FONDO MEXICANO PARA LA CONSERVACIÓN DE LA NATURALEZA, A.C.
INSTITUCIÓN PRIVADA
FMCN

ANNEX 10

ECONOMIC AND FINANCIAL ANALYSIS

Sustainable Communities for Climate Action in the Yucatán Peninsula (ACCIÓN)

FONDO MEXICANO PARA LA CONSERVACIÓN DE LA NATURALEZA, A.C.
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Summary

This document describes the selection process of activities for the "Economic and financial analysis of the ACCIÓN project" of the Mexican Fund for the Conservation of Nature (FMCN). Subsequently, an analysis is developed that evaluates the economic and socio-environmental viability of these productive activities: agroforestry systems, beekeeping, blue carbon credits, sustainable fishing, charcoal production from mangroves, ecotourism, and silvopastoral systems. These activities were selected for their potential to strengthen sustainability and ecosystem-based adaptation in the region and their presence in the area.

The paper highlights the importance of adopting a comprehensive approach that not only considers economic returns but also environmental and social benefits, aligning productive activities with the principles of sustainability, climate resilience, and adaptation. It also describes how the proposed transition model aligns with the investment criteria of the Green Climate Fund through the potential for impact, sustainable development, paradigm shift, beneficiary needs, country ownership, efficiency, and effectiveness.

As part of the results, it is concluded that the proposed activities are profitable at the private and social level, that they offer alternatives that promote the sustainable use of natural resources and, therefore, the financial security of those who depend on these resources for their livelihoods. All activities were compared with traditional economic practices, i.e. *Business as Usual* (BAU). Finally, it is mentioned that the proposed model presupposes the existence of adequate governance structures and active participation of local communities in project management.

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Acronyms and abbreviations

EbA	Ecosystem-based Adaptation
BAU	*Business as usual*
CAR	*Climate Action Reserve*
CMIC	Mexican Chamber of the Construction Industry
FAEF	Annual Equivalent Cash Flow
FAO	Food and Agriculture Organization of the United Nations
FMCN	Mexican Fund for the Conservation of Nature
GEI	Greenhouse gases
Ha	Hectare
CBI	Cost Benefit Index
CEI	Cost Effectiveness Index
INEGI	National Institute of Statistics and Geography
IPCC	*Intergovernmental Panel on Climate Change*
VAT	Value Added Tax
IOM	Input-Output Matrix
NGO	Non-governmental organization
OSCO	Civil Society Organization
PY	Peninsula of Yucatan
SCIANS	North American Industry Classification System
SECTUR	Secretariat of Tourism
SEMARNAT	Secretariat of the Environment and Natural Resources
SHCP	Secretariat of Finance and Public Credit
SiPS	Silvopastoral intensive silvopastoral system
tC	Ton of carbon
$tCOe_2$	Tons of carbon dioxide equivalents
IRR	Internal Rate of Return
EMU	Environmental Management Unit
NPV	Net Present Value

I. Introduction

This document is part of the Sustainable Communities for Climate Action in the Yucatan Peninsula Project (ACCIÓN). Concerning marine coastal ecosystems, Pech (2010) points out that they constitute one of the most valuable ecosystems from a socioeconomic and cultural point of view. He also mentions that these ecosystems' resilience and adaptation capacity are very relevant for combating the effects of global climate warming and maintaining biodiversity. In this context, actions aimed at building sustainable, productive systems in marine coastal ecosystems are necessary to construct a sustainable future.

Therefore, this document details the process to select and analyze Ecosystem-based Adaptation activities that are expected to be implemented through the project, mainly through Component 1. It is based on the requirements from GCF "Guidelines on preparing the economic and financial analysis for SAP proposals". The spreadsheets are available in Spanish in this link.

To identify the activities, interviews were conducted with leaders of local organizations, and those contained in the ACCIÓN project bank were considered, resulting in the selection of seven productive Ecosystem-based Adaptation activities considered to have the potential to strengthen sustainability and climate resilience in the region. For this work, seven productive activities were considered for evaluation. This identification was made based on interviews with people in charge of organizations working in the ACCIÓN project area and a project bank developed under the project's Preparedness Resources Framework (PPF) (New Ventures, 2023). The selected activities are the following: agroforestry systems, beekeeping, mangrove restoration with blue carbon credits, sustainable fishing, charcoal production from mangroves, ecotourism, and silvopastoral systems. All of the above activities were chosen for their economic, environmental, and social relevance for the Yucatan Peninsula and their capacity to increase the resilience of people and ecosystems.

The analysis contained in this work offers both a quantitative and qualitative evaluation of the costs and benefits associated with each selected activity in order to provide a robust and rigorous basis for decision-making during the implementation of the ACCION project. Following the lines of work that guide ACCIÓN's activities, objectives, and vision, it should be noted that the work was carried out considering the importance of adopting an integral approach that not only considers the economic returns but also the environmental and social benefits.

II. Methodology of economic and financial analysis

The formula used to evaluate profitability (Figure 1), whether financial or economic, is presented below.

FIGURE 1. ECONOMIC AND FINANCIAL PROFITABILITY

$$VPN = \sum_{i=1}^{N} \overbrace{\left(\underbrace{\sum_{t=0}^{T} \frac{B_{i,t} - C_{i,t} - I_{i,t}}{(1+d)^t}}_{\text{Financial profitability}} + \sum_{t=0}^{T} \frac{E_{i,t} + D_{i,t} + I_{i,t}}{(1+d)^t} \right) - \sum_{t=0}^{T} \frac{F_t}{(1+d)^t}}^{\text{Economic outlook}}$$

Where B represents the benefits of productive activities for the ejido/community/property (i) over time t, C represents the total costs of productive activities, I the net taxes generated by the activities, E represents the externalities (which can be monetized), [1]D the economic spillover generated by economic activities, F the fixed costs related to the studies required for the entire ACCIÓN project and the discount rate d the discount rate.

As shown in Figure 1, the economic perspective includes all direct and indirect costs and benefits generated by the activities. On the other hand, the financial perspective includes the costs and benefits that occur at the private level. It is worth mentioning that taxes are accounted for from a financial standpoint but neutralized from an economic perspective, considering that these taxes are returned to society.

In this sense, we can report the results of the economic analysis in a table that allows us to identify the profitability from an economic and financial perspective of the entire ACCIÓN project. To assign monetary values to this table, we need an approximation of the fixed costs, the costs associated with the local relationship, the costs and benefits of each productive activity, as well as the number of individual projects of each activity (for example, the number of beekeeping projects, agroforestry systems, etc.), the economic value of the environmental externalities generated by the activities and the economic spillover.

[1] The assumption is made that the net effect of the economic value of environmental externalities is positive, otherwise it would not be worthwhile

II.1. Analysis assumptions

The analysis requires establishing several assumptions. This section describes the assumptions considered.

- **Discount rate**. A nominal discount rate of 10% and an inflation rate of 4% are considered, which generates a real discount rate of 6%. The nominal rate of 10% is established based on the Ministry of Finance and Public Credit (SHCP) criteria, which requires the evaluation of investment projects with this rate.[2] The inflation rate is established based on Banco de México's inflation expectations for 2024, which amounts to 4% (Banco de México, 2024).

- **Economic spillover**. The technical coefficients of the Input-Output Matrix prepared by the National Institute of Statistics and Geography (INEGI, 2018) are considered for calculating economic spillover. Specifically, the matrix of direct and indirect technical coefficients by Branch of the North American Industrial Classification System (SCIAN) is considered.[3] Table 1. Investment multipliers for selected activities. shows the multipliers used for the activities considered in the analysis. These multipliers result from the sum of the column coefficients that most closely resemble the activity under analysis.

TABLE 1. INVESTMENT MULTIPLIERS FOR SELECTED ACTIVITIES.

Activity	Multiplier
Fishing	1.67
Agriculture (agroforestry)	1.22
Livestock (silvopastoral)	1.59
Aquaculture	1.79
Forestry	1.30
Ecotourism	1.33

Source: Own elaboration based on INEGI (2018).

- **Social value of carbon**. To value carbon from a social perspective, the shadow price estimated by the World Bank (2017) amounts to between 44 and 87 dollars per tCO_2 e for 2024. Complementarily, the analysis was performed based on the transaction value of carbon credits in some projects in Mexico, which amounts to between 4 and 12 dollars per tCO_2 e (Government of Mexico, 2020).

- **Evaluation horizon**. The productive activities are considered to last for a total of 20 years, of which 5 years correspond to the implementation of the project and 15 years

[2] https://www.gob.mx/cms/uploads/attachment/file/748091/OFICIO_234_25_JULIO_2022_act_TSD_.pdf
[3] https://www.inegi.org.mx/programas/mip/2018/#tabulados

to the continuity of its execution. If reinvestments are required before this period, the necessary reinvestments are accounted for.

- **Tax rate**. A rate of between 1 and 2.5 percent is considered following the Simplified Trust Regime that currently applies to small and medium-scale agricultural producers.4 A Value Added Tax (VAT) rate of 16% is also considered.

II.2. Characterization of productive activities.

This section describes the productive activities under analysis. This characterization makes it possible to identify each activity's cost and benefit items. Flow diagrams are presented in the appendix to describe the different phases of each productive activity. Subsequently, these phases are expressed in monetary terms and used to estimate cash flows. This generates profitability indicators from an economic and financial perspective, presented in another section. All selected activities were chosen because of their mention in the ACCIÓN's project bank as relevant to the area. This subset was further refined through interviews with professionals engaged in activities on the Peninsula.

II.2.1. Agroforestry systems

This activity essentially refers to establishing multi-layer live fences in agricultural areas. It was chosen because it can represent a complementary source to other rural activities and reduce deforestation pressures. Although agrarian activity is mainly carried out in the central areas of the Yucatan Peninsula, there are agricultural areas in the study area, which amounted to 112,000 hectares as of 2015, according to UNDP (2018). Table 2 presents the situation with and without a project for an agroforestry system.

TABLE 2. SITUATION WITH AND WITHOUT PROJECT FOR AGROFORESTRY SYSTEMS.

Situation without project	Desired system
People engage in traditional agricultural practices mainly to meet their needs for self-consumption and with sales when there is a surplus. Yucatán's most important agricultural products are pasture, grain corn, oranges, and lemons **(Secretaría de Agricultura y Desarrollo Rural, 2022[a])**. In Quintana Roo, sugarcane, pineapple, grain corn, lemon, and coconut fruit **(Representación AGRICULTURA Quintana Roo, 2018)**. And in Campeche, grain corn,	In contrast to traditional agricultural practices, the implementation of agroforestry systems offers a sustainable and diversified alternative. By incorporating trees, shrubs and intercrops in the agricultural landscape, soil conservation and biodiversity are promoted (Montagnini, F., 2020). It also makes it possible to obtain a greater variety of food for self-consumption. Since agroforestry systems improve soil quality and increase crop

4 https://www.gob.mx/agricultura/prensa/el-sistema-tributario-para-el-campo-debera-contribuir-a-la-autosuficiencia-alimentaria?idiom=es

sugarcane, and soybean **(Secretaría de Agricultura y Desarrollo Rural, 2022b).** However, the continued use of these techniques can cause soil erosion, resulting in the long-term inability to cultivate in the same areas. Over time, this leads to the expansion of the agricultural frontier, contributing to the depletion of natural resources and loss of biodiversity.	resilience to adverse weather conditions, they provide a more secure source of food and possible income from sales, i.e. they improve economic sustainability (Gruberg Cazón, Helga, & Azero A., Mauricio. (2009). The project does not consider adding value to the products generated.

Source: Own elaboration.

II.2.2. Beekeeping

This activity consists of adding value to existing beekeeping projects or starting new ones. Beekeeping is highly economically valued and important in the Yucatan Peninsula (Becerril and Hernandez, 2020). In addition, beekeeping can be carried out in mangrove areas (Alvarado, Zaldívar, and Tucuch, 2023). Table 3. Situation with and without beekeeping project shows the situation with and without the project for this activity.

TABLE 3. SITUATION WITH AND WITHOUT BEEKEEPING PROJECT

Situation without project	Desired system
Beekeeping activities People obtain income from the sale of honey and, in some cases, from products derived from beekeeping activities (such as propolis and wax) (**Becerril García, J., & Hernández Cuevas, F. I., 2020)**. However, they do not have the tools to add value to their products, so the sale prices are very low.	Financing to add value to bee products would open up new opportunities for beekeepers. Producers could diversify their supply and create higher quality, value-added products by acquiring appropriate tools and equipment and training in processing and marketing techniques. This would allow them to access differentiated market segments and obtain higher prices for their products, generating higher income and improving beekeeping's general profitability. (Garry, S., Parada Gómez, Á. M., & Salido Marco, J., 2017)
No beekeeping activities **People earn income through other sources, such as:** 1) **Traditional agricultural activity** 2) **Livestock activity** 3) **Travel to other locations for tourism work** (Rosalía Andrade, executive director at Resiliencia Azul A.C., personal communications, January 2024).	Financing to develop a value-added beekeeping project would allow individuals to diversify their sources of income and increase their financial security. In addition, by adding value to bee products, such as honey, propolis, and wax, they could access higher-quality markets and obtain higher prices. This would allow them to improve their quality of life and reduce their exclusive dependence on other sources of income. (Becerril García, J., & Hernández

	Cuevas, F. I., 2020) and (Garry, S., Parada Gómez, Á. M., & Salido Marco, J., 2017).

Source: Own elaboration.

II.2.3. Mangrove restoration with blue carbon credits.

This activity consists of developing and implementing a mangrove restoration project with carbon credits in coastal areas, particularly in mangroves. It is well known that mangroves are among the most productive ecosystems in terms of ecosystem services, including carbon capture and storage, as well as coastal protection (Bimrah *et al.*, 2022). In this sense, there are opportunities to generate income from blue carbon credits. Table 4. Situation with and without mangrove restoration project with blue carbon credits. shows the situation with and without the project for this activity.

TABLE 4. SITUATION WITH AND WITHOUT MANGROVE RESTORATION PROJECT WITH BLUE CARBON CREDITS.

Situation without project	Desired system
People earn income through other sources, such as: 1) Traditional agricultural activity 2) Livestock activity 3) **Travel to other locations for tourism work** 4) Fishing in mangrove areas (Rosalía Andrade, Resiliencia Azul A.C. executive director, personal communications, January 2024).	With technical and financial support from stakeholders, the communities that own the land on which the mangroves are located carry out restoration and improvement activities in mangrove areas, which increase the carbon stocks stored in this ecosystem. The changes in the reserves are documented and estimated by standardized methodologies. Then, they undergo a certification process, allowing them to issue marketable credits in the voluntary carbon markets. This represents an annual income for the communities, which replaces or complements traditional income. In addition, improvements in the mangrove ecosystem generate ecosystem services with an economic value that exceeds the costs associated with restoration.

Source: own elaboration.

II.2.4. Sustainable fishing

This activity adds value to the fishing activity by improving product quality. According to Blasco (2024), fishing activity in the Yucatan Peninsula is characterized by very low added value and development in an oligopsonic market, where few intermediaries set the purchase price of fishery products. In addition, the cooperatives have a low level of organization that could allow for vertical integration of the activity. In view of this, the proposal is to finance such vertical integration, specifically through the establishment of infrastructure for the collection of fishery products, accompanied by training to maintain the quality of the products before they reach the beach and financing to increase energy efficiency in the activity.

TABLE 5. SITUATION WITH AND WITHOUT SUSTAINABLE FISHING PROJECT

Situation without project	Desired system
Groups of fishermen carry out the activity without adding value to their **products**, translating into considerably low sales prices. In addition, some fishermen are trapped in a cycle of dependence on intermediaries. These dynamic limits the fishermen's income potential and discourages investment in sustainable practices and improving product quality. Finally, overfishing and ***bycatch*** of non-target species contribute to the decrease in the volume of fish available (Rosalia Andrade, executive director of Resiliencia Azul A.C., personal communications, January 2024). This compromises the food security and economic livelihood of communities that depend on fishing.	Responsible fishing practices, maximum sustainable yield quotas, the adoption of less invasive technologies, and the delimitation of fishing refuge zones ensure the health and long-term viability of fish stocks. On the other hand, by rescuing value in the production processes, the project allows producers to access differentiated markets (SmartFish Rescate de Valor, AC, 2022). In addition, the energy efficiency of the value chain is improved, specifically through better equipment for the fishing fleet and storage infrastructure.

II.2.5. Charcoal made from mangrove harvesting

This activity consists of the sustainable use of mangroves to produce charcoal. It can be carried out in mangroves if a management plan is in place, as is the case of the Alvarado Lagoon System in Veracruz, Mexico (Pronatura Veracruz, 2018). The use of dead vegetative material in the mangrove represents a great potential for generating income at the rural level, as it is a product that is in high demand, can be processed in a relatively simple way, and is compatible with mangrove conservation.

TABLE 6. SITUATION WITH AND WITHOUT CHARCOAL PROJECT

Situation without project	Desired system
The group has logging permits, and the land has a land ownership scheme that allows for traceability of who will do the logging. Logging is not very technical and does not include regeneration practices, or they are minimal.	The implementation of improved management practices ensures the sustainability of resources offered by mangroves, such as fishing and timber harvesting, promoting the economic livelihood of communities in the long term. The production of charcoal with mangroves constitutes an opportunity for groups with harvesting permits to carry out an efficient, sustainable, legal, and value-added

	productive activity (Pronatura Veracruz A.C, 2018) (CONAFOR, 2021).

II.2.6. Ecotourism

This activity consists of establishing recreational activities in suitable areas, such as mangroves. The coastal zone of the Yucatan Peninsula is a suitable place for this type of activity (Bonfliglio, Fernandez, and Vazquez, 2021). Table 7. Situation with and without ecotourism projects describes the situation with and without a project for this activity.

TABLE 7. SITUATION WITH AND WITHOUT ECOTOURISM PROJECTS

Situation without project	Desired system
No tourism activities People earn income through other sources, such as: 1) Traditional agricultural activity 2) Livestock activity 3) Travel to other locations for tourism work **(Rosalía Andrade, Resiliencia Azul A.C. executive director, personal communications, January 2024).**	Financing to generate ecotourism projects would contribute to the economic well-being of local communities through the creation of long-term sustainable sources of employment, providing financial security (Orgaz Agüera, F., 2014).

Source: Own elaboration.

II.2.7. Silvopastoral systems

This activity involves establishing intensive silvopastoral systems (SiPS), integrating trees, pastures, and animals on the same land, and promoting sustainability and soil productivity. According to Cosío Ruiz, C. (2020), between 2003 and 2016, 73,302.790 km2 of tropical forest were deforested in the Yucatán Peninsula to destine pastures for extensive cattle ranching. Likewise, Proust, S., Anta, S., & Cepeda, M. F. (2015) find among the direct causes of deforestation in Campeche and Quintana Roo cattle ranching, as well as the development of infrastructure for agricultural companies in Yucatan. In this sense, it is considered that the area could benefit from better practices in the sector. Table 8 shows the situation with and without the project.

TABLE 8. SITUATION WITH AND WITHOUT SILVOPASTORAL SYSTEMS PROJECT

Situation without project	Desired system
Land use in traditional extensive livestock systems usually generates ecosystem degradation, such as deforestation, soil erosion, and loss of biodiversity. Also, since	Implementing silvopastoral systems improves soil productivity and resource use efficiency and contributes to biodiversity conservation, carbon sequestration, erosion

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it **requires large land extensions for grazing**, it has a **low productivity per hectare**. The **negative impact on the environment** and the **possible desertification of previously fertile areas** leads to a **decrease in the capacity of ecosystems to provide essential environmental services,** putting financial security at risk **(Ramírez-Cancino, L., & Rivera-Lorca, J. A., 2010).**	control, and water resource protection. Combining forestry and livestock farming generates a productive system that benefits both the environment and the producers, offering long-term financial security. In short, SiPS represents an economically profitable, ecologically sustainable, and socially inclusive option (Lara, J.A., Torres, J.M., and Guevara A., 2020).

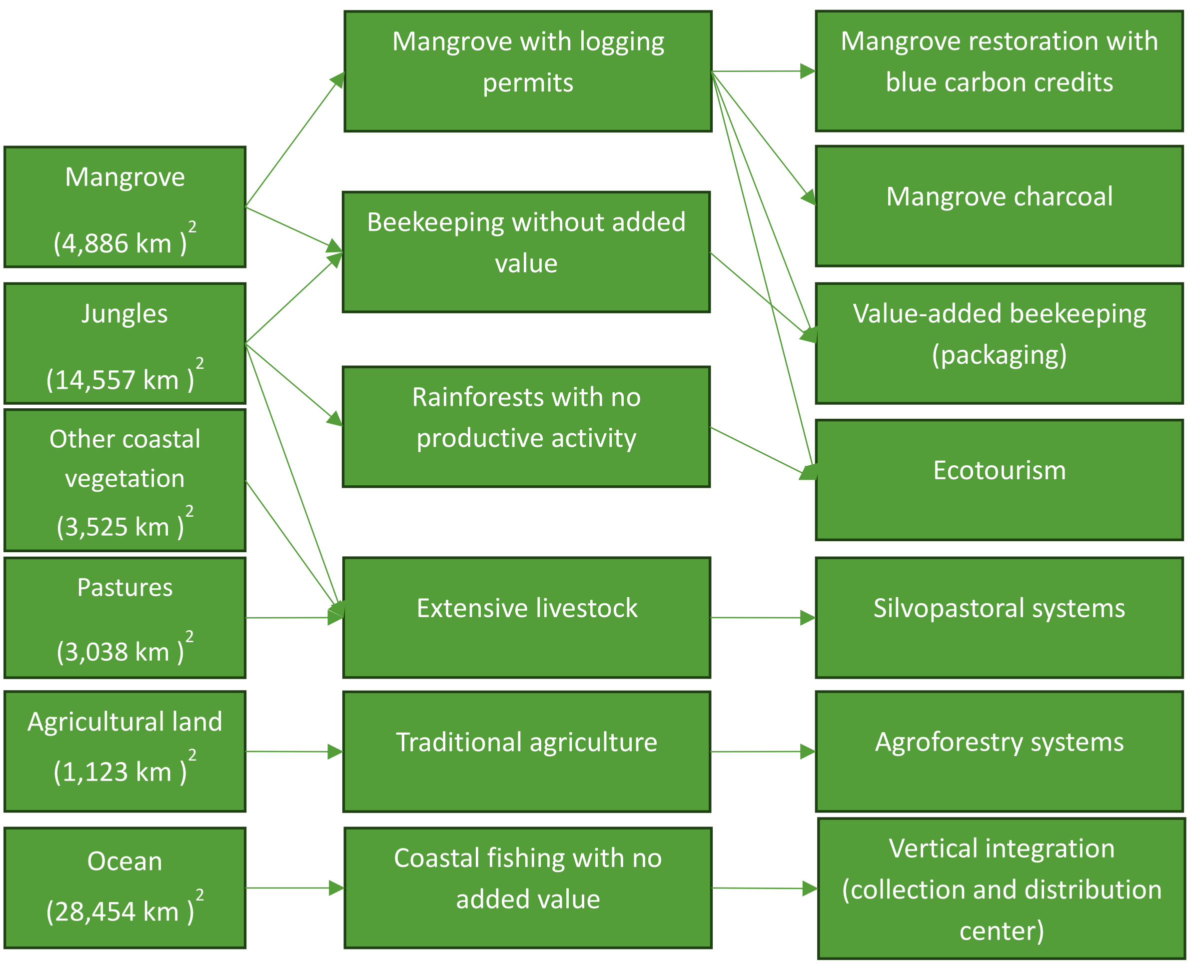
Source: Own elaboration

III. Financial results by activity

This section presents the results of the financial analysis of the productive activity. To obtain these results, the phases of each activity (described in the previous section) were expressed in terms of costs and benefits. These costs and benefits were expressed in monetary terms based on information collected from secondary sources and expert interviews. A spreadsheet was developed for each financial analysis activity (available in Spanish in this link). This spreadsheet calculates cash flows and the leading profitability indicators.

It is essential to mention that the profitability of the activities should be compared with a baseline, or in other words, with the situation without the project. In this sense, the profitability of baseline activities was also estimated, specifically traditional agriculture, extensive livestock farming, non-value-added beekeeping, and non-value-added riverine fishing. **Error! Reference source not found.** shows a transition diagram between the situations with and without projects for each activity and the physical space where they are carried out.

FIGURE 2. TRANSITION DIAGRAM OF PRODUCTIVE ACTIVITIES



Source: Own elaboration. Land use and vegetation areas of the eligible area for Component 1 ACCIÓN

The financial results for each productive activity are shown below.

III.1. Baseline activities

This section presents the financial results of the baseline activities.

III.1.1. Traditional agriculture

Traditional agriculture was modeled, with one hectare of corn crop as the primary unit. Data on costs and benefits were obtained from FIRA (2023). Land preparation, planting, fertilization, pest, weed, disease control, harvesting, sorting and packing, and miscellaneous costs are considered. In terms of income, the sale of corn is considered.

Table 9 shows the financial results for this activity. With the parameters considered, the financial profitability is 117 thousand pesos per hectare, which is equivalent to receiving 9,632 pesos per year for 20 years, which, as stated in a previous section, is the evaluation horizon of the activities.

TABLE 9. TRADITIONAL AGRICULTURE RESULTS

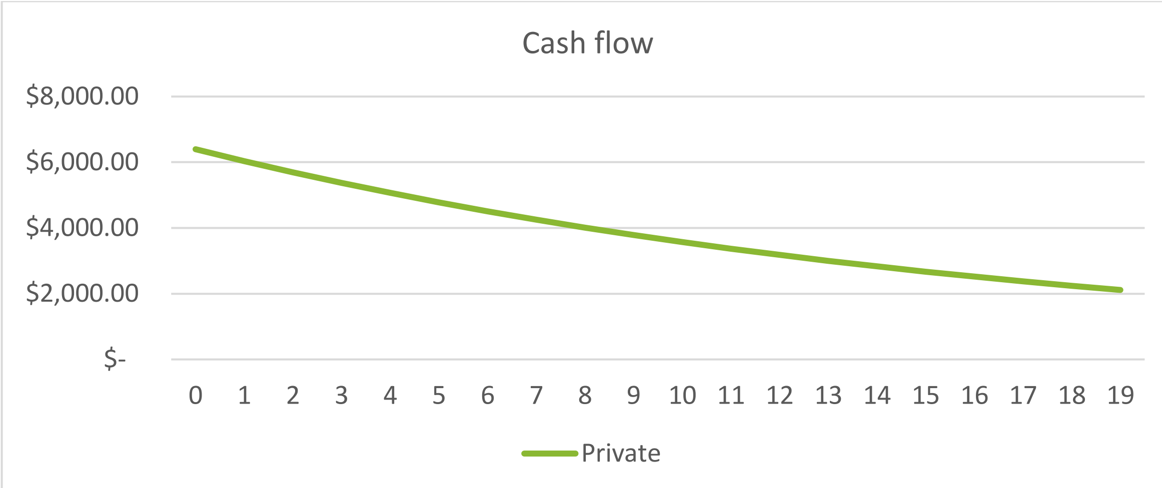
Indicator	Value	Units
Net Present Value (NPV)	77,775	Weights
Total costs	-214,991	Weights
Total Benefits	292,767	Weights
Cost Benefit Index (ICB)	1.36	Weights/ weight invested
Internal Rate of Return (IRR)	Not defined	Percentage
Annual Equivalent Cash Flow (AEFF)	6,397	Pesos/year
Recovery period	1	Years
Surface unit	1	hectare

Source: Own elaboration with data from FIRA (2023).

Figure 1 and Figure 4 shows the accumulated cash flow. Both flows are always positive because the activity does not consider initial investments, and the economic value of the corn produced is above costs. In this regard, this also implies that the IRR is not defined because there are no negative flows; in other words, the IRR is infinite.

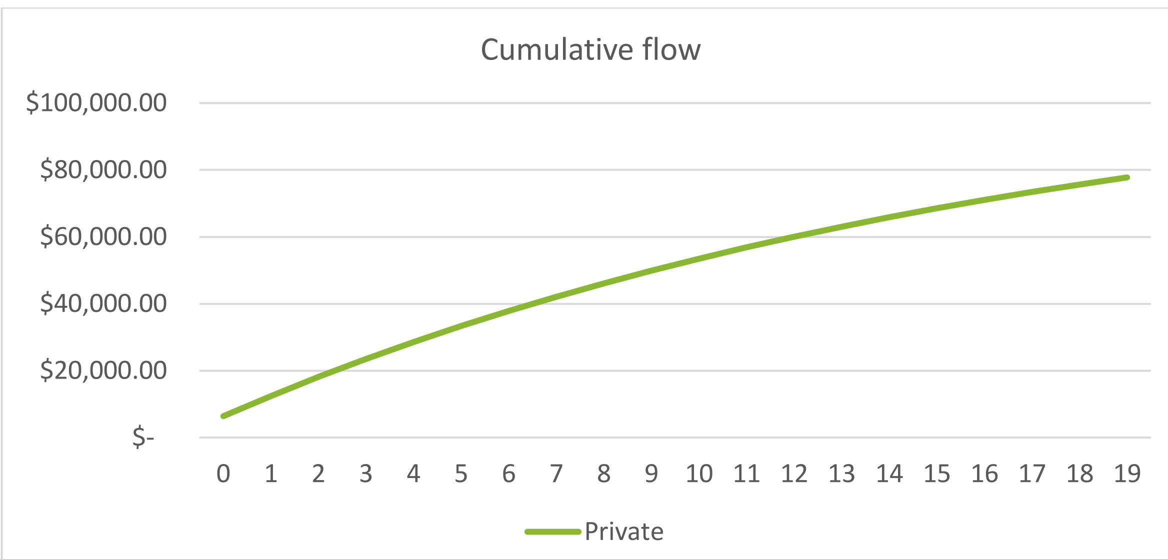
This activity and the other baseline activities constitute the point of comparison of activities that can replace it, specifically agroforestry systems (see Figure 2).

FIGURE 3. CASH FLOW FROM TRADITIONAL AGRICULTURE



Source: Own elaboration with data from FIRA (2023).

FIGURE 4. CUMULATIVE CASH FLOW FROM TRADITIONAL AGRICULTURE



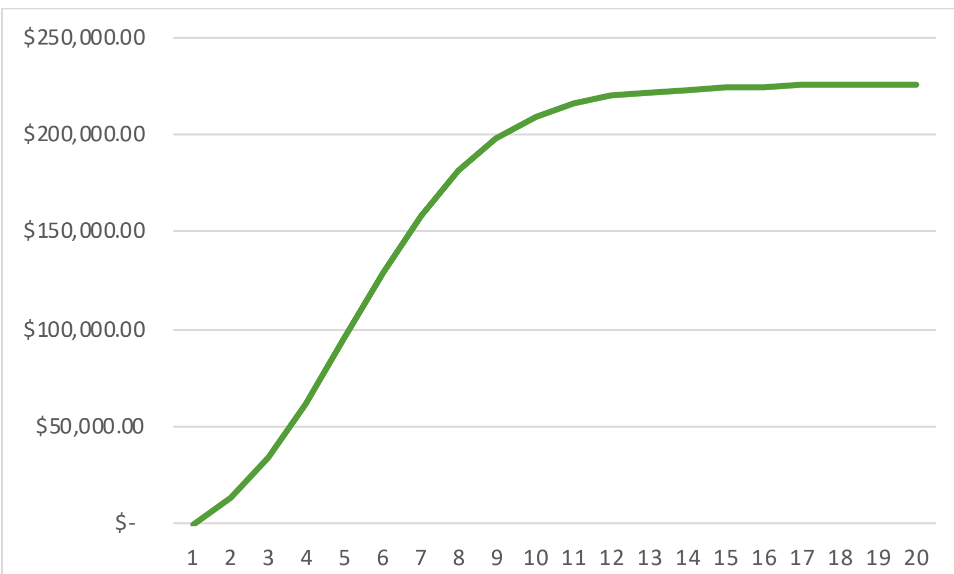
Source: Own elaboration with data from FIRA (2023).

III.1.2. Beekeeping without added value

This activity considered establishing an apiary with 100 hives, which corresponds to a producer of the stratum with the highest number of hives in the area, according to Uc and Magaña (2017). Regarding costs, beekeeping equipment (suit, tool kit, honey extractor), labor for preparation and installation of hives, inspection of hives, and harvesting and collection of beekeeping by-products are considered. In addition, the purchase of hives, a second-hand vehicle for transporting products and inputs, the cost of fuel, and the income generated by the sale of honey and bee by-products are also considered. Prices were obtained from internet searches of suppliers. A selling price of unpackaged honey of 90 pesos per liter was considered based on CIATEJ PROTEAA-ISEI (2022). Finally, a yield of 25 liters of honey per hive per year was considered based on Zavala *et al*. (2021).

In this activity, an additional assumption on sales behavior was considered; the Bass (1969) diffusion model was adopted, which allows modeling this item as a process of gradual sigmoidal increase (see Figure 5). This model depends on two parameters (the percentage of innovators who purchase a new product and the percentage of imitators who follow the first) that generate the shape of sales growth over time. Specifically, the higher the values of these two parameters, the faster the sales growth. This functional form was adopted in this activity (and others presented below) to model more realistically and conservatively those cost and revenue items that increase gradually over time. As seen in Figure 5, there is a stage of exponential growth before 5 or 6 years and then a slower growth stage, which stabilizes after about year 12. The two parameters of this function (innovators and imitators) determine these growth phases.

FIGURE 5. EXAMPLE OF SALES MODELING FROM THE BASS DIFFUSION MODEL.



Source: Own elaboration with data from Uc and Magaña (2017), ISEI (2022), and Zavala *et al*. (2021).

With these parameters, the results shown in Table 10 were obtained. As can be seen, a positive profitability of 346 thousand pesos per apiary, an IRR of 11%, and an annual cash flow equivalent of 28,460 pesos per year were obtained.

TABLE 10. RESULTS OF NON-VALUE-ADDED BEEKEEPING

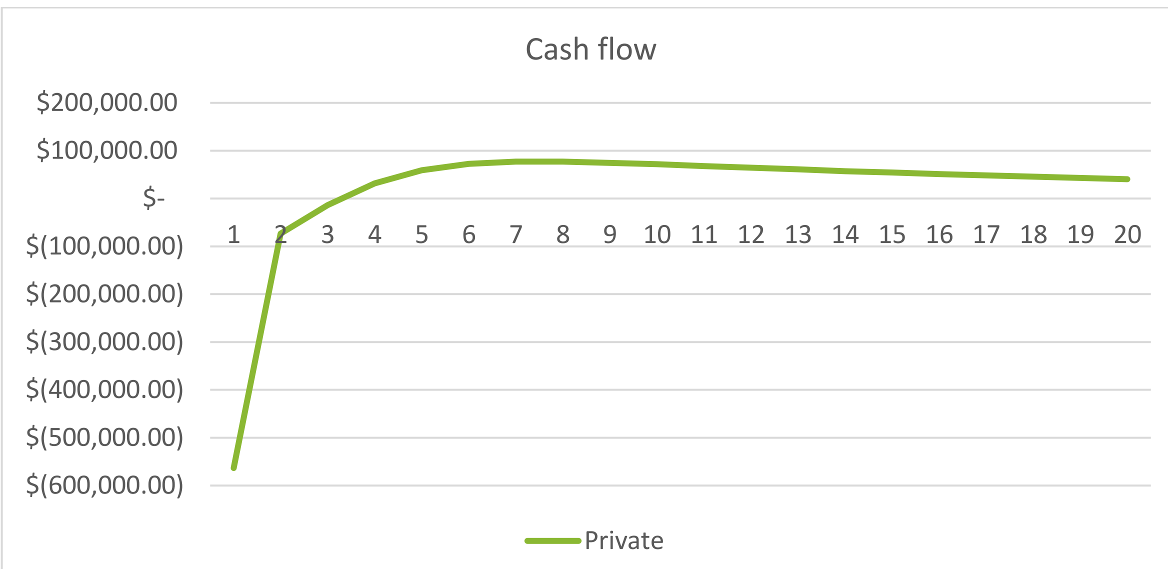
Indicator	Value	Units

Net Present Value (NPV)	346,146	Weights
Total costs	-2,081,346	Weights
Total Benefits	2,427,493	Weights
Cost Benefit Index (ICB)	1.17	Weights/ weight invested
Internal Rate of Return (IRR)	11%	Percentage
Annual Cash Flow Equivalent (APE)	28,470	Pesos/year
Recovery period	13	Years
Surface unit	25	hectares[5]

Source: Own elaboration with data from Uc and Magaña (2017), ISEI (2022), and Zavala *et al*. (2021).

Figure 6 y and Figure 7 show the cash flows and accumulated cash flows of this activity.

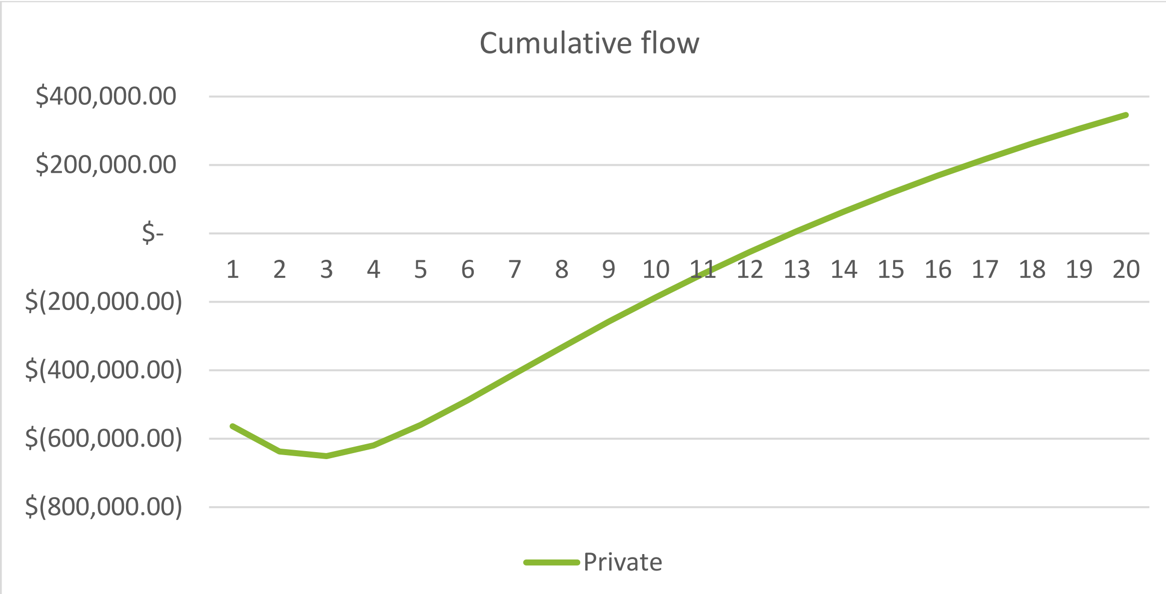
FIGURE 6. CASH FLOW FROM NON-VALUE-ADDED BEEKEEPING.



Source: Own elaboration with data from Uc and Magaña (2017), ISEI (2022), and Zavala *et al*. (2021).

[5] A recommended load of 4 hives per hectare is considered according to Apigranca.es (2023).

FIGURE 7. CUMULATIVE CASH FLOW FROM NON-VALUE-ADDED BEEKEEPING.



Source: Own elaboration with data from Uc and Magaña (2017); ISEI (2022); and Zavala *et al*. (2021).

III.1.3. Coastal fishing with no added value

A coastal fishing vessel was considered as the basic unit. The costs per day of fishing amount to 3100 pesos/day based on an update of EDF-UNAM (2022) and a fishing effort of 100 days per year is considered. It is assumed that the fishery is sold to middlemen on the beach. Grouper fishing volumes were obtained from Monroy-García *et al*. (2019) and extrapolated to other species fished in the area reported by EDF-UNAM (2022). Product prices were obtained from recent newspaper reports.[6]

Based on these parameters, a positive profitability of 2.6 million pesos per vessel was obtained, equivalent to a net profit per year of 216,555 pesos per vessel. Since there are no initial investments, the IRR is not defined since there is a profit from the first year. This is shown in Table 11.

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[6] https://www.pressreader.com/mexico/diario-de-yucatan/20230412/283089893435831, https://www.yucatan.com.mx/yucatan/2022/04/09/precio-record-del-negrillo-312636.html, https://www.yucatan.com.mx/yucatan/2022/04/15/dan-el-kilo-de-pescado-frito-150-en-progreso-314000.html, https://www.yucatan.com.mx/yucatan/2023/04/11/en-yucatan-el-mero-esta-escaso-caro-en-progreso-que-opciones-hay-397757.html

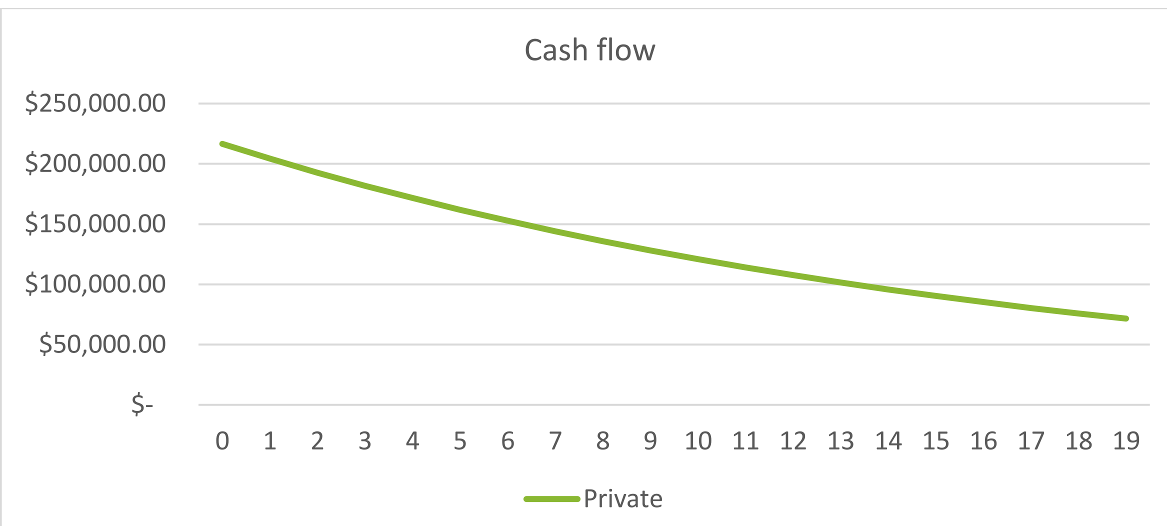
TABLE 11. TRADITIONAL COASTAL FISHING RESULTS

Indicator	Value	Units
Net Present Value (NPV)	2,632,900	Weights
Total costs	-3,774,912	Weights
Total Benefits	6,407,813	Weights
Cost Benefit Index (ICB)	1.70	Weights/ weight invested
Internal Rate of Return (IRR)	Not defined	Percentage
Annual Cash Flow Equivalent (APE)	216,555	Pesos/year
Recovery period	1	Years
Unit	1	Boat

Source: Own elaboration with data from de Monroy-García *et al*. (2019); and EDF-UNAM (2022).

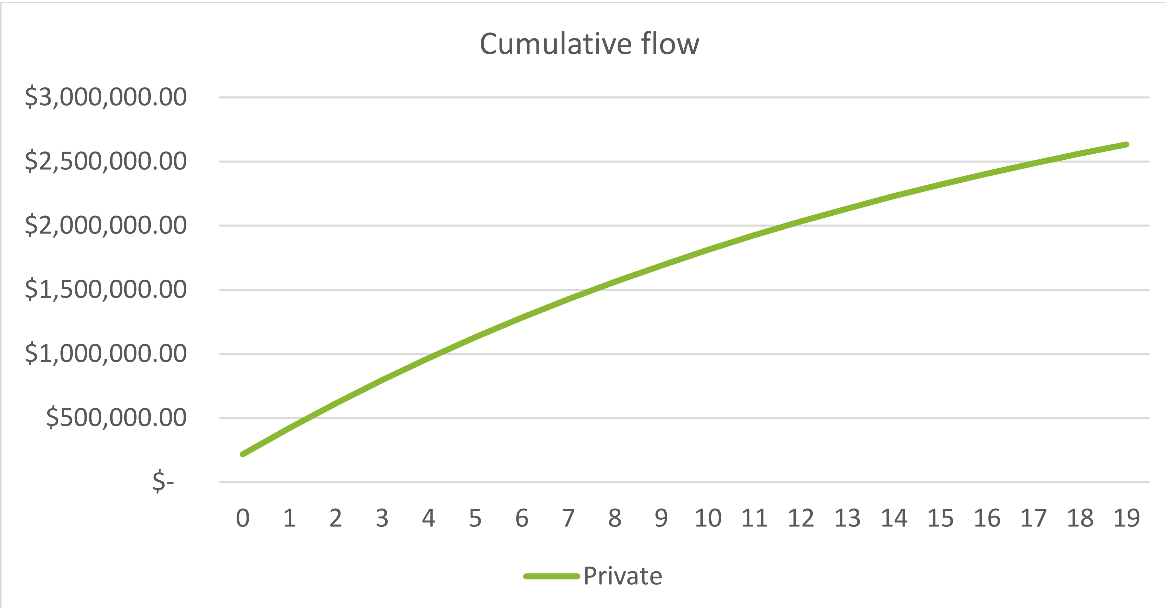
Figure 8 and Figure 9 show the cash flows and accumulated cash flow of this activity.

FIGURE 8. CASH FLOW FROM TRADITIONAL RIVERINE FISHERIES.



Source: Own elaboration with data from de Monroy-García *et al*. (2019) and EDF-UNAM (2022).

FIGURE 9. CUMULATIVE CASH FLOW FROM TRADITIONAL RIVERINE FISHERIES.



Source: Own elaboration with data from de Monroy-García *et al*. (2019) and EDF-UNAM (2022).

III.1.4. Extensive livestock

In traditional cattle raising, the basic production unit was considered a herd of 40 calves (175 kg each) for fattening, which are sold once they have reached a weight of 322 kg. A pasture coefficient of 4 hectares per animal unit is considered, according to SAGARPA (2014). Likewise, the activity is considered to be carried out in an area of 20 hectares, which implies an animal load of 1.67 cows per hectare, a figure that is similar to what is observed in the study area (TNC-UADY, 2021; Ramírez-Cancino and Rivera-Lora, 2010). Livestock costs were adjusted based on data from Lara, Torres, and Guevara (2020) and considered facility maintenance, machinery and equipment, permanent labor, other fixed costs, feed, salt and mineral supplements, pasture maintenance, sanitation, fuels and lubricants, other variable costs. In addition, the purchase cost of calves for fattening is considered at a price of 49 pesos/kg, and a sale price of 45 pesos/kg, considering the price of the cattle auction in Yucatán, published on the web page mexicoganadero.com. Finally, it is considered that 85% of additional feed is purchased since the pasture is not sufficient to feed the calves.

With these parameters, a positive profitability is found, as shown in Table 12.

TABLE 12. RESULTS OF TRADITIONAL CATTLE RAISING.

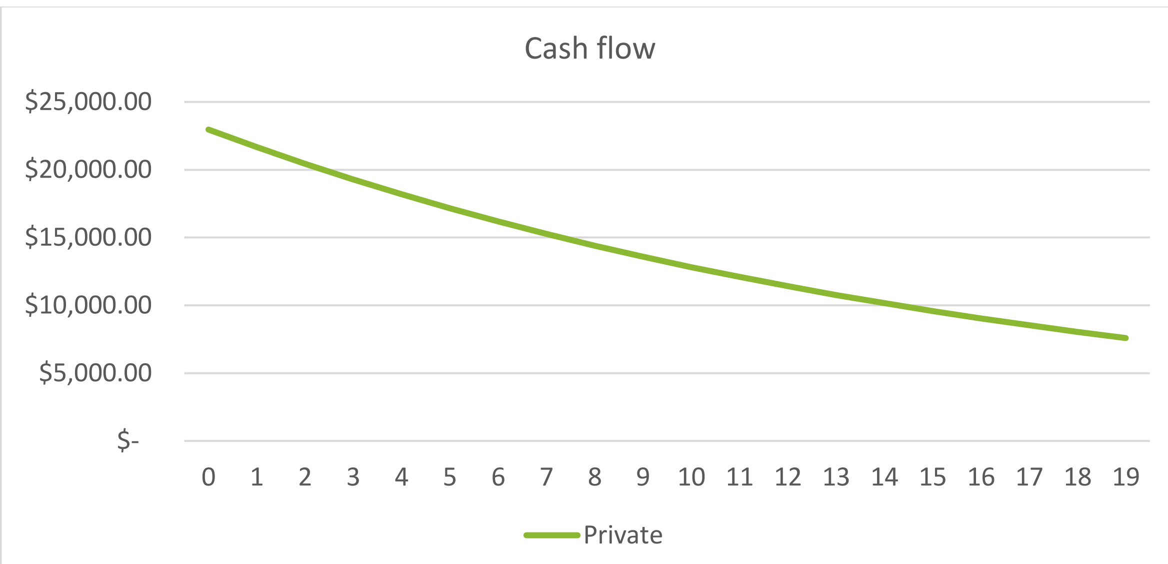
Indicator	Value	Units
Net Present Value (NPV)	279,150	Weights

Total costs	-6,297,904	Weights
Total Benefits	6,577,054	Weights
Cost Benefit Index (ICB)	1.04	Weights/ weight invested
Internal Rate of Return (IRR)	Not defined	Percentage
Annual Cash Flow Equivalent (APE)	22,960	Pesos/year
Recovery period	1	Years
Surface unit	30	hectares

Source: Own elaboration with data from Lara, Torres, and Guevara (2020) and SAGARPA (2014).

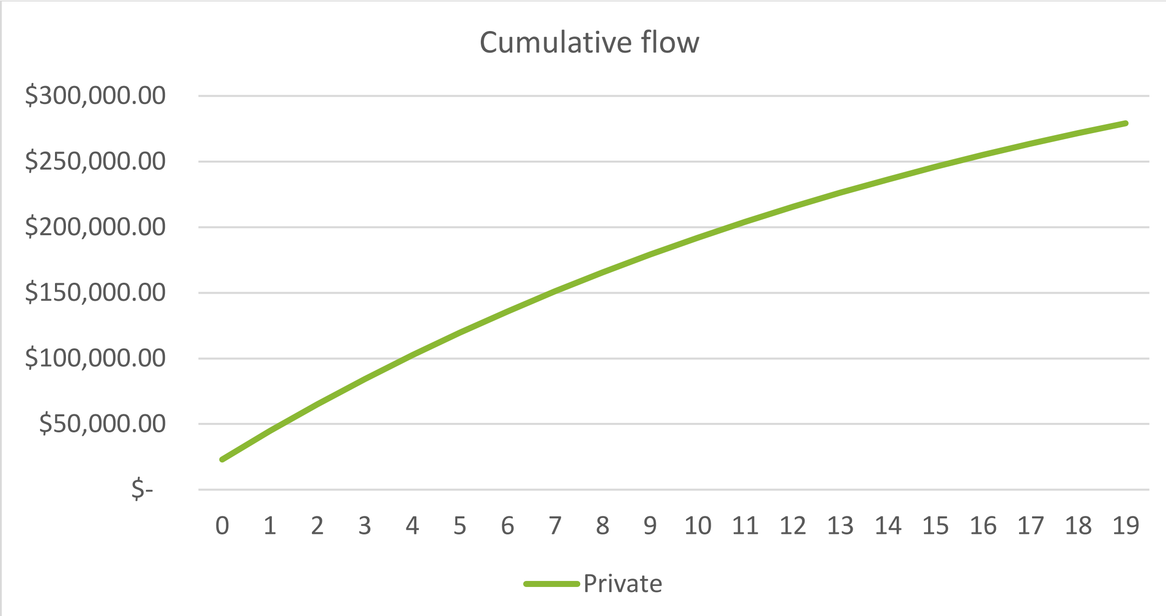
Cash flows and accumulated cash flows are shown in the and in the, respectively. In traditional agriculture, these flows are always positive because no initial investments are considered; it is assumed that there is already an existing infrastructure that is maintained.

FIGURE 10. CASH FLOW FROM TRADITIONAL CATTLE RANCHING.



Source: Own elaboration with data from Lara, Torres, and Guevara (2020) and SAGARPA (2014).

FIGURE 11. CUMULATIVE CASH FLOW FROM TRADITIONAL CATTLE RANCHING.



Source: Own elaboration with data from Lara, Torres, and Guevara (2020) and SAGARPA (2014).

III.2. Results of sustainable activities

This section presents the financial results of the sustainable activities, representing a transformation option shown in Figure 2.

III.2.1. Results of agroforestry systems

This activity consists of establishing live fences interspersed with crops. In particular, 12% of the land was planted with timber, fruit, and forage species, and the remaining 88% with corn. The costs of live fences were obtained from an update and adjustment for purchasing power parity (PPP) of data from Villanueva, Ibrahim, and Casasola (2008); the data on corn crop costs were obtained from the technological package for corn production in Quintana Roo, published by FIRA (2023). The price of timber products was obtained from CONAFOR (2023), the price of agricultural products from Servicio de Información Agroalimentaria y Pesquera (SIAP),[7] and the price of forage from El Sol de Hidalgo (2020). Regarding the quantities of products obtained in the living fence, data from Sampayo, Marín and García

[7] https://www.gob.mx/siap

(2011) for timber products,[8] from FIRA (2023) for corn yield and from Villanueva, Ibrahim, and Casasola (2008) for forage were considered. For forage, a diffusion model of Bass (1969) was considered for its growth and economic valuation.

The results shown in Table 13 were obtained with these assumptions and parameters. The estimated profitability is 137 thousand pesos per hectare, equivalent to an annual amount of 11,312 pesos. It has an associated IRR of 24% and an investment recovery period of 8 years (see Annex 2).

TABLE 13. RESULTS OF AGROFORESTRY SYSTEMS

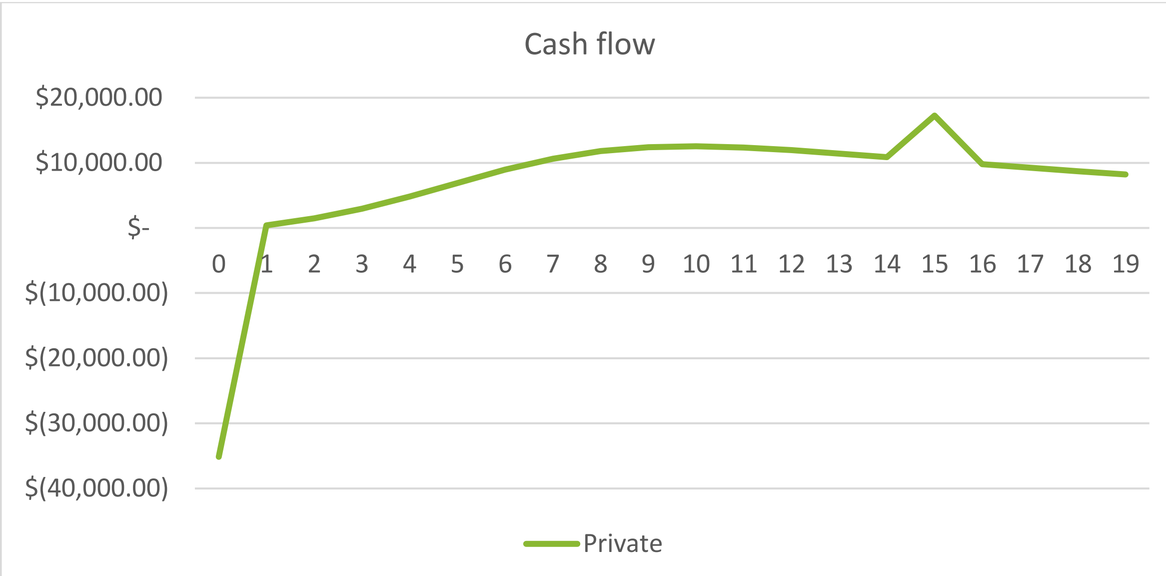
Indicator	Value	Units
Net Present Value (NPV)	137,542	Weights
Total costs	-297,012	Weights
Total Benefits	434,554	Weights
Cost Benefit Index (ICB)	1.46	Weights/ weight invested
Internal Rate of Return (IRR)	24%	Percentage
Annual Cash Flow Equivalent (APE)	11,312	Pesos/year
Recovery period	8	Years
Surface unit	1	Hectare

Source: Own elaboration with data from Villanueva, Ibrahim and Casasola (2008); FIRA (2023); CONAFOR (2023); Servicio de Información Agroalimentaria y Pesquera; El Sol de Hidalgo (2020); and Sampayo, Marín and García (2011).

Figures 12 and 13 show this activity's cash flows and accumulated cash flow. As can be seen, profitability peaks in year 15, when timber harvesting is considered. However, timber harvesting's economic value is much lower than that of corn and fodder. It should be noted that although these products are for self-consumption, they represent expenses that would be avoided in feeding people and animals.

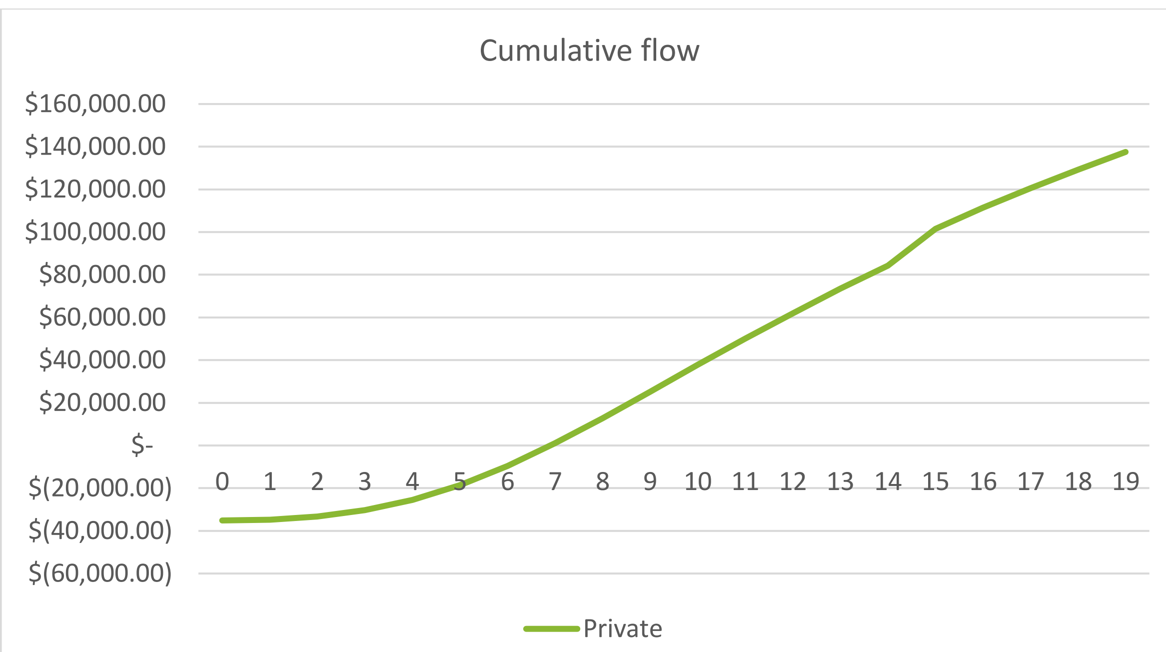
[8] The yield was considered to be one third of the average timber yield per hectare under the assumption that the area destined to live fence is proportionally distributed with fruit trees and forage species.

FIGURE 12. CASH FLOW FROM AGROFORESTRY SYSTEMS



Source: Own elaboration with data from Villanueva, Ibrahim and Casasola (2008); FIRA (2023); CONAFOR (2023); Servicio de Información Agroalimentaria y Pesquera; El Sol de Hidalgo (2020); and Sampayo, Marín and García (2011).

FIGURE 13. CUMULATIVE CASH FLOW OF AGROFORESTRY SYSTEMS.



Source: Own elaboration with data from Villanueva, Ibrahim and Casasola (2008); FIRA (2023); CONAFOR (2023); Servicio de Información Agroalimentaria y Pesquera; El Sol de Hidalgo (2020); and Sampayo, Marín and García (2011).

III.2.2. Value-added beekeeping results

This activity considers the establishment of an apiary with 100 hives. The cost and benefit concepts are the same as in non-value-added agriculture, but some additional costs are added, and a higher selling price is established for the value added to the process. Specifically, the acquisition of a packaging machine, the design of a value-added project, a training process, additional labor, the development of a brand and a marketing strategy, and packaging and labels for the final product are considered. The monetary values for these activities were assigned based on an internet search of suppliers and the consulting team's previous experience with consulting services. Regarding the selling price, 130 pesos per liter of packaged honey is considered 40 pesos higher than the bulk price without packaging.

With these assumptions and parameters, the results in Table 14 were obtained.

TABLE 14. VALUE-ADDED BEEKEEPING RESULTS

Indicator	Value	Units
Net Present Value (NPV)	602,238	Weights
Total costs	-3,071,445	Weights
Total Benefits	3,673,684	Weights
Cost Benefit Index (ICB)	1.20	Weights/ weight invested
Internal Rate of Return (IRR)	12%	Percentage
Annual Cash Flow Equivalent (APE)	49,533	Pesos/year
Recovery period	12	Years
Surface unit	25	Hectares

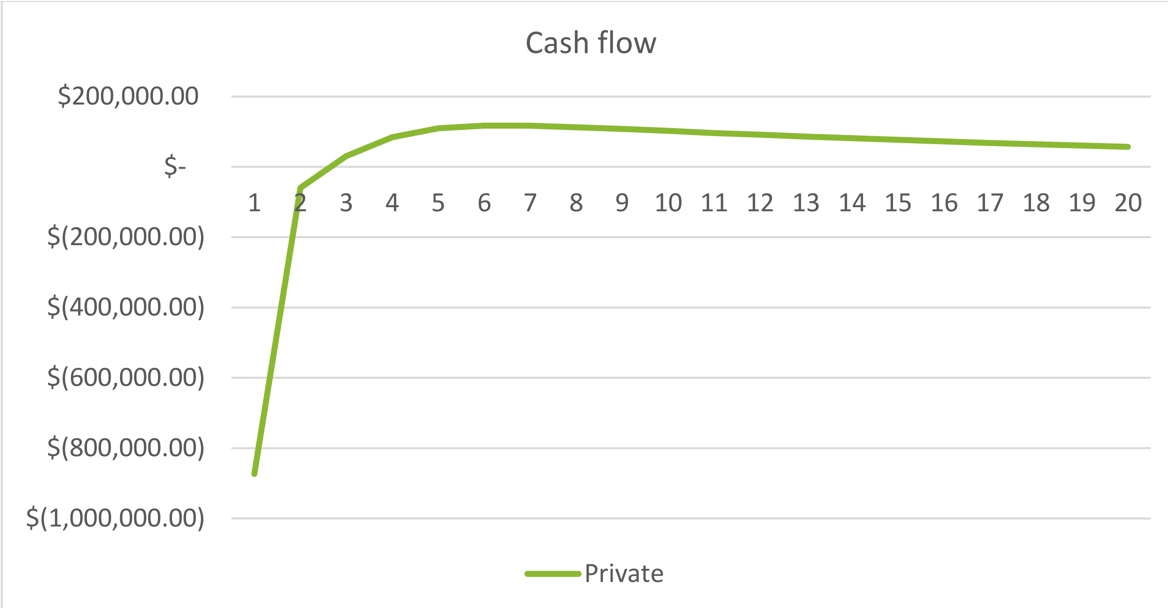
Source: Own elaboration with data from Uc and Magaña (2017); Zavala *et al.* (2021); and ISEI (2022).

In the

Figure 14 and

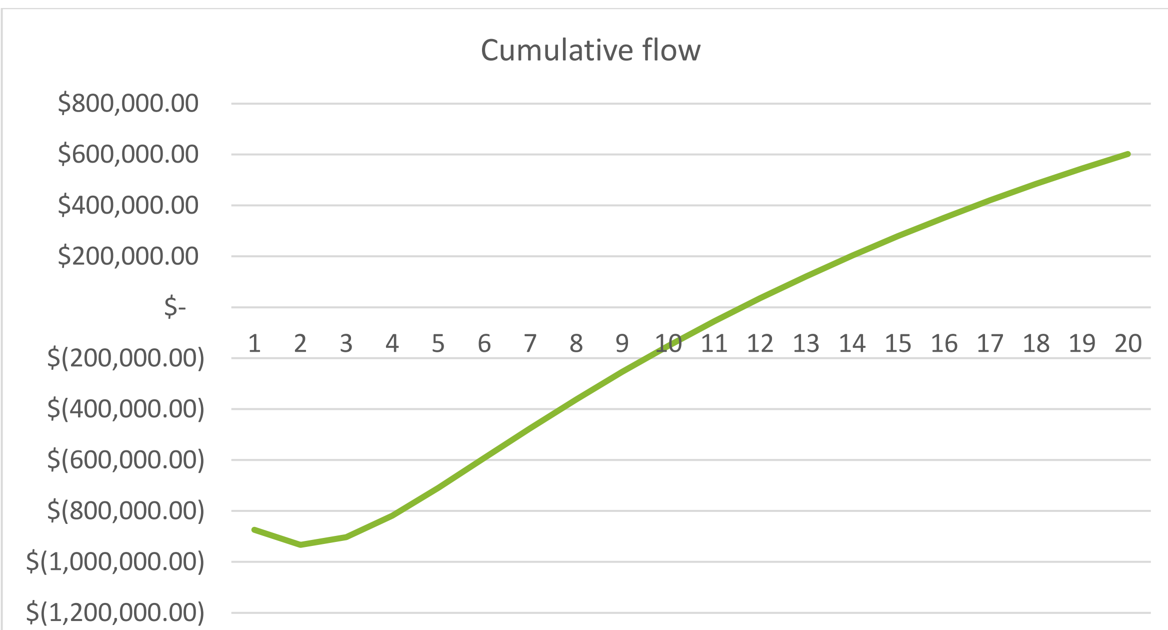
Figure 15 show the cash flow and accumulated cash flow for this activity.

FIGURE 14. CASH FLOW FROM VALUE-ADDED BEEKEEPING.



Source: Own elaboration with data from Uc and Magaña (2017), Zavala et al. (2021), and ISEI (2022).

FIGURE 15. CUMULATIVE CASH FLOW FROM VALUE-ADDED BEEKEEPING.



Source: Own elaboration with data from Uc and Magaña (2017), Zavala et al. (2021), and ISEI (2022).

III.2.3. Results of mangrove restoration with blue carbon credits

This activity consists of restoring mangroves and selling blue carbon credits derived from this activity. The process for this sale considers the evaluation of the sites, the design of a project and carbon inventory, the restoration of a percentage of the area (in this case, we assume 10%), the registration of the credits, the validation by third parties, the presentation of carbon reports, the sale of the credits, the administration of the processes, the continuous maintenance and monitoring of the mangroves, and an evaluation of the project. The selling price of the credits was set at US$6 per tCO_2 e according to the forestry projects in Mexico registered in the voluntary market reported by the Government of Mexico (2020). Carbon sequestration in mangroves was set at 1.39 tC/ha/year, according to Herrera-Silveira *et al.* (2010).

It is important to mention that most of the cost items are semi-fixed, which implies that they remain constant up to a certain level of mangrove hectares. Therefore, a minimum project extension of 3,000 hectares was considered. Table 15 presents the financial results of this activity.

Based on these parameters, a negative financial profitability is found, associated with the low price of carbon (US$6 per ton). However, as will be seen in a later section, this activity generates an important flow of ecosystem services that are worth more than the costs of this type of project. The financial profitability amounts to -118.2 million pesos.

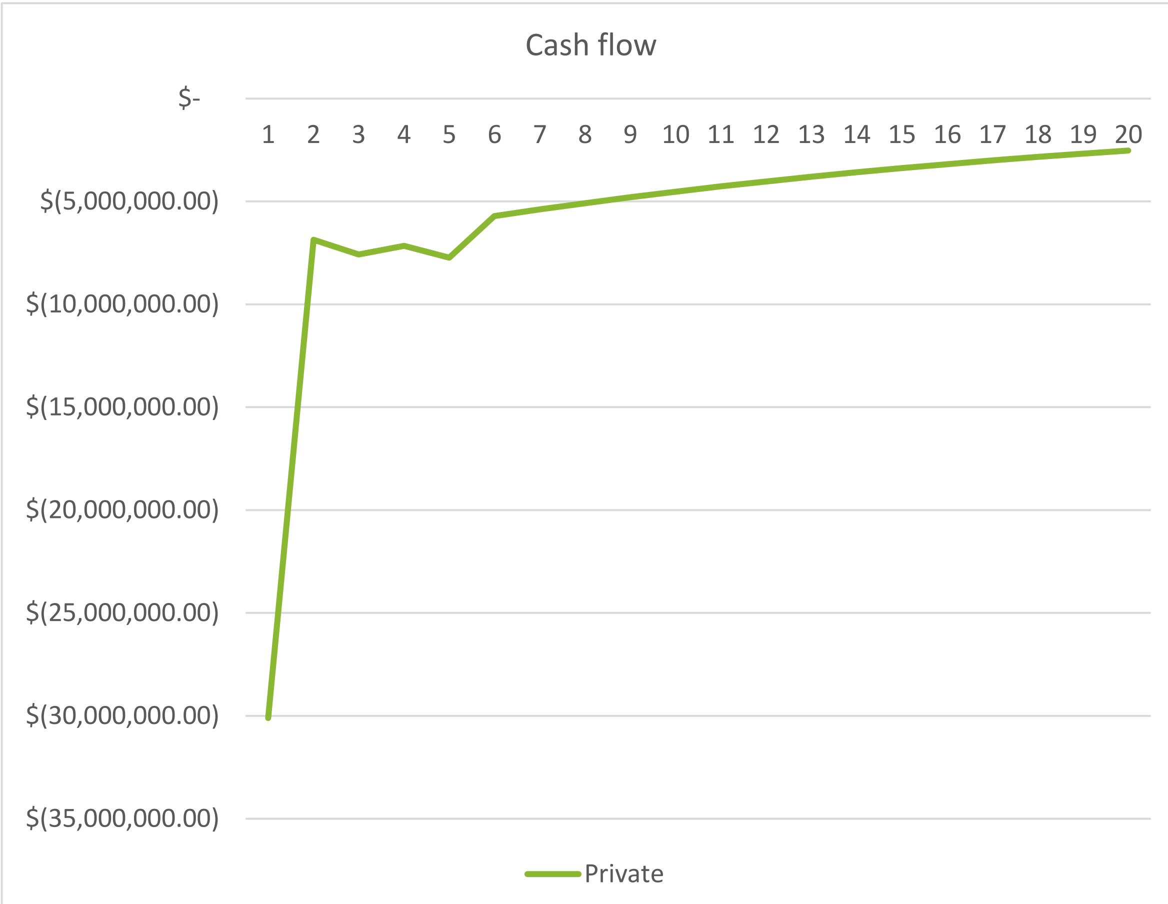
TABLE 15. RESULTS OF BLUE CARBON CREDITS

Indicator	Value	Units
Net Present Value (NPV)	-118,185,061.24	Weights
Total costs	-136,610,682.16	Weights
Total Benefits	18,425,620.93	Weights
Cost Benefit Index (ICB)	0.13	Weights/ weight invested
Internal Rate of Return (IRR)	Negative	Percentage
Annual Cash Flow Equivalent (APE)	-9,720,671.89	Pesos/year
Recovery period	Not defined	Years
Surface unit	3,000	Hectares

Source: Own elaboration with data from the Government of Mexico (2020) and Herrera-Silveira *et al.* (2010).

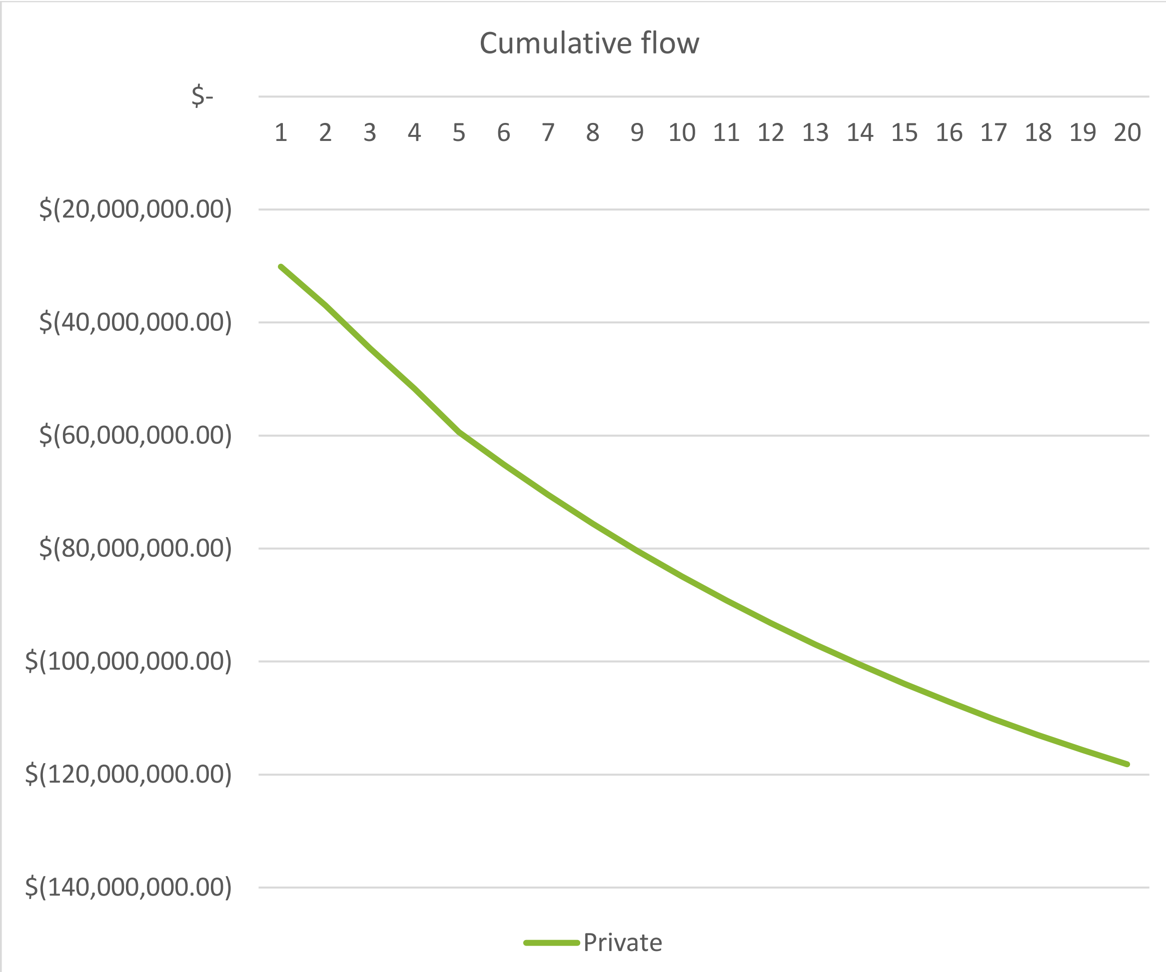
Figure 16 and Figure 7 show the cash flows and accruals for this activity.

FIGURE 16. CASH FLOW OF BLUE CARBON CREDITS



Source: Own elaboration with data from the Government of Mexico (2020); and Herrera-Silveira *et al.* (2010).

FIGURE 17. CUMULATIVE CASH FLOW OF BLUE CARBON CREDITS.



Source: Own elaboration with data from the Government of Mexico (2020) and Herrera-Silveira *et al.* (2010).

III.2.4. Sustainable fishing results

This activity consists of adopting lighted nets for fishing, which reduces fishing effort and avoids bycatch. According to Senko *et al*. (2022), this adoption does not reduce the value or volume fished and constitutes a low-cost option to reduce environmental impact. For the analysis, it was considered that there is a 25% reduction in fuel use due to less fishing effort, which is obtained by reducing fishing trips by between 55.5 and 70.6 minutes per day, according to the authors.

With these assumptions, it is found that the company has a positive profitability of 2.8 million pesos, equivalent to 232 thousand pesos per year of net profit.

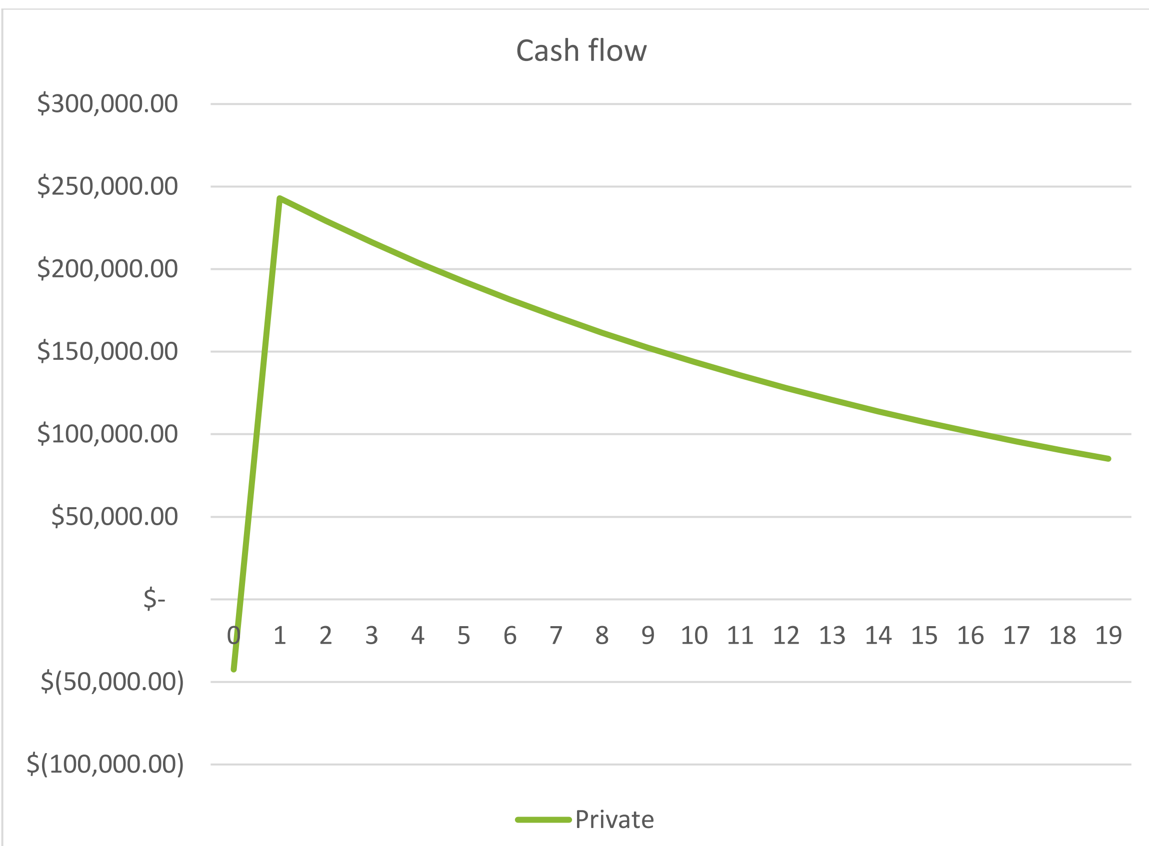
TABLE 16. SUSTAINABLE FISHING RESULTS

Indicator	Value	Units
Net Present Value (NPV)	2,830,994	Weights
Total costs	-3,576,819	Weights
Total Benefits	6,407,813	Weights
Cost Benefit Index (ICB)	1.79	Weights/ weight invested
Internal Rate of Return (IRR)	606%	Percentage
Annual Equivalent Cash Flow (AEF)	232,848	Pesos/year
Recovery period	2	Years
Surface unit	1	Vessel

Source: Own elaboration with data from Senko *et al*. (2022).

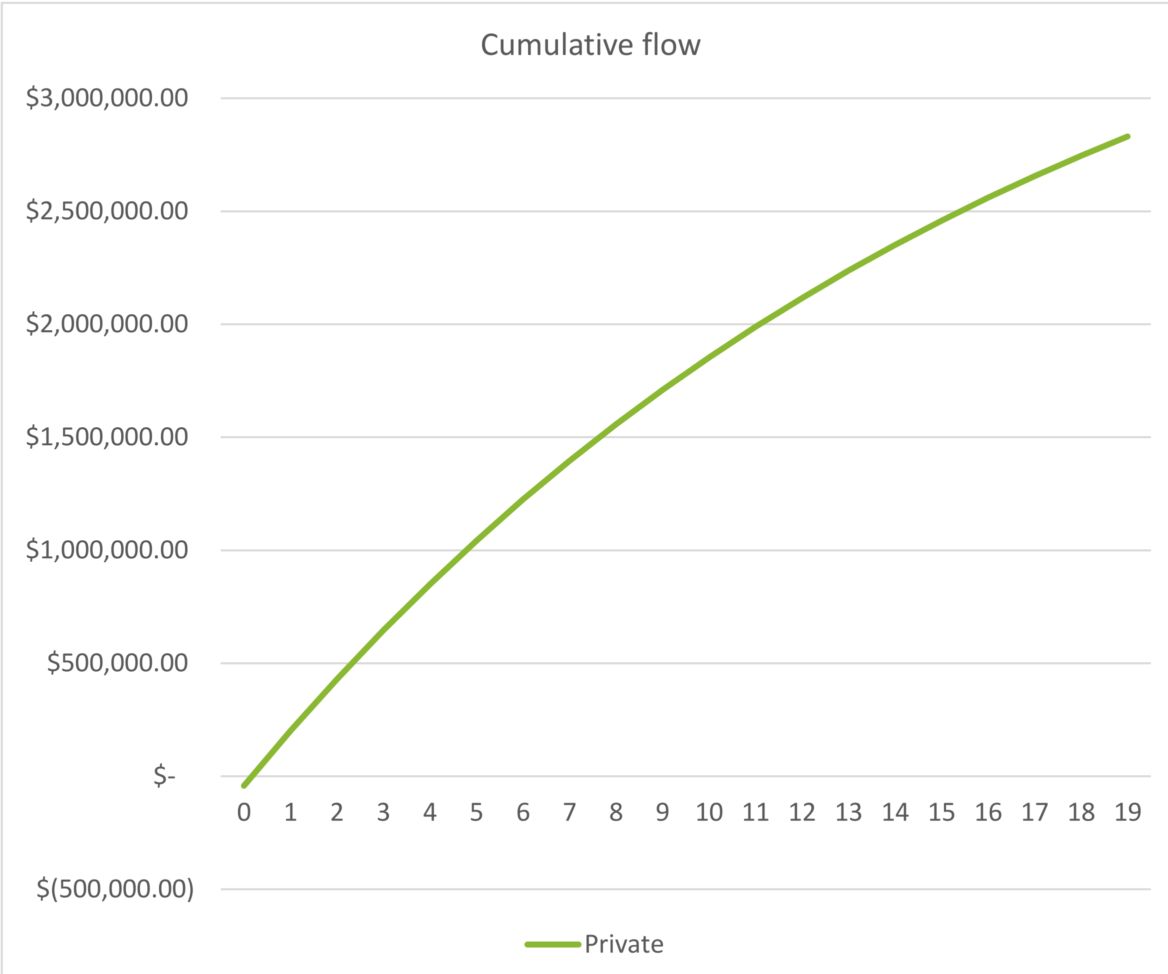
Cash flow and accumulated cash flow are shown in Figure 16 and Figure 17, respectively.

FIGURE 16. SUSTAINABLE FISHING CASH FLOW



Source: Own elaboration with data from Senko *et al*. (2022).

FIGURE 17. CUMULATIVE CASH FLOW FROM SUSTAINABLE FISHERIES.



Source: Own elaboration with data from Senko *et al*. (2022).

III.2.5. Results of charcoal produced from mangrove harvesting

This activity consists of producing charcoal from mangrove wood for its sustainable use. This requires a kiln[9] for charcoal production. A technological package that includes the kiln, training, and materials for charcoal production, whose costs and other specifications were established based on CONAFOR (s.f.), is considered. The kiln can produce 105 tons of charcoal, which comes from the use of 105 hectares of mangrove forest. This figure comes from considering that with the use of 1 m2 of mangrove, it is possible to produce 2 kg of charcoal per year and that there is a 20-year turnaround for vegetation regeneration (Chumacero, Linares, and González, 2020). With these parameters, sustainable harvesting is possible in the 105-hectare area. Distribution, administration, and marketing costs are considered, as well as developing a management plan and establishing environmental management units. The sale price of the charcoal was established based on market prices.

Based on these assumptions and parameters, a positive profitability of the activity is obtained, amounting to 7.7 million pesos, equivalent to an annual net profit of 632 thousand pesos and an IRR of 28%. The payback period for the investment is 8 years (see Table 17).

TABLE 17. MANGROVE CHARCOAL RESULTS

Indicator	Value	Units
Net Present Value (NPV)	7,690,428	Weights
Total costs	-12,593,713	Weights
Total Benefits	20,284,142	Weights
Cost Benefit Index (ICB)	1.61	Weights/ weight invested
Internal Rate of Return (IRR)	28%	Percentage
Annual Cash Flow Equivalent (APE)	632,534	Pesos/year
Recovery period	8	Years
Surface unit	105	Hectares

Source: Own elaboration with data from CONAFOR (n.d.); and Chumacero, Linares and González (2020).

In

[9] There are 2 types of furnaces, Rabo Quente and metallic. In this case a metallic furnace was considered because it is mobile.

Figure 18 and Figure 19 show the cash flow and the accumulated cash flow of this activity.

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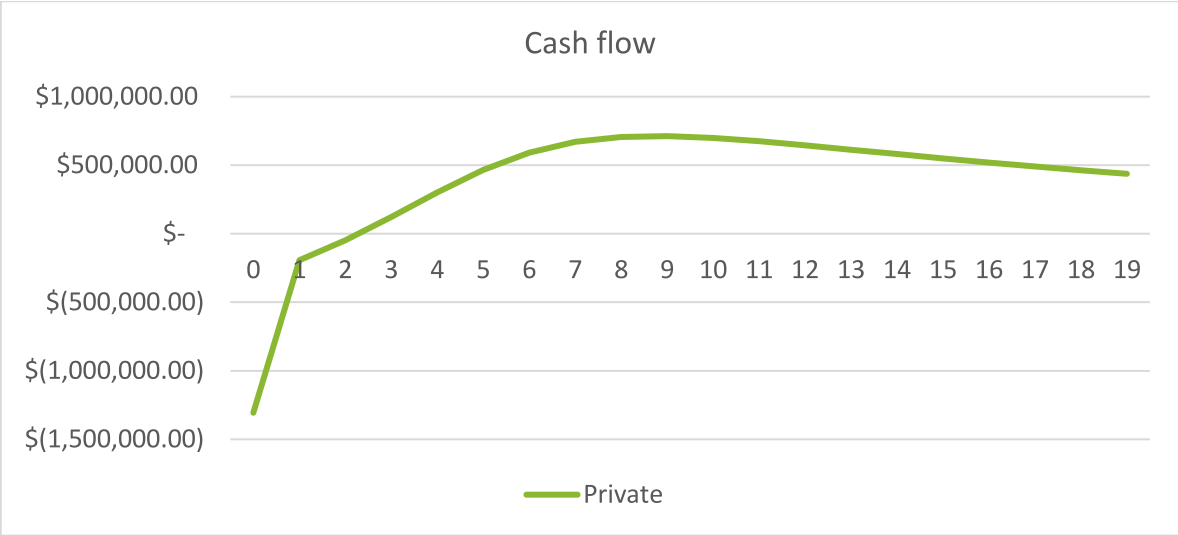
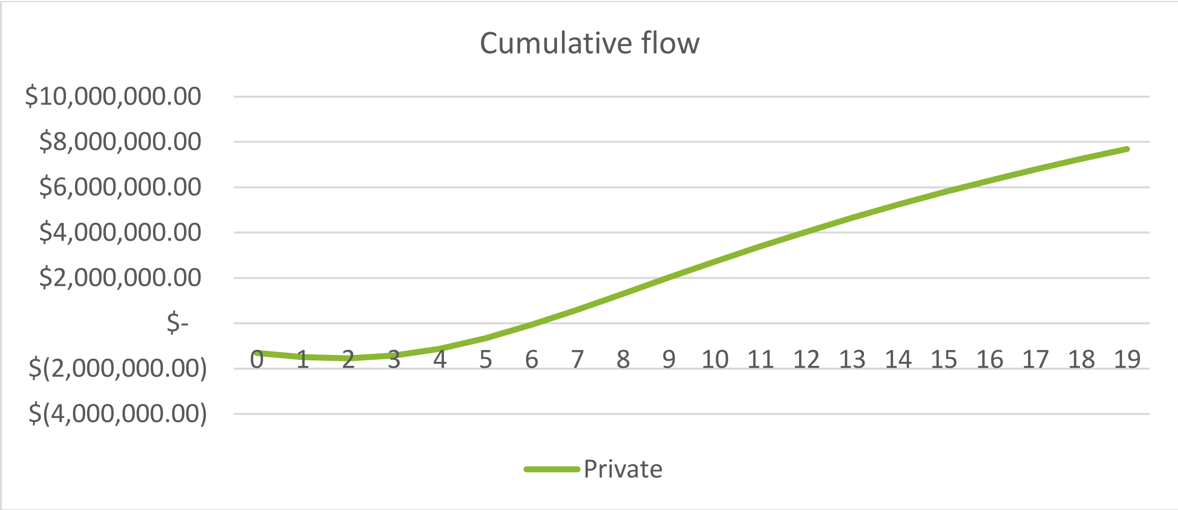
FIGURE 18. MANGROVE CHARCOAL CASH FLOW



Source: Own elaboration with data from CONAFOR (n.d.); and Chumacero, Linares and González (2020).

FIGURE 19. CUMULATIVE CASH FLOW FROM MANGROVE CHARCOAL.



Source: Own elaboration with data from CONAFOR (n.d.); and Chumacero, Linares and González (2020).

III.2.6. Ecotourism results

This activity considers an ecotourism project on 10 hectares. Costs include a market study, a business plan and a carrying capacity study, technical training, construction of 5 cabins and a reception area, tour equipment (kayaks, vests), equipment and furniture for cabins and the reception area, waste management equipment, labor, and personnel. Revenues include lodging and tour sales. Information on construction costs was taken from the Mexican Chamber of the Construction Industry (CMIC), and equipment and furnishings were taken from Quintero (2013). They were costed based on consultations with suppliers online. For the estimation of demand, the data López, Aguiar, and Centeno (2019) reported for the mangrove ecotourism activity in the Ejido of San Crisanto, Yucatan, Mexico, were taken as a basis. It is considered that the volume of visitation grows gradually with the diffusion model of Bass (1969).

Based on these parameters, a positive profitability of 4.1 million pesos was found, equivalent to receiving an annual net profit of 339 thousand pesos per year and an associated IRR of 15%. The payback period for the investment is 10 years. Table 18. Ecotourism results shows these results.

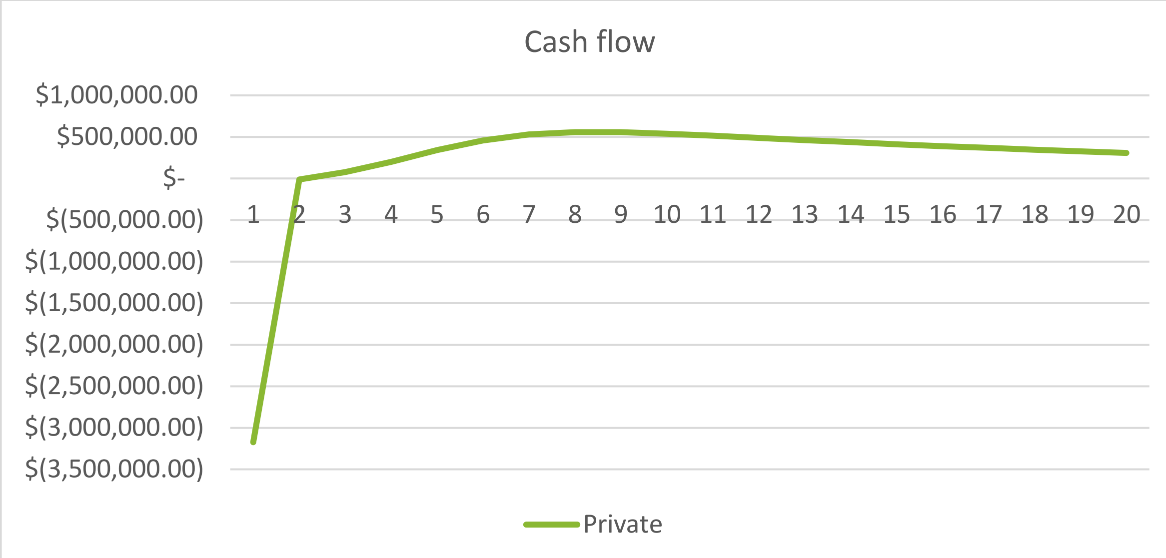
TABLE 18. ECOTOURISM RESULTS

Indicator	Value	Units
Net Present Value (NPV)	4,121,081	Weights
Total costs	-8,258,242	Weights
Total Benefits	12,379,323	Weights
Cost Benefit Index (ICB)	1.50	Weights/ weight invested
Internal Rate of Return (IRR)	15%	Percentage
Annual Equivalent Cash Flow (AEFF)	338,957	Pesos/year
Recovery period	10	Years
Surface unit	10	Hectares

Source: Own elaboration with data from Cámara Mexicana de la Industria de la Construcción; Quintero (2013); and López, Aguiar, and Centeno (2019).

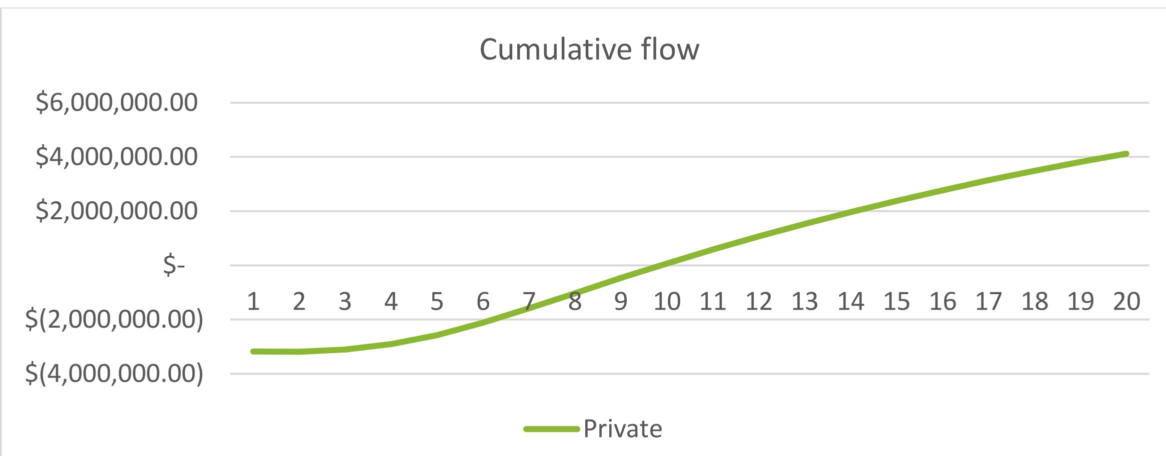
Figure 20 and Figure 21 present the cash and accumulated cash flows.

FIGURE 20. ECOTOURISM CASH FLOW



Source: Own elaboration with data from Cámara Mexicana de la Industria de la Construcción; Quintero (2013); and López, Aguiar, and Centeno (2019).

FIGURE 21. CUMULATIVE CASH FLOW FROM ECOTOURISM.



Source: Own elaboration with data from Cámara Mexicana de la Industria de la Construcción; Quintero (2013); and López, Aguiar, and Centeno (2019).

III.2.7. Results of silvopastoral system

The modeled silvopastoral system considers all the cost items of traditional cattle ranching, plus the establishment of improved pastures, shrub, and tree material for a protein bank on 5 hectares and a total land for the activity of 30 hectares (including the protein bank). This results in a two-fold increase in the productivity of the fattening activity, according to TNC-UADY (2021). The cost of investments required for the system was adapted from Lara, Torres, and Guevara (2020). It is assumed that the productivity increase is gradual according to the Bass diffusion model and grows according to the growth of the protein bank. Labor and other variable costs increase in the same way as the stocking rate increases.

Based on these considerations, a positive return of 1.9 million pesos, an annual equivalent of 161,000 pesos, and an IRR of 20% are obtained.

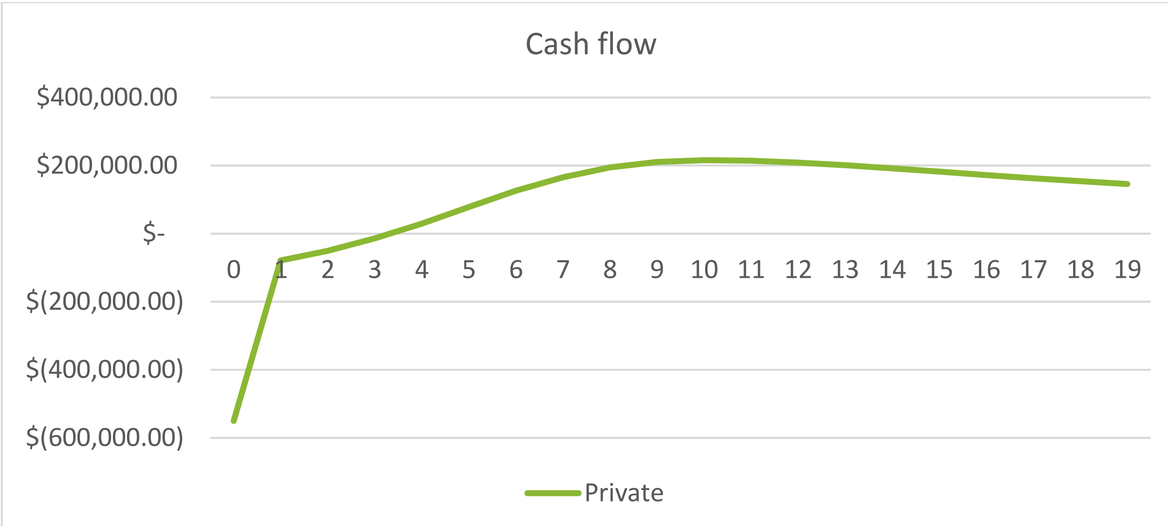
TABLE 19. RESULTS OF SILVOPASTORAL SYSTEM

Indicator	Value	Units
Net Present Value (NPV)	1,961,155	Weights
Total costs	-8,245,784	Weights
Total Benefits	10,206,939	Weights
Cost Benefit Index (ICB)	1.24	Weights/ weight invested
Internal Rate of Return (IRR)	20%	Percentage
Annual Cash Flow Equivalent (APE)	161,304	Pesos/year
Recovery period	10	Years
Surface unit	30	Hectares

Source: Own elaboration with data from de Lara, Torres, and Guevara (2020) and TNC-UADY (2021).

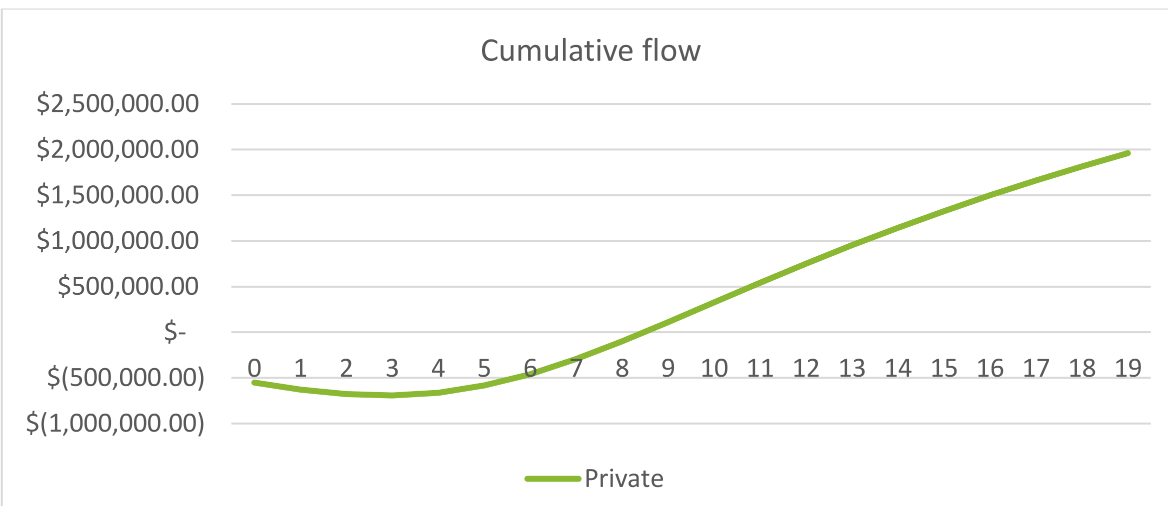
Figure 22 and Figure 23 show the cash flows and accruals for this activity.

FIGURE 22. CASH FLOW OF SILVOPASTORAL SYSTEM.



Source: Own elaboration with data from de Lara, Torres, and Guevara (2020) and TNC-UADY (2021).

FIGURE 23. CUMULATIVE CASH FLOW OF SILVOPASTORAL SYSTEM.



Source: Own elaboration with data from de Lara, Torres, and Guevara (2020) and TNC-UADY (2021).

Table 20. Financial results of the activities considered synthesizes the financial results and adds a column of approximate taxes to be paid in each activity to know the net present value after this concept. Table 21 shows the additional profitability obtained by transitioning to

sustainable activities per unit area. In all cases, the transition is profitable from a financial perspective.

TABLE 20. FINANCIAL RESULTS OF THE ACTIVITIES CONSIDERED

Activity	Type	VPN	ICB	FAE	Taxes	NPV less tax	Qty.	Unit
Agriculture	Baseline	77,775	1.36	6,397	11,700	66,075	1	Hectare
Agroforestry	Alternative	137,542	1.46	11,312	22,143	115,399	1	Hectare
Value-added beekeeping	Baseline	602,238	1.20	49,534	98,920	503,319	25	Hectare
Beekeeping without added value	Alternative	346,146	1.17	28,470	60,270	285,876	25	Hectare
Mangrove charcoal	Alternative	7,690,429	1.61	632,535	1,167,102	6,523,327	105	Hectare
Blue carbon credits	Alternative	-118,185,061	0.13	-9,720,671	0	-118,185,061	3000	Hectare
Ecotourism	Alternative	4,121,082	1.50	338,957	690,540	3,430,541	10	Hectare
Livestock	Baseline	279,150	1.04	22,960	41,993	237,157	30	Hectare
Silvopastoral system	Alternative	1,961,155	1.24	161,304	309,867	1,651,288	30	Hectare
Traditional fishing	Baseline	2,632,901	1.70	216,555	396,070	2,236,831	1	Boat
Sustainable fishing	Alternative	2,830,994	1.79	232,848	432,259	2,398,735	1	Vessel

Source: Own elaboration.

TABLE 21. UNIT FINANCIAL RESULTS FOR EACH ACTIVITY

Activity	Type	VPN	ICB	FAE	Taxes	NPV less tax	Qty.	Unit
Agriculture	Baseline	77,775	1.36	6,397	11,700	66,075	1	Hectare
Agroforestry	Alternative	137,542	1.46	11,312	22,143	115,399	1	Hectare
Value-added beekeeping	Baseline	24,090	1.20	1,981	3,957	20,133	1	Hectare
Beekeeping without added value	Alternative	13,846	1.17	1,139	2,411	11,435	1	Hectare
Mangrove charcoal	Alternative	73,242	1.61	6,024	11,115	62,127	1	Hectare
Blue carbon credits	Alternative	-39,395	0.13	-3,240	0	-39,395	1	Hectare
Ecotourism	Alternative	412,108	1.50	33,896	69,054	343,054	1	Hectare
Livestock	Baseline	9,305	1.04	765	1,400	7,905	1	Hectare
Silvopastoral system	Baseline	65,372	1.24	5,377	10,329	55,043	1	Hectare
Traditional fishing	Alternative	2,632,901	1.70	216,555	396,070	2,236,831	1	Boat

Sustainable fishing	Alternative	2,830,994	1.79	232,848	432,259	2,398,735	1	Vessel

Source: Own elaboration.

III.3. Financial results

This section discusses the analysis results from an economic perspective, in which externalities of the activities analyzed are considered. In particular, the potential for mitigating emissions, other ecosystem services generated, and the economic spillover generated by new investments are considered. In Table 22, the externalities of the activities analyzed are considered. Table 22. Additional profitability of the transition of activitiesIt presents the annual equivalent flow (AEF) for the sustainable transition, the economic spillover, the mitigation potential of each activity, and the Cost Effectiveness Index (CEI) of each tCO2 e, i.e., the mitigation cost per ton.

TABLE 22. ADDITIONAL PROFITABILITY OF THE TRANSITION OF ACTIVITIES

Baseline		Alternative	Additional FAE for transition	Economic spillover	Mitigation	CEI
			Pesos/year/ hectare	(pesos/ hectare)	(tCO2e/ ha in 20 years)	(pesos/ tCO2e)
Traditional agriculture	Transition to	Agroforestry system	4,300	70,003	-241.1	1,232.0
Traditional livestock		Silvopastoral system	4,110	23,850	-72.7	3,782.2
Beekeeping		Value-added beekeeping	758	54,828	-101.4	1,211
Inactivity		Mangrove charcoal	5,417	15,882	-86.7	1,384
Inactivity		Blue carbon credits	-39,395	12,977	-96.8	470
Inactivity		Ecotourism	29,909	418,249	-203.9	40,508
Traditional fishing[a]		Sustainable fishing	209,133	544,217	-60.0	60,708

Source: Own elaboration. a. data by vessel.

The following is a description of how emissions reductions were estimated for each activity:

Agroforestry systems. Emission reductions were estimated using FAO's EX-ACT tool (2022) for a multi-strata agroforestry system. This reduction amounts to 14.6 tCO_2 e per hectare per year. The reduction in emissions from the agroforestry system occurs gradually as the vegetation that captures carbon increases. In addition, emissions generated by traditional agriculture were subtracted, amounting to 2.27 tCO2e, estimated with the same tool for one hectare of traditional agriculture.

Silvopastoral system. Emission reductions were estimated with the EX-ACT tool for a silvopastoral system that is established on an area of 5 hectares and a total grazing area of 30 hectares (i.e., from the 30 hectares that were previously pasture, a silvopastoral system is established on 5 hectares). This also assumes that the stocking rate can be doubled. The carbon balance between the capture of the system plus livestock emissions is positive and amounts to 60 tCO_2 e per year. In addition, traditional extensive livestock farming in an area generates emissions of 69 tCO_2 e per year. As in the agroforestry system, it is assumed that the silvopastoral system generates carbon sequestration gradually. The increase in stocking rate is also gradual.

Value-added beekeeping. It is assumed that beekeeping is generating the conservation of 25 hectares of mangrove forest, which is the area required to maintain 100 hives. This area has a carbon sequestration of 1.39 tC/ha per year (Herrera-Silveira *et al*., 2010). The emissions from the fuel used for distributing bee products are subtracted. It is assumed that 240 liters of fuel are consumed annually, approximately 200 km of transport per month. The amount of fuel is multiplied by the gasoline emission factor, which was set at 2.659 $kgCO_2$ e/liter (INECC, 2014).

Mangrove charcoal. It is assumed that the sustainable use of mangroves allows the conservation of 105 hectares of mangroves, which is related to the sustainable use rate for mangrove charcoal production, according to Chumacero *et al*. (2020). A carbon capture of 1.39 tC/ha per year is considered (Herrera-Silveira *et al*., 2010), and fuel consumption for charcoal distribution is subtracted, considering an annual consumption of 1,400 liters of gasoline per year and an emission factor of 2.659 $kgCO_2$ e/liter (INECC, 2014).

Mangrove restoration with blue carbon credits. It is considered that this activity is carried out in an area of 3,000 hectares, that 10% of these are restored, and that the rest is maintained in a good state of conservation. A capture of 1.39 tC/ha per year is considered (Herrera-Silveira *et al*., 2010), and the carbon in the restored hectares increases gradually.

Ecotourism. It is assumed that an ecotourism project dedicates 2 hectares of a total of 20 hectares of mangrove forest for conservation. A capture of 1.39 tC/ha per year is considered (Herrera-Silveira *et al*., 2010).

Sustainable fishing. The EX-ACT tool estimated a 25% reduction in emissions generated using better fishing gear (lighted nets) and subtracted emissions from traditional fishing. As a reference, the tool indicates that emissions from traditional fishing are 8 tCO_2 e/year per vessel.

Table 23 shows the ecosystem services considered for each activity, which are integrated into the economic valuation of externalities. Table 24 shows the ecosystem services considered for each activity and presents the economic value of the activities' externalities. The sources of information used are described in a later section.

TABLE 23. ECOSYSTEM SERVICES INCLUDED IN THE ANALYSIS

Activity	Carbon emissions	Pollination	Biological control	Water quality	Soil quality	Nutrient cycling	Water flow regulation	Coastal protection	Sedimentation reduction	Pollution reduction	Provision of services	Services for fisheries	Biodiversity
Agriculture	x												

Activity	Carbon emissions	Pollination	Biological control	Water quality	Soil quality	Nutrient cycling	Water flow regulation	Coastal protection	Sedimentation reduction	Pollution reduction	Provision of services	Services for fisheries	Biodiversity
Agroforestry	x	x	x	x	x	x	x						
Value-added beekeeping	x	x											
Beekeeping without added value	x	x											
Mangrove charcoal	x							x	x	x	x	x	x
Blue carbon credits	x							x	x	x	x	x	x
Ecotourism	x							x	x	x	x	x	x
Livestock	x												
Silvopastoral system	x					x			x				
Traditional fishing	x												
Sustainable fishing	x												

Source: Own elaboration.

TABLE 24. ECONOMIC VALUE OF ACTIVITY EXTERNALITIES.

Activity	Unit	VPN other externalities	VPN mitigation	Private VPN	Total NPV
		Weights	Weights	Weights	Weights
Traditional agriculture	1 ha	0	-29,763	77,775	48,012
Agroforestry system	1 ha	2,446,998	105,804	137,542	2,690,345
Traditional livestock	30 ha	0	-906,022	279,150	626,872
Silvopastoral system	30 ha	18,248	432,397	1,961,155	2,411,800
Value-added beekeeping	25 ha	117,021	1,664,698	602,238	2,383,959
Mangrove charcoal	105 ha	707,109,976	5,974,974	7,690,428	720,492,635
Blue carbon credits	3,000 ha	15,406,847,917	159,219,970	-118,185,061	15,447,882,825
Ecotourism	10 ha	13,597,199	133,846	4,121,082	17,852,127
Traditional fishing	1 vessel	0	-105,046	2,632,900	2,527,854
Sustainable fishing	1 vessel	0	-65,654	2,830,994	2,765,340

Source: Own elaboration.

III.4. Sensitivity analysis

A sensitivity analysis of costs and benefits, discount rate, mitigation potential, and some specific parameters of each activity is presented.

III.4.1. Sensitivity analysis of traditional agriculture

The most sensitive parameter in this activity is the sale of corn; if the price or the quantity sold decreases by 26%, losses are generated. Table 25 shows the sensitivities of each cost and benefit concept of this activity.

TABLE 25. AGRICULTURE SENSITIVITY ANALYSIS

Concept	Elasticity[a]	Breakpoint[b]
Corn sales	3.9	-26%
Land preparation	0.2	412%
Sowing	0.6	175%
Fertilization	0.9	118%
Pest, weed, and disease control	0.7	151%
Harvesting, sorting, and packing	0.3	375%
Various	0.3	370%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.2. Sensitivity analysis of traditional agriculture

Table 26 shows the sensitivity of each cost and benefit concept of agroforestry systems. The concept that most represent sensitivity is the value of self-consumption of products and fodder. Profitability responds more than proportionally.

TABLE 26. SENSITIVITY ANALYSIS OF AGROFORESTRY SYSTEMS

Concept	Elasticity[a]	Breakpoint[b]
Live fence	0.2	423%
Live fence management	0.4	228%
Land preparation	0.1	963%
Sowing	0.2	410%
Fertilization	0.4	275%
Pest control_ weeds and diseases	0.3	354%
Harvesting_ sorting and packing	0.1	876%
Various	0.1	865%
Value of forest products	0.0	2,486%
Value of self-consumption products	1.7	60%
Fodder value	1.2	84%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.3. Sensitivity analysis of value-added agriculture

Table 27 shows the sensitivity analysis of value-added agriculture. Revenues from honey sales and maintenance costs are highly sensitive to profitability. In particular, only a 19% decrease in honey revenues generates losses.

TABLE 27. SENSITIVITY ANALYSIS OF VALUE-ADDED BEEKEEPING

Concept	Elasticity[a]	Breakpoint[b]
Project design	0.1	1204%
Training	0.1	1004%
Equipment and tools (extraction equipment, protective equipment and field material)	0.2	598%
Packaging machine	0.2	401%
Labor for preparation and installation of hives	0.0	13383%
Salary for hive inspections	0.1	917%
Purchase of colognes or packages	0.5	203%
Labor for harvesting and by-product collection	0.3	357%
Labor for honey filtration and packing	0.1	960%
Brand development and sales strategy	0.1	1204%
Maintenance	2.6	39%
Fuel	0.1	826%
Used vehicle	0.2	401%
Honey sales	5.3	19%
Sale of by-products (beeswax)	0.8	126%
Packaging and labels	0.5	213%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.4. Sensitivity analysis of traditional beekeeping

Table 28 shows the sensitivities of profitability to cost and profit variations of value-added beekeeping show the sensitivities of profitability to variations in costs and benefits of value-added beekeeping. It is found that the items with the most significant impact on profitability are honey sales and maintenance. A decrease of only 22% in honey sales generates losses, and the same occurs with a 37% increase in maintenance costs.

TABLE 28. SENSITIVITY ANALYSIS OF VALUE-ADDED BEEKEEPING

Concept	Elasticity[a]	Breakpoint[b]
Equipment and tools (extraction equipment, protective equipment, and field material)	0.2	452%
Labor for preparation and installation of hives	0.0	10124%

Salary for hive inspections	0.1	694%
Purchase of colognes or packages	0.7	153%
Labor for harvesting and by-product collection	0.4	270%
Maintenance	2.7	37%
Fuel	0.2	625%
Second-hand vehicle	0.3	304%
Honey sales	4.6	22%
Sale of by-products (beeswax)	0.7	145%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.5. Sensitivity analysis of mangrove charcoal

Table 29 shows the sensitivity analysis of mangrove charcoal. It was found that a 37% decrease in charcoal sales would generate losses. For the rest of the items, the change in profitability is less than proportional to the change in costs.

TABLE 29. MANGROVE CHARCOAL SENSITIVITY ANALYSIS

Concept	Elasticity[a]	Breakpoint[b]
Technology package (includes oven, training, and materials)	0.0	2469%
Depreciation	0.2	486%
Mangrove harvesting	0.1	1020%
Labor	0.7	138%
Distribution per kg of coal (gasoline)	0.0	2753%
Sale of coal	2.7	37%
Vehicle	0.1	1058%
Administration and marketing costs	0.4	260%
Accounting	0.1	846%
Management plan	0.0	2620%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The break point means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.6. Sensitivity analysis of mangrove restoration with blue carbon credits

Table 30 shows the sensitivity of profitability to the costs and benefits of blue carbon credits. The parameter that most affects profitability is the cost of restoration, which is very high; according to the interviews conducted for this study, these amount to 96,000 pesos per hectare initially, without considering annual maintenance. In addition, the price received for each credit is lower than the costs. This is confirmed in Table 30. When observing the sensitivity of the cost of restoration (0.816) and the sale of credits (0.156), an increase in the price of carbon or a reduction in restoration costs are the variables that fundamentally affect financial profitability.

TABLE 30. SENSITIVITY ANALYSIS OF BLUE CARBON CREDITS

Concept	Elasticity[a]	Breakpoint[b]
Site evaluation	0.001	196975%
PIN and inventory phase	0.004	26263%res
Restoration	0.244	410%
Restoration maintenance	0.816	123%
Registration	0.004	23546%
Third-party validation	0.005	18539%
Reporting	0.012	8308%
Sale of receivables	0.156	641%
Administration	0.011	9053%
Maintenance and monitoring	0.051	1958%
Evaluation	0.008	11936%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.7. Sensitivity analysis of ecotourism

Table 31 shows the sensitivity analysis of ecotourism. Profitability is highly sensitive to lodging and tour sales decreases. A decrease of 56% and 83%, respectively, would generate losses.

TABLE 31. SENSITIVITY ANALYSIS OF ECOTOURISM

Concept	Elasticity[a]	Breakpoint[b]
Market research	0.0	8242%
Business plan and carrying capacity study	0.0	8242%
Technical training	0.0	6868%
Inputs for infrastructure construction	0.5	199%
Labor for the construction of infrastructure	0.1	960%
Investment in equipment (kayaks, life jackets)	0.0	6060%
Cabin equipment	0.0	2433%
Visitor's center equipment	0.0	2368%
Consumables at the visitor center	0.0	159361%
Garbage collection	0.1	1246%
Garbage cans	0.0	22895%

Market strategies	0.0	8242%
Personnel who carry out activities (tours, talks, snorkeling, etc.)	0.4	245%
Accounting personnel	0.1	1130%
Staff for visitor services (receptionist, cost inquiries, reservations, etc.)	0.1	947%
Maintenance	0.6	179%
Hosting	1.8	56%
Tours	1.2	83%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.8. Sensitivity analysis of traditional livestock farming

The profitability of traditional cattle ranching is extremely sensitive to decreases in sales (only a 4% decrease generates losses) and increases in the cost of calves for fattening (a 7% increase in this item generates losses). In addition, profitability is sensitive to changes in labor and feed costs; in both cases, a 51% increase in these items generates losses (see Table 32).

TABLE 32. SENSITIVITY ANALYSIS OF TRADITIONAL LIVESTOCK

Concept	Elasticity[a]	Breakpoint[b]
Cost of the fattening calf	14.9	7%
Maintenance of installations/machinery/equipment	1.0	100%
Permanent labor	2.0	51%
Other fixed costs	0.2	604%
Food	2.0	51%
Salt and mineral supplements	0.4	270%
Meadow maintenance	0.4	237%
Health	0.5	184%
Fuels and lubricants	0.5	184%
Other variable costs	0.7	153%
Sale of heifers	23.6	4%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The break point means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.9. Sensitivity analysis of traditional fishing

Traditional fishing is sensitive to the costs associated with the activity; a 70% increase in these costs would generate losses (see Table 33).

TABLE 33. SENSITIVITY ANALYSIS OF TRADITIONAL FISHING

Concept	Elasticity[a]	Breakpoint[b]
Cost per day of fishing	1.4	70%
Sale of grouper	0.8	125%
Sale of negrillo	0.8	125%
Sale of canané	0.2	451%
Sale of chac-chi	0.2	564%
Red snapper for sale	0.3	376%
Snapper for sale	0.2	578%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or profit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.10. Sensitivity analysis of sustainable fishing

Sustainable fishing is somewhat sensitive to the costs associated with the activity; an increase of 88% would generate losses (see Table 34).

TABLE 34. SENSITIVITY ANALYSIS OF SUSTAINABLE FISHING

Concept	Elasticity[a]	Breakpoint[b]
Cost per day of fishing	1.1	88%
Sale of grouper	0.7	135%
Sale of negrillo	0.7	135%
Sale of canané	0.2	485%
Sale of chac-chi	0.2	606%
Red snapper for sale	0.2	404%
Snapper for sale	0.1	622%
Illuminated nets	0.0	5775%
Training	0.1	944%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.11. Sensitivity analysis of silvopastoral systems.

Table 35 shows a sensitivity analysis of silvopastoral systems. As with traditional cattle raising, profitability is sensitive to changes in the cost of calves for fattening and in the sale of heifers. However, this sensitivity is much lower in this system.

TABLE 35. SENSITIVITY ANALYSIS OF SILVOPASTORAL SYSTEMS.

Concept	Elasticity[a]	Breakpoint[b]

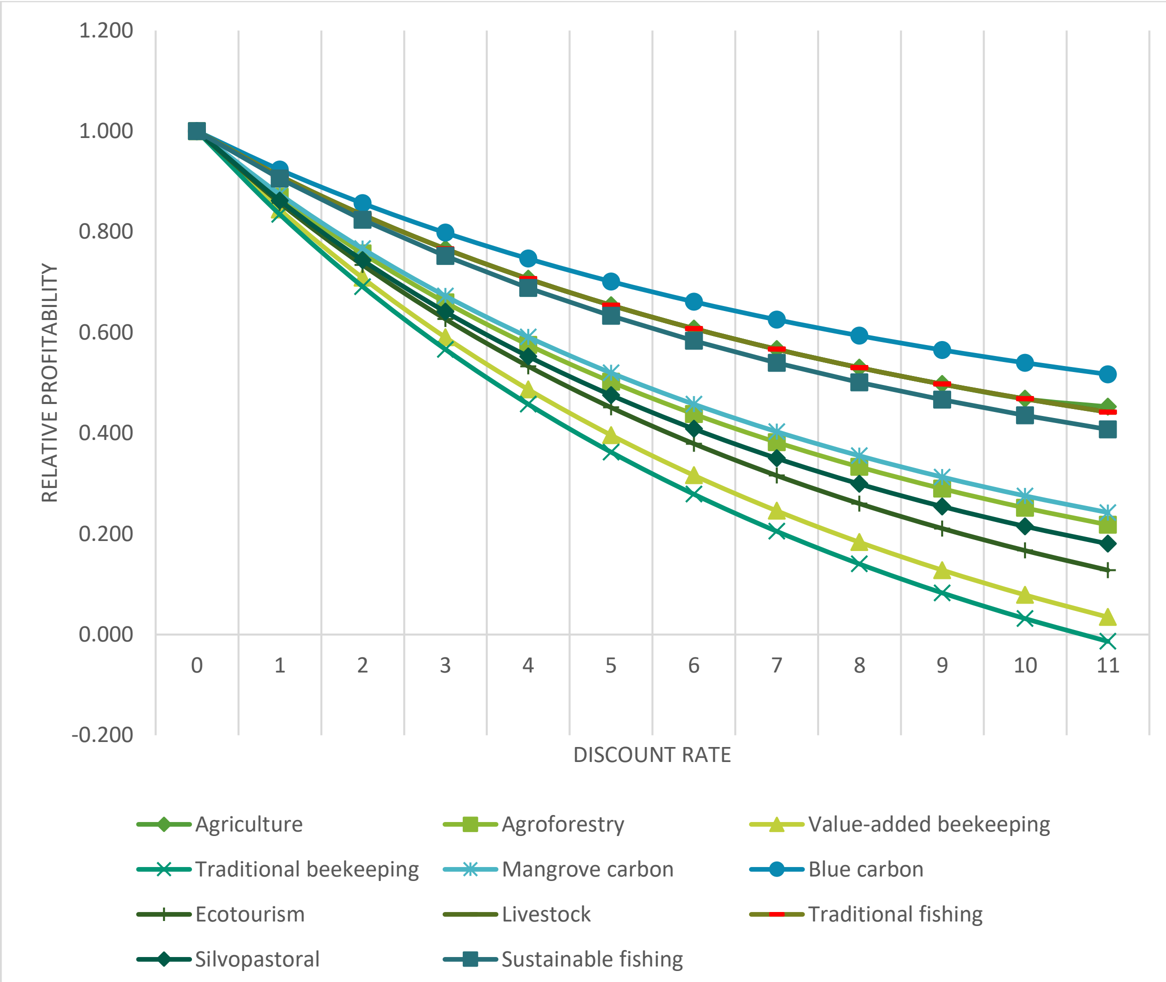
Cost of the fattening calf	2.1	47%
Maintenance of installations/machinery/equipment	0.1	701%
Permanent labor	0.3	358%
Other fixed costs	0.0	4245%
Food	0.3	358%
Salt and mineral supplements	0.1	949%
Meadow maintenance	0.1	831%
Health	0.2	645%
Fuels and lubricants	0.2	645%
Other variable costs	0.2	538%
Heifers	3.4	30%
SiPS Investment	0.2	436%
SiPS Maintenance	0.4	248%
Sale of heifers	1.9	54%

Source: Own elaboration. a. Elasticity is interpreted as the percentage change in profitability for a percentage change in each cost or benefit. b. The breakpoint means the percentage of income (cost) that has to decrease (increase) to generate losses.

III.4.12. Discount rate sensitivity analysis

Figure 24 shows a graph of the relative profitability of each activity as a function of discount rates. This means that the profitability of an activity at an initial rate (0% in this case) is expressed as the unit, and its relative change is observed as the discount rate increases. It is observed that the activities most sensitive to discount rates are beekeeping, ecotourism, and silvopastoral systems. In contrast, the activities with the lowest sensitivity are traditional livestock, agriculture, traditional fishing, and blue carbon credits. This is a direct result of the fact that the 3 traditional activities do not require initial investments, contrary to what is required for the former. In the case of blue carbon, low sensitivity is observed because restoration costs are very high, and most of these are incurred at the beginning of the activity, which implies that the discount rate has a relatively low effect on profitability.

FIGURE 24. RELATIVE PROFITABILITY VS. DISCOUNT RATES



Source: Own elaboration.

III.5. Co-benefits (externalities)

All the selected activities have associated social and environmental co-benefits (positive externalities). In social terms, they generate jobs, reducing incentives for migration. In addition, it is estimated that the projects generate between 1.3 and 1.8 times the initial economic spillover investments, considering the input-output matrix (IOM) for Mexico from INEGI (2018). This is presented in Section III.3 results. The sources of information and concepts of these results are specified in this section.

Table 36 shows the sources of information used to value ecosystem services in the ecosystems analyzed. These values were used to estimate the economic profitability of each activity. The results are shown in Table 36, and, in general, the financial analysis of the activities considers these values.

TABLE 36. SOURCES OF INFORMATION FOR VALUING CO-BENEFITS.

Ecosystem / land use	Ecosystem service	Value	Unit	Source
Tropical forest	Pollination	384	Weights/ha/yea r	De Groot *et al.* (2012)
Ceercas vivas	Biological control	554	Weights/ha/yea r	Morandin, Long & Kremen (2016) and Alam *et al.* (2014).
Live zebras	Water quality	6900	Weights/ha/yea r	Alam et al. (2014).
Ceercas vivas	Soil quality	2159	Weights/ha/yea r	Alam et al. (2014).
Ceercas vivas	Nutrient cycling	210	Weights/ha/yea r	De Groot *et al.* (2012) and Alam et al. (2014).
Ceercas vivas	Water flow regulation	4380	Weights/ha/yea r	De Groot *et al.* (2012)
Live fences	Carbon sequestration	14.6	tCO2e/year	FAO (2022)
Not applicable	Social value of carbon	60	USD/ha/year	World Bank (2017)
Mangrove	Carbon sequestration	1.39	tC/ha/year	Herrera-Silveira et al. (2010)
Not applicable	Diesel emission factor	2.596	kgCO2/liter	INECC (2014)
Mangrove	Coastal protection	20800 0	Weights/ha/yea r	Kairo, Wanjiru & Ochiewo (2009)
Mangrove	Sedimentation reduction	7400	Weights/ha/yea r	Mukherjee *et al.* (2014).
Mangrove	Pollution reduction	10000 0	Weights/ha/yea r	Mukherjee *et al.* (2014).
Mangrove	Provisioning services (food)	19500	Weights/ha/yea r	Mukherjee *et al.* (2014).
Mangrove	Services for fisheries	21900 0	Weights/ha/yea r	Mukherjee *et al.* (2014).
Mangrove	Biodiversity	5282	Weights/ha/yea r	Novianti *et al.* (2022).

Source: Own elaboration

III.6. Summary of results of EbA's potential portfolio of activities

Table 37 shows the summary. As can be seen, all activities, except mangrove restoration with carbon credits, have a positive financial NPV. However, when externalities are included, the economic NPV is positive for all activities. This reinforces the importance of the project's concesionality due to its overall environmental benefits.

TABLE 37. DISTRIBUTION OF PROJECTS

Activities	Hectares / vessels per project type	Financial NPV by activity (thousands of pesos)	Economic NPV by activity (including externalities) (thousands of pesos) (thousands of pesos)	Total costs by activity (thousands of pesos)	Initial investment by activity (thousands of pesos)[10]
Agroforestry system	10	1,375	3,412	2,970	407
Silvopastoral system	30	1,961	2,411	8,246	450
Value-added beekeeping	25	602	2,376	3,071	862
Mangrove charcoal	105	7,690	720,492	12,593	1,282
Blue carbon	3000	-118,185	15,447,882	136,610	29,310
Ecotourism	10	4,121	17,582	8,258	3,145
Fishing	30	84,930	82,950[11]	107,310	10,000
Total					

Source: Own elaboration.

[10] It considers only the initial investment that has to be made in the first year to start the project, which can serve as a reference for the initial financing. The total costs column considers all costs to be incurred throughout the life of the activity.

[11] This profitability does not consider the baseline emissions reduction, therefore, the NPV with externalities is lower than the financial NPV. When considering emissions from traditional fishing there is a net reduction in emissions.

IV. Conclusions

The analysis carried out in this document reflects an evaluation of the economic and socio-environmental feasibility of the ACCIÓN project. To evaluate the relevance of the proposed activities, the estimated profitability levels were contrasted with those of traditional economic activities in the area (*Business as Usual*, BAU), which were taken as a baseline. The results suggest that the activities are profitable at the private level (in financial terms) and the social level. In this sense, they offer sustainable alternatives to extensive traditional practices that tend to degrade ecosystems and make unsustainable use of natural assets.

It is worth mentioning that the study conducted and, therefore, the conclusions presented assume that certain social conditions are met, including the existence of governance structures that allow organized groups to access sources of financing for the implementation of the projects, and that they can carry out prior diagnoses to demonstrate the viability of their participation in the project. Therefore, the acceptance and active participation of local communities in implementing and managing projects is assumed.

Each of the activities suggests different financial and social advantages, and the choice of one or the other will depend on the context in which it is to be applied and on the priorities of the project investor. The analysis provides for each activity, in addition to an estimate of the net present value of the projects in the defined time frame and an estimate of the NPV integrating externalities whose monetary value is approximated using literature findings. The purpose of the above is to exemplify the magnitude of the social and environmental benefits generated by the projects, which in current markets cannot be accounted for in monetary terms.

Mangrove charcoal is an innovative and highly profitable activity. It is essential to mention that the interested parties must have forest harvesting permits. The activity offers a way to use resources often wasted, such as the remains of dead mangroves and fallen branches. Harvesting also contributes to cleaning up the ecosystem, thus representing an effective and highly profitable alternative for carbon generation.

In the case of beekeeping, its wide presence in the Yucatan Peninsula and its profound cultural importance are highlighted, being considered an ancestral practice maintained by many indigenous communities. Therefore, a broad niche of potential stakeholders is identified to improve their practices to produce higher-quality products while implementing systems that ensure the long-term sustainability of resources. Finally, in environmental terms, this activity stands out for integrating regional agricultural production with biodiversity conservation, improving soil health, and providing ecosystem services.

Agroforestry, on the other hand, is a viable activity on smaller plots of land, which makes it suitable for stakeholders who are not part of large groups. It offers the advantage of generating products for self-consumption so that economic benefits do not depend exclusively on sales. Also, compared to other activities, it requires a smaller initial budget.

Ecotourism requires significant initial investments but is very profitable. This activity requires excellent internal coordination on the part of the groups that implement it. It is considered a favorable alternative for those with a long-term commitment, especially because of the investment required in infrastructure.

In addition to their profitability, all activities are more likely to offer long-term financial security for community members. This is because environmental degradation and overexploitation of resources, such as forest, fishing, and water resources, compromise the availability on which livelihoods depend.

It is also observed that, for certain activities, the Net Present Value (NPV), net of taxes, reaches profitable figures. Mangrove charcoal, blue carbon credits, ecotourism, sustainable fishing, and silvopastoral systems stand out in descending order. However, the application of these values covers large areas of land. The project with the largest extension corresponds to blue carbon credits (3000 ha), followed by mangrove carbon (105 ha), and in third place, sharing position, sustainable fisheries, and silvopastoral systems (both with 10 ha). It is also important to note that the above activities generate an equivalent annual flow exceeding 160,000 pesos/year.

On the other hand, when analyzing the unit financial results for each activity, the equivalent annual flow of agroforestry activities ranks third in profitability, only surpassed by sustainable fishing and ecotourism. Regarding the cost-benefit index, sustainable fishing has the highest benefits, followed by ecotourism and mangrove charcoal.

In this context, the above results suggest that the different activities adapt to various needs and conditions. It is essential to mention that diversification of productive activities reduces the risks associated with dependence on a single product or market. On the other hand, economies of scale maximize investments in enabling conditions and resource management efficiency by integrating diverse activities. This not only improves the profitability and sustainability of productive practices but also contributes to local communities' economic and environmental resilience. This recommendation seeks financing for a possible mix of activities, not just one specific activity.

Diversification of productive activities and transition to sustainability schemes are necessary not only for environmental preservation and climate change mitigation but also to offer viable and sustainable economic opportunities for local communities in the region. The adoption of these systems and practices reveals an alternative toward a more resilient and sustainable future, where production and environmental conservation go hand in hand.

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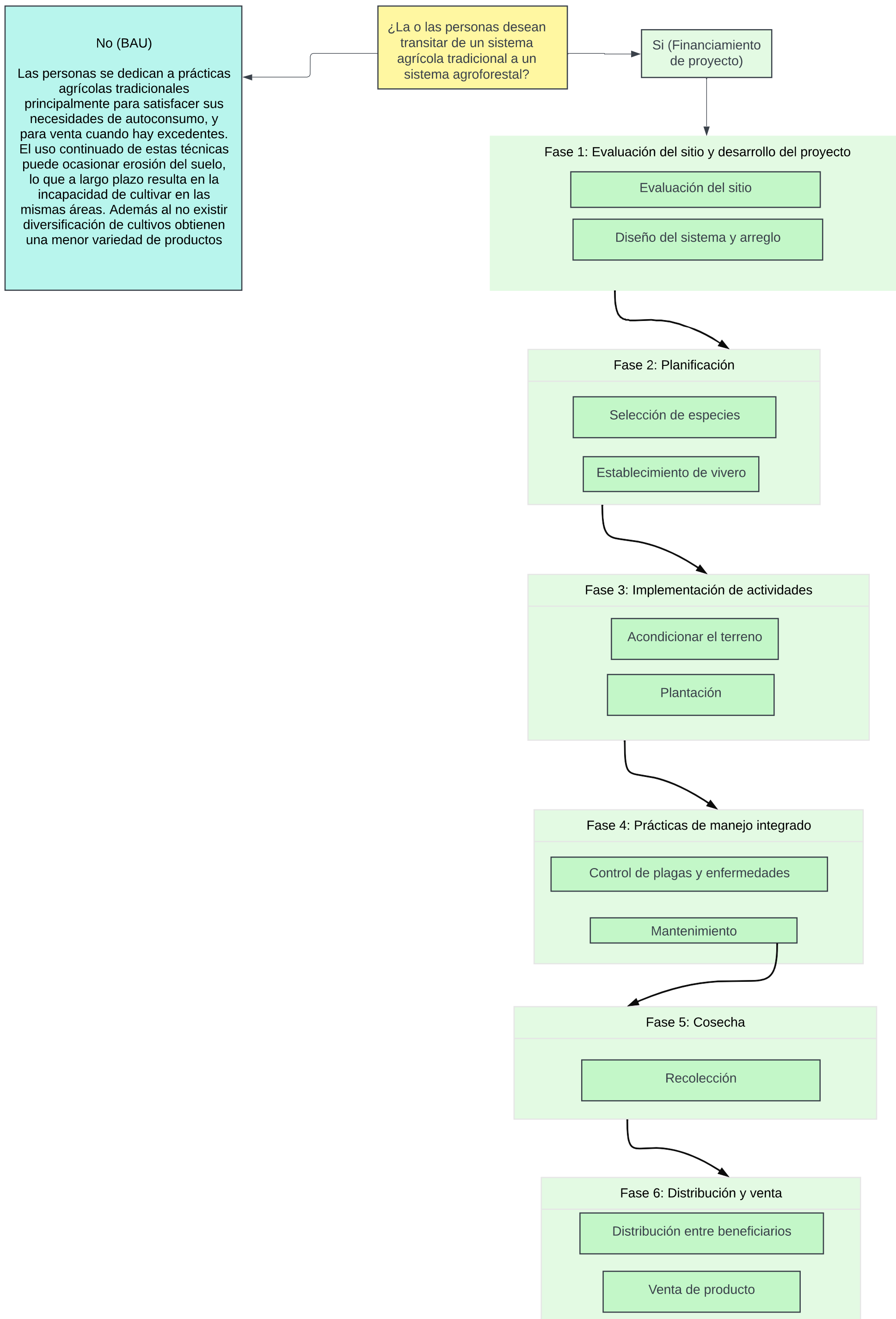
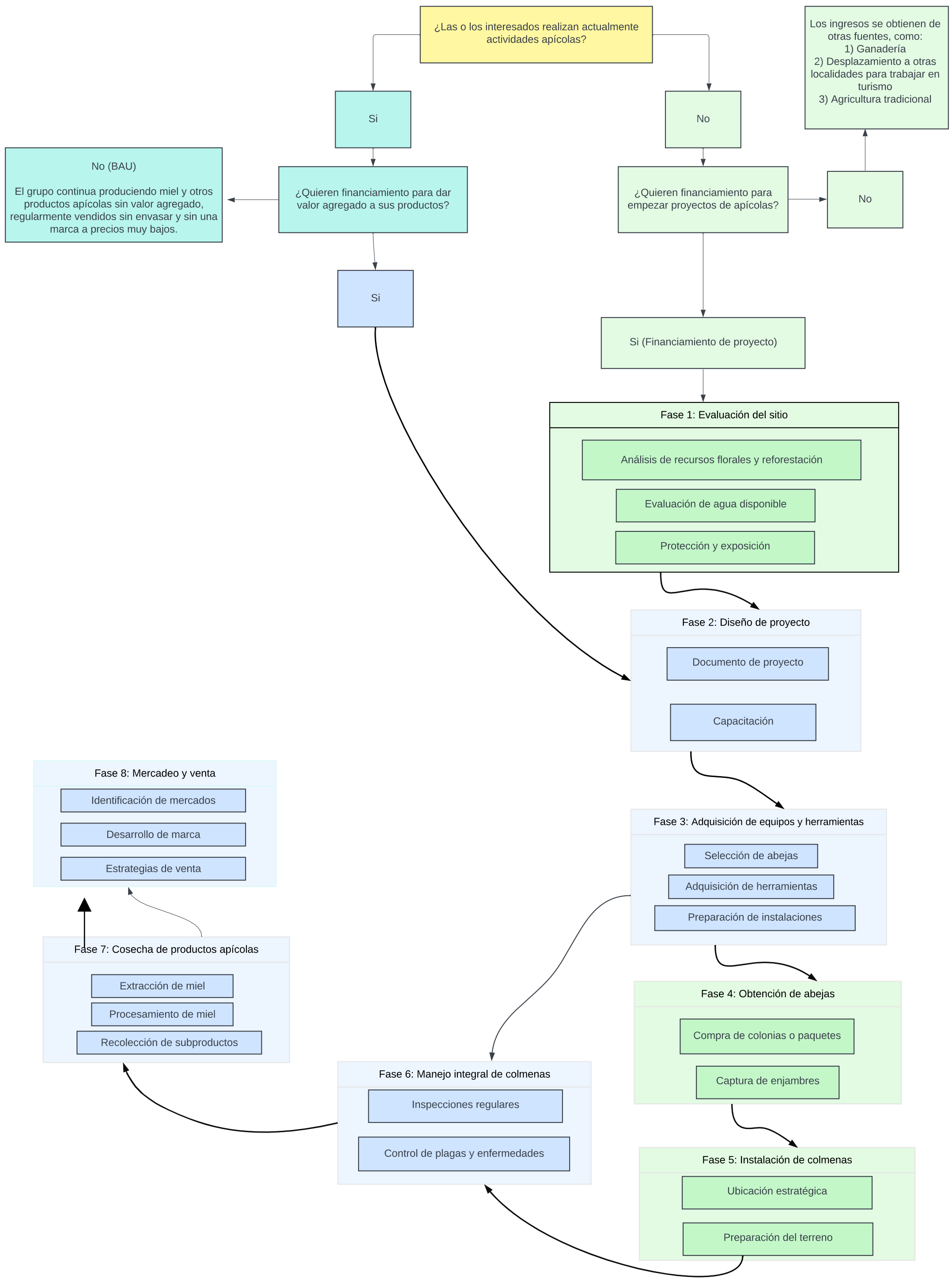
VI. Annexes

Annex 1. Flow diagram of agroforestry systems



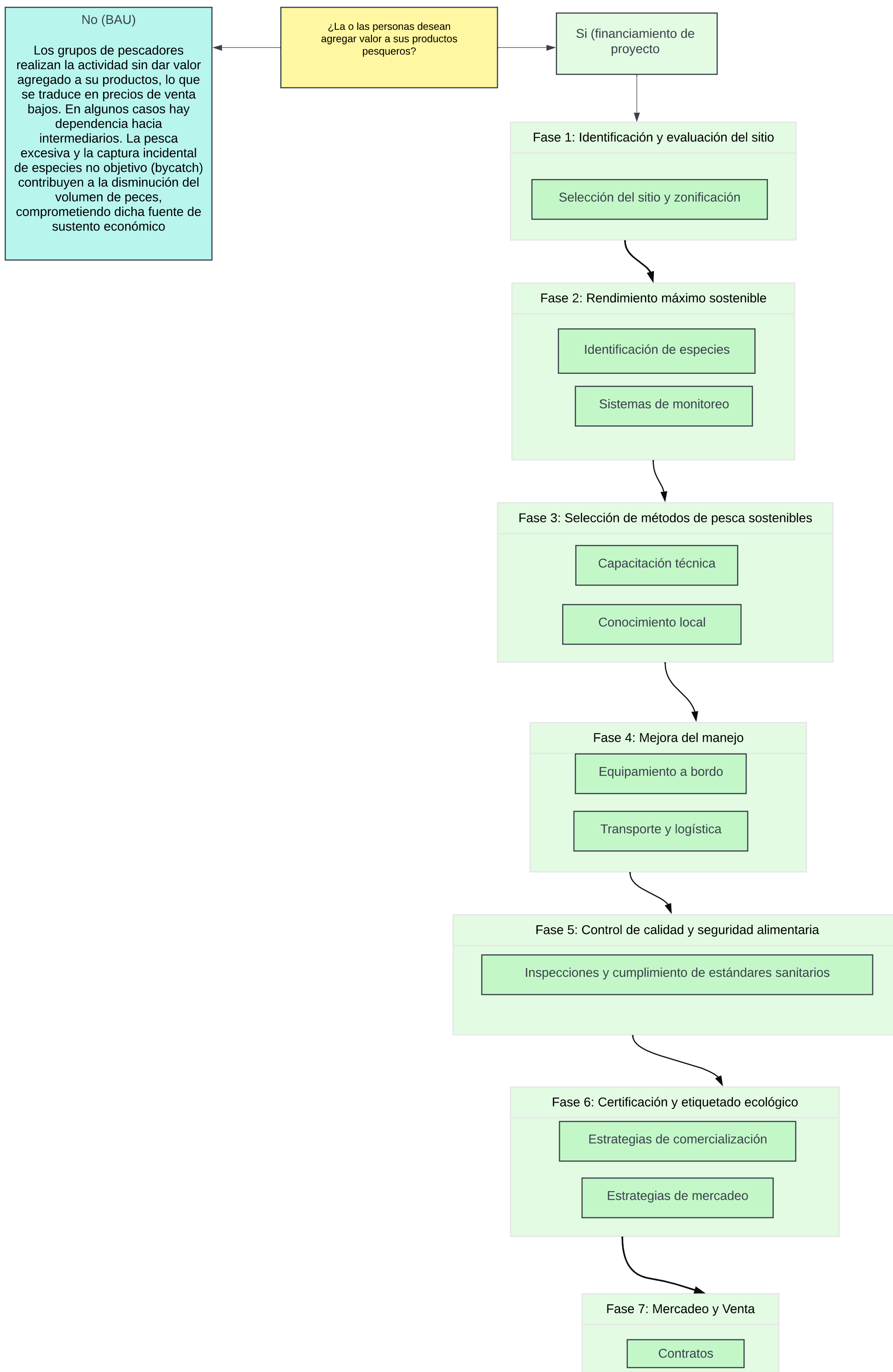
Source: Own elaboration

Annex 2. Beekeeping flow chart



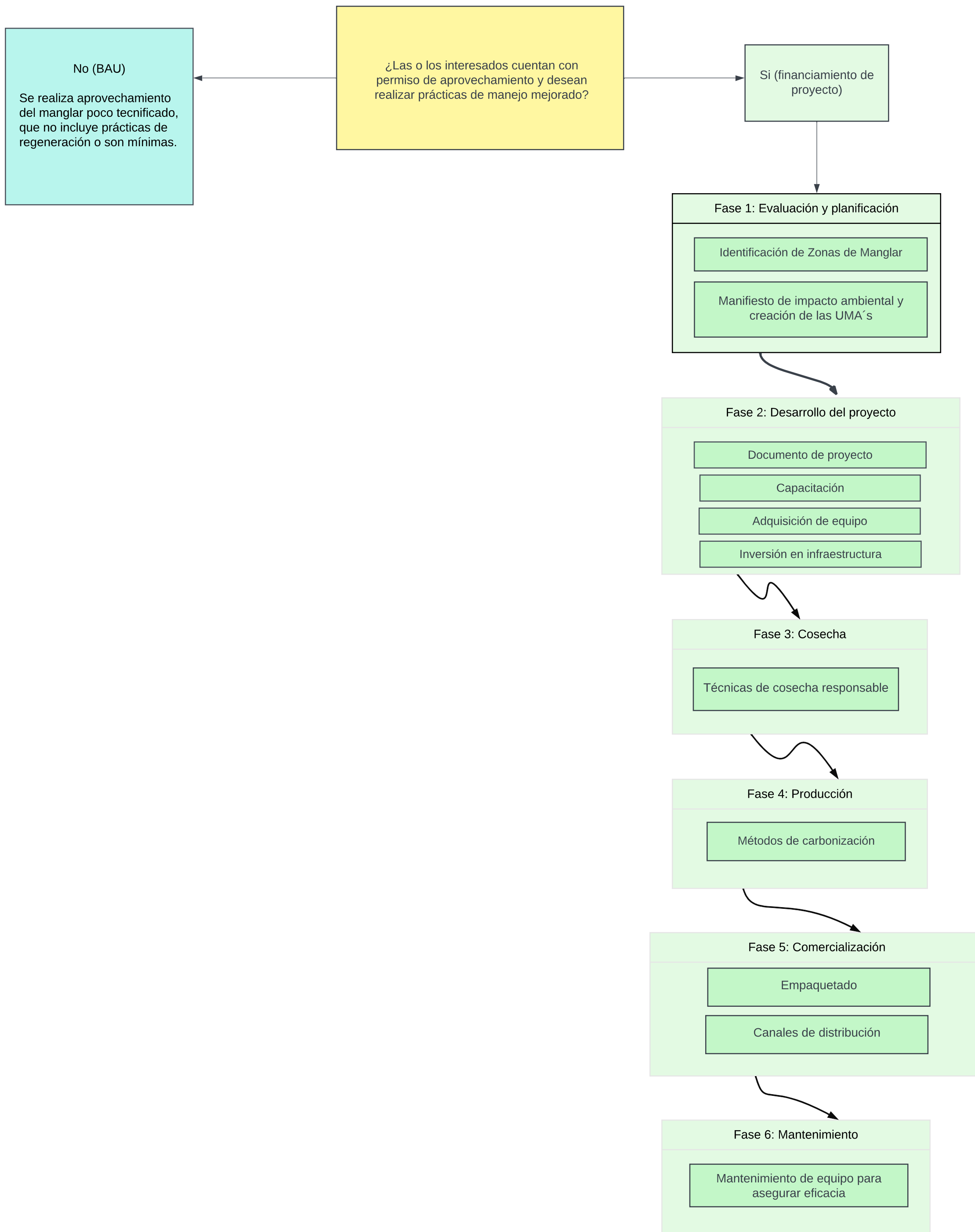
Source: Own elaboration

Annex 3. Sustainable fishing flow chart



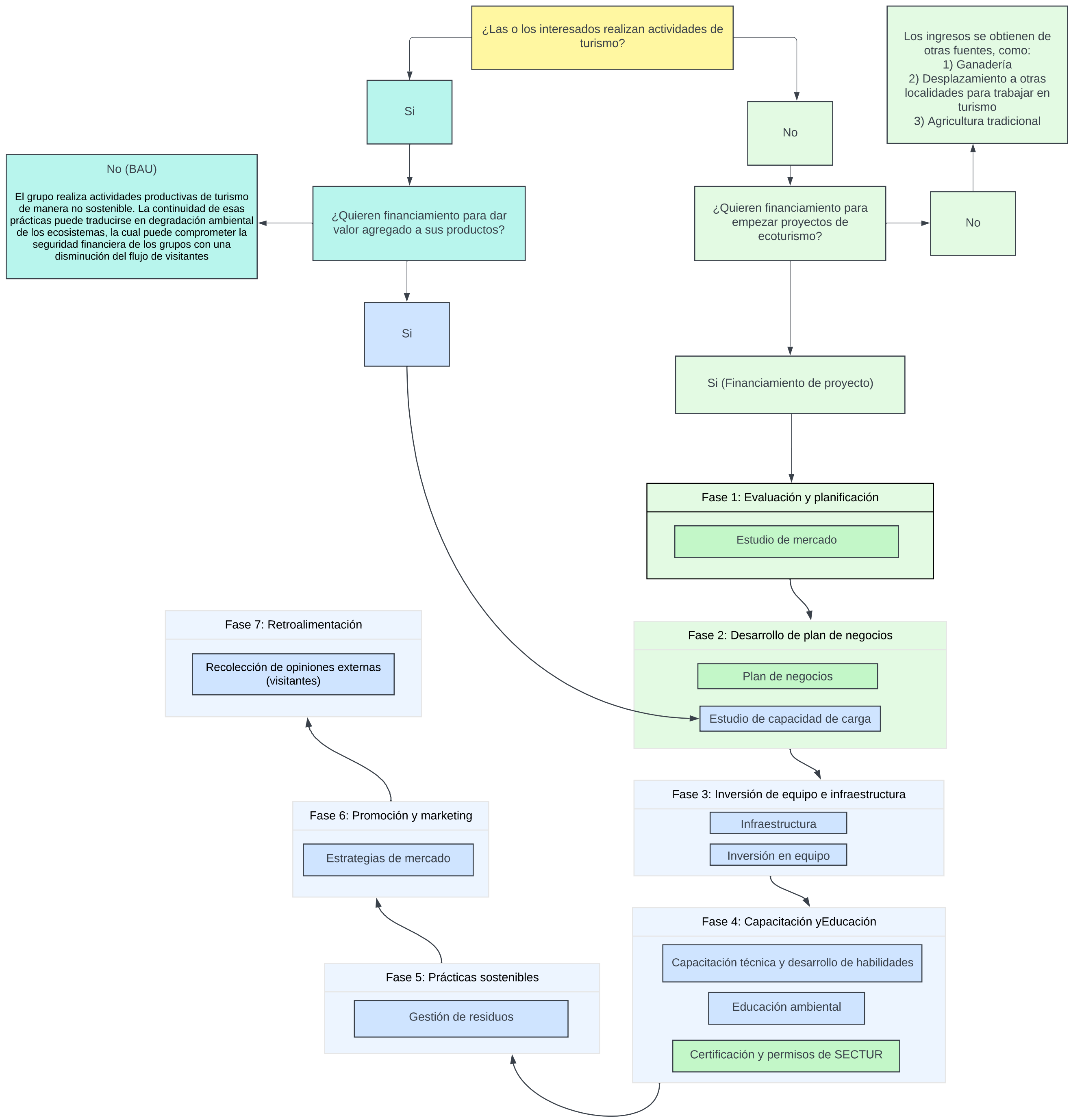
Source: Own elaboration

Annex 4. Coal flow diagram



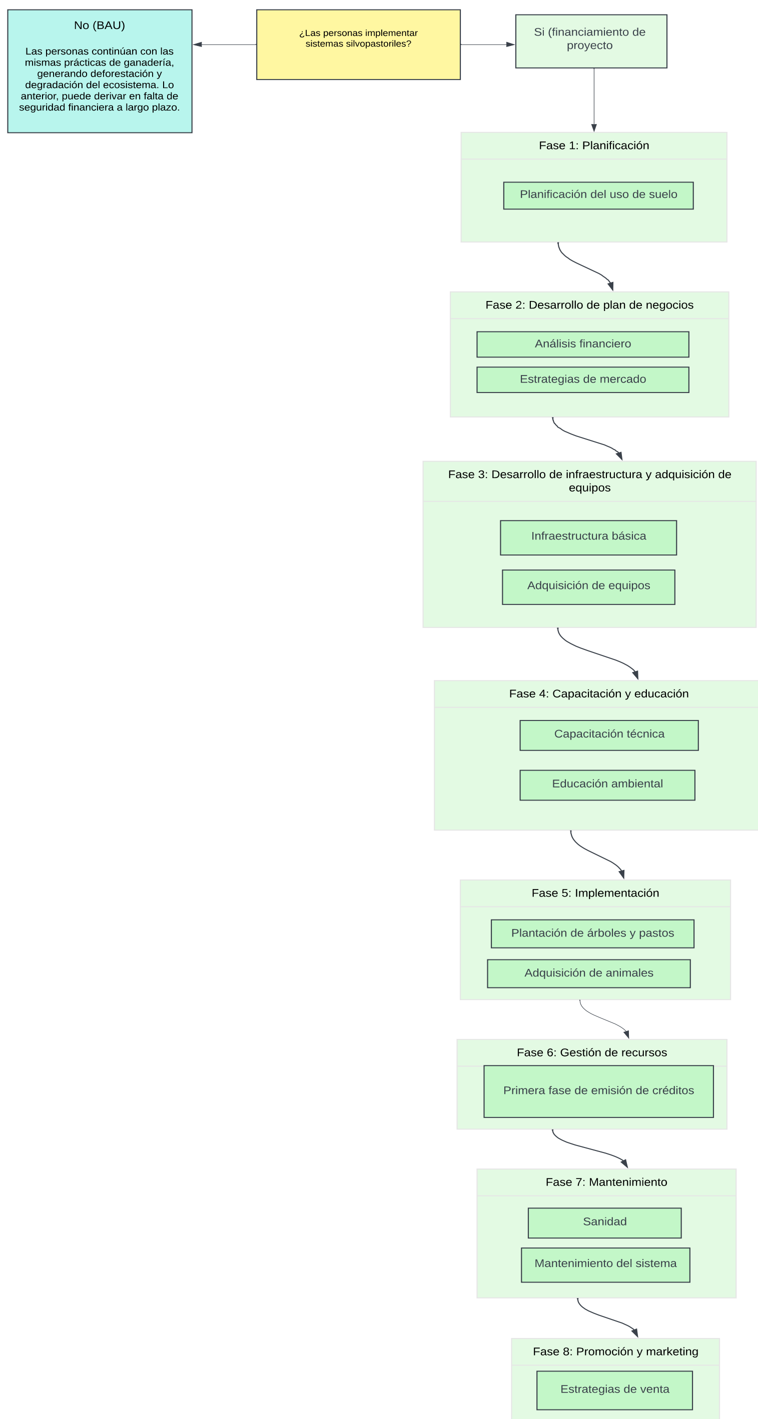
Source: Own elaboration

Annex 5. Ecotourism diagram



Source: Own elaboration

Annex 6. Flow diagram of silvopastoral systems



Source: Own elaboration

Annex 7. Definition of profitability indicators

a. **Net present value (NPV)**. A measure in pesos that reflects the present value of the cash flows of an activity.

$$VPN = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+\delta)^t}$$

Where *B* represents the benefits and *C* the costs at time *t*; δ the discount rate and *T* the evaluation horizon (the end date of each activity).

b. **Cost Benefit Index (ICB)**. Relative measure that indicates how many monetary units I obtain for each unit that is invested, when it is greater than 1 it means that there is a positive profitability.

$$ICB = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+\delta)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+\delta)^t}}$$

c. **Annual Cash Flow Equivalent (APE)**. It is a constant flow for each period whose net present value is equivalent to the net present value of the entire activity. It is intended to express the NPV in a constant and annualized figure. It is useful when comparing the profitability of activities that have different evaluation horizons.

$$FAE = \frac{VPN}{\sum_{t=0}^{T} \frac{1}{(1+\delta)^t}}$$

d. **Payback period of the investment (*T**)**. This is the time in which the discounted cash flows take a value greater than or equal to zero. It should be noted that this time may be indeterminate if the flows are never positive.

$$\sum_{t=0}^{T^*} \frac{B_t - C_t}{(1+\delta)^t} \geq 0$$

e. **Cost Effectiveness Index (CEI).** Traditionally, the CEI is expressed as the total costs discounted between a goal that is achieved with an activity. We express the ECI as the NPV between that goal. The interpretation of this indicator is the net benefit per unit of the desired goal. For example, in the case of CO reductions$_2$, it is expressed as the monetary units of net benefit obtained for each tCO_2 e reduced. If desired, the ECI can be obtained in the traditional way by accounting only for the costs of the activity, in which case it is interpreted as the cost per unit of the desired target.

$$ICE = \frac{VPN}{Q^*}$$

Where Q^* represents a desired target generated by an activity, e.g., reduction of tons of carbon dioxide.

f. **Internal Rate of Return (IRR)**. The IRR is the discount rate at which the NPV of an activity is equal to zero. If the IRR is negative it indicates that the project is not profitable, it is also possible that the IRR is not defined, this occurs when there is no number such that the NPV is equal to zero. The IRR is more useful from the private perspective to know the return on investment in percentage terms.

$$\sum_{t=0}^{T} \frac{B_t - C_t}{(1 + TIR)^t} = 0$$

g. **Probability of success (P)**. Based on a Monte Carlo simulation, where minimum and maximum values of the prices and quantities (of the costs and benefits) of an activity under analysis are considered, the NPV associated with a random round is calculated. This random round is characterized by having a random value of the prices and quantities of each cost and benefit of an activity. It is assumed that each cost and benefit is normally distributed, with an average value and a standard deviation that is defined by the approximation $\sigma_x \approx \frac{(x_{máx} - x_{mín})}{4}$ where $x_{máx}$ represents the maximum value of the variable *x*, and $x_{mín}$ its minimum value. In this way, a certain number *N* of random rounds is simulated, which allows us to obtain *N* values of the NPV. What interests us is to know how many times the NPV is positive and this is interpreted as the probability of success of the activity.

$$P = \left(\frac{1}{N}\right) \cdot \sum_{k=1}^{N} \mathbf{1}_{VPN_k \geq 0}(VPN_k)$$

Where **1** represents the value of 1 if the NPV is positive and 0 otherwise.

h. **Elasticity of each cost and benefit** ($\in_x$). To perform a sensitivity analysis, the elasticity of each cost and benefit of each activity will be estimated, which is interpreted as the percentage change in profitability for a percentage change in the cost or benefit *x*. It is possible to show that the elasticity can be expressed with the following formula,

$$\in_x = \frac{\partial VPN}{\partial x} \cdot \frac{x}{VPN} = \frac{\sum_{t=0}^{T} \frac{x_t}{(1+\delta)^t}}{VPN}$$