Climate-Smart Agriculture in Nicaragua

Supplementary material

This publication is a product of the collaborative effort between the International Center for Tropical Agriculture (CIAT) – lead Center of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) – and the World Bank to identify country-specific baselines on CSA in Africa (Kenya and Rwanda), Asia (Sri Lanka) and Latin America and the Caribbean (Nicaragua and Uruguay).

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Contents

This Supplementary Material is in support of the Climate-Smart Agriculture in Nicaragua profile within the Country Profiles for Latin America and the Caribbean Series. The annexes below are references where relevant in the text. The Supplementary Material cannot and should not be read in isolation. It can only be read in association with the chapter.

Annex I: Acronyms and abbreviations

ADDAC	Association for Communal Agriculture Diversification and Development
AF	Adaptation Fund
ANA	National Authority of Water
BCN	Central Bank of Nicaragua
Cafenica	Association of Coffee Small-Producers Cooperatives of Nicaragua
CAC	Central American Agriculture Council
CAFTA-DR	Dominican Republic-Central America Free-Trade Agreement
CATIE	Tropical Agricultural Research and Higher Education Center
CCAD	Central American Commission of Environment and Development
CECOCAFEN	Central Association of Northern Coffee Cooperatives
CEPAL	Economic Commission for Latin America and the Caribbean
CETREX	Center for Exports Procedures
CH4	Methane
CIAT	International Center for Tropical Agriculture
CRS	Christian Relief Services
CSA	Climate Smart Agriculture
ENACC	National Environmental and Climate Change Strategy
ERCC	Regional Strategy on Climate Change
FADGANIC	Foundation for the Autonomy and Development of Nicaraguan Atlantic Coast
FAO	Food and Agriculture Organization of the UN
FENACOOP	National Federation of Agricultural and Agribusiness Cooperatives
FIDES	Latin American Federation of Insurers
Fonadefo	National Forest Development Fund
FUNICA	Nicaraguan Agriculture and Forestry Technological Development Foundation
GCMs	Global Climate Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHGs	Greenhouse Gases
GPCC	Cabinet of Production, Consumption and Trade
IDB	Inter-American Development Bank
INAFOR	National Forestry Institute
INETER	Nicaraguan Institute for Territorial Studies
INIDE	National Institute of Development Information
INISER	Nicaraguan Institute of Insurances
INPESCA	Nicaraguan Institute for Fisheries and Aquaculture
INTA	Nicaraguan Institute for Agricultural Technology
JICA	Japan International Cooperation Agency
MAG	Ministry of Agriculture
MARENA	Ministry of Environment and Natural Resources

MaxEnt	Maximum Entropy
MCN-Mt	Nicaraguan Communal Movement – Matagalpa
MEFCCA	Ministry of Family, Community, Cooperative and Associative Economy
MEM	Ministry of Energy and Mines
N2O	Nitrous Oxide
Nitlapan-UCA	Institute for Research and Development – Central American University
NTON	Mandatory Technical Standards
OECD	Organization for Economic Co-operation and Development
PNDH	National Human Development Plan
POSAF	Social-Environmental Program for Forestry Development
RCP	Representative Concentration Pathways
SCCF	Special Climate Change Fund
SDC	Swiss Agency for Development and Cooperation (COSUDE, Spanish acronym)
SINAPRED	National System for Disaster Prevention, Mitigation and Response
SRELIC	Scaling-Up Renewable Energy in Low-Income Countries
Soppexcca	Agricultural Cooperative Union
UNA	National Agricultural University
UNAG	National Union of Farmers and Ranchers
UNEP	United Nations Environmental Program
UNFCCC	UN Framework Convention on Climate Change
UNREDD+	UN Program for Reducing Emissions from Deforestation and Forest Degradation
UPANIC	Union of Agricultural Producers of Nicaragua
UPOV	International Union for the Protection of New Varieties of Plants
USAID	U.S Agency for International Development
WB	World Bank

Annex II: Top production systems methodology

Table 1. Selection of main production system for the study

Production System	Contribution to GDP*	Net Production Value (NPV, Constant 2004-2006 USD)	Calories (Kcal/capita/day)	Variation in production	Harvested area	Total (weighted)	Ranking
Dual purpose cattle	6.42	566759572	160	0.21	3267060	9791316	1
Sugar Cane	2.13	191936892	390	0.08	61209	3263975	2
Bean	1.48	126205966	178	0.16	202565	2148948	3
Rice	1.25	110675586	405	0.10	92832	1883070	4
Coffee	1.09	95766536	0.67	0.10	116129	1630005	5
Maize	0.81	62944828	629	0.12	271514	1074689	6
Sorghum	0.13	2736620	11	0.42	47593	47332	7
Cocoa	0.02	1857234	4.67	0.08	6277	31680	8

*The data for productions systems is for the period 2009–2013. Source: FAOSTAT and BCN.

Dual purposes cattle

The main areas for cattle in Nicaragua are located in departments of Matagalpa, Boaco, Chontales, Rio San Juan, RAAN and RASS. The double purposes production (milk and meat) is very important for economy and food security. It also represents an important pressure for forested lands and protected areas in RAAS, RAAN and Jinotega.

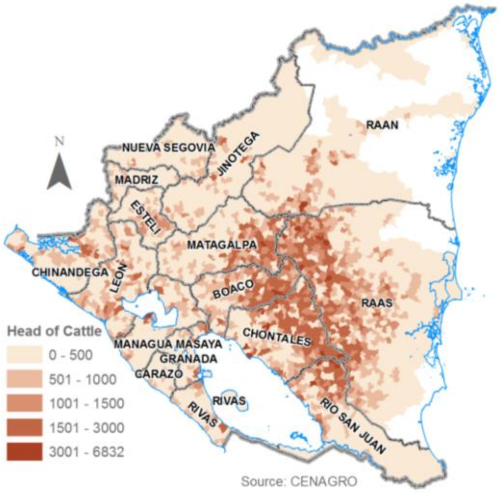
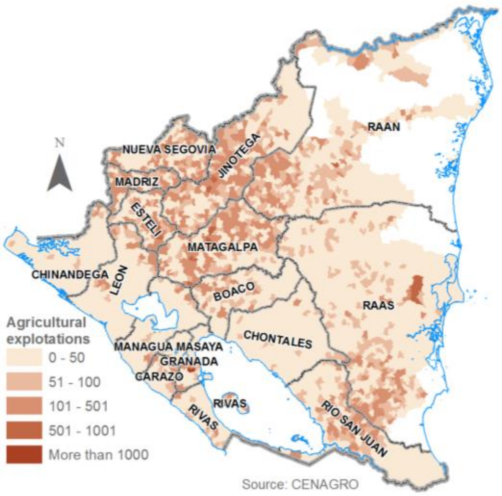


Figure 1. Distribution of Cattle in Nicaragua.

Beans

Beans are produced in almost the entire territory of Nicaragua by small-farmers, although the main areas are in north departments like Nueva Segovia, Jinotega and Matagalpa, and southeast departments Rio San Juan and RAAS. The growing seasons in the Pacific and central zones typically follow the seasonal rains in May–July (referred to as the primera) and September–November (or the postrera), while in the rainier southeastern of the country, a 3rd growing season during the dry season from December to March is called the apante.



Source: CENAGRO

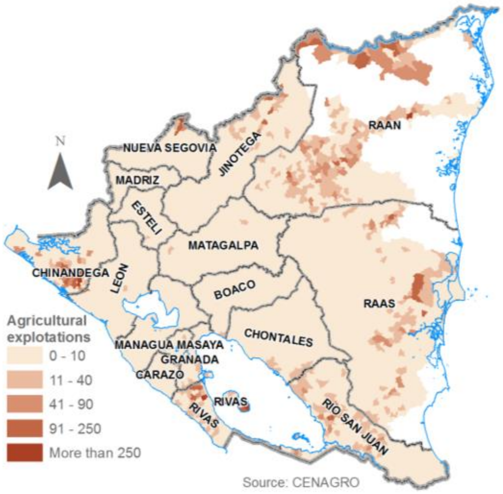
Figure 2. Distribution of beans in Nicaragua

Table 2. Data for production and harvested area of beans in the last 5 production cycles in Nicaragua. Source: MAG.

Beans	**08/09**	**09/10**	**10/11**	**11/12**	**12/13**
Harvested area (Ha)	215098	207774	160837	229275	199843
Production (Tons)	138565	123729	92387	143979	147787

Rice

Rice is an important staple grain in the Nicaraguan diet. Two different systems can be differentiated: irrigated rice and upland rice. The first is located mainly in Sebaco (Matagalpa) and Malacatoya (Granada), and is a system handled by large-farmers. The second, upland rice, is managed by small-farmers located in Chinandega, Rivas, RAAN, RAAS and Rio San Juan. The map in the right is showing the distribution areas for upland rice.



Source: CENAGRO

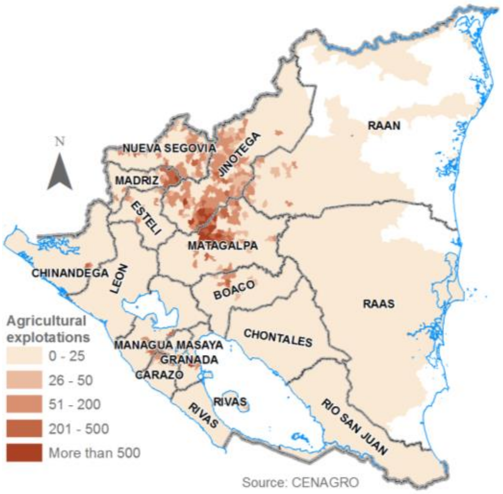
Figure 3. Distribution of upland rice in Nicaragua

Table 3. Data for production and harvested area of rice in the last 5 production cycles in Nicaragua. Source: FAOSTAT.

Rice	**08/09**	**09/10**	**10/11**	**11/12**	**12/13**
Harvested area (Ha)	73755	88314	100377	110892	90819
Production (Tons)	334516	453990	413321	418656	377470

Coffee

Coffee growing areas are located mainly in the north of the country, in Matagalpa, Jinotega and Nueva Segovia. Also there are some areas in Managua, Granada and Carazo. 97% of the coffee producers have less than 14 ha. So this is a crop managed by small-farmers that contribute for GDP and local food security, and the fact that Nicaraguan coffee is managed under agroforestry systems make it important for increase resilience facing climate change and variability.



Source: CENAGRO

Figure 4. Distribution of coffee in Nicaragua

Table 4. Data for production and harvested area of coffee in the last 5 production cycles in Nicaragua. Source: FAOSTAT.

Coffee	**08/09**	**09/10**	**10/11**	**11/12**	**12/13**
Harvested area (Ha)	118679	113680	120283	119927	108074
Production (Tons)	92204	78712	103881	86943	83948

Annex III: Climate impacts on agriculture in Nicaragua

1.a Current climate

For the current climate (baseline) we used historical climate data from www.worldclim.org database (Hijmans et al., 2005). The WorldClim data are generated through interpolation of average monthly climate data from weather stations on a 30 arc-second resolution grid (often referred to as "1 km" resolution). Variables included are monthly total precipitation, and monthly mean, minimum and maximum temperature, and 19 bioclimatic variables (Hijmans et al., 2005).

Bioclimatic variables

Within the WorldClim database, there are bioclimatic variables that were derived from the monthly temperature and rainfall values to generate more biologically meaningful variables, which are often used in ecological niche modeling (e.g., BIOCLIM, GARP). The bioclimatic variables represent annual trends (e.g., mean annual temperature, annual precipitation), seasonality (e.g., annual range in temperature and precipitation) and extreme or limiting environmental factors (e.g., temperature of the coldest and warmest month, and precipitation of the wettest and driest quarters[1]).

Table 5. The derived bioclimatic variables.

Bio No.	Description
Bio 1	Annual mean temperature
Bio 2	Mean diurnal range (Mean of monthly (max temp - min temp))
Bio 3	Isothermality (Bio2/Bio7) (* 100)
Bio 4	Temperature seasonality (standard deviation *100)
Bio 5	Maximum temperature of warmest month
Bio 6	Minimum temperature of coldest month
Bio 7	Temperature annual range (Bio5 – Bi06)
Bio 8	Mean temperature of wettest quarter
Bio 9	Mean temperature of driest quarter
Bio 10	Mean temperature of warmest quarter
Bio 11	Mean temperature of coldest quarter
Bio 12	Annual precipitation
Bio 13	Precipitation of wettest month
Bio 14	Precipitation of driest month
Bio 15	Precipitation seasonality (coefficient of variation)
Bio 16	Precipitation of wettest quarter
Bio 17	Precipitation of driest quarter
Bio 18	Precipitation of warmest quarter
Bio 19	Precipitation of coldest quarter

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[1] A quarter is a period of three months (1/4 of the year).

Additionally to bioclimatic variables, modeling includes nine variables related to potential evapotranspiration. This is to estimate the contribution of ETP for identify climate suitable areas for tropical crops, this relation has been point out as transcendental in some studies (Anim-Kwapong y Frimpong, 2005). These ETP variables are estimated from monthly estimations obtained from an empiric method (Hargreaves, 1985). This method was used because requires less data than other very known method, Penman-Monteith FAO 56 (Allen et al, 1998). Results from both methods are very similar (Hargreaves y Allen, 2003). In fact, recent research shows similarity of results in tropical areas for both (Asare et al., 2011).

Table 6**.** Evapotranspiration variables (ETP)

ETP No.	**Description**
ETP1	Annual Evapotranspiration
ETP2	Evapotranspiration of Wettest Month
ETP3	Evapotranspiration of Driest Month
ETP4	Evapotranspiration of Wettest Quarter
ETP5	Evapotranspiration of Driest Quarter
ETP6	Evapotranspiration of Warmest Quarter
ETP7	Evapotranspiration of Coldest Quarter
ETP8*	Excess of precipitation over ETP during the driest quarter (ETP8=BIO17-ETP5)

1.b Future climate

Predictions of future climate

Future climate was based on the results of 30 global circulation models (GCMs), from The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, produced in a number of specialized atmospheric physics laboratories around the world. The spatial resolution of the GCM results is inappropriate for analyzing the impacts of climate change on agriculture as in almost all cases the grid cells measure more than 100 km a side. This is especially a problem in heterogeneous landscapes such as highly mountainous areas, where, in some places, one cell can cover the entire width of the mountain range.

Downscaling is therefore needed to provide higher-resolution surfaces of expected future climates if the likely impacts of climate change on agriculture are to be forecast more accurately. The method basically produces a smoothed (interpolated) surface of changes in climates, which is then applied to the baseline climate taken from WorldClim. The method assumes that changes in climates are only relevant at coarse scales, and that relationships between variables are maintained towards the future (Ramírez and Jarvis, 2010).

CIAT downloaded the data from the Earth System Grid (ESG) data portal and applied the downscaling method to 30 GCMs for the RCP 4.5 from the IPCC and for a 30-year running mean periods (2020–2049 [2030s]). Each dataset (RCP scenario–GCM–time-slice) comprises 4 variables at a monthly time-step (mean, maximum, minimum temperature, and total precipitation), on a spatial resolution of 30 arc-seconds.

Table 7: Global Circulation Models (GCMs) included in the modeling of future climatic suitability of crops in Nicaragua.

Centre(s)	**model**
Beijing Climate Center. China.	bcc_csm1_1
Beijing Climate Center. China.	bcc_csm1_1_m
Beijing Normal University. China.	bnu_esm
Canadian Centre for Climate Modelling and Analysis. Canada.	cccma_canesm2
National Center for Atmospheric Research. USA.	cesm1_bgc
National Center for Atmospheric Research. USA.	cesm1_cam5
Commonwealth Scientific and Industrial Research Organization/Bureau of Meteorology. Australia	csiro_access1_0
Commonwealth Scientific and Industrial Research Organization/Bureau of Meteorology. Australia	csiro_access1_3
Commonwealth Scientific and Industrial Research Organization/Queensland Climate Change Centre of Excellence. Australia.	csiro_mk3_6_0
The First Institute of Oceanography, SOA. China	fio_esm
Geophysical Fluid Dynamics Laboratory. USA.	gfdl_cm3
Geophysical Fluid Dynamics Laboratory. USA.	gfdl_esm2g
Geophysical Fluid Dynamics Laboratory. USA.	gfdl_esm2m
NASA/GISS (Goddard Institute for Space Studies). USA.	giss_e2_h_cc
NASA/GISS (Goddard Institute for Space Studies). USA.	giss_e2_r
NASA/GISS (Goddard Institute for Space Studies). USA.	giss_e2_r_cc
Russian Academy of Sciences, Institute of Numerical Mathematics. Russia.	inm_cm4
Institut Pierre Simon Laplace. France.	ipsl_cm5a_lr
Institut Pierre Simon Laplace. France.	ipsl_cm5a_mr
Institute of Atmospheric Physics, Chinese Academy of Sciences. China	lasg_fgoals_g2
Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	miroc_esm
Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	miroc_esm_chem
Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	miroc_miroc5
Met Office Hadley Centre. United Kindom	mohc_hadgem2_cc

Met Office Hadley Centre. United Kindom	mohc_hadgem2_es
Max Planck Institute for Meteorology . Germany.	mpi_esm_lr
Meteorological Research Institute. Japan.	mri_cgcm3
National Center for Atmospheric Research. USA.	ncar_ccsm4
Bjerknes Centre for Climate Research, Norwegian Meteorological Institute. Norway	ncc_noresm1_m
National Institute of Meteorological Research, Korea Meteorological Administration. South Korea.	nimr_hadgem2_ao

1.c Crop prediction

Maximum Entropy

Maximum entropy (MAXENT) is a general-purpose method for making predictions or inferences from incomplete information. The idea is to estimate a target probability distribution by finding the probability distribution of maximum entropy, subject to a set of constraints that represent the incomplete information about the target distribution. The information available about the target distribution often presents itself as a set of real-valued variables, called ‘features’, and the constraints are that the expected value of each feature should match its empirical average - “average value for a set of sample points taken from the target distribution”(Phillips et al., 2006). Similar to logistic regression, MAXENT weights each environmental variable by a constant. The probability distribution is the sum of each weighted variable divided by a scaling constant to ensure that the probability value ranges from 0–1. The algorithm starts with a uniform probability distribution and iteratively alters one weight at a time to maximize the likelihood of reaching the optimum probability distribution. MAXENT is generally considered to be the most accurate method for this sort of analysis (Elith et al., 2006).

Data collection and model calibration

For the future predictions we required evidence data of current distribution of cocoa production. The evidence data was compiled through existing databases, maps, expert knowledge and GPS points. For coffee (1185 points) and cocoa (1128 points) data was obtained from previous studies (Läderach et al, 2012; Läderach et al, 2012b). Data for spatial distribution for rice, sugar cane, beans, maize and sorghum was obtained from the compendium of maps for potential use of land (MAGFOR, 2013).

After some trial runs of the MAXENT procedure, we asked local experts to validate the predictions (Annex I). We incorporated these experts’ opinions and reran MAXENT. We presented the results in a cocoa summit representing the cocoa sector and supply chain (see annex III for the list of attendees) in Accra, Ghana on 6 April, 2011. We incorporated participant´s feedback and reran MAXENT for the final analysis.

Suitability changes

After runs of the MAXENT for current and future conditions, the difference of current results was subtracted from future results using geospatial tools. This allows us to identify where are the areas that could be more affected by climate change in terms of gaining or loosing climatic suitability

Results

The results for all crops in current and future conditions as well as predicted changes are presented below.

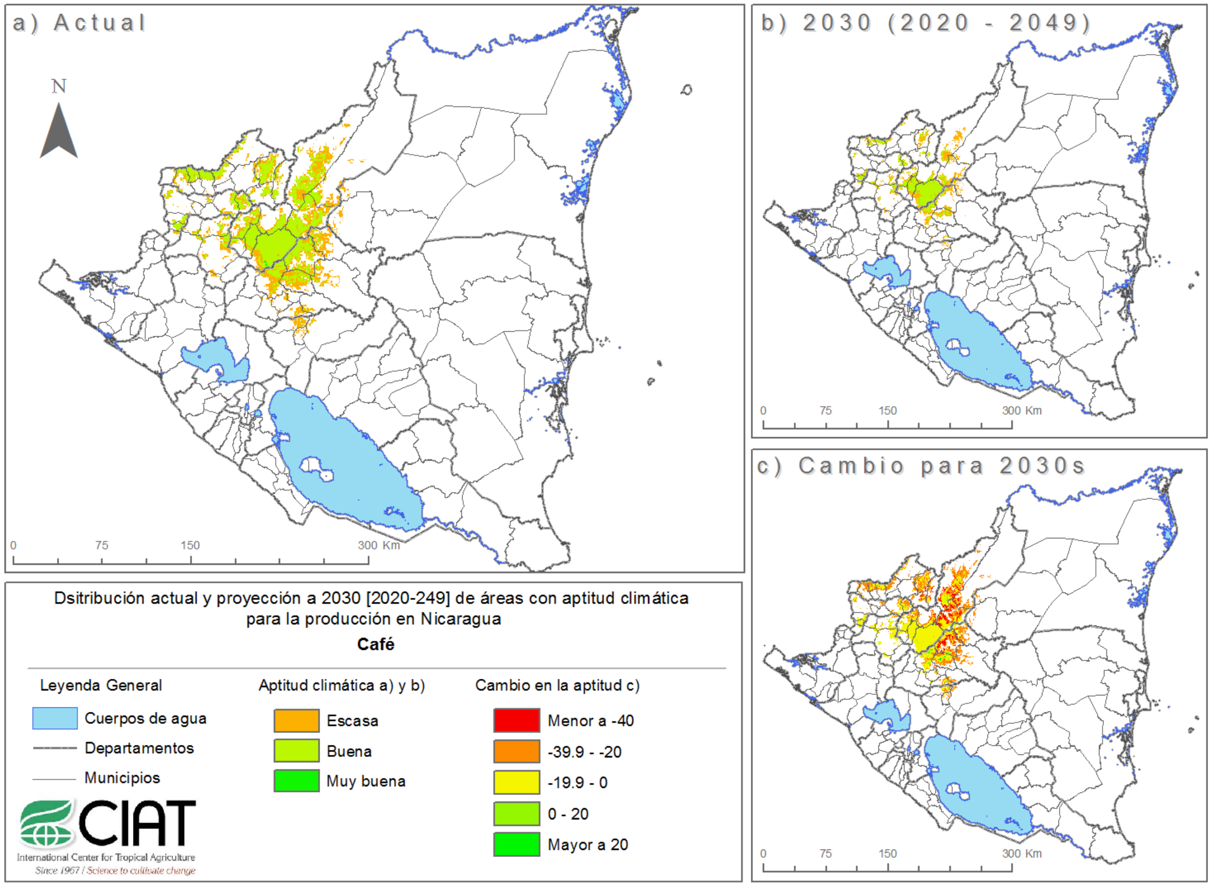

Figure 5. Current (a), future (b) and changes (c) in suitability for coffee. Green colors in a) and b) express very good, light green means good and orange means low suitability. While changes in suitability (c) are expressed in a color ramp from red (less than -40%) to green (More than 20%).

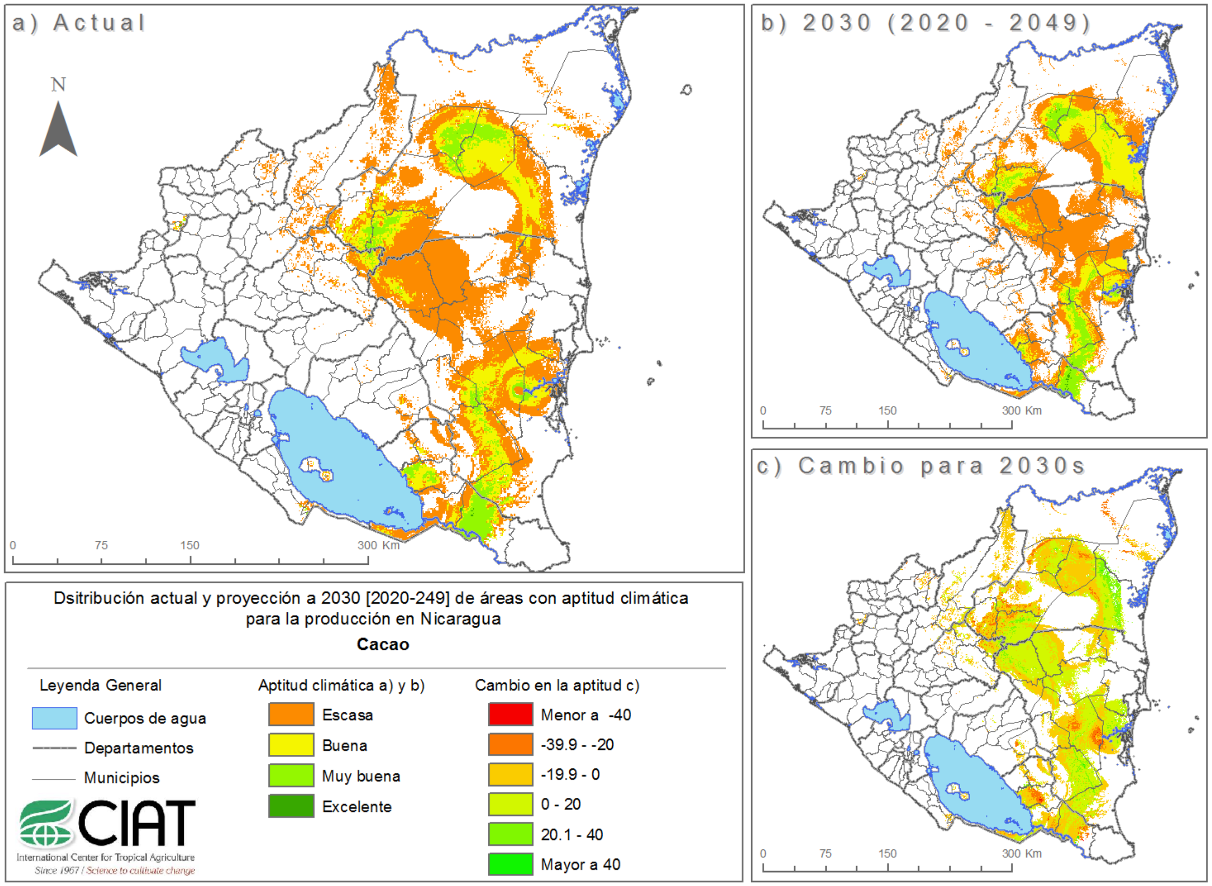

Figure 6. Current (a), future (b) and changes (c) in suitability for cocoa. Dark green colors in a) and b) express excellent, light green means very good, yellow means good and orange means low suitability. While changes in suitability (c) are expressed in a color ramp from red (less than -40%) to green (More than 20%).

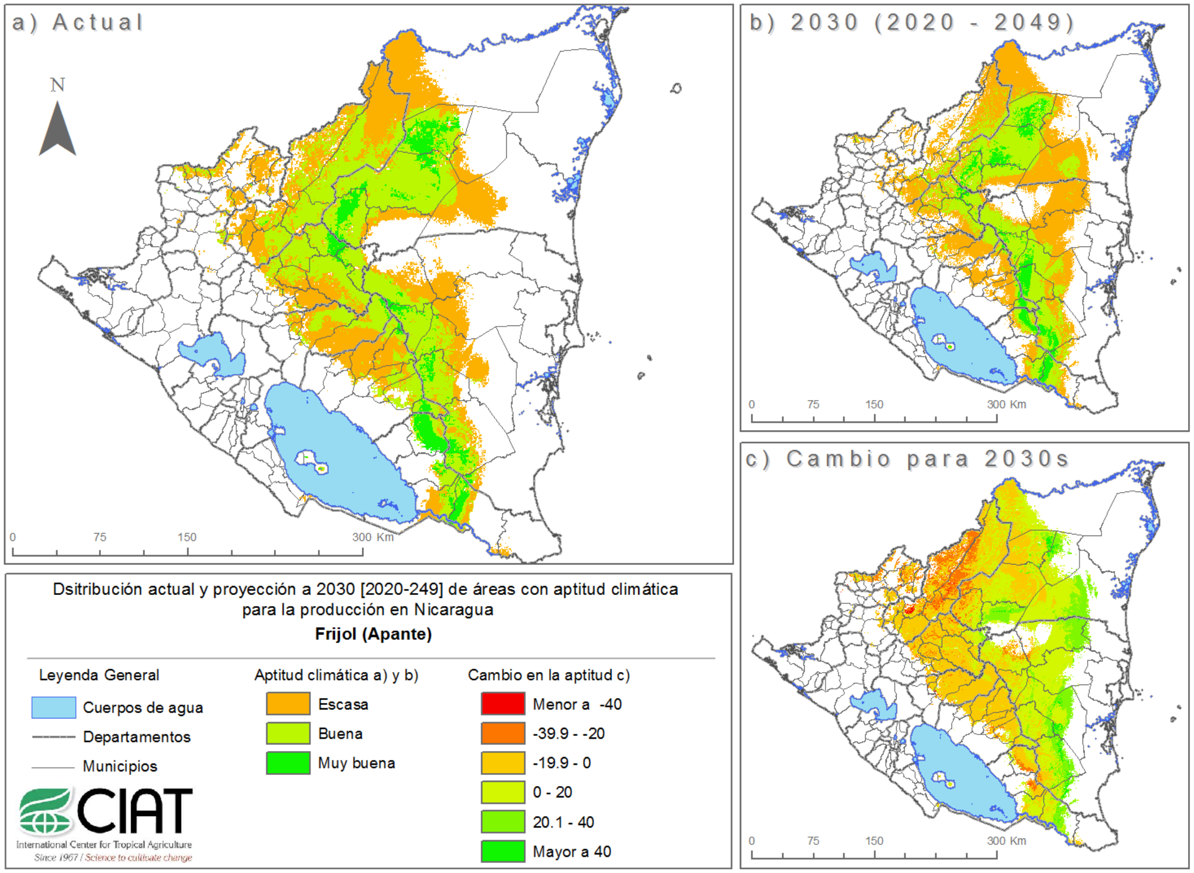

Figure 7. Current (a), future (b) and changes (c) in suitability for beans in apante. Green colors in a) and b) express very good, light green means good and orange means low suitability. While changes in suitability (c) are expressed in a color ramp from red (less than -40%) to green (More than 20%).

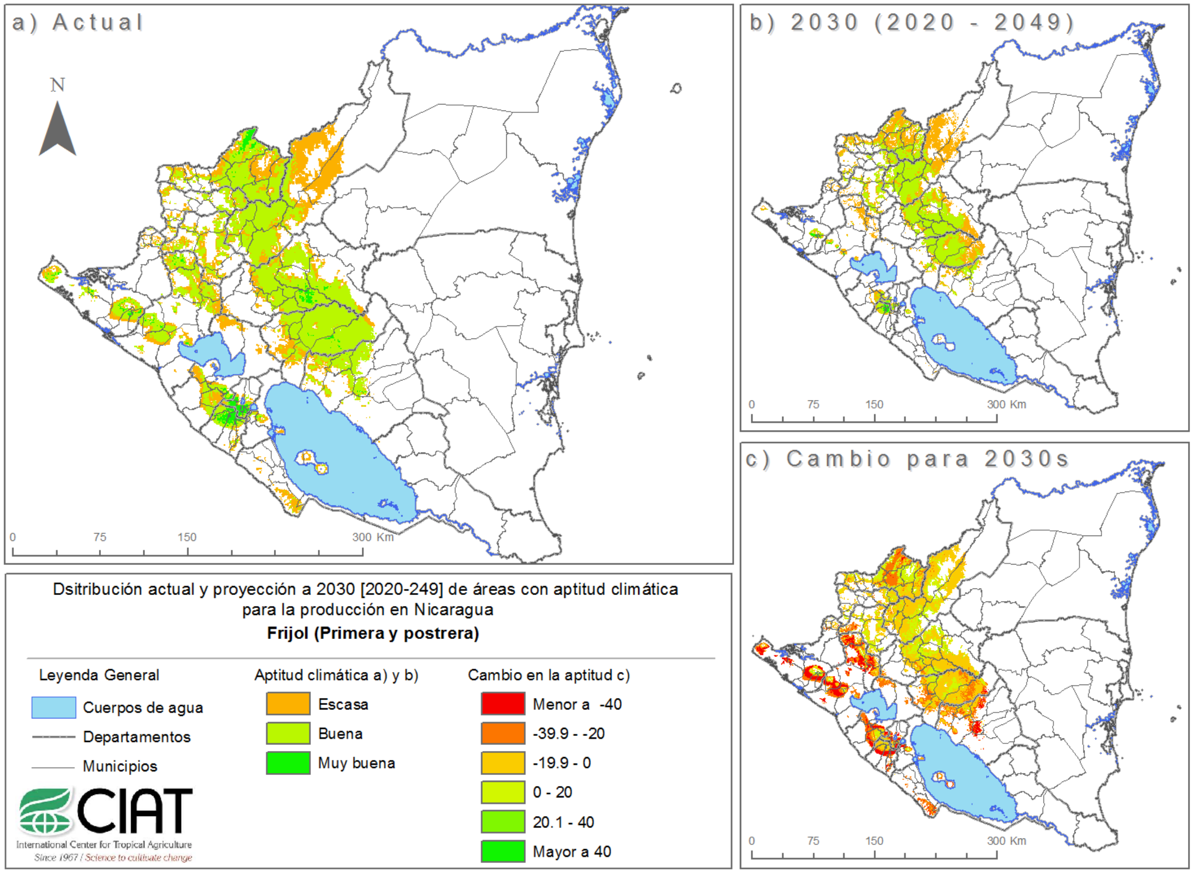

Figure 8. Current (a), future (b) and changes (c) in suitability for beans in primera and postrera. Green colors in a) and b) express very good, light green means good and orange means low suitability. While changes in suitability (c) are expressed in a color ramp from red (less than -40%) to green (More than 20%).

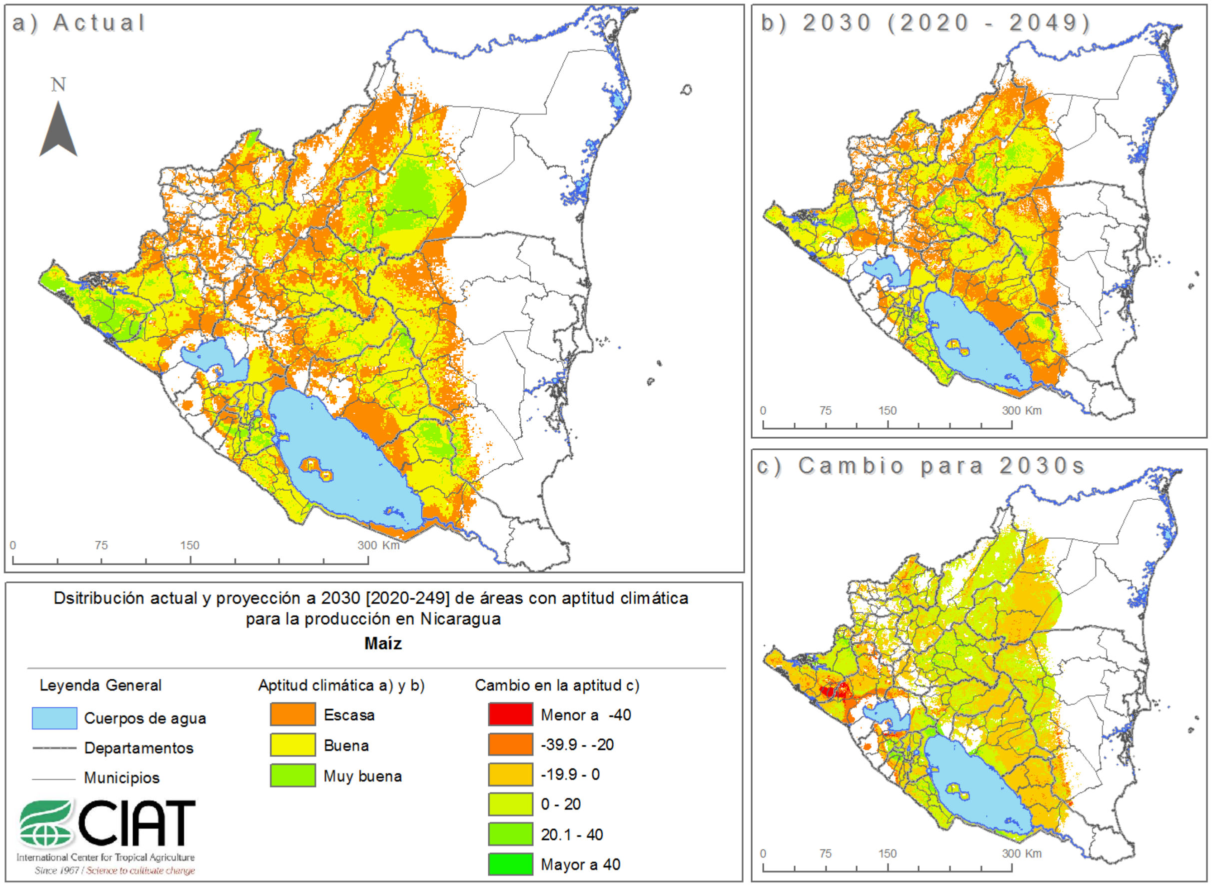

Figure 9. Current (a), future (b) and changes (c) in suitability for maize. Green color in a) and b) express very good, yellow means good and orange means low suitability. While changes in suitability (c) are expressed in a color ramp from red (less than -40%) to green (More than 20%).

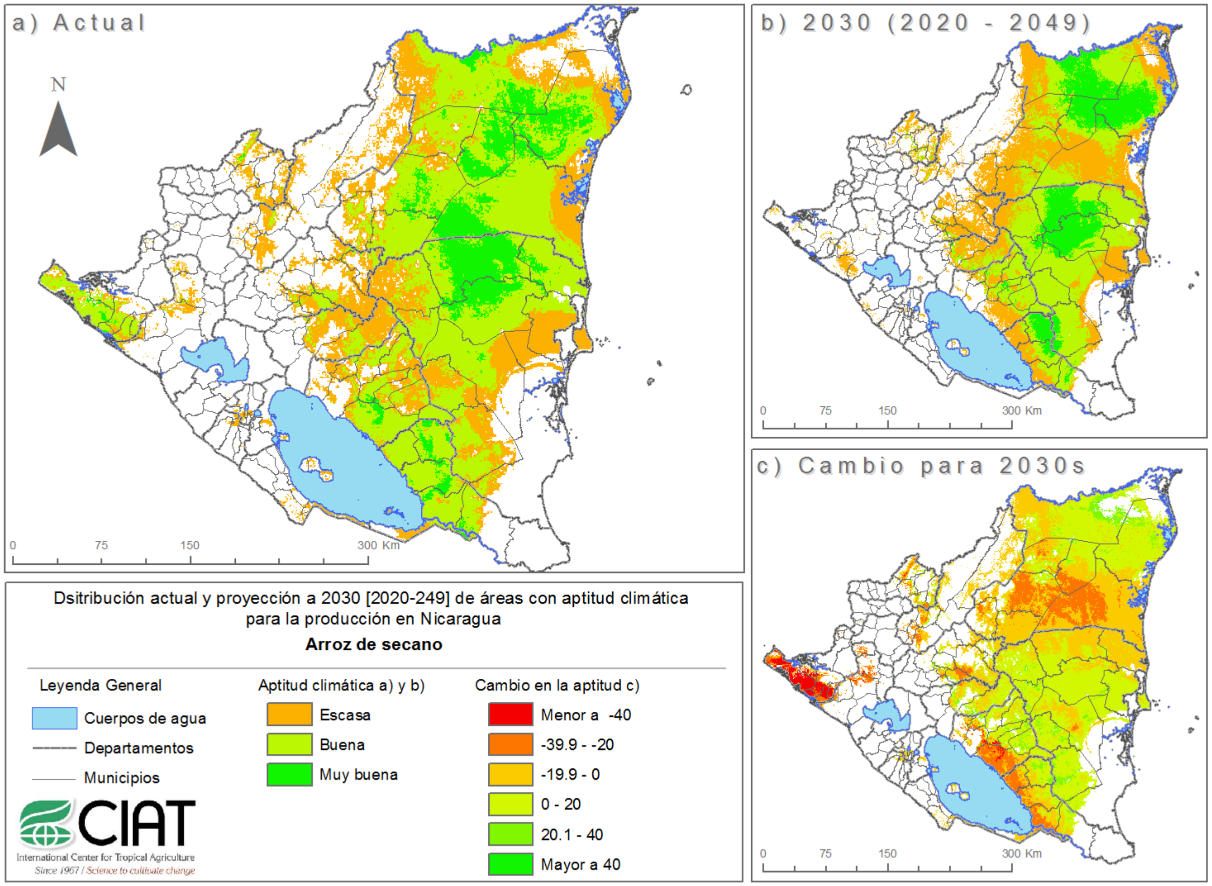

Figure 10. Current (a), future (b) and changes (c) in suitability for rain fed rice. Green colors in a) and b) express very good, light green means good and orange means low suitability. While changes in suitability (c) are expressed in a color ramp from red (less than -40%) to green (More than 20%).

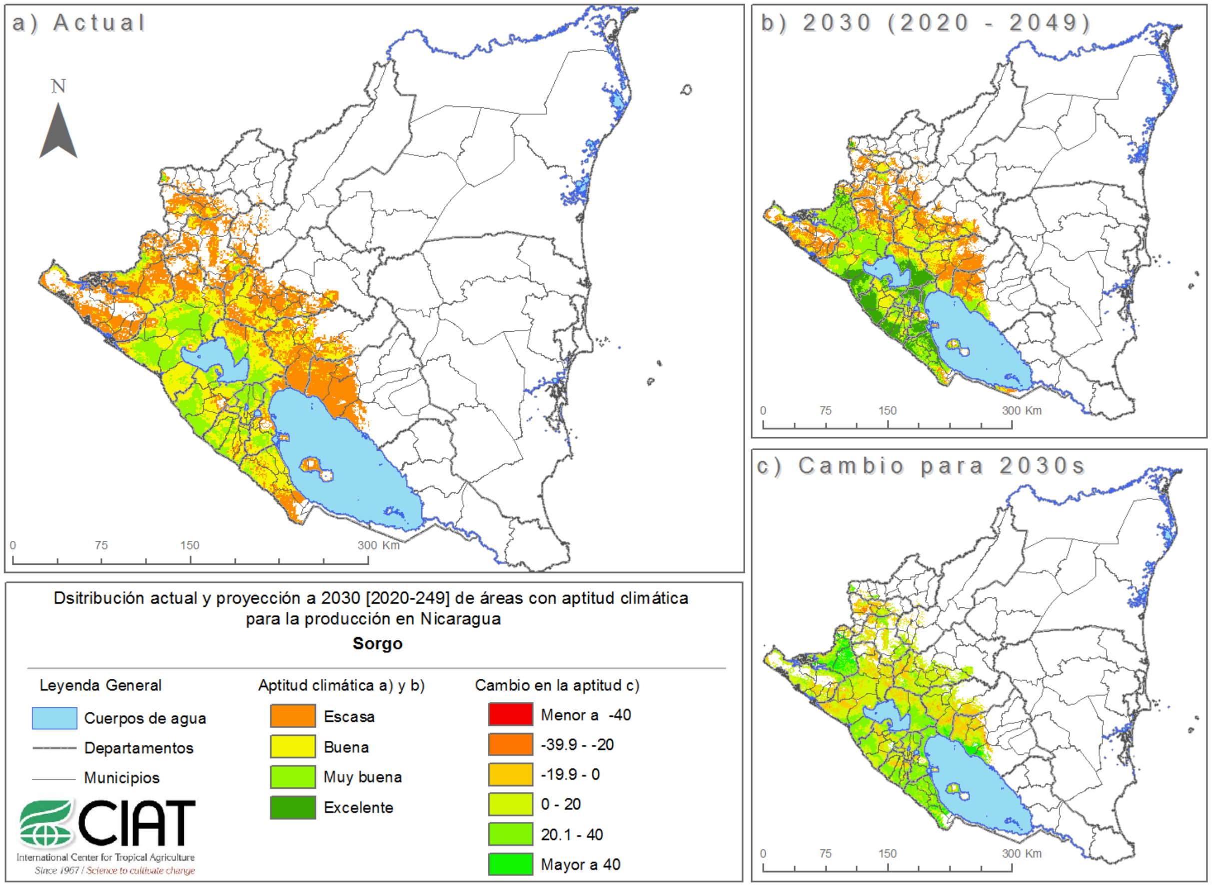

Figure 11. Current (a), future (b) and changes (c) in suitability for sorghum. Dark green colors in a) and b) express excellent, light green means very good, yellow means good and orange means low suitability. While changes in suitability (c) are expressed in a color ramp from red (less than -40%) to green (More than 20%).

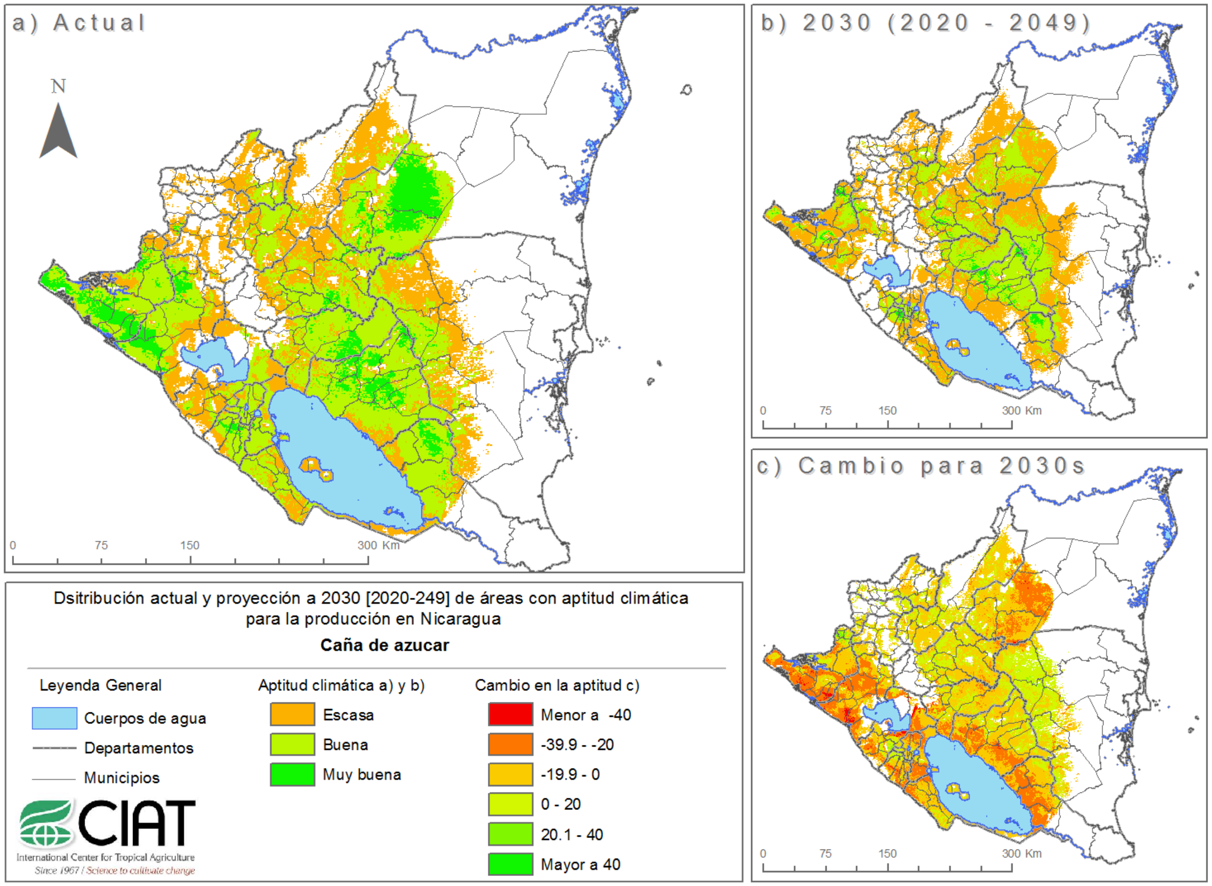

Figure 12. Current (a), future (b) and changes (c) in suitability for sugar cane. Green colors in a) and b) express very good, light green means good and orange means low suitability. While changes in suitability (c) are expressed in a color ramp from red (less than -40%) to green (More than 20%).

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Annex IV: Climate smartness methodology

Protocol for assessing climate smartness of ongoing and promising practices

The objective of the 'Climate Smart Agriculture Technologies and Practices' section of the CSA Country Profiles is to: a) identify ongoing CSA practices for key production systems in each country; b) assess how 'climate smart' these practice are; c) assess each country's current efforts to achieve 'climate smartness'; and d) identify promising future CSA practices for each country. This document outlines the protocols used for assessing this information.

a) What is climate smartness?

CSA practices have different dimensions and levels of 'climate-smartness', meaning that some practices contribute to mitigation of GHG emissions through carbon management ('carbon smart'), while others might increase water retention ('water smart') and therefore improve resilience. Many practices incorporate multiple dimensions of 'climate-smartness'. For example, Conservation Agriculture increases nutrients in soil ('nitrogen smart') through the incorporation of crop residues on the soil, captures carbon ('carbon smart'), and increases infiltration of water ('water smart'). Other practices, such as improved seeds for climate extremes, help farmers adapt to climate change from a 'knowledge-smart' approach.

b) Types of climate smartness

The following are key questions that help assess the smartness of different practices:

<u>Weather</u>
Does the CSA practice reduce climate - related risks (droughts, floods, etc.)?

<u>Water</u>
Does the CSA practice enhance water availability?
Does the CSA practice enhance water use efficiency?

<u>Carbon</u>
Does the CSA practice enhance soil carbon stock?
Does the CSA practice reduce Carbon emissions?

<u>Nitrogen</u>
Does the CSA practice enhance soil N stock?
Does the CSA practice reduce Nitrogen based gases emissions?

<u>Energy</u>
Does the CSA practice promote energy use efficiency?
Does the CSA practice promote alternative energy use?

Knowledge

Does the CSA practice promotes local knowledge and social networks for increasing producers' adaptive capacity to climate change?

Methodology for the identification of ongoing CSA practices

The identification of ongoing and promising CSA practices has been carried out in several stages:

- Development of a list of CSA practices building on the FAO Sourcebook (FAO, 2013) (See Annex 1, Survey document).
- Review of literature to identify in-countr,y ongoing CSA practices documented in peer-reviewed literature.
- Interviews and/or long surveys4 with technical experts related to the main production systems identified and/or regional experts in order to pinpoint:
    - practices that are currently being implemented in the country and associated with the main production system
    - the geographical and agro-ecological region they are associated with
    - an estimate of the adoption rate (from total agricultural land) of the practice
    - actors and institutions engaged in the implementation of the practice
    - practices that have not been mentioned previously/ implemented in the country but could be applicable to specific agro-ecological areas
    - Opportunities and barriers to adoption related to existing and promising practices.

- Development of a short baseline survey that was sent to key experts in the main production systems in the country to gather a list of CSA practices (existing and promising) in the country.

Only a few of the practices from this master list of CSA practices were selected for further investigation. They related to the main production systems identified in the country (See Annex II) based on the following criteria:

1) Adoption rate - practices that were mentioned most often during interviews and the baseline survey.
2) Impact on CSA pillars - practices that have a high impact on productivity + adaptation, productivity + mitigation), identified via the detailed survey.
3) Climate-smartness effort - practices that have the highest overall climate-smartness scores, according to expert assessments (long survey).

d) Methodology for the evaluation of country level efforts towards climate smartness

Identifying current adoption rate of a certain CSA practice

Research informants were asked to estimate the adoption rate of the practice based on the following scale (some country specific modifications were necessary):

3 = High (60-100%)
2 = Medium (30-60%)
1 = Low (<30%)
0 = Not adopted

Evaluating the climate smartness of certain CSA practices

For the assessment of the relationship between a CSA practice and the smartness categories (i.e. the potential impact of the CSA practice on the total climate smartness score), a simple scale of 0 to 5 was used as illustrated in Table below:

Value	Potential impact
5	The CSA practice has a **Very High** positive impact on the overall climate smartness score
4	The CSA practice has a **High** positive impact on the overall climate smartness score
3	The CSA practice has a **Medium** positive impact on the overall climate smartness score
2	The CSA practice has a **Low** positive impact on the overall climate smartness score
1	The CSA practice has a **Very low** positive impact on the overall climate smartness score
0	The CSA practice has not impact on the overall climate smartness score
-	No information

References

Aggarwal P, Zougmoré R and Kinyangi J. 2013. Climate-Smart Villages: A community approach to sustainable agricultural development. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org

Food and Agriculture Organization of the United Nations. 2013. Climate-Smart Agriculture: Sourcebook. Rome, Italy: FAO.

Annex V: Detailed assessment of impacts of ongoing CSA practices on CSA pillars in Nicaragua

	CSA Practice	Adaptation	Mitigation	Productivity
Dual purpose cattle	Silages for forage conservation (cutting grass, forage sorghum) Low adoption (30%)	Feeding during the dry season. Allows for a greater number of animals per unit area.	No significant benefits.	Good quality food using existent farm resources.
	Silvopastoral systems with disperse trees on improved pastures. Medium adoption (30-60%)	Recovery of degraded soils, reduced soil erosion, water conservation, biodiversity conservation.	Net carbon storage during the growth of forest species.	Production diversification: wood, fruit, wooden posts with potential for improved incomes and profit
	Protein-rich shrub legumes (mixed with others sources of food) Low adoption (30%)	Bolster livestock resilience to climate variability as shrub legume's deep roots reduce erosion and optimize recycling of nutrients. Also used as source of food, timber and medicines	Increased carbon sequestration.	With controlled feeding, may increase protein content in cattle's diet without negative effects of tannins. Potential source of food, timber and medicines.
	Herbaceous legumes for hay Low adoption (30%)	Feeding during the dry season feeding. Improved soil cover.	No significant benefits.	Reduced the cost of feed milking cows during the dry season by to avoiding to buy food out of the farm
	Sugarcane energy banks. Low adoption (30%)	Improved feeding during the dry season.	No significant benefits.	Alternative feeding source that contributes to increased income per hectare.

	CSA Practice	Adaptation	Mitigation	Productivity
Maize	Hybrid varieties Medium adoption (30-60%)	Materials having a cycle of adaptation to specified current conditions.	No significant benefits.	Ensures commercially acceptable yields in the crop, based on the behavior of the climate of each locality.
	Contour planting Medium adoption (30-	Optimized on-field water resources. Optimized effects of other factors	No significant benefits.	Optimized water that is the main limitation of climate change on

	60%)	such as erosion and wind.		agriculture.
	Minimum tillage Medium adoption (30-60%_	Increased water retention and reduced soil erosion. Maintains biochemical and physical conditions of the soil, while reducing damages to microfauna.	Reduces GHG emissions by limiting the use of farming machinery and keeping carbon stock on soils.	Productivity increases due to the retention of nutrients in the soil. Greater yields may be associated with higher incomes.
	No-burn Medium adoption (30-60%)	In conditions of drought or excessive rains, favors crop adaptation and allows greater water infiltration, also reducing soil erosion.	Reduction of GHG emissions (CH4 and N2O).	Protection of soils permits the current or future production of commercial crops.

	CSA Practice	Adaptation	Mitigation	Productivity
Bean	Green manures Low adoption (30%)	Improved physical, chemical and biological properties of soils. Improved water availability and storage.	No use of synthetic chemical fertilizers. Provides permanent soil cover.	Improved plant nutrition and reduced investments in synthetic fertilizers.
	Use of Rhizobium Low adoption (30%)	Increased biological nitrogen fixation in plant cultivation. Reduced pollution of groundwater and soils by reducing synthetic fertilizers application.	No use of fertilizer from chemical synthesis.	Enhance growth, yield, photosynthesis, nodulation, nutrient uptake and nitrogen fixation increases in productivity.
	Drought-resistant varieties Medium adoption (30-60%)	Good root system even under drought conditions. , Ability to form pods under water stress conditions and fill the grain inside the sheath.	No significant benefits.	Better yields under drought conditions.
	Bean Quesungual system. Low adoption (30%)	Greater resilience for food production to extreme natural events such as drought or water excess	Reduced GHG emissions and increased carbon storage.	Sustainable productivity increases through improved soil quality and water availability.

	CSA Practice	Adaptation	Mitigation	Productivity
Coffee	Pest management (berry borer - *Hypothenemus hampei*) with entomopathogenic fungi. Low adoption (30%)	Increased crop resistance to berry borer.	Reduced use of chemicals.	Increased grain yields by at least 40%.
	Diseases management (rust) with Lime sulfur and Bordeaux mixture. Low adoption (30%)	Increased crop resistance to rust.	No significant benefits.	Increased yields by at least 30%. Reduction in investment in fungicides.
	Pruning Medium adoption (30-60%)	Better entry and distribution of sunlight and improved aeration in planting to create an unfavorable environment for development of pests and diseases.	No significant benefits.	Increased yields by at least 60%.
	Shade regulation Medium adoption (30-60%)	Regulates high and low temperatures.	Carbon dioxide fixation.	Increased yields by at least 30%.
	Management of wastewater and coffee pulp Low adoption (30%)	Biofilters treat water used in post-harvest production of coffee pulp so that it can be re-used for cultivation, thus improving adaptive capacity in the face of water shortage.	Reduced GHG emissions.	Improves water efficiency and costs associated with irrigation, reducing overall production costs by as much as 30%

	CSA Practice	Adaptation	Mitigation	Productivity
Cacao	Pruning Medium adoption (30-60%)	Management to allow the entry of sunlight and air, control the growth and development of productive sectors, and reduce the presence of pests and diseases.	Increased carbon storage	May increases yields from 5 to 20%.
	Cultural practices for management of Monilia Low adoption (30%)	No significant benefits.	Reduced use of chemicals.	Increased yields between 5-30%.
	Grafting techniques using improved genetic material with high productive capacity and tolerant / resistant to brown rot. Low adoption (30%)	By incorporating genetic material that is tolerant or resistant to pests and disease associated with climate change, such as brown rot, farmers are better able to adapt to their increased prevalence.	Reduced use of chemicals.	Proper treatment of brown rot can improve yields by 5–30%, with potential income gains.