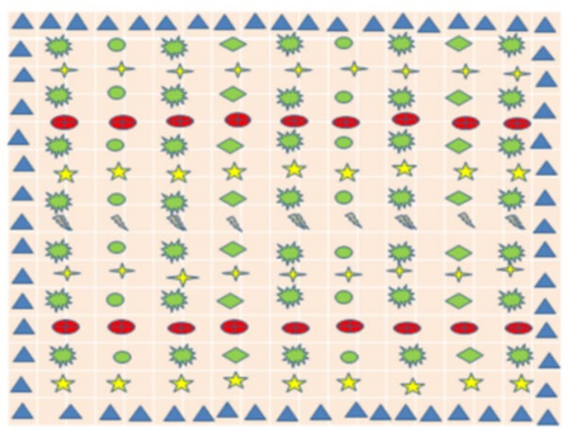
FRUAGR: AGROFORESTRY SYSTEM WITH FRUIT TREES, AGRICULTURAL CROPS AND LIVING FENCES

Objective	Increase the resistance of communities and households to Climate Change through a sustainable agroforestry system that will guarantee food security and generate income to reach adequate levels of the quality of life of individuals and families.
Description	Agroforestry system with fruit trees, agricultural crops and live fences. We present several citrus fruits (56 trees / ha) and mango (64 trees / ha) in combination with the rotation of crops, which include cassava, sweet potato, corn, beans and several species of green fences. The fruit species that will be used are: sweet orange or Chinese orange (Citrus sinenis), mandarin (Citrus reticulata), mango (Manguifera indica). The species of several crops are: beans (Phaseolus vulgaris), beans (Vigna sp), sweet potatoes (Ipomoea batatas), cassava or manioc (Manihot esculenta), corn (Zea mays). The species for live fences are: naked Indian (Bursera simaruba) and common plum (Spondias purpurea). The proposed system is based on agro ecological practices such as polyculture and crop rotation to increase their capacity for recovery and, at the same time, maintain and increase soil fertility and reduce the incidence of pests and diseases. This module can have numerous variants that will depend on the interests of the villagers, the local demand for products, the market prices and the soil conditions of the farm.
Experiences in Cuba	Experiences in family farms in the Velásquez. Las Tunas, The Avocado, Santo Domingo.
Problem to be solved (current state):	In general, in Cuba and in particular in the area of interest, agroforestry systems (mix of fruit trees, agricultural crops and living fences) have not spread widely, despite numerous examples in the country that demonstrate the multiple benefits of these systems. The erroneous concept, but deeply rooted in rural areas, of the advantages of monocultures and of considering trees as competitors (enemies) of "sowing" are aspects that have impeded the development of systems such as the one proposed in this project. . . However, in recent years there has been a change in the attitude of farmers, usufructuaries, technicians and officials of these systems. On the other hand, current food production in Cuba does not meet the demand or per capita consumption requirements of food, grains, fruits and vegetables. In the productive history, these crops are highly demanded by the population.
Benefits	- Restore the functions of ecosystems in areas with high risk of desertification and degradation covered with Marabou - Reduce runoff from rainfall. - Groundwater recharge

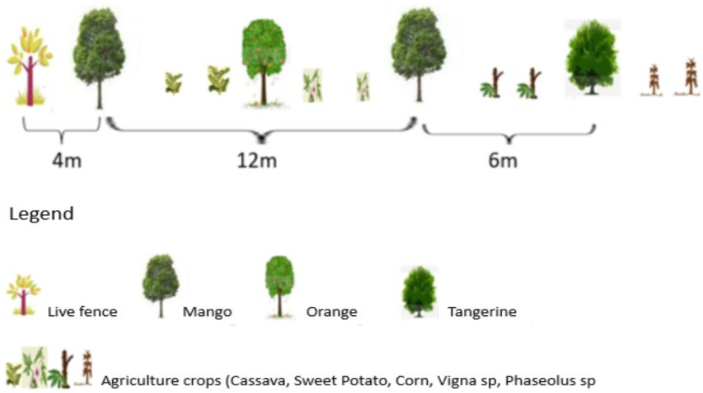
	- Reduce soil erosion. - Increase in soil biomass. - Reduction of wind speed and evapotranspiration. - Increase the water and nutrients cycle. - Sequestration of CO2 by accumulation in biomass. - Employment for young people and women.
	Area of Villa Clara - Los Arabos (Los Arabos, Santo Domingo, Quemado de Guiñes) and Area of Las Tunas (Jobado, Colombia y Amancio Rodríguez), marabou affected areas (2529 ha).
Potential area for implementation	The proposed system is based on agro ecological practices such as polyculture and crop rotation to increase their capacity for recovery and, at the same time, maintain and increase soil fertility and reduce the incidence of pests and diseases: promote food and nutrition security . For the implementation of the module, drip irrigation is promoted, with pumps operated by solar energy, as well as the construction of small reservoirs of water, which will store the water during the winter and will be used during the dry season. An important (but not limiting) criterion is that producers wishing to implement the module are close to surface water sources. The use of the brush cutter and other equipment for the preparation of land, will be an important point within the module, since this technology is not available in Cuba.

GRAPHIC REPRESENTATION

Legend	Specie	Plantation Arrangement (m)	Number of plants
	Mango	12 x12	64
	Orange	6 X 24	32
	Tangerine	6 X 24	24
	Phaseolus sp	0,30 X 0,70	
	Sweet Potato	0,15 X 0,25	
	Cassava	0,90 X 0,90	
	Corn	0,25 X 0,50	
	Live fence	1,5	266



AERIAL VIEW



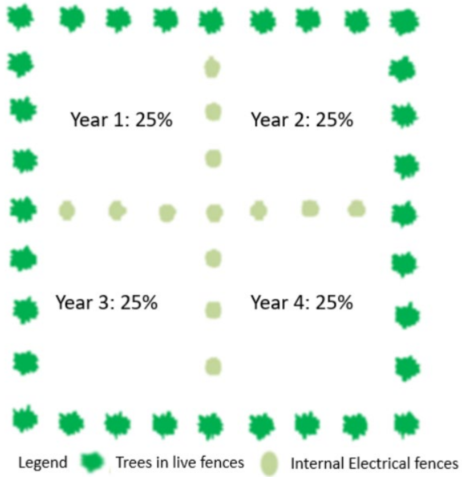
SIDE VIEW

SILLEC: SILVOPASTORIL SYSTEM WITH ARBUSTIVE LEGUMINOUS

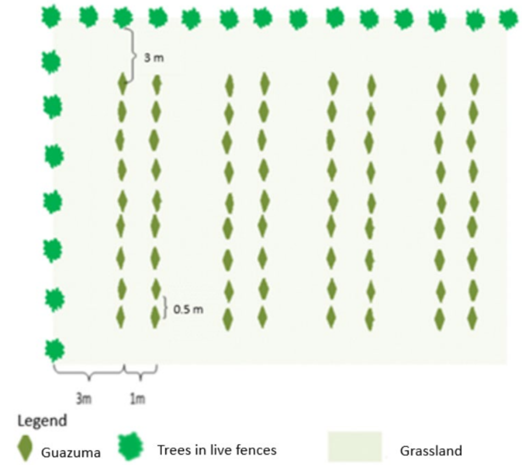
Objective	Increase the resilience of communities and households to Climate Change through the establishment of silvopastoralists practices that will improve the low yields of animal production (milk and meat) and guarantee the generation a stable source of employment to achieve adequate levels of the quality of life of individuals and families.
Description	Silvopastoral practices are an imperative need of cattle activity in Cuba in view of the effects of Climate Change to improve the low yields of animal production (milk and meat), low birth rates and high mortality. The module will develop in degraded natural savannas with little precipitation, lack of flooding, prolonged drought, high animal load and low plantation, soils of low agro productivity; focusing on for-farming (under perturbation fouling) and the establishment of Guazuma ulmifolia in double strips every 3 m, and the progressive introduction of varieties of improved pastures, more resistant to drought Brachiaria brizantha and Arachis pintoi.). In addition, it will implement the green contour surrounding with Bursera simaruba and Spondias mombim trees and an internal electrical fence to regulate the grazing of livestock and allow for the recovery of pastures and the conservation of the soil.
Experiences in Cuba	Experiences at the Institute of Animal Science (ICA)
Problem to be solved (current state):	The scenario in which livestock farming in the area of interest is in natural pastures degraded by continuous pasture, lack of free pasture, prolonged drought and high animal charge. Soil in general is very low agro productivity, with the presence of numerous limiting factors such as: compaction, low organic matter content, rockiness, and low effective depth, among others. It maintains pastures of spontaneous natural grasses of low yield and quality, without presence of legumes, low or no presence of trees and low level of mineral or organic fertilization and, in general, low birth rates and high mortality.

	Cattle productivity is an indicator of marked variability in the country, but, in general, with low levels; on average, 2 liters of milk / cow / day are produced and a weight gain of 200 g / animal / day is obtained.
Benefits	- Restoration of the functions of ecosystems, in areas with high risk of desertification and degradation, really covered with natural degraded pastures - Increase soil organic matter (greater retention of nutrients and water) - Reduction of run-off. - Increase in rainfall infiltration. - Improvement of the pasture (it stays green for longer). - Reduction of soil erosion. - Improvement of animal welfare and productivity. - Increase in the production of forages. - Increase in the porosity of soils and the improvement and stability of their structure. - Sequestration of CO2 by accumulation in biomass.
Potential area for implementation	Area Villa Clara - Los Arabos (Los Arabos, Santo Domingo, Corralillo) and Area of Las Tunas (Jobado, Colombia and Amancio Rodríguez), in areas of degraded natural savannas (10499 ha).
Technological proposal	The technology proposed in this module is more effective when carried out in degraded natural pastures and proposes the development of actions that combine species to produce fodder (Arachis pintoi), the sowing of Guazuma ulmifolia and grazing grass. These components interact within the system with a different dynamic than that which would only have the interaction of the animals with the grass, because the trees will have an effect on the pastures, the animals and the soil; and in turn, the soil will have an effect on the pastures and animals. Additionally, the construction of small reservoirs of water is envisaged to work as drinking troughs, as well as the introduction of electric fences based on photovoltaic panels. These electric fences combined with live fences, will come to give a new way of managing livestock, with the promotion of items for the management of pasture and livestock. At the same time, the introduction of electric fences has a novel aspect and improves the resilience of producers to CC, especially in the possibility of better managing livestock distribution and pasture growth, and decreasing the use of conventional wire on the which is also difficult and expensive to use in Cuba. Electric fences will allow them to be easily installed and rotated if necessary. Producers have also considered it the improvement of milking systems, as well as the maintenance of cold milk.

GRAPHIC REPRESENTATION



AERIAL VIEW

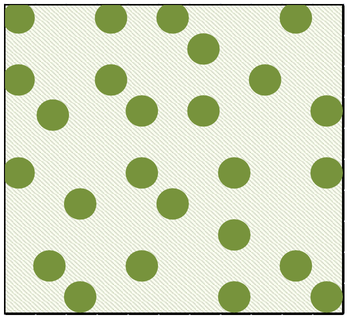


AERIAL VIEW (distances)

SILSOM: SILVOPASTURE WITH SHADOW TREES AND PROTEIN BANKS

Objective	Increase the resistance of communities and households to climate change through the establishment of silvopastoral practices that will improve the low yields of animal production (milk and meat) and guarantee the generation a stable source of employment to reach adequate levels of quality of life of people and families.
Description	The Module will be implemented in degraded natural pastures by continuous management with little rainfall, lack of afforestation or free pasture, prolonged drought and high-loaded animals. Soils, in general, have a very low agro productivity (category IV), with severe limitations, focusing on farms for plots (low subsoil) and the progressive introduction of more resistant grass varieties (Brachiaria brizantha) in combination with 30 shade trees / ha (Samanea saman) and contour fences (Guazuma ulmifolia, Spondias purpurea, Bursera, Spondias) and pasture rotation. Establishment of "banks" of proteins (Morus sp, Moringa oleifera) And energy (Saccharum officinarum) in 15% of the area as food to be cut and harvested in dry periods.
Experiences in Cuba	Experiences from the Pasture and Fodder Research Institute (IIPF)
Problem to be solved (current state):	The scenario in which livestock farming in the area of interest is in natural pastures degraded by continuous pasture, lack of free pasture, prolonged drought and high animal charge. Soil in general is very low agro productivity, with the presence of numerous limiting factors such as: compaction, low organic matter content, rockiness, and low effective depth, among others. It maintains pastures of spontaneous natural grasses of low yield and quality, without presence of legumes, low or no presence of trees and low level of mineral or organic fertilization and, in general, low birth rates and high mortality. Cattle productivity is an indicator of marked variability in the country, but, in general, with low levels; on average, 2 liters of milk / cow / day are produced and a weight gain of 200 g / animal / day is obtained. Soils, in general, have a very low agro productivity (category IV), with severe limitations. Overgrazing accelerates the erosive processes due to the compacting of the surface by the trampling of the cattle that leads to the reduction of the capacity of infiltration; He is an agent of geomorphological changes since his helmets physically reconfigure the surface of the soil, creating "saltanejos" (Spanish) especially in plastic soils.
Benefits	- Restoration of the functions of ecosystems, in areas with high risk of desertification and degradation really covered with degraded natural pastures - Increase soil organic matter (greater retention of nutrients and water) - Reduction of run-off. - Increase in rainfall infiltration.

	- Improvement of the pasture (it stays green for longer). - Reduction of soil erosion. - Improvement of animal welfare and productivity. - Increase in the production of forages. - Increase in the porosity of soils and the improvement and stability of their structure. - Sequestration of CO2 by accumulation in biomass. - Production of biogas for home use.
Potential area for implementation	Area Villa Clara - Los Arabos (Los Arabos, Santo Domingo, Corralillo, Quemado de Guines) and Area of Las Tunas (Jobado, Colombia and Amancio Rodríguez), in areas of degraded natural pastures (soils of low agro productivity, 9 691 ha).
Technological proposal	The multiple use of the land, as well as the presence of the arboreal component in the grasslands in the initial phase, allows facing in better biophysical and socioeconomic conditions, extreme events such as prolonged and frequent droughts, the increase of temperatures and strong winds. Thanks to the agroecosystem created, it will be possible to continue producing food in a sustainable manner due, among other reasons, to the fact that there will be a greater availability of water and an appreciable increase in soil fertility levels. The grazing of a plantation is gradual and, as the trees grow and receive a silvicultural management, they tolerate the presence of the cattle better. Additionally, the construction of small reservoirs of water is envisaged to work as drinking troughs, as well as the introduction of electric fences based on photovoltaic panels. These electric fences combined with live fences, will come to give a new way of managing livestock, with the promotion of items for the management of pasture and livestock. At the same time, the introduction of electric fences has a novel aspect and improves the resilience of producers to CC, especially in the possibility of better managing livestock distribution and pasture growth, and decreasing the use of conventional wire on the which is also difficult and expensive to use in Cuba. Electric fences will allow them to be easily installed and rotated if necessary. Producers have also considered it the improvement of milking systems, as well as the maintenance of cold milk.
GRAPHIC REPRESENTATION	



AERIAL VIEW

SIDE VIEW:

16. Supplementary material 2.6.4. Productive forms contributing in municipalities

	Amancio	Colombia	Corralillo	Jobabo	Los Arabos	Quemado de Guines	Sto Domingo	Total
CCS	22	21	6	19	5	2	23	98
CPA	10	2	10	11	8		3	44
Farm							1	1
UBPC	2	4	12	15	10		18	61
UBF	3	2	15	2	16	5	5	48
Total	37	29	43	47	39	7	50	252

16.1 Technical description of the machinery and equipment to be procured.

Prepared by IAGRIC. La Habana, Cuba April 2019. Pedro San José, IAGRIC, email prueba9@boyeros.iagric.cu

The mechanization of the activities included in the production system of sustainable agroforestry modules with a technology lead for the removal of marabou and the enlistment of that soil for its sowing and care and guarantee the seedling and other low medium growth within the plantation and to create silvopastoril systems for

<u>Technical Task for the 120 hp tractor with 4 x 4 moto diagram.</u>

TECHNICAL REQUIREMENTS 120 HP TRACTOR WITH 4 X 4 MOTO DIAGRAM	
Motor	Hydraulic distributor with forced lowering / gravity with the other options.
Diesel with direct injection and cooling by water.	Four or more additional sockets placed on the back of the tractor and two sides with fast coupling in all.
With dry air filter with safety cartridge and dust ejector.	Lifting capacity greater than 2 600 kg.
Line fuel injection pump / injector pump.	Integral suspension system of three points.
Aspiration by intercooler turbo or normally aspirated	Category ISO II and III
Specific fuel consumption at a nominal rate of less than or equal to 250 g / kW-h	With rear oscillating clutch bar with a traction capacity of more than 4000 kg
Starter motor of 12 V.	Tree taking power. (a.t.f)
Alternator of 500/750 W and 14 V.	Independent diameter of 35 mm with 6 stretch marks.
The engine cooling system must guarantee that it works at its maximum efficiency, taking into account the following climatic conditions: ambient temperature 36 degrees Celsius and relative humidity of 90%	Angular velocity 540 and 1 000 rpm.
Mechanical motor regulator.	Placed on the back.
Capacity of the fuel tank equal to or greater than 80 L.	Mechanism of mechanical or hydraulic connection
Regulations for emission of polluting gases TIER II or EURO II.	Front bridge
Dimensions	4x4 motor diagram.
Front trowel 1 600 - 2 100 mm.	Keep mud or keep mud from front.
Rear trowel 1 600 - 2 100 mm.	Transmission
Weight	With mechanical control.
Total 2 400/3 800 kg.	Five synchronized marches of two to four ranges.
Tires	Hydrostatic / mechanical clutch.
Forwards 7.5 / 9 - R24	Single disc
Rear 16.9 / R38 is recommended	Ceramic or graphite metal disk.
In both cases, more than 8 layers or equivalent	Brake system
Hydraulic steering system.	Hydraulic actuated moisture with oil bath disks.
Hydrostatic.	Multi-position parking brake in oil bath and mechanical drive.
Hydraulic suspension system.	Electrical system
Hydraulic pump greater than 50 L / min.	12 v
Folding rear part with duplex crystal	Front and rear lighthouse for night work.
Cab used in tractors for different climates, it will have a comfortable and comfortable seat, with backrest and mechanical suspension	Ear electric jack for trailers
The air conditioning system must guarantee temperatures between 18 and 22 degrees Celsius.	Heated cabin
Brackets fixed to both sides of the front for mirrors	Tubular structure of roll-resistant structure, arch located behind the operator
Ceiling, resistant to solar irradiation with a superior door	Front, frame with duplex crystal, with windshield wipers

In addition, the following requirements must be met:

Additional Components 120 hp tractor with 4 x 4 moto diagram
The seals that are used to prevent the exit of oil must be placed on double lips.
The tractor must have the front and rear counterweights.
Water decanters should be installed that are transparent material in easily accessible places, in the case of a fuel system
Provide a module of elements for maintenance after the settlement and the basic tools for a period of one year.
You must bring 10% of your value in replacement parts, which must be in the technical offer.
The manual of exploitation and catalog of parts in Spanish.
The ISO 9001 and 1400 certificates must accompany the tractor. With the fundamental engine indexes, such as nominal power, specific fuel consumption at nominal revolutions, maximum torque and test curves of the bank, the document must also be delivered which certifies compliance with the EURO II or TIER II standards.
In the tractors manufactured under the Tier 3 standard, the supplier will be responsible for the breakage or damage caused by the use of the national diesel, which has a high sulfur content.
With the offer of the tractor must come official document of manufacture of the equipment (place where it was manufactured).

Technical Task of 90 hp tractor with 4 x 4 moto diagram

Technical requirements

TECHNICAL REQUIREMENTS 90 HP TRACTOR WITH 4 X 4 MOTO DIAGRAM	
Motor	Rear 16.9 / R38 is recommended
Diesel with direct injection and cooling by water.	In both cases, more than 8 layers or equivalent
With dry air filter with safety cartridge and dust ejector.	Hydraulic steering system.
Line fuel injection pump / injector pump.	Hydrostatic.
Aspiration by intercooler turbo or normally aspirated	Hydraulic suspension system.
Specific fuel consumption at a nominal rate of less than or equal to 250 g / kW-h	Hydraulic pump greater than 50 L / min.
Starter motor of 12 V.	Hydraulic distributor with forced lowering / gravity with the other options.
Alternator of 500/750 W and 14 V.	Four or more additional sockets placed on the back of the tractor and two sides with fast coupling in all.
The engine cooling system must guarantee that it works at its maximum efficiency, taking into account the following climatic conditions: ambient temperature 36 degrees Celsius and relative humidity of 90%	Lifting capacity greater than 2 600 kg.
Mechanical motor regulator.	Integral suspension system of three points.
Capacity of the fuel tank equal to or greater than 80 L.	Category ISO II and III
Regulations for emission of polluting gases TIER II or EURO II.	With rear oscillating clutch bar with a traction capacity of more than 4000 kg
Dimensions	Tree taking power. (a.t.f)
Front trowel 1 600 - 2 100 mm.	Independent diameter of 35 mm with 6 stretch marks.
Rear trowel 1 600 - 2 100 mm.	Angular velocity 540 and 1 000 rpm.
Weight	Placed on the back.
Total 2 400/3 800 kg.	Mechanism of mechanical or hydraulic connection
Tires	Front bridge
Forwards 7.5 / 9 - R24	4x4 motor diagram.

Transmission	12 v
With mechanical control.	Front and rear lighthouse for night work.
Five synchronized marches of two to four ranges.	Rear electric jack for trailers
Hydrostatic / mechanical clutch.	Heated cabin
Single disc	Tubular structure of roll-resistant structure, arch located behind the operator
Ceramic or graphite metal disk.	Front, frame with duplex crystal, with windshield wipers
Brake system	Brackets fixed to both sides of the front for mirrors
Hydraulic actuated moisture with oil bath disks.	Ceiling, resistant to solar irradiation with a superior door
Multi-position parking brake in oil bath and mechanical drive.	Folding rear part with duplex crystal
Electrical system	Cab used in tractors for different climates, it will have a comfortable and comfortable seat, with backrest and mechanical suspension
The air conditioning system must guarantee temperatures between 18 and 22 degrees Celsius.	

In addition, the following requirements must be met:

Additional Components 90 hp tractor with 4 x 4 moto diagram
The seals that are used to prevent the exit of oil must be placed on double lips.
The tractor must have the front and rear counterweights.
Water decanters should be installed that are transparent material in easily accessible places, in the case of a fuel system
Provide a module of elements for maintenance after the settlement and the basic tools for a period of one year.
You must bring 10% of your value in replacement parts, which must be in the technical offer.
The manual of exploitation and catalog of parts in Spanish.
The ISO 9001 and 1400 certificates must accompany the tractor. With the fundamental engine indexes, such as nominal power, specific fuel consumption at nominal revolutions, maximum torque and test curves of the bank, the document must also be delivered which certifies compliance with the EURO II or TIER II standards.
In the tractors manufactured under the Tier 3 standard, the supplier will be responsible for the breakage or damage caused by the use of the national diesel, which has a high sulfur content.
With the offer of the tractor must come official document of manufacture of the equipment (place where it was manufactured).

Technical Task, Subsoiler 3 organs

Technical Requirements:

Technical Task, Subsoiler 3 organs
Frame structure resistant to impacts with buried stones;
Required power of 90-120 hp mats tractor and traction class 20 kN;
Category II full coupling
Subsoil at a maximum depth of 35 cm, with 3 rigid organs;
With wheel for adjustable depth control;
Working bodies with chisels resistant to wear and impact;
Detachable arms inserted in the frame that do not deform or split;
Distance between work organs or arms fixed at 700 or 800 mm;
Total weight not exceeding 1000 kg;
Paint with good quality corrosion protection;
Possess operator operating manual and parts catalog in Spanish language;
Guarantee a spare parts kit

Technical Task of the three-organ furrower

Technical Requirements:

Technical Task of the three-organ furrower
For universal tractors of 80-90 hp and traction class 14 kN;
Integral coupling: Category II;
Robust frame with a length of 1500 - 1800 mm;
With three adjustable rigid bodies from 500 to 900 mm;
Possess fuses for impacts;
Universal shrink wrappers adjustable in width and with the tip of the wear resistant chisel, to be used on all floors;
Depth of work on fluffy terrain from 20 to 30 cm
Disc markers on both sides of the mechanically driven implement;
Painting with good quality corrosion protection;
You must have the operating manual of the operator and pieces in Spanish language.
Guarantee a spare parts kit.

Technical Task Agricultural Trailer 7 T

Technical Requirements:

Technical Task Agricultural Trailer 7 T
Metal reservoir and corrosion-resistant cover;
Fifth wheel with 4 grease grinders;
Angle of rotation of 30 - 45 degrees;
Energy demand: 14 kN tractor and engine power 75 hp;
Additional rack 0.50 m (maximum height 1.50 m);
Front rail height 1800 mm;
Folding railing and rail;
Maximum charge 6 t with parking brakes;
Volume of charge of the deposit 9.5 - 11.5 m3
Rear and side compartments with manual sealing;
Hydraulic, side-to-side and rear baseboard;
Agricultural tires with a 9-11 layer chamber;
Replacement tire with its rim and ladder;
Damping by four edges and reinforced axes;
Rear and refractory electric lights system.
Manual of exploitation and catalog of parts delivered in Spanish language;
Provide a module of parts, parts and aggregates for the operation of the equipment (disks, bearings and screws)

Technical Task - Average depth tiller

Technical Requirements:

Technical Task - Average depth tiller
Frame of resistant structure of section 100 x 100 mm;
Tiller or cultivator of medium depth with 11 flexible organs;
To perform land enrollment and the first crop;
With wheel for adjustable depth control from 15 to 25 cm;
Wear-resistant reversible chiselled organs;
Distance between adjustable organs from 300 to 400 mm;
Total weight not exceeding 600 kg;
Required power of the tractor from 60-80 hp, traction class 14 kN;
Category II integral hitch
Traction of the variable tractor from 1400 to 1800 mm.
Repair and maintenance kit. Possess operating manual for the operator and pieces in Spanish language.

Task Technical of the Underground drill (Hoyadora).

Technical requirements

Task Technical of the Underground drill
Stiff structure and solid.
Energy demand: 90 hp tractor;
Integral coupling of three point category II;
Cardanic transmission with safety clutch.
Inverter mechanism of the drill bit.
Transmission from a.t.f to 540 r.p.m.
With an approximate weight of 500 to 600kg.
With three sets of drills or drills with diameters 200-300 and 400 mm. (9-12 and 18 inches),
Rotation of the drill from 130 to 180 rpm.
Depth of work up to 1200 mm.
Reinforced head and in oil bath.
Mechanism of change of the drill bit during the transfer.
Possess operating manual for the operator and parts in Spanish language;
Guarantee a spare parts kit.

Technical task of the integral sprinkler with a capacity of 800 L.

This sprinkler must be protected from the **middle** of the tank and the entire bottom with a 3 mm thick GALVANIZED steel plate to avoid the impact of the marabou.

Technical task of the integral sprinkler with a capacity of 800 L.	
Frame	Self-leveling system
Galvanized and reinforced in the coupling columns with a clearance height of 15 cm. with respect to the ground. With safety flanges.	With teflon separators placed on both sides to avoid friction between metals.
With the possibility of vertical adjustment of the boom between 35 cm. at 1.50 m taking as a reference the tip of the nozzle with respect to the ground.	Be able to maintain automatic horizontality relative to the ground, as well as present support at the ends.
Diameter of the hole of the side bars 27mm with 3 holes.	Security pin for transport.
Minimum internal distance between the faces of the third point from 50 to 55 mm.	Universal Joint
Minimum interior distance of the ladder scale of the sidebars is 50 to 55 mm. Folding ladder that allows access to the filling hole.	Agricultural cardan with protection according to regulations, for agricultural equipment and 60 -80 hp tractors.
Diameter of the hole of the third point 25 mm.	Others
Deposit	Maximum limit of empty weight of the sprinkler 450 kg
High-density polyethylene tank (virgin raw material) with additional tanks for the hygiene of the operator with a capacity of 10 liters and a tank for the washing of the circuit with a capacity of 60-80 liters.	Replacement kit and accessories for the maintenance, repair, start-up and operation of the machine, during the warranty period agreed with the supplier.
Handshake to supply the tank.	Operator's manual for the operator and manual of spare parts in Spanish language.

Load capacity level indicator with graduated scale of 100 in 100 liters and intermediate markings for 50 liters.	Optional
The tank that is supported inside the frame with rubber bands for protection.	Devices through the nozzles for the connection of spears for manual work.
Have a hydraulic or mechanical agitation system and return the pump to the tank.	Total spears 10 with filters and opening and closing controls (high pressures).
180 degree folding filler hole lid.	Hose section of 10 m resistant to a work pressure 40 bar and diameter of 10 mm with fittings.
Pump	Stepped filtering system from the filling hole to the nozzles.
Membrane pump, membrane material unmoving, with delivery up to 105 lts./min. at 540 rpm. or piston with ceramic shirt.	An independent filter with closing valve in case you have to clean it while the tank is full, 3 filters placed in the pressure line.
With protection for the cardan and safety valve	Filters in the nozzles.
Total protection of the pump and the obstacle filter, with inverted screws with a nut of security for periodic review.	Counterweight loader with counterweight for immersion.
The main filter of the suction line must be located on one side; in addition, it must have a quick hitch for the hose coupling of the filled car with an anti-pollution filter.	With 25 nozzles distributed in the bar, with anti-drip membrane system, independent distribution system led by valves for the right, left and center section in the command.
Winch	Flat fan nozzles installed in stainless steel pipes at a distance of 50cm. With a cost of 1.2 l / min at a pressure of 5 bar.
With a maximum lift of 1.50 m for the lift system and 1.80 m of regulation for the frame.	Line filters placed on the spray bars.
Position in the lateral position for better handling.	Control Switch
With steel wire resistant to friction and to the action of agrochemicals.	With proportional flow at the idle and keep the same flow of delivery in the application bar regardless of the segments that are in operation, with pressure gauge in glycerin bath and must be within the reach of the operator.
Application Side Bars	Filtering System
Three sections galvanized and reinforced sections in the hinges, with a width of work 12 meters.	Diameter of the 40 mm filling hose.
Be foldable in three sections,	

Technical task of the motorized backpack sprinkler

Technical requirements

Technical task of the motorized backpack sprinkler
Tank with a maximum capacity of 15 liters of high density polyethylene, resistant to ultraviolet rays, that provides ergonomics to the operator, with adequate design to achieve a low center of gravity and at the same time a greater balance.
Atomization head with 6 nozzles or dosing tips color or number coded and a baffle for the application of liquids. Also bring the kit to apply powders.
Fuel tank located under the engine.
Unified command to achieve better control of the main functions of the machine by the operator.
Two-stroke or four-stroke engine with low fuel consumption and low pollutant emissions.

Do not exceed 105 decibels of noise.
Delivery system of the final solution or powder through air through nozzles.
Ignition by electronic control magnet.
Start by retractable string.
Power from 2 to 4.5 hp.
Reach 10 to 12 linear meters and 8 vertical meters.
Do not exceed 25 kg the sprayer with the full pesticide tank.
Efficient agitation by means of air injection.
Have operating manual for the operator and parts in Spanish language;
Guarantee a kit of spare parts.

Technical Task of the backpack sprinkler

Technical requirements:

Technical Task of the backpack sprinkler
Backpack with nozzles for herbicidal and insecticidal application;
High density polyethylene tank with a capacity of 16 liters, resistant to ultraviolet rays and impacts.
Proper ergonomics of the design of the tank.
Ambidextrous
Spear with a length of 50 - 60 cm.
Mechanical stirrer within the tank.
Nylon straps with pads.
Grab for transportation.
Cone nozzles to apply fungicide and insecticide, flat fan tip for herbicide application.
Filtering system from the filling hole to the nozzle.
Empty mass up to 4.3 kg.
Own operating manual for the operator and parts in Spanish language;
Guarantee a spare parts kit.

Technical Task of Chainsaws

Technical Requirements:

Technical Task of Chainsaws
Cylinder capacity (cc) 80 to 90
KW power (CV) 4.9 (6.7)
Net weight (Kg) 7 to 8 kg.
Chain passage. 3 / 8¨
Length of the sword (cm). 50
Have a chain brake.
Double lubrication system.
With automatic decompression on startup.

Rapid sharpening and sharpening response kit.
Operation manual in Spanish.
Tropicalized engine.

Technical Task of Forestry Mower.

Technical requirements:

Technical Task of Forestry Mower
2 to 4 stroke engines.
Cylinder 51.7 cm^3 - 58.2 cm^3
Anti vibration system.
Multifunctional handle.
Double handlebar, handlebar adjustment without tools.
With universal harness.
Straight tube, rigid transmission shaft, rod diameter 35 mm.
Cutting organ, 3-point disc, saw disk.
Net weight 9 - 11 kg.
Have operating manual for the operator and parts in Spanish language;
Guarantee a spare parts kit.

Technical task Height Mower

Technical requirements:

Technical task Height Mower
Cylinder capacity 21.2 - 25.4 cc.
Net weight of 4 to 5 kg.
Length of the sword 25 cm.
Length with extension from 4 to 5.20 m.
Chain passage 3/8
Automatic lubrication system.
Gasoline starter.
Total length from 2.4 to 3.72 m

Electric forage machine.

Technical requirements:

Electric forage machine
Power source: Electric motor 220 v, single-phase 10 to 15 HP of 60 HZ.
Thermostat switch for bass and over voltage with 3 meters of 3-way ROYAL COLL cable with a connection jack to the female and female line.

Productivity from 3000 to 5000 kilograms per hour
Particle size up to 5 cm.
Rotor work bodies of 2 to 4 blades
Structure for stationary equipment with one or two feed channels.

Technical task windrower

Technical requirements:

Technical task windrower
Maximum working width 3.50 m.
Transport width 1,5 m.
Number of arms per rotor 9 - 10.
Power required 80 hp, revolutions of the ATF 540 rpm, with safety mechanism.
Row width 0, 8 to 1.5 m,
Pendular tires.
Two rotors.
Work speed of 7- 12 km / h.
High quality paint that guarantees good corrosion protection.
Minimum working height. 3 to 5 cm from the ground.
Replacement kit and accessories for the maintenance, repair, start-up and operation of the machine, during the warranty period agreed with the supplier.
Operator's manual for the operator and manual of spare parts in Spanish language

Technical task – siloharvester

Technical requirements:

Technical task – siloharvester
Silo-harvester for erect pastures and forages and towed trailers laterally coupled to the tractor with transmission to the shaft with a rotation of 540 rpm.
Energy demand: Tractor with a power between 90 hp and traction class 20kN;
With impact cutting system;
Cutting body formed by 30 to 40 reversible layered blades with edges on both sides and heat treatment that guarantees resistance to impacts;
Working width of 1.50 to 1.60 m;
Conveyor shroud to transport the cut forage to the repique organ;
With disc type repique system with 6 to 10 blades in V, against blade and sharpening system;
With a discharge tower operated from the operator's cab by means of a hydraulic mechanism which rotates the tower to 900;
Height of the discharge tower of 4000 mm ± 10%; with adjustable baffle from the operator's cabin;
With rear hitch to attach a 4-6 t fodder trailer;
Slice size: 70% between 20 mm and 70 mm;
Hydraulic regulation of the cutting height;
With adjustable cut height between 50 and 150 mm;

Anti-corrosive protection;
Convenient and easy-to-carry technical maintenance, given in its operating manual;
Guarantee the safety of the worker and another regarding the protection and hygiene of work;
Guarantee a spare kit for the first year of operation.

Technical task – hay packing

Technical requirements:

Technical task – hay packing
Pick up and tie the paca with nylon or rope.
Piston speed from 90 to 120 strokes per minute
Working speed 3 - 7 km / h
Transport speed up to 15 km / h
Required power of 90 hp frequency in the atf at 540 r.p.m.
Cardan with 6 stretch marks and safety mechanism (friction mechanism or free rotation)
Working width 1650 mm
Collector width 1.25 to 1.80 m
Pour 200 - 250 mm
Weight of the bales 10 -15 kg
Adjustable pressing density of 80 - 200 kg / cm3
Dimensions of the adjustable shovel.
Owning paca account.
Deposit for the cord with a capacity of 6 - 8 bovines.
Productivity of 200 to 300 pacas per hour.
Have a good quality paint that guarantees good corrosion protection.
Width of the picker 1.25 to 1.8 m.
Replacement kit and accessories for the maintenance, repair, start-up and operation of the machine, during the warranty period agreed with the supplier.
Operator's manual for the operator and manual of spare parts in Spanish language.

Technical task of the mower

Technical requirements:

Pasture mower with cutting width 2.10 m, with 4 drums and 2 blades per drum, pivoting with edges on both sides.
Integral coupling system, with 540 rpm at the outlet of the take-off shaft.
Power required 90 hp.
Disc speed up to 2080 rpm.
Bring protective canvas.
Bring a mechanism to change position of transport to work and vice versa with hydraulic operation.

Height of cutting 4 - 8 cm.
Transmissions with gears and trapezoidal belts.
Approximate weight 500 - 600 kg.
Working speed 5 to 8 kg.
Minimum clear 280 mm.
Transport speed 20 km / h.
Have quality paint that guarantees an anti-corrosion protection.
Replacement kit and accessories for the maintenance, repair, start-up and operation of the machine, during the warranty period agreed with the supplier.
Operator's manual for the operator and manual of replacement parts in Spanish.

Electrical fitting systems for an area of 134,202 m2, (13.42 hectares)

Technical requirements:

Composition. For a 260 W. module

ITEM	QUANTITY
Electronic electrified equipment	1 u
Lightning protection	1 u
Mobile unipolar switches	15 u
Unipolar fixed switches	45
Galvanized smooth wire for fencing 2 mm	4 km
Intermediate posts cabilla 0.95 cm (3/8 ") x 115 cm (1.15 m), wood or Plastic	160 u
Ceramic tension insulators, plastic or LDPE	280 u
Insulators of ceramic poles, plastic or LDPE	860 u
Landing bars	3 u
12 V battery for solar systems, up to 200 Ah	1 u
Photovoltaic panel for systems for Solar systems, up to 130 W	1 u
Katao bipolar	1 u
Basis for the solar panel	-
Solar charging regulator MPPT. Change the orientation point according to the sun's position.	-
It must bring the warning signs and warning symbol that must be placed every 100 meters away	-
u: unit.	

Parameters
Maximum voltage output voltage (V) 10 000
Nominal voltage output voltage (V) = 9 000
Pulse energy RMSM joule (J) = 5
Ohm (O) 5 000 isolation rules
Watt / rms pulse power (W / rms) 6 500

Pulse frequency pulsations per minute (p / min) = 60
Microsecond pulse duration (µs) 300
Nominal range kilometers (km) 15 - 50
Annual electricity consumption per kilowatt / hour, (kW / h) per year 12 - 14
Voltage supply (V) 110 or 220 VAC or 12 V of VCD

Technical task – mechanical milking equipment

Milking systems of 4 and 6 positions are similar, with the difference in milking positions.

Technical specifications of mechanical milking systems for 4 and 6 stationary positions.

Technical task – mechanical milking equipment
Single phase electric motor 3 kw.
Voltage 220 volts.
Frequency; 60 Hz.
Motor protection; IP 55.
Protection of the unit; IP 44.
Lubricated pallet vacuum pump with oil.
Base with extensor, pulleys, belt, muffler with anti-shock valve and extender, safety guard at engine rotation, 40L Emptying Reservoir, 2 mm wall.
Connection of the pump to the motor by belt.
Capacity of the pump; 900 Lts / min.
Stainless steel vacuum tank with a capacity of 30-60 liters.
Pressure; 50 Kpa.
3 regulator lubricator, used oil collection reservoir and ½ Lts of special oil for vacuum pumps. Precision vacuum of 63 mm with stainless steel box and glycerin, Servo-Regulator 0-3500 lt and their respective 1 "and ½" clamps, 6 vacuum faucets, drain valve for vacuum pipe. Test-port of 50 mm.
Synthetic rubber sanitary napkin for 2500 milts of durability.
Pressing Rhythm; 60 ppm.
Pulse ratio; 60/40 (milking / massage).
Milk conduit pipes; Stainless steel AISI 304, food grade.
Air duct and pulsation pipes; PVC
Muffler; maximum noise level; 80 db.
Download of electric milk.
420 ml collector - 450 ml, 12 mm milk inlet nipples, 16 mm milk outlet and maximum 3.5 kg total weight.
HP 101 pulse system and repeater RM 4.
Ubre wash system.
Milking system cleaning kit.
All hoses (milk, double pulse, vacuum and pulsed distributor) are of a nutritional grade, free of phathalate and biophenol.

Technical task for milk tank with 1000 literal capacity.

Technical specifications:

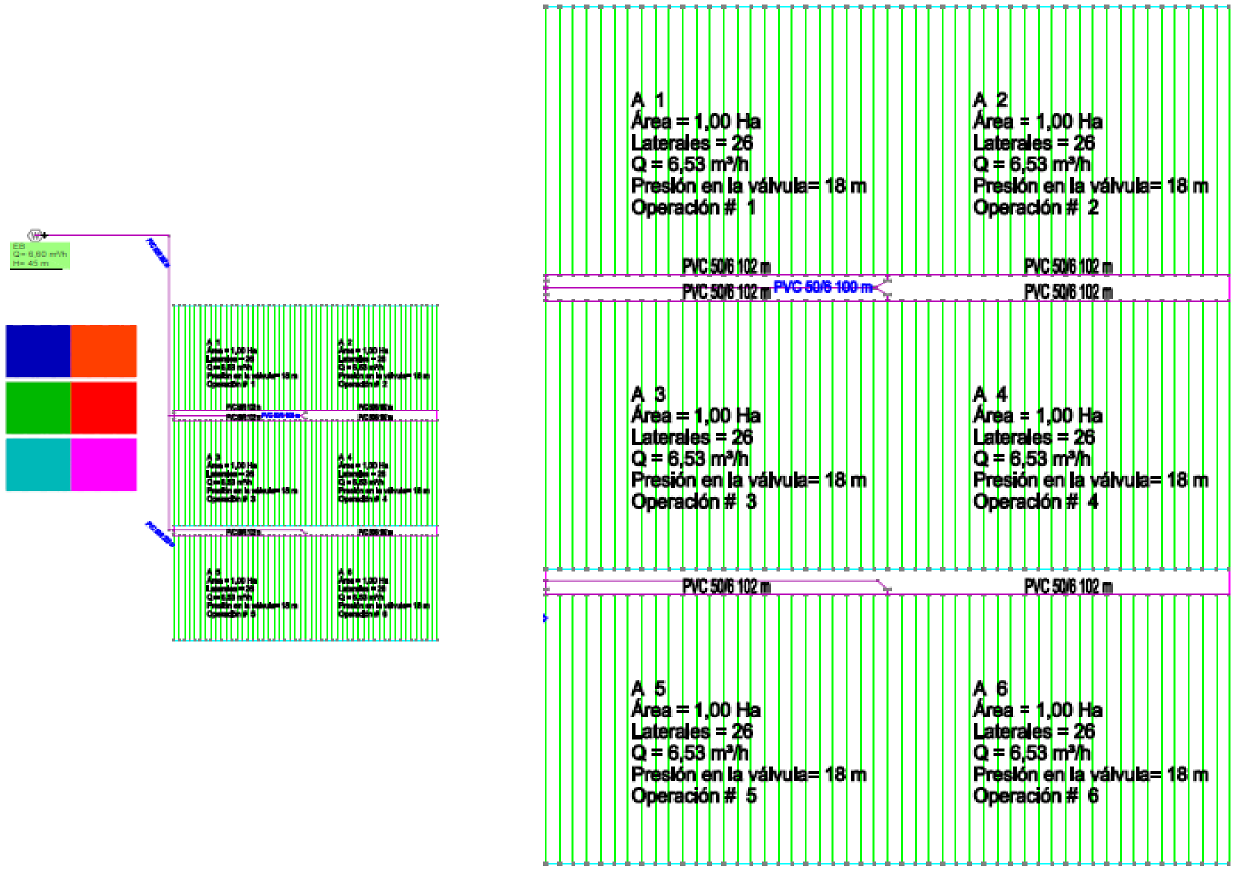
Technical task for milk tank with 1000 literal capacity
Tank: Open circular format.
Inner body: Stainless steel AISI 304 of 1.25 mm thick and surface finish 2B. Interior body welds that meet the constructive requirements for sanitary use, which are polished and measured electronically to be able to certify their roughness values below what is specified in ISO 9708 (RA <1).
Exterior and bottom lining: AISI 304 stainless steel of 1.00mm thick and surface finish.
Evaporator: Direct expansion system of stainless steel AISI 304 with welding for addressing the coolant manufactured in Europe with laser welding technology.
Thermal Insulation: Polyurethane injected (CFC-free) from 50mm to 60mm thickness and 40 Kg / m³ density to prevent the temperature rise in cold milk above 1.2ºC in a period of time of 12 hours without cooling and in the presence of an ambient temperature of 32 ° C.
Top lid: AISI 304 stainless steel folding hinged lid with support for gas cylinder.
Upper rim: Special design to prevent contamination of the milk made in stainless steel AISI 304.
Support: 6 stainless steel AISI 304 legs adjustable for leveling the tank.
Stirring: Recessed motorcycle equipped with electric motor with axis and palette in stainless steel AISI 304 and enabled with disconnection mechanism when opening the lid. AISI 304 stainless steel agitation trowel with 8 ºC stirring angle to create a uniform distribution of temperature and grease throughout the tank volume without damaging the fat globules and maintaining the good quality of the milk.
Download of the product: Through a valve of butterfly SMS of 51mm in stainless steel AISI 304 with lid and chain.
Controls: Control box class IP55 according to IEC-144/63 equipped with a controller for controlling the temperature of the milk and automatic stirring sequence, the visual indication of the temperature of the milk and the operating voltage and automatic disconnection below the minimum voltage and above the maximum permitted voltage, both user programmable values. Automatic reconnection for voltage within the programmed range. Equipped with transient protection in the supply of electrical fluid and protection against currents with breakers and fuses. Automatic disconnection in case of failure of a phase.
Relay against voltage drop protection.
Capacity measurement: linear system, graduated rule in stainless steel AISI 304 and conversion table.
Refrigeration equipment: Condenser unit with airtight compressor with control box and presostato safety circuits for low.
Voltage: 220V / 1x phases / 60Hz
Cooling gas: Not contaminating the environment R 404
Ensure that the milk at 35 ° C is cooled to 4 ° C within 3 hours maximum results at an ambient temperature of + 32 ° C
Must comply with ISO 5708 international standard

16.2 Description of technical specifications of underground sprinkler and reservoir irrigation systems.

Sprinkler irrigation system - 6.0-hectare unit.

Technical specifications:

Drip irrigation system distribution plan for 6.0 ha, divided into 1.0 ha plots.



Fuente: IAGric-MINAG, Cuba 2019.

The irrigation system is designed to cover 6.0 ha, considering the following components; i) Water source, through rainwater of superficial stinging, capable of deriving water from a well, river or reservoir, ii) Pumping and conduction system of piped water to the plots and iii) Irrigation system that includes a water valve control, pipes, drippers and filters.

The system is designed to operate individually with each of the plots of one ha., For semi-perennial crops (banana) and annual crops (corn, beans, sweet potatoes and cassava).

Detail of the components of the sprinkler irrigation system:

The following table details the necessary accessories and quantities for the installation and operation of the system, from the pumping station to the distribution and discharge.

GRUPO B.M. Interinvest Technologies S.L.

No.	CODE	DESCRIPTION		QUANTITY	U/M
1		**BOMBING STATION**			
2	77450-000121	1 "ball valve - male - female		1.00	U
3		Short filter 1 "of 120 mesh rings		1.00	U
4	77400-032900	Valv 1 "retainer (epdm plastic) threaded		1.00	U
5	6670160205	Plastic combined air valve barak d-040 1 "		1.00	U
6	6660630010	Glycerin pressure gauge 2.5 "10 atm.		1.00	U
7	6625150040	Reducer 1/2 "mx1 / 4" h		1.00	U
8	6461590200	1/2 "plastic elbow		1.00	U
9	6441010004	Reduced pvc 1 "m x 1/2" h		1.00	U
10	77000-001100	1/2 "x 5 cm pvc elevator		1.00	U
11	6448010420	Tee p.v.c 1 "(threaded-female)		2.00	U
12	77000-005100	1 "threaded n.p.c.		2.00	U
13	77000-006200	1 "l = 1.0 m threaded pvc elevator		1.00	U
14	75200-025300	Compress elbow 32x1 "female		1.00	U
15	77400-022155	1 "hh universal pvc union		1.00	U
16	77400-016200	1 "plastic elbow (female) x1" (female)		1.00	U
17	6110010216	Clear glue up to 12 "1/2 lt.		1.00	U
18	6110019906	Clear first 1/2 liter		1.00	U
19	77000-005300	1 "x 20 cm pvc nipple		2.00	U
20	6110300600	Teflon		5.00	U
21		PUMP Q = 6.6M3 / H AND H = 45 mca		1.00	U
22		End of distributors			
23	77400-015000	Pvc elbow 90 degrees cemented 50mm		6.00	U
24	75280-001150	Plasim meridor tube 50-16		15.00	M
25	77300-012300	Cemented pvc union thread 50 * 1		6.00	U
26	77400-013800	PVC thread 1		6.00	U
27	32000-008400	Valv air / vacuum relief 1/2 gray mod600		6.00	U
28	77400-010200	Reduce link thread 1m * 1 / 2h		6.00	U
29	77450-000121	Nmv pvc ball vlv 1 union 1 "fmt bsp		6.00	U
		End of conductors			
	77400-015000	Pvc elbow 90 degrees cemented 50mm		2.00	U
	75280-001150	Plasim meridor tube 50-16		5.00	M
	77300-012300	Cemented pvc union thread 50 * 1		2.00	U
	77400-013800	PVC thread 1		2.00	U
	32000-008400	Valv air / vacuum relief 1/2 gray mod600		2.00	U
	77400-010200	Reducer link thread 1m * 1 / 2h		2.00	U
	77450-000121	Nmv pvc ball vlv 1 union 1 "fmt bsp		2.00	U
30		Dripnet pc + connectors			
31	32500-013720	Start conn-pvc barb 16 w / seal-mt-50 / bag		4.00	U
32	32500-017030	Barb 16 - ring 16 w / o ring 50 / bag		4.00	U
33	32500-016730	Ring coupling16 mm body w / o rings 50 / bag		3.00	U
34	32500-017620	Ring 16 alone - white 50 / bag		10.00	U
35	40500-004510	Pipe for irrigation 16/4 400m		1.00	U
36	17655-004750	Dripnet pc as 16009 1.6l / h 0.60m 500m		35.00	U
37	75260-006100	50/6 cemented pvc tube		1,250.00	M
39		Valve knots			
	77400-017200	Elbow pvc 90 grad. Cemented thread 50 * 1.5		2.00	U

	77400-014390	Cemented pvc thread 50 * 11/2 * 50		4.00	U
	77400-018900	Cemented pvc adapter 50/40 * 1.5m		6.00	U
	77400-015000	Pvc elbow 90 degrees cemented 50mm		15.00	U
	77400-019000	Cemented pvc adapter 63/50 * 2m		12.00	U
40	71600-002300	Dorot Valv 2 Series 75		6.00	U
41	71680-029000	Kit for 110-dc-pr29100 el-aqu-support		6.00	U
42	75280-001400	Plasim meridor tube 50mm		10.00	M
47		accessories			
48	77400-015000	Pvc elbow 90 degrees cemented 50mm		5.00	U
	77400-012600	Cemented pvc tea 50		5.00	U
49		General Accessories			
50	45000-005010	Bosh recharge hand drill-blue-complete		1.00	U
51	45000-003200	16mm initial pvc concect drill		3.00	U
52	45000-003400	3/4 "Teflon		50.00	U
53	76900-001000	Universal cement 717 - 1000 gr '		12.00	U
54	76900-001100	Ips first cleaning solution 1000gr '		12.00	U
55	75600-004400	Needle for testing pressure		2.00	U
56	77540-003350	Manometer 250 gals 8bar 1/4 bsp		2.00	U

<u>Sprinkler irrigation system - Unit of 1.0 hectare.</u>

Technical specifications:

The irrigation system is designed to cover 1.0 ha, considering the following components; i) Water source, through rainwater stored in excavated reservoir, ii) Pumping and conduction system of piped water to the plot and iii) Irrigation system that includes control valve, pipes, drippers and filters.

The system is designed to operate individually each parcels of one ha., For semi-perennial crops (banana) and annual crops (corn, beans, sweet potatoes and cassava).

Detail of the components of the sprinkler irrigation system: The following table provides details of the accessories and necessary quantities for the installation and operation of the system, from the pumping station to the distribution and discharge.

DESCRIPTION	MEASURE	QTY	U/M
Pipe pebd agricultural 4 atm	50	100	M
Pipe pebd agricultural 4 atm	50	100	M
End cap pe	50	1	U
Valve. esf.met. handle crom.r.h	1 1/2" PN-25	1	U
Nipple met Male-male thread	1 1/2"-20 cm	1	U
Metal clapper valve elastic closure	1 1/2"	1	U
H-m threaded metal reduced sleeve	11/2"-1"	1	U
Line filter eg male thread outlet	11/2"	1	U
Mixed straight link male pe	50-1 1/2"	1	U
Simple take collar	50-1"	1	U

Simple take collar	50-1/2"	1	U
Double-acting suction cup b.plast	1"	1	U
Reduction nut M-H thread	1/2"-1/4"	1	U
Pressure gauge dt.63 mm glycerin	0-6 bar	1	U
Acod. Link 90º equal mouths	50	2	U
Acod. Link 90º equal mouths	50	2	U
Mixed straight link male pe	50-1 1/2"	1	U
CROSS 90º MET.ROSCA FEMALE	1 1/2"	1	U
Reduction nut M-H thread	11/2"-1"	1	U
Double-acting suction cup b.plast	1"	1	U
Machón double met. Male thread	1 1/2"	2	U
Valve.esf.pvc salt. R-h epdm	1 1/2"	2	U
Acod. Link Pe 90º	50mm-11/2"	2	U
Take orange security	16	30	U
Plug	16	30	U
Drip pipe PBD Ø 16mm, qe = 1.6 l / h, Se = 0.5m L = 100	16	3000	U
Orange Security Link	16	30	U
Teflon rolls	12 M	10	U
Straight link pe	50	1	U
1ha modular irrigation system. Total			

Source: IAGric-MINAG, Cuba 2019.

<u>Covered excavated reservoir</u>

Technical specifications:

Changes in rainfall behavior patterns and their reduction, the increase in evaporation, together with the increase in saline intrusion as a result of the rise in the mean sea level, are expected to affect the availability and quality of water resources of the AIP. Hence the need to project the construction of reservoirs that guarantee the availability of water in times of drought.

Excavated reservoirs have been designed, fed by rainwater directly and by runoff, covered with 750 micron geomembrane, to store and use the water in the development of productive activities in Agroforestry Systems (individually operate each of the One ha plots for semi perennial crops (banana) and annual crops (corn, beans, sweet potatoes and cassava), as well as silvopastoral systems (milk and meat production) to have water available year-round for animal consumption.

The structure of the reservoir will be complemented with the pumping equipment, pipeline and drip irrigation systems, for bananas and crops (annual and permanent fruit trees). In the case of livestock, basic pumping and drinking equipment of 500 liters capacity is included.

Due to the diversity of activities that will develop and incorporate the use of water, reservoirs of different capacities have been designed, information detailed below:

Production System	Water Use	Reservoir Specification			
		Length (m)	Width (m)	Depth (m)	Capacity (m3)
Plantain	Drip irrigation	35.0	30.0	3.5	3,675
Various crops	Drip irrigation	35.0	35.0	4.0	4,900
Livestock	Animal consumption	5.0	5.0	2.5	62.5

For the calculation of reservoir capacity, the following aspects were considered:

- Average annual total rainfall (in mm). Environmental Panorama, 2017 - ONEI.
- Volume of use per crop and animals.
- Evapotranspiration
- Days of use of the irrigation system.
- Total demand

Source: National Institute of Water Resources, INRH, IAgric-MINAG. Manual of basic technical specifications for the elaboration of rainwater harvesting structures (SCALL) in the agricultural sector. 2010.

16.3 Calculation of rainwater harvest structure by water runoff and rainwater harvesting.

Table 50 Runoff influence area in (m2): An area of 10,000 m2 of water collection is established to take it to the reservoir.

Runoff efficiency (in%):	Surface type
90%	Smooth surface, ceilings
80%	Paved surface
60%	Treated soils
30%	Soil in natural state

Source: Technical specifications Manual - SCALL, CEDEME -U. National, Costa Rica, 2010

Tabla 51: Modules, activities, areas and water source included in the calculation per ha: Agroforestry Module

Module	*Crop*	*Area in agroforestry arrangement by producer / ha.*	*Activity under irrigation*	*Proposal 1: 6.0 ha irrigation system. Source: Rainwater reservoir (Escorrentia).*	*Proposal 2 Irrigation system of 1.0 ha. Source: Rainwater reservoir (Runoff)*	*Proposal 3: No irrigation coverage.*	*Area per module (ha)*
CEDPLA	Plantain	0.50	Yes	267	152	0	**1,754**
	Spec. Forestry	0.50	-	-	-	-	**-**
FRUAGR	Mango	0.27	-	-	-	-	**-**
	Sweet orange	0.14	Yes	173	300	1,192	**2,529**
	Tangerine	0.10					
	Bean	0.13					
	Sweet potato	0.13					
	Yucca	0.13					
	Corn	0.13					

Tabla 52: Modules, activities, areas and water source included in the calculation per ha: CEDPLA Module

Concept	*Value*	*Unit of measurement*		
Evapotranspiration (ETo)	3.5	mm/day		
Vegetative cycle (CV)	365	days	12	months
Irrigation system operation (OSR)	146	days	4.9	months
Crop coefficient (Kc)	0.87			
Consumption Use (UC)	1111.43	mm	1.11	m
Area in meters (A)	2,000	m2	625	plantas
Volume for agricultural use (VUA)	**2,223**	**m3**	**2,222,850**	**lt**
Reservoir Capacity (CR)	**3,675**	**m3**		
Long (L)	35	m		
Width (A)	30	m		
Depth (h)	3.5	m		
Reservoir Evaporation (Vevap)	**1,341**	**m3**		
Factor	10			
Mirror area (S)	0.11	he has	1050	m2
Evaporation (E)	1277.5	mm / year		
Summary				
Water requirement (m3)	**2,223**			
Reservoir evaporation (m3)	**1,341**			
Volume of water required (m3)	**3,564**			
Reservoir capacity (m3)	**3,675**			

Source:
Calculations based on FAO Bulletin 33, Doorenbos and Kassan 1986. Cuba database.
Technical specifications Manual - SCALL, CEDEME -U. National, Costa Rica, 2010

Tabla 53: Modules, activities, areas and water source included in the calculation per ha: FRUAGR Module Different crops: (Beans, Sweet potato, Casava, Corn) and Fruits (Orange, Tangerine)

Bean				
Concept	*Value*	*Unit of measurement*		
Evapotranspiration (ETo)	1.02	mm/day		
Vegetative cycle (CV)	110	days	3.7	months
Irrigation system operation (OSR)	90	days	3.0	months
Crop coefficient (Kc)	0.70			
Consumption Use (UC)	78.54	mm	0.08	m
Area in meters (A)	1,250	m2		
Volume for agricultural use (VUA)	**98**	**m3**	**98,175**	**lt**
Sweet potato				
Concept	*Value*	*Unit of measurement*		
Evapotranspiration (ETo)	1.49	mm/day		
Vegetative cycle (CV)	125	days	4.2	months
Irrigation system operation (OSR)	75	days	2.5	months
Crop coefficient (Kc)	0.77			
Consumption Use (UC)	143.41	mm	0.14	m

Area in meters (A)	1,250	m2		
Volume for agricultural use (VUA)	**179**	**m3**	**179,266**	**lt**
Cassava				
Concept	*Value*	*Unit of measurement*		
Evapotranspiration (ETo)	2.3	mm/day		
Vegetative cycle (CV)	210	days	7.0	months
Irrigation system operation (OSR)	120	days	4.0	months
Crop coefficient (Kc)	0.50			
Consumption Use (UC)	241.50	mm	0.24	m
Area in meters (A)	1,250	m2		
Volume for agricultural use (VUA)	**302**	**m3**	**301,875**	**lt**
Corn				
Concept	*Value*	*Unit of measurement*		
Evapotranspiration (ETo)	1.15	mm/day		
Vegetative cycle (CV)	180	days	6	months
Irrigation system operation (OSR)	90	days	3.0	months
Crop coefficient (Kc)	0.75			
Consumption Use (UC)	155.25	mm	0.16	m
Area in meters (A)	1,250	m2		
Volume for agricultural use (VUA)	**194**	**m3**	**194,063**	**lt**
Tangerine				
Concept	*Value*	*Unit of measurement*		
Evapotranspiration (ETo)	3.29	mm/day		
Vegetative cycle (CV)	365	days	12	meses
Irrigation system operation (OSR)	128	days	4.3	meses
Crop coefficient (Kc)	0.70			
Consumption Use (UC)	840.60	mm	0.84	m
Area in meters (A)	1,350.00	m2		
Volume for agricultural use (VUA)	**1,135**	**m3**	**1,134,803**	**lt**
Orange				
Concept	*Value*	*Unit of measurement*		
Evapotranspiration (ETo)	3.29	mm/day		
Vegetative cycle (CV)	365	days	12	meses
Irrigation system operation (OSR)	128	days	4.3	meses
Crop coefficient (Kc)	0.70			
Consumption Use (UC)	840.60	mm	0.84	m
Area in meters (A)	1,350.00	m2		
Volume for agricultural use (VUA)	**1,135**	**m3**	**1,134,803**	**lt**
Mango - Without irrigation				
Concept	*Value*	*Unit of measurement*		
Evapotranspiration (ETo)	0	mm/day		
Vegetative cycle (CV)	0	days	0	meses
Irrigation system operation (OSR)	0	days	0.0	meses
Crop coefficient (Kc)	0			
Consumption Use (UC)	0.00	mm	0.00	m
Area in meters (A)	1,350.00	m2		
Volume for agricultural use (VUA)	**0**	**m3**	**0**	**lt**
Volumen for agriculture use acumulated	**3,043**	**m3**	**3,042,985**	**lt**

Capacity of the Reservoir (CR)	**4,900**	**m3**		
Large (L)	35	m		
With (A)	35	m		
Deep (h)	4	m		
Evapotraspiration of the Reservoir (Vevap)	**1,451**	**m3**		
Factor	10			
Mirror area (S)	0.12	ha	1225.00	m2
Evapotraspiration (E)	1184.4	mm/mes		
Summary				
Water requierement (m3)	**3,043**			
Evapotranspiration of the reservoir (m3)	**1,451**			
Requirement of water (m3)	**4,494**			
Capacity of the Reservoir (m3)	**4,900**			

Source: Based on the FAO bulletin 33 , Doorenbos y Kassan 1986. Cuba´s database.and Technical specifications Manual - SCALL, CEDEME -U. National, Costa Rica, 2010

Tabla 54: Modules, activities, areas and water source included in the calculation per ha: Silvopasture modules

Module	*Activity*	*Number of fountains per Ha*	*Volumen capacity of the fountains (m3)*	*Option 1: To fill the fountains Source: Rainwater-Runoff Water .*	*Option 2 To fill the fountains Source: Reservoir of water (runoff water)*	*Option 3: Without fountains*	*Area per module (Ha)*
SILLEC	filling up the fountains	1.00	0.50	7,150	350	2,998	**10,498**
SILOM	filling up the fountains	1.00	0.50	3,512	350	5,829	**9,691**

Tabla 55: Modules, activities, areas and water source included in the calculation per ha: Silvopasture modules: SILLEC y SILSOM, Filling up the fountains.

Concept	*Value*	*Measurement unit*		
Evapotranspiration (ETo)	3.00	mm/day		
Cicle fountains fillling up(CA)	135	days	4.5	Months
Operation of the fountains filling up system (OSA)	135	days	4.5	Months
Requierement per day/cow (CDV)	0.18	m3	450.00	lt
Number of average cows/ha (V)	2.5	Vacas		
Volume requierement of the fountains/ha (VA)	**61**	**m3**	**60,750**	**lt**
Capacity of the Reservoir (CR)	**63**	**m3**		
Large (L)	5	m		
With (A)	5	m		
Deep (h)	2.5	m		
Evaporation of the Reservoir (Vevap)	**0.0000011**	**m3**		
Factor	10			
Mirror area (S)	0.003	ha	25.00	m2
Evaporation (E)	3600	mm/mes	0.0000432	m3
Summary:				
Water requierement (m3)	**61**			
Evapotranspiration of the reservoir (m3)	**0**			
Requirement of water (m3)	**61**			
Capacity of the Reservoir (m3)	**63**			

16.4 Calculation of the availability of water per Reservoir.

Exact water reservoir volumes will be determined for each specific location. However, representative reservoir sizes for 1ha plots have been considered to be between 3,575m3 in the case of CEDPLA module and 4,900m^3 in the case of FRUAGR modules.

a. Monthly potential harvesting of water for representative reservoirs

Table 56: Las Tunas reservoir water harvesting potential

Month	Rainfall (mm)	Catchment area (m2)	Runoff coefficient (%)	Total rainwater (m3)
Jan	23.98	10000	40	95.92
Feb	23.03	10000	40	92.12
Mar	40.34	10000	40	161.36
Apr	72.74	10000	40	290.96
May	143.81	10000	40	575.24
Jun	143.48	10000	40	573.92
Jul	110.86	10000	40	443.44
Aug	128.78	10000	40	515.12
Sep	168.92	10000	40	675.68
Oct	127.75	10000	40	511
Nov	69.69	10000	40	278.76
Dec	25.96	10000	40	103.84
				4,371.36

Table 57: Villa Clara reservoir water monthly harvesting potential

Month	Rainfall (mm)	Catchment area (m2)	Runoff coefficient (%)	Total rainwater (m3)
Jan	23.98	10000	40	150.12
Feb	23.03	10000	40	141.12
Mar	40.34	10000	40	231.2
Apr	72.74	10000	40	288.04
May	143.81	10000	40	857.48
Jun	143.48	10000	40	1000.56
Jul	110.86	10000	40	571.68
Aug	128.78	10000	40	746.16
Sep	168.92	10000	40	834.84
Oct	127.75	10000	40	694.24
Nov	69.69	10000	40	267.36
Dec	25.96	10000	40	154.72
				5,937.52

b. <u>Potential irrigation needs, calculated for representative modules</u>

The following potential irrigation needs for CEDPLA (plantain) and FRUAGR modules (mixed) have been identified using crop-specific coefficients, considering an irrigation efficiency of 90%[8].

Tabla 58: Summary of annual water requirements and expected annual water reservoir volume in Las Tunas and Villa Clara

NEEDED		POTENTAL AVAILABILITY	
Water requirements FRUGAR (1ha) Las Tunas	**3,643 m³**	Villa Clara rainwater harvested potential (m³)	**5,937.52 m³**
Water requirements FRUGAR (1ha) *Villa Clara*	**2,931 m³**	Las Tunas rainwater harvested potential (m³)	**4,371.36 m³**
Water requirements CEDPLA (1 ha) Las Tunas	**2,289 m³**		
Water requirements CEDPLA (1 ha) *Villa Clara*	**1,796 m³**		

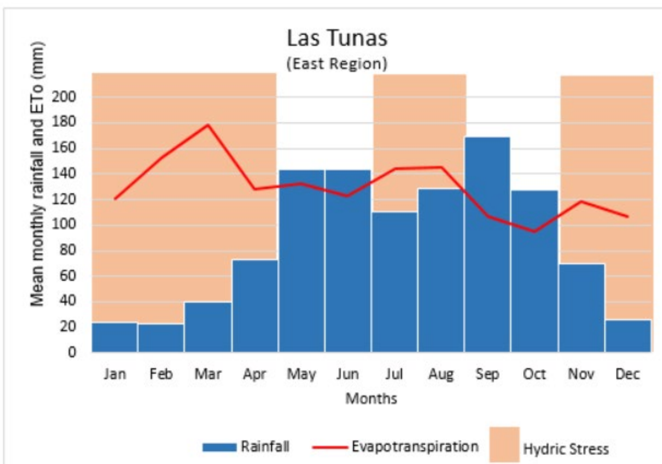


Figura 21: Mean monthly rainfall and Evapotranspiration (mm) in Las Tunas.

Source: (Rainfall) Las Tunas, Colon and Santo Domingo, Weather Stations. Evapotranspiration (ETo): MOD16A2 - MODIS/Terra Net Evapotranspiration 8-Day L4 Global 500 m SIN Grid. Average 2001-2008

[8] For the analysis of the water requierement per crop and Module, we have used the SAFEGUARD_WATER_–_Water_Requirement_Tool.xlsx Available at: https://energypedia.info/wiki/File:SAFEGUARD_WATER_%E2%80%93_Water_Requirement_Tool_V1.0.xlsx This tool is based on the FAO Training Manual no. 3: Irrigation Water Management: Irrigation Water Needs, available at: http://www.fao.org/3/s2022e/s2022e07.htm

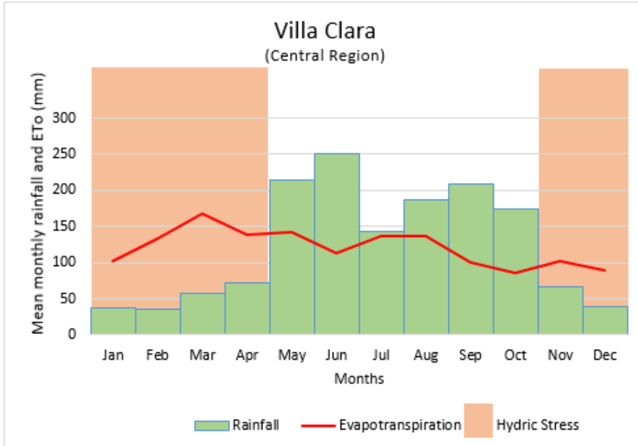


Figura 22: Mean monthly rainfall and Evapotranspiration (mm) in the area of las Villa Clara.

Source: (Rainfall) Las Tunas, Colon and Santo Domingo, Weather Stations. Evapotranspiration (ETo): MOD16A2 - MODIS/Terra Net Evapotranspiration 8-Day L4 Global 500 m SIN Grid. Average 2001-2008

c. Change in volume of water in the reservoirs

The below table shows the monthly dynamic overview of reservoir volume of a representative reservoir in the project, considering monthly inflows, water harvesting and crop specific crop / irrigation water requirements as well as irrigation efficiency.

Tabla 59: Las Tunas reservoir water harvesting potential and water needs per crops in each type of module

	Yearly water needs in m3 per crop (m3/month) of irrigation			Yearly water harvested using 10,000 m2 surface area (m3/month)			
Months	CEDPLA	FRUAGR		Rainfall (mm)	Catchment area (m2)	Runoff coefficient (%)	Total rainwater (m3)
JAN	272.8	334.8		**23.98**	10000	40	95.92
FEB	251.1	744		**23.03**	10000	40	92.12
MAR	226.3	846.3		**40.34**	10000	40	161.36
APR	164.3	601.4		**72.74**	10000	40	290.96
MAY	0	170.5		**143.81**	10000	40	575.24
JUN	15.5	111.6		**143.48**	10000	40	573.92
JUL	105.4	151.9		**110.86**	10000	40	443.44
AUG	43.4	68.2		**128.78**	10000	40	515.12
SEP	62	0		**168.92**	10000	40	675.68
OCT	328.6	0		**127.75**	10000	40	511
NOV	396.8	0		**69.69**	10000	40	278.76
DEC	471.2	0		**25.96**	10000	40	103.84
							4371.36

Tabla 60: Villa Clara reservoir water monthly harvesting potential and water needs per crops in each type of module

	Yearly water need in m3 per crop (m3/month) of irrigation		Yearly water harvested using in 10,000 m2 surface area (m3/month)				
Months	CEDPLA	FRUAGR		Rainfall (mm)	Catchment area (m2)	Runoff coefficient (%)	Total rainwater (m3)
JAN	238.7	310		**37.53**	10000	40	150.12
FEB	217	651		**35.28**	10000	40	141.12
MAR	189.1	719.2		**57.8**	10000	40	231.2
APR	155	430.9		**72.01**	10000	40	288.04
MAY	0	0		**214.37**	10000	40	857.48
JUN	0	0		**250.14**	10000	40	1000.56
JUL	24.8	0		**142.92**	10000	40	571.68
AUG	0	0		**186.54**	10000	40	746.16
SEP	0	0		**208.71**	10000	40	834.84
OCT	189.1	0		**173.56**	10000	40	694.24
NOV	390.6	0		**66.84**	10000	40	267.36
DEC	427.8	0		**38.68**	10000	40	154.72
							5937.52

-

Tabla 61: Water needs per modules / highest daily irrigation needs

		Highest daily irrigation water needs per day	Pump utilization rate	Yearly water needs in m3
Las Tunas	CEDPLA	15.2 m3 in December	41%	2289
	FRUAGR	27.3 m3 in March	30%	2931
Villa Clara	CEDPLA	13.8 m3 in December	36%	1796
	FRUAGR	23 m3 in March	24%	2032

16.5 Crop water requirements for different agroforestry modules in the two project locations

CEDPLA MODULE LAS TUNAS

SAFEGUARD WATER – Water Requirement Tool

Enter basic rainfall and climatic data for you location.

1 GENERAL GEOGRAPHIC INFORMATION

Country	Cuba-Las Tunas	**Region**	Las Tunas
Farm code/name	Las Tunas-CEDPLA	**Date**	01/16/2020
Name of the farm	IRES PROJECT		
Village	Las Tunas		
Division			
District			

	January	February	March	April	May	June	July	August	September	October	November	December
Mean daily temperature [°C]:	23.93	24.23	24.87	26.00	26.73	27.70	28.35	28.40	27.67	26.66	25.38	24.39
Rainfall [mm/month]:	24.80	22.03	38.33	76.06	147.10	142.65	113.84	133.74	169.99	127.23	67.94	27.08

Use to obtain indicative monthly rainfall and temperature data for the site: http://www.worldclimate.com http://sdwebx.worldbank.org/climateportal

SAFEGUARD WATER – Water Requirement Tool

Select crop intended for planting at your location, for automatic indication of water requirements

2 CROP WATER REQUIREMENT

Area measurement unit: ha

Conversion factor to 1 ha: 1.00 ha = 1 hectar

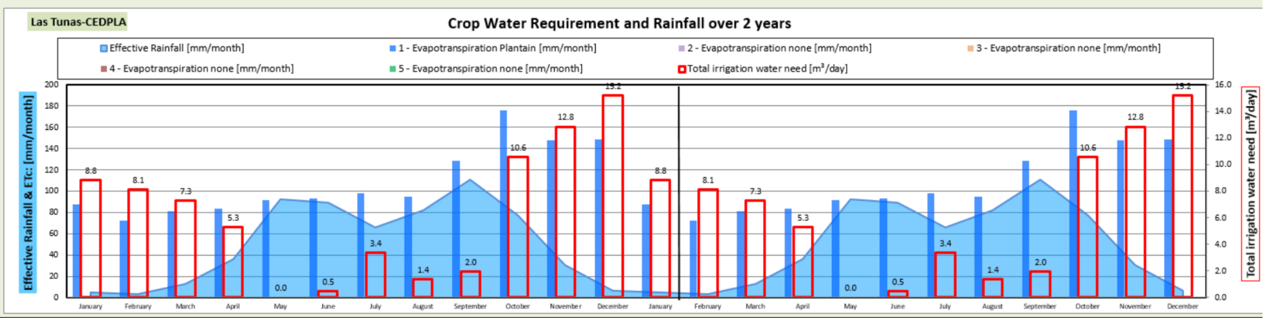
Farm code/name: Las Tunas-CEDPLA

Area conversion ratios to ha:			
ha	1	Sq. m	10000
acre	2.47105	Sq. yard	11960
Sq. km	0.01	Sq. ft	107639

	January	February	March	April	May	June	July	August	September	October	November	December		
Mean daily temperature [°C]:	24	24	25	26	27	28	28	28	28	27	25	24	° C	Summer months
Rainfall [mm/month]:	24.7953596	22.0295851	38.33171	76.063809	147.09636	142.6485737	113.8443	133.7398	169.988	127.231	67.94388	27.07844	mm/month	Rainy season
Irrigation Water need [m³/day]:	8.8	8.1	7.3	5.3	0.0	0.5	3.4	1.4	2.0	10.6	12.8	15.2	m³/day	

Crop to be irrigated	Area in ha	Planting date (dd.mm.yyyy)	Crop growing time	Irrigation scheme	Irrigation Efficiency	Cropping density
Plantain	1	01/01/2020	Average	Drip	90 %	triple spacing

Highest daily irrigation water need per day: **15.2** m³ in the month of December **in Cuba-Las Tunas** | Pump utilization rate: **41%** | Yearly Water need in m³: **2,289**



CEDPLA MODULE VILLA CLARA

SAFEGUARD WATER – Water Requirement Tool

Enter basic rainfall and climatic data for you location.

1 GENERAL GEOGRAPHIC INFORMATION

Country	Cuba-Villa Clara	Region	Villa Clara
Farm code/name	Villa Clara-CEDPLA	Date	01/16/2020

Name of the farm	IRES PROJECT
Village	Villa Clara
Division	
District	

	January	February	March	April	May	June	July	August	September	October	November	December
Mean daily temperature [°C]:	22.06	22.50	23.39	24.95	25.88	26.82	27.54	27.54	26.69	25.70	23.96	22.83
Rainfall [mm/month]:	35.48	32.51	52.39	76.69	187.74	203.64	141.94	190.16	207.73	174.74	62.86	39.74

Use to obtain indicative monthly rainfall and temperature data for the site: http://www.worldclimate.com http://sdwebx.worldbank.org/climateportal

SAFEGUARD WATER – Water Requirement Tool

Select crop intended for planting at your location, for automatic indication of water requirements

2 CROP WATER REQUIREMENT

Area measurement unit: ha

Conversion factor to 1 ha: 1.00 ha = 1 hectar

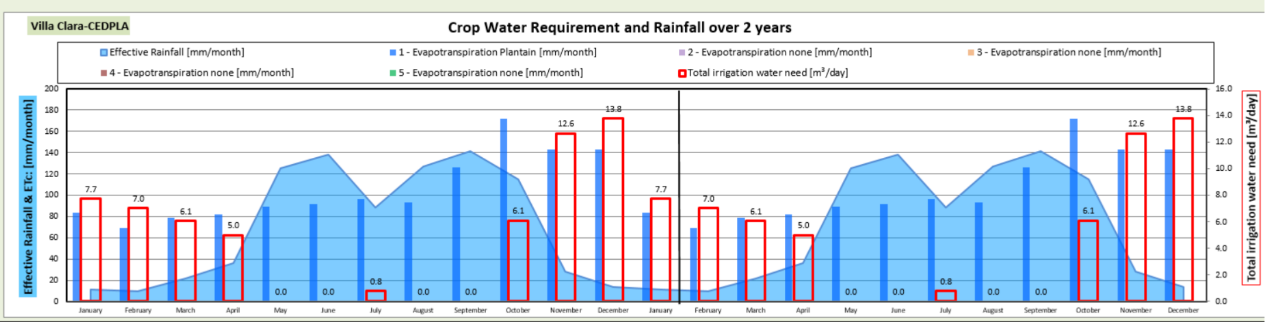
Area conversion ratios to ha:			
ha	1	Sq. m	10000
acre	2.47105	Sq. yard	11960
Sq. km	0.01	Sq. ft	107639

Farm code/name: Villa Clara-CEDPLA

	January	February	March	April	May	June	July	August	September	October	November	December		
Mean daily temperature [°C]:	22	22	23	25	26	27	28	28	27	26	24	23	° C	Summer months
Rainfall [mm/month]:	35.4803129	32.5068971	52.394721	76.686291	187.73915	203.6442348	141.9417	190.1618	207.7258	174.7435	62.86028	39.73764	mm/month	Rainy season
Irrigation Water need [m³/day]:	7.7	7.0	6.1	5.0	0.0	0.0	0.8	0.0	0.0	6.1	12.6	13.8	m³/day	

Crop to be irrigated	Area in ha	Planting date (dd.mm.yyyy)	Crop growing time	Irrigation scheme	Irrigation Efficiency	Cropping density
Plantain	1	01/01/2020	Average	Drip	90 %	triple spacing

Highest daily irrigation water need per day:	13.8	m³ in the month of December	in Cuba-Villa Clara	Pump utilization rate:	36%	Yearly Water need in m³:	1,796



FRUAGR MODULE LAS TUNAS

SAFEGUARD WATER – Water Requirement Tool

Enter basic rainfall and climatic data for you location.

1 GENERAL GEOGRAPHIC INFORMATION

Country	Cuba-Las Tunas	Region	Las Tunas-FRUAGR
Farm code/name	Las Tunas	Date	01/16/2020

Name of the farm	IRES PROJECT
Village	Las Tunas
Division	
District	

	January	February	March	April	May	June	July	August	September	October	November	December
Mean daily temperature [°C]:	23.93	24.23	24.87	26.00	26.73	27.70	28.35	28.40	27.67	26.66	25.38	24.39
Rainfall [mm/month]:	24.80	22.03	38.33	76.06	147.10	142.65	113.84	133.74	169.99	127.23	67.94	27.08

Use to obtain indicative monthly rainfall and temperature data for the site: http://www.worldclimate.com http://sdwebx.worldbank.org/climateportal

SAFEGUARD WATER – Water Requirement Tool

Select crop intended for planting at your location, for automatic indication of water requirements

2 CROP WATER REQUIREMENT

Area measurement unit: ha

Conversion factor to 1 ha: 1.00 ha = 1 hectar

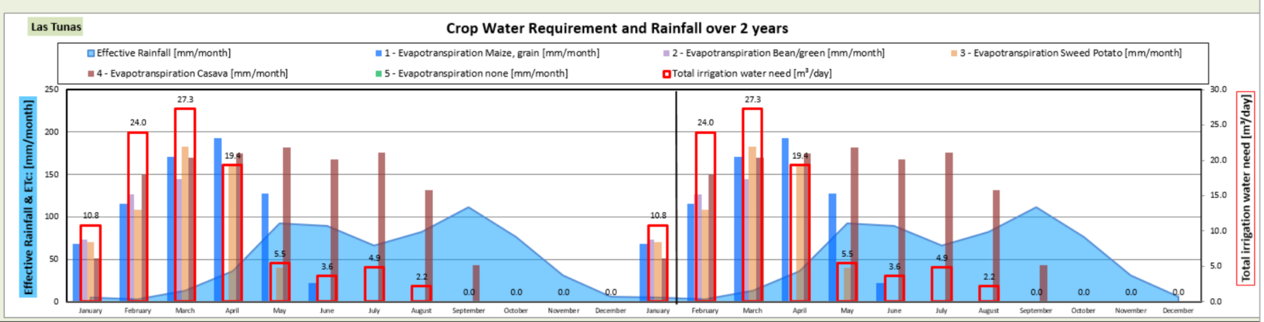
Area conversion ratios to ha:			
ha	1	Sq. m	10000
acre	2.47105	Sq. yard	11960
Sq. km	0.01	Sq. ft	107639

Farm code/name: Las Tunas

	January	February	March	April	May	June	July	August	September	October	November	December		
Mean daily temperature [°C]:	24	24	25	26	27	28	28	28	28	27	25	24	° C	Summer months
Rainfall [mm/month]:	24.7953596	22.0295851	38.33171	76.063809	147.09636	142.6485737	113.8443	133.7398	169.988	127.231	67.94388	27.07844	mm/month	Rainy season
Irrigation Water need [m³/day]:	10.8	24.0	27.3	19.4	5.5	3.6	4.9	2.2	0.0	0.0	0.0	0.0	m³/day	

Crop to be irrigated	Area in ha	Planting date (dd.mm.yyyy)	Crop growing time	Irrigation scheme	Irrigation Efficiency	Cropping density
Maize, grain	0.25	01/01/2020	Average	Drip	90 %	double spacing
Bean/green	0.25	01/01/2020	Average	Drip	90 %	double spacing
Sweed Potato	0.25	01/01/2020	Average	Drip	90 %	double spacing
Casava	0.25	01/01/2020	Average	Drip	90 %	double spacing

Highest daily irrigation water need per day: **27.3** m³ in the month of March **in Cuba-Las Tunas** Pump utilization rate: **30%** Yearly Water need in m³: **2,931**



FRUAGR VILLA CLARA

SAFEGUARD WATER – Water Requirement Tool

Enter basic rainfall and climatic data for you location.

1 GENERAL GEOGRAPHIC INFORMATION

Country	Cuba-Villa Clara	**Region**	Villa Clara
Farm code/name	Villa Clara	**Date**	01/16/2020
Name of the farm	IRES PROJECT		
Village	Las Tunas		
Division			
District			

	January	February	March	April	May	June	July	August	September	October	November	December
Mean daily temperature [°C]:	22.06	22.50	23.39	24.95	25.88	26.82	27.54	27.54	26.69	25.70	23.96	22.83
Rainfall [mm/month]:	35.48	32.51	52.39	76.69	187.74	203.64	141.94	190.16	207.73	174.74	62.86	39.74

Use to obtain indicative monthly rainfall and temperature data for the site: http://www.worldclimate.com http://sdwebx.worldbank.org/climateportal

SAFEGUARD WATER – Water Requirement Tool

Select crop intended for planting at your location, for automatic indication of water requirements

2 CROP WATER REQUIREMENT

Area measurement unit: ha

Conversion factor to 1 ha: 1.00 ha = 1 hectar

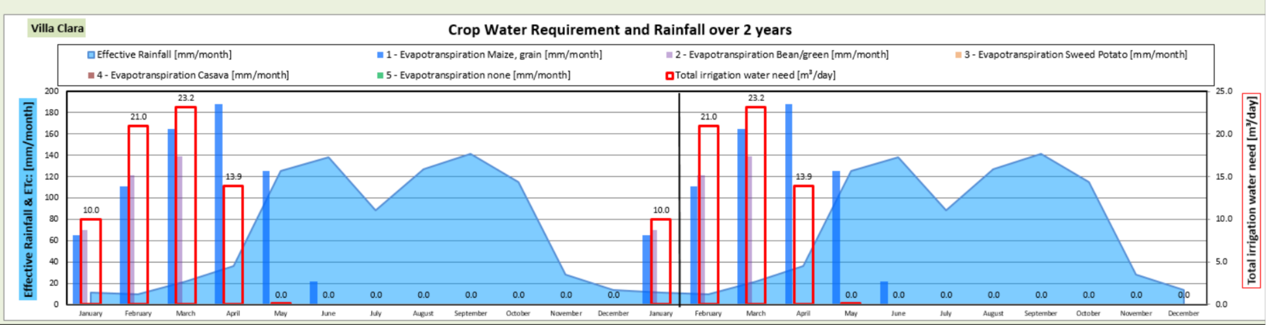
Farm code/name: Villa Clara

Area conversion ratios to ha:			
ha	1	Sq. m	10000
acre	2.47105	Sq. yard	11960
Sq. km	0.01	Sq. ft	107639

	January	February	March	April	May	June	July	August	September	October	November	December		
Mean daily temperature [°C]:	22	22	23	25	26	27	28	28	27	26	24	23	° C	Summer months
Rainfall [mm/month]:	35.4803129	32.5068971	52.394721	76.686291	187.73915	203.6442348	141.9417	190.1618	207.7258	174.7435	62.86028	39.73764	mm/month	Rainy season
Irrigation Water need [m³/day]:	10.0	21.0	23.2	13.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	m³/day	

Crop to be irrigated	Area in ha	Planting date (dd.mm.yyyy)	Crop growing time	Irrigation scheme	Irrigation Efficiency	Cropping density
Maize, grain	0.25	01/01/2020	Average	Drip	90 %	normal spacing
Bean/green	0.25	01/01/2020	Average	Drip	90 %	normal spacing
Sweed Potato	0.25	01/01/2020	Average	Drip	90 %	normal spacing
Casava	0.25	01/01/2020	Average	Drip	90 %	normal spacing

Highest daily irrigation water need per day:	23.2	m³ in the month of March	in Cuba-Villa Clara	Pump utilization rate:	24%	Yearly Water need in m³:	2,032



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16.6 Risk Assessment of the invasion of Moringa oleifera Lam.

RISK ASSESSMENT OF INVASION

SPECIES:	*Moringa oleifera* Lam.
FAMILY:	Moringaceae
SYNONYMS:	*Anoma moringa* (L.) Lour., *Guilandina moringa* L., *Hyperanthera decandra* Willd., *Hyperanthera moringa* (L.) Vahl, *Hyperanthera pterygosperma* Oken, *Moringa edulis* Medic., *Moringa erecta* Salisb., *Moringa moringa* (L.) Small, *Moringa myrepsica* Thell., *Moringa nux-eben* Desf., *Moringa octogona* Stokes, *Moringa oleifera* Lour., *Moringa parviflora* Noronha, *Moringa polygona* DC., *Moringa pterygosperma* Gaertn., *Moringa zeylanica* Pers., *Copaiba langsdorfii* (Desf.) Kuntze, *Copaifera langsdorffii* Desf., orth. var., *Copaifera nitida* Hayne, *Copaifera sellowii* Hayne
AREA OF DISTRIBUTION:	The species is native to India but has been widely distributed in tropical and subtropical regions around the world.
GENERAL DESCRIPTION OF THE SPECIES:	*Moringa oleifera* is a small to medium sized deciduous tree that usually does not exceed 10m in height. It usually has a single trunk and an open, umbrella-shaped cup. It has alternate, odd-shaped leaves, 25 to 60 cm long, each with a variable number of leaflets 1 to 2 cm in length. The flowers are zygomorphic, creamy white and are grouped in panicles. The fruit is a pod of triangular section, they are very distinctive, up to 2 cm wide and 30 to 50 cm long (up to 120 cm long in some cultivated varieties). Contains oily black seeds up to 1 cm in diameter.
RISK ASSESSMENT SYSTEM USED / MAIN CHARACTERISTICS:	The risk assessment protocol used is a development of the Governance Strengthening Project for the Protection of Biodiversity through the Formulation and Implementation of the National Strategy on Invasive Exotic Species (ENEEI) (GCP / ARG / 023 / GFF). This is an adaptation of the tool developed by the Horus Institute for Environmental Development and Conservation of Brazil (www.institutohorus.org.br), and the proposal developed by Pheloung, Williams & Halloy (1999) for Australia and New Zealand. The protocol includes 45 questions that are answered with “yes” or “no”. The scores of each question vary depending on the background that indicate the degree to which each of the aspects considered is related to the

invasive potential or to the potential impacts associated with the species. The score is added so that a species will present a high risk of invasion if it accumulates a high number of risk factors. The higher the final value, the greater the probability that the species will become invasive. The system records the number of questions answered in each section. The protocol accepts that there are some "gaps" of knowledge. However, a minimum of responses in each subject area is required to consider the assessment as valid.

EVALUATOR:	Sergio Martín Zalba, Dr. in Biology, FAO Specialist Consultant on Invasive Exotic Species
AREA / REGION FOR WHICH THE ASSESSMENT IS DEVELOPED:	The evaluation corresponds to a project using *M. oleifera* in the territory of Cuba, country in which the species is already introduced. In particular, it is an initiative to develop over a total area of 670 hectares in the provinces of Las Tunas (municipalities of Amancio, Colombia and Jobabo), Matanzas (municipality of Los Arabos) and Villa Clara (municipalities of Corralillo, Quemado de Güines and Santo Domingo). The proposal foresees the planting of moringa trees in degraded grasslands and low pruning for use as a protein source for livestock.
MAIN RESULTS OF THE ASSESSMENT:	The extensive information available about the species allowed to develop a solid assessment, based on 23 reliable sources of information whose specific contributions are detailed in Annex 2. No accurate data were found for just two of the 45 questions applied. The assessment developed resulted in a 47.5% percentile level of risk (calculated as the percentage with respect to the highest possible level of risk provided by the tool applied). **This value corresponds to a MODERATE RISK. This implies that, in case the use of the species is promoted, the eventual possibility of spontaneous dispersion should be recognized and measures will have to be taken to prevent expansion, detect, control and eradicate possible leaks and mitigate eventual damages.** The level of risk calculated coincides with similar judgments regarding the species obtained by other agencies dedicated to risk assessment such as CABI, Biosecurity Queensland and HEAR.
RECOMMENDATIONS:	The observed preexistent facts for *M. oleifera*, added to the results of this assessment, highlight the ability of the species to propagate and establish itself spontaneously, especially in environments subject to disturbance. The species has characteristics that enhance its invasive capacity including its

rapid growth, the short time to reach maturity, the abundant production of seeds and the interest of its cultivation. Although there are numerous examples of spontaneous moringa populations, the majority correspond to small nuclei located near cultivated specimens. The propagation of the species seems to be limited by the absence of efficient long-distance dispersal mechanisms, although its value as a multi-purpose crop implies that intentional human transport allows it to reach sites away from the original plantations. Its rate of spontaneous dispersion, on the other hand, seems to be faster along water courses. These characteristics allow us to propose a series of recommendations in case cultivation initiatives are developed.

In the first place, and to limit the possibilities of dispersion, planting near rivers and streams should be avoided.

It is also recommended to ensure that the remains of pruning activities and any other action that involves cutting the stems of the species are burned, composted or disposed of in some other way to ensure that they lose their ability to establish.

Early pruning of the specimens (before flowering) will reduce the risk of dispersion through the inhibition of seed production.

It is recommended to establish a safe area around the plantations where the eventual spontaneous recruitment of plants of the species is monitored. This area should be reviewed with a periodicity not less than one semester to allow the detection of possible leaks before the specimens produce seeds. The individuals detected should be safely disposed of (see above).

The plants have a high regrowth capacity so ensuring the extraction of specimens from the root is necessary, or otherwise be complemented with chemical control techniques.

It is recommended that the actions be complemented with spontaneous nucleus control tasks at the level of the work area, if any, even if they were not associated with the crop. It is very important to inform the population that beyond its positive attributes, the species must be kept in cultivation, eliminating concentrations of spontaneous establishment. Therefore, a communication strategy must be developed that conveys the risks associated with the expansion of the species.

Regardless of the measures taken at the level of the enterprise in which the cultivation of the species is developed, the risk that people carry propagules of the species to other places where they are used for other purposes and/or without the aforementioned controls should be considered. The same applies to the work site itself once the project deadlines have been met. To reduce these risks, regulation, prevention and control measures applied at regional or national level are required.

RISK ASSESSMENT FORM – RESULTS (Check List)

Section	Group		Question	*Moringa oleifera* moringa
	A. Historical-biogeographic aspects			
A	Cultivation / Domestication	1.01	Does the taxon show signs of cultivation / domestication?	yes
A	Cultivation / Domestication	1.02	Are there records that the taxon is expanding spontaneously from the sites where it is grown?	yes
A	Cultivation / Domestication	1.03	Is the taxon registered as a harmful plant or pest?	no
A	Climate	2.01	Does the taxon occur naturally or is there a record that it is established in some region with **very high climatic similarity** with respect to the area of destination of the introduction (see details in module of climatic similarity?	yes
A	Climate	2.02	Does the taxon occur naturally or is there a record that it is established in some region with **high climatic similarity** with respect to the area of destination of the introduction (see details in module of climatic similarity?	no
A	Climate	2.03	Does the taxon occur naturally or is there a record that it is established in some region with **moderate climatic similarity** with respect to the area of destination of the introduction (see details in module of climatic similarity?	no
A	Occurrence and invasion records	3.01	Does the taxon have a history of introductions outside its natural range?	yes
A	Occurrence and invasion records	3.02	Are there records that the taxon is established outside its natural range?	yes
A	Occurrence and invasion records	3.03	Are there records of impacts caused by this taxon in gardens, reclaimed areas or degraded areas?	no
A	Occurrence and invasion records	3.04	Are there records of impacts caused by the taxon in agricultural, forestry or horticultural areas?	no
A	Occurrence and invasion records	3.05	Are there records that the species is invasive of natural environments somewhere in the world?	no
A	Occurrence and invasion records	3.06	Are other species of the same genus considered invasive in other regions or are they established in Cuba?	yes
	B. Undesired Characteristics			
B	Undesired Characteristics	4.01	Does the taxon have thorns or other structure capable of causing injuries or preventing the passage of people or animals?	no

		4.02	¿ Is there evidence that the taxon produces chemical changes in the soil? (Examples: allelopathy, change in pH, nitrogen fixation)	yes
		4.03	Is it a parasitic taxon?	no
		4.04	Is it a non-palatable taxon for native or introduced herbivores?	no
		4.05	Is it an aquatic plant? (which grows in freshwater, salty or brackish environments, in water or in direct association with the shoreline) Is it a toxic taxon for humans or for native or domesticated animals of economic importance?	no
		4.06	Is it a toxic taxon for humans or for native or domesticated animals of economic importance?	no
		4.07	Are there records that the taxon is a host or vector of pests or pathogens that affect native species and / or economic value?	yes
		4.08	Does the taxon cause some kind of allergy in humans?	no
	Habit and competition for resources in natural environments	5.01	Is there evidence that the taxon produces physical alterations in ecological interactions? (Example: increased risk of fire occurrences, alteration of natural erosion processes, modification of the soil hydrological system)	no
		5.02	Is a taxon with shadow tolerance at some stage of the life cycle?	yes
		5.03	Can the taxon live in sandy, acidic or low fertile soils?	yes
		5.04	Is the taxon a vine or does it have a form of growth capable of suppressing other plants?	no
		5.05	Does the taxon form dense bushes?	yes
		5.06	Is the taxon a tree, woody perennial shrub, grass, grass or geophyte? (In case the taxon does not belong to any of these groups you must select "none").	Tree
	C. Biological and ecological characteristics			
C	Reproductive mechanisms	6.01	Is there evidence about the presence of biotic factors in the natural range of the species that reduce its reproductive capacity?	yes
		6.02	Does the taxon produce viable seeds?	yes
		6.03	Is there evidence that the taxon is capable of performing interspecific hybridization?	no
		6.04	Are there endemic congener species in the country?	no
		6.05	Is the taxon capable of self-pollination or apomixis?	no
		6.06	Does the taxon need specialized pollinators?	no
		6.07	Does the taxon reproduce by vegetative fragments different from the apomictic or geophytic?	no
		6.08	What is the duration of the youth period? Up to one year, one to four years, more than four years.	Up to one year

	Dispersion mechanisms	7.01	Does it produce propagules with probabilities of involuntary dispersion by people, machinery, etc.?	no
		7.02	Does it produce propagules that are intentionally dispersed by people?	yes
		7.03	Does it produce propagules with dispersion probabilities as product contaminants?	yes
		7.04	Does it produce propagules adapted to wind dispersion (anemocoria)?	no
		7.05	Does it produce propagules adapted to water dispersion (hydrochloric)?	yes
		7.06	Does it produce propagules that are dispersed by birds (ornitocoria) or bats (chiropterocoria)?	no
		7.07	Does it produce propagules dispersed by animals (externally)?	no
		7.08	Does it produce propagules dispersed by animals that feed on fruits and/or seeds that survive the passage through the digestive system?	no
	Persistence Attributes	8.01	Is the taxon a prolific seed producer?	yes
		8.02	Is there evidence that taxon seeds remain viable in the soil for more than 1 year?	no
		8.03	Is it possible to find an effective way to control the species at reasonable costs?	undetermined
		8.04	Is any effective natural taxon controller present in the country?	undetermined

SOURCES OF INFORMATION OF ASSESSMENT BY ITEM

Number	Question	*Moringa oleifera*
A. Historical-biogeographical aspect		
1.01	Does the taxon show signs of cultivation / domestication?	*Moringa oleifera* is a widely spread crop. "*M. oleifera* is a perennial tree thought to be native to India but now widely introduced and naturalized across the tropics and subtropics. It is also widely cultivated for a range of purposes including for human consumption, as livestock feed and for use in cosmetics." CABI - Invasive Species Compendium. 2019. Moringa oleífera full datasheet. https://www.cabi.org/isc/datasheet/34868.
1.02	Are there records that the taxon is expanding spontaneously from the sites where it is grown?	1) "naturalized across the tropics and subtropics" CABI - Invasive Species Compendium. 2019. *Moringa oleífera* full datasheet. https://www.cabi.org/isc/datasheet/34868. 2) Reported as naturalized, invasive or as a weed in a variety of countries and regions, including: Puerto Rico, USA, Costa Rica, Belize, Australia, Mozambique, Madagascar, Laos, Chad, China, South Africa, Botswana, Yemen, India, Zimbabwe, Cape Verde, Cuba, Brazil, Seychelles, Burundi, Anguilla, Aruba, Bahamas, Bonaire, Cameroon, Comoros, Cook Islands, Democratic Republic of the Congo, Dominica, Dominican Republic, Laos, Maldives, Marshall Islands, Micronesia, Palau, Samoa, Saudi Arabia , Solomon Islands, Tonga, Vietnam. Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. 3) "*M. oleifera* has naturalized in at least 70 countries across the tropical and subtropical regions of the world." Csurhes S & Navie S. 2016. Horseradish tree, *Moringa oleifera*, Invasive plant risk assessment. Department of Agriculture and Fisheries, Biosecurity Queensland, Australia. https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/69262/IPA-Horseradish-Tree-Risk-Assessment.pdf 4) Oviedo Prieto & Oliva. 2015. National list of invasive and potentially invasive plants of the Republic of Cub. Bissea 9 (Special Number 2): 1-88.
1.03	Is the taxon registered as a harmful plant or pest?	Although Randall, R.P. (2017), A Global Compendium of Weeds. 3rd Edition Perth, Western Australia cites it as a weed for several countries, there are no references on possible negative effects on productive systems. GRIIS (Global Register of Invasive and Introduced Species) reports it as present in ten countries, but does not report negative effects of its presence (http://www.griis.org/)
2.01	The taxon occurs naturally or there is a record that it is established in some region with very high climatic similarity with respect to the area of destination of the introduction (see details in module of climatic similarity).	The target area of the species corresponds to a humid Equatorial climate with dry winter (AW), according to the Koppen-Geiger classification. This climatic type coincides with that of the native area of the species in India, and with that of many areas in which the species is established or behaves as an invader in Central America, northern South America, Africa and northern Australia. Kottek M, Grieser J, Beck C, Rudolf B & Rubel F. 2006. World Map of the Köppen-Geiger climate classification updated. Meteorol. Z., 15, 259-263. DOI: 10.1127/0941-2948/2006/0130. http://koeppen-geiger.vu-wien.ac.at/present.htm. CABI - Invasive Species Compendium. 2019. *Moringa oleífera* full datasheet. https://www.cabi.org/isc/datasheet/34868.
2.02	The taxon occurs naturally or there is a record that it is established in some region with high climatic similarity with respect to the area of destination of the introduction (see details in	NON-APPLICABLE (SEE 2.01)

	module of climatic similarity).	
2.03	The taxon occurs naturally or there is a record that it is established in some region with moderate climatic similarity with respect to the area of destination of the introduction (see details in module of climatic similarity).	NON-APPLICABLE (SEE 2.01)
3.01	Does the taxon have a history of introductions outside its natural range?	*Moringa oleifera* is a widely spread crop. "*M. oleifera* is a perennial tree thought to be native to India but now widely introduced and naturalized across the tropics and subtropics. It is also widely cultivated for a range of purposes including for human consumption, as livestock feed and for use in cosmetics." CABI - Invasive Species Compendium. 2019. Moringa oleífera full datasheet. https://www.cabi.org/isc/datasheet/34868.
3.02	Are there records that the taxon is established outside its natural range?	1) Reported as naturalized, invasive or as a weed in a variety of countries and regions, including: Puerto Rico, USA, Costa Rica, Belize, Australia, Mozambique, Madagascar, Laos, Chad, China, South Africa, Botswana, Yemen, India, Zimbabwe, Cape Verde, Cuba, Brazil, Seychelles, Burundi, Anguilla, Aruba, Bahamas, Bonaire, Cameroon, Comoros, Cook Islands, Democratic Republic of the Congo, Dominica, Dominican Republic, Laos, Maldives, Marshall Islands, Micronesia, Palau, Samoa, Saudi Arabia , Solomon Islands, Tonga, Vietnam.Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. 2) The species is not included in the global database on invasive species of the IUCN (GISD - IUCN, http://www.iucngisd.org/gisd/)
3.03	Are there records of impacts caused by this taxon in gardens, reclaimed areas or degraded areas?	No impacts are reported. 1) Cited by GRIIS (Global Register of Invasive and Introduced Species) as present in ten countries, but without impact reports (http://www.griis.org/) 2) "There is conflicting information about the invasive nature and potential spread of this species. It is listed as invasive in the British Indian Ocean Territory, China, Philippines, Palau, the Solomon Islands and Cuba; though there is a lack of information about its invasive nature or its effect on native flora and natural habitats in these countries. Furthermore, despite being listed as a weed in many countries, it has not been observed invading intact habitats or displacing native flora. As a result, M. oleifera should be regarded at present as a widely cultivated species with low invasive potential." CABI - Invasive Species Compendium. 2019. *Moringa oleífera* full datasheet. https://www.cabi.org/isc/datasheet/34868. 3) The species is not included in the global database on invasive species of the IUCN (GISD - IUCN, http://www.iucngisd.org/gisd/)

3.04	Are there records of impacts caused by the taxon in agricultural, forestry or horticultural areas?	No impacts are reported. 1) Cited by GRIIS (Global Register of Invasive and Introduced Species) as present in ten countries, but without impact reports (http://www.griis.org/) 2) "There is conflicting information about the invasive nature and potential spread of this species. It is listed as invasive in the British Indian Ocean Territory, China, Philippines, Palau, the Solomon Islands and Cuba; though there is a lack of information about its invasive nature or its effect on native flora and natural habitats in these countries. Furthermore, despite being listed as a weed in many countries, it has not been observed invading intact habitats or displacing native flora. As a result, *M. oleifera* should be regarded at present as a widely cultivated species with low invasive potential." CABI - Invasive Species Compendium. 2019. *Moringa oleífera* full datasheet. https://www.cabi.org/isc/datasheet/34868. 3) The species is not included in the global database on invasive species of the IUCN (GISD - IUCN, http://www.iucngisd.org/gisd/)
3.05	Are there records that the species is invasive of natural environments somewhere in the world?	1) Cited by GRIIS (Global Register of Invasive and Introduced Species) as present in ten countries, but without impact reports (http://www.griis.org/) 2) "There is conflicting information about the invasive nature and potential spread of this species. It is listed as invasive in the British Indian Ocean Territory, China, Philippines, Palau, the Solomon Islands and Cuba; though there is a lack of information about its invasive nature or its effect on native flora and natural habitats in these countries. Furthermore, despite being listed as a weed in many countries, it has not been observed invading intact habitats or displacing native flora. As a result, *M. oleifera* should be regarded at present as a widely cultivated species with low invasive potential." CABI - Invasive Species Compendium. 2019. *Moringa oleífera* full datasheet. https://www.cabi.org/isc/datasheet/34868. 3) The species is not included in the global database on invasive species of the IUCN (GISD - IUCN, http://www.iucngisd.org/gisd/)
3.06	Are other species of the same genus considered invasive in other regions or established in Cuba?	*Moringa peregrina* is cited as a weed for Australia*, M. pterygosperma* as a crop getaway, naturalized or weed for South Africa, Madagascar and Australia, and *M. stenopetala* (Baker f.) Cufod as an invader in Australia and the United States. Randall R. 2017. A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia
B. Undesired Characteristics		
4.01	Does the taxon have thorns or other structure capable of causing injuries or preventing the passage of people or animals?	No (see description of the species in World Agroforestry Centre). 2009. *Moringa oleifera*. Agroforestry Database 4.0. http://old.worldagroforestry.org/treedb/AFTPDFS/Moringa_oleifera.PDF).
4.02	Is there evidence that the taxon produces chemical changes in the soil? (Examples: allelopathy, change in pH, nitrogen fixation)	The presence of allelopathic compounds in the extract of *M . oleifera* leaves is known. Iqbal M. Hussain M, Ur Rehman M, Ali M, Rizwan M & Irfan M. 2013. Allelopathy of Moringa. A review. Sci. Agri. 3 (1): 9-12. https://www.researchgate.net/profile/Muhammad_Aamir_Iqbal2/publication/278019706_Allelopathy_of_Moringa_A_review/links/5578abf808aeb6d8c01f1984.pdf.
4.03	Is it a parasitic taxon?	No (see description of the species in World Agroforestry Centre). 2009. *Moringa oleifera*. Agroforestry Database 4.0. http://old.worldagroforestry.org/treedb/AFTPDFS/Moringa_oleifera.PDF).

4.04	Is it a non-palatable taxon for native or introduced herbivores?	The widespread use of the species as food for cattle, poultry and fish suggests that it is potentially consumable by a variety of wild species. Yasmeen A, Gull T & Cervantes Alcayde M. 2014. Potential of *Moringa oleifera* L. as livestock fodder crop: a review. Turk. J. Agric. For. 38: 1-14.
4.06	Is it a toxic taxon for humans or for native or domesticated animals of economic importance?	"The aqueous extract from the leaves of *Moringa oleifera* was evaluated for its oral toxicity by the oral route, and for the sub-acute toxicity on haematological, biochemical and histological parameters in rats. In the acute toxicity test, *M. oleifera* extract caused no death in animals even at 2000 mg/kg dose. Oral treatments in rats with this extract at 400, 800 and 1600 mg/kg caused varied significant changes in the total RBC, packed cell volume (PCV), haemoglobin percentage (HB), mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), total and differential WBC. The extract did not cause any significant change in the level of platelets. In the biochemical parameters, the extract at different doses also caused varied significant changes in the levels of total proteins, liver enzymes, and bilirubin. Clinic-pathologically, changes were also noted in the body weights, slight dullness at the onset of extract administration and no significant changes were noticed in all the organs examined in the course of this study. The study concluded that the plant is relatively safe both for nutritional and medicinal uses." Adedapo A, Mogbojuri O & Emikpe B. 2009. Safety evaluations of the aqueous extract of the leaves of *Moringa oleifera* in rats. Journal of Medicinal Plants Research, 3(8): 586-591. http://www.academicjournals.org/JMPR.
4.07	Are there records that the taxon is a host or vector of pests or pathogens that affect native and economically valuable species?	"*M. oleifera* is one of the host plants of *Leveillula taurica*, which causes major damage to papaya (*Carica papaya*). Caution is needed when the species occurs near papaya plantations" Mridha, M. A. U., & Barakah, F. N. (2017). Diseases and pests of moringa: a mini review. Acta Horticulturae, (1158), 117–124. doi:10.17660/actahortic.2017.1158.14
4.08	Does the taxon cause some kind of allergy in humans?	The known history of allergies is limited to the effect of ingestion of the seeds. Berglund L. 2018. Anaphylaxis to *Moringa oleifera*: First description. Australasian Medical Journal 11(3) DOI: 10.21767/AMJ.2018.3344. The presence of the species itself does not seem to be associated with these types of problems.
5.01	Is there evidence that the taxon produces physical alterations in ecological interactions? (Example: increased risk of fire occurrences, alteration of natural erosion processes, modification of the soil hydrological system)	There is no background in this regard.
5.02	Is a taxon with shadow tolerance at some stage of the life cycle?	"shade has significant effect on germination and seedling growth variables. Medium shade resulted in fast rate of germination and high germination percentage. Also, it gave higher values for the seedling growth variables and produced erect and strong shoot than the other two treatments. " Ahmed L, Warrag E & Abdelgadir A. 2014. Effect of Shade on Seed Germination and Early Seedling Growth of *Moringa oleifera* Lam. Journal of Forest Products & Industries, 3(1): 20-26.

5.03	Can the taxon live in sandy, acidic or low fertile soils?	1) Moringa is a drought tolerant plant that can be grown in diverse soils, except those that are waterlogged. Slightly alkaline clay and sandy loam soils are considered the best media for this species due to their good drainage. Nouman W, Basra S, Siddiqui M,Yasmeen A, Gull T & Cervantes Alcayde M. 2014. Potential of *Moringa oleifera* L. as livestock fodder crop: a review. Turk. J. Agric. For. 38: 1-14. ---------- 2) "can grow in a wide range of habitats on a variety of soils" Csurhes S & Navie S. 2016. Horseradish tree, Moringa oleifera, Invasive plant risk assessment. Department of Agriculture and Fisheries, Biosecurity Queensland, Australia. https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/69262/IPA-Horseradish-Tree-Risk-Assessment.pdf
5.04	Is the taxon a vine or does it have a form of growth capable of suppressing other plants?	No (see description of the species in World Agroforestry Centre). 2009. *Moringa oleifera*. Agroforestry Database 4.0. http://old.worldagroforestry.org/treedb/AFTPDFS/Moringa_oleifera.PDF).
5.05	Does the taxon form dense bushes?	"While it spreads slowly, over time it can form dense populations around parent trees. Like other tree species it may replace native vegetation and even transform areas such as grasslands and open woodlands." Csurhes S & Navie S. 2016. Horseradish tree, *Moringa oleifera*, Invasive plant risk assessment. Department of Agriculture and Fisheries, Biosecurity Queensland, Australia. https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/69262/IPA-Horseradish-Tree-Risk-Assessment.pdf
5.06	Is the taxon a tree, woody perennial shrub, grass, grass or geophyte? (In case the taxon does not belong to any of these groups you must select "none").	Tree (see description of the species in World Agroforestry Centre). 2009. *Moringa oleifera*. Agroforestry Database 4.0. http://old.worldagroforestry.org/treedb/AFTPDFS/Moringa_oleifera.PDF).
C. Biological and ecological characteristics		
6.01	Is there evidence about the presence of biotic factors in the natural range of the species that reduce its reproductive capacity?	“Moringa plants suffer from fruit rots, stem rots, root rot, twig canker, etc. Major pests include pod fly, budworm, hairy caterpillars, red mites, etc.” Mridha, M. A. U., & Barakah, F. N. (2017). Diseases and pests of moringa: a mini review. Acta Horticulturae, (1158), 117–124. doi:10.17660/actahortic.2017.1158.14
6.02	Does the taxon produce viable seeds?	Yes, with high viability percentages and germination rates of around 90%. Muhl, Q. E., du Toit, E. S., & Robbertse, P. J. (2011). Temperature effect on seed germination and seedling growth of *Moringa oleifera* Lam. Seed Science and Technology, 39(1), 208–213. doi:10.15258/sst.2011.39.1.19
6.03	Is there evidence that the taxon is capable of performing interspecific hybridization?	There is no evidence and there are no taxonomically close species in the destination area. Acevedo-Rodríguez P & Strong M. 2016. Catalogue of Seed Plants of the West Indies. Smithsonian Contributions to Botany. https://naturalhistory2.si.edu/botany/WestIndies/catalog.htm.
6.04	Are there endemic congener species in the country?	No. Acevedo-Rodríguez P & Strong M. 2016. Catalogue of Seed Plants of the West Indies. Smithsonian Contributions to Botany. https://naturalhistory2.si.edu/botany/WestIndies/catalog.htm.
6.05	Is the taxon capable of self-pollination or apomixis?	"Apomixis and autogamy experiments did not yield any fruit". Jyothi P, Atluri J & Reddi C. 1990. Proc. Indian Acad. Sci. (Plant Sci.) 100: 33-42. https://doi.org/10.1007/BF03053466.

6.06	Does the taxon need specialized pollinators?	“At Visakhapatnam (17°42´N-82°18´E), *Moringa oleifera* Lam. flowers twice a year, once during February-May and again during September-November. Both geitonogamous and xenogamous pollinations produce fruit, but the latter mode is superior. The flowers are zygomorphic and gullet type. They open during 0300-1900 h, and are visited only by diurnally active insects during 0600-1500 h. Bees are the dominant foragers, of which *Xylocopa* and *Amegilla* carry pollen on the head and/or thorax to effect nototribic pollination. *Xylocopa* was more frequent and proved to be the major pollinator.” Jyothi P, Atluri J & Reddi C. 1990. Proc. Indian Acad. Sci. (Plant Sci.) 100: 33-42. https://doi.org/10.1007/BF03053466
6.07	Does the taxon reproduce by vegetative fragments different from the apomictic or geophytic?	Not spontaneously although it does spread through stakes or pruned waste discarded at appropriate sites for the species. "Discarded branches can remain viable for long periods" (Csurhes and Navie, 2016).
6.08	What is the duration of the youth period? Up to one year, one to four years, more than four years.	"Flowering generally begins at an early age, usually within the first year and often within 6 months after planting. Trees generally produce good seed crops for about 12 years". Parrotta, J. 2009. *Moringa oleifera*. En: Roloff A, Weisgerber H Lang U & Stimm B. Enzyklopädie der Holzgewächse, Handbuch und Atlas der Dendrologie WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. https://www.researchgate.net/profile/John_Parrotta/publication/288327947_Moringa_oleifera/links/5bbe6a67a6fdccf297923720/Moringa-oleifera.pdf
7.01	Does it produce propagules with probabilities of involuntary dispersion by people, machinery, etc.?	It does not naturally produce appropriate propagules for accidental dispersion, but it can disperse through the disposal of pruning remains. "Populations of *M. oleifera* have been observed near dumpsites, which suggests the species is establishing from seeds or cuttings from garden waste". CABI - Invasive Species Compendium. 2019. Moringa oleífera full datasheet. https://www.cabi.org/isc/datasheet/34868.
7.02	Does it produce propagules that are intentionally dispersed by people?	"*Moringa oleifera* is most commonly and quickly cultivated by cuttings." Csurhes S & Navie S. 2016. Horseradish tree, *Moringa oleifera*, Invasive plant risk assessment. Department of Agriculture and Fisheries, Biosecurity Queensland, Australia. https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/69262/IPA-Horseradish-Tree-Risk-Assessment.pdf. The species is widely cultivated for numerous purposes and easily reproduced by stakes, so it is expected that these will be used as a means of intentional dispersion.
7.03	Does it produce propagules with dispersion probabilities as product contaminants?	"Discarded branches can remain viable for long periods" (Csurhes and Navie, 2016).

7.04	Does it produce propagules adapted to wind dispersion (anemocoria)?	1) "The mature, dehiscent capsules, mature about 3 months after flowering, and remain on the tree for several months, releasing the seeds that are dispersed mainly by wind and water, but probably also by seed-eating animals." Parrotta, J. 2009. *Moringa oleifera*. En: Roloff A, Weisgerber H Lang U & Stimm B. Enzyklopädie der Holzgewächse, Handbuch und Atlas der Dendrologie WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. https://www.researchgate.net/profile/John_Parrotta/publication/288327947_Moringa_oleifera/links/5bbe6a67a6fdccf297923720/Moringa-oleifera.pdf 2) "*M. oleifera* seeds are winged and can be dispersed over short distances by wind. The wings also aid seed dispersal in streams. The pods float on water helping the dispersal of the species (Csurhes and Navie, 2016)." CABI - Invasive Species Compendium. 2019. *Moringa oleifera* full datasheet. https://www.cabi.org/isc/datasheet/34868.
7.05	Does it produce propagules adapted to water dispersion (hydrochloric)?	1) "The mature, dehiscent capsules, mature about 3 months after flowering, and remain on the tree for several months, releasing the seeds that are dispersed mainly by wind and water, but probably also by seed-eating animals." Parrotta, J. 2009. *Moringa oleifera*. En: Roloff A, Weisgerber H Lang U & Stimm B. Enzyklopädie der Holzgewächse, Handbuch und Atlas der Dendrologie WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. https://www.researchgate.net/profile/John_Parrotta/publication/288327947_Moringa_oleifera/links/5bbe6a67a6fdccf297923720/Moringa-oleifera.pdf 2) "There is little information in the literature as to the dispersal mechanisms of *M. oleifera*; however, much can be determined from its seed morphology and the locations in which it tends to become naturalized. Seed and mature pods dispersal downstream in water during floods (seems to be an efficient mechanism of dispersal), as populations are sometimes found growing along waterways." Csurhes S & Navie S. 2016. Horseradish tree, *Moringa oleifera*, Invasive plant risk assessment. Department of Agriculture and Fisheries, Biosecurity Queensland, Australia. https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/69262/IPA-Horseradish-Tree-Risk-Assessment.pdf
7.06	Does it produce propagules that are dispersed by birds (ornitocoria) or bats (chiropterocoria)?	There is no background in this regard. "Like many other tree species that do not have very effective dispersal mechanisms (e.g. bird or animal-dispersed fruit), *M. oleifera* seems to spread at a relatively slow rate. It seedlings generally do not appear far from parent plants, instead forming thickets around older individuals." Csurhes S & Navie S. 2016. Horseradish tree, *Moringa oleifera*, Invasive plant risk assessment. Department of Agriculture and Fisheries, Biosecurity Queensland, Australia. https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/69262/IPA-Horseradish-Tree-Risk-Assessment.pdf
7.07	Does it produce propagules dispersed by animals (externally)?	Fruits and seeds have no characteristics that allow us to assume that the ectozoocoria is relevant or even possible. Fotouo M, du Toit E, & Robbertse P. 2015. Germination and ultrastructural studies of seeds produced by a fast-growing, drought-resistant tree: implications for its domestication and seed storage. AoB PLANTS, 7, plv016. doi:10.1093/aobpla/plv016.

7.08	Does it produce propagules dispersed by animals that feed on fruits and / or seeds that survive the passage through the digestive system?	The dispersal mechanisms by animals seem to be highly inefficient. "Like many other tree species that do not have very effective dispersal mechanisms (e.g. bird or animal-dispersed fruit), *M. oleifera* seems to spread at a relatively slow rate. It seedlings generally do not appear far from parent plants, instead forming thickets around older individuals." Csurhes S & Navie S. 2016. Horseradish tree, *Moringa oleifera*, Invasive plant risk assessment. Department of Agriculture and Fisheries, Biosecurity Queensland, Australia. https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/69262/IPA-Horseradish-Tree-Risk-Assessment.pdf
8.01	Is the taxon a prolific seed producer?	"Each tree can produce between 15,000 and 25,000 seeds/year." Foidl N, Makkar H & Becker K. 2002. The potential of *Moringa oleifera* for agricultural and industrial uses. En: Development potential for moringa products: International workshop. 29th October - 2nd November 2001, Dar es Salaam, Tanzania. https://www.moringatrees.org/moringa-doc/the_potential_of_moringa_oleifera_for_agricultural_and_industrial_uses.pdf
8.02	Is there evidence that taxon seeds remain viable in the soil for more than 1 year?	1) "Seeds do not retain their viability in storage at ambient temperatures for longer than 2 months [52, 63]; germination percentages of 60, 48 and 7.5 % were reported for seeds after 1, 2, and 3 months, respectively, in India [37]. In test conducted in Brazil, however, seeds retained their viability for several years in cold storage, or inside hermetically sealed containers stored at ambient temperatures [59]. Parrotta, J. 2009. *Moringa oleifera*. En: Roloff A, Weisgerber H Lang U & Stimm B. Enzyklopädie der Holzgewächse, Handbuch und Atlas der Dendrologie WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. https://www.researchgate.net/profile/John_Parrotta/publication/288327947_Moringa_oleifera/links/5bbe6a67a6fdccf297923720/Moringa-oleifera.pdf 2) "Many studies have found that *M. oleifera* seeds lose their viability and vigour within 6–12 months". Fotouo M, du Toit E, & Robbertse P. 2015. Germination and ultrastructural studies of seeds produced by a fast-growing, drought-resistant tree: implications for its domestication and seed storage. AoB PLANTS, 7, plv016. doi:10.1093/aobpla/plv016. 3) The seeds of *M. oleifera* do not have a significant dormancy, they lose viability relatively fast and are usually not viable after two years (Csurhes and Navie, 2016).
8.03	Is it possible to find an effective way to control the species at reasonable costs?	"As this species is not yet regarded to be a problem of any significance, control has not been required and there is a lack of information in this area. However, it should be noted that *M. oleifera* re-shoots vigorously after damage and older plants usually develop a swollen underground rootstock, which no doubt contains significant energy reserves. Any successful control measures will have to overcome these survival mechanisms." Csurhes S & Navie S. 2016. Horseradish tree, *Moringa oleifera*, Invasive plant risk assessment. Department of Agriculture and Fisheries, Biosecurity Queensland, Australia. https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/69262/IPA-Horseradish-Tree-Risk-Assessment.pdf
8.04	Is there any effective natural taxon controller present in the country?	There is no information in this regard, however numerous and diverse natural enemies of the species are cited throughout the world and it is very likely that there are some that affect their reproductive or vegetative tissues in the area of introduction.