Contribution of the AFOLU sector to the improvement of Belize's NDCs

Final Report - October 30th, 2020

- Fundación Bariloche -

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Executive Summary

This report provides general information and priority analysis about a series of actions and activities (practices, measures and technologies) necessary to strengthen Belize's proposal in its next NDCs. This part of the study is focused on four sectors: agriculture, forestry, biodiversity, and land use. The list of activities include recommendations for mitigation and adaptation based on mitigation potential of single activities and their interactions.

Given the interdependence that exists between the processes of the four sectors, a comprehensive analysis was performed by taking into account the synergies and trade-offs that exist in the AFOLU sector. In this sense, it is conceived that the best route to achieve carbon neutrality or to strengthen NDCs is the one that obtains co-benefits with several goals simultaneously.

The Agriculture Sector proposed action plan comprises four actions (Water Management, Crops Management, Cattle Management and Early Warnings System), each one consists of several specific activities. The adaptation/mitigation potential of these activities was compared to the BAU scenario to address their effectiveness, and their interactions and synergies were discussed. However, a Climate Smart Agriculture proposal that integrates such actions was selected as the most efficient way to cope with climate change issues, since no significant tradeoffs were identified among them. By 2050, this could contribute with a sequestration 45 % greater than that of business as usual (BAU), plus a reduction of crop emissions (45 %), livestock emissions (73%) and land use changes related ones (53 %), sparing more than 150,000 ha of forests in the process.

Within the forestry sector, a series of practices have been identified and described. These practices show different potential to mitigate CO_2e emissions associated with deforestation and forest degradation due to different disturbance sources. Mitigation potentials under specific scenarios were modeled and ranked on basis to four complementary criteria: a) absolute output

differences with BAU (D), b) the absolute reduction of emissions per unit area (effectiveness, E) with respect to BAU projections, c) the relative reduction of emissions per unit of emission (Practice Sensitivity Index, PSI) regarding BAU projections, and d) a preliminary rough estimate of the relative feasibility (F) of instrumentation. In order to provide a prioritization ranking, a multicriteria analysis was then performed, using unweighted D, E, PSI and F values as inputs. Preliminary results indicate that according to the simulated effects of practices, restoration, reduced impact logging (RIL), conservation and slow down degradation rates by logging are the four out nine most promissory forestry practices for the mitigation of mitigations from Belize´s AFOLU sector. A deeper estimation of the economic, social, and technological components of implementation feasibility are necessary to provide better prioritization recommendations.

The biodiversity analysis was based on “the pixel conservation value” (PCV), an *ad hoc* indicator that was developed for representing the conservation priorities of species threatened with extinction in a spatially explicit way on a national scale map. This information was superimposed on the different land covers and uses, including the protected area system, quantitatively estimating the gains or losses in conservation value linked to changes in land use. The BAU scenario with a scenario of duplication of protected areas in all the ecoregions of Belize was compared. The latter represents the additional sequestration of 2.5 Mt of CO_2e regarding the non-application of the recommended measures. This additional capture to be achieved in the 2050 scenario represents a 50% increase in the total carbon sequestration capacity with respect to the BAU.

The Land Use sector computes and integrates all these results by the use of a model, the FABLE calculator, which helps us to measure the importance or sensitivity of each of the proposed measures and thus be able to elucidate which are the most effective.

The results indicate that Belize has the biophysical capacity to be carbon-neutral if the measures that are proposed here are applied, especially emphasizing that it is not necessary to carry out major mitigation efforts in the agricultural sector, whose emissions are very low compared to the total. Rather, Belize should focus on seeking nature-based solutions as the most efficient mitigation and adaptation strategy.

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List of acronyms

AFOLU	Agriculture, Forestry, and Other Land Use (including biodiversity conservation)
BAU	Business as Usual scenario
CAEP	Climate Action Enhancement Package- Belize
CBD	Convention on Biological Diversity
CO_2e	Carbon dioxide equivalent
CSA	Climate Smart Agriculture
CRM	Crop Management
CTM	Cattle Management
CDM	Clean Development Mechanism
CIAT	International Center of Tropical Agriculture
EAW	Early Warning Forecast
ELE	Extracted Log Emission
FABLE	Food, Agriculture, Biodiversity, Land Use and Energy coalition
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	Greenhouse gases
ha	Hectare
IFM	Improved Forest Management
IPCC	International Panel of Climate Change
IIASA	International Institute for Applied System Analysis
IUCN	International Union for Conservation of Nature
Ka	kilo hectare (thousand hectares)
LDF	Logging Damage Factor
LEDS GP	Low Emission Development Strategies Global Partnership
LIF	Logging Infrastructure Factor
LTS	Long-term strategies
LULUCF	Land Use, Land Use Change, and Forestry
MoU	Memorandum of Understanding
Mg	Megagram (ton)
Mt	Megaton (million megagrams)
NDC(s)	Nationally determined contribution
iNDC	Intended Nationally Determined Contribution
NCCO	Belize National Climate Change Office
PCV	Pixel Conservation Value
PSI	Practice Sensitivity Index
RIL	Reduced Impact Logging
SDGs	Sustainable Development Goals
TWG	Technical working group- Belize
UNFCCC	United Nations Framework Convention on Climate Change
WAM	Water Management

1. Introduction

The contributions proposed by each country to reduce greenhouse gas emissions (NDCs) are insufficient to achieve the goals of the Paris Agreement (IPCC, 2018). For this reason, international technological and financial efforts have been carried out to urge countries to be more ambitious in complying with their NDCs. Belize has to present a new proposal, more ambitious in reducing emissions than the one presented in 2016 (Government of Belize, 2016), by addressing different barriers like availability, identification of reliable information, identification of appropriate practices, sizing their mitigation potentialities and their suitability, among others. However, from a global perspective, Belize's main link with climate change is more related to adaptation to its consequences than to mitigation of its causes.

That said, in this analysis of the AFOLU sector a list of adaptation activities is presented, some of them also having mitigation potential, which integrates agriculture, land-use, forestry and biodiversity. Given the synergistic and/or antagonistic interactions between these sectors, it is proposed that the best route to link national ambitions with global goals is the one that meets three selection criteria: co-benefits, political feasibility, and biophysical opportunity. These criteria have guided us to carry out this work.

The first criterion for selecting activities, then, is the prioritization of climate solutions that have co-benefits with other sustainability goals, such as the protection of biodiversity and the maintenance of the functionality of ecosystems, together with mitigation and adaptation functions (Greve et al., 2013; Soto-Navarro et al., 2020).

A second selection criterion, among the numerous possible measures, is political feasibility, prioritizing those that correspond to the political will expressed in the country, that correspond to pre-established government plans, those in progress, partially or totally financed, or agreed with the sectors, i.e. Belize’s NDC (2016) and national plans cited there.

A third and final selection criterion is the biophysical opportunity. The geography of Belize clearly shows us that the country has a great opportunity to offset all its emissions on a natural basis (Griscom et al., 2017), strengthening the management of its large forest areas and extensive protected areas with technologies that increase carbon capture and retention. Unlike many countries, Belize can meet and exceed its climate goals without the need for major land-use transformations or substantial changes to its food system (Government of Belize, 2016).

These three criteria show us that Belize's problem is not in the mitigation of its low emissions level, a goal that it can easily achieve, but in the technological needs of adaptation to the consequences of climate change. Although this study presents mitigation activities, it is highlighted that in global climate change governance forums, Belize should be shown not only as a country that can achieve negative emissions, providing solutions to the concert of nations, but also as a country that has been and will be harmed by the effects of climate change that the economies of the world's nations have caused. In this sense, just as the mitigation narrative proclaims the co-responsibility of all countries to arrive at a solution, the case of Belize should be shown to the world community as an example that it is necessary to strengthen co-responsibility in the negative effects that the industrialized world have caused outside their territories.

The next sections provide an analysis of Agriculture, Forestry, Biodiversity and Land Use sectors aimed to contribute for Belize´s adaptation and mitigation efforts. This study includes a multi-criteria analysis of the activities, and descriptions of measures suggested for each sector. The criteria and their corresponding weights was obtained from surveys in the available literature and databases. One of the criteria to calculate and weight consisted of calculating the sensitivity of emissions to the adoption of specific activities by applying the FABLE calculator (IIASA, 2020).

2. General procedures

2.1 Definition of the BAU Scenario for Agriculture sector

In order to test the potential of the proposed actions for mitigating the causes and/or adapting to the consequences of climate change, a modelling work on the FABLE Calculator (IIASA, 2020) was carried out. The FABLE Calculator uses information extracted from a global modelling tool called GLOBIOM (Havlík et al., 2018) and allocates land use and production of a selected country (each country has to be constructed in the model through specific data) according to a set of scenarios that are used to simulate trends and possible changes (e.g. Business as Usual (BAU), increasing exports or imports, forbidding or allowing deforestation, increasing crop productivity, forestry mitigation practices, etc.). It works from the demand side (population and GDP growth, determining both internal and exports consumption) and allocates production to supply this demand, which in turn links to the area that is needed to fulfill that production (considering the available land uses and possible changes of the selected country). The results are a set of indicators that are projected in 5-years steps from 2000 to 2050 (2005 to 2020 can be used to validate the model).

The strongest point of this model is that it integrates Agriculture with Forests and Biodiversity through Land Use, adding value to the set of activities on each sub-sector by combining them and providing projected values that can be used to test for possible synergies and trade-offs among them. For example, since land is a finite resource, it will not be possible to increase both reforestation and agricultural land beyond a point. The model could be used to find out which combination of land uses and productions is optimal according to the pre-selected scenarios. Besides, it provides a scaled up combination of the effects of such activities and decisions on the indicators, including GHG emissions and sequestrations.

To assess the impact of the selected actions, a BAU scenario was constructed through a combination of methods. Before doing so, a version of the Calculator was specifically designed for Belize, constructed from an empty Reference Calculator. To do that, country specific information on population, income, food consumption, land use, production, yield, imports and exports, costs and a great number of additional characteristics of Belize's food and land use systems was collected from an extensive literature and internet review. The model needs information for the year 2000 to set the starting point (baseline), and also for the years 2005, 2010 and 2015 to validate the results.

Fable calculator was set up by selecting the combination of scenarios that fit the most to the country statistics up to 2020, but also those that allow a final land use distribution that was close to the projection. This set of scenarios can be described as an ambitious evolution of food production systems, not depending on imports (other than products that are not able to be produced in Belize), and even exporting at levels that double or triple current values of main exported products (e.g. banana, citrus, sugarcane). Besides, this BAU scenario considers no measures regarding forest protection, biodiversity, or GHG emissions reduction (such as Bonn Challenge, the Aichi Targets, the Paris Agreement, etc.). The main indicators to describe this BAU can be found in the Annex.

Then, all the proposed measures were incorporated into the model separately by changing the scenario settings, thus creating a total of 15 versions of the calculator. Their mitigation and adaptation potential was then estimated as the difference between the relevant indicators of these versions and the BAU scenario. In all cases, since the Calculator works from the production demand side, the adaptation potential of all practices was automatically considered. The logic of the model does not allow a measure to diminish food production. For example, if a country were to protect all natural areas and halt agricultural expansion, the model will force a way to provide its estimated population to be fed (through increasing imports, decreasing exports, switching to more yielding products, etc.). So, all the measures proposed were compared in a way that their implementation would not affect future food security and trade balance of food products, even considering in all cases a climate change scenario of global GHG concentration trajectory that would lead to a global mean warming increase likely between 2°C and 3°C above pre-industrial temperatures by 2100 (RCP 6) (van Vuuren et al., 2011).

2.2 Definition of the BAU Scenario for Forestry sector

Land use changes for the period 2000-2018 were used to project land use distribution up to 2050 (Land Use BAU 2050), based on land cover and land use data provided by the Belize Forest Department (2020). Land Use BAU 2050 was obtained by adjusting and exponential model to land use data for the 2000-2018 period as provided by supplementary material in Belize Forest Department (2020), and following the approach of Puyravaud (2003).

2.3 Definition of the modelling analyses for Agriculture and Forestry sectors

Agriculture Sector:

The selected actions were incorporated in the modelling through different scenarios (Table 3.1).

Table 3.1. Simulated agriculture scenarios; all figures as compared to BAU.

Agricultural Actions	**Scenarios definition**
Water Management	- Increase in productivity of crops (20-50%) according to irrigation potential) and importance of crop - Increase in milk production - Increase in vegetables production (20%) - Reduction in N_2O emissions (20%) due to proper fertilization - Increase in irrigation water use efficiency - Increase in rice productivity (20%)
Crops Management	- Increase in productivity of crops (30-60%) - Increase in vegetables production (20%) - Reduction in N_2O emissions (20%) due to proper fertilization - Reduction of CO_2 emissions from agricultural soils
Cattle Management	- Increase in productivity of beef and milk (20%) - Increase in pork and poultry production (30%) - Reduction in N_2O and CH_4 emissions (20%) - Reduction of CO_2 emissions from agricultural soils
Early Warnings	- Increase in stability of beef and milk production (20%) - Increase in stability of crop production (20%)
Climate Smart Agriculture	- Combination of all of the above

Forestry Sector:

Mitigation potentials of a series of forestry practices were assessed through the following steps: 1) Land Use BAU 2050 was translated to emission or sequestration terms using gases flow data from Belize Forest Department (2020, supplementary material), 2) specific scenarios of emission or sequestration rates were simulated for comparable levels of adoption, for nine of the most important forestry practices, and using published parameters or conservative assumptions (Table 3.2), 3) in order to prioritize these practices according to their mitigation potential, four partial prioritization criteria were defined and quantified: a) absolute output differences between simulated emissions (with practices) and simulated emissions according to BAU (D), b) the absolute reduction of emissions per unit area (effectiveness, E) with respect to BAU projections, c) the relative reduction of emissions per unit of emission (Practice Sensitivity Index, PSI, calculated as D/BAU emissions) regarding BAU projections, and d) a preliminary rough estimate of the relative feasibility (F) of instrumentation. In order to provide a prioritization ranking, a multicriteria analysis was then performed, using unweighted D, E, PSI and F values as inputs.

Table 3.2. Simulated forestry scenarios; all figures as compared to BAU.

Forestry practices	Scenarios definition	Targets
Conservation	A 20% reduction in the forest covers that would be transferred to other uses according to BAU projections. Allocation of that 20% to strict conservation (no logging, no grazing).	All forest types affected by anthropic disturbances during the 1999-2018 period, and according to BAU predicted proportions
Protecting forests from disturbances - Suppression of forest fires	A 20% reduction in expected forest cover affected by fires according to BAU projections.	All forest types affected by fires during the 1999-2018 period and according to BAU predicted proportions
Protecting forests from disturbances - Grazing	A 20% reduction in expected forest cover affected by grazing according to BAU projections.	All forest types affected by grazing during the 1999-2018 period and according to BAU predicted proportions
Protecting forests from disturbances - Pests	A 20% reduction in expected forest cover affected by pests according to BAU projections.	Forest type affected by beetles during the 1999-2018 period (Pine forests)
Protecting forests from disturbances - Logging	A 20% reduction in expected forest cover affected by logging according to BAU projections.	All forest types affected by logging during the 1999-2018 period and according to BAU predicted proportions
Reforestation with fast-growing species	A 20% increment in expected plantations with fast-growing tree species to BAU projections.	All forest types affected by replaced by plantations during the 1999-2018 period and according to BAU predicted proportions
Forest restoration	A 20% increment in expected forest cover according to BAU projections plus 20% increment in the above- and below-ground forest growth rate.	All forest types according to BAU predicted proportions
Low / Reduced impact logging (RIL)	A 20% reduction in CO_2e emissions from logging used forests.	All forest types affected by logging during the 1999-2018 period and according to BAU predicted proportions

2.4. Biodiversity analysis

To ensure the benefits that greenhouse gas mitigation has for biodiversity conservation, a numerical index was generated that indicates the priority of conservation in a spatially explicit way (see section 5).

To construct this indicator, the species of mammals, birds, reptiles and amphibians with the highest degree of threat in Belize (70 species) were selected, the shapes with the geographical range were obtained, a weight was assigned to each species according to its category threat level and proceeded to add that value for each pixel, obtaining a conservative valuation map of Belize, broken down for each land use.

In this way, the effect that each change in land use has on biodiversity conservation goals can be calculated. The effectiveness of biodiversity conservation goals in mitigating GHG is also calculated.

3. Agriculture Sector

3.1 Context and recent history

Agriculture plays an important role in Belize's economy, contributing around 15% to Gross Domestic Product (GDP), about 50% to export earnings, and provides a significant base for employment and income generation in the rural areas. In the last years, agricultural exports were of approximately US$ 232 million per year (sugar, orange concentrate, banana, papayas and animal feed), while in contrast, agricultural imports were very modest (US$ 15 million per year), including wheat, corn flour, malt, potatoes and rice. Since the beginning of this century, there has been growth in the agricultural sector. However, there is no shortage of recommendations on what still needs to be done (Budram, 2014).

Up until now, most policies seeking to facilitate the long-term growth of the sector were market-led approaches (e.g. the need to make the sector more competitive in both the domestic and export markets, diversification of production, incorporation of the issue of sustainability in agricultural production, strengthening of inter-sectoral linkages).

These policies emphasized the country’s dependence on a few traditional agricultural products that were exported to preferential markets (oranges, bananas, sugar). Since Belize’s major agricultural exports are not competitive enough compared with major exporters, added to the fact that the small size of the domestic market limits diversification and achievement of scale economies, major threats to the sector became relevant.

On the other hand, non-traditional production expansion is critical to contribute to food security, diversification and small farm development. Various vegetables and livestock products and animal feed, oils and fats are imported and could be produced locally and even exported. Belize could produce soybean competitively, it could explore an agriculture-tourism linkage (e.g. for onions, tomatoes, cabbage, carrots, lettuce, milk, and meat products). Belize is self-sufficient in poultry meat, which is also a critical food security commodity, but there is a need to improve production efficiency. The country has much potential to expand livestock production but is constrained by the small local market size. More efficient production systems are needed for Belize to compete in external markets. Similarly, both the dairy and pig sub-sectors need to be more competitive with imports and to meet the growing local demand.

Although the Belizean economy and its agricultural sector have undergone many changes since the 1990s, most of the policy and strategic options recommended then are still relevant for improving its performance. However, the sector faces new challenges and issues, coming from both internal and external origins. The food system is changing: more competition, greater diversity, increased demand for quality, year round availability and safer food products. The emergence of food chains is becoming increasingly important: off-farm food systems, more industrial (processing), greater commercialization (marketing, retailing, branding) of food products. Information and communication technologies are playing a larger role, from planning at the farm level to all aspects of the value chain and the emergence of precision agriculture. Moreover, of course, climate change is becoming an increasing threat that affects the sector in multiple ways (Budram, 2014).

Agriculture in Belize is susceptible to weather variability and vulnerable to climate hazards, such as hurricanes, floods, and droughts. This vulnerability will likely increase over time, potentially resulting in rainfall decreases ranging from 7% to 10% (north to south). Besides the decrease in annual precipitation, an increased variability in the seasonal distribution of rainfall is expected to lead to more frequent droughts and floods. Additionally, projected rises in temperature of 1.3 °C by the 2030s will increase stress on crops and livestock, affecting agricultural systems, forcing changes in management practices, and threatening food production (CIAT-World Bank. 2018a).

Belize's agricultural sector contribution to greenhouse gasses emissions is negligible: around 0.3 Mt CO_2e in 2015 (Gauss International Consulting S.L., 2019), which justifies putting most efforts in Adaptation rather than Mitigation. Besides coping with climate change and its effects, agricultural products need to maintain and increase its production, since they are integral to the average Belizean food basket, hence critical to food security. The policy objectives recommended were to achieve and maintain self-sufficiency on a competitive basis, achieve output increases in the medium and longer term to meet projected higher demand in the domestic market, and improve productivity and incomes of small and medium-sized farmers.

Strategies to achieve a higher self-sufficiency level, reduce government subsidies, make local production more competitive with imports, reduce production costs and improve quality through improved seeds, better technology, improved infrastructure, irrigation and support facilities and access to credit are key to achieve food security. Besides, climate change effects require that Belize develop a more Climate Smart Agriculture and one that can continually adapt to the challenges of climate change (CIAT-World Bank. 2018a).

Although there have been advances in identifying, describing and prioritizing such measures, the adoption of Climate Smart Agriculture practices has been slow due to multiple barriers, including lack of information about those promising practices, lack of technical knowledge on the part of farmers, lack of resources to finance initial investment costs, and lack of affordable credit and crop insurance, among others (CIAT-World Bank. 2018b).

3.2 List of Agriculture actions and activities

Proposed ideas to cope with climate change effects in the agricultural sector were organized in five “Action Points”, with each one consisting of one or more “Activities”. The last action point is transversal to the rest of them, and consists of basic policies and strategies that the government should pursue in order to facilitate the successful implementation of a Climate Smart Agriculture in Belize (Table 3.3). To list and describe the activities, several existing documents, reports and other publications were analyzed and integrated (FAO, 2010; Calle *et al.*, 2012; Foster *et al.*, 2017; CIAT-World Bank, 2018a,b; Government of Belize, 2018; Belize Forest Department, 2020).

Table 3.3. The list of Action Points and their activities is as follows

Action Point	Activity	Mitigation (M) or Adaptation (A)?	Most relevant for these products
Water Management	Drainage and Irrigation Infrastructure	A	Banana, Citrus, Rice, Sugarcane
	Irrigation and Fertigation	A	Banana, Beans, Citrus, Corn, Potato, Sugarcane, Vegetables
	Cover structures	A	Vegetables (e.g. tomatoes, cabbage, carrots, lettuce)
	Integrated Water Management	A > M	Sugarcane
Annual and Perennial Crops Management	Crop Rotation	A	Alfalfa pastures, Beans, Corn, Mombasa, Soybean,
	Cover crops	A	Alfalfa, Cowpeas, Clovers, Sesbania
	Intercropping	A	Alfalfa, Banana, Citrus, Coconut, Pineapple
	Enhanced Crop Genetics	A	Beans, Coconut, Corn, Irish Potatoes, Sugarcane, Vegetables
	Precision Agriculture	A > M	All current and future annual and perennial crops
	Conservation Agriculture	A & M	All current and future annual and perennial crops
Cattle Management	Pasture improvement	A > M	Beef Cattle, Dairy Cattle
	Feed Supplements	A > M	Beef Cattle, Dairy Cattle, Pigs, Poultry
	Livestock breeds	A	Beef Cattle
	Agroforestry	M > A	Beef Cattle, Dairy Cattle
	Manure Management	M - A	Beef Cattle, Dairy Cattle, Pigs, Poultry
Early Warnings	Weather forecasting and early warnings for Hurricanes, Floods, Droughts	A	All crops and cattle products

Transversal activities/measures needed to implement a successful Climate Smart Agriculture	Adopt innovative approaches to develop efficient small-farm production systems (loans, technology transference, market developments, and combinations).
	Develop new approaches to finance Climate Smart Agriculture through accessible loans and helping farmers access to international sources of funds.
	Improve the incentive system to attract both local and foreign investment, e.g. simplify regulations and bureaucratic procedures in order to reduce the costs of doing business, improve access to specific markets and improve the sector's competitiveness in open markets.
	Invest in support services and basic infrastructure (e.g. roads, access, ports, basic services)
	Increase investments in agricultural research and development (in all of the action points mentioned above), including the establishment of information systems for decision making.
	Assistance and Technology transfer, especially to small farmers
	Establish a national Climate Smart Agriculture coordination mechanism to support knowledge sharing, avoid overlapping work, and add value to ongoing work.
	Formulate an agricultural development strategy, identifying the principal policy objectives and measures to be adopted for the sector, and priority areas to be targeted.

3.2.1 Water Management

The effects of global warming are already evident in Belize, namely increase of surface air temperature and high variability in seasonal rainfall (GOB-NCCO, 2016). Harsh growing conditions due to eventual heavy rainfalls, excessive heat, excessive evaporation, direct solar radiation, proliferation of pests (insects and birds), etc. are also consequences of this process. Irrigation is barely present or inefficient, less than 50% of potato crop is under drip irrigation (northern Belize). On the other side, corn, beans, and tubers are mostly rain fed, which results in low and variable yields. Rice is cultivated with flood irrigation in the Orange Walk District, dry spells affect yields and cause outbreaks of pests and diseases. There is also a growing environmental concern around the Vinasse, a by-product of the ethanol industry, generated from the rectification and distillation operations.

A water management approach that drip irrigation with fertilization could result in increased rainwater harvesting, increased yields and stable production. It could also be used to decrease the appearance of weeds and diseases (due to dry soil between rows), reduce the need of fertilizers (through their progressive liberation), limit drought effects and at the same time prevent soil salinization and erosion.

Cover structures can reduce evaporation and pest incidence in vegetable production systems, improving produce quality, reducing cost of production, maximizing water conservation and reducing dependence on pesticides. There are four types: Tropical Greenhouse, Bubble House, Bel Tunnel and Plastic Covered Structure. These structures may incorporate cooling technologies such as passive or mechanical ventilation, evaporative cooling fans and heat exchange systems).

Finally, an integrated industrial-agricultural system could benefit from harnessing the Vinasse from ethanol production and irrigating sugarcane crops with it, leading to increased yield and stability, resistance to droughts and reduced dependence on pesticides. Besides, this could reduce eutrophication of water bodies by giving alternative management to industry waste.

According to the results of the modelling, applying these activities aimed at improving water management could decrease the emission of agriculture-related GHGs by 37.4 % by 2050, and result in a more beneficial GHG balance (around 1.8 Mt CO_2e per year) due to land sparing from higher and more stable yields in agricultural lands (Table 3.4). These savings in deforestation for agricultural expansion result in 11% increase of sequestration and 60% decrease in emissions due to land use changes by 2050. Besides, Total crop area could be reduced while maintaining production levels, and the water footprint could be drastically reduced because of more efficient irrigation.

Table 3.4. Selected indicators to address the potential capacity of Water Management (WAM) for climate change Adaptation/Mitigation

Indicator	**Units**	**2030**		**2050**	
		BAU	**WAM**	**BAU**	**WAM**
Total GHG emissions from AFOLU sector	Mt CO_2e yr^{-1}	-4.530	-5.280	-4.934	-6.707
GHG Emissions from crops	Mt CO_2e yr^{-1}	0.082	0.063	0.131	0.082
Total area of annual and perennial crops	ha	174,905	143,820	260,356	176,254
Total area of forests	ha	1,320,013	1,354,874	1,179,061	1,305,692
Total blue water footprint	Mm^3	21.83	18.29	37.94	18.30
GHG Emissions from forests	Mt CO_2e yr^{-1}	-6.542	-3.357	-6.860	-7.597
GHG Emissions from land use change	Mt CO_2e yr^{-1}	1.710	1.179	1.374	0.551

Although effective in both mitigating and adapting to climate change, the high costs of implementation (land movements, construction of channels, etc.) and need for accurate topographic studies, as well as the initial costs for drip/sprinkler irrigation systems could prevent farmers and communities from pursuing these actions. Besides, water availability and reliability during the dry season, maintenance costs, energy sources for water pumps, and lack of technical capacity are issues that could also arise. Under poor management, these systems can result in water loss and inefficiency. Tropical greenhouses are challenging to control, high internal temperatures limit the number of working hours inside. Initial costs for cooling system components are too high for individual small, subsistence farmers. In the case of industrial-agricultural integration, the economic feasibility is linked to favorable economic indicators for the biofuel industry.

On the other hand, implementing these actions could generate employment for construction and maintenance. This technology can be used in conjunction with other climate change adaptation measures such as water harvesting, multi-cropping and fertilizer management (fertigation system). Besides, the reduced need for synthetic fertilizers could decrease GHG emissions from the industry and transport sectors.

3.2.2 Annual and Perennial Crops Management

In previous years, the expansion of mono-cropping agriculture with no soil conservation strategy has led to increased release of agrochemical, increased sedimentation and decreased soil fertility. Other problems include low yields and high inter-annual variability, presence of insect-transmitted viruses in Irish potatoes, soil erosion, nutrient leaching, and excessive evaporation. The unsustainable land use impacts soil and water quality (e.g. in the Greater Belize River Watershed, where more than 40% of Belize’s population. As stated before, the effects of climate change will exacerbate this situation in the short and medium term.

To cope with this situation, there is a need for improved soil and water quality, land value and crop yields, increased diversification in production, processing and exports, and improved access to productive resources and economic opportunities for small/young farmers, women and indigenous people, particularly in poor, marginal areas, and thus increasing food security. Another relevant objective of these activities is the reduction of soil and water pollution due to more efficient use of agrochemicals, increased production and stability, reduced soil erosion and its externalities.

The rotation of different annual crops and pastures enhances root exploration, soil cover, balanced nutrients extraction and diversification of production. Besides, the use of service crops is an efficient way to reduce soil erosion, evaporation, weeds invasions and increase soil fertility. Another feasible option is to sow varied crops in patches or stripes (e.g. citrus with coconut or pineapple, or bananas with N-fixing leguminous plants), in order to diversify income and food sources, allowing constant production throughout the year. Besides the inclusion of climate resilient varieties of open pollinated corn, beans and Irish potatoes, high sugar content sugarcane, heat- and drought- tolerant varieties for other crops (e.g. rice) could boost these benefits.

Through precision agriculture, which consists of the determination of site-specific plant densities, sowing and harvesting dates (to adjust to regional rain patterns), soil management practices, and the use of fertilizers pesticides, agricultural production could enhance food security. In combination with the latter, conservation agriculture consists of three aspects: minimal soil mechanical disturbance (no tillage or vertical tillage), maintenance of mulch cover, and rotations or associations of crops, trees and pastures, including nitrogen-fixing legumes. This type of agriculture contributes to adaptation by reducing crop vulnerability (shield from heat, wind and rain, reduces crop water requirements, facilitates deeper rooting, rainwater infiltration, etc.). It also minimizes soil erosion and nutrient losses through leaching. Conserves soil biota, structure, and in situ moisture. Regarding mitigation, it promotes soil carbon stocks and organic matter accumulation, thus reducing GHG emissions attributed to minimum soil disturbance and the lower use of fossil fuels.

In the model, the application of the mentioned crop management activities results in an estimated decrease of the emission of agriculture-related GHGs of by 45 % by 2050, and increased sequestration of 1.3 Mt CO_2e per year (Table 3.5). This improvement is achieved through forestland sparing, which reduces land use change related emissions by half and increases sequestration in around 8 % by 2050.

Table 3.5. Selected indicators to address the potential capacity of Crops Management (CRM) for climate change Adaptation/Mitigation

Indicator	**Units**	**2030**		**2050**	
		BAU	**CRM**	**BAU**	**CRM**
Total GHG emissions from AFOLU sector	Mt CO_2e yr^{-1}	-4.530	-5.055	-4.934	-6.252
GHG Emissions from crops	Mt CO_2e yr^{-1}	0.082	0.067	0.131	0.073
Total area of annual and perennial crops	ha	174,905	150,962	260,356	161,137
Total area of forests	ha	1,320,013	1,343,957	1,179,061	1,276,516
GHG Emissions from forests	Mt CO_2e yr^{-1}	-6.542	-6.660	-6.860	-7.427
GHG Emissions from land use change	Mt CO_2e yr^{-1}	1.710	1.318	1.374	0.682

In order to introduce these practices in Belize’s agricultural systems, minimal to mediate increases in costs associated with seeds, inputs and technology distribution need to be considered. Besides, there is need for research on the optimal crop rotation and intercropping schemes for each region, which cover crops could be most beneficial, etc. Regarding cover crops, there seems to be limited awareness and knowledge of this new approach, which requires investigation/development of climate resistant varieties.

Possible identified complications for implementing precision agriculture are: 1) lack of interest to participate, 2) inability to get the necessary capital investment for monitoring, 3) lack of political will to support the establishment of laboratories, providing weather, soil and satellite information (this activity is linked to the successful implementation of action 3.2.4). Specific research is needed for each crop in each region, and access to technology and information is key for this action. Regarding conservation agriculture (e.g. no till), there are technological and adoption constraints, so it will require intervention from the government and/or investment sector. On the negative side, no till practices usually need an increase in the use of pesticides to replace the weed control that is carried out by tillage.

3.2.3 Cattle Management

Adaptation issues related to livestock management should be centered in mitigation rather than adaptation, since the impacts of climate change on the sector are projected to be modest.

However, cattle production in Belize suffers from very low productivity and quality, leading to the need of imports (e.g. selected cuts for tourists). Besides, production is highly variable and vulnerable to extreme conditions (temperatures, droughts, etc.).

The proposed actions aim at increasing animal yield and income through high-quality food, decreasing vulnerability to drought and feed scarcity, reducing methane GHG emissions due to high-quality feed, increasing profits and reducing production costs and reducing fodder/forage required for attaining maximum yield. Besides, increased resilience to extreme climate conditions, diversified production, risk spreading, are all increasingly important as impacts of climate change may become more pronounced.

To do this, decisions such as incorporation of silage, hay and grain into cattle rations, use of improved breeds (such as Brangus, a desirable Angus beef-type animal that retains the Brahman's natural ability to thrive under adverse conditions), and the efficient treatment of manure (on field distribution, anaerobic digestion, composting) are proposed. More integral solutions such as the development of Intensive Silvopastoral System (Use of trees and shrubs in agricultural crops and/or animal production for improved fallows), multipurpose trees and shrubs (ornamental, feed, shadow for animals), boundary planting, windbreaks, conservation hedges, live fences, tree apiculture are also complementary alternatives. .

In line with the previous described actions, cattle management options to cope with climate change issues were modelled and results are presented in Table 3.6. The implementation of such practices resulted in an increase in sequestration from the AFOLU sector of almost 20%. Through a 50% reduction of the area of pastures and number of cattle heads (considering only beef cattle) by 2050, the livestock sector contributes to an equivalent saving in emissions (especially CH_4 and N_2O). In turn, this sparing of forestlands increases sequestration and reduces emissions associated with land use changes.

With respect to the requirements to implement these actions, the need for investments and management technology dissemination are the most noticeable. Pasture improvements and provision of feed supplements can be more or less easily covered by the government in the form of subsidies. On the other hand, manure management systems, and individuals from improved breeds require more than just financial aids, these technologies need to be adapted for the country and then disseminated. For example, manure management needs infrastructure to collect, storage, distribute and/or process it.

Table 3.6. Selected indicators to address the potential capacity of Cattle Management (CTM) for climate change Adaptation/Mitigation

Indicator	**Units**	**2030**		**2050**	
		BAU	**CTM**	**BAU**	**CTM**
Total GHG emissions from AFOLU sector	Mt CO_2e yr^{-1}	-4.530	-4.807	-4.934	-5.912
GHG Emissions from livestock	Mt CO_2e yr^{-1}	0.220	0.180	0.420	0.207
Total area of pastures	ha	57,260	45,947	112,462	51,982
Total number of heads of beef cattle	TLU*	57,649	46,246	112,829	52,092
Total area of forests	ha	1,320,013	1,330,685	1,179,061	1,237,334
GHG Emissions from forests	Mt CO_2e yr^{-1}	-6.542	-6.595	-6.860	-7.199
GHG Emissions from land use change	Mt CO_2e yr^{-1}	1.710	1.525	1.374	0.949

* TLU = Tropical livestock units

Agroforestry is still constrained by local customs, institutions and national policies. There is a need for capacity building, extension and research programs to screen and to match species with the right ecological zones and agricultural practices. On the bright side, there is a strong synergy with reduction in GHG emissions and biodiversity protection. It could even be useful to qualify for carbon credits for reforestation and afforestation projects.

3.2.4 Early Warnings and Weather Forecasting

As stated before, agriculture in Belize is susceptible to weather variability and vulnerable to climate hazards, such as hurricanes, floods, and droughts. There is not much to do in regard to hurricanes, but in a constantly changing environment, improving the use of climate science data for agricultural planning can reduce the uncertainties generated by climate change. By generating an Early Warning System for drought, flood, pest and disease incidences, the capacity of farmers and agricultural planners to allocate resources effectively and reduce risks could be increased. Accurate, timely and consistent environmental information to inform policy makers and farmers will definitely increase resilience to climate change and security. Yield forecasting also contributes to better planning.

In the results, this better planning was converted into increased yields for crop and cattle activities, generating results similar to the combination of the previous ones (Table 3.7). However, in order to reach these goals, the early warning system is not sufficient on its own, and in order to fulfill these objectives, it needs the implementation of some (or even most) of the strategies described earlier. The real outcome of such a system could be the reduction in production variability due to climatic oscillations (a feature that cannot be addressed in a 5-year step deterministic model).

Table 3.7. Selected indicators to address the potential capacity of Early Warnings (EAW) for climate change Adaptation/Mitigation

Indicator	**Units**	**2030**		**2050**	
		BAU	**EAW**	**BAU**	**EAW**
Total GHG emissions from AFOLU sector	Mt CO_2e yr^{-1}	-4.530	-4.936	-4.934	-6.283
GHG Emissions from crops	Mt CO_2e yr^{-1}	0.082	0.076	0.131	0.105
Total area of annual and perennial crops	ha	174,905	165,660	260,356	216,924
GHG Emissions from livestock	Mt CO_2e yr^{-1}	0.220	0.191	0.420	0.256
Total area of pastures	ha	57,260	48,981	112,462	65,430
Total number of heads of beef cattle	TLU*	57,649	49,304	112,829	65,549
Total area of forests	ha	1,320,013	1,337,078	1,179,061	1,269,065
GHG Emissions from forests	Mt CO_2e yr^{-1}	-6.542	-6.262	-6.860	-7.384
GHG Emissions from land use change	Mt CO_2e yr^{-1}	1.710	1.423	1.374	0.741

* TLU = Tropical livestock units

This implementation will need a strong investment in technology (e.g. environmental/marine observation platforms, data loggers, software and hardware, increased database analysis capacity, etc.). In marginal lands from semiarid areas, which are particularly vulnerable to climate change, improved forecasting of risks, determination of the effects of climate change, early detection and control of disease outbreaks are fundamental to allow prompt responses and build resilience.

3.2.5 Climate Smart Agriculture (integration of previous actions)

Table 3.8 lists under the implementation of a Climate Smart Agriculture (CSA) for Belize a number of transversal activities that the government could pursue in order to establish, disseminate and make the most of the previously listed actions and activities. To incorporate them into the modelling approach, it was assumed that CSA would need a synergistic combination of most of the activities from each of the action points.

The outcome of this combined approach (Table 3.8) resulted in a negative AFOLU sector's emissions balance that could be 45 % greater (an extra 2.3 Mt CO_2e per year sequestered by 2050). This global achievement would be obtained by a 45% reduction of crops emissions, a 73% reduction of livestock emissions, and a 53% reduction of the emissions related to land use changes. If this is fulfilled, more than 150,000 ha of forests could be spared (and not converted to around 100,000 ha of crops and 50,000 ha of pastures), and at the same time, maintaining the country's production levels that are relevant both for food security and the economy.

Table 3.8. Selected indicators to address the potential capacity of Climate Smart Agriculture (CSA) for climate change Adaptation/Mitigation

Indicator	**Units**	**2030**		**2050**	
		BAU	**CSA**	**BAU**	**CSA**
Total GHG emissions from AFOLU sector	Mt CO_2e yr^{-1}	-4.530	-5.492	-4.934	-7.162
GHG Emissions from crops	Mt CO_2e yr^{-1}	0.082	0.061	0.131	0.074
Total area of annual and perennial crops	ha	174,905	139,673	260,356	161,831
GHG Emissions from livestock	Mt CO_2e yr^{-1}	0.220	0.135	0.420	0.155
Total area of pastures	ha	57,260	45,947	112,462	51,982
Total number of heads of beef cattle	TLU*	57,649	46,246	112,829	52,092
Total area of forests	ha	1,320,013	1,361,873	1,179,061	1,331,816
GHG Emissions from forests	Mt CO_2e yr^{-1}	-6.542	-6.749	-6.860	-7.749
GHG Emissions from land use change	Mt CO_2e yr^{-1}	1.710	1.061	1.374	0.358
Total blue water footprint	Mm^3	21.83	18.56	37.94	17.76

* TLU = Tropical livestock units

However, this will not be an easy task, given that it carries, at least, all the requirements, problems for implementation, costs and implications of the previous actions. However, Belize stands a solid chance to have a climate smart agriculture, and a climate resilient AFOLU sector.

3.3 Prioritization of actions

As stated before, the most successful way for the agricultural sector of Belize to tackle climate change would be the establishment of a CSA that includes the proposed actions and activities. The modelling results showed no significant trade-offs within CSA; i.e. its potential to mitigate GHG emissions and, at the same time, maintain food production and consumption was the highest (Figure 3.1). However, as it can be seen in the figure, the results from the isolated actions are not linearly additive (i.e. part of the savings in land or emissions from one activity may be already be achieved by another one).

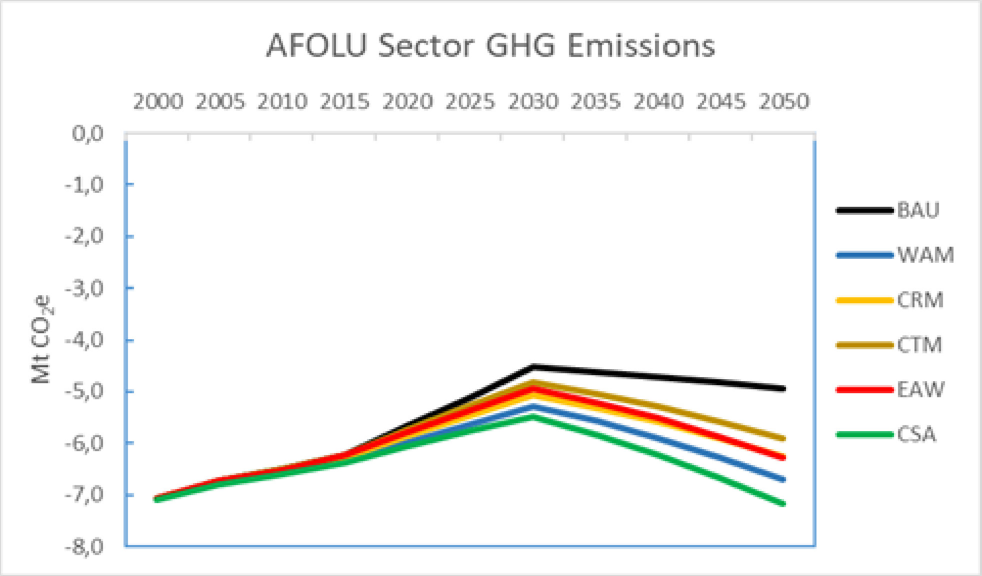

Figure 3.1. Evolution of GHG Emissions of Belize’s AFOLU Sector according to a Business as Usual (BAU) and the implementation of several proposed actions to address climate change mitigation and adaptation: Water Management (WAM), Crops Management (CRM), Cattle Management (CTM), Early Warnings (EAW) and Climate Smart Agriculture (CSA).

However, given that most resources are often limited, an attempt at priorizating them was carried out. As part of this work, a survey on opportunities and challenges for the application of these practices was performed (see Supplementary Information) but was not yet implemented. In lack of this input, the evolution of the contribution of these actions to each of the sources and sinks of GHG is presented in Figure 3.2.

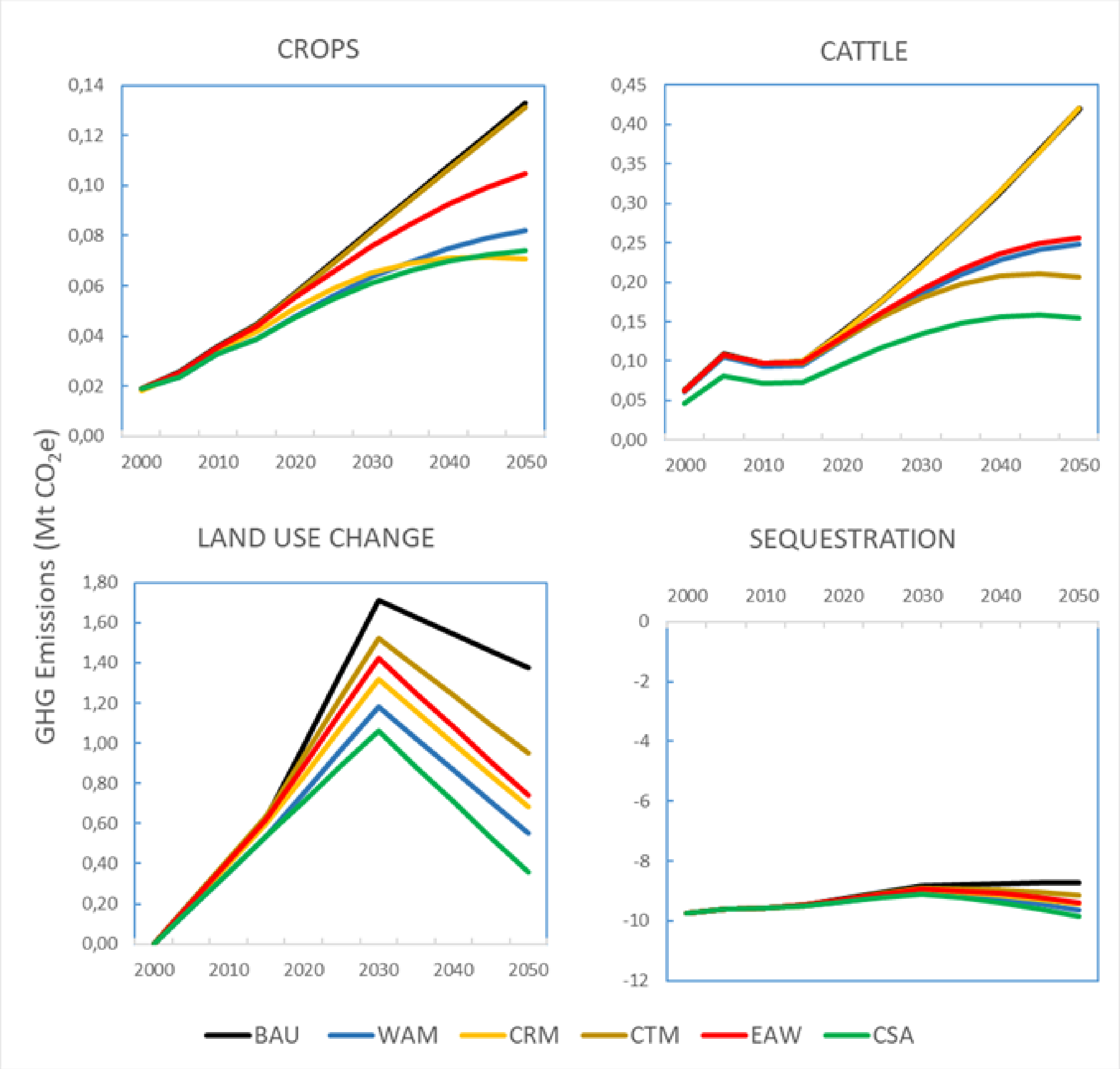

Figure 3.2. Evolution of GHG Emissions of Belize's AFOLU by sub-sector. Lines correspond to Business as Usual (BAU), Water Management (WAM), Crops Management (CRM), Cattle Management (CTM), Early Warnings (EAW) and Climate Smart Agriculture (CSA).

From the analysis of Figure 3.2, different strategies seem to have different levels of success in reducing GHG emissions and/or enhancing CO_2 sequestration. However, the most sound way seems to be the implementation of a Climate Smart Agriculture for Belize, because it could harness all the potential beneficial effects of such practices. None of the selected proposals impose a negative trade-off with food production, since they were designed this way. The only limits for their implementation are costs (not only in terms of investment, but also in time, intellectual effort, technology availability, and dissemination measures to secure the adoption). Nevertheless, Belize has the opportunity to have an AFOLU sector that acts as a sink to its emissions, and should make use of it.

An additional representation of the contribution of CSA to climate change mitigation by each one of the GHGs is presented in Figure 3.3.

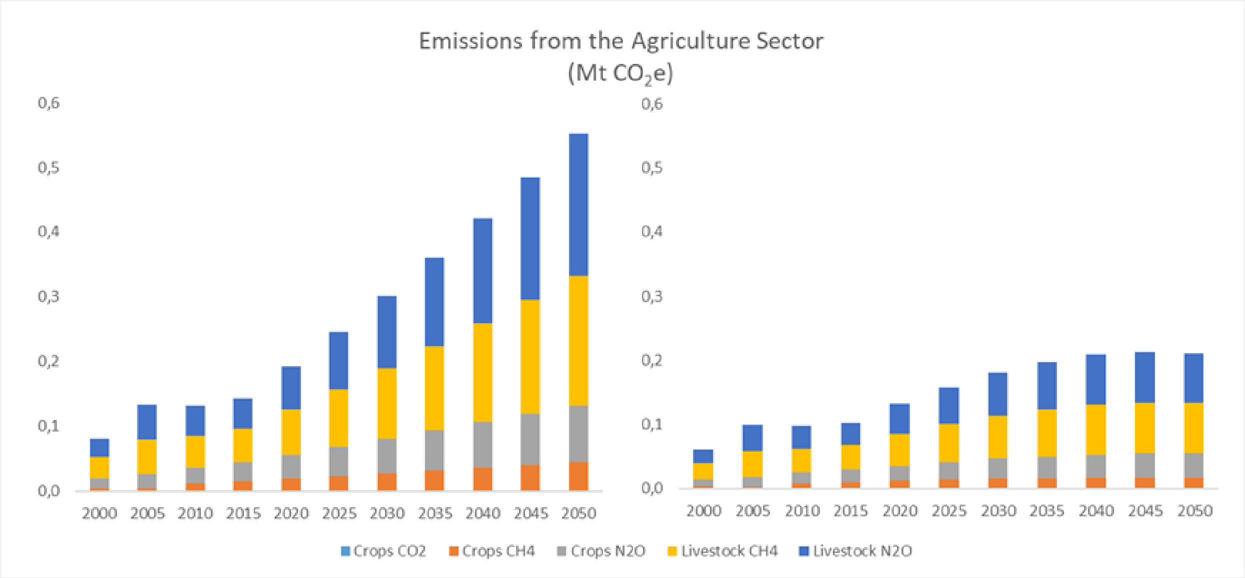

Figure 3.3. Evolution of the emissions from the Agriculture Sector by gasses in the period 2000-2050 in Belize in the BAU (right) and CSA (left) scenarios.

4. Forestry sector

4.1 Background

Belize has extensive forest and associated woodland resources characterized primarily by tall, highly diverse broadleaf forest, and secondarily by pine forests, low scrubby woodland areas, and abundant mangroves. According to Belize´s Forest Department (Belize Forest Department 2020 & suppl. material) in 2018 Belize had 1,353.13 kha of natural forest, which extended over 59% of its territory. In addition, the same year, 1.31 kha were occupied by forest plantations, and 10.35 kha were occupied by regenerating forestlands.

According to Belize´s Forest Department the AFOLU sector of Belize is a net destiny of CO_2, absorbing 11,018,810 Mg CO_2e (GHG emissions) in 2018, and an average of 19,724,914 Mg CO_2e during the 2000-2018 period. This is explained by the absorbing capacity of the forest cover (the main C destiny), that in 2018 absorbed 12,848,257 Mg CO_2e, largely overcompensating the net 1,802,467 Mg CO_2e emission from croplands (the main C emission source). It is very feasible to improve the C balance of this sector due to 1) the extension of the country's surface covered (and potentially covered) by woody vegetation, 2) the magnitude of its carbon fluxes, and particularly, 3) due to the sensitivity of these flows to different management practices, most of them well known and with low requirements of technology and new knowledge. Through the search for secondary information, a series of forestry suitable practices for mitigation of C emissions have been identified, many of them already implemented in Belize.

In the following section, these practices will be a) defined and explained in detail, b) assessed quali-quantitatively in terms of their ability to mitigate C emissions from Belize, using b.1) secondary information available in published literature and reports, and b.2) sensitivity analysis of the practices mitigation effects using the Fable Calculator .

4.2 Forestry practices for mitigation. Technological, feasibility, and impact considerations.

The main forestry practices for emissions mitigation were selected on the basis of previously reported evidence about their mitigation capacity. Mitigation capacity of those practices is described in qualitative or quantitative terms, by transfer of general information or by application to these modeling procedures, according to the type of available information (Table 4.1).

Table 4.1. List of selected forestry practices for the analysis of potential mitigation impact, and procedures applied according to available data.

Practice name		Estimation of potential mitigation impact	
		Transfer of secondary information	**Modeling & Sensitivity analysis**
1	Conservation	yes	yes
2	Protecting Forests from Disturbances - Forest Fires Suppression	yes	yes
3	Protecting forests from disturbances - Grazing Suppression	yes	yes
4	Protecting forests from disturbances - Pests Control	yes	yes
5	Protecting forests from disturbances - Logging Slow Down	yes	yes
6	Reforestation with Fast-growing Species	yes	yes
7	Forest Restoration	yes	yes
8	Low / Reduced Impact Logging (RIL)	yes	yes
9	Slowing Deforestation Rates	yes	no
10	Agroforestry	yes	no
11	Other Forestry Practices	no	no

4.2.1 Forest Conservation

From 2001 to 2018, Belize lost 183.27 kha of natural forest, according to Belize´s Forest Department (2020), but deforestation rate reached 235 kha according to Global Forest Watch (2020) for a similar (2001-2019) period. These figures reflect a limited efficiency of current conservation instruments. Although the total area affected by some level of legal protection is important (38% of the country's surface), most of it corresponds to reserves under forest use, and less than half corresponds to strict reserves for the conservation of biodiversity (13%).

Available data show that Broad-leaf Forest presents positive aboveground growth rates (ABG), even in stand categorized mature, so conservation of this largely dominant forest not only contributes to conservation of existing C pools but also to significant C sequestration (Belize Forest Department 2020). In the same document, it is reported that ABG doubles in the Mature Broad-leaf Forest affected by hurricanes, but it is reduced compared to the intact Mature Broad-leaf Forest, when it is affected by logging, grazing, shifting cultivation and other disturbances. It is estimated that the ABG rate of the Broad-leaf Secondary Forest is almost three times that of the intact Mature Broad-leaf Forest, even when affected by different sources of disturbance (fire, hurricanes, logging). Compared to the latter, mangroves show similar growth rates, while plantations show rates 1.5 times higher. Pine forests, less well studied, show much lower ABG rates than those of the Mature Broad-leaf Forest**.**

A survey on opportunities and challenges for the application of forestry practices was developed (see Supplementary Information) but it could not be applied yet; thus, no primary information on the feasibility of extending and deepening Forest Conservation is currently available.

Table 4.2. Selected indicators to address the potential capacity of Forest Conservation for climate change Mitigation. E: Effectiveness per area unit, PSI: Practice Sensitivity index (see Section 2.3 for details about E and PSI calculations).

Indicator	**Description**	**Units**	**Values from the Model**			
			2000	**2020**	**2030**	**2050**
GHG Emissions	Total Emissions of Belize if only this action is applied	Mt of CO_2e year^{-1}	-7.078	-5.672	-4.530	-6.717
Difference with BAU	Difference in GHG emissions with the corresponding values from BAU	Mt of CO_2e	0.000	0.000	0.000	-1.783
Emissions from the forest sector	Total Emissions or Sequestrations of the forest sector if only this action is applied	Mt of CO_2e year^{-1}	-7.160	-5.864	-4.832	-7.081

E	Savings in GHG emissions per ha of action applied	t of CO_2e ha^{-1} $year^{-1}$	0.000	0.000	0.000	-6.763
PSI (total)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	-	-	-	0.361
PSI (forest sector only)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	-	-	-	0.225

4.2.2 Protecting forests from disturbances - Forest Fires Suppression

An average of 3,561 $ha.year^{-1}$ of forest lands were affected by fire between 1999 and 2018 (Belize Forest Department, 2020). Wildfires are a common occurrence across Central America from February through May, associated with the region's "dry season." By far, the majority of these fires are caused by agricultural practices (but also by cultural and institutional factors). Such practices include clearing and burning forests for shifting agriculture, burning of field stubble in preparation for planting, and burning to rejuvenate pastures for cattle grazing. Extensive areas of dead trees create excessive fuel loads that become subject to severe wildfires for several years following bark beetle outbreaks (Billings & Schmidtke 2002; Billings *et al*., 2004).

Limitations of Belize's legal framework have been reported to establish adequate forest fire suppression policies (Avella et al., 2009). In face to a progressive perception on the incidence and frequency of forest fires, in April 2020, a new legislation, known as the Environmental Protection Regulations (Prohibition of the Open-Burning of Refuse and Other Matter), came into effect via Statutory Instrument No. 59 of 2020. Some auspicious news about the effectiveness of this regulation was released by the government of Belize shortly after its enforcement (https://www.pressoffice.gov.bz.../2020/04/EPA-Burning.pdf)

A survey on opportunities and challenges for the application of forestry practices was developed (see the attached Supplementary Information: SI Feasibility of proposed Actions for Belize's next NDCs_Survey), but it could not be applied yet; thus, no primary information on the feasibility of extending and deepening Forest Fires Suppression is currently available. Some articles available on the web provide elements to take into account (e.g. https://ambergriscaye.com/BzLibrary/trust89.html).

While there precise information about Belize is not available, there is evidence of the existence of technological and logistical gaps limiting prevention and control of wildfires in most countries (Hesseln 2018; Plucinski 2019), so that a substantial reduction in emissions from AFOLU through fire suppression practices may be preliminarily considered feasible.

Table 4.3. Selected indicators to address the potential capacity of Forest Fires Suppression for climate change Mitigation. E: Effectiveness per area unit, PSI: Practice Sensitivity index (see Section 2.3 for details about E and PSI calculations).

Indicator	**Description**	**Units**	**Values from the Model**			
			2000	**2020**	**2030**	**2050**
GHG Emissions	Total Emissions of Belize if only this action is applied	Mt of CO_2e $year^{-1}$	-7.149	-5.735	-4.589	-4.981
Difference with BAU	Difference in GHG emissions with the corresponding values from BAU	Mt of CO_2e	-0.071	-0.063	-0.059	-0.047
Emissions from the forest sector	Total Emissions or Sequestrations of the forest sector if only this action is applied	Mt of CO_2e $year^{-1}$	-7.231	-5.928	-4.891	-5.532
E	Savings in GHG emissions per ha of action applied	t of CO_2e ha^{-1} $year^{-1}$	-15.801	-14.030	-13.057	-10.280
PSI (total)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.010	0.011	0.013	0.009
PSI (forest sector only)	Ratio between the difference with and without the action and	dimensionless	0.010	0.011	0.012	0.008

	the emissions from BAU					

4.2.3 Protecting forests from disturbances - Grazing Suppression

An average of 132 ha.year^{-1} of forest lands were affected by grazing between 1999 and 2018, which is in agreement with the very low cattle stocking rates reported for the country (Belize Forest Department, 2020).

A survey on opportunities and challenges for the application of forestry practices was developed (see the attached Supplementary Information: SI Feasibility of proposed Actions for Belize's next NDCs_Survey), but it could not be applied yet; thus, no primary information on the feasibility of extending and deepening Grazing Suppression within forests is currently available.

Table 4.4. Selected indicators to address the potential capacity of Grazing Suppression within forests for climate change Mitigation. E: Effectiveness per area unit, PSI: Practice Sensitivity index (see Section 2.3 for details about E and PSI calculations).

Indicator	**Description**	**Units**	**Values from the Model**			
			2000	**2020**	**2030**	**2050**
GHG Emissions	Total Emissions of Belize if only this action is applied	Mt of CO_2e year^{-1}	-7.079	-5.673	4.531	-4.936
Difference with BAU	Difference in GHG emissions with the corresponding values from BAU	Mt of CO_2e	-0.002	-0.001	-0.001	-0.001
Emissions from the forest sector	Total Emissions or Sequestrations of the forest sector if only this action is applied	Mt of CO_2e year^{-1}	-7.161	-5.866	-4.833	-5.487

E	Savings in GHG emissions per ha of action applied	t of CO_2e ha^{-1} year^{-1}	-16.528	-15.675	-14.855	-12.151
PSI (total)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.000	0.000	0.000	0.000
PSI (forest sector only)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.000	0.000	0.000	0.000

4.2.4 Protecting forests from disturbances - Pests Control

A total of 603 ha (mean= 31 ha.year^{-1}) of forest lands were affected by pests between 1999 and 2018 (Belize Forest Department, 2020), which mostly affected the Pine forest type, one of the less extended main forest types (20,910ha) within the Belize´s territory.

A survey on opportunities and challenges for the application of forestry practices was developed (see the attached Supplementary Information: SI Feasibility of proposed Actions for Belize's next NDCs_Survey), but it could not be applied yet; thus, no primary information on the feasibility of extending and deepening Pest Control within forests is currently available.

Table 4.5. Selected indicators to address the potential capacity of Pests Control for climate change Mitigation. E: Effectiveness per area unit, PSI: Practice Sensitivity index(see Section 2.3 for details about E and PSI calculations).

Indicator	**Description**	**Units**	**Values from the Model**			
			2000	**2020**	**2030**	**2050**
GHG Emissions	Total Emissions of Belize if only this action is applied	Mt of CO_2e year^{-1}	-7.078	-5.672	-4.530	-4.934

Difference with BAU	Difference in GHG emissions with the corresponding values from BAU	Mt of CO_2e	0.000	0.000	0.000	0.000
Emissions from the forest sector	Total Emissions or Sequestrations of the forest sector if only this action is applied	Mt of CO_2e year^{-1}	-7.160	-5.864	-4.832	-5.486
E	Savings in GHG emissions per ha of action applied	t of CO_2e ha^{-1} year^{-1}	0.000	0.000	0.000	0.000
PSI (total)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.000	0.000	0.000	0.000
PSI (forest sector only)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.000	0.000	0.000	0.000

4.2.5 Protecting forests from disturbances - Logging Slow Down (or Slow Down Degradation Rates by Logging).

A total of 35,990 ha of forest lands were affected by logging during the 1999-2018 period, representing an average of 1894 ha.year^{-1} (Belize Forest Department, 2020), that is the 0.14% of the current area covered by forests.

Forest degradation occurs when there is a direct, human-induced loss of canopy cover, which is insufficient to be classified as deforestation, and results in impaired ability of the forest to provide goods and services such as carbon sequestration, water regulation, and slope stabilization. Degradation of tropical forests is an important source of carbon emissions (Asner et al., 2005; Nepstad et al., 1999; Pearson et al., 2017). This action is used here as a synonym for slow down degradation. It is not a practice in itself, but like the "slow down deforestation", the slowdown of degradation depends on a series of measures that need to be considered together. There is practically no information on comprehensive analysis of this problem, where legal and illegal access mechanisms converge. The implementation in Belize of this approach would require interdisciplinary studies capable of estimating its efficacy and feasibility.

A survey on opportunities and challenges for the application of forestry practices was developed (see the attached Supplementary Information: SI Feasibility of proposed Actions for Belize's next NDCs_Survey), but it could not be applied yet; thus, no primary information on the feasibility of extending and deepening Logging Slow Down within forests is currently available.

Table 4.6. Selected indicators to address the potential capacity of Slow Down Degradation Rates by Logging for climate change Mitigation. E: Effectiveness per area unit, PSI: Practice Sensitivity index (see Section 2.3 for details about E and PSI calculations).

Indicator	**Description**	**Units**	**Values from the Model**			
			2000	**2020**	**2030**	**2050**
GHG Emissions	Total Emissions of Belize if only this action is applied	Mt of CO_2e year^{-1}	-7.282	-5.866	-4.715	-5.087
Difference with BAU	Difference in GHG emissions with the corresponding values from BAU	Mt of CO_2e	-0.204	-0.195	-0.185	-0.152
Emissions from the forest sector	Total Emissions or Sequestrations of the forest sector if only this action is applied	Mt of CO_2e year^{-1}	-7.364	-6.059	-5.017	-5.638
E	Savings in GHG emissions per ha of action applied	t of CO_2e ha^{-1} year^{-1}	-199.893	-190.245	-181.048	-148.842
PSI (total)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.029	0.034	0.041	0.031

PSI (forest sector only)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.028	0.032	0.037	0.027

4.2.6 Reforestation with Fast Growing Species

This practice consists in the re-establishment of forest through planting and/or deliberate seeding/planting on land already in forestland use. A high area for reforestation is available in Belize, which is linked to the high levels of deforestation already indicated in the Background. Due to the high growth rates of exotic fast-growing tree species, industrial reforestations have a greater capacity of carbon sequestration than reforestation with native species. Intensively managed productive plantations, i.e., semi natural planted forests and protection plantations; scattered planted woodlots are excluded. Managed plantations generally produce 20 to 30 times more wood than do natural forests, resulting in higher sequestration rates per hectare (Dombro, 2015). However, accumulated experience on reforestation and restoration in Mesoamerica allow for considering the utilization of native trees feasible as well advantageous in terms of the provision of ecosystem services of global and local concern.

Intensively managed productive plantations, i.e., semi-natural planted forests and protection plantations; scattered planted woodlots are excluded. Managed plantations generally produce 20 to 30 times more wood than do natural forests, resulting in higher sequestration rates per hectare (Dombro, 2015).

A survey on opportunities and challenges for the application of forestry practices was developed (see the attached Supplementary Information: SI Feasibility of proposed Actions for Belize's next NDCs_Survey), but it could not be applied yet; thus, no primary information on the feasibility of extending and deepening Reforestation with Fast Growing Species is currently available.

Table 4.7. Selected indicators to address the potential capacity of Reforestation with Fast Growing Species for climate change Mitigation. E: Effectiveness per area unit, PSI: Practice Sensitivity index (see Section 2.3 for details about E and PSI calculations).

Indicator	**Description**	**Units**	**Values from the Model**			
			2000	**2020**	**2030**	**2050**
GHG Emissions	Total Emissions of Belize if only this action is applied	Mt of CO_2e $year^{-1}$	-7.087	-5.674	-4.534	-4.940
Difference with BAU	Difference in GHG emissions with the corresponding values from BAU	Mt of CO_2e	-0.000	-0.003	-0.004	-0.006
Emissions from the forest sector	Total Emissions or Sequestrations of the forest sector if only this action is applied	Mt of CO_2e $year^{-1}$	-7.161	-5.866	-4.833	-5.487
E	Savings in GHG emissions per ha of action applied	t of CO_2e ha^{-1} $year^{-1}$	0.000	-2.117	-2.868	-3.746
PSI (total)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.000	0.000	0.001	0.001
PSI (forest sector only)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.000	0.000	0.001	0.001

4.2.7 Forest Restoration

The purpose of forest restoration is to promote the capacity of degraded forestland to deliver forest products and services. Forests may be restored and rehabilitated by protective activities (e.g. protection from fire or grazing and erosion control), activities to accelerate natural recovery (e.g. through direct seeding or by planting seedlings in degraded primary or secondary forests), activities to assist natural regeneration (e.g. through weed control on degraded lands and marginal agricultural sites), and the planting of native or introduced trees in single-species or mixed-species plantations, in agroforestry production systems and as trees outside forests. A restoration potential map, calculated according to Batin *et al.* (2019), is provided by https://earthmap.org. According to Chazdon *et al*. (2016), Belize`s potential carbon sequestrationfrom regenerating (secondary) forests may reach 7.60 Mt of $CO_2$by 2050).

Vivid Economics Gap Analysis found a "minimal coverage" for Restoration of Riparian Forests in Watersheds, from National Land Degradation Neutrality Targets and Measures Report, and "partial progress" from the NDC (Government of Belize, 2016). Vivid Economics Gap Analysis also identified a "partial progress" Mangrove Restoration with Blue Carbon Incentive, from the NDC.

A survey on opportunities and challenges for the application of forestry practices was developed (see the attached Supplementary Information: SI Feasibility of proposed Actions for Belize's next NDCs_Survey), but it could not be applied yet; thus, no primary information on the feasibility of Forest Restoration is currently available.

Table 4.8. Selected indicators to address the potential capacity of Forest Reforestation for climate change Mitigation. E: Effectiveness per area unit, PSI: Practice Sensitivity index(see Section 2.3 for details about E and PSI calculations).

Indicator	**Description**	**Units**	**Values from the Model**			
			2000	**2020**	**2030**	**2050**
GHG Emissions	Total Emissions of Belize if only this action is applied	Mt of CO_2e year^{-1}	-9.016	-7.517	-6.287	-8.616
Difference with BAU	Difference in GHG emissions with the corresponding values from BAU	Mt of CO_2e	-1.939	-1.846	-1.758	-3.681
Emissions from the forest sector	Total Emissions or Sequestrations of the forest sector if only this action is applied	Mt of CO_2e year^{-1}	-9.098	-7.710	-.,589	-8.979

E	Savings in GHG emissions per ha of action applied	t of CO_2e ha^{-1} $year^{-1}$	-8.221	-7.828	-7.454	-14.815
PSI (total)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.274	0.325	0.388	0.746
PSI (forest sector only)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.213	0.239	0.267	0.389

4.2.8 Low / Reduced Impact Logging (RIL)

The selective logging in humid tropical forests is one of the most important sources of forest degradation and emission sources, and this effect consists of three main mechanisms: 1) emissions relative to extracted volume or extracted log emissions (ELE) 2) damaged biomass in the process of logging, characterized by the logging damage factor (LDF); and 3) damaged biomass resulting from infrastructure necessary for logging, characterized by the logging infrastructure factor (LIF). Published data from Belize, and based on a logging operation of 2 m^3 ha^{-1}, suggests one of the lowest ELE (0.28MgC m^{-3}) and the largest LDF (1.26MgC m^{-3}) values, as compared to other humid temperate forests of Congo, Indonesia, Bolivia, Brazil and Guyana (Pearson et al., 2014). While no LIF data was found for Belize, LIF values from these other countries are similar or more than two times higher than ELE values.

Reduced impact logging (RIL) is the intensively planned and carefully controlled implementation of timber harvesting operations aimed to minimize environmental impacts on forest stands and soils. It involves a number of practical activities, such as pre-harvest forest inventories and the mapping of individual crop trees. These techniques have been applied to tropical forests in different parts of the world and it was calculated that they achieve a reduction of between 18% and 79% of the emissions associated with logging operations (Ellis *et al*., 2019).

An approach closely related to RIL is known as Improved Forest Management (IFM). IFM basically consists of any change from conventional logging that reduces net emissions and other negative environmental and social impacts of forestry activities while maintaining forest product supply. Main IFM practices include: a) better harvesting in areas where logging occurs (e.g. road and skid planning, directional felling, vine cutting, among others, b) protection, or set-aside of some areas from logging (e.g. riparian buffers, forests of high biodiversity value, steep slopes), and c) silvicultural practices to improve growth (e.g. extended rotations, thinning, protecting large seeding trees, favoring seedling recruitment) (Griscom et al., 2009; 2013). No data about these practices has been found for Belize yet, but there exists examples of their mitigation potential for other tropical forests. For instance, in well managed Amazonian forests, post-logging regeneration was found to be relatively fast, and losses of 10, 25 or 50% of pre-logging C stocks requires 12, 43 or 75 years, respectively, to recover (Rutishauser et al., 2015). Under current forest management regulations (e.g. 30–60 years of cutting cycle & harvest intensity of 10–30 m^3 ha^{-1}), managed forests require between seven and 21 years to recover their initial carbon stocks (Rutishauser & Herold, 2017).

A survey on opportunities and challenges for the application of forestry practices was developed (see the attached Supplementary Information: SI Feasibility of proposed Actions for Belize's next NDCs_Survey), but it could not be applied yet; thus, no primary information on the feasibility of Reduced Impact Logging is currently available.

Table 4.9. Selected indicators to address the potential capacity of Reduced Impact Logging (RIL) for climate change Mitigation. E: Effectiveness per area unit, PSI: Practice Sensitivity index (see Section 2.3 for details about E and PSI calculations).

Indicator	Description	Units	Values from the Model			
			2000	2020	2030	2050
GHG Emissions	Total Emissions of Belize if only this action is applied	Mt of CO_2e $year^{-1}$	-7.421	-5.998	-4.841	-5.190
Difference with BAU	Difference in GHG emissions with the corresponding values from BAU	Mt of CO_2e	-0.343	-0.327	-0.311	-0.256
Emissions from the forest sector	Total Emissions or Sequestrations of the forest sector if	Mt of CO_2e $year^{-1}$	-7.503	-6.191	-5.143	-5.742

	only this action is applied					
E	Savings in GHG emissions per ha of action applied	t of CO_2e ha^{-1} $year^{-1}$	-335.622	-319.423	-303.981	-249.907
PSI (total)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.049	0.058	0.069	0.052
PSI (forest sector only)	Ratio between the difference with and without the action and the emissions from BAU	dimensionless	0.046	0.053	0.060	0.045

4.2.9 Slowing Deforestation Rates

This action is not a practice in itself, but the result of a set of measures that require to be considered together, under a conceptual framework capable of considering their interactions, avoiding reductionist and ineffective solutions. Thus, slowing deforestation requires more than simply outlawing deforestation. In the context of Amazonian forests, but preliminarily plausible for Belize, Fearnside (1989) proposed a series of measures feasible to be applied in the medium term. a) discourage speculation for the value of land through heavy taxes tending to reduce the profitability of these businesses; b) discourage the provision of land for other uses (crops, pastures), taxing such activities or redirecting aid programs to other activities not dependent on deforestation; c) stop possible perverse tax incentives; d) stop the creation of infrastructure (roads) that facilitate illegal logging activities; e) Strengthen the environmental impact assessment requirements for deforestation projects, where C emissions and the loss of other ecosystem services are explicitly incorporated. The relevance of this type of measure for Belize remains to be evaluated based on consultation with experts and stakeholders.

A survey on opportunities and challenges for the application of forestry practices was developed (see the attached Supplementary Information: SI Feasibility of proposed Actions for Belize's next NDCs_Survey), but it could not be applied yet; thus, no primary information on the feasibility of Slowing Deforestation Rates is currently available.

4.2.10 Agroforestry

Agroforestry is defined by FAO as a collective name for land-use systems and technologies where trees and/or shrubs are used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. It is usually sustained that integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (Verchot *et al*., 2007). Carbon sequestration potential of tropical agroforestry systems produce a median sequestration value of 95 ton/ha/yr (Albrecht & Kandjl, 2003), and considering variables of location, soil type, rainfall and species it can be as high as 228 ton/ha/yr. Assuming a median of 95,000 kg divided by 1,250 trees per hectare one would get 76 kg per tree. In a managed plantation, trees are culled back to about 600 trees per hectare, which would result in 158 kg per tree per year (Albrecht & Kandji, 2003).

4.3 Other forestry practices

Afforestation. It is the establishment of a forest or stand of trees in an area where there was no previous tree cover. Establishment of forest through planting and/or deliberate seeding on land that, until then, was not defined as forest. In order to achieve co-benefits with other goals, investments in afforestation should use native flora species as far as possible, to favor the expansion of areas compatible with biodiversity. Added to this, select sites where afforestation improves ecosystem services, such as water supply, slope stabilization, etc. (Hall *et al*., 2011). Belize has been signed as one of the eligible countries for afforestation under Clean Development Mechanism (CDM) (Hoch *et al*., 2015). Suitable area for afforestation, however, it is presumably low due to the previously mentioned high original forest cover within the country.

Rehabilitation. Forest rehabilitation re-establishes the original productivity of the forest and some, but not necessarily all, of the plant and animal species thought to be originally present at a site. Forests may be restored and rehabilitated by protective activities (e.g. protection from fire or grazing and erosion control), activities to accelerate natural recovery (e.g. through direct seeding or by planting seedlings in degraded primary or secondary forests), activities to assist natural regeneration (e.g. through weed control on degraded lands and marginal agricultural sites), and the planting of native or introduced trees in single-species or mixed-species plantations, in agroforestry production systems and as trees outside forests.

Rejuvenation. In the context of practices aimed at mitigating carbon emissions, forest rejuvenation consists of an improvement in the balance of carbon that is achieved after an optimal harvesting frequency. In other terms, increases in carbon sequestration are observed in managed forests by maintaining the forest at high growth rates through harvesting rejuvenation effects. There are antecedents that would allow us to measure the contribution of this effect, and establish optimal harvest frequencies through simulation models (Pukkala, 2017), but in essence, they aim to explain the increases in carbon sequestration that are observed in managed forests.

4.4 Prioritization of forestry practices for mitigation of AFOLU emissions

Mitigation potentials under specific scenarios were modeled and ranked on basis to four complementary criteria: a) absolute output differences with BAU (D), b) the absolute reduction of emissions per unit area (effectiveness, E) with respect to BAU projections, c) the relative reduction of emissions per unit of emission (Practice Sensitivity Index, PSI) regarding BAU projections, and d) a preliminary rough estimate of the relative feasibility (F) of instrumentation (see Section 4.2). In order to provide a prioritization ranking, a multicriteria analysis was then performed, using unweighted D, E, PSI and F values as inputs.

The ranking of potential capacities to reduce absolute emissions (E) is mostly uncoupled from those ranks resulting from E and PSI criteria (Table 4.10), reflecting their complementary information content. For example, while the absolute emission reduction per area basis reflects the practice payoff in Mg CO_2e year^{-1} ha^{-1} units and can be used as a direct input for cost-benefit analysis, sensitivity analysis reflects the effectiveness for emission reduction per emission unit basis. Thus, a given forestry practice may be high cost-effective per unit area basis, but poor cost-effective per emission unit basis, or vice versa. Indeed, a high rank according to cost-effectiveness per unit area basis, can be irrelevant when the suitable area for application of the practice is small, and analogously, a high rank according to cost-effectiveness per emission unit basis can be irrelevant when the emissions level without practice is small.

The final prioritization rank also includes an expert feasibility rank, which by the moment only consists of the authors of this report, and that is mostly based on the considerations exposed in the 4.2 section (Table 4.10). Preliminary results indicate that according to the simulated effects of practices, restoration, reduced impact logging (RIL), conservation and slow down degradation rates by logging are the four out nine most promissory forestry practices for the mitigation of mitigations from Belize´s AFOLU sector. A deeper estimation of the economic, social, and technological components of implementation feasibility is necessary to provide better prioritization recommendations.

Table 4.10. A tentative ranking of forestry options according to the sum of mitigation potential and implementation feasibility ranks. PSI: practice sensitivity index; RIL: reduced impact logging. Prioritization rank was calculated on basis to the unweighted sum of PSI 2050 AFOLU, effectiveness per area unit and feasibility rank of the proposed forestry practices. See more methodological details in Section 2.

Practices	**Mitigation ranks**					**Prioritization rank**
	Difference with BAU (Mt of CO_2e $year^{-1}$)	**PSI 2050 AFOLU**	**PSI 2050 Forests**	**Effectiveness per area unit**	**Feasibility**	
Forest Conservation	2	2	2	6	1	3
Fire Suppression	5	5	5	5	2	5
Grazing Suppression	7	7	7	4	1	6
Pest Control	8	7	7	8	3	8
Logging Slow Down	4	4	4	2	1	3
Reforestation	6	6	6	7	1	7
Restoration	1	1	1	3	3	1
RIL	3	3	3	1	2	2

According to this preliminary analysis, the reduced impact logging (RIL) practice deserves to be prioritized according to the combined application of area-unit effectiveness, emission-unit effectiveness, and feasibility criteria, followed by logging suppression and restoration practices.

5. Biodiversity conservation

5.1. Species account and their conservation value

According to (IUCN's Red List (IUCN, 2020), Belize has 895 species of vertebrates in its territory. Based on this list, the taxonomic status, the level of threat according to the IUCN and the habitat affinity of each of the species was analyzed in order to calculate the incidence of changes in land use on biodiversity. Supplementary Information SI 5.1 shows the complete list, and the information associated with each species.

Based on the full list, the criterion of considering only threatened and near threatened species for our biodiversity analysis was selected. This decision is justified considering that non-threatened species do not need financial efforts or conservation strategies to be safe from extinction. On the contrary, threatened species need technological assistance to reduce their risk of extinction.

A survey of 158 species of mammals inhabiting the territory of Belize rendered that 6 are data deficient, 135 least concerned, 6 Near Threatened, 7 Vulnerable, 3 Endangered and 1 extinct species. Belize has a high species richness of birds (585 species), of which 33 are reported as threatened (22 near threatened, 7 vulnerable, 4 endangered). Regarding reptiles, Belize has 114 species of reptiles, of which 14 are reported as threatened (3 near threatened, 5 vulnerable, 1 endangered, 2 critically endangered). Only 14 species of amphibians are recognized for Belize, surely this number will increase substantially when the studies in this taxonomic group increase. Notably, 10 of the 14 species of amphibians report some level of threat (8 near threatened, 1 vulnerable, 1 endangered). Supplementary Information SI 5.2 provides a detailed list of the 70 terrestrial, endangered species considered in this study.

To estimate the relative importance for the conservation of each type of land cover and land use, a weight as surrogate of extinction risk for each species was used, assigning 10 points to critically endangered species, 9 points to endangered, 8 points to endangered species and 7 points to near threatened, following Monjeau et al. (2008) and Martin et al. (2020).

Then weights of each species present in a given pixel were added (Figure 5.1), determining the conservation value of each pixel (PCV = pixel conservation value). The criteria and recommendations for the protection of biodiversity have used these activities as a guideline.

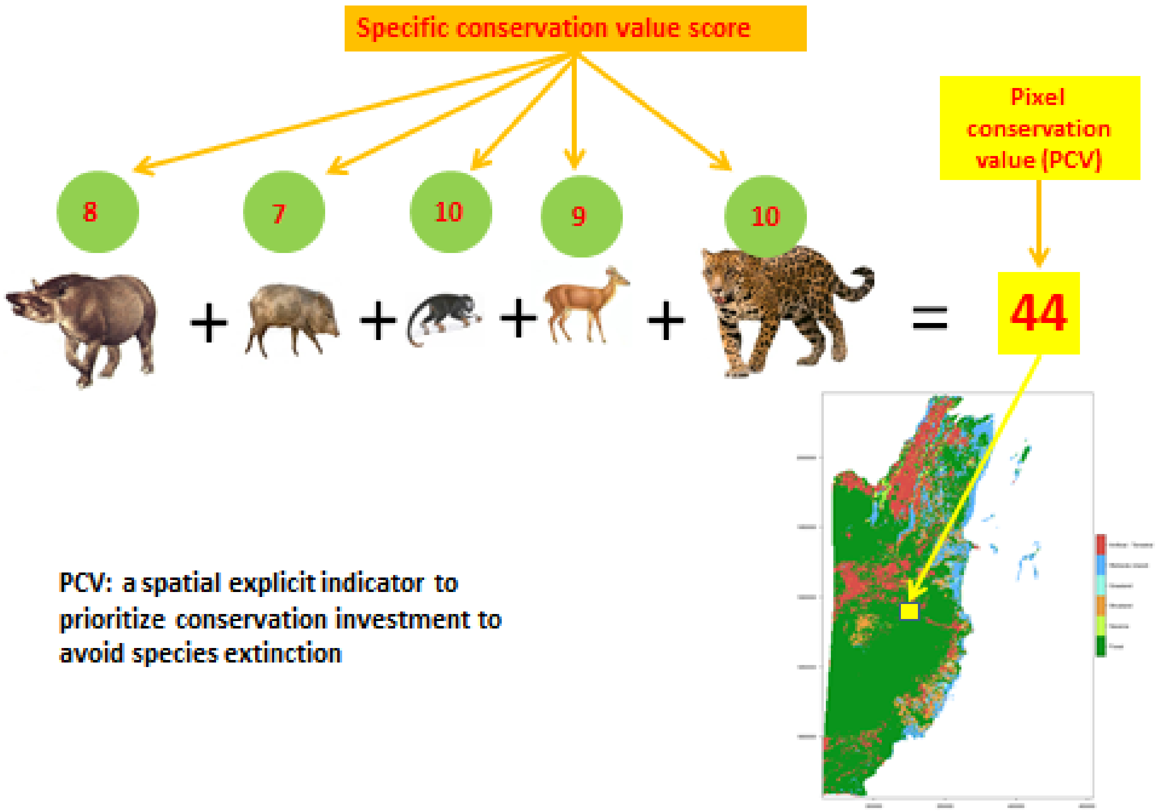

Figure 5.1. Methodological scheme for the construction of the conservation priority indicator. A numerical value is assigned to each species according to its conservation category (Specific conservation value score). Numbers in the figure are arbitrary examples. In each pixel, the numerical values of each species. In each pixel, the numerical values of each of the threatened species that inhabit that pixel are added, obtaining the PCV (Pixel conservation value), which is a surrogate of the risk of extinction of the species that inhabit each pixel. Source: own for this report.

The next step was to obtain the shapes of each of the 70 selected species using an IUCN API for this purpose. The shapes were refined using information on the presence points of each species publicly available on the web, as well as by habitat affinities. In this way, it is considered that the distributional ranges of each species correspond approximately, to what Brooks et al. (2019) define as Area of Habitat (AOH).

Once the AOHs were obtained, the map of the conservative value of Belize (for the species considered) was obtained, obtaining the distribution of the PCV (Figure 5.1) for Belize (Figure 5.2).

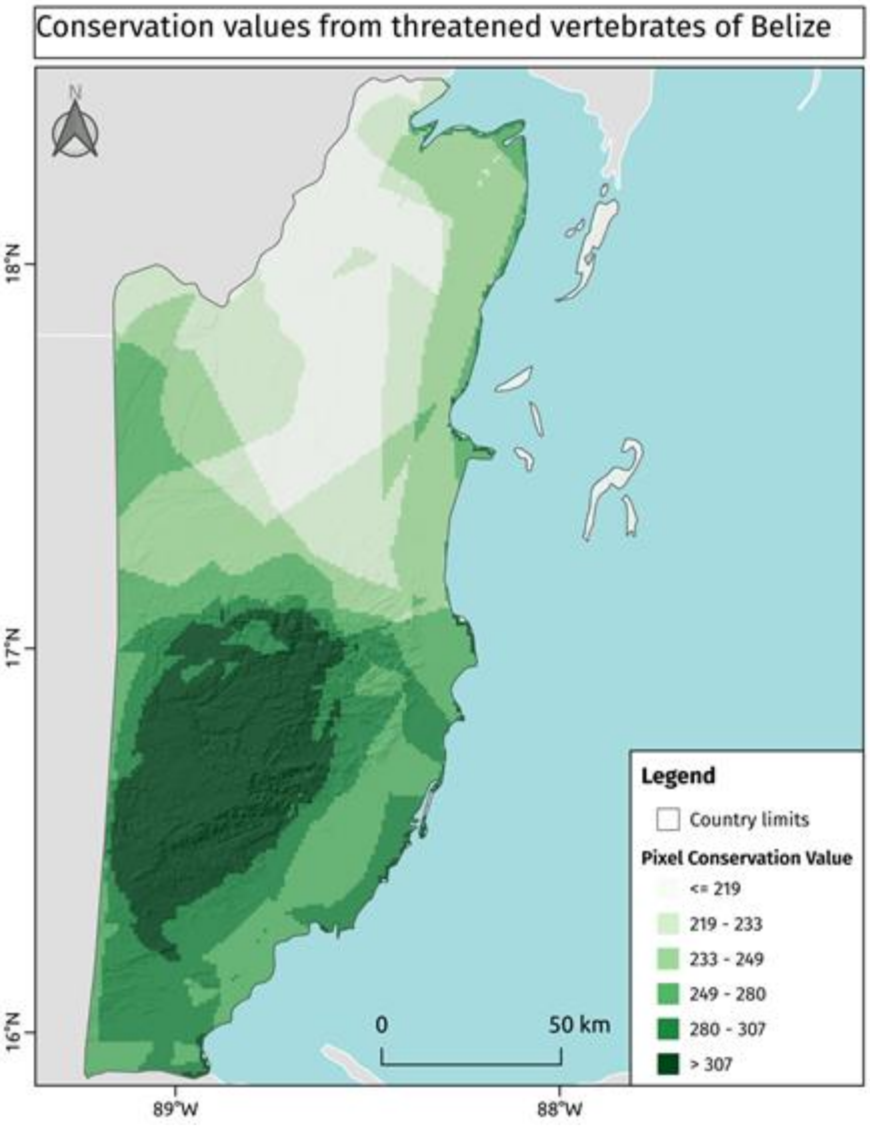

Figure 5.2: Conservation value map of Belize: Own elaboration based on geographic ranges of tetrapods with threat categories according to the IUCN Red List. The map shows the distribution of the pixel conservation value considering the overlap of the complete geographic pool of the species considered in this study.

With the information from the conservative value map, the PCV value of each type of coverage and each type of land use was obtained (See Supplementary Information SI 5.3).

Given that this analysis was done with secondary information, obtained from the available databases, that is, there does not exist a field census with the list of species that inhabit each pixel, the analysis was carried out assuming that:

1) the geographic pool of species is complete in strictly conservation protected areas (Ia, Ib and II according to the IUCN classification). For this reason, 100% of the PCV assigned to each coverage is computed when it overlaps with protected areas I and II.

2) the geographic pool of species is incomplete in protected areas with resource use (III to VI), computing in these cases 80% of the PCV value assigned to each coverage when it overlaps with protected areas III to VI.

3) the geographic pool of species is impoverished in habitats that do not have any type of protection, computing in these cases 50% of the value of PCV to each unprotected cover.

These assumptions are supported by conservation theory (Ceballos and Erlich, 2002) and in field studies where detailed censuses were available (Macedo et al., 2019). Building this method on the basis of these assumptions, the idea that protected areas are the most effective tool to avoid extinction is considered key, and that it has been shown that the possibility of presence of medium and large vertebrate species is inversely proportional to the human footprint or its surrogates (Macedo et al., 2018). Supplementary information SI 5.3 provides the distribution of PCV per type of habitat and/or land use.

This methodological procedure allows us to associate the gains or losses in conservation objectives for each modification that occurs in each type of land cover. As the objective of the project is to strengthen Belize's NDCs, this methodology allows calculating how much is gained in biodiversity conservation for each ton of carbon equivalent that is retained or sequestered in each decision making that involves changes in land cover areas. In this way, the best route can be chosen to mitigate the effects of climate change, accounting in a quantitative and spatially explicit way for the gains in conservation goals.

5.2. Protected areas

Belize has 119 protected areas occupying a total area of 1,414,521.7 ha. The marine areas are 33, and the terrestrial ones are 76, adding 10 areas that are coastal-marine. Terrestrial protected areas occupy 823,807.98 hectares (Figure 5.3), the majority being category VI forest reserves.

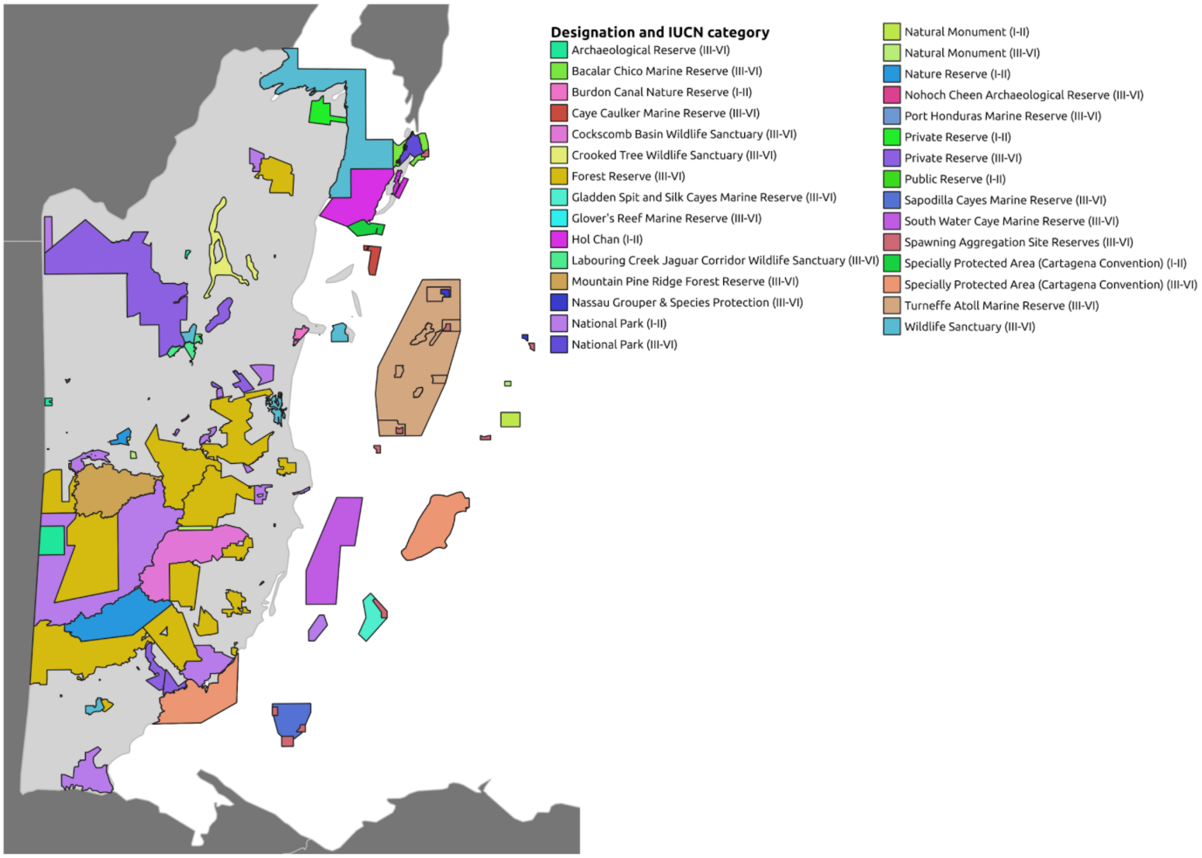

Figure 5.3. Map of protected areas system of Belize and IUCN categories. Source: World Database of Protected Areas, GIS elaborated for this report.

Protected areas are the only legally protected surface to implement conservation objectives, and therefore, they should not neglect their irreplaceable role in preventing extinction and in ensuring the maintenance of ecosystem functions and the services they provide to the human economy (Monjeau, 2010). Although areas with managed resources generate additional income to nature tourism, it is essential to achieve comprehensive governance of large mosaics, integrating different types of protected areas and different land uses (Macedo et al., 2019), including unprotected areas that where natural processes still predominate. Figure 5.4 shows that there is a happy congruence between the sites that potentially contain the highest conservation value (the darkest greens in the color palette) and a compact mosaic of protected areas, including good coverage of protected areas I and II. The analyses shows that in this core, Belize has a great opportunity to implement a greenhouse gas mitigation strategy in synergy with the conservation of biodiversity.

Despite this good spatial arrangement of protected areas and their overlap with priority sites to avoid extinction, it must be taken into account that it is a large mosaic, but relatively isolated from large masses of intact or well-preserved forest. In this sense, it would be advisable, as was well indicated by the pioneering works of Jan Meerman (2000), that future reforestation actions and creation of protected areas take place connecting this mosaic with the northern part of Belize. These corridors are essential for large mammals such as the jaguar or tapir, which require large spaces to sustain a minimum viable population.

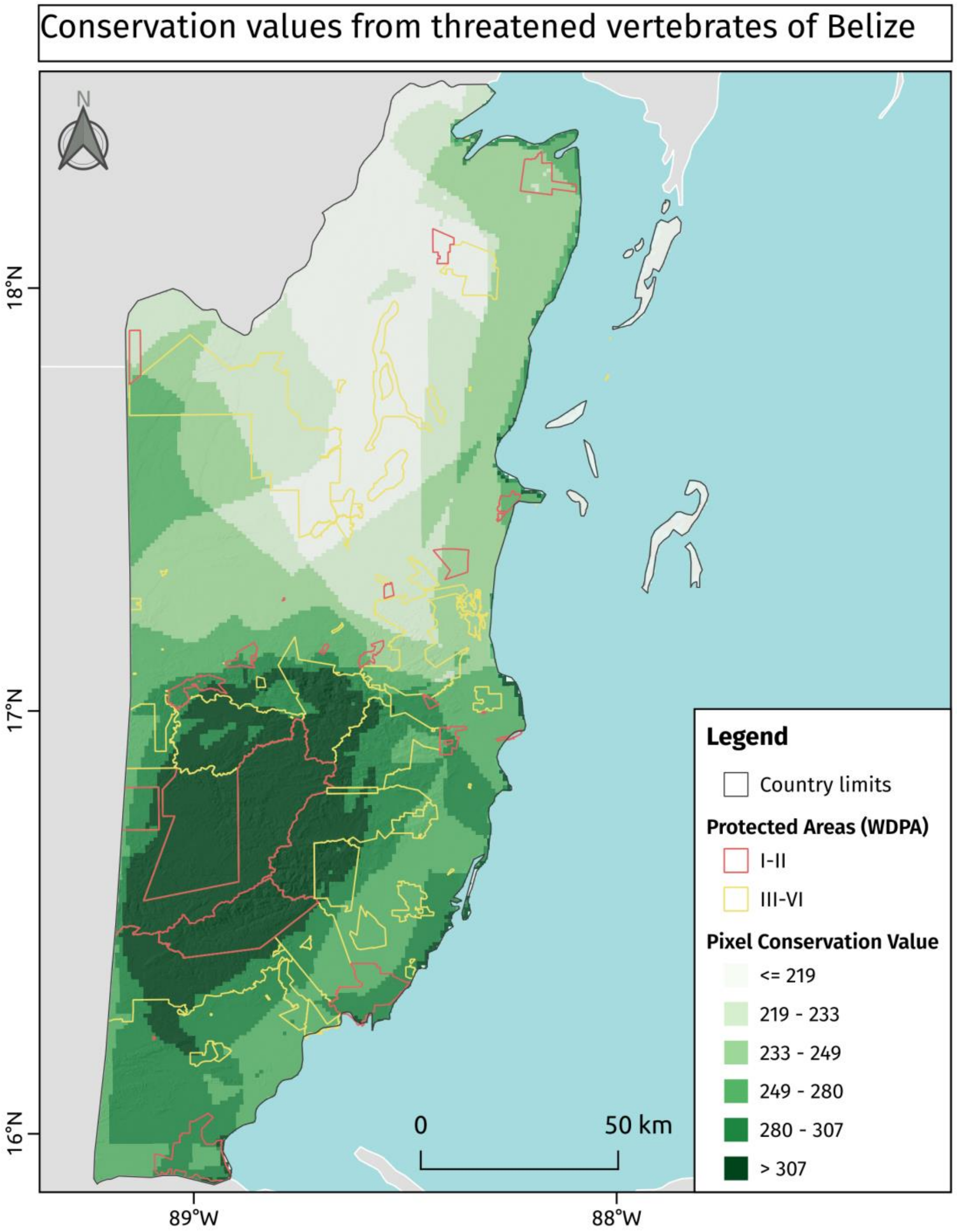

Figure 5.4: Overlap between priority sites for the conservation of vertebrates threatened with extinction according to the PCV indicator, and types of protected areas.

5.3. Biodiversity conservation actions

Biodiversity conservation strengthens NDCs because it is linked to GHG sequestration, as has been quantitatively demonstrated in this report. Supplementary information SI 5.4 indicates the gains in carbon sequestration in the AFOLU sector applying biodiversity conservation measures compared to the trend scenario (BAU). The expansion of areas destined for conservation must be coordinated with the actions that take place in each of the AFOLU sectors. For instance, reducing impact logging (RIL), logging suppression, restoration practices and forest conservation are measures directly linked with biodiversity conservation goals.

For this reason, in this study, the biodiversity solutions were linked to the measures proposed by agriculture, forestry and land use. It should be noted, however, that the synergy between the different AFOLU sectors does not imply identical measures. For the biodiversity goals, the scenario is more ambitious in terms of changes in land use, proposing a doubling of the area destined for conservation (Figure 5.6).

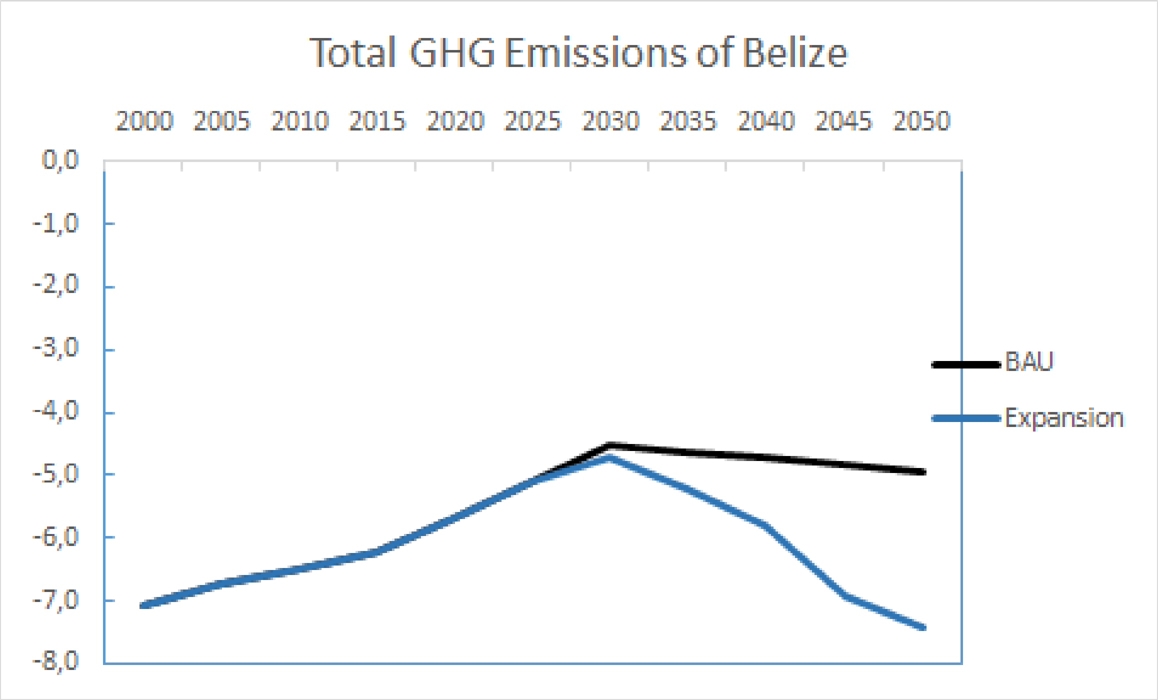

Figure 5.6. GHG sequestration according to the BAU scenario and applying measures of expansion of areas compatible with the conservation of biodiversity, combining all the conservation measures.

Figure 5.6 shows that applying biodiversity conservation measures, 2.50 Mt CO_2e can be sequestered in comparison with BAU, which means a 50% increase in Belize's contribution to climate change mitigation by 2050. To achieve this substantial advance in NDCs, the following measures and recommendations should be taken into account in the roadmap:

5.3.1. Socioeconomic measures at a national scale

1) **Paradigm shift**: the just transition towards a sustainable economy implies a gradual change of the economic and political paradigm (Diaz *et al*., 2019). This change, in Belize, can provide significant economic benefits that exceed investment costs, especially if part of those costs come from international cooperation. Economic and financial incentives must be created in order to value nature as a profitable asset, taking into account that the basis of this asset is in the intrinsic value of natural processes, although these are not easily converted to money in classical economic theory (TWI2050, 2018). The negative externalities of natural resource extraction must be properly accounted for. The protection and sustainable management of the national natural capital is a generator of employment and economic growth through tourism, the sustainability of agriculture (Schmidt-Traub *et al*., 2019), the protection of water sources (Mulligan *et al*., 2011), among other ecosystem services (Balvanera *et al*., 2012), and can generate five times more income than its cost in annual terms (CEPAL, 2020).

2) **The post-pandemic economic recovery** should not neglect the AFOLU sector, because the consequences of doing so are very costly. The COVID-19 crisis has taught us that it is much less expensive to prevent than to face the consequences of poor management of the human-nature relationship (CEPAL, 2020). Zoonotic diseases, worldwide, are mainly caused by environmental malpractice (Quammen, 2018). Tropical natural environments host numerous epidemiological vectors that integrated ecosystem management must take into account to mitigate the risk to the population. Obtaining information about these vectors, especially understanding what type of habitats and what type of practices favor their spread is of fundamental importance for land use planning.

3) **Strengthen the role of the state** as guarantor of the functioning of ecosystems, the services they provide to society and their fair distribution. The state must guarantee access to water, energy and food, emphasizing the most vulnerable populations, such as those that depend directly on them (CEPAL, 2020).

5.3.2. Activities for the management of biodiversity and land use

1) **Territorial environmental management.** At the national level, a territorial environmental management plan should align efforts to preserve ecoregional diversity, avoiding fragmentation and degradation of natural environments. Due to the strong interconnection

between components at different scales, isolated initiatives do not work if there is no integrated management of ecosystems.

2) **Ecological intensification.** In crop production areas, increase spatial heterogeneity by creating or conserving native flora patches to increase alpha and beta diversity. This increases functional diversity (Fahrig *et al*., 2011), which in turn increases crop productivity (Garibaldi *et al*., 2013, 2020). The creation of woodland islets (Benayas *et al*., 2008) along with biological corridors (Meerman, 2000), through ecological restoration technologies, favors several goals at the same time, including carbon sequestration, biodiversity conservation and increased resilience to effects of climate change, which also has beneficial effects on mitigating the social-ecological trade-off, since it comprehensively solves the demands of conservation biology and favors agricultural production (Mastrangelo & Laterra, 2015). In this study the specific effect of ecological intensification was not computed because the spatially explicit information is not available. However, part of the expansion of the area destined for conservation that is intended to be applied includes islets linked to ecological intensification goals. Recent studies estimated that the mosaics of agriculture and natural areas require at least 20% of areas where natural processes predominate to guarantee the ecosystem services that favor agriculture (Garibaldi et al., 2020). The alternative scenario to BAU proposed in this study far exceeds this percentage.

3) **Apply conservation prioritization tools** for groups of species (and not for flag species), establishing indicators of "extinction risk density", that is, prioritizing sites that contain endangered species, minimizing the cost of the value of the land, that is, optimizing the sites where extinction risk density is mitigated with the least investment or opportunity cost possible. If the IUCN Red List criteria to categorize endangered species is followed, the prioritization should target for each species to conserve at least 2000 square kilometers of Habitat of Area of the species listed in threatened categories, so that they move to the Least concern category. For a country like Belize, perhaps this achievement implies transnational conservation agreements for the creation of large continuous blocks of conservation.

4) **Create green corridors** between protected areas and jungle patches. Preferably corridors in the north-south direction, joining the north and south blocks of protected areas (see Meerman 2000 analysis in northern corridors). To do this, it is recommended:

a) implement an incentive policy so that the blocks of forest reserves allow the installation of continuous corridors, the same in private properties that have surfaces superimposed on the possible corridors;

b) restore corridor sites through reforestation with native tropical plants, choosing the species most associated with biodiversity (keystone species). The creation of corridors through reforestation technologies has many advantages: job creation, carbon sequestration, increased biodiversity, especially of large vertebrates that need large spaces for their feeding and reproduction activities. Corridors should be at least 600 meters wide to mitigate the effects of human footprint (Macedo et al., 2018);

c) reforest steep slopes;

d) use high risk sites for natural disasters (tornadoes, floods, landslides) as federal reserves. Meerman (2000) mentions several challenges to the implementation of corridors in Belize. Jan Meerman found that, although Belize has great coverage of broadleaf forest, "*...there were very few viable options for linking the individual forested areas by means of (forest) corridors. Virtually all the potentially viable corridors were very narrow and under great human pressure. Without further action each of the identified corridors can be expected to cease functioning as such within the next decade*." The main challenge seems to implement land use planning on local and national government level. The recommendations 9 and 10 are related to these challenges. This is related to the attached Concept Note.

5) **Increase the surface of type Ia, Ib and II protected areas** through the creation of new ones (as part of the corridor projects), and through the recategorization of pre-existing reserves, ensuring a percentage of surface destined to core area or strict conservation, designed, as far as possible, contiguously, so as to obtain a mosaic of land uses with a large continuous core area, or at least, connected by corridors. This is the measure that has the greatest impact on carbon sequestration, since the change of protection category and the expansion in this type of land use (strict conservation) can obtain a gain of 1.86 Mt of CO_2 compared to the BAU (Figure 5.7 and Supplementary Information SI 5.4).This is related to our Concept Note.

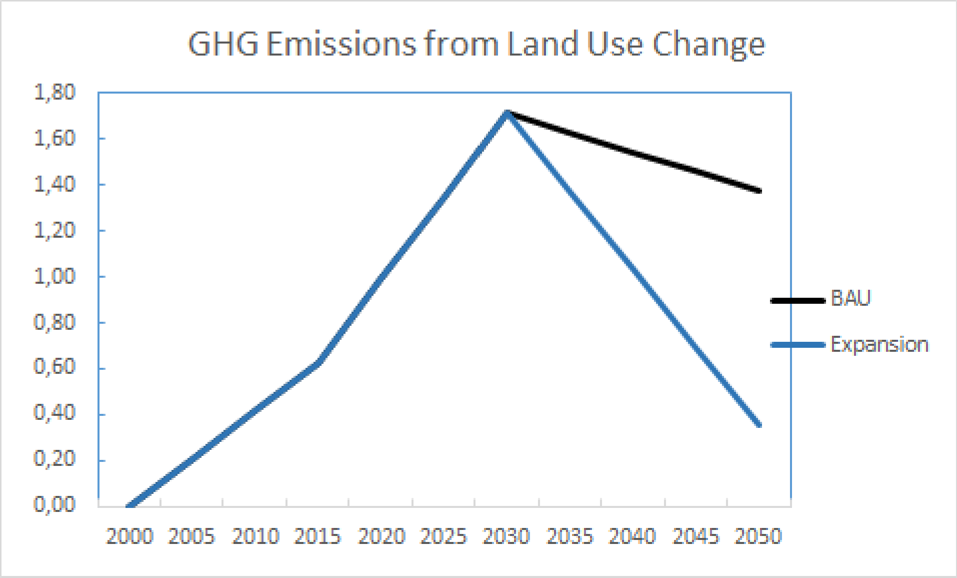

Figure 5.7. Impact on carbon sequestration attributed to converting surfaces into protected areas

6) **Conservation agreements.** Private areas: establish conservation agreements in private reserves in such a way as to ensure the functionality of corridors and a portion of the surface destined to strict conservation (source places for species). Also, wildlife crossings over main highways are needed to avoid wildlife mortality and human accidents. Agreement with the transport sector is needed.

7) **Joint prioritization.** Conserve, as a priority, the forest environments associated with greater effectiveness in protecting threatened species, such as large vertebrates (See S3 for quantitative details). Also broaden the category of protection in the main ecotones between ecoregions, since these are the sites with the highest species richness. This is related to the attached Concept Note.

8) **Rewilding.** Sustain the conservation of the biodiversity of threatened species with refaunation plans (Fernandez *et al*., 2017) and management of populations in numerical decline. Restore ecosystem functions linked to biodiversity, such as the refaunation of the main seed dispersal species, prioritizing functional diversity and minimizing redundancy. For example, the agouti for medium-sized seeds, the tapir for large-sized seeds. Refaunation can be done in secondary or recovering forests, or at a stage after reforestation with native ones. The refaunation tool for seed dispersers has several benefits, of course, it increases the species richness of protected areas, increases the attractiveness of nature tourism and the function of dispersing seeds itself, by promoting the germination of new trees, encourages the

fixation of atmospheric carbon by capturing it in biomass production by photosynthesis. This measure is linked to the measure of "rejuvenation" mentioned in the Forest section, since seed dispersers play a fundamental role in the birth of new seedlings.

9) **Slope stabilization.** Prioritize sites where the goals of biodiversity, carbon capture and retention and protection of water sources and stabilization of slopes for erosion protection occur concurrently. In this sense, sites with high slopes (40 degrees or more) should be a priority for strict conservation, guarding the forest cover of these slopes. On the other hand, the altitudinal gradients are generally rich in species.

10) **Nature-based technological solutions.** Belize being a country with a very low contribution to GHGs, the recommendation is to use offset tools for emissions from the agriculture, transportation and energy sector based on nature-based solutions. By investing in nature conservation technologies (those mentioned in forestry, land use and biodiversity), an additional 2.5 Mt COeq can be sequestered, which can serve to offset emissions from other sectors.In other words, managing the protected area to make Belize an eminently GHG capturing country, which can have great advantages in the carbon credit market (Griscom *et al*., 2017) It is not convenient to make large technological investments in mitigation activities for food production, on the contrary, it is more efficient to make investments in compensation mechanisms, expanding the coverage of protected areas. This is related to the Concept Note.

11) **Modeling technologies.** It is recommended to use modeling technologies to prioritize coupled goals (biodiversity, carbon sequestration, protection of ecosystem services, increase in tourism potential, generation of green employment), looking for sites where several Sustainable Development Goals (SDGs) can be met simultaneously. The goal is to achieve total compatibility between NDCs and Long Term Strategies through the joint prioritization of sustainability goals (Jung et al., 2020). The models harmonize what is desirable at the national level with what needs to be achieved at the global level. There are several prioritization tools that can be applied to select such sites. This is related to the attached Concept Note.

12) **Sources of funding.** Possible funding of these actions: From the initiatives promoted by the next COPs (of biodiversity in Kunming (China) and climate in Glasgow, postponed to 2021), and other global incentives from the United Nations, there will be a huge amount of money aimed at the so-called "greening economy", especially for a tropical country that proposes to be a compensator of emissions from other countries. With these scientifically

legitimate arguments, it is possible to work on proposals that attract large international funds destined to promote Long Term Strategies (LTSs) in the long term , especially if the technological example of Belize has the potential to have a multiplying effect to be replicated in other tropical countries. The difference between Intended Nationally Determined Contributions (iNDCs) and more ambitious NDCs should be implemented through international cooperation. The tools recommended here can serve as inputs for future grant proposals.

6. Land Use

6.1 Context and recent history

Belize comprises an area of 2.3 million ha (5,676,011 acres), with about 38% of the land area suitable for agriculture, but only 7% of it actively used. From that 7%, roughly 20% is planted to permanent crops, 30% consists of permanent meadows, and 50% is arable land (FAOSTAT, 2018). With nearly two-thirds of the national land area with severe limitations for agriculture, Belize is extremely vulnerable to land degradation, caused mainly by the expansion of the agricultural frontier through deforestation, combined with the use of unsustainable crop and livestock (CIAT-World Bank, 2018a).

In the last years of the previous century, forest clearing rates (the most common land use change) were estimated around 5,000; 6,700 and 13,000 ha per year in southern, central and northern Belize, respectively (White *et al.,* 1996). The major cause for this deforestation was clearing of land for agriculture and the establishment and expansion of human settlements (Meerman & Cherrington, 2005). By 2018, Belize's forest area declined by 28.4%, (250,000 ha) compared to 1986 values, representing a land cover change of 4% across the country (Folkard-Tapp, 2020).

In Meerman & Cherrington (2005), some figures that show the extent of land degradation processes that Belize has suffered in the recent past are added to a 12% of forest loss between 1990 and 2004. Namely, 31% of agricultural lands are considered grade 4 or 5 (severe limitations for agriculture), 71% of soils subjected to acidic leaching, 4% of agricultural lands on steep slopes and heavy rainfalls subjected to water erosion, 59% of agricultural lands on karst landscapes, 38% of agricultural lands on marginal precipitation regimes, and so on.

6.2 Land Use actions and activities

The NDCs about Land Use should result from the technical and political evaluation of the contribution of practices and other measures (e.g. regulations) corresponding to the different AFOLU plus Biodiversity sectors. In this context, the technical dimension takes into account the contributions of these practices to mitigation and adaptation to climate change.

On the other hand, the political dimension considers the consequences of these practices on other national objectives, among which the following stand out: a) food security, b) public health, c) job creation, d) gender equity, e) provision of ecosystem services.

At the present stage of the analysis, the actions and activities related to the Land Use sector consist of the "translation" of the most plausible and most effective practices around Agriculture, Forestry and Biodiversity sectors, in terms of changes in Land Use and Land Cover (LULC). The main results of these analyses can be seen in Figure 6.1.

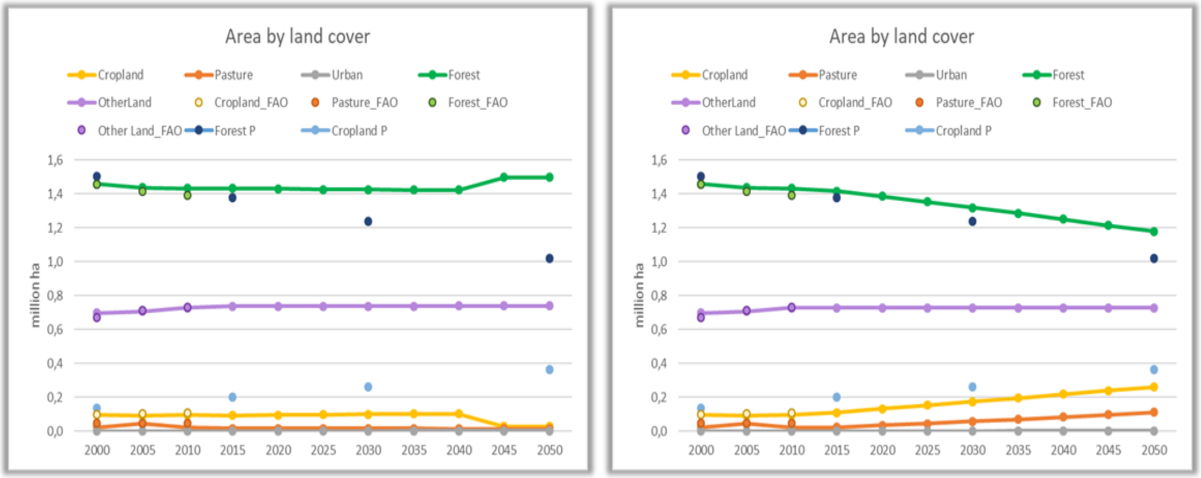

Figure 6.1. Projections of land use form main categories by 2050 for Belize under two contrasting scenarios (without proposed actions and with them) using the FABLE Calculator.

The main source of information available for this translation of LULC practices and measures consists of the AFOLU Greenhouse Gas Inventory and Forest Reference Emission Level / Forest Reference Level REDD + Belize (Belize Forest Department, 2020). This tool integrates the information available for the forestry sector and other land uses, and is being complemented from other sources, with more specific data on agricultural practices and biodiversity management.

The operationalization of LULC changes has three basic requirements: a) land use planning (e.g. zoning maps where different practices should be allowed, promoted, discouraged or prohibited), b) enabling national policies and rules (taxes, Land-Use and PES regulations), c) national and/or international financing. This report only includes advice about available practices (methods) for land-use planning, capable of spatializing the recommended land-use figures.

Spatially explicit land-use planning can be approached with varying levels of precision and realism, depending on the quality of the data and the available knowledge on synergies and trade-offs between alternative land uses. There are sufficiently flexible tools to integrate the necessary changes in agricultural areas, with different categories of forest use and conservation, in order to satisfy different levels of biodiversity conservation and provision of ecosystem services, including carbon storage and sequestration (mitigation). These tools include InVEST, NatureMap and ECOSER, among others.

One aspect in which the impact of various types of Land Use converges is land degradation. According to Meerman and Cherrington (2005), the main causes of land degradation are: (i) deforestation and other land cover conversions, (ii) farming on marginal lands including acidic soils, (iii) farming on steep slopes, (iv) fire, (v) growth and expansion of human settlements, (vi) invasive species, (vii) overgrazing of livestock, (viii) logging, and (ix) surface mining.

Almost a third of the roughly 1 million acres of agricultural land in Belize occurs on land classified as marginal or unsuitable for agricultural activity. More than a third of all agricultural land in Belize is on acidic soils particularly sensitive to land degradation. Almost a tenth of agricultural activity occurs on steep slopes prone to erosion - mainly in central Belize, such as for instance, along the Hummingbird Highway. What’s more, 4% of all agricultural land is located in areas at extreme risk of erosion, should there be sufficient rainfall (such as in a storm event). Where land conversion is a major cause of land degradation, it is also worth noting that available data indicate that half a million acres (almost a tenth) of the nation's land have been deforested in the past thirteen or so years, doubling national agricultural cover in a short period of time. Drought, on the other hand, may affect a greater proportion of agricultural lands. Almost two-thirds of all agricultural lands overlie limestone (i.e. prone to desiccation), while almost forty percent of all agricultural land is in low-rainfall prone areas. These factors combine to put almost a third of Belize’s agricultural land in very drought-prone areas. When both land degradation and drought are combined into a spatial model of risk, it is indicated that almost forty percent of the country’s landmass is at risk for degradation. In terms of the raw human impact of such phenomena, it is estimated that at least fifty-five communities representing at least 18,000 people are affected by degraded and drought-prone lands.

7. Synthesis: synergistic pathways to achieve the NDCs

As it was stated before, the best route to improve NDCs is the one that, in parallel to achieving carbon neutrality, obtains co-benefits with other sustainability goals. Sustainable development goals are at a crossroads because they contain trade-offs, and these problems cannot be solved with each goal moving forward separately. To avoid these problems, in this study, integrated solutions for the AFOLU sector are proposed, computing the effect of each recommended solution in each of the sectors.

There has been advances in the prioritization of the agricultural, forests, and biodiversity practices, according to their positive effects on productivity, adaptation to– and mitigation of climate change effects, also considering their economic costs and adoption barriers (e.g. CIAT-World Bank, 2018b). From this, it can be learnt that cover structures, drip irrigation systems, water harvesting, adjustment of planting dates, crop rotation, intercropping, conservation tillage, use of improved planting material, and improved livestock breeds, pasture improvement, production of hay and silage, and introduction of agroforestry systems are listed as the most important. However, such exercises do not consider their relevance in terms of area and total production of each crop and cattle activity, nor the combined effects, synergies and trade-offs among them (e.g. intercropping may not be feasible if there is going to be foraging on the same area, expanding one crop limits the expansion of another one, etc.). Although Belizean Agriculture may not be that much of a contributor to GHG emissions, the country could benefit from quantifying the impacts on emission reduction of such practices (e.g. to apply for carbon credits).

To overcome this situation, a model called FABLE Calculator (IIASA, 2020) was used to test these practices, together with the Forest and Biodiversity sectors practices, alone and combined, and see how they merge, interact, and contribute to the country's GHG emissions/sequestration profile by 2050. Besides, since the model includes aspects like food security, food production, imports/exports balance, biodiversity, water use, and land use changes, it was very useful to analyze the combined effects of proposed practices.

The strongest point of this model is that it integrates Agriculture with Forests and Biodiversity through Land Use, adding value to the set of activities on each subsector by combining them and providing quantifications and projections that can be used to test for possible synergies and trade-offs among them. For example, since land is limited, it will not be possible to increase both reforestation and agricultural land beyond a point. The model could be used to find out which combination of land uses and productions is optimal according to the preselected scenarios. Besides, it provides a scaled up combination of the effects of such activities and decisions on the indicators, including GHG emissions and sequestrations (Figure 7.1).

Figure 7.1. Projections of GHG emissions (Mg of CO_2e year^{-1}) use form main categories by 2050 for Belize under two contrasting scenarios (without proposed actions and with them) using the FABLE Calculator.

In Figure 7.1., there is an example of the comparison between a “BAU Scenario” for Belize (increased exports, no technological change, free expansion of crops, no afforestation, no changes in protected areas, etc.), and a “Sustainable Scenario” (reduced exports, afforestation and protected areas targets, technological improvements, etc.) through their different contributions to land use change and GHG emissions up to 2050.

The FABLE Calculator was used in this report to calculate the sensitivity coefficients of the actions within each sector, to be integrated in the future multi-criteria analysis of these actions and activities.

The results of this report provide measures and recommendations for guidance purposes, tested for their effectiveness with the FABLE Calculator. To implement the proposed measures, it is necessary to carry out a spatially explicit prioritization model that optimizes joint solutions between various goals coupled with the climate change mitigation goals. The concept note that accompanies this report delves in that direction.

8. Annexes

8.1 Main results of the BAU Scenario

The following Figures illustrate the main characteristics of the BAU Scenario that was constructed to address the effectiveness of the proposed practices and actions:

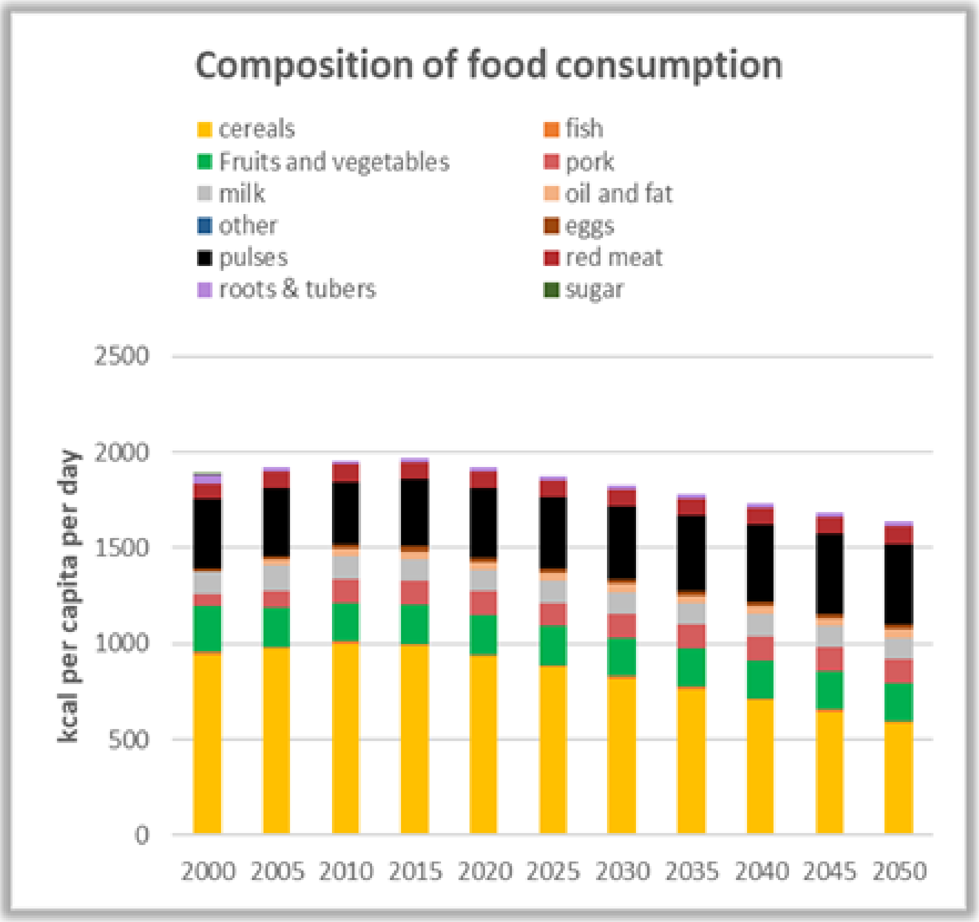

Figure A.1. Composition of food consumption by product groups in Belize in the period 2000-2050 in the BAU Scenario.

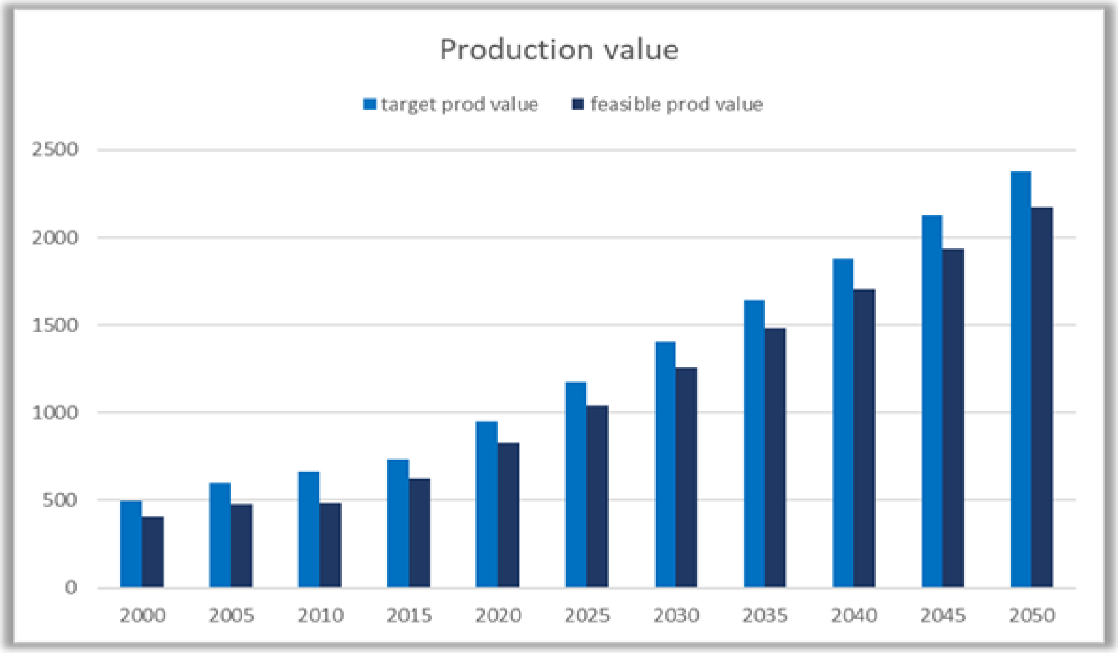

Figure A.2. Target and feasible total food production in million USD in the period 2000-2050 in Belize in the BAU Scenario.

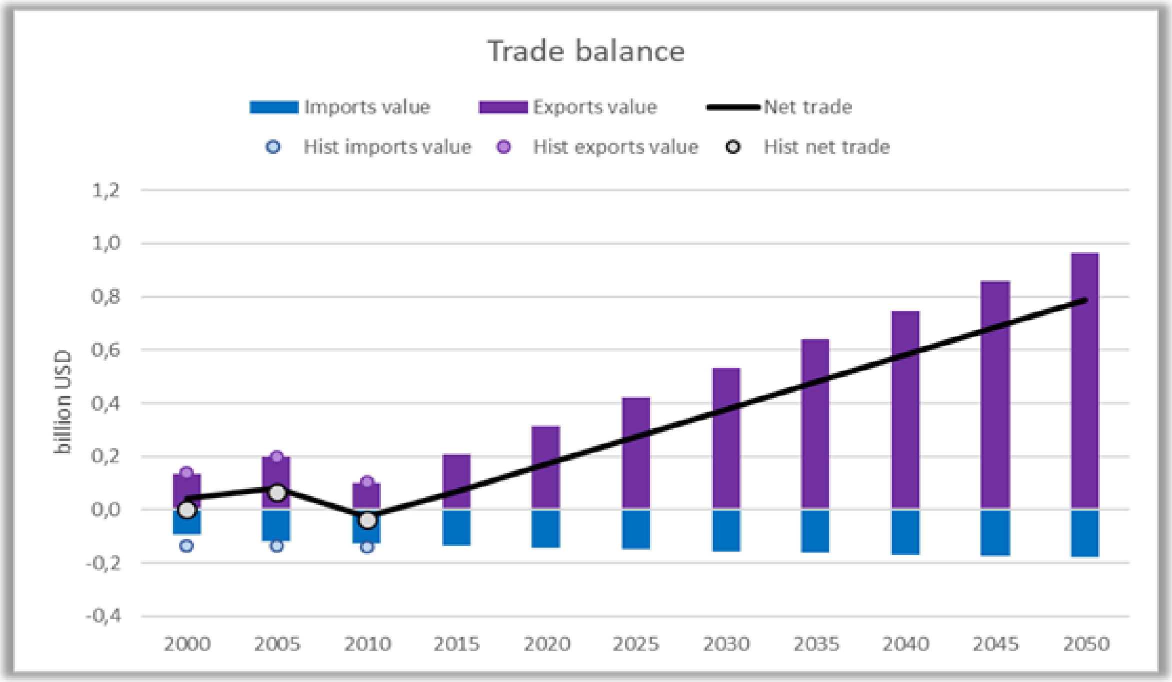

Figure A.3. Historical and projected imports and exports of food production in Belize in the period 2000-2050 in the BAU Scenario.

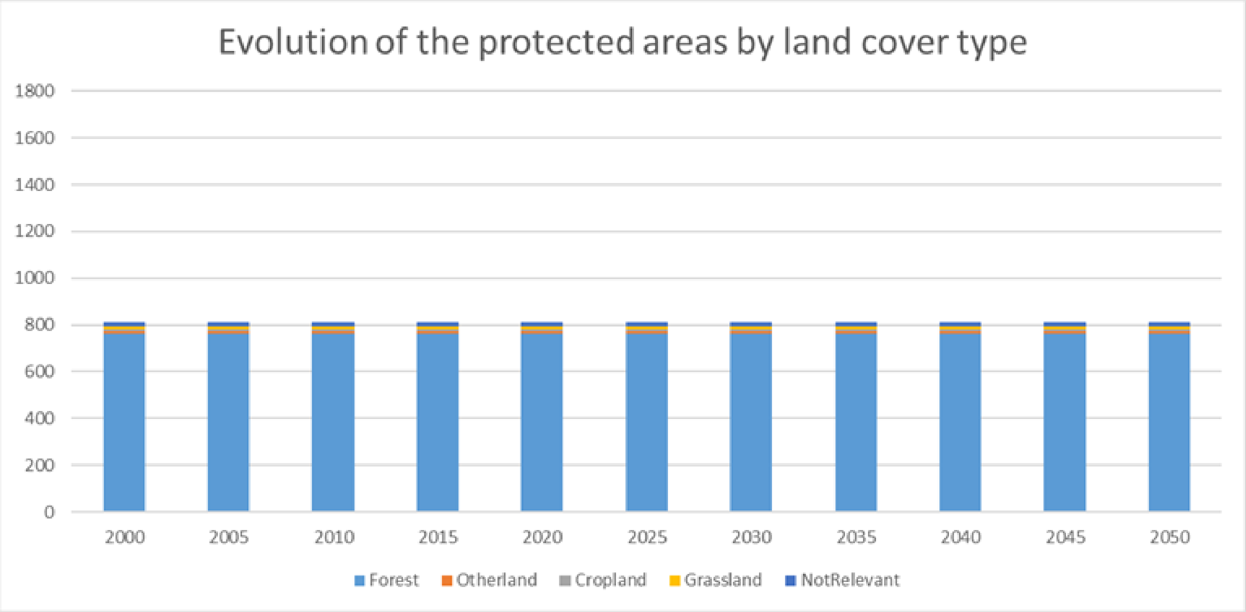

Figure A.4. Evolution of Protected Areas in Belize in the period 2000-2050 in the BAU Scenario.

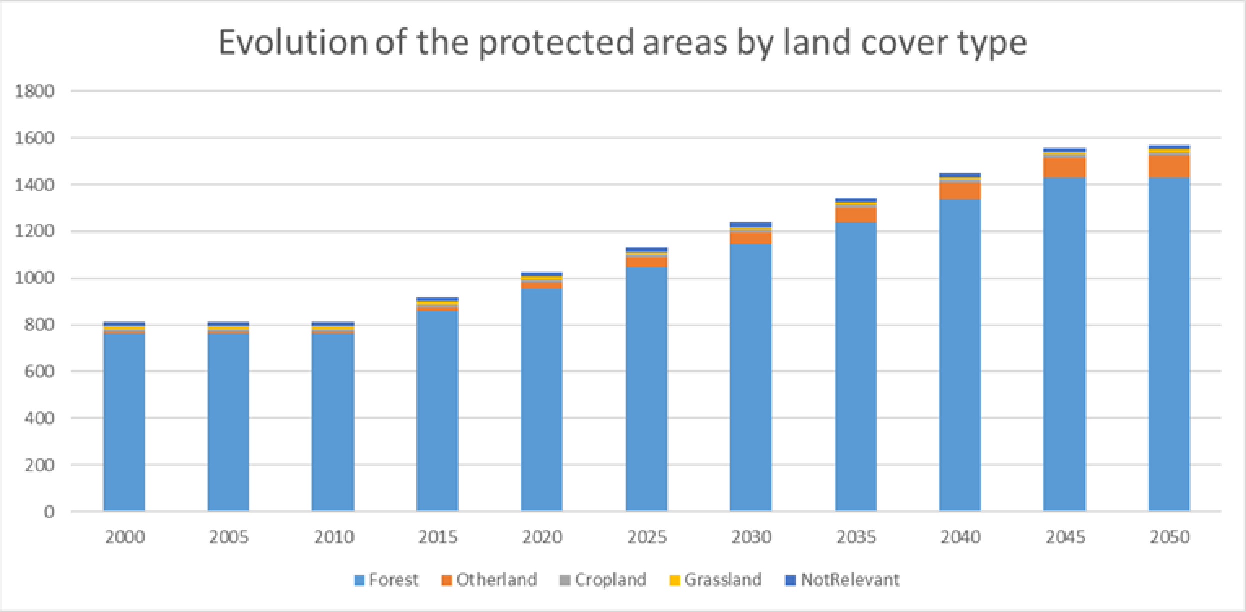

Figure A.4.1. Evolution of Protected Areas in Belize in the period 2000-2050 in the BIODIVERSITY Expansion Scenario.

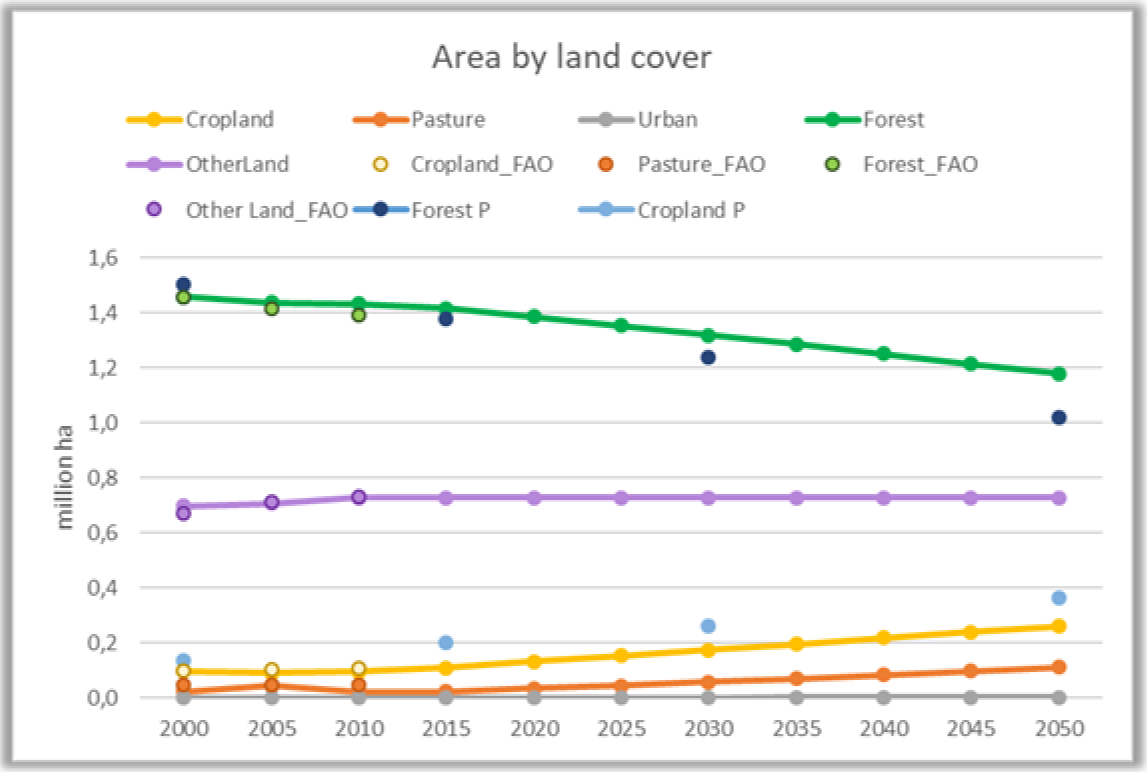

Figure A.5. Evolution of land use in Belize in the period 2000-2050 in the BAU Scenario.

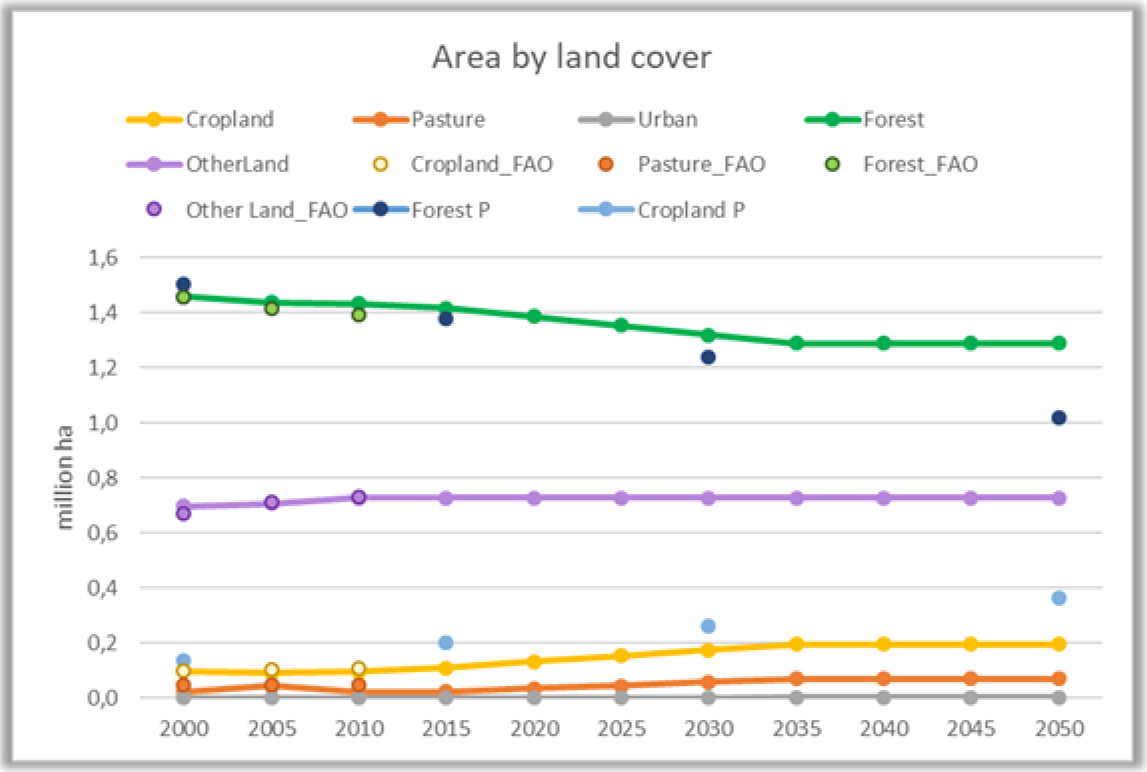

Figure A.5.1. Evolution of land use in Belize in the period 2000-2050 in the FORESTRY Conservation Scenario.

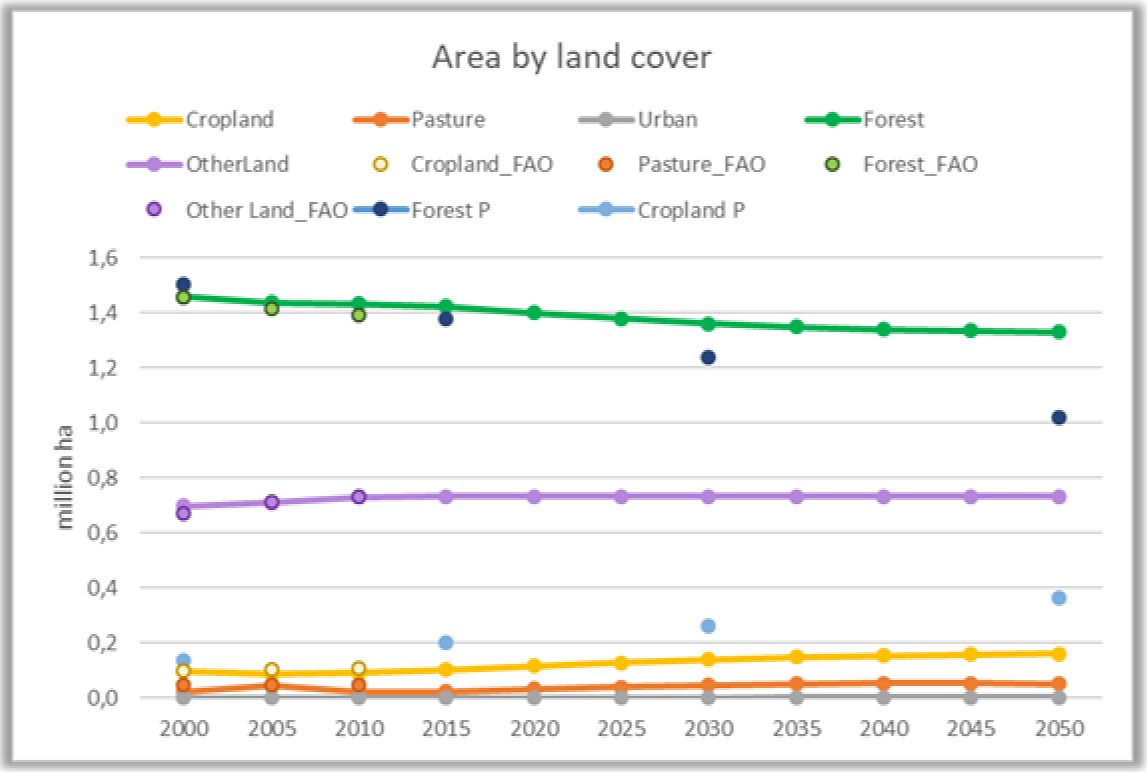

Figure A.5.2. Evolution of land use in Belize in the period 2000-2050 in the AGRICULTURE Climate Smart Scenario.

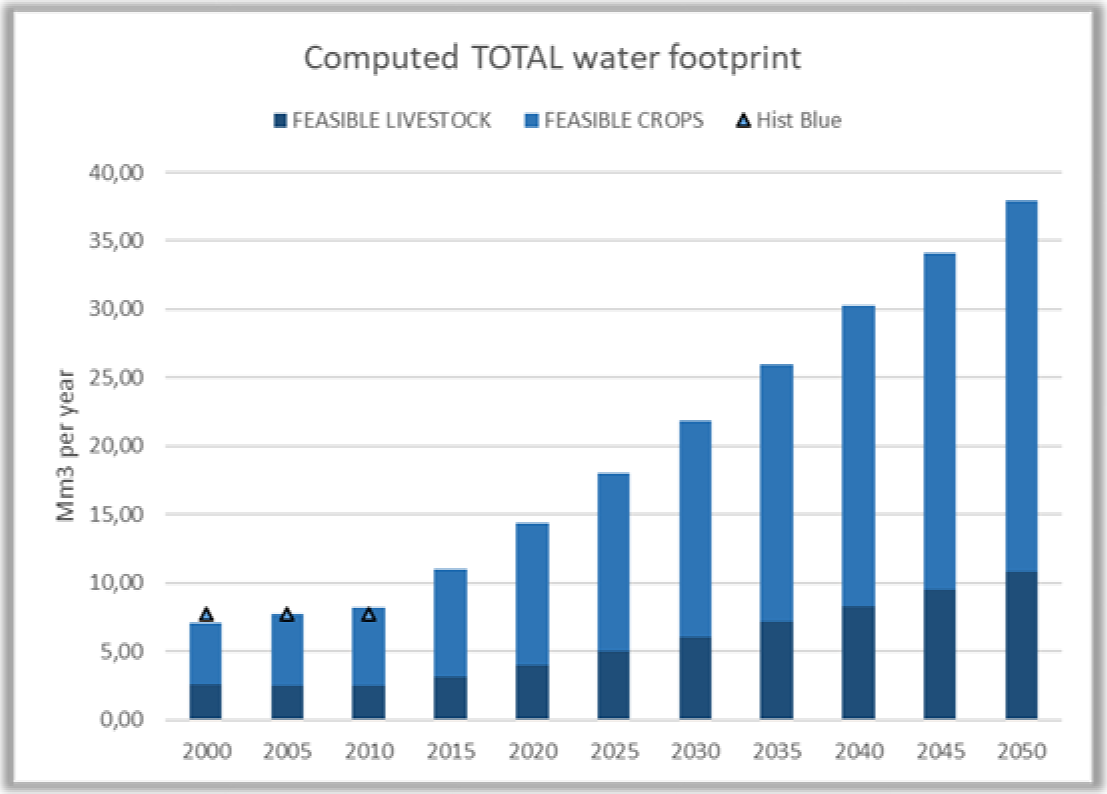

Figure A.6. Evolution of blue water footprint of food products in Belize in the period 2000-2050 in the BAU Scenario.

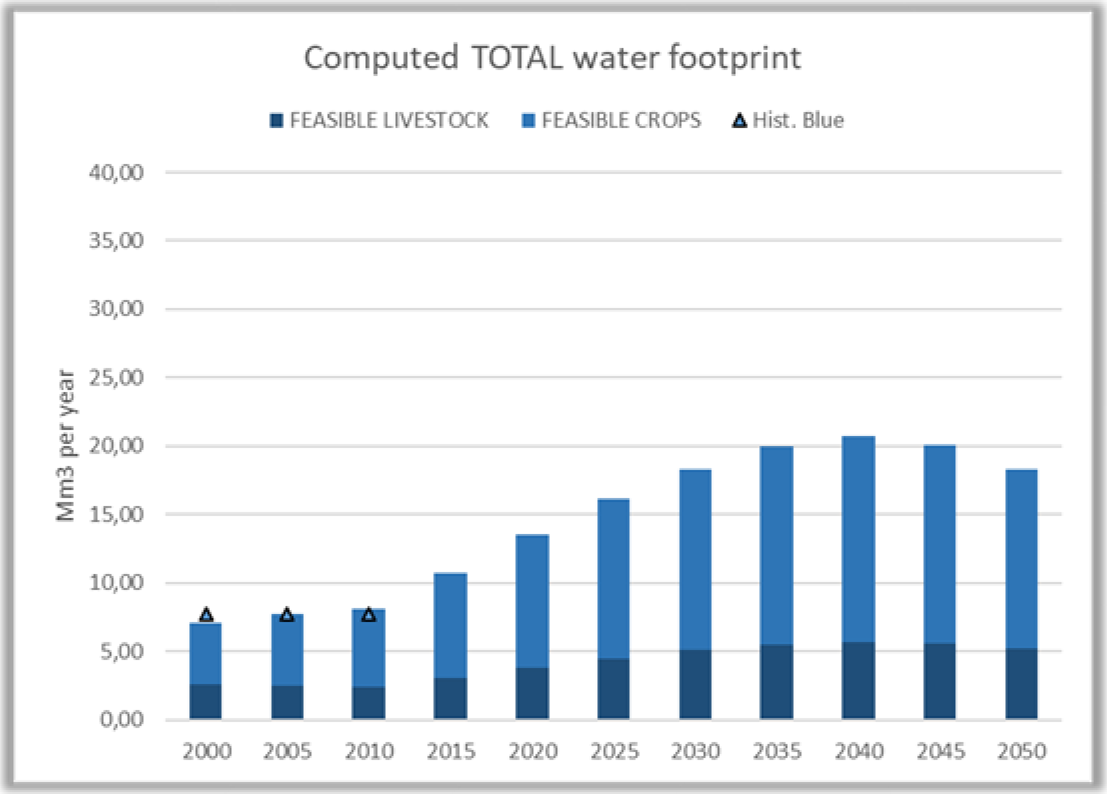

Figure A.6. Evolution of blue water footprint of food products in Belize in the period 2000-2050 in the AGRICULTURE Water Scenario.

9. Supplementary information

List of attached files

FB-AFOLU_Concept Note.doc

SI 5.1. List of terrestrial vertebrates of Belize and database.xlsx

SI 5.2. List of threatened terrestrial vertebrates and category.xlsx

SI 5.3. Pixel Conservation Value per type of habitat.xlsx

SI 5.4 Gains in carbon sequestration with biodiversity measures.xlsx

Feasibility of proposed Actions for Belize's next NDCs_Survey.pdf

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