ANNEX 10
Economic Analysis

Restoration for adaptation to Climate Change (RIOS)

Valuation of benefits from river restoration

It is difficult to quantify the effects of river restoration on human well-being in monetary terms. Non-market benefits are usually the most difficult to quantify and monetize, but may play a crucial role in the cost-benefit analysis informing policy and decision-making with respect to river restoration (Lago, 2014).

In the case of Mexico, we identified five studies that valuate the benefits of river restoration. All of them used Contingent Valuation to assess the households' Willingness to Pay (WTP). Ojeda et al. (2008) studied the Yaqui River Delta in Sonora. They found that households' WTP in a downstream city Ciudad Obregon was US$ 5.5 monthly per household to preserve riparian vegetation, recreation services, the fauna habitat, local fisheries and diluting pollutants. Donoso (2009) analyzed the Apatlaco River Morelos and estimated US$ 7.7 monthly per household for a program offering strategic basin management. Ayala and Abarca (2014) analyzed the WTP to improve water quality in a section of Lerma River, and estimated that households' WTP was between US$ 3-3.7. Soto and Ramirez (2017) analyzed the WTP of households in the Atoyac river and found a US$ 4.13 WTP monthly per household (Lago, 2014).

Also, an Economic Valuation of ecosystem services in the Puerto Vallarta Region carried out by INECC (2018) shows the importance of the ecosystem services in the area, which overlaps TIOS Ameca-Mascota Basin. The study used as a background the Common International Classification of Ecosystem Services and the Economy of Ecosystems and Biodiversity (TEEB). It identified the following ecosystems services that the Vallarta watershed provides: (i) provision services: fishing and water for human consumption, water for industrial and agricultural uses; (ii) regulation services: storage and carbon sequestration, coastal protection, cycle maintenance, regulation of water flows, water purification, soil conservation, agricultural products and livestock products; and (iii) cultural services: recreation, scenic beauty and sport fishing. The analysis conducted a Discrete Choice Experiment which concluded that there was a positive willingness to pay of 30.4% of the tourists of $ 2,056 pesos per visit (about US$ 110) for the conservation of hydrological services and $ 2,372 pesos (about US$ 120) per visit for scenic beauty. These results support the importance of ecosystem services in the region. Those results provide a positive potential for a PES scheme in the region.

Globally, Lago (2014) analyzed 30 environmental economics papers published in academic journals during of 2000-2013 that valuated the benefits from river restoration. The majority were related to European river restoration projects (19 papers), followed by American (7 papers) and Asian (4 papers). The most commonly considered benefits were higher wildlife and aquatic life diversity, improved water quality, flood protection, carbon sequestration, erosion protection, better river appearance and recreational amenities of a riparian forest, better possibilities of recreation activities, and nitrate and phosphorus cycling and retention. The majority of reviewed studies (23) assumed that the primary beneficiaries of river restoration were local households. They used different forms of contingent valuation studies or discrete choice experiments to elicit their valuation of the restoration projects. Most WTP estimates were within the US$ 25-80 range. Most of them were per household per month.

The mentioned global and Mexican studies on the valuation of river restoration projects were performed with different goals and, consequently, using different valuation techniques. As a result, monetary estimates are not directly comparable. Furthermore, different cases assume a variety of payment vehicles. Thus, the estimates of the value of ecosystem services were stated monthly, bi-monthly or annual payments, and one-time contributions or daily access fees.

In the context of RIOS, the value of ecosystem services per hectare of the restored river would be an ideal measurement unit that would allow the comparison of costs and benefits of river restoration. Still, the majority of the available valuation studies provide WTP estimates per household derived from stated choice experiments (Lago, 2014). Moreover, those cases do not valuate the actual benefits of the communities implementing restoration activities, and none of them mentions the implementation of sustainable productive practices to restore rivers. Therefore, the use of those cases to quantify ex-ante RIOS benefits and co-benefits may not be suitable. To complement the limited ex-ante information, the project will implement a series of analysis related to the valuation of ecosystem services under Component 2.

Economic analysis of RIOS

We decided to apply an approach similar to the World Bank economic analysis of recent rural development projects in Mexico (World Bank 2020, 2019 and 2018). This approach allows valuating benefits at the watershed level, comparing the costs as a future step, and comparing the benefits of other projects that are currently being implemented in Mexico (for example, CONECTA).

Economic valuation of benefits and co-benefits from RIOS

We anticipate that RIOS is expected to provide three main economic benefits: (i) the improved provision of ecosystem services through river restoration and improved watershed management, (ii) enhanced carbon stocks and sequestration through the activities implemented, and (iii) associated with the sustainable livestock and agroforestry activities at the producer level that have positive private (financial) and social returns. In direct terms, all three relate the most with Component 1 of RIOS. In contrast, Component 2 and 3 will aim to indirectly increase the first and second benefits, and to provide sustainability to the third benefit.

Benefit stream 1: Improved provision of ecosystem services through river restoration and improved watershed management. For this benefit, healthy watersheds provide many ecosystem services that are necessary for social and economic well-being. These services include water filtration and storage, cleaning of air, nutrient cycling, soil formation, recreation, food, and timber (see Table 4.3). To estimate the benefits, it considers the reduction in total hectares of landscapes under deforestation pressure due to project intervention as defined in the Project Logical Framework. Following the World Bank (2020), we assumed that the total area is homogenously divided and is based on the triangular number distribution[1] [2] for five project years, that is, the project divided by 15 to obtain the factor that is each year added to the growth of the previous year.

Monetary value associated with key ecosystem services is taken from recognized studies that assessed the incremental economic benefits of the ecosystem services in Mexico. Based on previous studies related to the valuation of river restoration (see Chapter 4.2), we followed World Bank (2020) approach and used two meta-analyses of ecosystem services: an upper bound and a lower bound. The upper bound is from Lara-Pulido, Guevara-Sanginés, and Arias (2018), who provide specific estimates for Mexico based on 106 studies. The lower bound is taken from Siikamäki et al. (2015), who offer global estimates based on 123 robust analytical reviews and project estimates per country, including Mexico.

Table 4.4 shows those two different bounds of ecosystem services valuation. The selected ecosystem services are the most relevant identified in Chapter 4. Siikamäki et al. (2015) include relevant services such as Recreation (US$ 28.1/ha/year), habitat (US$ 3/ha/year), climate (US$ 26.2/ha/year), non-timber forest products (NTFPs, US$ 26.2/ha/year), and water (US$ 86.4/ha/year), giving a total of (US$ 143.70/ha/year). The upper bound represents an aggregate value of ecosystem services (US$ 293) valued by Lara-Pulido et al. (2018), which includes the conservation of coastal zones (US$ 252/ha/year), wetlands (US$ 315/ha/year), cultivated areas (US$ 212/ha/year, for provisioning), and forest (US$ 291/ha/year). Both studies have been used in previous similar analysis (see World Bank 2020), are methodologically sound, focused on Mexican territory, and relevant for the present analysis.

Table 4.4 Overview of Study Estimates on Economic Values of relevant Ecosystem Services in Mexico (per hectare)

Ecosystem Services (Mexico)	**Lower Bound US$**	**Ecosystem Services (Mexico)**	**Upper Bound US$**
	Siikamäki et al. (2015)		**Lara-Pulido et al. (2018)**
Recreation	28	Coastal zones	252
Habitat	3	Wetlands	315
NWFPs	26	Cultivated (for provisioning)	212
Water	86	Forest	291
Total	**143**	**Total (Aggregate value)**	**293**

Source: Own elaboration by the World Bank Task Team.

Benefit stream 2: Reduction of carbon emissions. Due to restoration activities, agroforestry activities, and sustainable livestock, improved vegetation leads to a reduction in carbon emissions and the enhancement of carbon stocks. Estimates by activity by the co-financed project CONECTA were used.

The social cost of carbon (SCC) is a commonly-estimated measure of the economic benefits of

[1] The triangular number is n (n+1)/2, and for five project years 5 x 6 / 2.
[2] The formula for year n is therefore: n x n (n+1) / 2.

greenhouse gas (GHG) emission reductions (EPA, 2010). In this project, SCC represents the global social benefits of emission reductions by avoiding deforestation and sustainable, productive activities in RIOS. Monetary SCC values were taken from the World Bank (2017), which estimates the carbon social value, in US$ 60 as an upper bound and US$ 40 as a lower bound. To provide a carbon value closer to the market value, we use in the analysis the value of voluntary carbon market US$ of 3.01 t/C (Forest Trend's Ecosystem Marketplace, 2019).

According to the High-Level Commission on Carbon Prices and aligned with the economic analysis of World Bank (2020) it is recommended that the project's economic analysis use a low and high estimate of the carbon price and take a value that is consistent with achieving the core objective of the Paris Agreement of keeping temperature rise below 2 degrees C. For the last reason, a higher value (US$ 60) was taken as an objective indicator in the economic analysis.

Benefit stream 3. Private-level benefits for landowners. The main assumption under this type of benefit is that landowners voluntarily decide to participate, and therefore we can assume that private benefits surpass the costs. It is considered that three types of activities are going to be financed at the producer level: (i) agroforestry systems, (ii) sustainable livestock systems, and (iii) conservation and restoration activities. Because the final number of hectares will be based on a voluntary request for proposals (RFP), for this analysis it is assumed that the total area for each type of activity is homogenously divided and is based on the triangular number distribution [3] for five project years (see Table 4.5)[4] and that they are equally distributed in both regions.

According to the World Bank (2020) there are two potential ways to assess economically this benefit stream: (i) estimating the difference of benefits between conventional (current or baseline scenario) and regenerative production practices (sustainable practice scenario), or (ii) taking a percentage that represents an improvement in benefits for adopting regenerative production practices compared to conventional. Here, the second approach is adopted, given that RIOS has a specific target on productivity for the activities. The benefit of the second approach is that it allows to re-assess the economic benefits ex-post, after the project is implemented. Following the CONECTA assumptions, we assume 70 percent of the beneficiaries implementing the sustainable activities will increase in their their utility by at least 10 percent (this is an assumption included in the outcome indicators of the co-financed CONECTA project).

Table 4.5. Distribution of the increase of areas under landscape management through sustainable practices (in ha)

Producer level activities	Expected number of ha
1. Area of landscapes under agroforestry system (cumulative)	732
2. Area of landscapes under sustainable livestock system (cumulative)	6,592
3. Area of landscapes under river restoration (cumulative)	402

[3] The triangular number is n (n+1)/2, and for five project years 5 x 6 / 2.
[4] The formula for year n is therefore: n x n (n+1) / 2.

4. Area of landscapes under conservation and reduced pressure of deforestation (cumulative)	260,333
Total area	268,059

Source: Own elaboration

The four types of selected activities are the agroforestry system, sustainable livestock system, and conserved and restored areas taken from Lara-Pulido et al. (2014). Lara-Pulido et al. (2014) provide the socio-economic value of these activities for Mexico additional to the private (financial) return. The direct and indirect costs and benefits and externalities were quantified. Direct costs and benefits are generated by the operation of activity and generally translate into monetary flows, for example, income from the sale of a forest product. The indirect ones are costs and benefits generated by the operation of the project, and that affect it, but that are generally not monetized; for example, unsustainable agricultural practices generate erosion, which eventually translates into a decrease in productivity, but the producer does not consider this. Therefore, there may be an underestimation of the benefits.

Costs and benefits of RIOS

Aligned with other previous studies and GCF implementation plan, it is assumed: (i) a 20-year period to assess the economic feasibility of the project, aligned with the RIOS period; (iii) that there are no further incremental changes of project-generated benefits beyond the 20-year project evaluation period; (iii) that project costs are only in the five years of project implementation, but the benefits and opportunity costs are assumed to be generated beyond the implementation period (for 15 more years); (iv) and because the areas per activity will be based on a voluntary RfP more time is required at the start than at a later point of the project, and (iv) that the distribution of benefits (an increase of areas under improved landscape management and sustainable practices) is based on the triangular number[5] for five project years; the project divided by 15 to obtain the factor that is added to the growth of the previous year each year.[6]

The distribution of project costs is assumed to follow the same pattern, having lower investment costs in the early years and increasing project investments in later project years. Project costs over the implementation period are approximated considering the project financing of US$10 million by GCF (including US$1 million co-financed). The opportunity costs of traditional agricultural production (US$ 54.65) and traditional cattle ranching (US$ 120.99) in the intervened areas taken from Lara-Pulido et al. (2014),[7] and an assumption of two percent, as an additional operating cost, were added along with the projection of a 20-year project evaluation that will be added for the incremental economic analysis.

To assess project robustness, we followed the approach used for the CONECTA economic

[5] The triangular number is n (n+1)/2, and for five years 5 x 6 / 2.
[6] The formula for year n is therefore: n x n (n+1) / 2.
[7] Number converted from Mexican Peso Currency to U.S. Dollars at April exchange rate, which is equivalent to 24.39 currency units per U.S. Dollar.

analysis and included a sensitivity analysis mainly in the discount rate (alternative rates of six and nine percent) and project horizon (10 and 20 years). This set of sensitivity assessments enables a comprehensive analysis of the economic robustness of the project concerning the changing or differentiated value parameters.

Table A10.1 shows the results and sensitivity analysis, including Net Present Value (NPV) and Benefit-Cost Ratio. The first panel shows the 20-year baseline scenario. The second panel decreases the project lifetime from 20 years to 15 years. The third panel reduces further project lifetime to ten years.

Table A10.1. NPVs (US$) and BC Ratio under Different Scenarios Robustness Check 1. Realistic scenario: project implementation of 20 years and project costs included

		Upper Bound		Lower Bound	
		NPV US$	BC-Ratio	NPV US$	BC-Ratio
Carbon Price (US$60)	Discount rate 6%	$68,071,208	2.30	$30,602,165	1.58
	Discount rate 9%	$52,419,496	2.29	$28,075,381	1.59
Carbon Price (US$40)	Discount rate 6%	$51,776,946	1.99	$14,307,903	1.27
	Discount rate 9%	$39,451,411	1.97	$13,126,516	1.27
Carbon Price (US$3.01)	Discount rate 6%	$21,640,709	1.41	($15,828,334)	0.70
	Discount rate 9%	$15,466,938	1.38	($14,521,408)	0.68

Robustness Check 2.Intermediary scenario: project lifetime 15 years and project costs included

		Upper Bound		Lower Bound	
		NPV US$	BC-Ratio	NPV US$	BC-Ratio
Carbon Price (US$60)	Discount rate 6%	$55,392,295	2.27	$25,152,786	1.57
	Discount rate 9%	$32,864,592	2.20	$20,730,317	1.58
Carbon Price (US$40)	Discount rate 6%	$41,594,997	1.95	$11,355,488	1.26
	Discount rate 9%	$23,747,617	1.87	$9,279,239	1.26
Carbon Price (US$3.01)	Discount rate 6%	$16,076,893	1.37	($14,162,616)	0.68
	Discount rate 9%	$6,885,770	1.25	($11,899,531)	0.66

Robustness Check 3. Conservative scenario: project lifetime 10 years and project costs included

		Upper Bound		Lower Bound	
		NPV US$	BC-Ratio	NPV US$	BC-Ratio
Carbon Price (US$60)	Discount rate 6%	$27,969,251	1.87	$7,404,490	1.23
	Discount rate 9%	$23,747,617	1.87	$6,519,390	1.24
Carbon Price (US$40)	Discount rate 6%	$27,969,251	1.87	$7,404,490	1.23
	Discount rate 9%	$23,747,617	1.87	$6,519,390	1.24
Carbon Price (US$3.01)	Discount rate 6%	$8,631,252	1.27	($11,933,509)	0.63
	Discount rate 9%	$6,885,770	1.25	($10,342,457)	0.62

The results of the economic analysis highlights that all scenarios have a positive NPV and C-B Ratio except the case with lower bound economic values of ecosystem services and carbon Price at voluntary market. In all cases the NPV and C-B ratio is positive when considering the carbon shadow price. This highlights the importance of the Project for global social benefits, and justifies the need for certain activities that may not have a private NPV but have a positive social NPV when considering the shadow carbon price.

Economic analysis of sustainable livestock

One of the main strengths of RIOS is the capacity to leverage private funding, and ensuring long-term sustainability by promoting profitable sustainable practices. This analysis proves that, from a private perspective, RIOS will bring socio-economic co-benefits to the farmers transitioning to sustainable livestock practices. These results sustain the rationale of the schemes supported under Component 1.
There are different ways of implementing livestock activities, with varying levels of technology and interaction with the natural environment. In a complementary approach, there are also the Intensive Silvopastoral Systems (ISPS), a technological module that can be incorporated into grazing systems and consists of establishing protein sources (generally shrubs) for livestock the use of trees to provide shade and enrich the soil. This system has the objective of creating an interaction between vegetative material and livestock, which has been found to significantly increase the productivity of the activity and preserve or restore the ecological integrity of the territory (Azuara-Morales et al., 2020; Chará et al., 2019).

ISPS can produce 12 times more meat than extensive grazing and 4.5 times more than improved pastures without trees, but methane (CH_4) emissions do not increase in the same proportion, being 6.8 and 2.8 times higher in ISPS respectively, which is why which emissions of the same gas per ton of meat are 1.8 times lower in the ISPS than in extensive grazing (Murgueitio, Chará, Barahona, Cuartas, & Naranjo, 2014). In Mexico, an SSP with *Leucaena leucocephala* and *Cocos nucifera* retains between 101.19 and 128.62 tons of carbon per hectare per year (Anguiano, Aguirre, & Palma, 2013). Also, ISPS maintains soil moisture, reduces high ambient temperatures in pastures, improves the productivity and quality of forages, and reduces the seasonality of meat and milk production (Murgueitio et al., 2014). On the other hand, it is pertinent to point out that ISPS is suitable for tropical climates. In dry environments (as in Chihuahua), the low productivity of the soil makes this type of technology unaffordable the investment is well above the increase in productivity.

Table A10.2. Basic parameters for the cost-benefit analysis

Parameter	Units	Jalisco	Veracruz
Ecosystem [a, b,]	Type	Temperate forest Jungles Scrub Pastureland	Pine-oak forests Mountain mesophilic forests Low, high and medium forests Coastal dunes

			Mangroves
Production system (s) [a, b]	Type	Meat production Milk production	Double purpose Broodstock Fattening
Cattle stocks [c]	Heads	3,290,786	4,306,215
Surface [d]	he has	3,726,000	3,600,000
Animal load	Heads/ha	0.883	1,196
Range coefficient	ha/head	1.1	0.8
Weighted range coefficient [b]	ha / AU	8.5	1.8
Cattle standing [e]	ton	432,079.19	479,077.52
Carcass [e]	ton	238,585.99	257,934.74
Meat/hectare [e]	kg / ha	64.0	71.6
Lechel [e]	thousands of liters	2,433,016.85	723,614.93
Milk/hectare	lt / ha	653.0	201.0
Emissions/head [f]	tCO2e / head	1.40	1.40
Emissions	Gg CO2e / year	4607.1	6028.7
Emissions / hectare	ton CO2e / ha	1.24	1.67

Source: Own elaboration with information from a. FONNOR (2020), b. Gulf of Mexico AC Fund (2020), c. SADER (2019a), d . SEMARNAT (2018), e . SADER (2019b) , f . IPCC (2014).

Data and methods

For the cost-benefit analysis, data were collected from reports commissioned within the framework of the GANARE project of the Mexican Fund for the Conservation of Nature (FMCN) financed with resources from the French Development Agency (AFD). Additionally, for the maintenance costs of infrastructure and facilities, information on the technological packages for conventional livestock generated by the Instituted Trusts in Relation to Agriculture (FIRA) was considered the maintenance cost of the facilities that were not reported by the previously referred reports. Other sources were used to estimate greenhouse gases (GHG) produced by this economic activity. In particular, data from Tubiello et al. (2015) to assign methane emissions from livestock, and World Bank (2017) to establish a social valuation of said emissions.

Also, a carbon price of $5per ton was considered to approximate the commercial value of these emissions. The latter was considered to compare the social value of carbon (taking into account the value referred to by the World Bank) with the market value of carbon.
Table A10.3 presents the base data used for each state. The data were used to obtain the baseline of the livestock activity's profitability in the states under analysis. Information regarding the additional investment is required to analyze the profitability of alternative livestock farming, the additional annual costs, and the effect that said investments have on the system's productivity, which is presented below.

Table A10.3. Livestock data for the cost-benefit analysis

Jalisco				
Parameter	**Unit**	**Average value**	**Minimum value**	**Maximum value**

Animal load	Heads/ha	1.45	1.25	1.54
Surface	Hectares	19	5	33
Bellies in production	Heads	28	one	fifty
Milk days	Days/year	290	260	300
Milk production	Liters / day	8.25	6.5	10
Calf weight	Kg	200	300	150
Finished animal weight	Kg	200	198	205
Waste animal weight	Kg	530	500	550
Fertility	Animal / cow / year	one	0.50	one
Total heads	Heads	55	two	100
Cows in milk production	Cows	0	0	0
Belly weight	Kg	600	600	600
Percentage of heads of waste	%	10	10	10

Source: Own elaboration with information from FONNOR (2020).

Veracruz				
Parameter	**Unit**	**Average value**	**Minimum value**	**Maximum value**
Animal load	Heads/ha	one	0.4	one
Surface	Hectares	10	10	2 0
Bellies in production	Heads	10	one	fifteen
Milk days	Days/year	290	260	300
Milk production	Liters / day	16	14	18
Calf weight	Kg	190	180	200
Finished animal weight	Kg	200	198	205
Waste animal weight	Kg	530	500	550
Fertility	Animal / cow / year	0.67	0.67	0.67
Total heads	Heads	17	two	25
Cows in milk production	Cows	10	0	fifteen
Belly weight	Kg	600	600	600
Percentage of heads of waste	%	10	10	10

Source: Own elaboration with information from the Gulf of Mexico Fund (2020).

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Jalisco. Prices and quantities.							
Parameter	**Unit**	**Average amount**	**Minimum amount**	**Maximum quantity**	**Average price (pesos)**	**A minimum price (pesos)**	**Maximum price (pesos)**
Feeding							
Balanced food [to]	Head/year	28	10	Four. Five	5913.00	2190.00	13140.00
Supplements [to]	Head/year	28	10	Four. Five	985.50	365.00	2190.00
Vitamins [a]	Head/year	28	10	Four. Five	197.10	73.00	438.00
Mineral salts [a]	Head/year	28	10	Four. Five	492.75	182.50	1095.00
Health							
Ticks [to]	Head/year	28	10	Four. Five	295.65	109.50	657.00
Antibiotics [a]	Head/year	28	10	Four. Five	295.65	109.50	657.00
Vaccines [to]	Head/year	28	10	Four. Five	197.10	73.00	438.00

Dewormers [to]	Head/year	28	10	Four. Five	197.10	73.00	438.00
Mantto. of paddock							
Barbed wire [a]	Head / year	28	10	Four. Five	197.10	73.00	438.00
Wire for elec fence. [to]	Head / year	28	10	Four. Five	98.55	36.5	219
Grass seed [a]	Head / year	28	10	Four. Five	197.10	73.00	438.00
Herbicides [a]	Head / year	28	10	Four. Five	295.65	109.50	657.00
mosquicidas [to]	Head / year	28	10	Four. Five	197.10	73.00	438.00
pesticides [to]							
Others							
Earrings [a]	Head/year	28	10	Four. Five	98.55	18.50	1095.00
Labor [to]	Head / year	28	10	Four. Five	855.18	1282.77	641.39
Maintained and installed. [b]	Head / year	28	10	Four. Five	470.00	470.00	470.00
Income							
Milk	Liters / year	0	0	0	5.5 6	5.08	7.44
Calves	Calves / year	25	0.50	Four. Five	8,160	7,350	8,970
Waste animals	Heads / year	3	one	5	10,600	8,500	14,850
Emissions							
Capture of CO_2e in vegetation	tCO_2e	0	0	0	1,380	920	1,840
Methane emissions [c]	tCO_2e / head	1,344	1,176	1,512	1,380	920	1,840

Source: Own elaboration with information from a. FONNOR (2020) , b. FIRA (2016) , c. Tubiello et al. (2015) and World Bank (2017) .

Veracruz. Prices and quantities.							
Parameter	**Unit**	**Average amount**	**Minimum amount**	**Maximum quantity**	**Average price (pesos)**	**Minimum price (pesos)**	**Maximum price (pesos)**
Supplies							
Food , stubble, vaccines, dewormer [a]	Head / year	10	7	1 7	12,605	6,948	18,262
Labor [to]	Head / year	10	7	1 7	5,533	5,533	5,533
Fuels and lub. [b]	Head / year	10	7	1 7	253	154	614
Others							
Maintained and installed. [c]	Head / year	10	7	1 7	470	470	470
Income							
Milk [to]	Liters / year	43,152	0	75,330	6.24	5.00	11.22
Calves [to]	Calves / year	5.6	0.5 6	8. 5	6,080	6,798	8 800
Waste animals [to]	Heads / year	one	0. 7	1. 7	10,600	8,500	14,850
Cheese [a]	Kg / year	3,020	0	5,273	40	40	90
Emissions							
Capture of CO_2e in vegetation	tCO_2e	0	0	0	1,380	920	1,840
Methane emissions [d]	tCO_2e / head	1,344	1,176	1,512	1,380	920	1,840

Source: Own elaboration with information from a. Gulf of Mexico Fund (2020) , b. FONCET (2020) , c. FIRA (2016) , d . Tubiello et al. (2015) and World Bank (2017) .

To characterize the transformation of conventional livestock activity towards a sustainable option, the work of Azuara-Morales et al. (2020) , who report the parameters of increase in productivity of silvopastoral systems in tropical climates and of Muñoz-González, Huerta-

Bravo, Lara Bueno, Rangel Santos, & Arana (2016) for the productivity parameters of conventional livestock . For the establishment costs of this type of systems, information from Hernandez Trujillo (2013) was considered , who reports establishment costs for different arrangements of silvopastoral systems .
For the analysis, 3 scales of producers were considered according to the size of their herd and its surface. Table A10.4 presents a description of these scales, the production system and the reduction of greenhouse gas emissions due to technological improvement.

Table A10.4. Characterization of production systems

Parameter	Unit	Jalisco	Veracruz
Transformation option	Type	ISPS	ISPS
Surface			
Small Prod.	Hectare	5 [a]	10 [b]
Medium Prod.	Hectare	19 [to]	10 [b]
Large Prod.	Hectare	33 [to]	20 [b]
Heads			
Small Prod.	Heads	10 [to]	7 [b]
Medium Prod.	Heads	28 [to]	10 [b]
Large Prod.	Heads	45 [to]	17 [b]
Increase in productivity	%	412.9 [c]	625.8 [c]
Carbon capture	tCO2e / ha	24.5 [d]	24.5 [d]
Cost of ISPS	Weights / ha	62,931 [e]	284,601 [e]
Reduction of methane emissions	%	20 [f]	20 [f]

Source: Own elaboration with information from a. FONNOR (2020) , b . Gulf of Mexico AC Fund (2020) , c . Muñoz-González et al. (2016) and Azuara-Morales et al. (2020) , d . Chará et al. (2019) , e . (Hernandez Trujillo, 2013) f . DeRamus, Clement, Giampola, & Dickison (2003) .

The process to perform the cost-benefit analysis was as follows: First, the conventional livestock activity and the option of transformation into a silvopastoral system were parameterized. Then, tables of costs and benefits were generated for each state, both for the baseline and alternative options (see table 4.8). These tables (baseline and alternative livestock system) were processed in the tool available on the website www.acbgiz.org , which allows obtaining the profitability indicators mentioned in Table A10.5. It should be noted that this tool allows a statistical analysis to be carried out to estimate the profitability indicators and their confidence interval, which is estimated from the variation in the input parameters (for example, in sales prices, in the amount of produced milk, etc.). Subsequently, a sensitivity analysis was performed on alternative scenarios with differences in costs and benefits.
The assumptions used for the analysis are a discount rate of 6 and 8%. A period of 20 years was considered to be aligned with the life of the project. The extension of the baseline is maintained, so the adoption of alternative livestock generates an increase in the animal load; that is, more is produced with the same. For Jalisco, it is assumed that l to livestock production is car ne for

Veracruz that l to livestock is dual purpose, and l 100% of cows produce milk e l 7% milk becomes cheese

The analysis does not consider other potential benefits to be derived from the processing of livestock, including those highlighted in Chapter 4.2. In particular, Pezo, Ney RIOS, & Gómez (2018) identify the following co-benefits derived from ISPS: (i) Nutrition and animal welfare. This benefit is directly translated into higher system productivity, which is why it is indirectly considered in the economic analysis; (ii) Nutrient cycle. The ISPS benefits the soil, the feces benefit the plants, and these, in turn, provide the animals with minerals that help their metabolism. Similarly, this benefit is indirectly reflected in the productivity of the system. (iii) Nitrogen fixation and carbon sequestration. The additional vegetation implied by the ISPS increases the levels of nitrogen and carbon in the soil. Carbon sequestration is considered in the economic analysis as previously described. Regarding nitrogen fixation, Solorio et al. (2017) find that this type of system can fix around 400 kg/ha/year, which avoids the purchase of fertilizers such as Urea 46. Conservation of biodiversity. According to the findings of Chará, Murgueitio, Zuluaga, & Giraldo (2011), this type of system can increase the presence of birds by around 32% and of dung beetles by 56%. Water infiltration. According to Villanueva Najarro, Casasola Coto, & Detlefsen Rivera (2018), surface runoff can be reduced from 48% in an overgrazed area to 5% in an ISPS. Erosion avoided. Based on the results of Chará et al. (2011), ISPS can reduce soil erosion by 740 kg/ha / year.

Results

Table A10.6 shows the profitability indicators for conventional livestock. From the private perspective (column 4 of Figure 2), profitability is only found for all types of producers in Veracruz. These results should not be interpreted as in other cases and places this generates activity losses, because have several interpretations, to name a few : (i) Only farms with scale some profiteers because they have better indicators of productivity and lower costs at scale, (ii) they have a percentage of labor that is not paid (the analysis assumes that all labor is paid), (iii) producers receive subsidies that keep the activity apparently profitable, (iv) Producers have alternative activities from which they receive income and do not perceive the losses that they are obtaining from livestock.

The mentioned scale factor can be confirmed by looking at the column "probability of success," which indicates the proportion of cases in which a positive profit is obtained. As can be seen for Jalisco and Veracruz, profitability increases as the size of the producer increases, confirming that, to larger areas, larger l herd, better technology, and the probability of profit is higher. This is not to say that the recommendation is to expand the livestock frontier; it is simply found that the largest producers have a higher chance of success, which is a common finding in economic activities regardless of the sector.

The results in Table A10.6 serve as a baseline for comparison with an alternative option. In particular, the establishment of ISPS for Jalisco and Veracruz is considered.

Other relevant information presented in Table A10.6 is the net present value from a social perspective (second column). This indicator records the economic value of GHG emissions generated by livestock activity. For this, the social value of carbon estimated by (World Bank, 2017) is used. As can be seen, social profitability is always lower than private profitability (column 4), which is because emissions from livestock have a negative impact on the world. Similarly, these values serve as a baseline for comparison with alternative livestock to identify the mitigation contribution of this second option. The third column presents the economic profitability, including GHG emissions, but considering a price of $ 5 per tCO_2e. This value is considered because it is close to the carbon exchange prices that currently exist in Mexico.

In summary, column 2 indicates the social net present value (SNPV), that is, how much livestock is worth to humanity (using the social value of carbon), column 3 what the market value of livestock considering GHG emissions and column 4 what the private value of this activity is.

Table A10.6 Profitability indicators for conventional livestock

Producer type	S NPV (thousands of pesos) (social value of C2Oe)	S NPV (thousands of pesos) (market price of CO2e)	NPV (thousands of pesos)	ICB (social)	ICB (private)	Chance of Success (Private)	Surface (ha)	Herd (animals)
				Jalisco				
Small	-401.9	-121.5	-99.6	-0.34	-0.11	42%	5	10
Medium	-1,155.9	-386.8	-326.7	-0.35	-0.13	35%	19	28
Large	-1,808.8	-551.5	-453.2	-0.34	-0.11	36%	33	Four. Five
				Veracruz				
Small	679.3	772.4	779.6	0.94	1.25	84%	10	7
Medium	1,738.1	1,970.6	1,988.8	0.98	1.31	91%	10	10
Large	1,742.7	1,975.2	1,993.3	0.99	1.31	94%	twenty	17

Source: Own elaboration. N / A: Not available.

Table A10.7. Profitability indicators for alternative livestock

Producer type	VPNS (thousands of pesos) (social value of C2Oe)	VPNS (thousands of pesos) (market price of CO2e)	NPV (thousands of pesos)	ICB (social)	ICB (private)	IRR (private)	Chance of Success (Private)	Optimal density (plants / ha)	Surface (ha)	Herd (animals)
					Jalisco					
Small	2,792.1	1,751.7	1,670.4	1.52	0.91	40.8	86%	7000	5	35
Medium	8,385.0	4,184.6	3,856.4	1.66	0.76	37.1	94%	6000	19	87
Large	14,432.9	7,068.7	6,493.4	1.79	0.8	36.6	98%	6000	33	141
					Veracruz					
Small	5,504.7	3,032.1	2,838.9	1.86	0.96	44	82%	6000	10	22
Medium	12,926.8	10,562.5	10,377.8	1.11	0.89	39.2	90%	12000	10	52
Large	13,241.5	8,331.0	7,947.3	1.7	1.01	45.5	92%	7000	twenty	59

Source: Own elaboration. N / A: Not available.

Table 6 shows the results of the option of transformation to a silvopastoral system . E l analysis assumes that the producer chooses a proportion of land with this system, and plant density maximizes its profit. This exercise was carried out, and it was found that the most profitable is to establish the ISPS on the whole farm, and the plant density depends on the scale and the state.

The results in table A10.7 indicate that the productive conversion is profitable from the private perspective in all cases since the profitability is positive (column 4). The probability of success is high in most cases. Furthermore, the Internal Rate of Return (IRR) is high in most cases. From the social perspective, the conversion is profitable in all cases, which means that humanity, the country, and the producers would all benefit from the productive transformation.

Breakeven point

Table A10.8 shows how the cash flow becomes positive (the breakeven point) and the term in which the investment is recovered (payback period). As can be seen, the terms are short; this means that only in the second year, the producers in Jalisco and Veracruz would have enough cash flow to pay possible financing to establish the ISPS. The table compares other states to demonstrate the feasibility of these systems in selected states.

Table Table A10.8 Break-even point and payback period (years).

State	Scale	Breakeven	Recovery period
Chiapas	Small	3	3
Chiapas	Medium	2	2
Chiapas	Large	2	2
Chihuahua (rot)	Small	6	17
Chihuahua (rot)	Medium	9	18
Chihuahua (rot)	Large	9	18
Chihuahua (int)	Small	8	> 20
Chihuahua (int)	Medium	10	> 20
Chihuahua (int)	Large	10	> 20
Jalisco	Small	2	2
Jalisco	Medium	2	2
Jalisco	Large	2	2
Veracruz	Small	2	2
Veracruz	Medium	2	2
Veracruz	Large	2	2

Source: Own elaboration.

Mitigation potential

To incorporate the emission reductions into the analysis, it was considered that an ISPS captures between 17 and 32 tCO_2e / ha per year and that there is a reduction of enteric emissions of 20%, according to Chará et al. (2019). Table A10.9 shows the mitigation potentials of GHG emissions for the different states, types of producers, and types of livestock. As can be seen, ISPS generates a reduction in GHG emissions in all states. From a per hectare perspective, the conversion to ISPS generates a reduction of approximately 25 tCO_2e / ha. This reduction comes from two ways, the reduction in enteric fermentation because the ISPS provides a better diet and through the capture of carbon by the vegetative material.

Table A10.9 . GHG mitigation parameters.

Status / size	Conventional	Alternative	Change in emissions	Average hectares	tCO2e / ha / year
Jalisco					
Small	27.2	-99.3	-6.3	0.3	-25.3
Medium	74.4	-402.7	-23.9	1.0	-25.1
Large	121.5	-707.0	-41.4	1.7	-25.1
Veracruz					
Small	9.1	-237.2	-12.3	0.5	-24.6
Medium	22.5	-225.7	-12.4	0.5	-24.8
Large	22.5	-470.3	-24.6	1.0	-24.6

Source: Own elaboration

The results indicate that investment in ISPS is a profitable option. ISPS generates significant benefits from both the private and social perspectives. The results observed in this analysis support the promotion of livestock transformation to a more sustainable not only option as a green investment but also as an opportunity to improve the livelihoods of the people dedicated to this activity.

Efficiency in achieving project outcomes

The project costs per ha in RIOS is based on the costs of the C6 Proyect. The C6 Implementation Completion and Results Report rated the project efficiency as substantial. The sustainable forest management and agroecology subproject efficiency, the project reported at closing a cost per hectare of USD $279 over four years or USD $69.75 annually. This cost included the payment of salaries of technicians in the field who advised the beneficiaries, labor and inputs equipment and training. The C6 costs remain relatively efficient as compared to other similar projects where studies have estimated costs of USD$ 230.77/ha/year for agroecosystem activities and US$446.15/ha/year for sustainable forest management activities according to CONAFOR`s data in 2014.

Within the general average, the project reported also the associated costs for the management of one hectare of agroforestry and the establishment of one hectare of silvopastoral systems at US$150 annual and US$450 annual respectively. The purchase of specialized equipment as scales and dryers for coffee or electric fences and solar cells for the silvopastoral systems, made the difference in costs per hectare. These costs also included the additional training and technical follow-up provided across subprojects. The C6 efficiency and the expected RIOS efficiency in this regard can also be attributed to the array of outcomes additionally benefiting project areas.