Annex 24: Baseline information for the forestry and agriculture sectors in the seven participating countries

Forestry sector

Guatemala

Deforestation and degradation of forests over time in Guatemala

In 2006 the territory of Guatemala had 3,868,708 ha of forest. For 2010, forest cover of 3,722,595 ha was reported. During the period 2006-2010 there was a loss of 500,219 ha of forest, however, during the same period 354,107 ha were recovered; having a net loss of 146,112 ha of forest (INAB et al, 2012).

These 146,112 hectares of net loss to the national territory represent a 3.78% decrease in the forest that existed in 2006. The estimated deforestation rate for the territory of Guatemala in that study period was 38,597 ha/year, equivalent to 1.00% per annum, depending on the existing forest reported for the year 2006 (Table 1) (INAB et al, 2012).

Table 1. Forest cover reported for the territory of the Republic of Guatemala in the period 1991-2010 (in hectares)

1991/93	1996	2001	2006	2010
5,121,629	4,699,691	4,152,051	3,868,708	3,722,595

Source: INAB et al, 2012

According to studies of forest dynamics conducted in Guatemala, it was established that the process of greatest net forest loss occurred in the period (1991-2001), which was 73,148 ha/year. For the second period (2001-2006) 48,084 ha/year of net loss were reported and in the third period evaluated (2006-2010)38,597 ha/year of net loss is reported. A continuous loss of the forest was maintained despite the reduction in the net trend (INAB et al, 2012). Guatemala has detailed studies of the dynamics of forest coverage for the period 2010-2016 showing statistics by department (Table 2 and Map 1 of Annex 1) and by municipality. Table 3 lists data for municipalities related to the Dry Corridor, and maps by municipality of interest are shown in Annex 1.

Table 2. Net change in forest cover (earnings – losses) per Department. Republic of Guatemala.

Department	Coverage 2010 (ha)	Coverage 2016 (ha)	Annual net exchange rate	
			(ha)	(%)
Alta Verapaz	372,597	369,916	-505	-0.14%
Baja Verapaz	100,229	91,773	-1,531	-1.53%
Chimaltenango	61,323	68,622	1,242	2.03%
Chiquimula	23,746	24,849	222	0.94%
Progress	37,368	36,831	-103	-0.27%
Escuintla	34,273	39,433	879	2.57%
Guatemala	53,003	48,180	-824	-1.56
Huehuetenango	257,035	265,698	1,379	0.54%
Izabal	270,521	268,603	-375	-0.14%
Jalapa	19,993	22,334	470	2.35%
Jutiapa	10,412	13,453	615	5.91%
Petén	1,798,929	1,633,521	-27,404	-1.52%
Quetzaltenango	56,138	63,106	1,257	2.24%
Quiché	**263,940**	**287,974**	**4,298**	**1.63%**
Retalhuleu	14,247	18,110	704	4.94%
Sacatepéquez	19,536	17,084	-417	-2.14%
San Marcos	85,220	96,595	2,158	2.53%
Santa Rosa	35,688	33,407	-416	-1.16%
Sololá	36,834	38,690	315	0.86%

Suchitepéquez	27,152	36,198	1,542	5.68%
Totonicapán	39,764	39,578	-32	-0.08%
Zacapa	57,840	60,289	494	0.85%
Overall total	**3,675,786**	**3,574,244**	**-18,350**	**-0.50%**

Source: INAB et al, 2019

Table 3. Dynamics of Forest Coverage by municipality selected for the Dry Corridor project. Republic of Guatemala.

Municipality	Coverage 2010 (ha)	Coverage 2016 (ha)	Net Change 2010-2016 (ha)	Annual change (ha/year)	Annual exchange rate (%)
Chicaman	21,514	23,208	1,694	344	1.67%
Uspantan	28,557	33,354	4798	973	3.4%
Canillá	1,706	1,643	-63	-13	-0.8%
San Andrés Sajcabaja	2,540	2,798	259	46	1.8%
Zacualpa	12,251	12313	62	11	0.18%

The biggest threats contributing to forest degradation in Guatemala are as follows (Melgar, W. 2003):

- Fragmentation of forested areas: which has reduced the size of forests, ecosystems and populations, resulting in loss of biodiversity.
- Changes in land use: forest land transformed to agricultural and livestock farms, human populations, etc.
- Lack of strong National Strategies for forest germplasm conservation.
- Limited use of trees to only a few species: which has put some of these species at risk, such as Mahogany, Cedar and Pinabete.
- Low appreciation towards the importance of forest genetic resources.
- Incipient institutional structure: which must respond to the needs of conservation and promotion of the sustainable use of the country's forest genetic resources.

Effects of climate change on Guatemala's forests

Central America's forests and ecosystems are home to about 7% of the planet's biodiversity (INBio, 2004) and are part of the megadiverse area of Mesoamerica (Ramírez, 1983). However, this ecological wealth is being degraded by unsustainable harvesting patterns and will be further affected by climate change (ECLAC, CCAD/SICA, UKAID AND DANIDA, 2011).

Potential impacts of climate change on ecosystems have been identified: changes in evaporation patterns and alteration of cloud cover at the vegetation level. In mountain ecosystems there are disturbances such as decreased tropical and montane floors and increase of the premontane floor, appearance of very dry tropical forest and dry premontane forest. Habitat losses could also occur due to the higher incidence of forest fires, droughts, floods and changes in soil sediments in lowlands, where invasive species and disease vectors can spread.

Within the factors of the MSA index (average species abundance index) that contribute to biodiversity loss, climate change contributes 2.5%, compared to the 34% contribution of land-use change (CUT). (ECLAC (Economic Commission for Latin America and the Caribbean) and MiAmbiente+ (Secretariat of Energy, Natural Resources, Environment and Mines-Honduras, 2016).

The adaptive capacity of ecosystems is also associated with the migration capacity of the species, and the latter depends on the configuration of the landscape. In this sense, "landscape fragmentation can reduce migration capacity by modifying seed dispersion rates or reducing suitable habitats for successful colonization" (Locatelli and Imbach, 2010 cited by ECLAC, 2018).

Adapting forest ecosystems to climate change requires Guatemala's environmental regulatory services to assess the efficiency and sustainability of economic activities that negatively affect them and encourage the reduction of such environmental Effects. Another measure to facilitate adaptation would be to increase the area and protection measures of protected natural areas (NSAs) and biological corridors. Forest conservation measures and their economic and social benefits should include the participation of local communities and the incorporation of their traditional knowledge of nature conservation and adaptability Technology. (ECLAC (Economic Commission for Latin America and the Caribbean), NDF (Nordic Development Fund), IDB (Inter-American Development Bank) and MARN (Ministry of Environment and Natural Resources - Guatemala), 2018).

In Guatemala some of the priority areas have risks ofdesertification. For example, in the Salinas River basin most of the associated territory is under a major to low medium threat (approximately 52%) (MARN, 2019).

Changes in land use in Guatemala

In the period 2001-2010, 1,039,602 ha of forest were deforested in Guatemala (106,845 ha per year), mainly due to livestock (35%) and production of basic grains, such as maize, beans and rice (31%); to a lesser extent, other crops that contributed to deforestation are: African Palm (4%), Cardamom (3%), Hule (3%) and other various crops (4%). Added to this is the change in use due to the growth of urban areas which is equivalent to 2% of deforestation. (GCI, 2018).

Causes of loss of forest cover include:

- The advance of the agricultural and livestock frontier
- Urbanizations
- Forest fires,
- invasions in Protected Areas,
- pests and natural disasters

According to FAO (2001), there are factors that affect deforestation processes such as:

- Extreme poverty and lack of job opportunities and sufficient household incomes for the economically disadvantaged population
- Lack of appropriate or misguided policies and legislation or policies on the occupation of forest space in the humid tropics
- Insufficient capacity in the decision-making of the forest authority in the occupation and use of land.
- Lack of planning in the occupation of the territory and use of inadequate or poor technologies in the use of land and forests

At the hypothesis level, in certain areas, the migration of the local population, both to urban and abroad, may have reduced to some extent the pressure on natural resources by favouring the recovery and/or stability of forest cover, although this effect is very localized and of low magnitude in national terms. (National Forest Institute National Council of Protected Areas, 2012).

An analysis of the remaining forests also shows that forests within protected areas may be and have also been more susceptible to deforestation based on the average slope values within which they are located. The average slope value in forests within protected areas was determined to be 16.1%, while forests outside protected areas are found at sites with an average slope of 37.1%. This means that many of the forests outside protected areas are actually marginal areas, undesirable for the shift towards agricultural uses and/or agro-industrial crops and probably much more stable or less susceptible to being deforested in the short (National Forest Institute National Council of Protected Areas, 2012)..

Forests within protected areas are less fragmented than outside of them. 78% of the forest area in patches greater than 50 thousand ha is within protected areas and these forests located in the largest patches identified comprise 45.8% of the total remaining forest as of 2010. (National Forest Institute National Council of Protected Areas, 2012).

Currently, protected areas retain the largest remnants of continuous forest in the country, which ensure better adaptation to climate change and are a source of strategic resources, such as water and soil stabilization, key to the economy and sustainability of development in Guatemala. (National Forest Institute National Council of Protected Areas, 2012).

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Honduras

Deforestation and degradation of forests over time in Honduras

Forest deforestation and degradation in Honduras are directly linked to the evolution of the forestry sector and that this is the result of various elements related to policies, legislation, institutionality and technical, social, financial and cultural properties. These elements, which in most cases have been conceived as a development option for the country, in their implementation have had a negative impact, directly or indirectly, on forest management and governance. (Vallejo, 2011).

According to Vallejo (2011) the figures on deforestation have always been confusing and inconspicuous in terms of forest degradation and there have been a number of figures on deforestation, often obsolete and without a definite source, where the same institution can generate different figures without justifying variations. Some estimates are shown in Table 4.

Table 4. Historical figures on deforestation in Honduras.

ANNUAL DEFORESTATION	SOURCE YEAR
80,000 has/year	Cohdefor 1980
87,596 ha/year	Cohdefor 1990
59,000 hectares	FAO 2003 (citation NEPHENTES)
108,000 has/year	Cohdefor 1996 (Planfor)
55 thousand to 120 thousand ha/year	ORGUT 2003
100,000 hectares	SAG 2004
80 - 108 thousand ha/year	FAO 2003
100,000 hectares	EIA 2005
80,000 hectares	Serna 2005
156,000 ha/year	Conadeh sf (2006?)
100,000 ha/year	EU 2007

70,000 hectares per year	Nation Plan 2010

Source: Vallejo 2011

These figures have given the wrong impression of the volumes of deforestation in the country. If you regress with the 80,000 ha/year that on average they have managed in different sources, for example in FAO's permanent parcel inventory in 2005-2006, the country's forested area was estimated at 5,791,603 ha (by 2011 they would have been lost 400 thousand ha, indicating that 5.3 million ha remain in Honduras, on the other hand, the FAO 1964 inventory reported a mass of forests of seven million ha, which means that there would currently be only 3.2 million ha, which requires the conclusion that the figure of 80 thousand ha annual deforestation is very high, considering that the increase by best management practices or by reforested area, is almost irrelevant (Vallejo, 2011).

According to the ICF, from satellite imagery, in 2010 the forest cover of the country was estimated at 6, 598,289 ha, which corresponds to 59% of the national territory (ICF 2011). In addition, to consider that the annual deforested area is on average 58,000 ha/year5, more reasonable and plausible data (Vallejo, 2011).

Table 5. Estimated deforestation in forest inventory in Honduras (in millions of ha)

Source /year	FAO (1968)	COHDEFOR (1986)	GTZ (1997)	FAO (2005)
Pine/mixed	2.7	2.4	3.1	2.2
Latifoliado	4.3	2.7	2.9	3.4
importe	**7.0**	**5.1**	**6.0**	**5.6**

Source: Vallejo 2011

In the map of changes in national coverage between 2004 and 2009 (Rivera 2010) it is shown that the highest concentration of loss of forest cover is observed in the areas of the Patuca basin, South Zone (especially the department Choluteca) and the North-West Zone. The corridor of Lake Yojoa and Valle de Sula (San Pedro Sula, Progreso and Puerto Cortes) are areas of high deforestation. Thisperiod observed an increase in pine cover that could indicate that the dense forest was degraded to forest by the extraction of larger trees, making it a forest of lower quality or lower density (number of trees per hectare) (Vallejo, 2011).

Deforestation has also been identified in northern Comayagua and other areas of the country caused by coffee crops; illegal cuts in several municipalities in North Olancho, Gualaco, San Esteban, among others; and degradation and deforestation in protected areas in La Mosquitia Hondureña (Biosfera Río Plátano and Patuca National Park and Tawahka Asagni Reserve). We must also add deforestation and degradation by the population explosion in the country (2.3% per year according to official data) and the expansion of human settlements, which is most noticeable in the big cities (Tegucigalpa and Comayag.ela, San Pedro Sula and the entire Sula Valley metropolitan area, La Ceiba) but equally significant in the remaining settlements that grew in area and number and degradation by forestry bad practices that are carried out under some management plans pine and latifoliated (Vallejo, 2011).

According to the data contained in the Proposal Reference Level of Forest Emissions by Deforestation in the Republic of Honduras (Secretariatof Energy, Natural Resources, Environment and Mines,2017), 2000 2016 total losses from deforestation amount to 372,856.90 ha (Table 6) with anaverage deforestation rate of 23,303.56 ha (Table 4). The coverage with the highest annual deforestation is the wet latifoliated forest with an average of 17,407.51 ha (Figure 5)

Table 6. Total deforestation data for the analysis period in Honduras

	Total area by period/coverage			
Year interval	**2000-2006 6**	**2006-2012 6**	**2012-2016 4**	**2000-2016 16**
Coverage	Area (ha)	Area (ha)	Area (ha)	Area (ha)

B. Wet Latifoliado	71,533.50	127,785.50	79,201.11	278,520.11
B. Conifer	28,918.05	10,030.33	3,205.35	42,153.72
B. Mangle	86.40	61.40	1,047.00	1,194.80
B. Latifoliado Deciduo	20,224.41	23,172.41	7,591.44	50,988.26
importe	**120,762.36**	**161,049.64**	**91,044.90**	**372,856.90**

Source: Secretariat of Energy, Natural Resources, Environment and Mines, 2017

Table 7. Average deforestation data for the analysis period in Honduras

	Average annual loss/coverage			
Year interval	**2000-2006**	**2006-2012**	**2012-2016**	**2000-2016**
	6.00	**6.00**	**4.00**	**16.00**
Coverage	Area (ha)	Area (ha)	Area (ha)	Area (ha)
B. Wet Latifoliado	11,922.25	21,297.58	19,800.28	17,407.51
B. Conifer	4,819.67	1,671.72	801.34	2,634.61
B. Mangle	14.40	10.23	261.75	74.68
B. Latifoliado Deciduo	3,370.73	3,862.07	1,897.86	3,186.77
Average annual/period loss	**20,127.06**	**26,841.61**	**22,761.22**	**23,303.56**

Source: Secretariat of Energy, Natural Resources, Environment and Mines, 2017

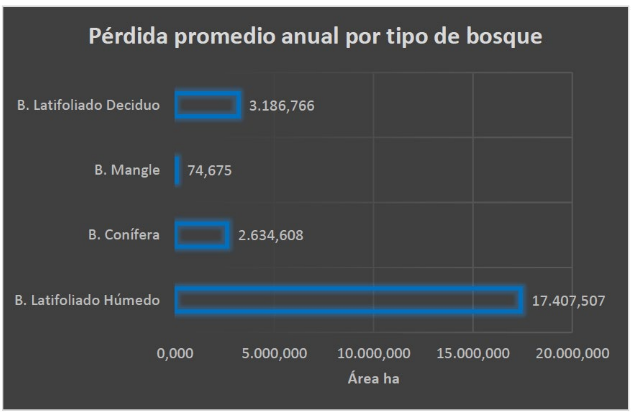

Figure 1 Average annual loss per forest type. Source: Secretariat of Energy, Natural Resources, Environment and Mines, 2017

Effects of climate change on the forests of Honduras

Climate records indicate that Honduras has already suffered an average temperature rise of approximately 0.75 degrees Celsius between the 1960s and 1990s. The climate scenarios of the ECC CA initiative, based on models recommended by the IPCC, foresee future changes in temperature and precipitation. (ECLAC (Economic Commission for Latin America and the Caribbean), NDF (Nordic Development Fund), IDB (Inter-American Development Bank) and MARN (Ministry of Environment and Natural Resources - Guatemala), 2018)

The increase in temperature would generate thermal stress in the trees caused by metabolic modifications that lead to photobreathing instead of photosynthesis at temperatures above 30oC, affecting mainly to important endemic genera such as Pinus and Querqus, this same condition would lead to the decrease in the rate of development and could lead to fragmentation or reduction of the forest. (SERNA, 2010).

The incidence and frequency of forest fires would be particularly noticeable in fragmented forests, areas of low forest density, and adjoining forest areas with agricultural and livestock areas, under a trending scenario of forces drivers of these events. Although the impact of temperature rise on plant pests and diseases is complex, it should be studied based on the variables that interact to determine their incidence and frequency; forest pests, such as *Dendroctonus frontalis,* may increase their reproductive and metabolic rhythms to a certain level, harmfully affecting coniferous forests (SERNA, 2010).

Heavy rains, heat waves and strong winds have adjuvant effects on wildfires; because, in the case of heavy rains, these would contribute to soil erosion, making it more prone to fire affectation in dry season; heat waves and strong winds would drive the spread of fires, particularly in dry conditions. Flooding, on the other hand, would cause overwater stress, and consequently, a greater propensity for pest attack and disease transmission, such as increased fire susceptibility for drier seasons (SERNA, 2010).

The effect of change in land use, in terms of habitat loss and reduction or elimination of biological corridors, will be a significant source of pressure towards, and/or an obstacle to, migration and adaptation. This could exacerbate the genetic degradation of species threatened by inbreeding by migratory disability, thus exacerbating their risks. The climate changes projected by the models are also consistent with possible alterations in trophic chains and ecosystem productivity, although these effects would particularly impact those less biodiverse ecosystems, and by both more fragile, and less fragile. The changes are also potentially consistent with alterations in symbiotic relationships between species and decreased biological controllers. On the other hand, climate change also opens up the possibility for the introduction of invasive or exotic species, particularly from warmer, drier climates, that is, more similar to projected future climates; such species would have an adaptive advantage over native species and, being exotic, probably few natural antagonists, which would pose a particular danger to endemic, less adaptable and more fragile species. (SERNA, 2010)

Changes in land use in Honduras

In Honduras the change in use of forest soils to paddocks is arguably the most obvious manifestation of how ineffective the forest mechanisms used to keep the land dedicated to its natural use have been forest management plans ended up as pastures for livestock or engaged in other agricultural activities. (ECLAC (Economic Commission for Latin America and the Caribbean) and MiAmbiente+ (Secretariat of Energy, Natural Resources, Environment and Mines-Honduras, 2016).

The effect of the change in land use, in terms of habitat loss and reduction or elimination of biological corridors, will be a significant source of pressure towards, and/or an obstacle to, migration and adaptation. This could exacerbate the genetic degradation of species threatened by inbreeding by migratory disability, thus exacerbating their risks (SERNA, 2010).

The eroded area in Honduras was estimated at 2.3 million hectares in 1987 and soil loss in some areas reached 500 ton/ha/year. Coffee has also been another factor of land use change, and there were few coffee areas originally forested, even within areas considered to be legally protected. Vulnerability to soil degradation has been enhanced by the ungovernability prevailing in rural areas and the lack of implementation of the competent legal framework, generating less effect on government and cooperation actions, as well as weak participation of the population in resource management, which impedes the integral development of communities. (SERNA, 2014).

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El Salvador

Deforestation and degradation of forests over time in El Salvador

In 2017, El Salvador is estimated to have 38.8% tree cover, dominated by the secondary forest stratum with a total of 474,776 hectares, representing 22.8% of the territory of the country. Shaded coffee plantations account for 174,979 hectares, or 8.3% of the national territory (MARN, 2018).

The trend in the forested area of the country, during the decade 2000 – 2010, showed that for the period between 2000 and 2005 there was a reduction of 16.13 %, that is, 86,958 hectares, equivalent to 17,392 hectares per year. However, between 2005 and 2010 there was a significant increase in the area, of 28.54% which is 129,073 hectares, equivalent to 25,815 hectares per year, showing an increase of 42,115 hectares between the period 2000 to 2010 (MARN, 2017), Table 8.

Table 8. Trends of the wooded area in El Salvador

Classification	2000		2005		2010	
	Surface (ha)	%	Surface (ha)	%	Surface (ha)	%
B. Latifoliado denso	2,498	0.12	2,413	0.11	2,424	0.12
B. Open latifoliado	8,423	0.40	8,689	0.41	8,600	0.41
B. Dense pine	10,874	0.52	10,205	0.48	11,699	0.56
B. Mixed	7,427	0.35	6,422	0.30	8,193	0.39
B. Dense Mangle	31,542	1.50	32,800	1.56	31,786	1.51
Guaimil*/cafetal	292,389	13.88	220,301	10.45	314,016	14.90
Dry scrub	372,303	17.72	321,547	15.26	397,964	18.89
B. Mangle ralo	7,036	0.33	5,683	0.27	5,706	0.27
Dry forest	151,830	7.21	145,244	6.89	173,549	8.24
Other ecosystems and land uses	1,194,709	56.70	1,333,423	63.28	1,127,934	53.53
Forest	**539,209**	**25.59**	**452,253**	**21.46**	**581,324**	**27.59**
No Forest	**1,568,012**	**74.41**	**1,654,970**	**78.54**	**1,525,898**	**72.41**

*Guaimil: wet secondary vegetation
Source: MARN 2018.

Another analysis carried out by marn in forest ecosystems, for the period 2000 to 2010, indicated that the country experienced a loss of 2.3% equivalent to 48,280 hectares. Analysis of images from 2000 allowed to estimate that the country had an area of forest, including mangroves, of 3226 km2 equivalent to 15.3% (322,600 hectares) of the territory and by 2010, the country showed an ecosystem extent of 2743 km2, or 13% (27% 4,321 ha) of the territory (MARN 2018).

One of the forested ecosystems most affected by the anthropic activities in El Salvador would be the deciduous and semi-deciduous latifoliated forests, which would have been affected by the expansion of agricultural and livestock activities, as well as by urbanization and lotification projects. Also gallery forests, which would have undergone continuous deforestation and degradation, mainly due to the expansion of agricultural and livestock activities. In addition to the expansion of agriculture, the ecotonal zone has been affected by the construction of hotel infrastructure, housing complexes and small hydroelectric power generation projects, which has been restricted to small patches scattered along the coast (MARN 2018).

Effects of climate change on El Salvador's forests

Climate change is a direct driver in the loss of biodiversity, causes changes in phenology that leads to the loss of synchronicity between species, in the abundance and distribution of species, and in the composition of communities, generates alterations in habitat, life cycles and functional levels, exceeding the tolerance and adaptability limits of populations of many species and biological communities. To this phenomenon is added the inadequate management and change in land use, which triggers the accelerated environmental degradation and deterioration of ecosystems, the breakdown of biological connectivity and the consequent decrease in the supply of ecosystem services critical to the development of productive activities and the well-being of society at large. (MARN M.d., National Climate Change Plan (PNCC), 2105).

El Salvador maintains significant biodiversity, with high diversity of ecosystems and species, and with genetic resources of importance to agriculture and food, which has, to some extent, mitigated the impacts of variability climate change over population and ecosystems. Considering that food security and most economic activities are critically dependent on biodiversity and the proper functioning of ecosystems, the authorities consider it imperative to take measures to adapt to the climate change that also increases carbon reserves toumentin ecosystem capacities to adapt and/or cope with the impacts of a changing climate (MARN M.d., National Strategy Environment: Biodiversity, 2013).

Changes in land use in El Salvador

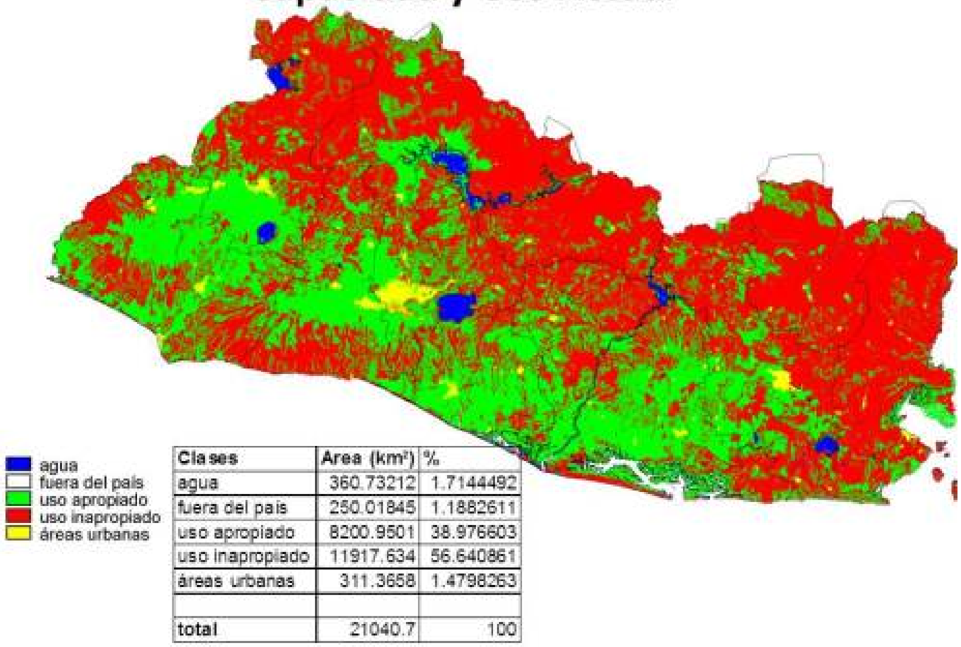
In general, the main causes of land use change and deforestation in El Salvador are complex and vary from area to area. However, a preliminary analysis indicates that, today, the main causes of deforestation and degradation of forests and soils in El Salvador are attributed to: the expansion of agricultural activities and the application of unsustainable practices; urban growth and infrastructure construction; livestock production; the extraction of firewood and wood, forest fires and agricultural burning and, in the case of mangroves, illegal logging and extraction of firewood and wood for dwellings, agricultural and livestock activities, as well as the establishment of salt and small shrimp (MARN 2018).

Migration from rural areas to some cities and urban growth is increasingly under pressure on natural ecosystems and agricultural areas adjacent to the cities. This trend is sometimes associated with the growth and distribution of industry and national trade, which has led to the formation of densely populated population centers, some of them industrialized as is the case in the municipalities of Apopa, Soyapango, Ilopango and others in the Metropolitan Area of San Salvador (AMSS) (MARN 2018).

The population concentration in the large cities and the urbanization processes in different parts of El Salvador show two important impacts. The first, affects the southwestern part of the country, which has led to a threat to shaded coffee plantations, and the most fertile agricultural areas of the Zapotitan Valley country. The second impact is related to the impact of important aquifer recharge zones. The latter in turn leads to a double threat on the water resource, on the one hand, an impact on deforsing and waterproofing the natural recharging area, and on the other, the increase and concentration of water demand in these same areas. This dynamic creates a growing trend of relying more on surface waters for urban supply (MARN 2018).

A CENTA/FAO project estimated that 57% of the land is inappropriately used according to its soil type, the biggest culprit being the basic grains on slopes without conservation measures.

Conflicto de Uso de la Tierra Basado en su Capacidad y Uso Actual



Clases	Area (km²)	%
agua	360.73212	1.7144492
fuera del país	250.01845	1.1882611
uso apropiado	8200.9501	38.976603
uso inapropiado	11917.634	56.640861
áreas urbanas	311.3658	1.4798263
total	21040.7	100

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Nicaragua

Deforestation and degradation of forests over time in Nicaragua

In 2015, the total area of forests in Nicaragua was estimated at 3.4 million hectares (ha) representing30% of the total area of the country. At the country level, 6 types of forest were identified according to their biological composition: palm forest, open pine forests, closed pine forest, open latifoliado forest, enclosed latifoliado forest and mangrove. According to the soil cover maps 2000, 2005, 2010 and 2015 prepared by INETER – MARENA 2017, between 2000 and 2010, the closed latifoliado forest decreased from 3 million ha to 2.2 million ha. For the period 2010 to 2015 the open latifoliado forest rose from 1.8 million ha to 1.2 million ha. The enclosed pine forest was more than halved in the 2000s to 2010s, from 136 thousand to 51 thousand ha.

Current maps show that forest coverage was 63.3% (of the total area of the country) in 1983 to 30.2% in 2015. This represented a 50% reduction in forest areas. In contrast, areas outside forests are observed to increase continuously throughout the period 1983-2015, and it is reported that quadruple or the estimated total area that increased from 27.8% to 60.31% in the same period (MARENA,2017). In the period 2010 to 2015, the net percentage of deforestation decreased significantly, at a rate of 14,021 ha per year, due in part to the recovery of forest cover in some areas of the country, other than those where deforestation occurred. However, gross deforestation in the same period is 528,844 ha equivalent to 105,769 ha annually mainly due to the loss of latifoliated forest and conifer that passed to agricultural and tacotal use. (from Camino Velozo, 2018).

The loss of dense latifoliated forests (approximately 4 million ha) accounts for or about 93% of the deforestation recorded in that period, and almost all remaining deforestation is due to the loss of dense pine forest (approx. 320,000 ha). The least changes were recorded in open forests, whether from latifoliados, conifers, mangroves and palms. (MARENA, 2017).

The enclosed pine forest was more than halved in the decade from 2000 to 2010, from 136 thousand to 51 thousand ha, although there is a slight increase in areas in 2015 with 100 thousand ha. Most of this loss occurs in pine savannahs in the northern Caribbean region. While the open pine forest remained during 2000 to 2010 with 171 thousand ha and 185 thousand ha respectively. However, in recent years there has been a reduction with 163 thousand ha for 2015. The increase in open pine forest for this period is 20,300 ha, meaning that most of the change in closed pine forest was by deforestation and less by degradation. Mangrove forests and palm forests have been suffering a slight decrease in their areas from 2000 to 2015, have gone from 103 thousand and 110 thousand ha to 98 thousand and 92 thousand ha respectively (from Camino Velozo, 2018).

Deforestation and forest degradation are processes caused by multiple factors, which can be trigger scars. For this reason, various studies classify the causes of deforestation and degradation into direct and indirect or underlying causes. Two direct causes of deforestation in Nicaragua, linked to the expansion of the agricultural border and extensive livestock, were identified. (MARENA,2017).

According to MARENA (2017), there has been a continuous loss of forest resources by the policies of the other sectors that have to do with land use, with forest loss and degradation both by invasions of landless migrants, and by changes in landless use towards agribusiness and livestock on a larger scale. This threat is motivated by the following factors:

- Because of poverty,
- The lack of consolidation of the forestry sector with stability and demonstration that it is a profitable sector for the State, communities, owners, investors.
- The almost non-existence in the present of functional experiences of sustainable forest management of latifoliated forests.

Paradomodely, because the forest does not have value for the one who manages it, there is a change of land use for immediate alternatives, large and small scale (migratory agriculture, extensive livestock, coffee, oil palm) in general towards crops with a better cash flow and fewer restrictions that cause transaction costs.

Effects of climate change on Nicaragua's forests

Wildfires are one of the main threats to forests that has increased with the threat of climate change, causing high severe negative impacts on ecosystems with the greatest impacts in different municipalities of the departments of León, Chinandega, Nueva Segovia, Madriz and the Autonomous Regions of the Caribbean Coast. (MARENA, 2017)

The main cause of the constant recurrence and aggressiveness of forest and agricultural fires lies in the burning as a traditional and estimated low-cost practice, the change of land use; transforming conservation areas into agricultural production areas, unplanned burnings that start in agricultural areas and end in forests. (MARENA, 2017).

According to MARENA (2017), the fires represent economic losses, in the short, medium and long term, causing among other effects the following:

- Serious impacts on the basis of environmental factors, mainly biodiversity and altering the functionality of forest ecosystems;
- Increased concentration of carbon dioxide emissions and decreases sinks, which increases the greenhouse effect;
- It affects infrastructure and human lives;
- Productive activities are deficient as a result of decreased soil fertility; And
- Increased rural poverty.

Wildfires can be caused by thunderstorms, spontaneous combustion of vegetative material exposed to the sun during the summer, or by producers for the development of agricultural and livestock activities, usually for cleaning of their plots in the months of February, March and April for the first planting. Fire is also a practice of producers who make migratory agriculture, so every year they affect new land in order to produce. They advance through the forest with the techniques of tomb, brush and burn. Comparative data from the last fire-related periods within protected areas show that fires are a recurring phenomenon that repeats its intensity every certain period of time. (MARENA, 2017)

Changes in land use in Nicaragua

The largest deforestation occurred from the 1990s with the end of the war in Nicaragua, during which time areas were assigned for agricultural activities including demobilized war and land reform titles. In addition, in the 1980s, part of the deforestation was caused by Hurricane Juana in 1988, which affected half a million hectares (Ruiz et al. 2001) cited by MARENA,2017.

Nicaragua was historically considered a country with forest-based soils, in 1969 there were 8 million hectares of natural forests representing 60% of the total area of the country. However, between 1983 and 2015 it lost 4.32 million hectares of forests, representing more than half of its forest area. These land-use changes are reflected in the latest report indicating the following usage distribution:

- 33.83% forestry and agroforestry system,
- 25.98% forest (protection, and conservation),
- 20.33% silvopastoralandile and special crops,
- 11.8% agricultural (intensive, restricted and livestock systems).

Fire is the main instrument used for the realisation of the change in land use that is closely related to the advance of the agricultural border, affecting annually large tracts of forests, degrading its floristic structure and composition (MARENA, 2017).

By 2015, latifoliated forests occupied an area of 5,030.96 km2 (88.2%), with dense forest areas decreasing 721.37 km2 (12.65%) and an increase in the forest of 573.94 km2 (10.06%). While changes in the extent of dense latifoliated forests occurred over a 15-year period, this did not prove to be significant in influencing the hydrological behavior of the basin's Hydrological Units of influence. Agricultural areas occupied 102.75 km2 (1.8% of the total area of the hydrological units they provide), and over a period of 15 years, these increased to 238.10 km2 (4.17%) mainly on flat to slightly sloping and moderately steep slopes. (Espinoza, 2017)

In 2005-2015 deforestation accounted for 8.3% and forest degradation 4.1% of the total area of the country. Historically, firewood and charcoal, as well as other biomass derivatives, have always played an important role in meeting basic energy needs, such as the cooking of Nicaraguan food. In 1990, according to nicaragua's Forest Plan, firewood accounted for 55% of net final energy consumption; 1% and petroleum derivatives 27%. According to this study, wood consumption was estimated between 1,500,000 and 1,800,000 metric tons (TM). 89% was consumed in residential and commercial areas, 5% in the industrial sector and the remaining 6% in charcoal production. So, it was also indicated that 1.8 million people used firewood as the main fuel. The previous consumption trend has implications for socio-economic and environmental types. Firewood and charcoal come almost entirely from natural forests. 60% of the wood used are tree branches, trees outside the forest, tacotals, shrubs and dry wood collected from the ground, 9% are considered to come from the cutting of trees and pruning. (MEM, 2007) cited by (MARENA, 2017).

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Costa Rica

Deforestation and degradation of forests over time in Costa Rica

In 2013, approximately 62% of Costa Rica's territory was covered with its natural vegetation in various conservation states. Of this area, 94% were evergreen forests of the mainland and forests and dry scrub, 5% undoubted palm or yolillal forests, 1% mangroves, and just over 0.3% moors. Of the 38% of the national area with anthropogenic coverage, most, about 91%, were in agricultural land-use systems in general, just under 7% to commercial forest systems, and the rest, approximately 2.5%, to urban systems, dense rural areas and infrastructure. Three out of ten agricultural hectares were dedicated to crops and 7 out of 10 to pastures for various types of livestock. According to the 2014 Agricultural Census, approximately 20% of the cultivated area corresponded to transient crops (rice, beans, maize, etc.), 79% to permanent crops (coffee, oil palm, sugar cane, etc.), and 1% to others. This pattern remained relatively stable from the late 1980s (Table 9) Sierra et al, 2016.

Table 9. Evolution of Costa Rican land cover, 1987-2013.

Soil Coverage (%)	1987	1992	1997	2001	2008	2011	2013
Forest	56.8	56.7	56.1	56.3	56.3	56.5	57.7
Yolillal	3.2	3.1	3.0	2.9	2.9	2.8	3.0
Mangrove	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Moor	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Pastures	23.8	25.0	25.1	25.1	25.5	25.2	24.1
Crops	10.6	10.8	11.2	11.4	11.4	11.2	10.6
Forest Plantation	2.9	2.7	2.8	2.4	2.0	2.2	2.5
Urban and Infrastructure	0.5	0.6	0.7	0.8	0.9	0.9	1.0
Costa Rica	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Sierra et al, 2016

According to FONAFIFO (2007), by 2005 Costa Rica had an estimated forest cover of 48% (2,446,118 ha). During the period 2000-2005, a loss of 23,900 was detected equivalent to an annual deforestation rate of the national territory of 0.09%. In terms of recovery of coverage or secondary growth it was possible to detect a recovery of 169 equivalent to an annual recovery rate of the national territory of 0.66%. Therefore, the recovery rate of forest cover is 7 times the rate of loss of coverage in the period 2000-2005 (Tables 10, 11).

Table 10. Results of the classification of Forest Coverage for Costa Rica in 2005.

Type of Coverage	Area on hectares	Percentage (%) National Territory
Forest Coverage	2,276,205	43.2
Non-Forest Coverage	2,346,823	45.6
Forest cover recovery	169,914	4.8
Loss of forest cover	23,689	0.5
Mangrove	41,121	0.8
Moor	11,061	0.2
Clouds	184,649	3.9
Urban areas	26,036	0.5
Water	23,740	0.5
importe	**5,103,238**	**100**

Fuente FONAFIFO 2007.

Table 11. Loss and recovery results of forest cover for Costa Rica period 2000-2005.

Variable	Area in ha	Units
Loss of coverage 2000-2005	23,689	ha of forest
Annual loss (5 years)	4,738	ha/year
Annual rate of loss of the national territory	0.09	%/year
Coverage recovery 2000-2005	169,914	ha of no forest
Annual recovery	33,983	ha/year
Annual rate recovery of the national territory	0.66	%/year

Source: FONAFIFO 2007.

According to Costa Rica's National Forest Inventory 2014-2015 The types of forests with the highest share of Costa Rica's area of forests are the Mature Forest and the Secondary Forest, which together account for 64.38% of the forested area of the country; the third largest area corresponds to the use Grass with trees, with a 31.54% share. The uses Natural Palm Forest, Mangrove Rods and Forest Plantations together account for only 4.09% of the area of interest (Table 1).

Table 12. Surface area and participation of forest types in Costa Rica in 2015

FLOOR USE (Forest Types)	Surface (km2)	Surface (ha)	Participation (%)
Maduro Forest	15,485.83	1,548,583.38	40.05
Secondary Forest	9,408.20	940,820.31	24.33
Mangle stands	362.50	36,250.34	0.94
Palm Forest	472.19	47,219.26	1.22

Grass with Trees	12,194.26	1,219,425,65	31.54
Forest plantations	745.97	74,596.85	1.93
importe	**38,668.96**	**3,866,895.79**	**100.00**

Source: Costa Rica National Forest Inventory 2014-2015

Effects of climate change on Costa Rican forests

In 2013, SINAC and CATIE concluded a study on the vulnerability to climate change of terrestrial wild protected areas (ASPs) and biological corridors. The vegetation of species of conservation importance, water quality for human consumption and carbon storage were assessed, inter alia. Among the findings obtained is the verification of changes in water supply and vegetation distribution, as well as the increase in temperatures, a situation that will aggravate the climate problems already facing the country (Corrales, 2014).

Based on simulations using climate models, it is estimated that temperature changes can occur in specific areas. For the period 2070-2099, and considering high emissions (EE) scenarios, the probability that the average annual temperature will increase by 3oC or more is low for the country in general, but is average in the Osa Conservation Area (Acosa) and the south of the Friendship-P Conservation Area (ACLAP). As a result of the increase in air temperature and the reduction of precipitation, it is expected that in more than 66% of the territory of the Arenal Huetar Norte (ACAHN), Tortuguero (ACTO), Tempisque (ACT) and Guanacaste (ACG) conservation areas, where there is wetland complexes) the surface temperature of freshwater bodies increases between 2.3 and 2.8ºC (Corrales, 2014).

In several ASPs, plant cover may change. In general, the highest potential impact values on vegetation are on the Pacific slope and in the Los Guatusos plain in the Huetar Norte region. Under climate-level conditions, and considering high EE, it is likely (> 66% of scenarios) that half of the country's tree vegetation has changed from one type of vegetation to another in the period 2070-2099. That is, it is estimated that most will have changes in its density and structure or have transited to a type of vegetation with greater predominance of shrubs and pastures. In these conditions, the territory of four conservation areas (Central Pacific, Tempisque, Arenal-Tempisque and Arenal Huetar Norte) has more than 60% of the extent of its tree vegetation with a very high probability of change; this proportion ranges from 34% to 59% when considering the ASP set (Corrales, 2014).

However, most listed species of conservation importance will have changes in their potential distribution, especially by reducing their habitat. Few species would have an increase in habitat area, but even in those cases, they would have habitat loss in certain areas of distribution. Most of the sweet aquaculture organisms modelled in the study showed a pessimistic scenario for species survival in the future, due to a large loss of habitat (Corrales, 2014).

Changes in land use in Costa Rica

Compared to historical trends, by the end of the 1980s Costa Rica's deforestation rates were low, remaining at around 0.2% per year between 1987 and 1997. The country went from net loser to net native forest winner between 1997 and 2008. Between 2008 and 2013 the natural forest area grew 0.5% per year. In absolute terms, the native forest area gradually went from losing approximately 100 km2/year in the late 1980s (c. 1987-1992) to gaining about 300 km2/year at the beginning of a decade in progress (c. 2011-2013). Of the three types of forest, the yollillales lost an average of 0.34% of their area annually. The forests of the mainland gained on average 0.02% of their area annually in and mangroves 0.04% (Sierra et al, 2016).

Three periods with characteristic change trends have been identified: A period of intensification of land use, from the late 1980s (c. 1987) to the late 1990s (c. 1997), characterized by patterns of deforestation and gross regeneration coupled, but with decreasing differences, resulting in the gradual reduction of net deforestation. A second transition period, from the late 1990s (c. 1997) to the late 2000s (c. 2008), with levels of lower edifted deforestation and regeneration and the like, resulting in relative stability of the natural forest area. And a third period, from the late 2000s (c. 2008) to the present (and possibly continuing at least in the short term), characterized by the recovery of the country's forest area because gross regeneration exceeds gross deforestation. Deforestation and gross regeneration also tend to spatially covary: where more deforestation tends to occur more regeneration. This is because, in periods of expansion of demand for new productive areas, exchange agents prefer to allocate available resources to create new productive areas by cutting mature forests, probably because of their greater productive potential allowing forests in the early stages of regeneration to recover until detectable in the satellite images used to make the soil cover maps (Sierra et al, 2016).

One of the most important patterns of the change in natural forest cover in Costa Rica is the strong tendency to focus on accessible areas. From the late 1980s to the late 1990s (c. 1987-1997) the net loss of forest area was intense especially far from urban areas. Most of the fall in annual deforestation to the next period (c.1997-2008) also occurred in these areas, remaining stable in areas with high and medium accessibility. Since the late 2000s (c. 2008), the gross deforested and gross regenerated area tended to increase and concentrate on accessible areas, close to urban areas and under a particular private tenure regime. The expansion of the network of protected areas, including areas with mixed communal property and nature reserve regimes, probably contributed to the reduction and concentration of deforestation in Costa Rica by expanding the area with non-forest land uses decrease the area without these restrictions (Sierra et al, 2016).

Most gross deforestation affects regenerated forests after 1987, but the proportion varies per usage system. 63% of the deforested pasture area between 2011 and 2013 was regenerated forests sometime after 1987. In this period almost 90% of the area deforested to make way for crops affected regenerated forests, 77% in the case of forest plantations and 48% for urban and infrastructure (Sierra et al, 2016).

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Panama

Deforestation and degradation of forests over time in Panama

By indirect methods (forest inventories) it was estimated that, by 1947, Panama's forest cover was approximately 5,245,000 ha, and for the year 1986 of 3, 664,761 ha (ANAM, 2010). For 1992 data were generated on the area of the country, estimated on this occasion an area of 74,926.77 km2. Significant data on the state of forests were obtained and a forested area of 36,951.60 km2 was found to be 49.3% of the country's total area (ANAM, 2010).

In 1992, mature forests accounted for 90.7% of forest cover, mangroves 4.9%, 1.9% mature secondary forest, 1.2% mixed flood forests and 1.1% cativales. In terms of area (km2) of each of the categories constituting forest cover, the following areas were recorded at the national level: mature forests 33,520.72 km2 (44.7%), mangroves 1,817.73 km2 (2.42%) and secondary forests 455.55 km2 (0.61%) (ANAM, 2010).

The country's forest edcover for 2000 was 33,645.91 km2 (3,364,591 ha), representing 45% of the country's total area. Of this total, the provinces that showed the most forests were: Darien, Panama, Comarca Emberá-Wounaan and Bocas del Toro, which accounted for 50.2% of the forest cover. Of this coverage, the provinces that showed low percentages were Los Santos and Herrera, with 0.83% and 0.28%, respectively (ANAM, 2010).

Nationally, mature natural forests have an area of 30,150.02 km2, representing 40.2% of the country's total area. These forests are located mainly in the provinces of Darien (7,775 km2), Panama (4,115 km2), Comarca Emberá-Wounaan (3,953.4 km2), Bocas del Toro (3,158.23 km2), Shire Ng'be-Buglé (2,745.9 km2), Veraguas (2,460.6 km2), Colón (2,269.3 km2) and Kuna Yala Shire (2,095.5 km2) (ANAM, 2010).

Of Panama's total forests, mature forests occupy 89.6% and are located mainly in the districts of: Cémaco, Sambú, Chepigana, Pinogana, Changuinola, Chepo, Panama and Chimán, among others. Followed by these forests are the mangroves, showing an area of 1,744.35 km2 (174,435 ha), which accounted for 5.2% of the national forest cover and 2.3% of the total area of the country. Mature secondary forests covered an area of 719.9 km2, i.e. 2.1% of the forested area and 0.96% of the total area of the country; are located in the provinces of Panama and Colón, specifically on the banks of the Panama Canal (ANAM, 2010).

Effects of climate change on Panama's forests

According to the Intergovernmental Panel on Climate Change (IPCC), climate change will cause gradual increases in the average temperature of land and ocean area, changes in precipitation patterns, changes in intensity and frequency of extreme weather events and an increase in mean sea level (IPCC, 2007). It is estimated that by the end of the 21st century, the increase in Earth's surface temperature could be between 2.6 and 4.8ºC, and that the rise in mean sea level could be between 45 and 82 centimeters. In addition, precipitation is likely to increase in high latitudes and in Ecuador, and decrease in subtropical areas (IPCC, 2013a) cited by (Botero, 2015).

Currently the Government of Panama considers the fight against climate change and its effects as a fundamental axis of government action, curbing deforestation and restoring plant cover to prevent desertification and reducing vulnerability development and implementation of adaptation and mitigation measures." Finally, the Strategic Governance Plan establishes as explicit indicators of success the adoption of the new Forest Law and the implementation of the Alliance for one Million Reforested Hectares, as part of the National Emissions Reduction Strategy by Deforestation and Forest Degradation (REDD+). (Government of Panama - UNDP, 2017).

Changes in land use in Panama

The causes of the deterioration of the country's forest heritage are multiple, due to complex, often interrelated processes. Generally speaking, the degradation and deterioration of forest ecosystems in Panama respond to two types of causes: direct, including those actions, development processes and sectoral policy measures that have a direct impact on resources and institutional resources, which respond to economic models and the means available to institutions to provide an answer to the problem of forest destruction (ANAM, 2010).

According to analyses carried out by the Inter-Agency Commission on Deforestation, in 1993, the expansion of the agricultural border has been identified as the main cause of deforestation in Panama. For its part, both the 1992 Forest Cover Report, as well as the Forest Cover and Land Use Report of the Republic of Panama: 1992-2000, indicate that the areas where this operates most intensively are Dariién, Panama East, Bocas del Toro, Coclé, Colón and the trans-seismic corridor. This expansive process has been fostered by soft credit policies to stimulate agricultural activity and land titling policies that encouraged the transformation of forest into agricultural crops and grasslands (ANAM, 2010).

Table 13. Change of Panama's forest cover by province, 1992-2000

Province Region	Wooded surface (ha)			Change of wood cover 1992-2000		
	1992	**2000**	**Km2**	**Rate (%)**	**Annual Change (%)**	**Annual Rate (%)**
importe	**36,951.60**	**33,645.91**	**-3,305.69**	**-8.95**	**-413.21**	**-1.12**
Bocas del Toro	3,522.52	3,421.91	-100.61	-2.860	-12.58	-0.36
Cocle	691.15	654.22	-36.93	-5.34	-4.62	-0.67
Columbus	2,844.72	2,606.26	-238.46	-8.38	-29.81	-1.05
Chiriquí	1,049.41	1,211.12	161.70	15.41	20.21	1.93
Darién	9,907.37	8,531.25	-1.376.12	-13.89	-172.01	-1.74
Herrera	102.25	93.21	-9.04	-8.84	-1.13	-1.10
Los Santos	212.30	279.71	67.42	31.76	8.43	3.97
Panama	5,670.53	4,978.32	-692.20	-12.21	-86.52	-1.53
Veraguas	3,019.05	2,830.53	-188.52	-6.24	-23.56	-0.78
Emberá-Wounaan Shire	4,018.92	3,976.14	-42.78	-1.06	-5.35	-0.13
Kuna Yala Shire	2,155.64	2,123.42	-32.22	-1.49	-4.03	-0.19
Ng'beShire -Buglé	3,757.75	2,939.82	-817.93	-21.77	-102.24	-2.72

Source: ANAM, 2010

The forests involved increased from 6,482.32 km2 in 1992, to 9,215.88 km2 by 2000, demonstrating that their total area represents8.6% by 1992 and by 2000 13%, an increase of 273,356 ha, with an annual decline rate of 5.3%. Stubble has also been similar to the forests involved. The area has increased from 9,094.16 km2 in 1992 to 11,427.0 km2; according to the total area, they show 12.4% and 15.25% respectively, with an annual exchange area of 29,160.5 ha, and an annual rate of decline of 3.2%. Contrary to the last two uses (intervened forests and stubble), agricultural use decreased its area from 1,527,372 ha in 1992 to 1,058,442 ha in 2000, which, according to the total area of the country, is 20.38% and 14.3% respectively. The change that occurred in eight years was -468,930 ha. This represented an annual decline of -58,616.25 ha and an annual decline rate of -3.84% Table 13 (ANAM, 2010).

Table 14. Main land uses in Panama, 1992-2000

Category	Surface 1992		Surface 2000	
	Surface area (km2)	**%**	**Surface area (km2)**	**%**
Forest	36,951.60	49.30	33,645.91	44.90
Intervened forest	6,482.32	8.65	9,215.88	12.30
Agricultural Use	15,273.72	20.38	10,584.42	14.13
Keep	5,620.18	7.50	8,160.58	10.89
Other Uses	332.80	0.44	594.52	0.79

Source: ANAM, 2010

Deforestation in Panama has been significantly reduced in the last period due to multiple factors, such as: strengthening environmental institutionality and creating environmental management instruments; creation of private nature reserves; increased population awareness; private company's largest share with national and international capital; decrease in forest concessions; national reforestation efforts through UNEP; creation of new protected areas; creation of new watershed restoration programmes and the requirement of ecologicalcompensation plans for development projects (ANAM, 2010).

A process of harmonisation of forest development policies to control and reduce deforestation has also been initiated. Therefore, sustainable forest management is promoted, including agroforestry and management in buffer areas and thus contributes to the reduction of pressure and the advancement of the population on forests (ANAM, 2010).

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Dominican Republic

Deforestation and degradation of forests over time in the Dominican Republic

The forest area of the Dominican Republic is composed of seven types of forest ecosystems with an area of 2 million 103 thousand 645.32 hectares, representing 43.6% of the territory. The largest forests are the Wet Latifoliado Forest (37.75%) and the Dry Forest (24.05%), which represent 61.80% of the total forested area; the third largest area corresponds to the Semi-wet Latifoliado Forest, with 15.39%. The wetland forest (mangrove and dredger) represents only 1.41%. (Ministry of Environment and Natural Resources, 2019).

It is estimated that the country has a forest cover of 18,923.45 km2, or 39 % of the national territory, with an annual rate of deforestation close to 4,000 ha/year. (Ministry of Environment and Natural Resources-GEF-UNDP, 2014-2017). Regarding forest regeneration, the average density is 28,014 plants/ha (Plants per hectare). In the Rodales strata of mangrove and dredger, wet latifoliated forest and dry forest the greatest amount of regeneration was found, with 52,233 plants/ha, 35,098 ha plants and 32,623 plants/ha respectively. (Ministry of Environment and Natural Resources, 2019).

According to the report published by the World Resources Institute in January 2016, the rocky coverage in the Dominican Republic was 54% as of 2000, with a tree loss of 10,158 hectares. The types of forest that predominate in Dominican soil are naturally regenerated (94%) planted (6%), according to this report18. In addition, it should be noted that in 2011 some 11,000 people depended on the forestry sector as the main economic activity, which contributed about USD 20.8 million for the nation's economy and accounted for approximately 0.04% of GDP.

Effects of climate change on Dominican Republic forests

According to the Assessment of Vulnerability and Adaptation of Biodiversity to Climate Change in the Dominican Republic, it is considered that, in terms of climate niches, all ecosystems and species in the Dominican territory will be by 2020 subject to very extreme weather conditions compared to the usual conditions of its traditional zone. Because of their island status, the RD's coastal and marine ecosystems are projected to be significantly affected by climate change, including beaches, mangroves, coral reefs, seagrasses and coastal wetlands. In the case of forests, deforestation is one of the main environmental problems of DR, as deforested areas are more susceptible to desertification and drought. In periods of drought, vulnerability to wildfires increases both because of lack of rain and poor management practices. Many of the recommended measures for ecosystems, biodiversity and forests are the same, as complex systems cannot be separated or departmentalised (Ministry of Environment and Natural Resources/UNDP/GEF, 2008).

The Dominican Republic's Climate Change-Compatible Economic Development Plan (DECCC) estimates a rate of deforestation for 2010 at 6,200 ha/year, although it notes that there is high uncertainty in forest coverage information and its evolution, due to a lack of consistent land use information and land use change and the country's lack of carbon inventory. Minimum temperatures and maximum temperatures show an increase in their annual average values, where there is a widespread trend increase of between 2oC and 3oC in the average annual values of minimum temperature and from 1oC to 3oC at the maximum temperature, involving increasingly warmer conditions that show a more intensified hydrological cycle (Ministry of Environment and Natural Resources/UNDP/GEF, 2008).

Total annual precipitation at the national level does not show a clear pattern of decrease or increase. There is a higher occurrence of extreme heavy rain events by 20% and 30% than those presented in the last two decades between the months of May to October (Ministry of Environment and Natural Resources/UNDP/GEF, 2008).

Changes in land use in the Dominican Republic

The Dominican Republic's forest cover is already scarce. The main forest masses are found in mountainous areas and, to a lesser extent, in the coastal plain and in the valleys. The predation of forests is a constant, either to sell the wood, plant conucos or make coal, the most harmful being these last two practices. The situation is exacerbated by wildfires (WFP, 2017). Soil degradation can aggravate the impact of natural threat disasters and increase food insecurity. This lens shows where efforts are required to stop and reverse degradation, whether through social safety nets, risk and disaster reduction, or through independent programs and public policies (WFP, 2017).

Key indicators for assessing soil degradation have been the change in land cover and use and erosion. The data were obtained from NASA's remote information on plant cover from 2001 and 2012. This is an indirect indicator that assigns values to the different magnitudes in the plant cover change and which were subsequently verified at the local level (WFP, 2017).

The second indicator is an analysis of soil erosion. This calculation used a simplified version of the Universal Soil Loss Equation (USLE), which considers rainfall incidence, soil lithology, plant cover extracted from NASA MODIS, as well as the length of the slope calculated through the SAGA-GIS19 digital elevation model, using NASA SRTM20. The original dataset was added to Municipal (Table 14) (WFP, 2017).

Table 15. Soil degradation in the Dominican Republic.

MCD12Q1 class	New name	Ecological Value
Always green broadleaf forest	Forest	**6**
Deciduous forest	Forest	**6**
Permanent wetlands	Wetland	**6**
Closed bushes	Grasslands	**5**
Grasslands	Grasslands	**4**
Farmland	Farmland	**3**
Sterile or sparsely vegetated	Sterile or sparsely vegetated	**2**
Urban accumulated	Urban	**1**
Fill value	Fill value	**0**
Snow and ice	Snow and ice	**0**

WFP Source, 2017

Changes over time refer to the difference in coverage and land use, calculated based on the initial value observed in 2001 and the end, in 2012. The result is a range of values ranging from -6 to +6, where negative values indicate deterioration in the ecological value, zero means no changes, and positive values show improvement in the ecological value. The average per municipality is calculated taking into account the extent of the changes, both positive and negative. Both the range of positive values is divided into three classes, using natural cuts (WFP, 2017).

Analysis shows that the most severe soil degradation is recorded in the provinces Azua, Barahona, Bahoruco, Independencia, Dajabón, Elías Piña, San Cristobal, San Juan, Sánchez Ramírez, San José de Ocoa, Monte Plata and Santo Domingo Oeste (WFP, 2017).
With regard to the evolution of forest cover at the national level during the period 1996-2003 in the northwest of the country (where the provinces of Dajabón, Monte Cristi, Santiago, Valverde and Santiago Rodríguez and the basins of interest are located), there was a slight increase in This. However, it should be noted that, however, this coverage in the provinces associated with the basins of interest is minimal, compared to the rest of the Dominican territory. (Paul J, 2011).

By comparing the areas occupied by vegetation units of the 1996 and 2003 coverage studies, prepared by the Ministry of the Environment, it can be noted that in terms of the dynamics of land uses, the most significant increase in wooded areas, from 28% to 33%; in pasture-covered areas, 5.5% to 8%; 14.1% to 16.2% and urbanized areas from 0.8% to 1.5%. It also shows a significant reduction in the areas used for agriculture, which of 48% of the area of the occupied territory in 1996, increased to 38% in 2003. These changes may be due to changes in the national production model, which tends towards a service economy. This, however, has contributed to the reduction of the pressure on the resource, as a result of the abandonment of land devoted to agricultural production. (Paul J, 2011).

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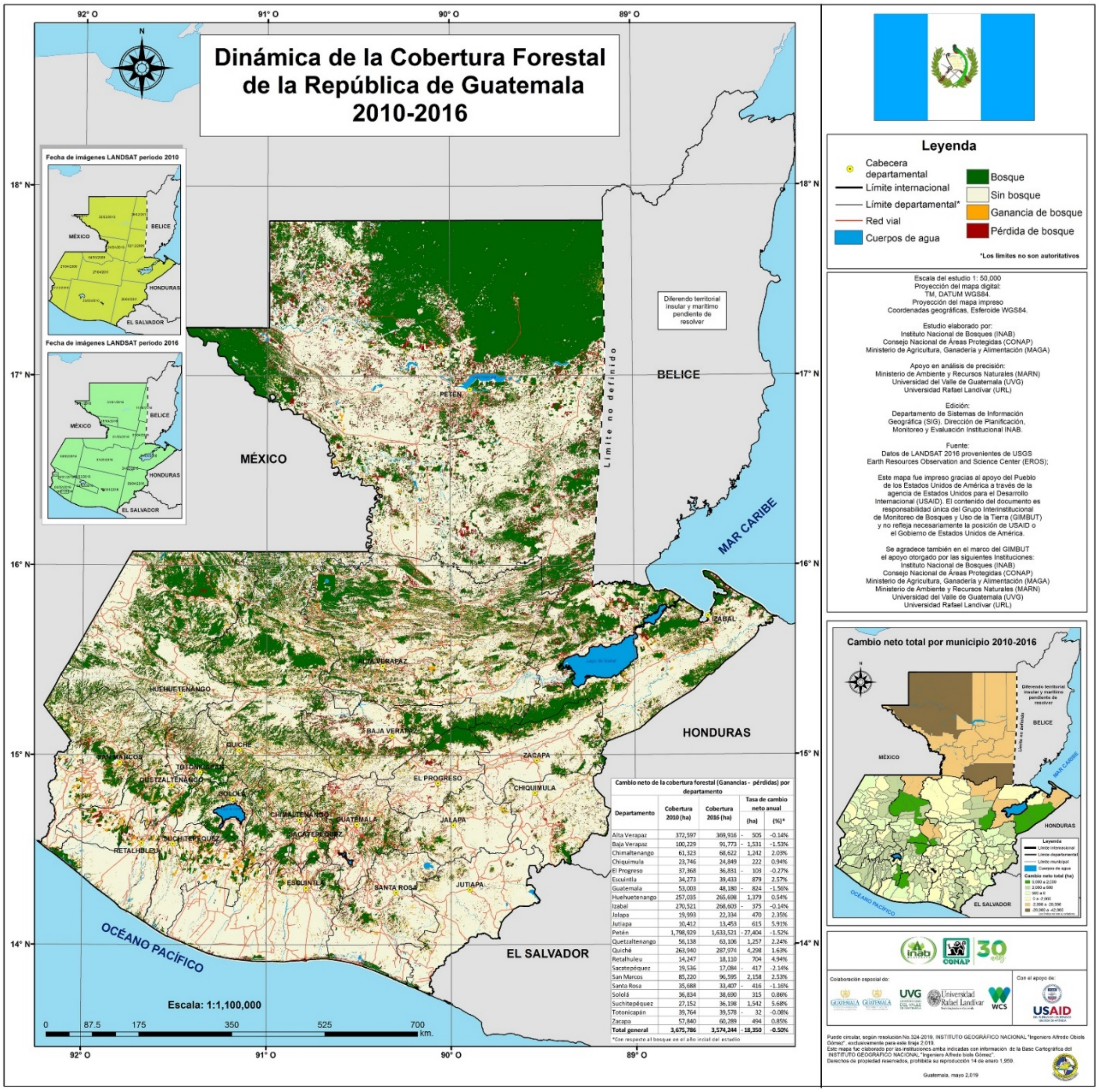
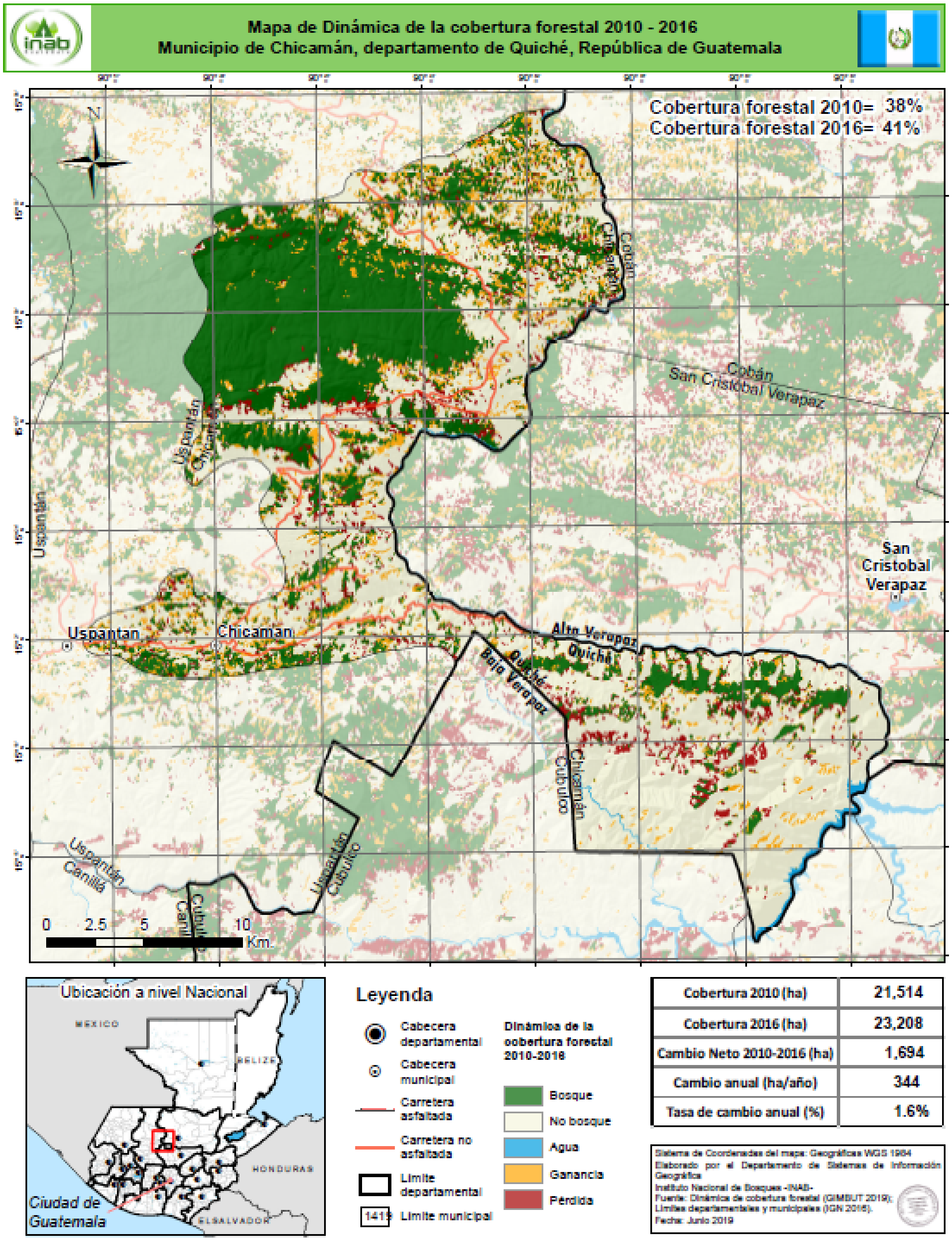
WFP. 2017. Integrated Context Analysis (ICA). Dominican Republic. United Nations World Food Programme (WFP).

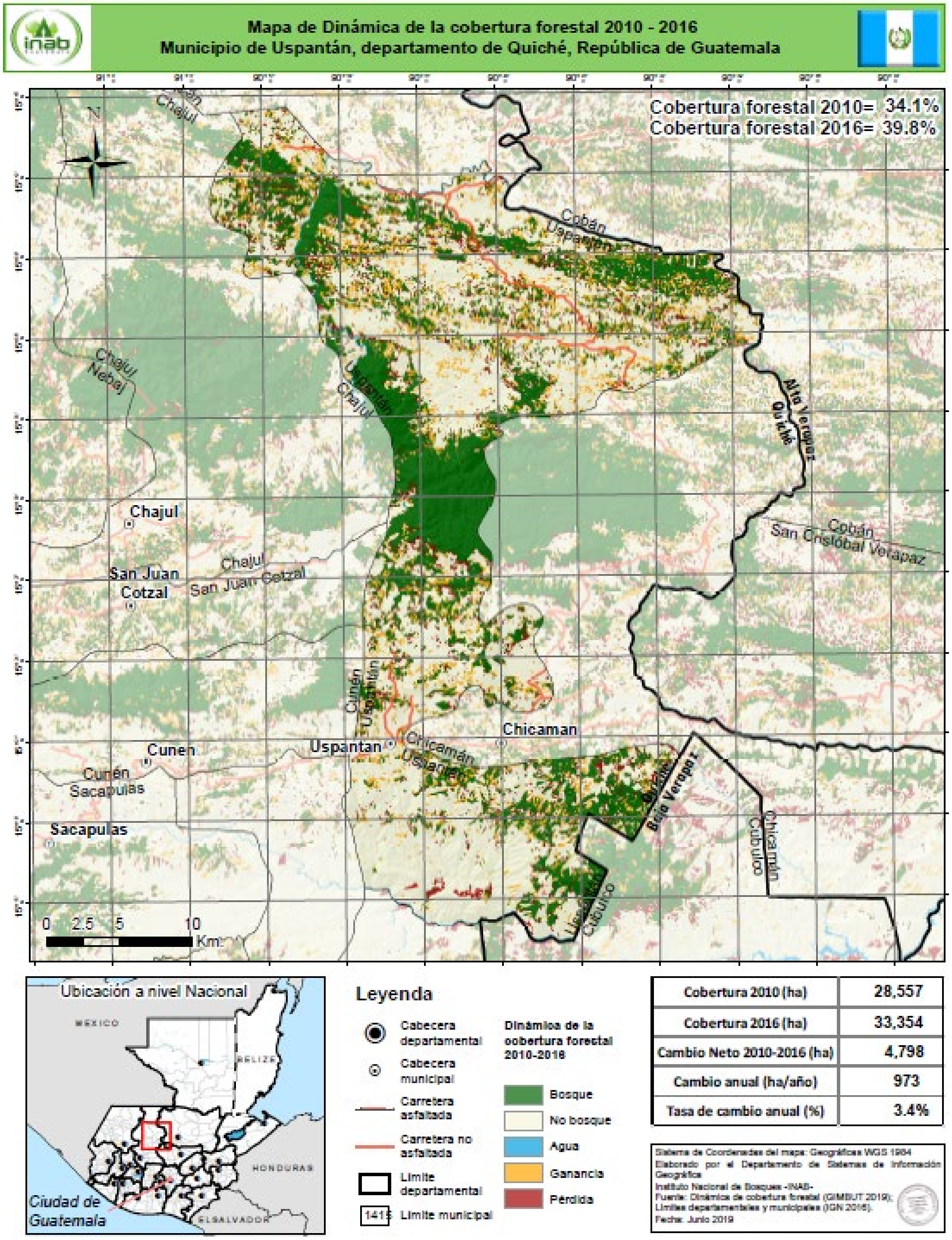
Annex 1 Maps



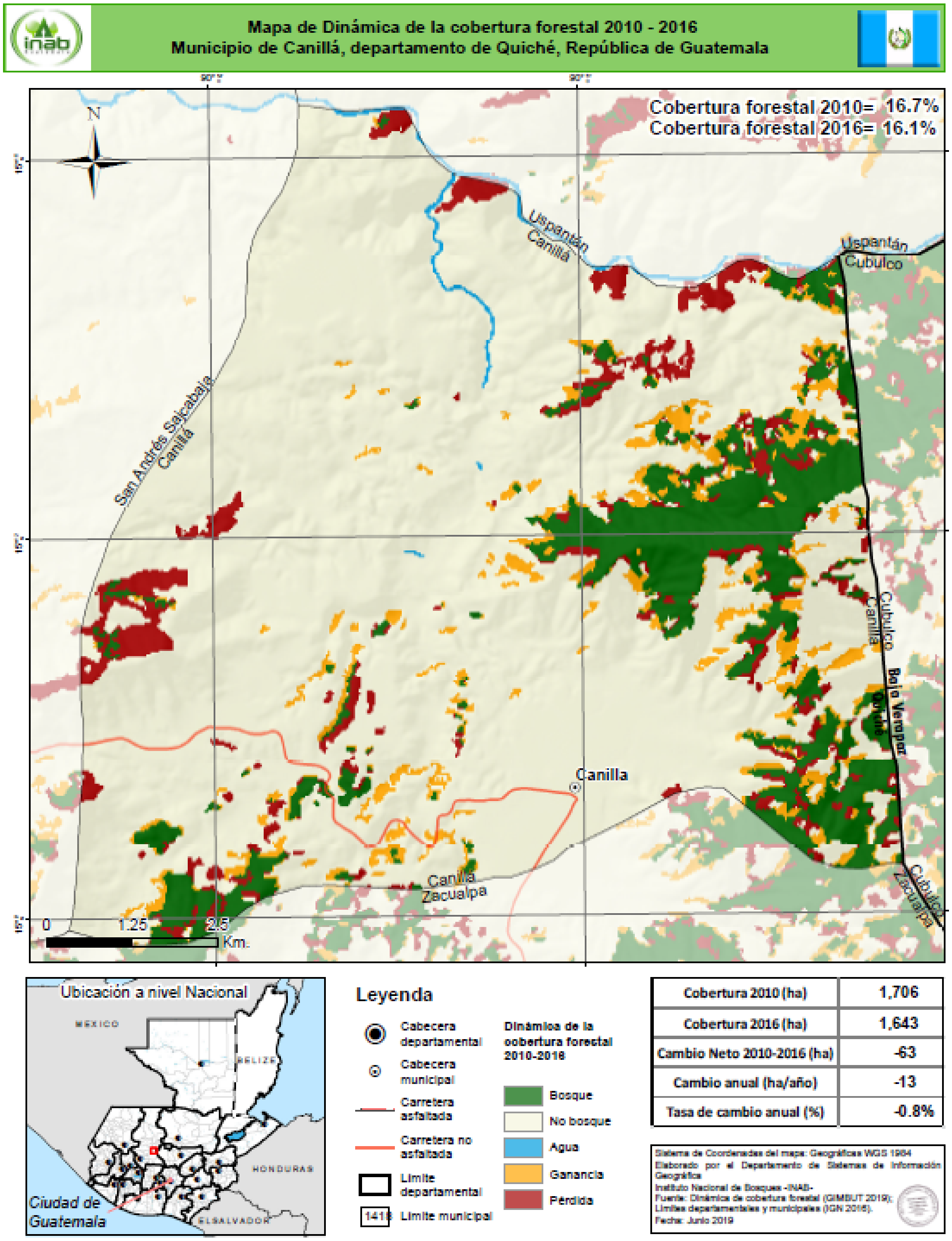
MAP 1. Dynamics of Forest Coverage of the Republic of Guatemala 2010-2016



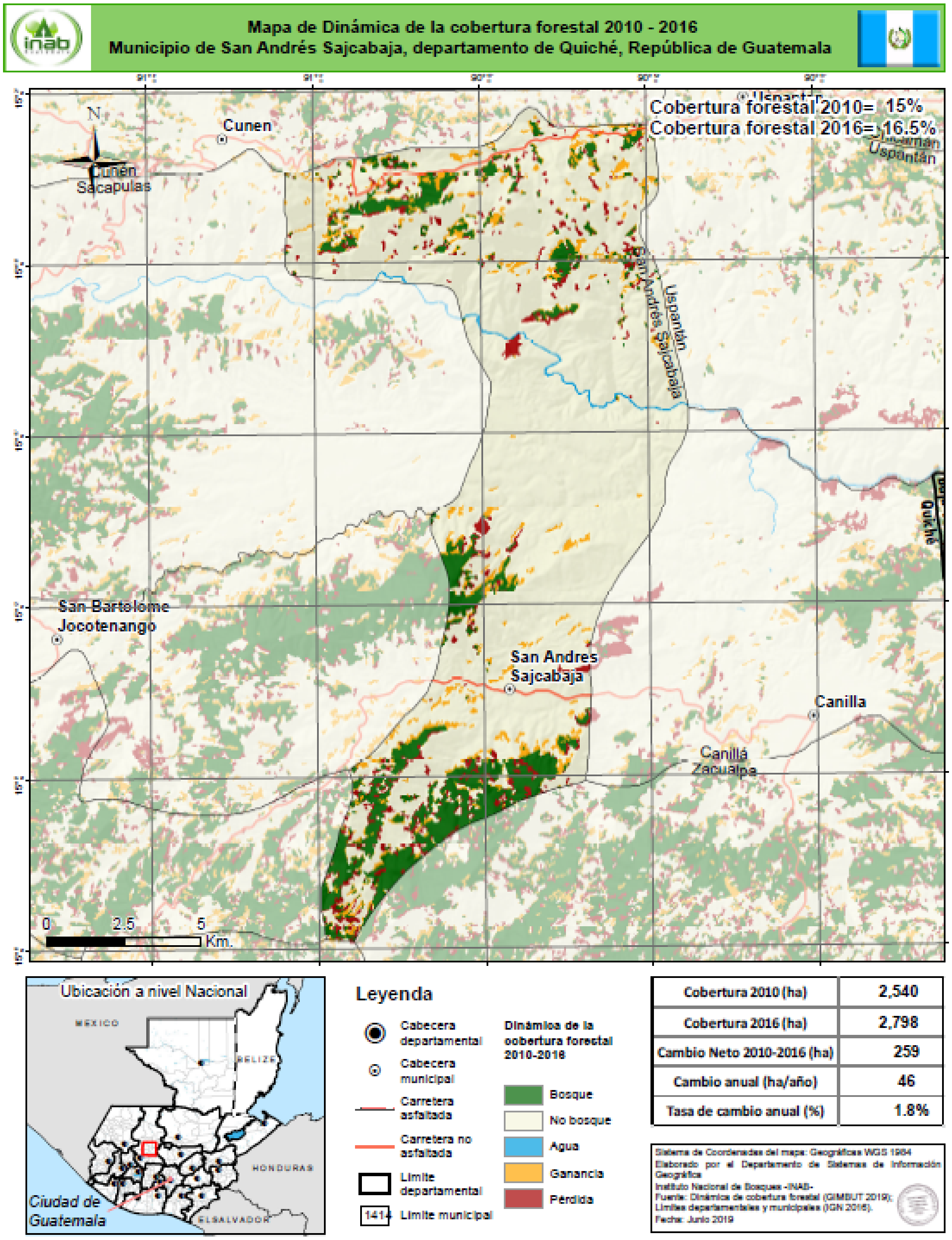
MAP 2. Forest cover dynamics 2010-2016 Chicaman Municipality, Quiché Department, Guatemala.



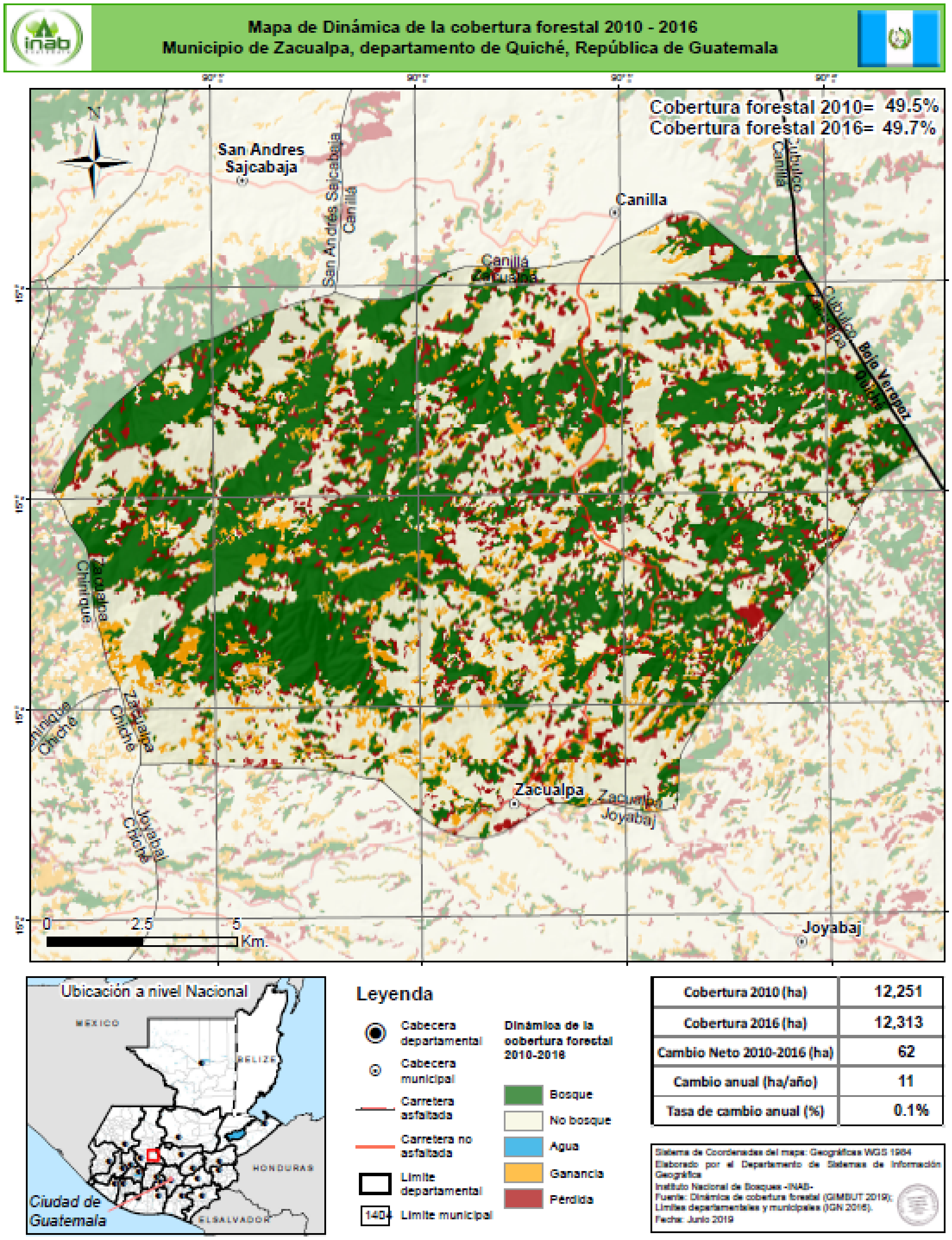
MAP 3. Forest cover dynamics 2010-2016 Municipality of Uspantán, Department of Quiché, Guatemala.



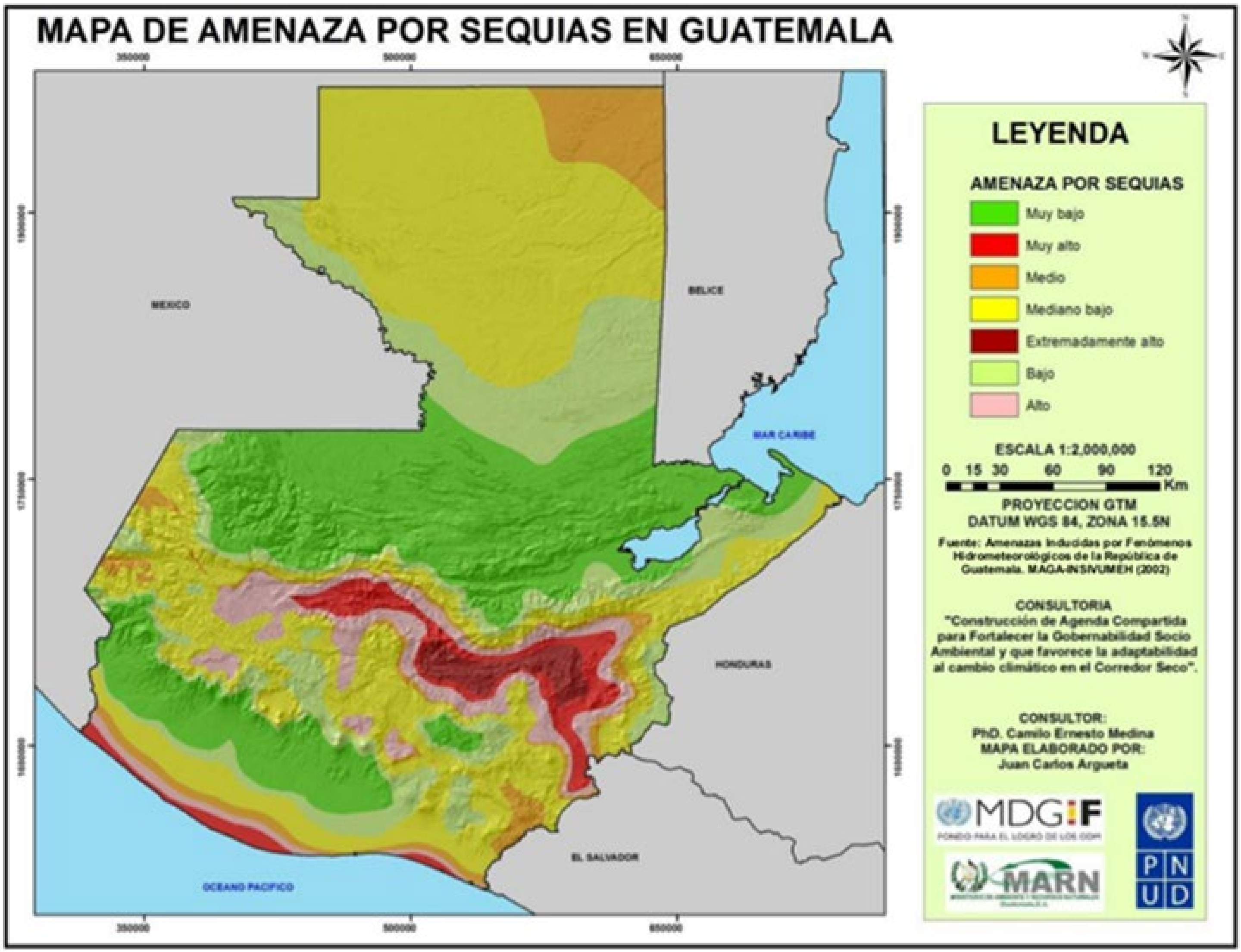
MAP 4. Forest cover dynamics 2010-2016 Municipality of Canillá,department of Quiché, Guatemala.



MAP 5. Forest cover dynamics 2010-2016 Municipality of San Andrés Sajcabaja,Department of Quiché, Guatemala.

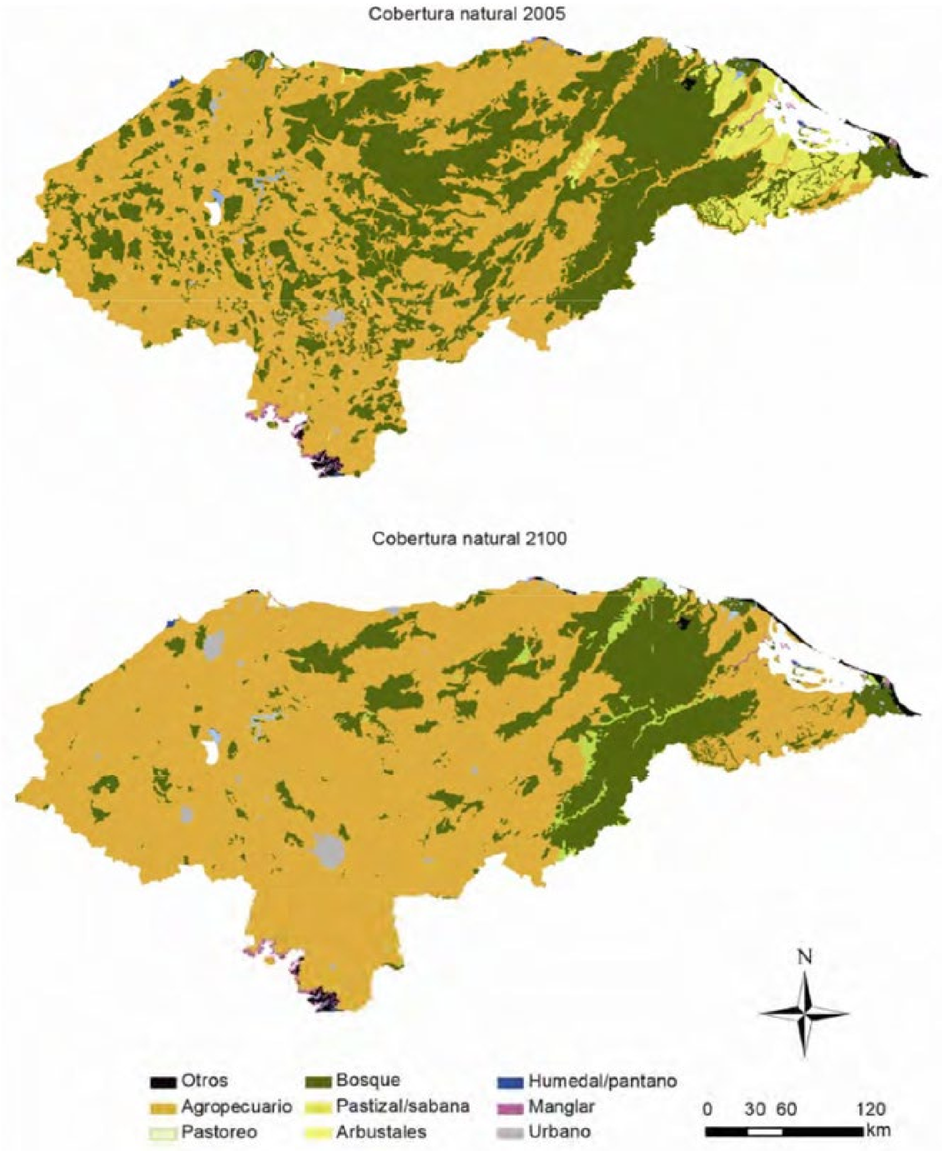


MAP 6. Forest cover dynamics 2010-2016 Zacualpa Municipality, Quiché department, Guatemala.



MAP 7. Map of drought threat in Guatemala.

MAPA I
HONDURAS: ESCENARIOS DE CAMBIO DE USO DE LA TIERRA 2005 (BASE) Y 2100 (TENDENCIAL)



Source: ECLAC, CCAD/SICA, UKAID and DANIDA, 2011. Quoted in: ECLAC and MiAmbiente, 2016.

MAP 8. Land Use Change Scenarios 2005 (Base) and 2100 (Trend)

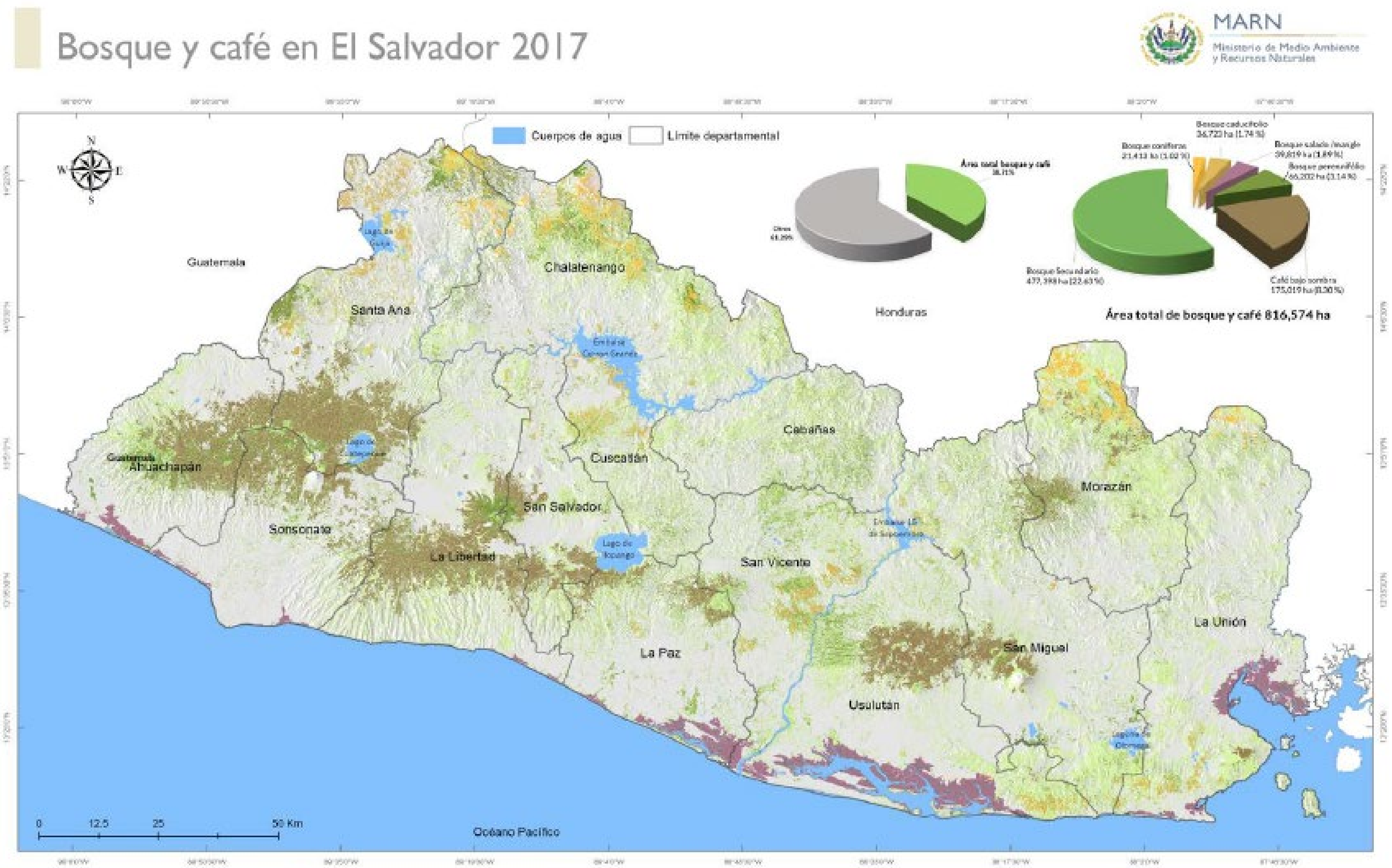


Figura 81. Bosque y café en El Salvador

Fuente: MARN, GIZ, UICN, Mapa de cobertura y uso del suelo (1:2500) con base en imágenes RapidEye de 2011. Junio, 2016.

MAP 9. Forest and coffee in El Salvador 2017

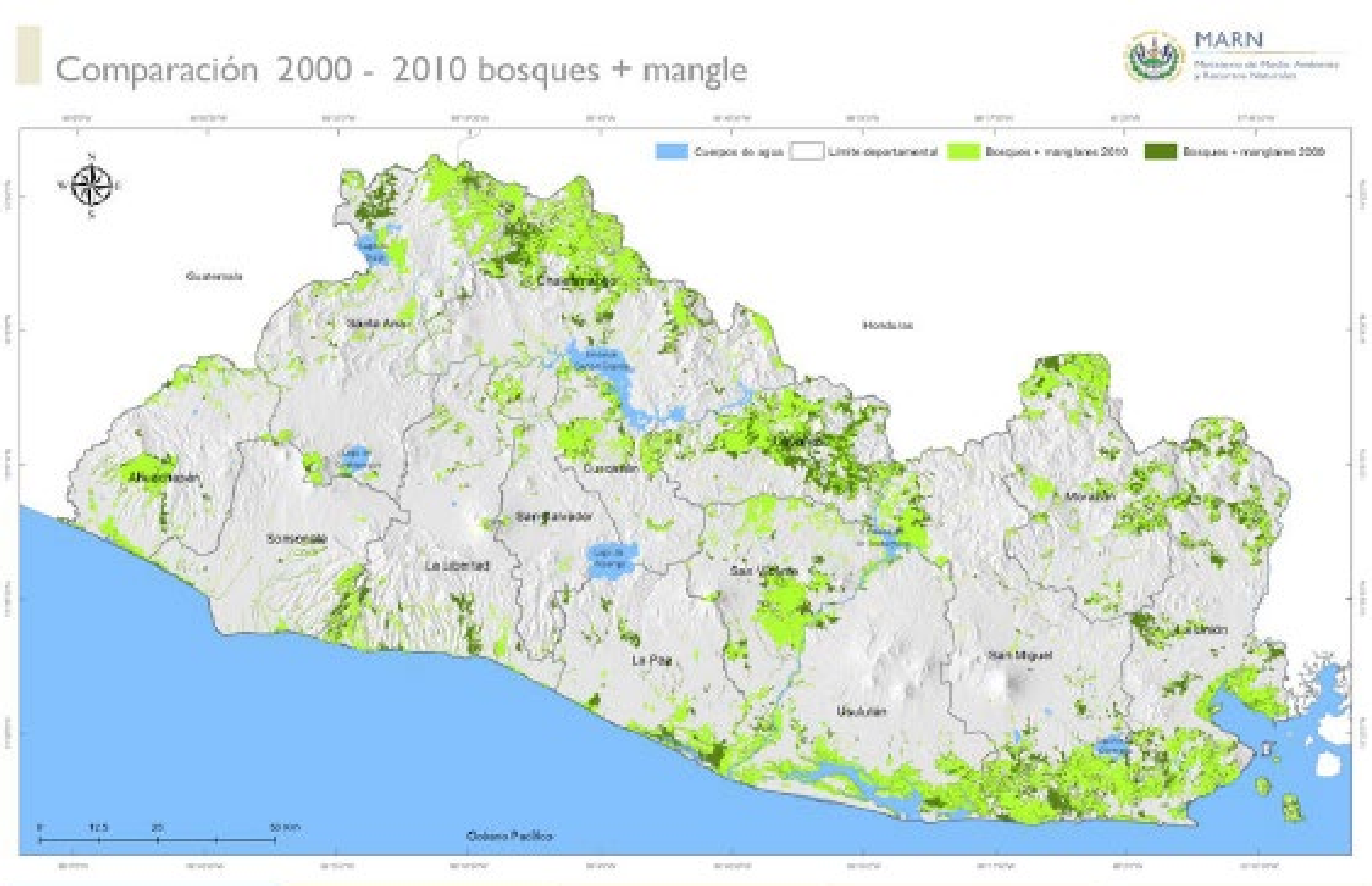


Figura 82. Sitios con pérdida de ecosistemas naturales entre 2000 y 2010
Fuente: MARN

MAP 10. Map comparison 2000-2010 forests + mangrove. El Salvador.

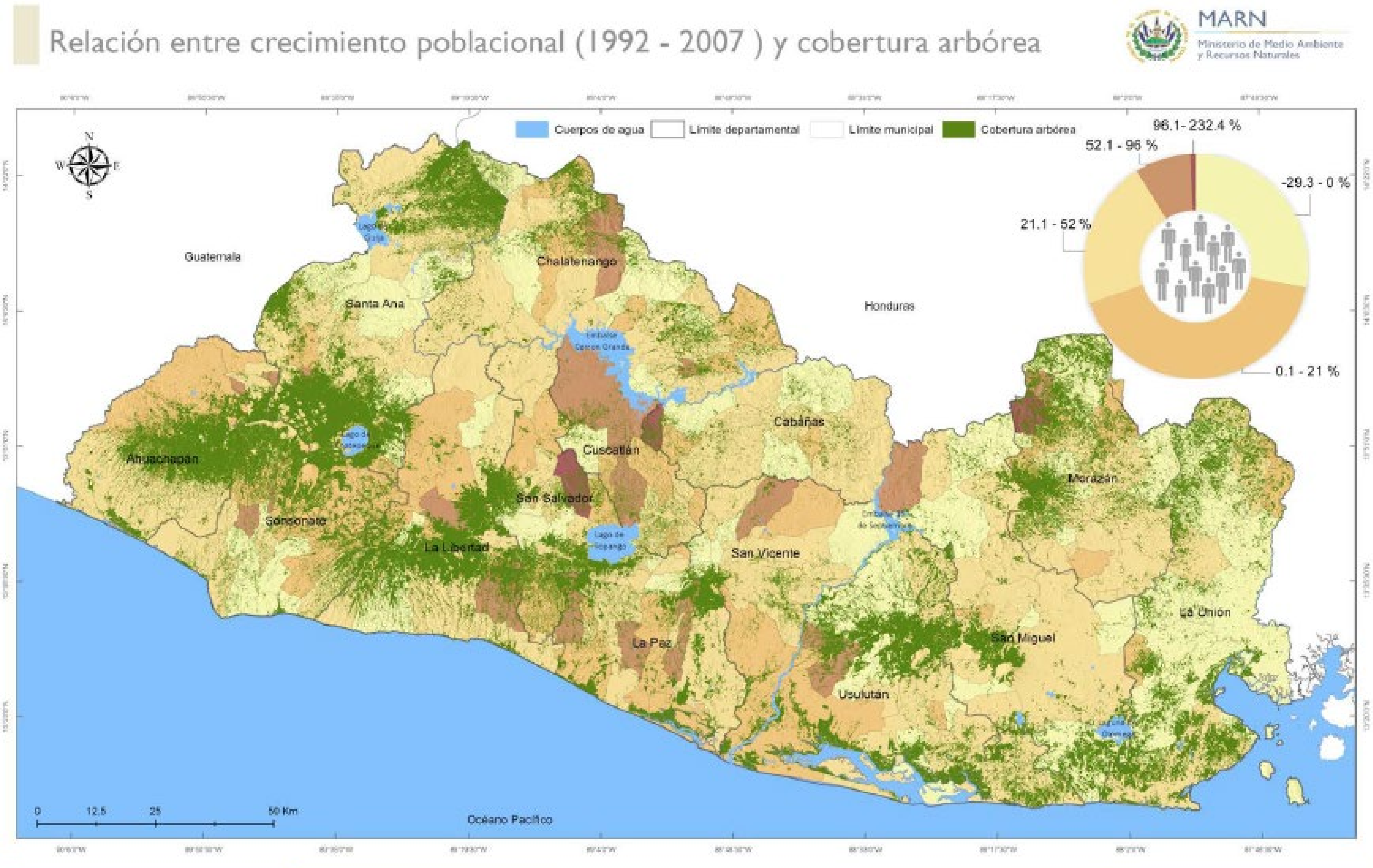
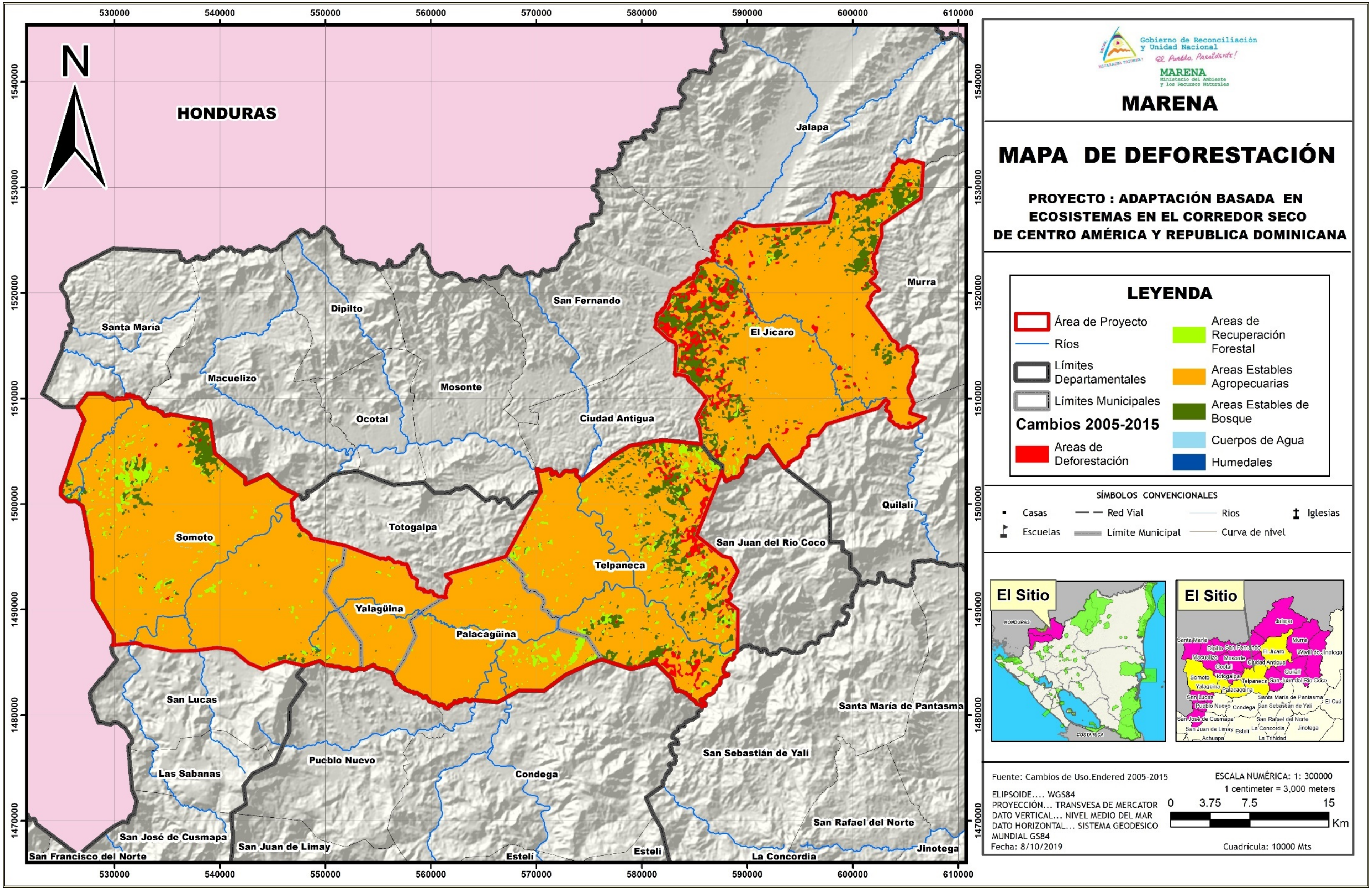
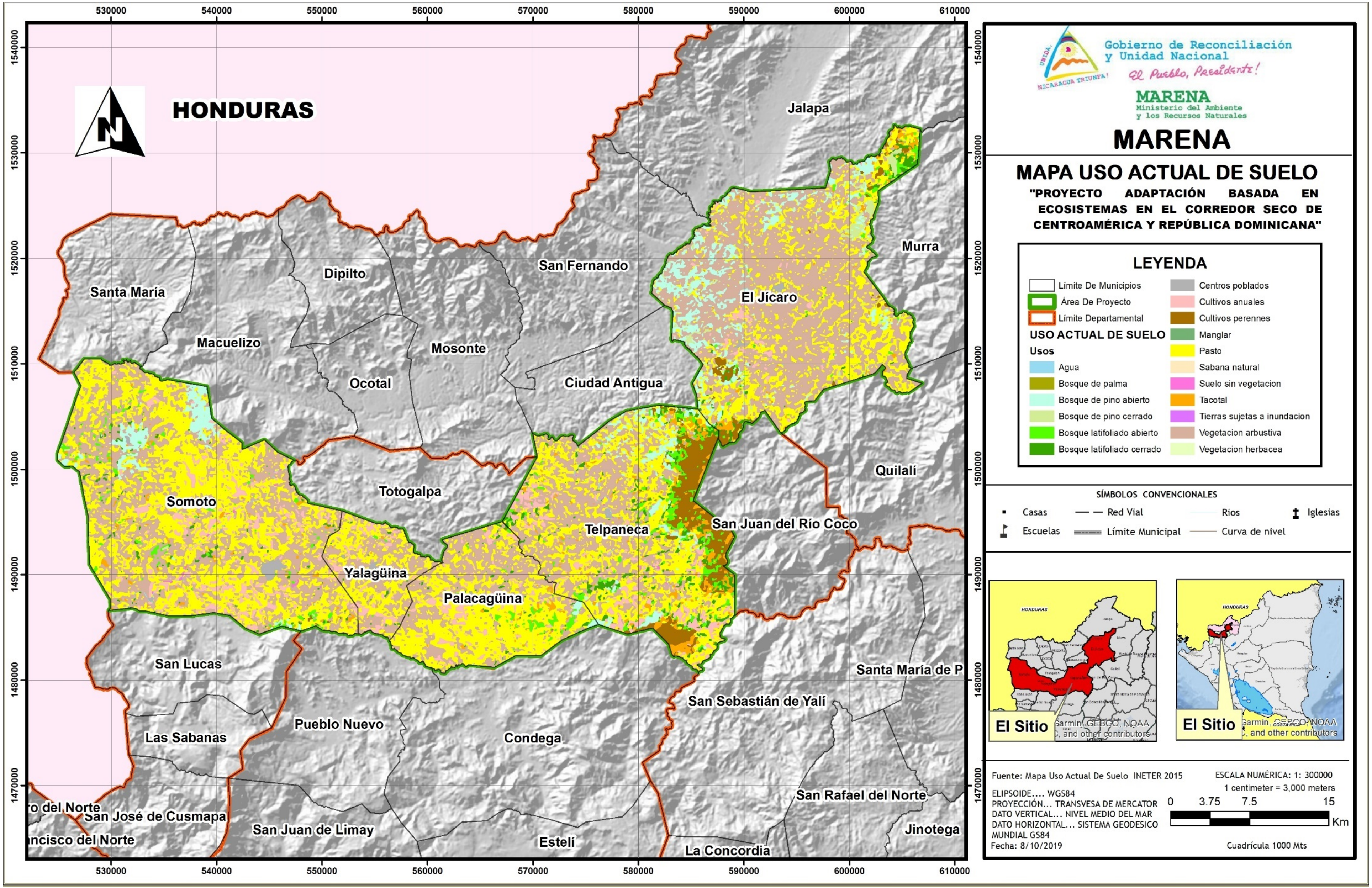


Figura 83. Dinámica de la cobertura arbórea y crecimiento poblacional
Fuente: MARN

MAP 11. Map ratio between population growth (1992-2007) and tree cover. El Salvador.

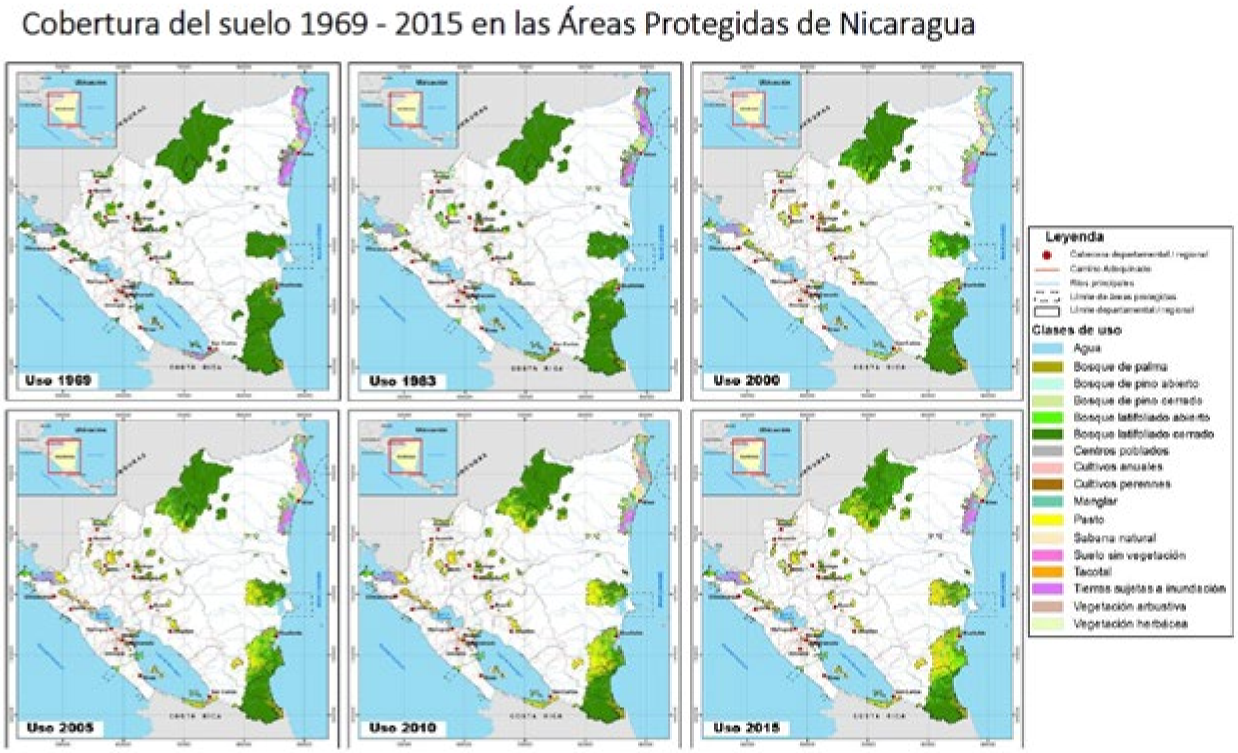


MAP 12. Map of deforestation sites Corredor Seco Nicaragua.



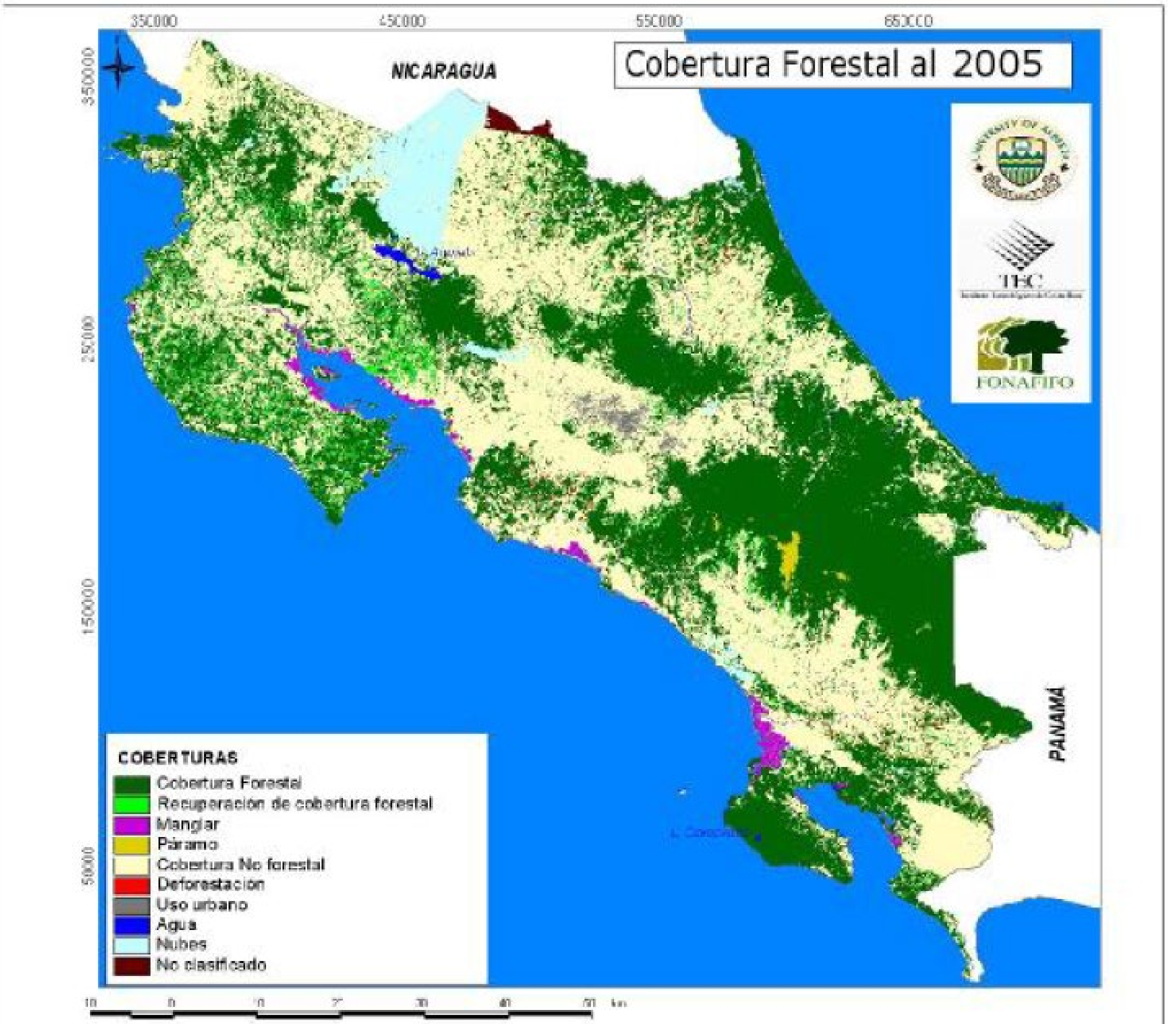
MAP 13. Map of current land use sites Corridor Seco Nicaragua.

Changes in forest cover from 1983 to 2015 of Nicaragua (Green color indicates the area occupied by closed and open forests, latifoliados, conifers, natural palm forests andmangroves).

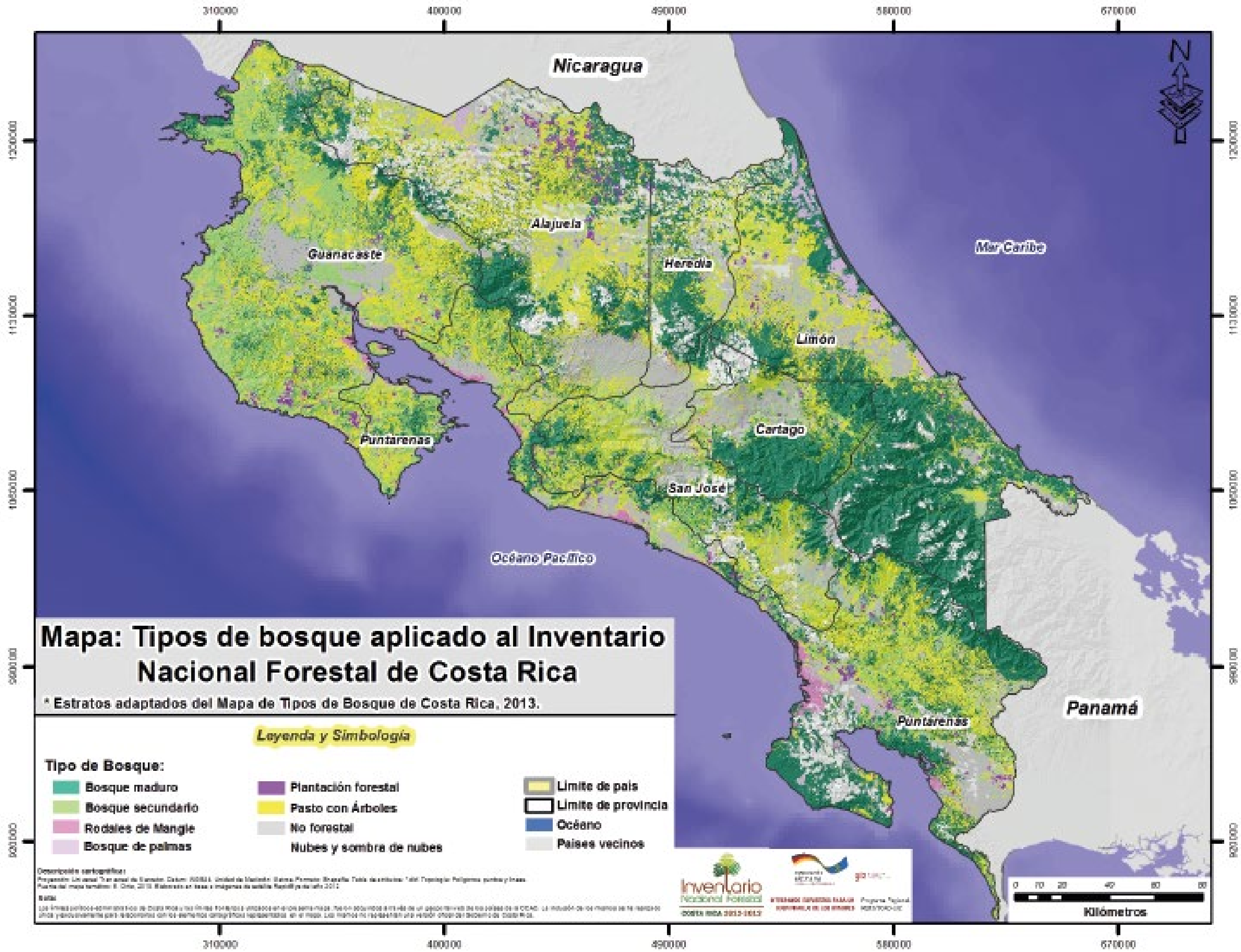


Source: Source: (from Camino Velozo, 2018). Diagnosis of the Forest Sector in Nicaragua.

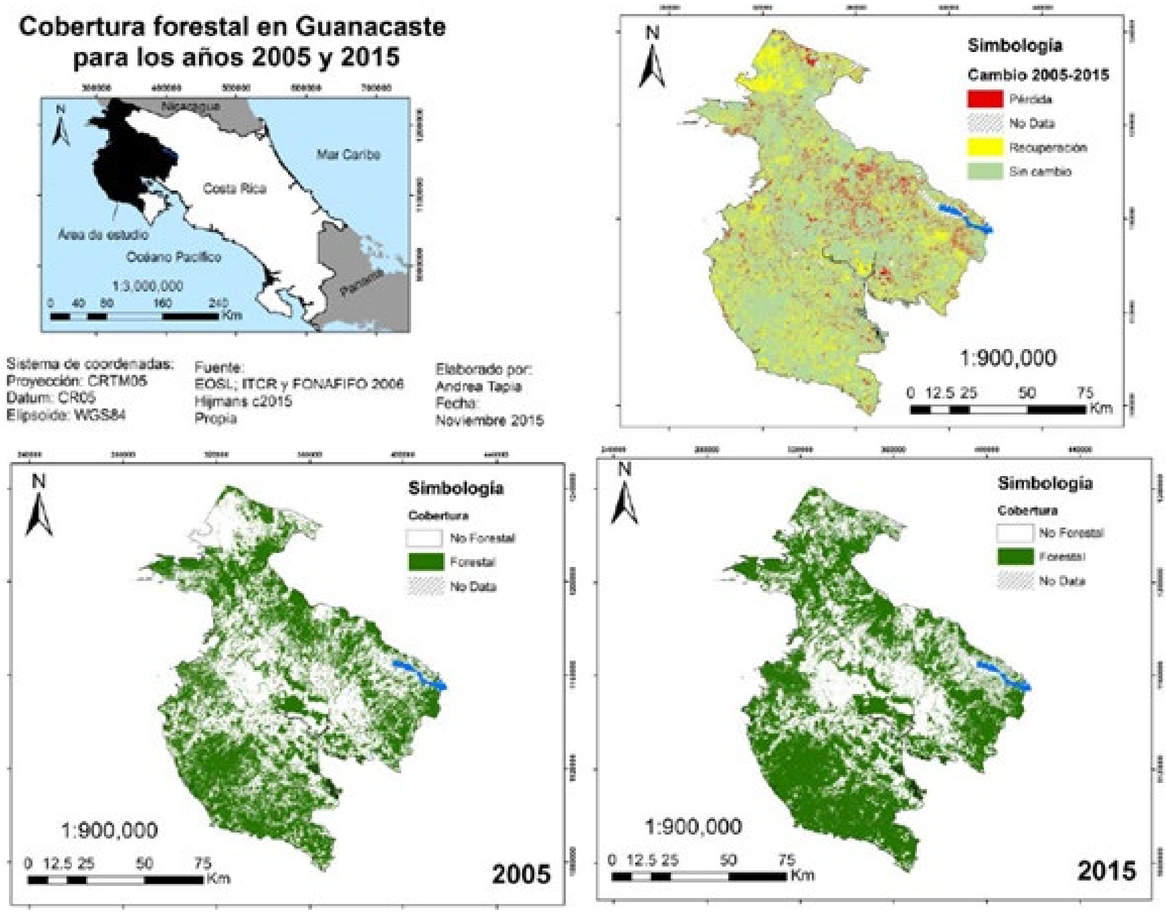
MAP 14. Forest coverage change maps. Nicaragua.



Cobertura Forestal al 2005
NICARAGUA
PANAMÁ
350000
450000
550000
650000
COBERTURAS
Cobertura Forestal
Recuperación de cobertura forestal
Manglar
Páramo
Cobertura No forestal
Deforestación
Uso urbano
Agua
Nubes
No clasificado
FONAFIFO

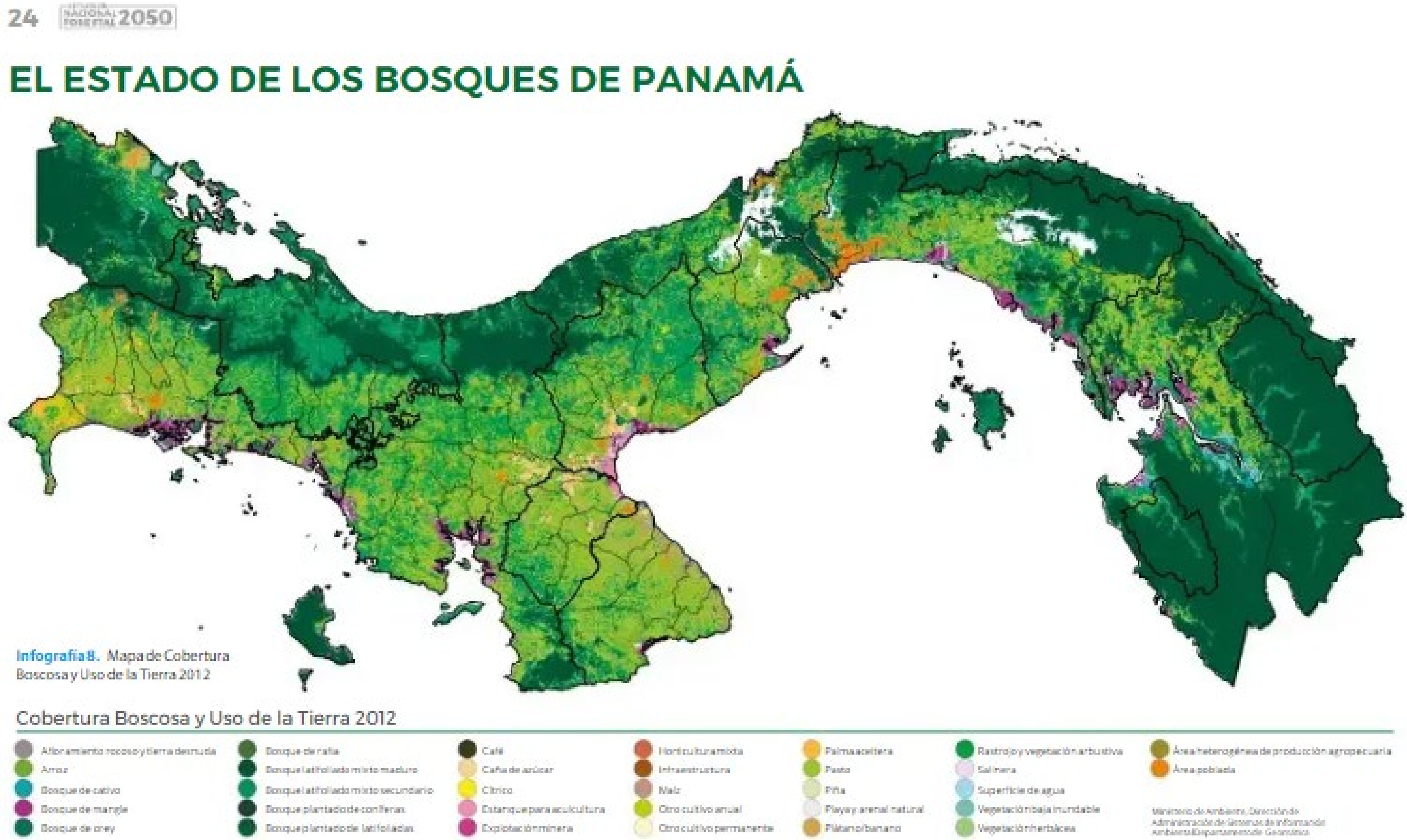


MAP 16. Map of forest types applied to the INF of Costa Rica.

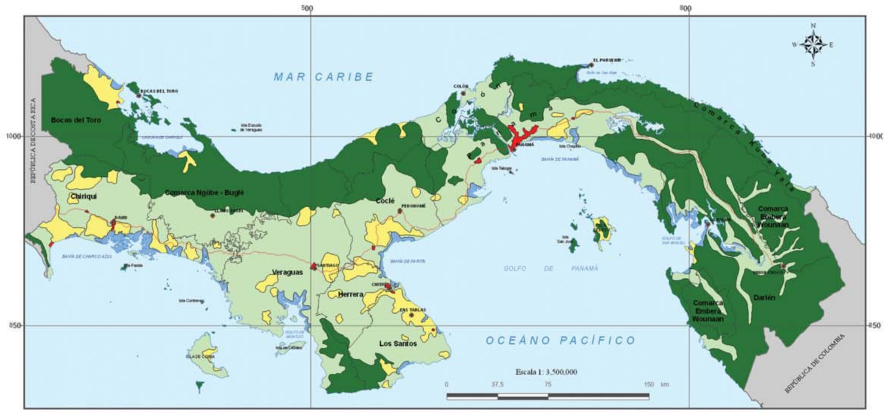


Source: Map of forest cover in 2005, 2015 and its changes in Guanacaste. (Tapia-Arenas, 2016).

MAP 17. Map of forest cover in Guanacaste for the years 2005 and 2015. Costa Rica.



MAP 18. Map of the state of the forests. Panama.



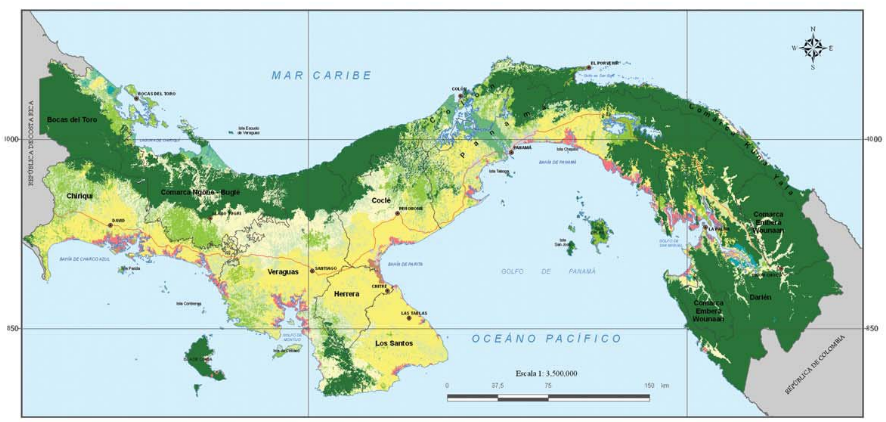
Leyenda

Uso de la tierra: año 1984

- Áreas urbanas
- Cultivos
- Pastizales-rastrojos
- Manglares, ciénagas y pantanos
- Bosques

Simbología

- Límite internacional
- Límite provincial
- Costas
- Cabecera de provincia
- Red vial
- Cuerpos de agua



Leyenda

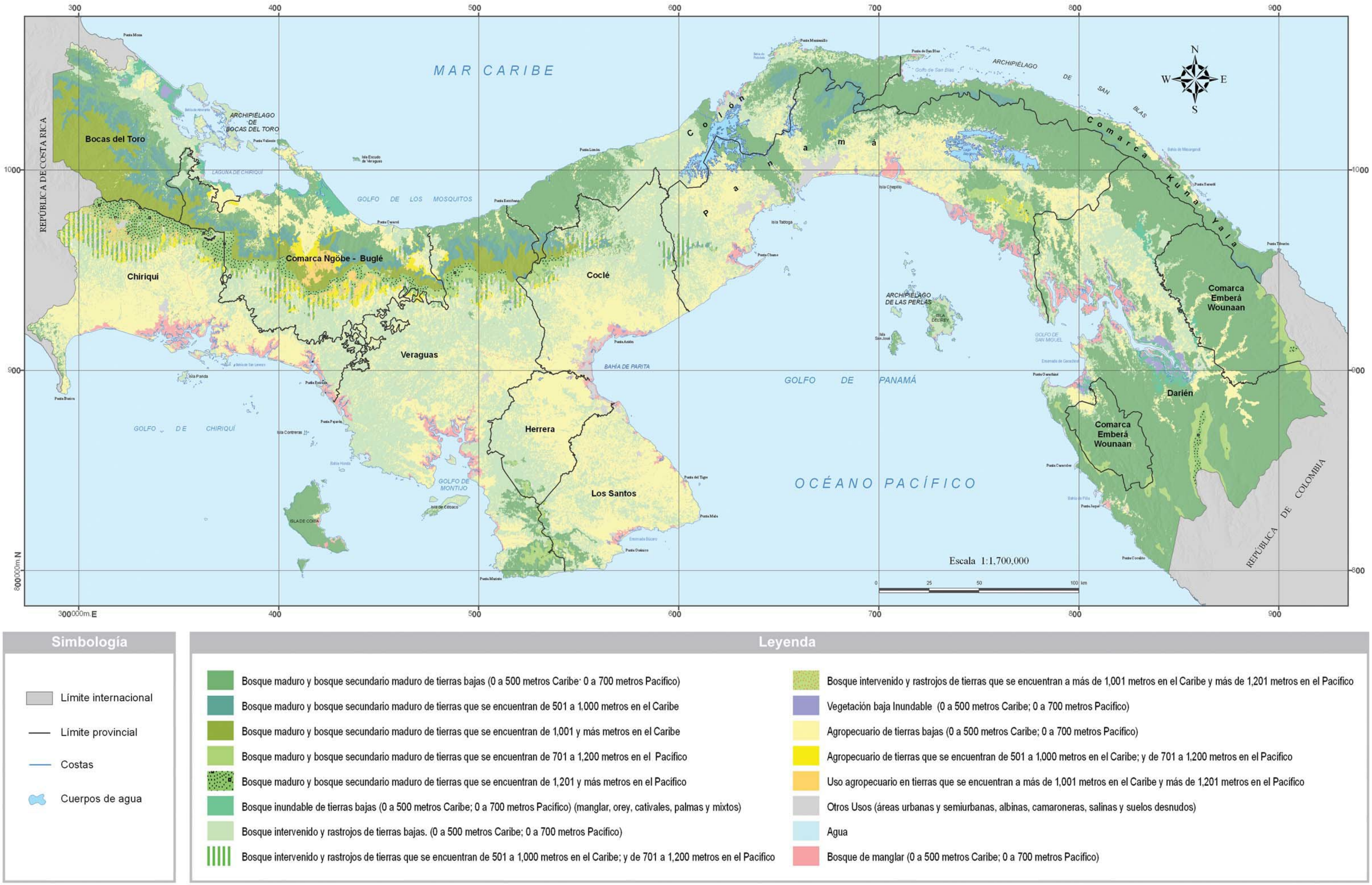
Categorías de cobertura boscosa: años 1992 y 2000

- Agua
- Albinas: Es un área plana o semiplana, se ubica cerca de la costa y es bañada por las mareas. La vegetación es escasa, producto de la alta concentración de sales, generalmente se encuentran especies de mangles y de tipo arbustivo.
- Bosque intervenido: Son formaciones naturales cerradas. con alteraciones visibles y no visibles, en la cobertura de copa, estructura y composición del bosque, causadas por la intervención humana o por fenómenos naturales.
- Bosque inundable mixto: Son superficies de terreno que se encuentran inundadas todo el año y presentan diferentes especies arbóreas, arbustivas, rastreras y herbáceas, sin el predominio de una de ellas.
- Bosque maduro: Son formaciones cerradas constituidas predominantemente de especies propias de la fase final de la sucesión ecológica, posee estratos verticales diferenciados con un dosel superior continuo, debajo del cual aparece un sotobosque igualmente diferenciado.
- Bosque secundario maduro: Son formaciones naturales cerradas. La vegetación se encuentra en estado de sucesión secundaria, producto de la remoción completa o parcial de la vegetación primaria, debido a causas antropogénicas o naturales.
- Bosque de Orey homogéneo: Son formaciones naturales cerradas. Con predominancia de la especie Orey *(Campnosperma panamensis)*. Dicha predominancia es mayor al 60%. Representan bosques típicos de las zonas inundables del litoral Atlántico.
- Cativo homogéneo: Son formaciones naturales cerradas. Con predominancia de la especie cativo *(Prioria copafeira)*. Estas formaciones crecen y se desarrollan en sitios inundables y secos del Bosque Húmedo Tropical (BhT).
- Cativo mixto: Son formaciones naturales cerradas. Con predominancia de la especie cativo *(Prioria copaifera)*. Estas formaciones crecen y se desarrollan en sitios inundables y secos del Bosque Seco Tropical (BsT). Se dan con mayor frecuencia en sitios secos.
- Manglares: Son formaciones naturales cerradas, conformadas por diferentes especies arbóreas que se desarrollan en zonas costeras y reciben la influencia del agua salada por periodos cortos, producto del flujo y reflujo de las mareas.
- Otros usos: Son aquellas áreas pobladas de tipo urbanas, semiurbanas, rurales, industriales, mineras, salinas, camaroneras y suelos desnudos.
- Plantaciones forestales: Formaciones boscosas constituidas por una o más especies arbóreas nativas o exóticas, establecidas mediante plantación o siembra. La FAO define las plantaciones forestales como "rodales establecidos mediante plantación o siembra en el proceso de forestación o reforestación".
- Rastrojos (bosque pionero): Son formaciones naturales cerradas, cuyo estado de sucesión secundaria está en una etapa inicial de desarrollo. Se encuentran plantas de tipo herbáceos, bejucos, arbustos y las especies presentes no tienen gran valor comercial pero ejercen funciones de mejoramiento de suelos.
- Uso agropecuario: Todas aquellas áreas que son utilizadas para cultivos agrícolas anuales, semipermanentes o permanentes y pastoreo, al igual que áreas cubiertas de herbazales, rastrojos e incluso algunos remanentes boscosos dispersos.
- Uso agropecuario de subsistencia: Son áreas utilizadas para actividades agrícolas y pecuarias de subsistencia, que incluyen áreas cubiertas de rastrojos y remanentes boscosos dispersos. Éstas se ubican principalmente a orillas de los ríos, caminos de penetración y en los polos de colonización.
- Vegetación baja inundable: Es aquella vegetación dominada por especies herbáceas (heliconias, cortaderas, bejucos, etc.) y palmas, que pueden incluir pequeñas áreas cubiertas de rastrojos y remanentes boscosos dispersos, la cual se encuentran en áreas planas cubiertas de agua dulce o salobre la mayor parte del año.

Simbología

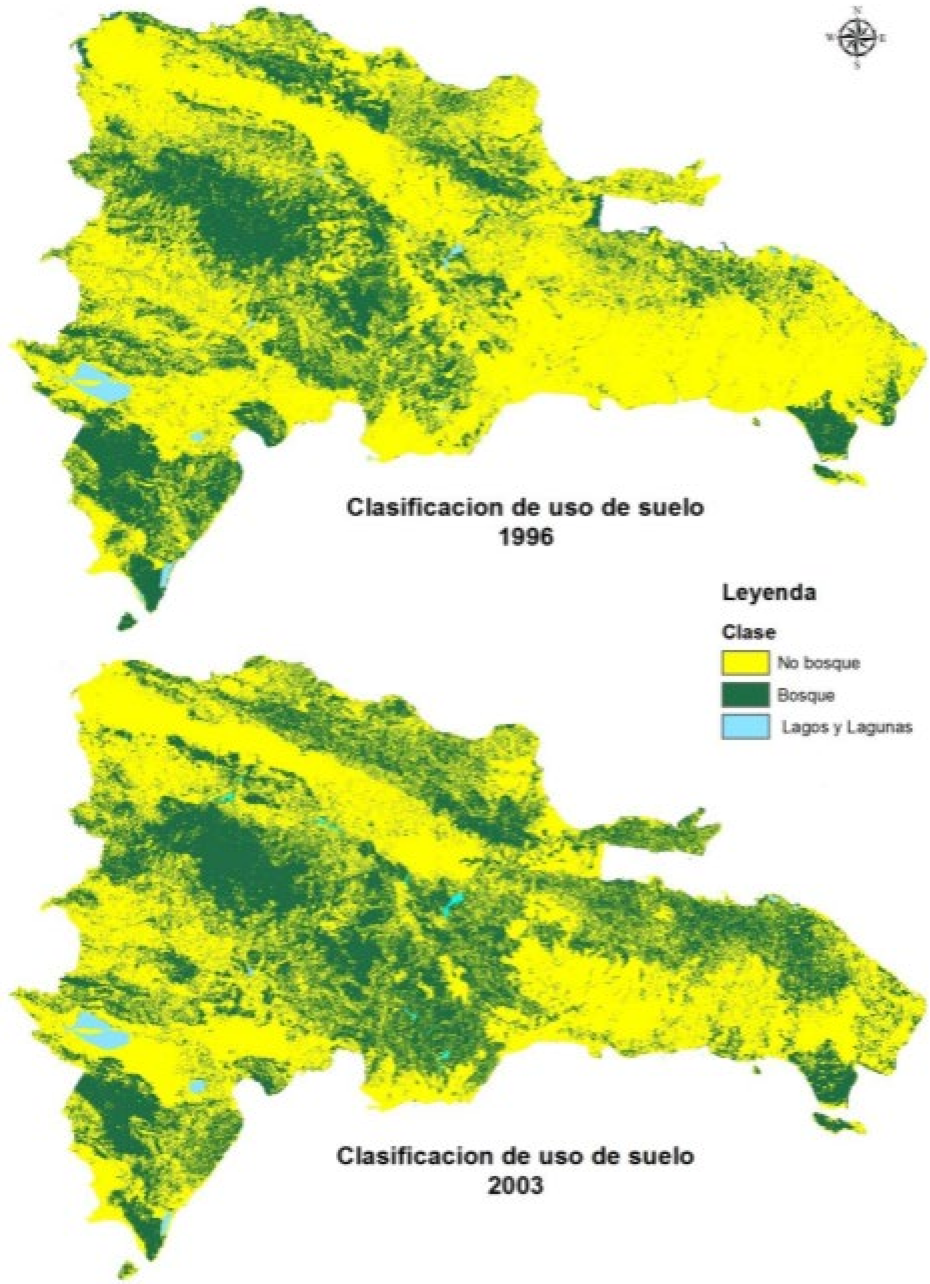
- Límite internacional
- Límite provincial
- Costas
- Cabecera de provincia
- Red vial
- Cuerpos de agua

MAP 19. Map of categories of forest cover 1992-2000. Panama.



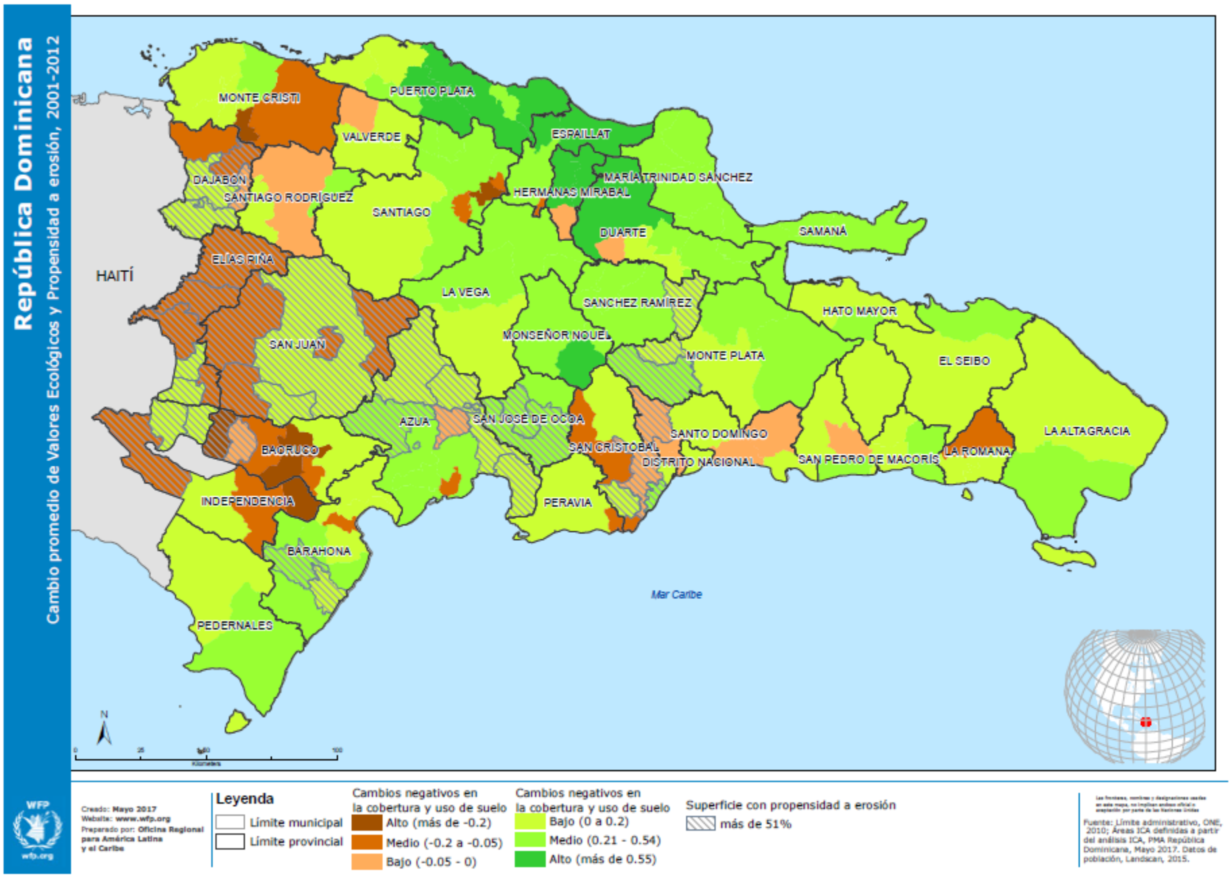
MAP 19. Map of changes of forest cover 1992-2000. Panama.

FIGURA 2. Reclasificación de los mapas de usos y cobertura de la tierra en la RD en 1996 y 2003.



Source: Dominican Republic Ministry of Environment and Natural Resources

MAP 20. Map of reclassification of land uses and cover maps in the Dominican Republic in 1996 and 2003



MAP 21. Map of average change of Ecological Values and Susceptibility to Erosion.

Agriculture sector

Guatemala

Main crops

Guatemala is a producer of three main grains for food, corn, beans and rice. The data presented in **Table 20** located in **Annex 1** show an increase in the production of these three basic grains because they constitute the food base of the population so that their cultivation is key for social subsistence.

The area occupied by agricultural crops in the 5 prioritized municipalities is 91,326.53 ha., corresponding to 34.68% of the total area, as detailed in the following table:

Table 1. Area of agricultural land by prioritized municipality

	Zacualpa	San Andrés Sajcabajá	Uspantán	Canillá	Chicaman	Total
Crops area	5,933.03	7,173.54	31,553.73	31,553.71	15,112.52	**91,326.53**
%	23.90%	42.38%	37.72%	38.81%	26.69%	**34.68%**
Total municipality area	**24,824.39**	**16,926.71**	**83,652.52**	**81,303.04**	**56,622.41**	**263,329.07**

data provided: source data

Main crops according to local area (Bouroncle, and others, 2013) are beans and corn. In the municipality of Uspantán the cultivation of Cardamom is an important crop (27.3%) of the cultivated area. The detail is shown in Table 21 located in Annex 1.

For the San Andrés Sajcabajá municipality, the information contained in the development plan on agricultural production is detailed, which indicates that the main crops are:

- Corn,
- Bean grown in I associate with corn,
- tomatoes produced in 28 communities for subsistence and
- Fruit citrus fruits like oranges, lemons and tangerines

Table 22 located in **Annex 1** the yield of major agricultural products from Guatemala (in metric tons per hectare) is shown in the period 2003-2013.

Area dedicated to subsistence agriculture versus commercial

At the national level it is reported that of the total number of units, 45 percent of the properties occupy only 3.2 percent of the area of all farms (Galvez, Andrews, & et al, 2014). It also indicates "… that the agricultural sector in Guatemala is characterized by a strong concentration of land in few owners and farmers in a restricted area. This encourages the proliferation of smallholdings, generally dedicated to subsistence agriculture on land unfit for agriculture and some large estates on land with an intensive agricultural or agroforestry vocation, dedicated to commercial agriculture."

Table 2. Area dedicated to agriculture of subsistence against commercial agriculture in prioritized municipalities in Guatemala, in hectares and percentage

Cultivation	Zacualpa	San Andrés Sajcabajá	Uspantán	Canillá	Chicaman	Total
Corn	1,224	SD	3,357	1,232	2,445	8,258
Bean	353	SD	1,563	732	971	3,618
Rice	0	SD	1	0	1	2
Sorghum	0	SD	0	0	13	13
Other grains	0	SD	1	0	1	2
Agro-industrial crops	38	SD	2,072	3	658	2,771
Commercial crops	82	SD	57	1	34	174
Total cultivated area	**1,709**	**SD**	**7,129**	**2,039**	**4,139**	**15,016**
% agro-industrial and commercial crops by municipality	7.0%	SD	29.9%	0.2%	16.7%	19.6%

Source: (Bouroncle, et al., 2013)

Population dependent on different crops / agriculture for their means of life

At the national level 87% of the rural poor depend on agriculture. The agricultural sector contributes 13.3% of GDP, generating 65.1% of rural employment, however, this employment barely represents 0.3% of GDP (Romero, 2013).

Crop yield over time together with projected future impacts on crops in municipalities prioritised by climate change.

Figure 12 located in Annex 2 shows a map with the index values of the Climate Change Vulnerability Assessment (CCVA) calculated by the company C4 ECOSOLUTIONS for prioritized municipalities and the following table shows the values of vulnerability assessments.

Table 3. Assessment of vulnerability to climate change (CCVA) by prioritized municipality.

	Zacualpa	San Andrés Sajcabajá	Uspantán	Canillá	Chicamán
CCVA[1]	0.59956125000	0.27113314700	0.02146293900	0.83959225600	0.26873937900
Change fitness for major crops (%)	17,224	SD	5.931	1.973	4.254

Source: Data provided by THE COMPANY C4 ECOSOLUTIONS and (Bournocle, et al, 2013)

Table 4 shows The yields of the main crops in the department of El Quiche (where all the selected municipalities are located), based on the annual average 2001-2009 (ton / ha), and the estimated yields in the climate change scenarios b2 and a2 with Cuts to 2020, 2030, 2050, 2070 and 2100 in%. (ECLAC (Economic Commission for Latin America and the

[1] The CCVA index (Assessment of vulnerability to climate change) considers for its calculation:
Climate exposure: Aqueduct Global Maps 3.0 Data that integrate water supply and demand, surface and groundwater modeling under RCP4.5 and RCP8.5 for population scenarios SSP2 and SSP3.
Sensitivity and adaptability of the agricultural and water sectors for municipalities or cantons of Central American countries
Sensitivity: rural population index, rural dependency index, change in crop suitability, agricultural employment.
Adaptive capacity: access to the water and sanitation service, population by health facility, rural economic activity, access to credit and irrigation.

Caribbean), NDF (Nordic Development Fund), IDB (Inter-American Development Bank) and MARN (Ministry of Environment and Natural Resources - Guatemala), 2018)

Table 4. Estimated yields under Climate change scenarios b2 and a2 with cuts to 2020, 2030, 2050, 2070 and 2100 in%.

Crop	2001-2009 (t / ha)	CC B2 Scenario (%)					CC A2 Scenario (%)				
		2020	**2030**	**2050**	**2070**	**2100**	**2020**	**2030**	**2050**	**2070**	**2100**
Corn	1.73	5.14%	2.71%	5.95%	11.84 %	13.63 %	- 5.20%	2.89%	-2.66 %	4.04%	6.06%
Bean	0.29	35.07 %	31.94 %	40.28 %	76.39 %	89.93 %	- 4.17%	6.60%	29.17 %	71.53 %	100.00 %
Rice	2.3	1.57%	- 1.35%	1.31%	3.75%	3.18%	- 7.67%	- 5.44%	10.41 %	- 8.93%	-12.46%
Coffee	1.06	- 3.22%	2.46%	- 2.37%	- 1.14%	- 3.51%	14.41 %	- 2.84%	- 2.56%	- 1.99%	-5.50%

Source: (ECLAC (Economic Commission for Latin America and the Caribbean), NDF (Nordic Development Fund), IDB (Interamerican Development Bank) and MARN (Ministry of Environment and Natural Resources - Guatemala), 2018)

Information on the change of aptitude of other crops at Central American level is shown in **Table 19.**

Existing techniques in the country that are efficient with the use of water

The Ministry of Agriculture, Livestock and Food (MAGA) has carried out an analysis of the distribution of the slopes, with a 1: 50,000 scale elevation model demonstrating the existence of areas semiplanes that can be dedicated to the agricultural activity, that increase the potential of the municipality to realize agriculture. (See **Table 23** in **Annex 1**).

The potential of these practices is associated, for example, with the improvement they provide in water regulation and soil erosion processes. Therefore, knowledge about the advantages, disadvantages, adaptive benefits and labor requirements must be documented, with the purpose of promoting their adoption and helping small farmers to take the necessary measures to adapt to climate change. (Chain-Guadarrama, (Chain-Guadarrama, Martinez-Rodriguez, Cárdenas, Vílchez-Mendoza, & Harvey, 2018).

The 2003 National Agricultural Census, cited by (MAGA, 2013) shows for the total irrigated area of the country **Table 5**, where it is noted that the most efficient type of irrigation only covers 6% of the irrigated area of the country.

Table 5. Type of irrigation, percentage of the total irrigated area and water efficiency

Type of irrigation	**% of the total irrigated area of the country**	**Water efficiency (MAGA , 2013)**
By surface (furrows or flood)	30%	50%
By sprinkling	54%	75%
Drip	6%	95%

Source: (MAGA, 2013)

In (Jimenez-Cisneros & Galizaia-Tundisi, 2012) indicate that water efficiency of sprinkler irrigation is 70%, drip irrigation is 90% and flood is 50% (see **Table 25** in **Annex 1).**

In the case of sugarcane cultivation, its efficiency has improved (from 0.9 to 1.7 ha / MI of water) between 1990 and 2010. (MAGA, 2013) also indicates that it is urgent to substantially increase efficiency in the mini irrigation, artisanal irrigation and irrigation units.

Of the total irrigated area, 54% corresponds to sugarcane, other vegetables and annual crops 13.75%, as shown in **Table 24 Box 23** in **Annex 1** (Jimenez-Cisneros & Galizaia-Tundisi, 2012)

Barriers to acceptance of more efficient agricultural practices

Barriers have been identified that affect the correct implementation of adaptation measures, such as the lack of specific laws and policies on water, and the lack of political will. On the local organization, there is a lack of funding and few opportunities for women, there is no information on markets available locally and community organization is very scarce (Bouroncle, et al., 2015).

Honduras

Main crops

The main crops present in the prioritized municipalities according to (Bouroncle, and others, 2013) are corn (46.2%) and sorghum (24.2%). In the municipality of Morcovia, the cultivation of cane is an important crop (54.4%) of the area cultivated in the municipality. The detail is shown in **Table 26** and **Table 27** located in **Annex 1**.

Area dedicated to subsistence versus commercial agriculture

The production of basic grains (corn, rice, beans and sorghum) has an important participation in the agricultural sector of the prioritized municipalities, the percentages of cultivated area for agro-industrial and commercial crops vary from 0.32 % up to 57.81%, with the average in these municipalities being 23.25% (Bouroncle, et al., 2013).

Table 6. Area dedicated to subsistence farming versus commercial agriculture in priority municipalities in Honduras, in hectares and percentage

Cultivation	Cholutec a	Marcovi a	Morolica	Apacilagu a	Orocuin a	Duyure	Total
Corn	4,858	3,033	770	1,474	1,579	390	12,104
Bean	313	16	186	211	546	276	1,548
Rice	8	40	7	0	0	0	55
Sorghum	2,992		636 386	1,033	1,110	181	6,338
Other grains	0	0	0	0	0	0	0
Agroindustrial crops	367	4,924	6	4	60	17	5,379
Commercial crops	225	180	219	5	60	3	692
Total area cultivated	**8.763**	**8.829**	**1.574**	**2.727**	**3.355**	**867**	**26,116**
% agribusiness and commercial crops by municipality	**6.76%**	**57.81%**	**14.27%**	**0.32%**	**3.58%**	**2.34%**	**23.25%**

Population dependent on different crops / agriculture for their livelihoods

In the prioritized municipalities the population dependent on agriculture is estimated between 60 % to 80%.

Table 7. Percentage of population dependent on agriculture

	Choluteca	Marcovia	Morolica	Apacilagua	Orocuina	Duyure
% population dependent on agriculture	nd	nd	80%	80%	nd	60% - 80%

Source: data provided by local consultants

Crop yield over the time together with projected future impacts on crops in municipalities prioritised by climate change.

Figure 13 located in Annex 2 shows a map with the vulnerability index values calculated by the company C4 ECOSOLUTIONS for prioritised municipalities and the following table shows the values of vulnerability assessments.

Table 8. Assessment of vulnerability to climate change (CCVA) by prioritized municipality.

	Choluteca	Marcovia	Morolica	Apacilagua	Orocuina	Duyure
CCVA	0.3120450490	0.2711331470	0.0548363800	0.8802456500	0.187007499	0.6394428880
Change fitness for major crops (%)	-1.221	-6.318	1.969	1.610	0.347	1.217

Source: Data provided by the company C4 ECOSOLUTIONS and (Bournocle, et al, 2013)

It is expected that by 2030 the annual average of the country will have increased 1.4° C, this will be accompanied by the intensification of the dry and hot periods, with the reduction of rainfall, so the water deficit will increase, producing a change in the areas suitable for different crops, for example; It could reduce the ability in the lowlands and valleys of the central region for the cultivation of corn and coffee, so it will end up in an economic impact for the farmers in that area.

For Central America and under the most pessimistic scenario of climate change (A2), it is expected that by the end of the century the area cultivated with corn will be reduced by 35% and that 62% of the areas that grow corn will have yields below 1.5 T / ha (Viguera, Nartinez Rodriguez, Donatti, Harvey, & Alpizar, 2017).

In the case of beans, production will decrease by 43%, and 61% of the crops will have yields below 0.55 T / ha.

Information on the change of aptitude of other crops at Central American level is shown in **Table 19.**

Existing techniques in the country that are efficient with the use of water

The country's economy depends heavily on the agricultural sector, so that the promotion of agricultural production under irrigation is considered essential to supply its internal consumption and expand its horizons for exporting products nontraditional The potential irrigable area is estimated at 500,000 ha, distributed as follows: 100,000 ha in the inland highlands, 340,000 ha in the lowlands of the Atlantic slope and 60,000 ha in the lowlands of the slope of the Pacific, however, only 89,697 hectares are equipped for irrigation. The greatest form of irrigation in the country is combining localized irrigation, by gravity and by sprinkling. (FAO, 2015).

Temporary crops represent 67.85% of the total flooded area, the remaining 32.15% of the area corresponds to Permanent Crops, as shown in **Table 28**. (FAO, 2015)

Water requirements per crop at the cessation level are detailed in **point 8** below.

Barriers to the acceptance of more efficient agricultural practices

The barriers identified have affected the development of projects, such as the level of illiteracy and lack of technical training, there is also low coverage of meteorological and hydrological stations, in addition to restricted access to information. Culturally, resistance to change has been found, in the past they used bad practices in agriculture, so a process of accompaniment and knowledge transfer related to the negative effects and how to prepare for this phenomenon should be provided. The level of citizen insecurity is high and the producer organization is weak. Despite these problems, the greatest has been the lack of political will to work on the issue. (PENDING APPOINTMENT)

El Salvador

Main crops

There are several departments that are characterized by having a great impact on the production of corn and beans, however; they are the places where there is greater food insecurity. Ahuachapán produces 12.3% of corn and 12.7% of beans of the national production and is in fifth place due to severe food insecurity, Usulután produces a little more than 10% of the national corn production and corresponds to the fourth place of severe food insecurity. Approximately 280,000 households dedicated to agriculture, 60% face some degree of food insecurity (Salazar, González, & Pettinato, 2016).

The main crops present in the prioritized municipalities according to (Bouroncle, and others, 2013) are corn (55.29%) and sorghum (18.67%). In the municipalities of Concepción Batres and El Transito, the cultivation of Caña is an important crop (23.66% and 24.01% respectively) of the area cultivated in the municipality. The detail is shown in **Table 29** and **Table 30** located in **Annex 1**.

Area dedicated to subsistence agriculture versus commercial.

The production of basic grains (corn, rice and sorghum) has an important participation in the agricultural sector of the prioritized municipalities, the percentages of cultivated area for agro-industrial and commercial crops vary from 1.72% to 31.41%, being the average in these 18.67% municipalities (Bouroncle, and others, 2013).

Table 9. Area dedicated to subsistence agriculture versus commercial agriculture in the prioritiSed municipalities in El Salvador, in hectares and percentage

Crop	Conception Batres	Jucuarán	El Carmen	The Transit	San Miguel	Total
Maiz	2,127	1,384	1,278	1,294	6,543	12,626
Bean	62	229	12	44	433	780
Rice	33	0	0	56	4	94
Sorghum	177	294	420	134	3,239	4,263
Other grains	0	0	0	0	0	0
Agroindustrial crops	950	217	0	586	1,978	3,730

Commercial crops	149	25	30	2	140	346
Total cultivated area	3,499	2,149	1,740	2,115	12,337	21,840
% agroindustrial crops and commercial by municipality	31.41%	11.25%	1.72%	27.79%	17.17%	18.67%

Population dependent on different crops / agriculture for their livelihoods

The following table shows the information of 3 of the municipalities where the labor participation of men and women is shown. women in the agricultural field where the significant participation of women in the municipalities of El Carmen and San Miguel is shown.

Table 10. Labor participation of men and women in the agricultural field

	Concepción Batres	**Jucuarán**	**El Carmen**	**El Transit**	**San Miguel**
Participation in labor force men (economically active population)	44%	41%	66.5%	47%	58.2%
Participation in labor force women (population economically active)			35.3%		41.8%

Source: (Bouroncle, et al., 2013)

At the national level, 50% of the rural population over 15 years old has agriculture as their main job. And small and medium producers represent 12% of the total population of the country (Fung, et al., 2015).

Crop yield over time together with projected future impacts on crops in municipalities prioritized by climate change

Figure 14 located in Annex 2 shows a map with vulnerability index values calculated for prioritiSed municipalities and the following table shows the values of vulnerability assessments.

Table 11. Assessment of vulnerability to climate change (CCVA) by prioritized municipality.

	Concepcion Batres	Jucuarán	El Carmen	El Tránsito	San Miguel
CCVA	0.19746236900	0.54052095000	0.46425668500	0.24787859800	0.43311580600
Change fitness for major crops (%)	0.670	-0.545	-3.161	1.864	0.989

Source: (Bournocle, et al, 2013)

For Central America and under the most pessimistic scenario of climate change (A2), it is expected that by the end of the century the area cultivated with corn will be reduced by 35% and that 62% of the areas that grow corn will have yields below 1.5 T / ha (Viguera, Nartinez Rodriguez, Donatti, Harvey, & Alpizar, 2017).

In the case of beans, production will decrease by 43%, and 61% of the crops will have yields below 0.55 T / ha. Information on the change of aptitude of other crops at Central American level is shown in **Table 19.**

During 2019, El Salvador suffered a great drought that led to losses; On corn, the agricultural cycle of 2018/2019 had 31% less production than in 2017/2018. And the beans lost 20% compared to the previous cycle. But nevertheless; in the production of sorghum and rice there were no significant variations (Central America Data, 2019). This is expected to be due to climate change.

It is estimated that by 2030 the average temperature of El Salvador may increase 1.5 ° C, with intensification of rains, which will result in a water deficit and would mean a change in areas for crops. It is estimated that almost 70% of municipalities may lose suitable areas. In the eastern part of the country the change in fitness will be more intense, they could lose up to 23% of their fitness. While other municipalities will have a slight increase, up to 6%, which are a high proportion of corn and sorghum (Fung, et al., 2015).

Existing techniques in the country that are efficient with the use of water

El Salvador is a country that has little water for its inhabitants, the population with less resources must choose to drink water from natural sources, since large-scale industry is located near these communities and the excessive use of groundwater leaves the communities without adequate resources, mainly due to the fact that “Big Business” has been given priority, as industrial plantations (Gies, 2018).

Water requirements per crop are detailed in point 8 below. To implement agricultural techniques that are more efficient with the use of water, agroecology has begun to be implemented, which seeks to implement sustainability and productivity through the application of ecological knowledge to its design and management. (Latin American Summary, 2016). Also FUNDAZUCAR, created a Manual of Good Agricultural Practices for the cultivation of sugarcane so that farmers can implement it in their crops. (Fundazucar, sf).

In 2012, the area equipped for irrigation was estimated at 45,229 ha of which 41,565 ha (91%) used surface irrigation, 2,488 ha (6%) used sprinkler irrigation and 1,176 ha (3%) used localized irrigation. Of the total equipped area, 31,523 ha (70%) corresponded to associations, 9,706 ha (21%) corresponded to irrigation districts, and 4,000 ha (9%) to other private farms of coffee, sugar cane, forest areas and fruit trees. However, the area effectively irrigated in 2012 was 33,839 hectares, of which 23,460 hectares correspond to irrigation associations, 6,379 hectares to irrigation districts and 4,000 hectares to other private farms. (FAO, 2015)

Barriers to the acceptance of more efficient agricultural practices

The barriers that limit the achievement of sustainable agriculture are grouped into a low political priority on the problem of climate change. There are also asymmetries for addressing the issue and in its existing national capacities, all this has affected El Salvador to generate a more ecological system (Sepúlveda & Ibrahim, 2009).

Nicaragua

Main crops

Crops for domestic consumption are mainly rice, beans, corn, sorghum and soybeans, and crops for export are mainly coffee, cotton, sesame, sugarcane, bananas, tobacco and peanuts. (FAO-AQUASTAT, 2015)

Regarding the departments where the prioritized areas are located, in Nueva Segovia 59% of its agricultural area is for coffee and tobacco. Corn, beans, dry rice and sorghum use 40% of the land and the rest (1%) is used for vegetables and fruits.

In the Madriz area, the sowing of temporary products is not recorded, 24% of the area is used as agricultural agricultural land, 43% is occupied by permanent crops, and vegetables and fruits only use 1%. (Baca, 2018).

The main crops present in the municipalities prioritized for the Dry Corridor project according to (Bouroncle, and others, 2013) are beans (45.53%) and corn (33.32%). In the municipality of Telpaneca the cultivation of coffee is important (it covers 29.17% of the area of this municipality). The detail is shown in **Table 31** and **Table 32** located in **Annex 1**.

Area dedicated to subsistence versus commercial agriculture

The production of basic grains (corn, rice and sorghum) has an important participation in the agricultural sector of the prioritized municipalities, the percentages of cultivated area for agribusiness and commercial crops varies from 0.41% to 30.8%, the average in these municipalities being 11.21% (Bouroncle, et al., 2013).

Table 12. Area dedicated to subsistence agriculture versus commercial agriculture in the prioritized municipalities in Nicaragua, in hectares and percentage

Crops	Telpaneca	Palacagüina	Yalagüina	Jícaro	Somoto	Total
Corn	1,995	1,296	607	4,779	2,852	11,529
Bean	2,683	1,046	789	8,025	3,208	15,751
Rice	211	1	0	3	0	215
Sorghum	117	491	270	2	1,986	2,866
Other grains	0	0	0	0	0	0
Agro-industrial crops	2,140	51	3	1,215	58	3,467
Commercial crops	112	51	10	125	115	413
Total cultivated area	7,299	3,035	1,690	14,234	8,339	34,597
% agribusiness and commercial crops by municipality	30.86 %	3.37%	0.76%	9.41%	2.07%	11.21%

Population dependent on different crops / agriculture for their livelihoods

The following table shows how a high percentage of the population depends on agriculture, although men remain the main actors in the sector

	Telpaneca	**Palacagüina**	**Yalagüina**	**El Jícaro**	**Somoto**
% population dependent on agriculture	52%	54%	53%	52%	56%
Main actors in agriculture	Mens	Mens	Mens		
Roles of women in the agricultural sector	Low	Regular	High		

Source: data provided by national consultants and (Bouroncle, et al., 2013)

The government has promoted the increase of the area planted with basic grains to reduce dependence on imports and the impact of the price increase on the national market. In addition to motivating national work since 72% of the rural population over 15 years of age have agriculture as their main job (Medellín Claudia, and others, 2014).

Crop yield over time together with projected future impacts on crops in municipalities prioritized by climate change.

Figure 15 located in Annex 2 shows a map with the vulnerability index values for prioritised municipalities and the following table shows the values of vulnerability assessments

Table 13. Assessment of vulnerability to climate change (CCVA) by prioritised municipality.

	Telpaneca	Palacagüina	Yalagüina	Jícaro	Somoto
CCVA	-0.560177421	0.96727853	-0.597251441	0.96727853	-0.597251441
Cambio en la aptitud para Crops principales (%)	nd	nd	-4.257	nd	-2.865

Source: (Bournocle, et al, 2013)

Information on the change of aptitude of other crops at Central American level is shown in **Table 19.**

In the departments of the North Central Region of the country, the change in fitness will be intense, with some municipalities losing up to 23% of fitness. Other municipalities could have a slight increase of up to 7% in their aptitude for current crops: mainly from less sensitive crops, such as cane and sorghum in the Atlantic regions; and corn in high altitude areas of Chinandega, León and other departments, this is shown in Figure 14. (Medellín Claudia, and others, 2014).

Existing techniques in the country that are efficient with the use of water

The Nicaraguan dry corridor is the territory most affected by climate change, has been characterized by a very erratic rainy season, with periods of excessive humidity, or prolonged periods of drought. This causes a shortage of water for crops and therefore a low yield that affects the lives of small farmers. According to the Ministry of Agriculture (MAG), Nicaragua irrigates approximately 18% of the total cultivated area, mainly for sugarcane and rice, in the Pacific zone. For the central part of the country, vegetables, tobacco and basic grains are irrigated. Even though Nicaragua is considered a region with a large lack of water (FAO in Nicaragua, 2018).

The gravity irrigation technique is the most important in the country, which is used in approximately 60,000 ha, secondly it is sprayed with approximately 30,000 ha and to a lesser extent, the drip technique used in 5,600ha is used (Zegarra & Chirinos, 2016).
Water requirements per crop are detailed in point 8 below.

Agricultural practices that are more sustainable with the environment, pedagogical resources have been carried out that are suitable for promoting the learning of small producers on issues of conservation agriculture and agroforestry systems (Social Promotion Foundation, 2018).

If these adaptation methodologies are to be implemented, work on different scales is necessary, so the support of local governments is necessary for the development of strategies. The conversion and diversification of production systems should be implemented, such as diversifying income to reduce the vulnerability sensitivity of rural communities (Medellín Claudia, and others, 2014).

Barriers to the acceptance of more efficient agricultural practices

All these situations have led farmers to try to find solutions for their crops. But there are barriers that have hindered this process, such as the lack of economic support, implementation of laws and development of regulations, by the government. There is also a lack of planning, as well as a decrease in the awareness of both political actors and the general population (Marguilis, 2016).

Costa Rica

Main crops

The main crops present in the prioritized municipalities according to (Bouroncle, and others, 2013) are cane (43.44%) and Irrigation rice (33.40 %%), also the melon has a percentage of the cultivated area of 8.21% . In the cantons of Nicoya and Santa Cruz, the cultivation of corn is an important crop (24.65% and 11.26% respectively). The detail is shown in **Table 33** and **Table 34** located in **Annex 1**.

Area dedicated to subsistence versus commercial agriculture

A large part of these crops are found throughout the national territory and many of these are exported, during 2017 the value of exports reached an amount of 4,878.1 million dollars, representing a 46% of the total value exported by the country (Mora S., 2018)

In the case of these prioritized cantons, the percentages of commercial crops are significantly higher, especially in the cantons of Liberia, Bagaces and Carrillo, where these values are above the 98%, in the cantons of Nicoya 55.45% of the cultivated areas are commercial areas. (Bouroncle, and others, 2013).

Table 14. Area dedicated to subsistence agriculture versus commercial agriculture in prioritied municipalities in Costa Rica, in hectares and percentage

Crops	Liberia	Nicoya	Santa Cruz	Bagaces	Carrillo	Tptal
Maíze	80	1,210	375	80	35	1,780
Frijol	50	335	350	60	75	870
Arroz	10,574	875	1,358	7,217	1,598	21,622
Sorgo	0	0	0	0	0	0
Otros granos	0	0	0	0	0	0
Crops agroindustriales	8,079	516	1,114	4,467	9,271	23,446
Crops comerciales	12,498	1,421	1,490	7,251	4,413	27,073
Area total cultivada	20,717	3,493	3,329	11,886	13,814	53,239
% Crops agroindustriales y comerciales	99.32%	55.45%	78.22%	98.59%	99.06%	94.89%

Population dependent on different crops / agriculture for their livelihoods

At the national level the proportion of the population that is actively in rural areas, working in agriculture is on average 40% of the population in rural areas, older than 15 years have agriculture as their main job, having approximately 5392 people belong clients to individual producing families who work in farm work (Donatti, et al., 2015).

The following table shows how the percentage of the population that depends on agriculture is moderate, although men remain the main actors in the sector.

Item	Liberia	Nicoya	Santa Cruz	Bagaces	Carrillo
% population dependent on agriculture	8,4%	16,9%	12,2%	29,2%	13,3%

Crop yield over time together with projected future impacts on Crops in municipalities prioritised by climate change

In Figure 16 located in Annex 2 shows a map with the vulnerability index values for Priority cantons and the following table shows the values of vulnerability assessments.

Table 15. Assessment of vulnerability to climate change (CCVA) by prioritized municipality.

	Liberia	Nicoya	Santa Cruz	Bagaces	Carrillo
CCVA	-0.53903257300	-0.6011182920	-0.6011182920	-0.8469386840	-0.77567319200
Change in the aptitude for main crops (%)	1.270	-1.280	0.131	0.787	-2.125

Source: data provided by (Bouros and others) 2013)

For Central America and under the most pessimistic scenario of climate change (A2), it is expected that by the end of the century the area cultivated with corn will be reduced by 35% and that 62% of the areas that cultivate corn will have yields below 1.5 T / ha. (Viguera, Nartinez Rodriguez, Donatti, Harvey, & Alpizar, 2017).

In the case of beans, production will decrease by 43%, and 61% of the crops will have yields below 0.55 T / ha.
Information on the change of aptitude of other crops at Central American level is shown in **Table 19.**

Existing techniques in the country that are efficient with water use

The region of the country with the greatest lack of water is Guanacaste. This province has historically faced the challenge of controlling and distributing its waters in fertile areas during intense times of droughts or floods. The University of Costa Rica created a DRAT in 1984 to manage the waters generated by the Arenal-Dengo-Sandillal hydroelectric complex to irrigate the agro-productive farms of the region. Thanks to this system, a total of 28,000 hectares can be irrigated and 18,800 hectares will be irrigated by various government projections by 2022 (O'neal, 2017).

Water requirements per crop are detailed in point 8 below.
In the country different techniques are used for water use, the area equipped for irrigation is 101,500 ha, of which 85% is surface irrigation, 10% is by means of sprinkling and the remaining 5% uses localized irrigation. Surface irrigation is mainly used in rice, pastures and sugarcane, as well as localized sprinkler irrigation is used for the cultivation of coffee, potatoes, vegetables and fruits (FAO, 2015).

As mentioned earlier, Costa Rica will suffer serious consequences from climate change and some of these have been seen in the country. The increase in temperature will affect the production of corn, beans and coffee. It is expected that doing nothing by 2100, the accumulated losses would reach about 4% of the GDP of 2007, which would significantly affect the economy both nationally and for small farmers (Ordaz, Ramírez, Mora, Acosta, & Sema, 2010).

Barriers to the acceptance of more efficient agricultural practices

These consequences have led the government to seek measures to implement crops with a sustainable production system; however, several barriers have been found to implement these methods, such as lack of labor training, certifications have high costs, the COmarket$_2$ is limited and there is little access to international financing. Similarly, there is little follow-up in the actions implemented.

Panama

Main crops

The main crops present in the prioritized municipalities according to (Bouroncle, and others, 2013) are dry rice (43.27%) and corn (40.68%), also irrigation rice has a percentage of the cultivated area of 7.32 %. The detail is shown in Table 33 and Table 34 located in Annex 1.

Area dedicated to subsistence versus commercial agriculture

Rice is the main crop in the area, followed by corn and coffee. And in areas like Los Santos, corn is the most important. In the provinces of Bocas del Toro and the indigenous regions Kuna Yala and Ngöbe-Buglé, the cultivation of bananas and cocoa dominates, while in some districts of Chiriquí, Veraguas and Herrera sugar cane is the main crop along with corn. The area devoted to different crops has changed in recent years. The latest national agricultural survey of rice, corn and beans (2012-2013) indicates that the area dedicated to the cultivation of corn and beans is growing while the area dedicated to rice is decreasing (Imbach, et al., 2014).

In the case of these prioritised municipalities, the percentages of cash crops are significantly very low, especially in the generality of all municipalities, where these values are below 6.1 %% (Bouroncle, et al., 2013).

Table 16. Area dedicated to subsistence farming versus commercial agriculture in priority municipalities in Panama, in hectares and percentage

Crops	Guararé	Macaracas	Pedasí	Pocrí	Tonosí	Total
Maiz	2,409	1,295	1,840	1,460	784	7,788
Frijol	34	44	6	19	110	214
Rice	826	967	444	434	7,014	9,685
Sorghum	48	5	117	22	6	197
Other grains	0	0	0	0	0	0
Agro-industrial crops	68	115	15	41	70	309
Commercial crops	61	37	4	36	366	504
Total cultivated area	3,542	2,533	2,428	2,043	8,603	19,150
% agribusiness and commercial crops	3.65%	6.01%	0.79%	3.75%	5.07%	4.25%

Source: (Bouroncle, y otros, 2013)

Population dependent on different crops / agriculture for their livelihoods

These consequences would affect a large percentage of the country, since 40% of the rural population which has more than 15 years has as its main job agriculture. This has encouraged the government to seek measures to solve these problems.

Crop yield over time together with projected future impacts on crops in municipalities prioritised by climate change.

Figure 17 located in Annex 2 shows a map with the vulnerability index values for the prioritised cantons and the following table shows the values of the vulnerability assessments.

Table 17. Assessment of vulnerability to climate change (CCVA) by prioritized municipality.

	Guararé	Macaracas	Pedasí	Pocrí	Tonosí
CCVA	-0.44686289400	0.44686289400	0.14833532100	-.51358672400	-0.52283849700
Change fitness for major crops (%)	2.690	2.744	5.969	6.792	-0.094

Source: Data provided by (Bournocle, et al, 2013)

Information on the change of aptitude of other crops at Central American level is shown in **Table 19.**

Existing techniques in the country that are efficient with the use of water

Water requirements per crop are detailed in item 8 below. Due to the droughts the country has undergone, the Drought Plan was created, which the national government executes through MIDA, 40 producers received training during an agricultural day in the district of Parita Herrera This to address issues such as water harvesting, and complementing actions, such as drilling or adaptation of deep wells and watering holes, repair of existing dams and maintaining water in the ravines (MIDA, 2019).

Barriers to the acceptance of more efficient agricultural practices

In Panama, situations have been found that limit the adaptation of farmers to climate change, mainly due to low political priorities regarding the issue and little awareness in the general population (Sepúlveda & Ibrahim, 2009).

Dominican Republic

Main crops

This country has an average income with the largest economy in Central America and the Caribbean, it has established itself as one of the fastest growing economies in the Americas, which is mainly based on the agricultural sector, which represents 10.6% of your income. But nevertheless; its production has been affected by climate change, an effect that causes heavy rains and intense droughts (IICA, 2016).

The Dominican Republic produces several types of crops and among these are (Dominican Agriculture, 2018):

a) Cereals: Rice and corn are the most important
b) Industrial crops: Sugarcane, coffee, cocoa, tobacco, aloe and flowers.

c) Fruit trees: Guineos, oranges, milky, avocado, chinolas, coconuts, pineapples, bananas, grapefruits, etc.
d) Legumes: French beans and guandules.
e) Vegetables: Chili peppers, eggplants, tomatoes, onions and carrots among others.

Among all the crops produced in the area, coffee beans, enrama tobacco, cocoa beans, raw sugar, organic bananas, avocado, melon and vegetables are the main products used for export. Those that are for internal consumption are; rice, cassava, corn, sorghum, tubers, bananas, coffee beans, cocoa, black cane and tobacco (Ministry of Agriculture, nd).

Area dedicated to subsistence agriculture versus commercial

For the selected municipalities, the national consultant indicates that in the area, medium and large-scale agricultural production is very scarce, what dominates is subsistence production, where there are no production cost data. In the case of small producers who sell their products in local markets, they do not estimate their costs, and they do not know the productivity of their land.

Population dependent on different crops / agriculture for their livelihoods

Climate change and its impact on crops could affect 12% of the Dominican population engaged in agriculture (Ministry of Agriculture, nd). This is due to a decrease in the production of some of the main crops in the region.

As Figure 25 presents, between 2014 and 2017 there was a great decrease in areas for crops; however, more sustainable crop measures have been implemented, so production has been maintained over time (García, 2018).

	Monción	Sabaneta	V. Los Almácigos	El Pino	Partido
% population dependent on agriculture	30%	30%	30%	20%	20%

Small farmers (farmers with farms under 3.13 ha) represent 72 percent, but only represent 28 percent percent of cultivated area (FAO, 2015)

Crop yield over time in conjunction with projected future impacts on crops in municipalities prioritised by climate change.

In **Figure 18** located in Annex 2 shows a map with values vulnerability index for cantons and prioritised in the following table values shown vulnerability assessments.

Table 18. Assessment of vulnerability to climate change (CCVA) by prioritized municipality.

	Monción	San Ignacio de Sabaneta	Villa Los Almácigos	El Pino	Partido
CCVA index	0.70662039000	0.70662039000	0.70662039000	0.65401231800	0.65401231800

Source: datos suministrados por LA EMPRESA C4 ECOSOLUTIONS y (Bouroncle, y otros, 2013)

Existing techniques in the country that are efficient with the use of water

Dominican Republic has an average annual rainfall of 1410mm, which is equivalent to an annual volume, of water throughout the territory, of 68.620 million m3. However, in many of the country's accounts an exploitation has been seen, so projects have been sought through adaptation measures, taking into account the vulnerability and resilience of the population. According to experts, if preventive measures are not taken in the Mao basin, there will be limited access to the body of water incurring problems for the population and a strong conflict over control, especially of agricultural producers (Santana, 2019).

Of the biggest problems due to the use of water basins, it is due to the fact that its main use is due to agriculture, as shown in figure 26.

According to the National Institute of Hydraulic Resources, the potential irrigation area is approximately 710,000 hectares, the largest part of the irrigated areas are found in the streets between the mountain ranges, presenting a medium to low rainfall and with some limitations in their soils. Since the 70s, the Dominican Republic has developed techniques to increase its irrigation area, this being the most used technique to date (FAO, 2015).

Table 19 shows information on the change of aptitude of other crops at the Central American level.

The Inter-American Institute for Cooperation on Agriculture (IICA) has taken different projects to the country to help the agricultural population to have a more sustainable crop system, and thus improve the productivity and competitiveness of the agricultural sector, enhance the contribution of agriculture to development of territories and rural well-being, improve the ability of agriculture to mitigate and adapt to climate change and make better use of natural resources and improve agriculture's contribution to food security.

All the projects carried out were carried out in the rural areas of the country, in order to improve the techniques already used by farmers and to have a more efficient system.

In 2009, the area equipped for irrigation amounted to 306,500 ha. In 2004, 216,200 hectares of the area equipped for irrigation were effectively irrigated.

Barriers for the acceptance of more efficient agricultural practices

In the Dominican Republic, agriculture is an activity that depends on the natural systems and climatic conditions that characterize the region, But situations have been found that hinder the development of more sustainable systems with the environment, such as the limited use of technologies, reduced investments and little financing in this sector. There is also a neglect of human capital, which makes it difficult to reduce poverty (Gonzales & Miranda, 2013).

Water efficiency of existing crops

Information on the main crops is presented (Ruíz Corrales, Medina García, Gonzalez Acuña, Flores Lopez, & et al, 2013) and which are present in the prioritized municipalities in each country.

Coffee

The annual precipitation requirement ranges from 1,500 to 2,500 mm, well distributed, but with a dry period of 6 to 12 weeks. It requires uniformly distributed precipitation for nine months, followed by three dry months, with approximately 25 to 50 mm of rain, to induce flowering. Precipitation requirements depend on soil retention properties, atmospheric humidity and cloudiness, as well as cultivation practices.

For plants with an average height of 2-3 m and in an orchard without vegetation cover, the crop coefficients (Kc)[2] for the initial, intermediate and final stages of development in a production cycle have a value of 0.9, 0.95 and 0.95 respectively. For weeds orchards, the Kc values vary from 1.05, 1.1 and 1.1. It prefers a relative humidity of medium to high, 70-85%.

Sugarcane

The annual rainfall requirement ranges from 1000-2200 mm. For plants with an average height of 3 m, the crop coefficients (Kc) for the initial, intermediate and final stages of development are 0.4, 1.25 and 0.75, respectively. It prefers a relative humidity around 50%. It is quite resistant to drought, but low production.

Bean

A rainfall regime between 1000 to 1500 mm is desirable in the year, but if the rains fall during flowering cause flower falls. Beans require 350 to 400 mm during the crop cycle. The water requirement is 110-180 mm between sowing and flowering and 50-90 mm during flowering and beginning of fruiting, but the two weeks prior to harvest must be dry.
For plants with an average height of 40 cm, the crop coefficient (Kc) for the initial, intermediate and late stages is 0.4, 1.15 and 0.35, respectively.

Corn

Sowing at maturity requires 500 to 800 mm, depending on the variety and climate. It prefers regions where annual rainfall ranges from 700 to 1100 mm. Water is required in the germination phases and its first three weeks of development and the period from two weeks before flowering to 4 weeks after it, without Do not overdo it because it harms the plant. If there is a stress due to lack of water, the decrease in the final yield may be 6 to 13% per day in the period around flowering and 3 to 4% per day in the other periods. From 30 days after flowering, or when the cob leaf dries, the crop should not receive more water. Its average water requirement per cycle is 650 mm. It is necessary that you have 6-8 mm / day from the beginning of the ear to its grain state. The consumptive use varies from 410 to 640 mm, with extreme values of 300 and 840 mm.

For grain maize and plants with an average height of 2 m, the crop coefficient (Kc) for the initial, intermediate and final stages of development is 0.7, 1.2 and 0.35-0.6 (depending on the degree of humidity with which will harvest). Para maíz dulce en plantas de 1-1.5 ma

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[2] The coefficient (kc) or culture factor is determined by the difference in evaporation and transpiration of the reference culture with respect to a particular crop. The Kc allows to calculate the water consumption or actual evapotranspiration of a particular crop from the reference evapotranspiration (ETr) through:
$ETc = Kc * ETr$
where ETc is the crop evapotranspiration (mm), Kc is the crop coefficient (dimensionless) and ETr is the reference evapotranspiration (mm)
The Etr estimate incorporates the effects of different meteorological factors to establish the demand for water that the atmosphere makes. Therefore, the Kc varies with the particular conditions of the crop, being affected by the weather only in a small proportion.

cosecharse en fresco, los Kc de estas etapas son 0.7, 1.15 y 1.05; si se cosecha secado en campo el Kc final es 0.35.

Change in the aptitude of the main crops in the face of Climate Change scenario

At the Central American level (Donatti, et al., 2015) estimated the effects of climate change on the changes of the appropriate areas to produce the main areas crops in Central America. For Central America and under the most pessimistic scenario of climate change (A2), it is expected that by the end of the century the area cultivated with corn will be reduced by 35% and that 62% of the areas that grow corn will have yields below 1.5 T / ha (Viguera, Nartinez Rodriguez, Donatti, Harvey, & Alpizar, 2017).

In the case of beans, production will decrease by 43%, and 61% of the crops will have yields below 0.55 T / ha.

Table 19. Percentage of the current total area suitable for certain crops, which is expected to be lost, maintained or enabled, as a result of climate change.

Crops	Area that will no longer be suitable for production in the context of climate change	Area that will continue to be suitable for production in the context of climate change	Zones that will become suitable for production in the context of climate change
Banana	10.5%	89.5%	20.6%
Beans	13.9%	86.1%	0%
Coffee	11.4%	88.6%	15.1%
Corn	0.3%	99.7%	0.1%
Oil palm	4.4%	95.6%	0.7%
Orange	3.6%	96.4%	0.9%
Pineapple	3.5%	96.5%	5%
Sugarcane	7%	93%	17.6%

Source: (Donatti, et al., 2015)

Below are the results obtained by (Roehrdanz, 2014), which shows the aptitude changes of the main crops in Central America, which are obtained under the data run of multiple global climate models (Global Climate Model GCM) and climate change trajectories (*Representative Concentration Pathways* RCP) RCP8.5 that considers a similar trend to the current one without changes and the RCP4.5 that considers a reduction in EMI Siones in the middle of this century.

In **Figure 1** located in **Annex 1** the total change is shown in the suitable area of the crops shown versus the percentage area currently being retained as suitable path RCP8.5 climate change until the period 2060-2080. The size of the bubbles is proportional to the current total area suitable for that crop.

Changes in aptitude for the main crops in the Central American region.

Figure 2 in **Annex 1** shows the distribution of the proportion of the change in the area of corn suitable for the climate change scenarios RCP8.5 and RCP4.5 for the periods 2040-2060 and 2060-2080

((future area - current area) / current area)

projected with the GCM for corn. Cash flow charts are grouped by scenario and by time period (for example, 8550 = RCP8.5; time period 2040-2060). A value of zero would indicate no change, while a value of -0.2 would indicate a 20% decrease in the eligible area. All binary thresholds are represented.

Figure 4 shows the distribution of the proportion of the change of the area of coffee of robust variety, in Figure 6 the distribution of the proportion of the change of the area of coffee of the Arabica variety is shown, in the Figure 8 shows the distribution of the proportion of the change in the area of sugarcane and in Figure 10 the distribution of the proportion of the change in the area of suitable beans of sugar is shown, Figure 3 shows the map of the change in the area suitable for corn under CPR8.5; in the period 2060-2080. The green areas are those where the suitable area is retained over time in more than half (> 50%) of the GCM projections with a darker green indicating greater agreement with the GCM (> 90%). Similarly, the blue areas represent new suitable areas in more than 50% and more than 90% of the GCM and the shades of red indicate reduced suitable areas in more than 50% and more than 90% of the GCM evaluated.

In **Figure 5** the distribution of the rate of change of the suitable area of robusta variety, in shows **Figure 7** the distribution of the rate of change of the suitable area coffee variety arabica shown in **Figure 9** the distribution shown The proportion of the change in the area of sugarcane in **Figure 11** is shown, and the distribution of the proportion of the change in the suitable area of beans is shown

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ANNEXES

Annex 1: Tables

Table 20. Area cultivated with the three main grains in Guatemala

Year	Crop	Area (Ha)	interval 95% confidence		coefficient Variation (%)
			Lower	Upper	
2013	Corn	803.990	741.058	866.921	4.0%
	Bean	184.182	153.137	215.226	8,6%
	Rice	14.348	5.235	23.462	32,4%
2014	Corn	819.227	756.906	881.548	3,9%
	Bean	55.638	40.745	68.308	12,6%
	Rice	9.619	2.197	17.040	39,4%
2015	Corn	725.442	666.424	784.460	4,2%
	Bean	79.706	59.710	99.703	12,8%
	Rice	2.563	-1422	6.547	79,2%
2017-2018	Corn	1.074.058	985.930	1.162.186	4,2%
	Bean	149.575	121.431	177.720	9,6%
	Rice	14.400	2.136	26.663	43,4%

Source: National Statistics Institute (2018)

Table 21. Main crops identified in Guatemala according to REGATTA-2013 study by percentage of cultivated area

Crops	Zacualpa	San Andrés Sajcabajá	Uspantán	Canillá	Chicamán	Total
Sesame	0.0%		0.0%	0.0%	0.1%	0.0%
Coffee	2.1%		0.8%	0.1%	4.5%	1.9%
Cane	0.1%		0.6%	0.0%	6.3%	2.0%
Cardamom	0.0%		27.3%	0.0%	4.9%	14.3%
Other agroind	0.0%		0.3%	0.0%	0.1%	0.2%
Bean	20.7%		21.9%	35.9%	23.5%	24.1%
Corn	71.6%		47.1%	60.4%	59.1%	55.0%
Sorghum	0.0%		0.0%	0.0%	0.3%	0.1%
Banana	0.3%		0.2%	0.0%	0.2%	0.2%
Mango	0.8%		0.0%	0.0%	0.1%	0.1%
Other fruit calid	3.0%		0.3%	0.0%	0.3%	0.5%
Frut temp	0.7%		0.4%	0.0%	0.2%	0.3%
Hort temp	0.6%		1.0%	3.4%	0.4%	1.1%
Total area	100.0%	nd	100.0%	100.0%	100.0%	100.0%

Source: (Bouroncle, y otros, 2013)

Table 22. Yield of the main agricultural products of Guatemala (in metric tons per hectare). 2003-2013 period.

Producto	2005	2006	2007	2008	2009	2010	2011	2012	2013
Traditional crops									
Sugar		9.33	9.34	9.16	9.37	9.83	8.23	9.63	10.54
Coffee		0.95	0.97	1	1.02	0.99	0.99	1.04	1.07
Banana		45.9	40.17	36.97	42.31	40.28	43.68	45.1	45.86
Cardamom		0.45	0.43	0.34	0.36	0.36	0.41	0.52	0.55
Banana		16.31	16.73	17.51	19.46	16.21	16.45	17.22	18.07
Cereals and basic grains									
Corn			2.58	2.32	2.01	1.98	1.99	1.99	2.03
Bean			0.85	0.87	0.87	0.84	0.83	0.84	0.91
Rice			3.16	2.82	3.06	2.89	3.23	3.1	2.89
Wheat			2.27	2.3	2.3	2.27	2.21	2.21	2.05
Sesame		0.7	0.71	1.07	1.11	1.12	1.11	1.35	1.38
Perennial crops									
Avocado		13.08	10.38	10.05	10.18	9.99	10.1	10.28	10.48
Lemon	16.87	13.91	16.23	16.23	16.23	15.9	16.42	17.81	18.19
Handle		7.98	12.79	12.68	12.83	11.75	11.91	12.11	12.14
Apple		7.24	6.66	5.5	3.24	3.24	3.27	3.34	3.42
Peach		9.87	12.98	12.98	12.98	11.36	11.52	11.35	11.23
Orange		22.64	25.69	26.46	26.93	26.74	26.82	27.92	27.58
Cocoa		2.92	2.6	2.66	2.7	2.69	2.81	2.92	3.03
Palma		n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
rubber		n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
Fruits									
Cantaloupe		26.69	29.2	25.08	26.61	21.09	21.51	22	22.48
Pineapple		25.61	24.65	24.32	27.33	27.24	27.62	27.85	28.31
Vegetables									
Chinese pea	7.55	5.8	6.5	6.29	6.95	6.43	5.39	5.28	5.31
Broccoli		13.14	13.44	15.02	10.78	11.52	12.4	13.01	12.42
Onion		32.43	32.43	32.43	29.19	28.52	28.91	29.53	30.32
Chile pepper	16.88	23.35	23.35	23.35	23.35	23.02	23.05	23.93	24.89
Pope		25.51	24.99	24.28	25.24	25.23	25.49	24.93	25.12
Cabbage		45.7	50.09	40.93	44.71	44.43	43.93	45.4	43.7
Tomato		43.16	35.09	36.13	36.32	34.39	35.16	35.18	35.78
Carrot		29.21	29.19	29.19	29.19	28.54	28.67	29.36	30.08

Source: (Gálvez, Andrews, & et al, 2014)

Table 23. Quantification of pending areas by prioritized municipality in Guatemala to implement intensification and diversification activities in agriculture and through soil conservation practices (ha.)

Intensification	Diversification		Intensification	
Medium soil conservation practices (IMPC)	Strong soil conservation practices (IFPC)	Medium soil conservation practices (IMPC)	Strong soil conservation practices (IFPC)	
Slopes of 0-12%	Slopes of 12-25%	Slopes of 0-12%	Slopes of 12-25%	
Zacualpa	700 ha	1,267 ha	4,555 ha	To diversify with strong practices of soil conservation and application of agroforestry systems
San Andrés Sajcabajá	1,394 ha	1,623 ha	4,231 ha	
Uspantán	3,543 ha	5,326 ha	13,870 ha	
Canillá	2,135 ha	1,268 ha	2,752 ha	
Chicamán	2,622 ha	3,671 ha	10,749 ha	

Table 24. Estimated irrigated area according to main crops in Guatemala.

Crops	Hectáreas	%
Banano	22,400	7.18
Sugarcane	168,490	54.00
flowers and foliage	2,800	0.90
Lemon	3,500	1.12
Mango	3,500	1.12
Berries	350	0.11
African Palma	30,800	9.87
Papaya	980	0.31
Pineapple	2,100	0.67
Banana	8,400	2.69
Pasto	14,000	4.49
Other permanent	2,170	0.70
Melon	5,530	1.77
Tomato	2,800	0.90
Onion	1,320	0.42
Other vegetables and annual crops	42,900	13.75
Totals	312,040	100.00

Source: (Jimenez-Cisneros & Galizaia-Tundisi, 2012)

Table 25. Estimation of demand for irrigation water in Guatemala (thousand hectares)

Efficiency and equivalent cultivation	Total surface area	Sprinkling	Drip	Flood	Other	Demand m3 / ha	Irrigation / year

Efficiency		0.7	0.9	0.5	0.6		
Equivalent							
Sugarcane	181.6	110.0	2.1	56.0	13.5	500	12
African palm	43.0	20.7	2.0	17.3	3.0	340	27
Banana-banana	30.8	14.0		14.0	2.8	500	27
Melon	9.8	3.0	0.4	5.0	1.4	525	25
Vegetables and other annual	46.4	21.3	14.6	1.9	8.6	280	24
Totals	**311.5**	**169.0**	**19.0**	**94.2**	**29.3**		

Source: (Jimenez-Cisneros & Galizaia-Tundisi, 2012)

Table 26. Main crops identified in Honduras according study REGATTA-2013 per cultivated area (ha.)

Crop	Choluteca	Marcovia	Morolica	Apacilagua	Orocuina	Duyure	Total
Coffee	9	11	5	3	14	2	44
Rod	323	4,810	1		11	13	5,157
Other Agroind	36	104		1	35	3	178
Rice	8	40	7				55
Beans	313	16	186	211	546	276	1,547
Corn	4,858	3,033	770	1,474	1,579	390	12,104
Sorghum	2,992	636	386	1,033	1,110	181	6,338
Banana			2		0	0	3
Melon	0		197				197
Orange	3	1		1	1	1	6
Banana	0	2	5		0		7
Other bananas	8	29		3	8	1	48
Other frut calid	214	148	14	1	52	2	430
Frut temp							0
Hort calid	2						2
Hort temp	13	3	1	15	6	2	39
Cassava	10	3	4	4	7	1	29
Other trop roots	0				4		5
Total area	8,789	8,836	1,578	2,744	3,373	870	26,189

Source: (Bouroncle, y otros, 2013)

Table 27. Main crops identified in Honduras according REGATTA-2013 study by percentage acreage

Crop	Choluteca	Marcovia	Morolica	Apacilagua	Orocuina	Duyure	Total
Coffee	0.1%	0.1%	0.3%	0.1%	0.4%	0.2%	0.2%
Cane	3.7%	54.4%	0.0%	0.0%	0.3%	1.4%	19.7%
Other agroind	0.4%	1.2%	0.0%	0.0%	1.0%	0.3%	0.7%
Rice	0.1%	0.5%	0.5%	0.0%	0.0%	0.0%	0.2%
Bean	3.6%	0.2%	11.8%	7.7%	16.2%	31.7%	5.9%

Corn	55.3%	34.3%	48.8%	53.7%	46.8%	44.8%	46.2%
Sorghum	34.0%	7.2%	24.5%	37.6%	32.9%	20.9%	24.2%
Banana	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Melon	0.0%	0.0%	12.5%	0.0%	0.0%	0.0%	0.8%
Orange	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Banana	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
Other bananas	0.1%	0.3%	0.0%	0.1%	0.2%	0.1%	0.2%
Other frut calid	2.4%	1.7%	0.9%	0.0%	1.5%	0.2%	1.6%
Frut temp	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hort calid	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hort temp	0.2%	0.0%	0.1%	0.5%	0.2%	0.2%	0.2%
Cassava	0.1%	0.0%	0.3%	0.1%	0.2%	0.1%	0.1%
Other roots trop	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Total area	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: (Bouroncle, y otros, 2013)

Table 28. Area under irrigation by crop in hectares and percentage

Crop	Year	Area (ha)	Percentage
Rice	2008	3000	3.43%
Corn	2008	31000	35.46%
Sor go	2011	700	0.80%
Vegetables	2008	5000	5.72%
Sweet potato	2008	194	0.22%
Potatoes	2008	2500	2.86%
Yucca	2008	1931	2.21%
Tobacco	2008	1997	2.28%
Cotton	2008	1000	1.14%
Sugar cane	2008	12000	13.73%
Temporary crops: total	**2008**	**59322**	67.85%
Banana	2008	8822	10.09%
Banana male	2011	13200	15.10%
Citrus	2008	6000	6.86%
Cocoa beans	2009	86	0.10%
Permanent crops: total	**2008**	**28108**	32.15%
Total		87430	

Table 29. Main crops identified in El Salvador according to REGATTA-2013 study by area cultivated (ha.)

Crop	Usulutan		La Unión	San Miguel		Total
	Concepción Batres	**Jucuarán**	**El Carmen**	**El Tránsito**	**San Miguel**	
Coffee	65	58		3	870	996
Cane	872	148		510	1,003	2,533
Other agroind	13	10		73	105	201
Rice	33	0		56	4	94
Bean	62	229	12	44	433	780
Corn	2,127	1,384	1,278	1,294	6,543	12,625
Sorghum	177	294	420	134	3,239	4,263
Frut	149	25	30	2	139	344

Frut temp					1	1
Hort calid	142	14	2	2	182	342
Hort temp	11	1	1	3	42	59
Sweet potato					1	1
Cassava	33	0	0	4	557	594
Other agriculture	13	10	0	73	105	201
Area total	3,684	2,164	1,744	2,124	13,119	22,834

Source: (Bouroncle, y otros, 2013)

Table 30. Major crops identified in El Salvador as REGATTA-2013 study by percentage of cultivated area

Crop	Usulutan	Usulutan	La Union	San Miguel	San Miguel	Total
	Concepción Batres	Jucuarán	El Carmen	El Tránsito	San Miguel	
Coffee	1.77%	2.69%	0.00%	0.13%	6.63%	4.36%
Cane	23.66%	6.85%	0.00%	24.01%	7.64%	11.09%
Other agroind	0.36%	0.48%	0.00%	3.44%	0.80%	0.88%
Rice	0.91%	0.02%	0.00%	2.63%	0.03%	0.41%
Bean	1.68%	10.60%	0.67%	2.06%	3.30%	3.41%
Corn	57.72%	63.94%	73.30%	60.92%	49.87%	55.29%
Sorghum	4.81%	13.57%	24.06%	6.29%	24.69%	18.67%
Frut calid	4.04%	1.14%	1.75%	0.07%	1.06%	1.51%
Frut temp	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
Hort calid	3.85%	0.67%	0.13%	0.10%	1.39%	1.50%
Hort temp	0.31%	0.03%	0.08%	0.16%	0.32%	0.26%
Sweet potato	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
Cassava	0.90%	0.01%	0.01%	0.18%	4.25%	2.60%
Other agriculture	0.36%	0.48%	0.00%	3.44%	0.80%	0.88%
Total area	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: (Bouroncle, y otros, 2013)

Table 31. Main The crops identified in Nicaragua according to the REGATTA-2013 study by cultivated area (ha.)

Crop	Telpaneca	Palacagüina	Yalagüina	Jícaro	Somoto	Area total
Cocoa	6	0		1	1	8
Coffee	2,129	15	1	1,091	30	3,265
Cane	4	6		123	10	142
Other agroind	2	30	2		18	52
Dry rice	1.4	1.4	0	3.1	0	6
Corn	1,995	1,296	607	4,779	2,852	11,529
Bean	2,683	1,046	789	8,025	3,208	15,751
Sorghum	117	491	270	2	1,986	2,865
Banana	10	4	0	25	15	55
Banana	11	3	0	9	1	25
Citrus	15	20	1	21	15	72
Other musaceas	56	4	4	54	21	139
Other frut calid	20	19	5	16	61	120
Hort calid	10	21	1	3	14	51
Hort temp	7	69	8	45	89	219
Quequisque	1	0		1	0	2

Cassava	17	6	2	32	14	71
Other roots trop	4	2		5	1	13
Total area	7,299	3,035	1,690	14,234	8,339	34,597

Source: (Bouroncle, y otros, 2013)

Table 32. Main crops identified in Nicaragua according REGATTA-2013 study by percentage acreage

Crop	Telpaneca	Palacagüina	Yalagüina	Jícaro	Somoto	Área total
Cocoa	0.08%	0.00%	0.00%	0.01%	0.01%	0.02%
Coffee	29.17%	0.49%	0.04%	7.66%	0.36%	9.44%
Cane	0.05%	0.20%	0.00%	0.86%	0.12%	0.41%
Other agroind	0.02%	1.00%	0.12%	0.00%	0.21%	0.15%
Dry rice	0.02%	0.05%	0.00%	0.02%	0.00%	0.02%
Corn	27.34%	42.69%	35.92%	33.57%	34.21%	33.32%
Beans	36.76%	34.45%	46.69%	56.38%	38.47%	45.53%
Sorghum	1.61%	16.18%	15.96%	0.01%	23.81%	8.28%
Banana	0.14%	0.14%	0.01%	0.18%	0.18%	0.16%
Banana	0.16%	0.09%	0.01%	0.06%	0.02%	0.07%
Citric	0.20%	0.66%	0.08%	0.14%	0.18%	0.21%
Other musaceas	0.76%	0.12%	0.22%	0.38%	0.25%	0.40%
Other fruits calid	0.27%	0.63%	0.27%	0.11%	0.73%	0.35%
Hort calid	0.14%	0.69%	0.08%	0.02%	0.17%	0.15%
Hort temp	0.09%	2.29%	0.48%	0.32%	1.07%	0.63%
Quequisque	0.02%	0.00%	0.00%	0.01%	0.00%	0.01%
Yucca	0.24%	0.21%	0.10%	0.22%	0.17%	0.20%
Other roots trop	0.06%	0.06%	0.00%	0.04%	0.02%	0.04%
Total area	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: (Bouroncle, y otros, 2013)

Table 33. Main crops identified in Costa Rica according to REGATTA-2013 study by cultivated area (ha.)

Crop	Liberia	Nicoya	Santa Cruz	Bagaces	Carrillo	Area total
Coffee		142	22			164
Cane	8,079	218	1,092	4,467	9,271	23,126
Other agroind		156				156
Dry rice	284	875	1,358	254	1,069	3,840
Rice	10,290			6,963	530	17,782
Bean	50	335	350	60	75	870
Corn	80	1,210	375	80	35	1,780
Mango	694	49	132	7	150	1,032
Melon	1,227	477			2,665	4,369
Orange		20				20
Banana	2			2		4
Other fruit calid	1			25		26
Hort calid	5	1			20	26
Hort temp	5	10		28	1	43
Total area	20,717	3,493	3,329	11,886	13,814	53,239

Source: (Bouroncle, y otros, 2013)

Table 34. Main crops identified in Costa Rica according to REGATTA-2013 study by percentage of cultivated area

Crop	Liberia	Nicoya	Santa Cruz	Bagaces	Carrillo	Area total
Coffee	0.00%	4.07%	0.67%	0.00%	0.00%	0.31%
Cane	39.00%	6.23%	32.80%	37.58%	67.11%	43.44%
Other agroind	0.00%	4.47%	0.00%	0.00%	0.00%	0.29%
Dry rice	1.37%	25.06%	40.79%	2.14%	7.73%	7.21%
Irrigation rice	49.67%	0.00%	0.00%	58.58%	3.83%	33.40%
Bean	0.24%	9.59%	10.51%	0.50%	0.54%	1.63%
Ma íz	0.39%	34.65%	11.26%	0.67%	0.25%	3.34%
Mango	3.35%	1.40%	3.96%	0.06%	1.09%	1.94%
Melon	5.92%	13.66%	0.00%	0.00%	19.29%	8.21%
Orange	0.00%	0.57%	0.00%	0.00%	0.00%	0.04%
Banana	0.01%	0.00%	0.00%	0.02%	0.00%	0.01%
Other fruit calid	0.00%	0.00%	0.00%	0.21%	0.00%	0.05%
Hort calid	0.02%	0.03%	0.00%	0.00%	0.14%	0.05%
Hort temp	0.02%	0.27%	0.00%	0.23%	0.00%	0.08%
Total area	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: (Bouroncle, y otros, 2013)

Table 35. Main crops identified in Panama according to REGATTA-2013 study by cultivated area (ha.)

Crop	Guararé	Macaracas	Pedasí	Pocrí	Tonosí	Total
Coffee		1			5	6
Caña	68	109	15	41	65	299
Dry rice	479	891	442	433	6,040	8,284
rice	348	76	3	2	974	1,401
Bean	34	44	6	19	110	214
Corn	2,409	1,295	1,840	1,460	784	7,788
Sorghum	48	5	117	22	6	197
Plantain		0	1		1	1
Coconut		0			1	1
Melon	32			30	122	183
Orange	2	3			4	9
Pineapple		5			14	18
Banana	3	13	3	1	27	46
Watermelon	18	9	0	4	196	227
Other fruit calid	6	7	1	1	2	17
Hort calid	53	19	0	15	119	206
Hort temp	23	7	0	0	6	36
Malanga	0	1	0	0	7	7
Yam	9	25	1	10	103	149
Ñampí	0	0	0	0	1	1
Yucca	11	19	2	5	18	55
Total	3,542	2,528	2,428	2,043	8,603	19,145

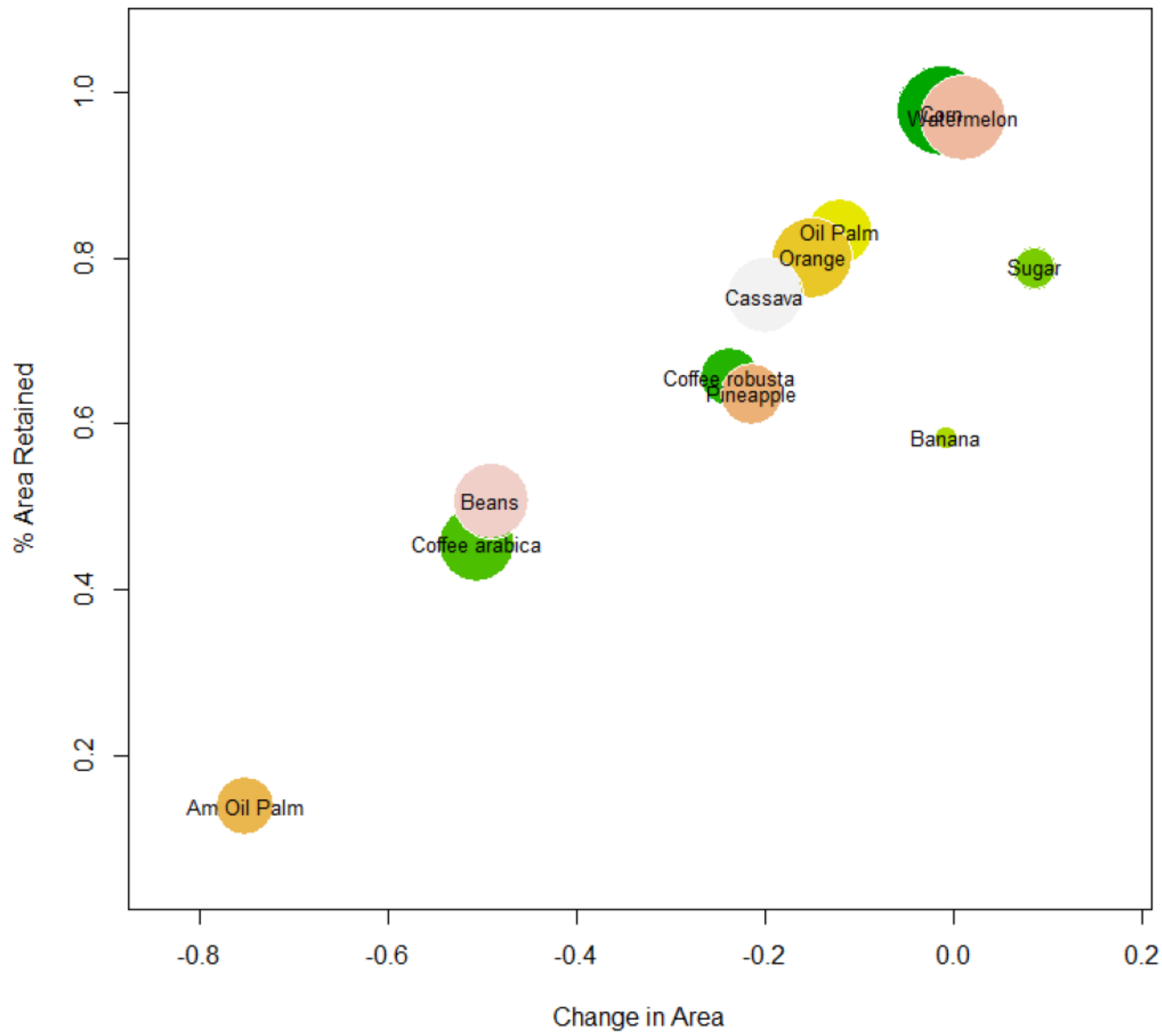
Source: (Bouroncle, y otros, 2013)

Table 36. Principales Crops identificados en Panama según estudio de REGATTA-2013 por porcentaje del área cultivada

Crop	Guararé	Macaracas	Pedasí	Pocrí	Tonosí	Total
Coffee	0.00%	0.05%	0.00%	0.00%	0.05%	0.03%
Cane	1.93%	4.33%	0.62%	1.99%	0.76%	1.56%
Dry rice	13.52%	35.23%	18.19%	21.19%	70.20%	43.27%
rice	9.81%	3.00%	0.10%	0.07%	11.32%	7.32%
Bean	0.95%	1.75%	0.27%	0.95%	1.28%	1.12%
Corn	68.00%	51.20%	75.76%	71.49%	9.12%	40.68%
Sorghum	1.35%	0.20%	4.80%	1.08%	0.07%	1.03%
Banana	0.00%	0.01%	0.02%	0.00%	0.01%	0.01%
Coconut	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%
Melon	0.89%	0.00%	0.00%	1.47%	1.41%	0.96%
Orange	0.06%	0.12%	0.00%	0.00%	0.05%	0.05%
Pineapple	0.00%	0.18%	0.00%	0.00%	0.16%	0.10%
Plantain	0.07%	0.50%	0.11%	0.05%	0.31%	0.24%
Watermelon	0.52%	0.36%	0.00%	0.20%	2.28%	1.19%
Other fruits calid	0.18%	0.28%	0.02%	0.03%	0.02%	0.09%
Hort calid	1.50%	0.73%	0.01%	0.74%	1.38%	1.08%
Hort temp	0.65%	0.27%	0.00%	0.02%	0.07%	0.19%
Malanga	0.00%	0.02%	0.00%	0.00%	0.08%	0.04%
Yam	0.26%	1.00%	0.03%	0.50%	1.20%	0.78%
Ñampí	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%
Yucca	0.31%	0.76%	0.08%	0.22%	0.21%	0.29%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

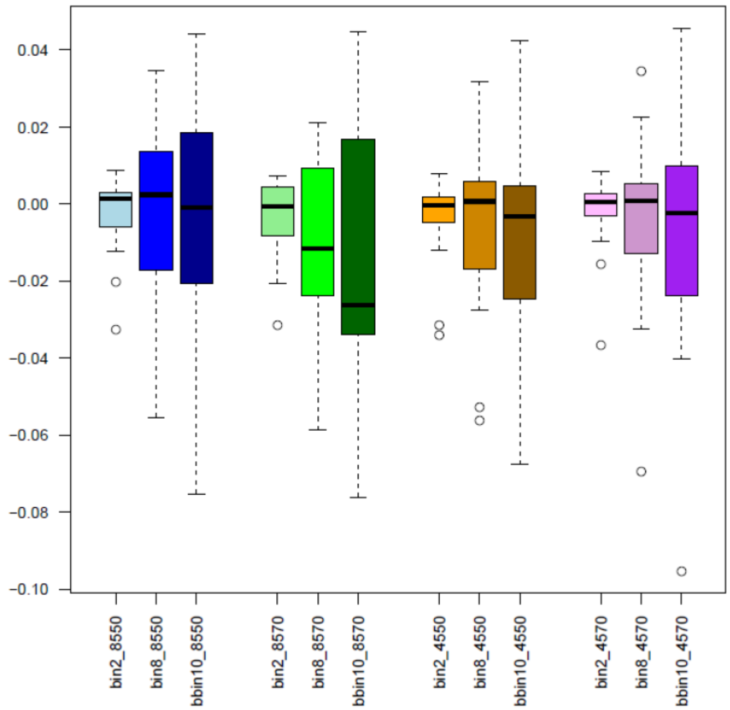
Annex 2: Figures

Figure 1, Change of the suitable area of cultivation vs percentage of suitable area that is maintained in the RCP8.5 scenario to the period 2060-2080



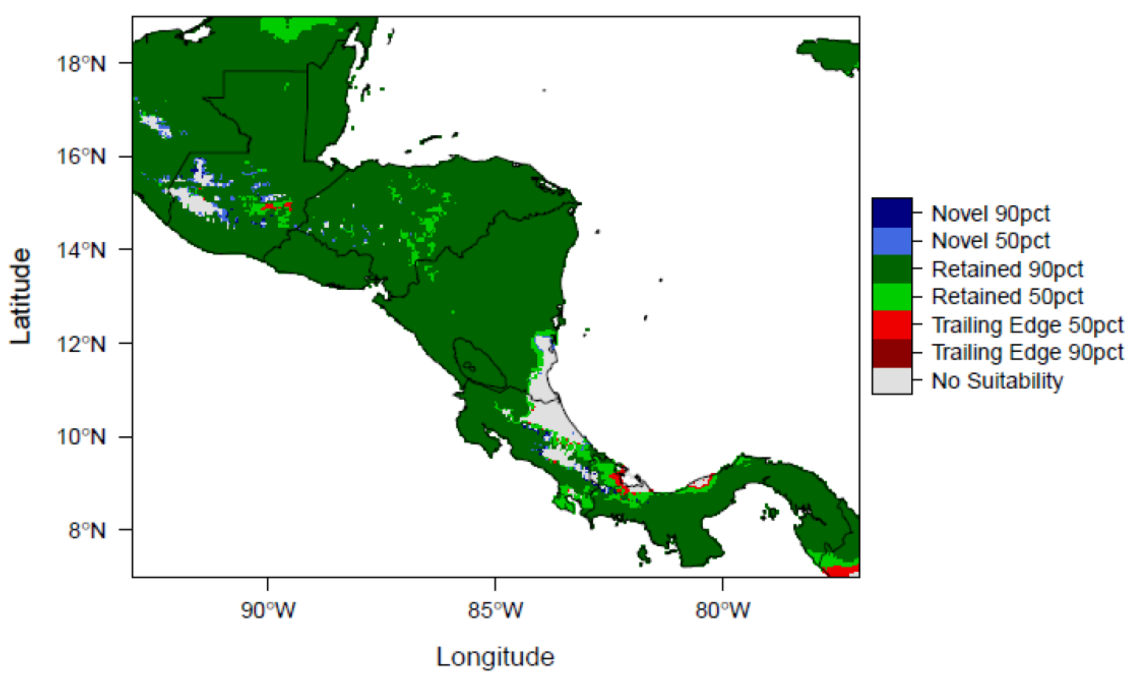
Source: (Roehrdanz, 2014).

Figure 2. Distribution of the proportion of the area suitable for corn for the climate change scenarios RCP8.5 and RCP4.5 for the periods 2040-2060 and 2060-2080



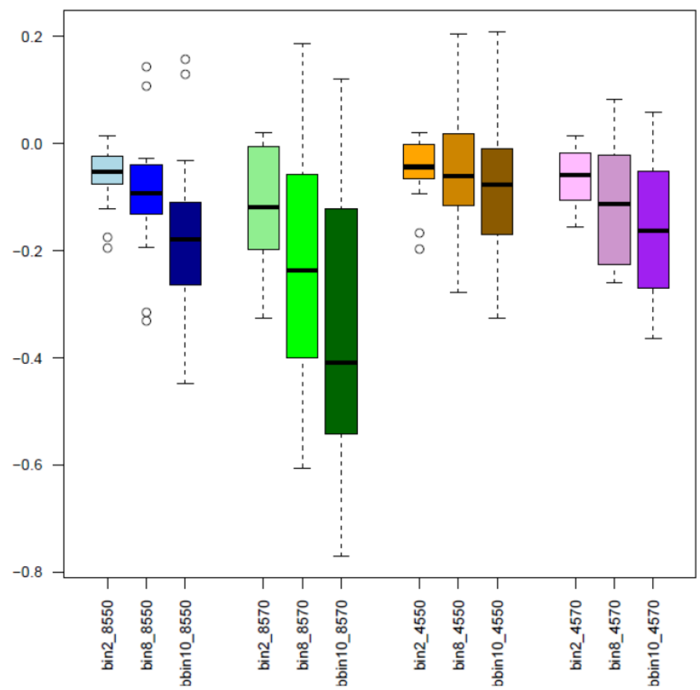
Source: (Roehrdanz, 2014).

Figure 3. Changes in the aptitude of corn cultivation in Central America under CPR8.5, to the period 2060-2080 (Binary threshold 0.8)



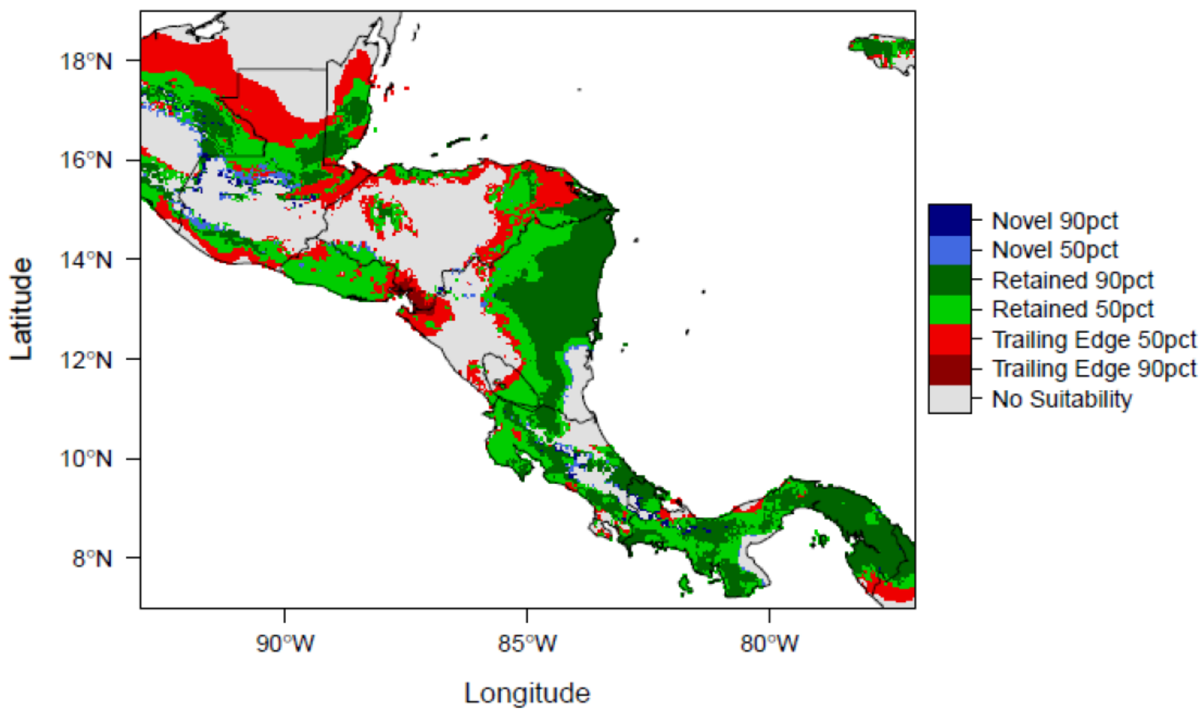
Source: (Roehrdanz, 2014).

Figure 4. Distribution of the proportion of the area of coffee variety robust variety for the climate change scenarios RCP8.5 and RCP4.5 for the periods 2040-2060 and 2060-2080



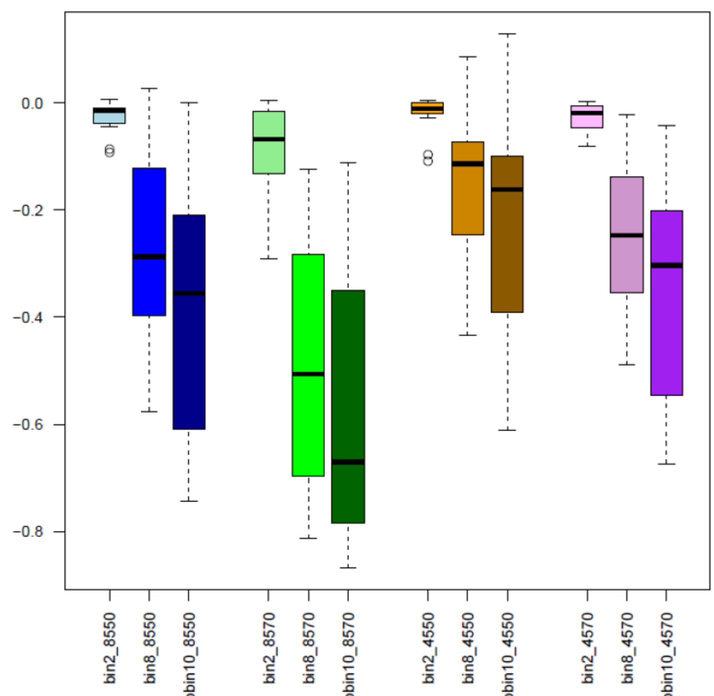
Source: (Roehrdanz, 2014).

Figure 5. Changes in the aptitude of the cultivation of the robust variety coffee in Central America under CPR8.5, to the period 2060-2080 (Binary threshold 0.8)



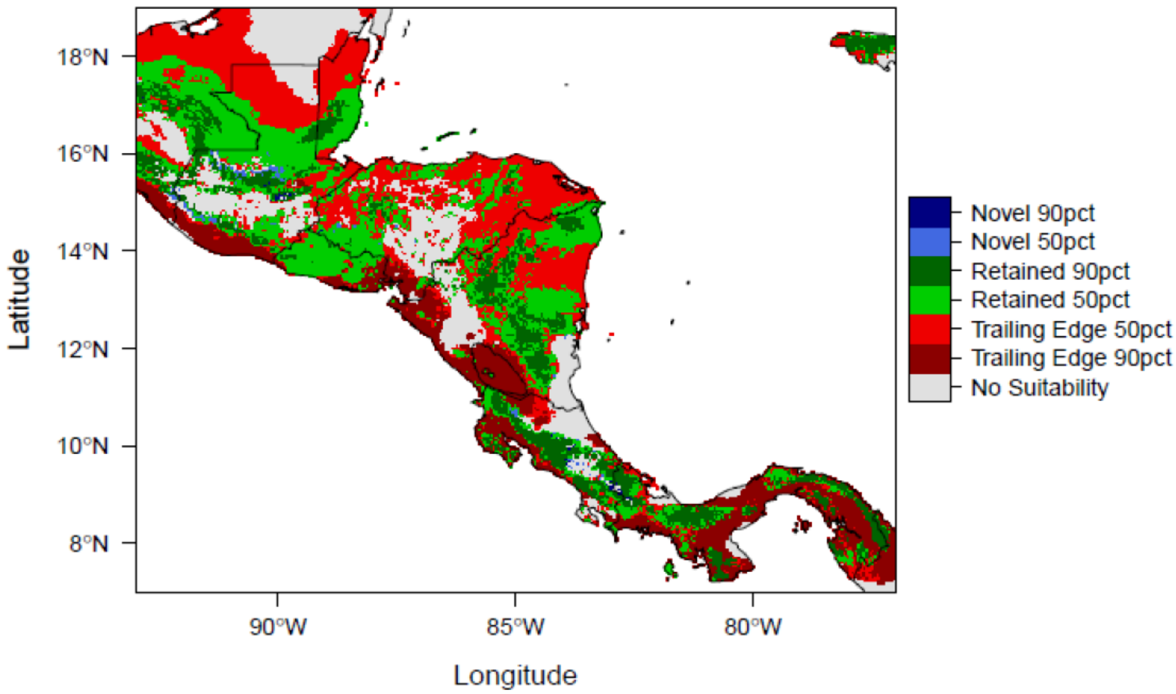
Source: (Roehrdanz, 2014).

Figure 6. Distribution of the proportion of the area of coffee variety arabica suitable for the climate change scenarios RCP8.5 and RCP4.5 for the periods 2040-2060 and 2060-2080



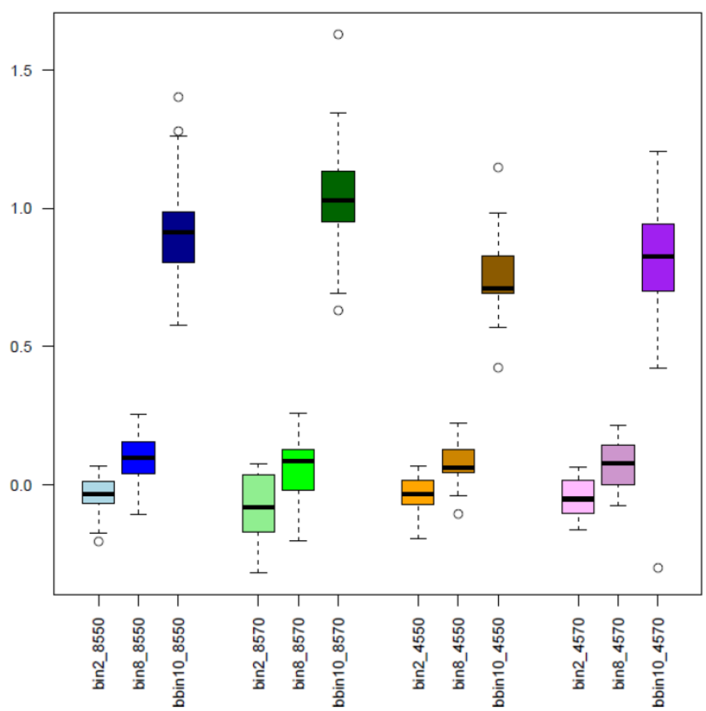
Source: (Roehrdanz, 2014).

Figure 7. Changes in the fitness of the Arabica coffee crop in Central America under CPR8.5, to the period 2060-2080 (Binary threshold 0.8)



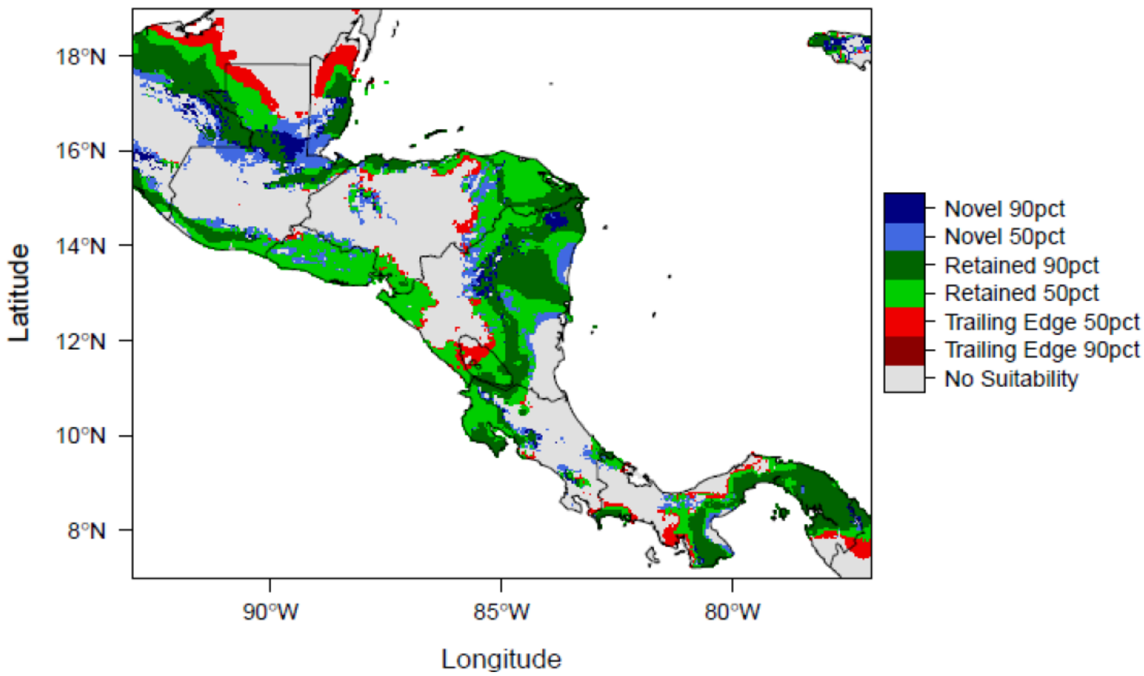
Source: (Roehrdanz, 2014).

Figure 8. Distribution of the proportion of sugarcane area suitable for the climate change scenarios RCP8.5 and RCP4.5 for the periods 2040-2060 and 2060-2080



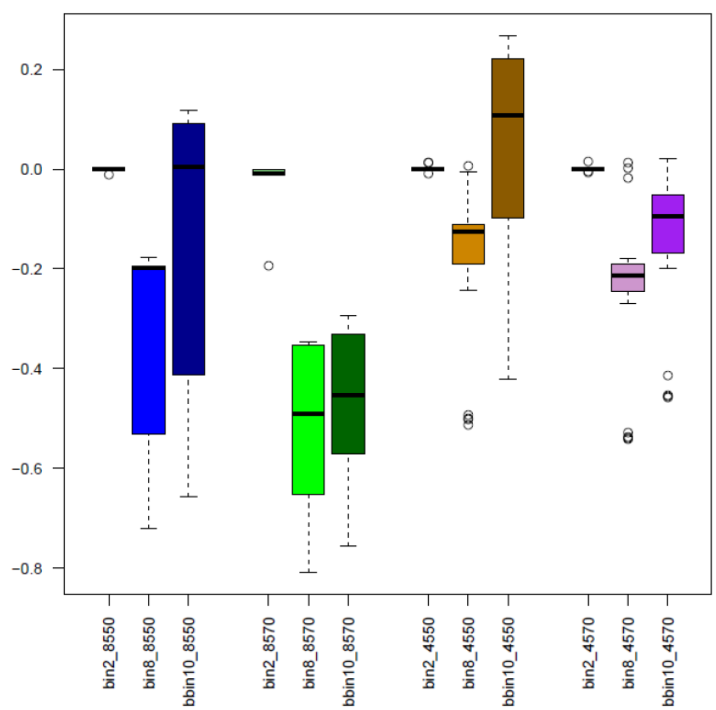
Source: (Roehrdanz, 2014).

Figure 9. Changes in the aptitude of sugarcane cultivation in Central America under CPR8.5, to the period 2060-2080 (Binary threshold 0.8)



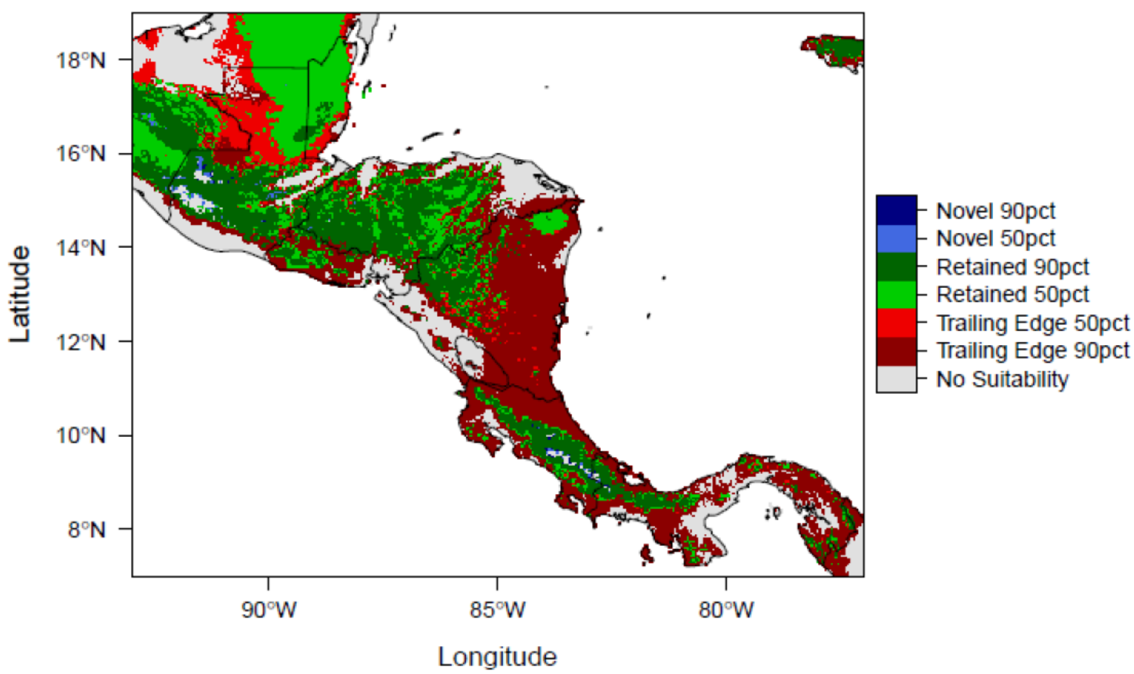
Source: (Roehrdanz, 2014).

Figure 10. Distribution of the proportion of the area suitable for growing beans for climate change scenarios RCP8.5 and RCP4.5 for the periods 2040-2060 and 2060-2080



Source: (Roehrdanz, 2014).

Figure 11. Changes in the aptitude of sugarcane cultivation in Central America under CPR8.5, to the period 2060-2080 (Binary threshold 0.8)



Source: (Roehrdanz, 2014).

Figure 12. Vulnerability index map of the prioritized municipalities in Guatemala.

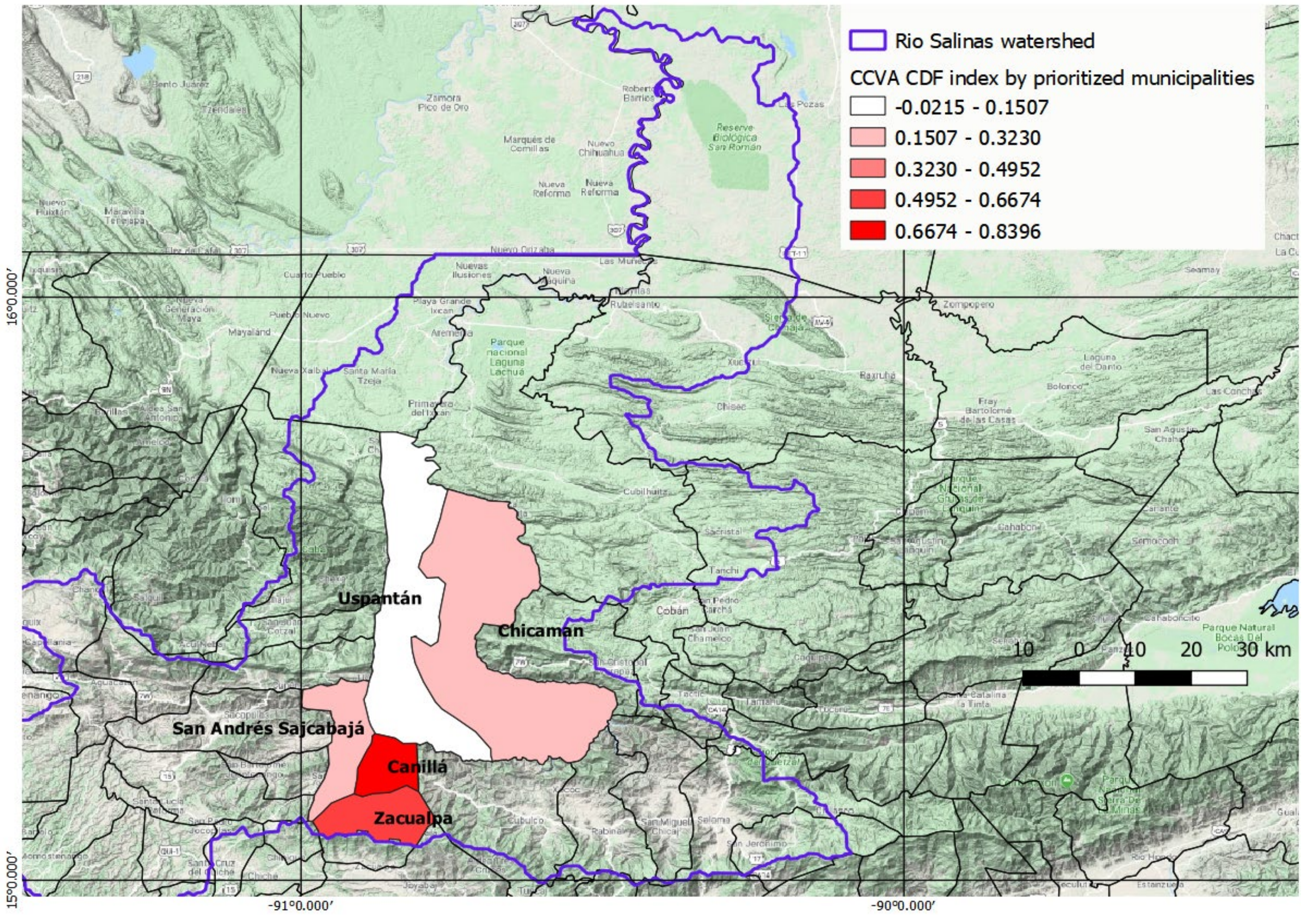


Figure 13. Vulnerability index map of the prioritized municipalities in Honduras.

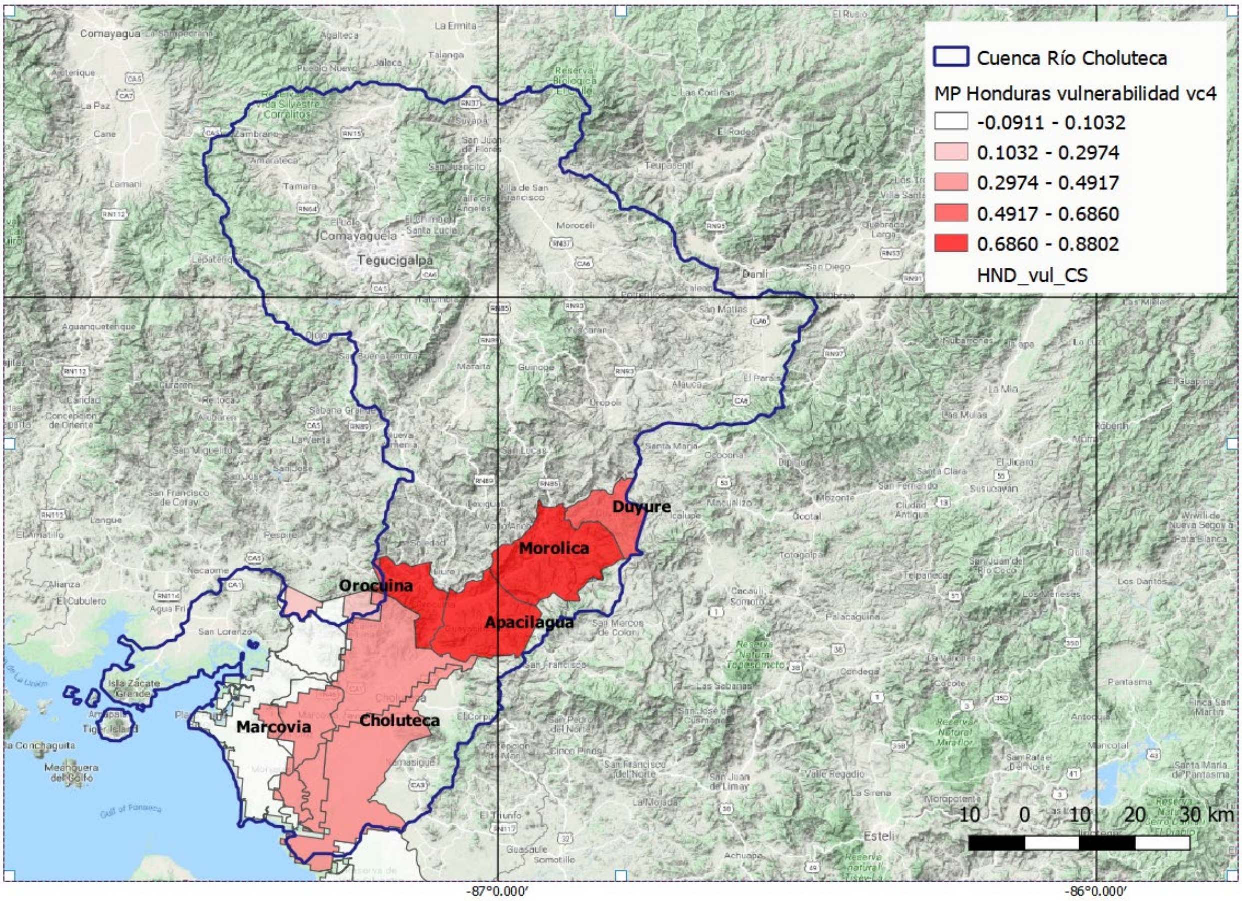


Figure 14. Vulnerability index map of the prioritized municipalities in El Salvador.

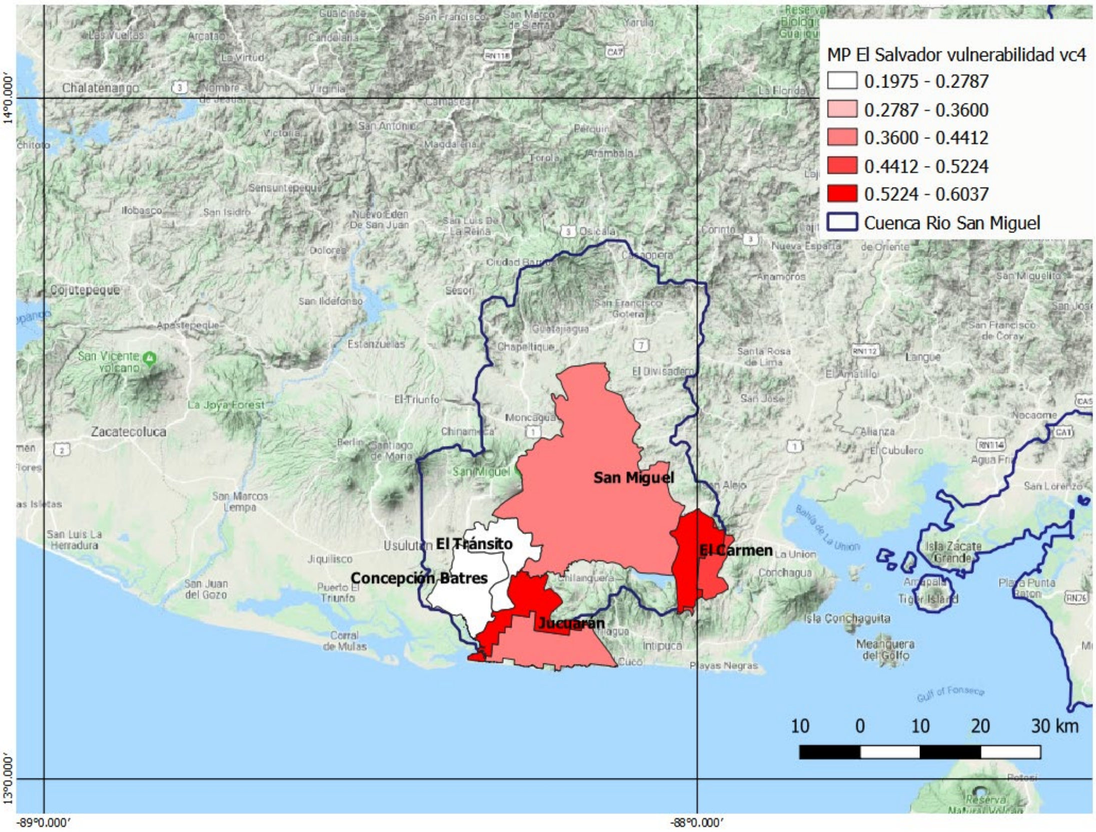


Figure 15. Vulnerability index map of the prioritized municipalities in Nicaragua.

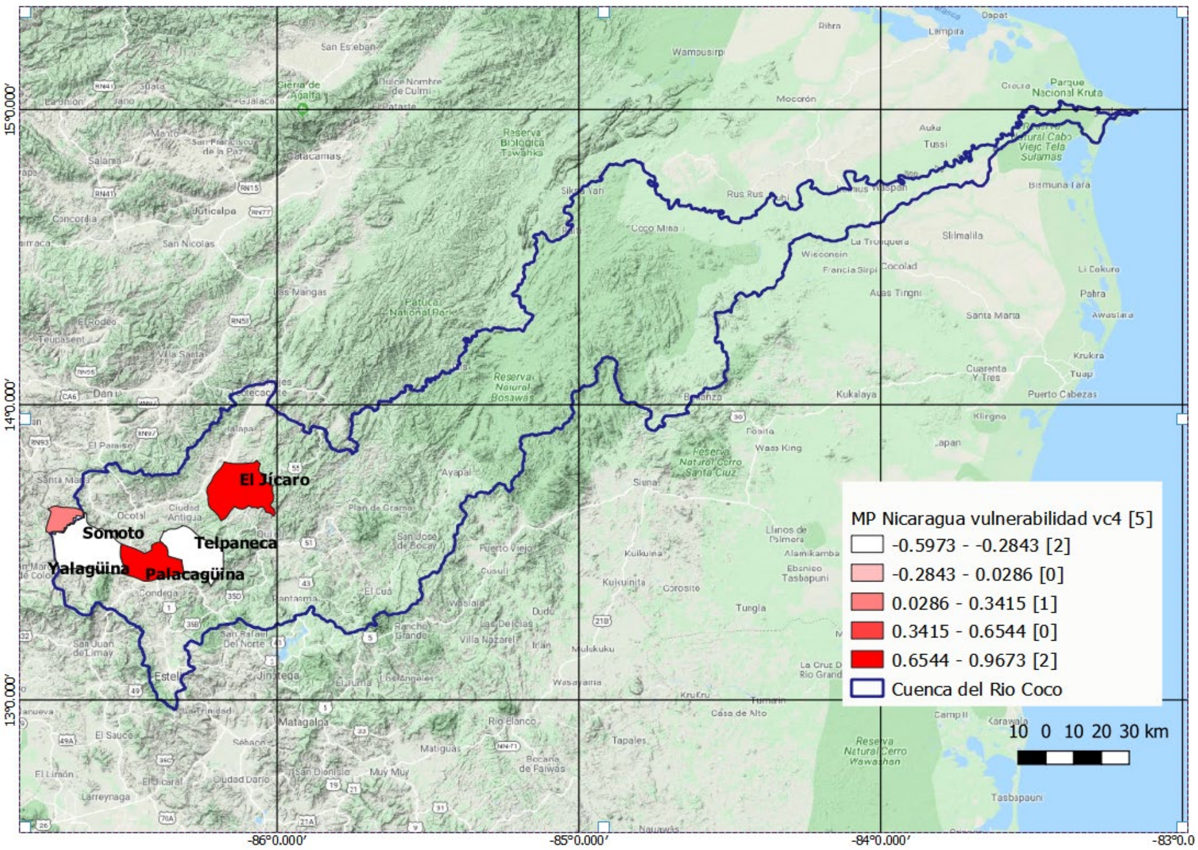


Figure 16. Vulnerability index map of the prioritized municipalities in Costa Rica.

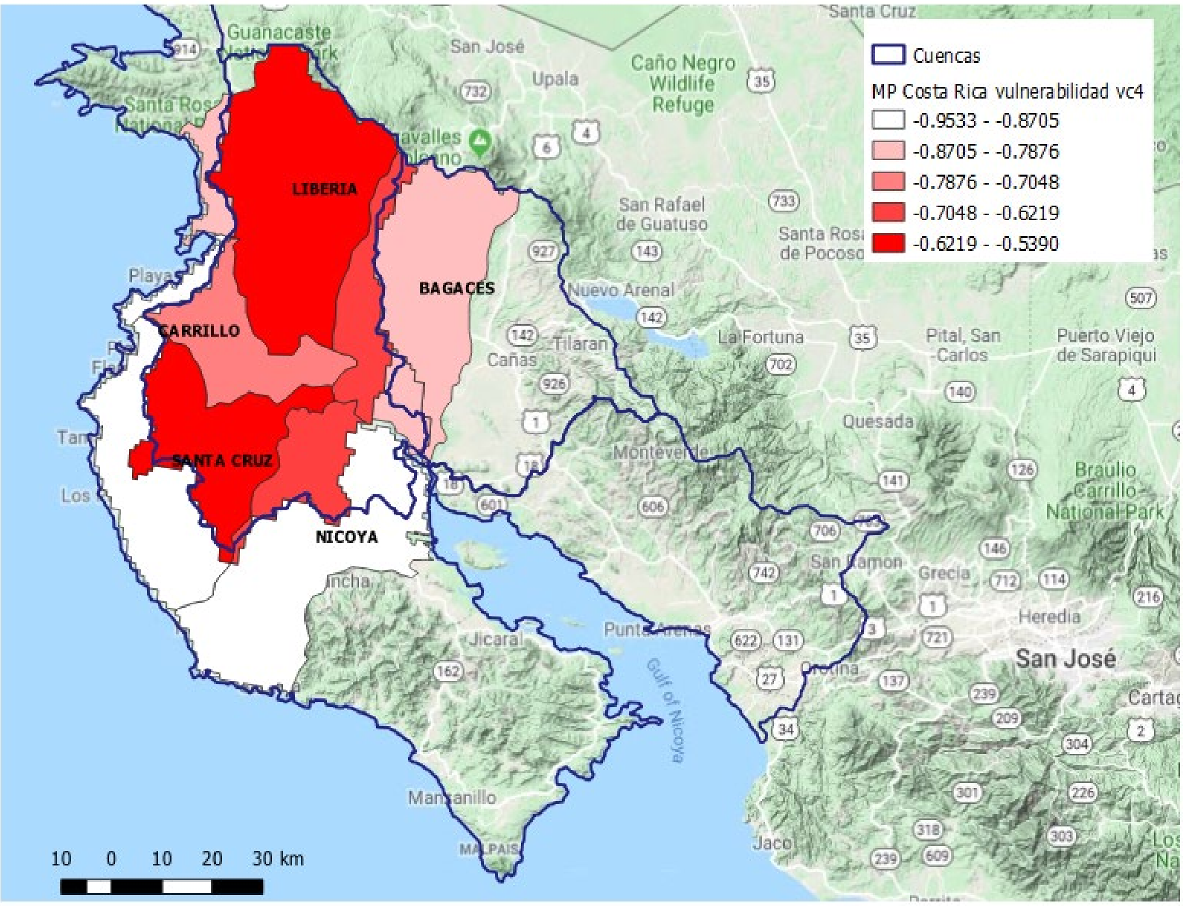


Figure 17. Vulnerability index map of the prioritized municipalities in Panama.

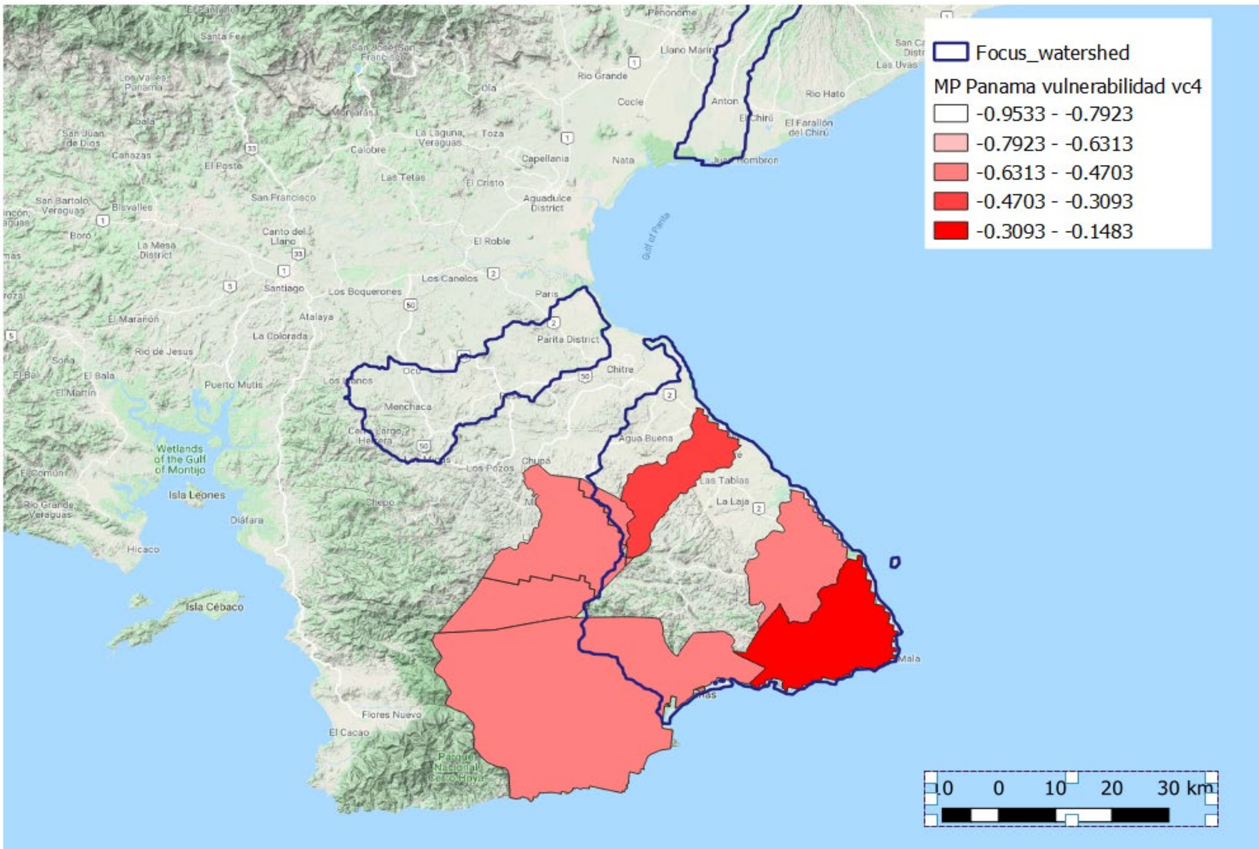
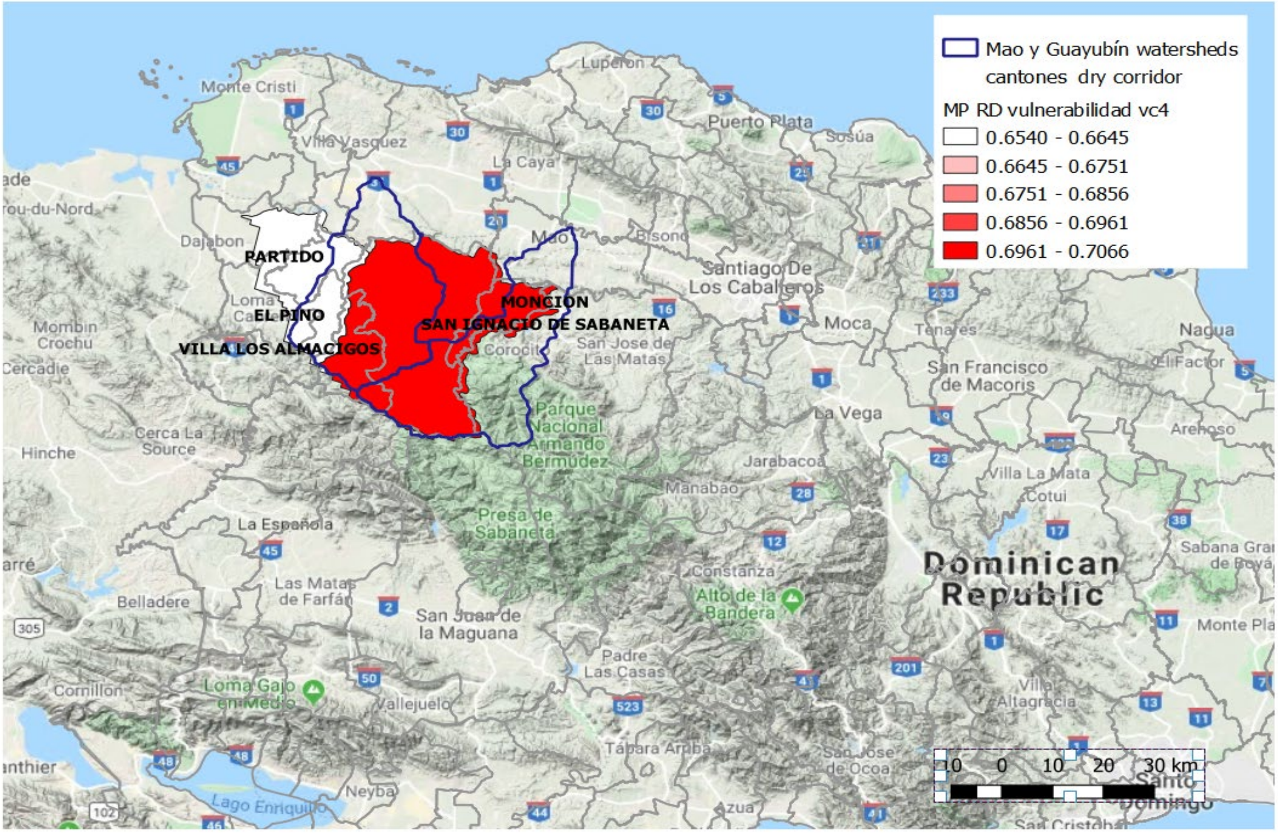


Figure 18. Vulnerability index map of the prioritized municipalities in the Dominican Republic.



Areas of intervention for EbA pilot activities

In the following table, we show some of the proposed pilot EbA activities related to the forestry and agroforestry sectors. The total prioritized area for each of the seven countries Is also shown, as well as the corresponding area to be used for EbA pilot activities.

	Costa Rica	Guatemala	Honduras	El Salvador	Nicaragua	Panama	Dominican Republic	Total
Total area of municipalities in ha	595999.86	228600.00	556680.00	116199.00	149133.00	267744.00	138500.00	2052855.86
Total prioritized area (municipalities within catchment) in ha	320705.00	194169.00	202738.00	98177.00	124472.00	119747.00	101529.00	1161537.00
Area of EbA pilot activities in ha	2639.00	3080.00	3160.80	3110.00	3322.00	2567.20	2980.00	20859.00
a) Area of forest protection (Activity 2.1.2) in ha	583.00	584.00	600.00	600.00	625.00	585.00	583.00	4160.00
b) Area of protection and restoration of natural forest in major recharge areas and riparian zones (Activity 2.1.3) in ha	250.00	250.00	270.00	275.00	275.00	250.00	250.00	1820.00
c) Area of restoration of forested areas (Activity 2.1.4) in ha	835.00	590.00	600.00	850.00	625.00	835.00	835.00	5170.00
d) Area of restoration of pine forests (Activity 2.1.5) in ha		250.00	270.00		300.00			820.00
e) Area of diversified living fence arrangements	99.00	99.60	108.00	120.00	150.00	100.20	99.00	775.80

in agroforestry systems (Activity 2.1.6) in ha								
f) Area of agroforestry systems for natural shade in coffee plantations (Activity 2.1.7) in ha	100.00	167.00	180.00		165.00			612.00
g) Area of diversified living fence arrangements in silvopasture systems (Activity 2.1.8) in ha	99.00	100.20	100.80	135.00	99.00	99.00	135.00	768.00
h) Area of silvopasture systems (Activity 2.1.9) in ha	165.00	167.00	168.00	225.00	165.00	165.00	225.00	1280.00
i) Area of sustainable fuelwood and timber plantations (Activity 2.1.10) in ha	490.00	850.00	840.00	875.00	900.00	515.00	835.00	5305.00
j) Area of firebreaks for forests and plantations (Activity 2.1.11) in ha	9.00	12.00	14.40	15.00	9.00	9.00	9.00	77.40
k) Area of living barriers for soil conservation (Activity 2.1.12) in ha	9.00	10.20	9.60	15.00	9.00	9.00	9.00	70.80
% of the prioritized area to be used for EbA pilot activities	**0.82**	**1.59**	**1.56**	**3.17**	**2.67**	**2.14**	**2.94**	**1.80**