IMPLEMENTATION OF THE CLIMATE-SMART VILLAGE APPROACH

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The thesis is submitted to NUI Galway in part fulfilment of the requirements for the degree of Masters in Climate Change, Agriculture and Food Security, which is a taught postgraduate program within the School of Natural Sciences.

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22nd August 2018

Declaration

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgement, the work presented is entirely my own.

I confirm that this thesis presented for the degree of Masters in Climate Change, Agriculture and Food Security (National University of Galway), has been composed entirely by myself, has been solely the result of my own work, and has not been submitted for any other degree or professional qualification.

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

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Acronyms

AR4D	Agriculture research-for-development
CAR	Autonomous Regional Corporations
CATIE	Tropical Agricultural Research and Higher Education Center
CCAFS	Climate Change, Agriculture and Food Security Research Program
CENICAFÉ	National Center for Coffee Research
CENICAÑA	National Center for Sugar Cane Research
CENIPALMA	National Center for Oil Palm Research
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIS	Climate informatics services
CONPES	National Council for Economic and Social Policy
CORPOICA	Colombian Corporation of Agricultural Research
CRC	Autonomous regional corporation of Cauca
CSA	Climate-Smart Agriculture
CSV	Climate-Smart Village
DNP	National Planning Department
ECDBC	Colombia Strategy for Low Carbon Development
ENREDD+	National Strategy for Reducing Emissions from Deforestation and Degradation
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations

GDP	Gross Domestic Product
GHG	Greenhouse gas
HFIAP	Household Food Insecurity Access Prevalence
HFIAS	Household Food Insecurity Access Scale
ICA	Colombian Agricultural Institute
IDEAM	National Institute of Hydrology, Meteorology and Environmental Studies
IFIAD	International Fund for Agricultural Development
INAP	Integrated National Adaptation Project
ITCZ	Intertropical Convergence Zone
MADR	Ministry Agriculture and Rural Development of Colombia
MADS	Ministry of Environment and Sustainable Development of Colombia
MARLO	Managing Agricultural Research for Learning and Outcomes
Mt CO_2e	Megatons of Carbon Dioxide (equivalent)
PIGCCTC	Integral Territorial Climate Change Management Plan for Cauca 2040
PNACC	Climate Change National Adaptation Plan
UNFCCC	United Nations Framework Convention on Climate Change

Acknowledgements

I would like to express my gratitude to Charles Spillane and Peter McKeown for their tutelage throughout this research thesis, and indeed for the master's program. Also, I would like to thank my NUI Galway thesis supervisors Una Murray and David Styles for their support during the thesis.

I would also like to thank my CIAT-CCAFS thesis supervisors Osana Bonilla-Findji and Deissy Martínez Barón for their opportunity to be at CIAT working with them. You supported me greatly and were always willing to help me. Also, I would like to thank Anton Eitzinger for his advice on the results section.

I must express my gratitude to my mother, brother and Alessia for their continued support and encouragement, and by the patience of Jason who experienced all the ups and downs of my research.

Abstract

Climate change is affecting global population and agriculture. Through climate-smart agriculture practices in climate-smart villages, it promotes adaptation, builds resilience to climatic stresses and ensures food security.

This research thesis aims to support the planning and decision-making processes to promote and scale out climate-smart agriculture among smallholder farmers in Colombia.

The research thesis analysed the data from a Gender-sensitive Smart Household Monitoring instrument to assess climate-smart agriculture performance and outcomes in Cauca climate-smart village.

Data was analysed through different indicators tracked at household level disaggregated by gender and examines the Climate-smart agriculture adoption and dis-adoption trends and related factors (financial, technical/operational and social) that enable its implementation.

The study found that climate-smart practices related to water and ensure food security during the year are the most preferred. This study highlights the importance of climate informatics services to promote a higher adaptation to climate change. Furthermore, this study give a recommendation to improve the surveys to future monitoring instruments to address correctly smallholder farmers and practitioners to scale out climate-smart agriculture.

1. Introduction

The world's population is currently around seven billion, and it is expected to reach nine billion by 2050 with most of the additional two billion people living in developing countries as stated by Thornton (2012). The growing global population is a fact, and this is likely to mean that future food production will have to increase and reduce its food loss and waste (Hiç et al., 2016). The food demand will be higher, and the need to provide enough nutritious food in all areas of the world will be essential for the future generations to ensure global food security (FAO and CCAFS, 2014a). Food and Agriculture Organization of the United Nations (FAO, 2013) estimates an increase by 60% of the agricultural production by 2050 to feed the global population.

Agriculture is affected by climate change, for example, in increases in the frequency and intensity of extreme weather events such as droughts, severe rainfalls, floods, storms, and high temperatures (Lipper et al., 2014). As mentioned by FAO (2010), FAO and CCAFS (2014b), climate change is already negatively affecting agricultural production. Thornton (2012) notes that the average temperature of the Earth's surface increased by about 0.8 °C over the past century, with about 0.6 °C of this warming occurring over just the past three decades. These changes of the climate patterns bring the need to farmers and scientists to modify their practices to ensure the resilience of agriculture to the changing climate.

Around 30% of the global greenhouse gas (GHG) emissions come from land use. According to Scherr et al. (2012), 18% of these emissions come from land use change (particularly deforestation) and 10-12% of crop production (soil erosion and tillage, nitrogen fertiliser). About 14.5% of them come from the livestock production (from animal digestion, feed production, manure management, and forest cover loss). Agriculture and related sectors are responsible for the 19-29% of the carbon dioxide (CO_2) emissions. 30-45% of Earth's terrestrial surface is pasture, and 80% of that one is used as agricultural land. Through the implementation of different measures such as reducing methane emissions in ruminants by changing diets, reducing or changing fertilisers to decrease nitrous oxide emissions, and reducing CO_2 gas in the atmosphere by increasing carbon sinks (e.g. afforestation) will help to solve some climate change problems.

Mitigating GHG emissions from those days will contribute to making easier to adapt to climate change.

The Green Revolution, well known for the massive increase in agricultural production worldwide, lead to soil degradation, biodiversity loss and a decrease in pest resistance. At the same time, the increase of soil and underground water pollution made by chemical pesticides and fertilisers put the environment and human health in a situation of risk (CGIAR-CCAFS, 2016a). In the wake of the Green Revolution and the emergence of climate change different practices, known as climate-smart agriculture (CSA), have been developed to allow agricultural practices to adapt to climate change while reducing emissions of agriculturally-derived greenhouse gases (GHG).

1.1. General objective

The Aim of this MScCCAFS Research Thesis is to develop an instrument to support local stakeholders and practitioners in their planning and decision-making processes to promote and scale out climate-smart agriculture (CSA) among smallholder farmers in Colombia.

1.1.1. Specific objectives

- To analyse the data collected through the Climate Smart Village (CSV) monitoring system in Cauca, Colombia, and assess core pre-defined indicators. This will include:
    - Assessing which CSA practices and portfolios where implemented in the community, by whom (gender and age disaggregated; household typologies); adoption drivers/motivations and constraints, perceived effects on productivity/income/food security as well as on gender aspects (labour and control over resources).
- To design an instrument prototype, through a participatory methodology, which will focus on the key elements that Ecohabitats Foundation and the Community committee “local stakeholders” need for planning and decision-making processes regarding out scaling of CSA.

- To examine and discuss CSV monitoring system results to explore their direct use and /or further analyses required to generate relevant and actionable information for local stakeholders planning and decision-making processes.

2. Literature Review

2.1. Climate-Smart Agriculture

Climate-smart agriculture (CSA), also known in Spanish as “Agricultura Sostenible Adaptada Al Clima” (ASAC) as defined and presented by Food and Agriculture Organization of the United Nations (FAO) at The Hague Conference on Agriculture, Food Security and Climate Change in 2010, contributes to the achievement of sustainable development goals. It integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges (FAO, 2013).

FAO and CCAFS (2014a) defined CSA as an approach that helps to guide actions needed to transform and reoriented agricultural systems to support development effectively sustainably and ensure food security in changing climate.

CSA is composed of three main pillars:

1. sustainably increasing agricultural productivity and incomes;
2. adapting and building resilience to climate change;
3. reducing and/or removing greenhouse gases emissions, where possible.

Lipper et al. (2014) defined Climate-smart agriculture (CSA) as an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change.

CSA highlights agricultural systems that use environmental system practices to support productivity, adaptation, and mitigation.

The climate-smart agriculture guide (CGIAR-CCAFS, 2017) has grouped the key characteristics of CSA being the following ones:

- CSA addresses climate change. It integrates climate change into the planning and development of the agricultural practices.
- CSA integrates multiple goals and manages trade-offs. It had triple-win outcomes: increases productivity, improves resilience to climate change and mitigates GHG.

- CSA maintains ecosystems services. It follows the principles of sustainable agriculture to adopt a landscape approach.
- CSA has multiple entry points at diverse levels. It considers the integration of the food system, landscape, value chain and policy level.
- CSA is context specific. Climate-smart practices cannot be universally applied. It involves various factors and interactions as landscape, institutions or policies have to be taken into consideration.
- CSA engages women and marginalised groups. It considers gender as a central aspect of CSA considering also the poorest and most vulnerable groups.

The main elements which are integrated into CSA approach considered by FAO and CCAFS (2014a), (2014b) are as follows:

1. Management of farms, crops, livestock, aquaculture, and capture fisheries to manage better and produce more with less while increasing resilience
2. Ecosystem and landscape management to conserve ecosystem services.
3. Services for farmers and land managers to allow them to implement the required changes.
4. Changes in the food system to ensure food security throughout the value chain, changes in harvesting, storage, transport, processing, retail, and consumption.

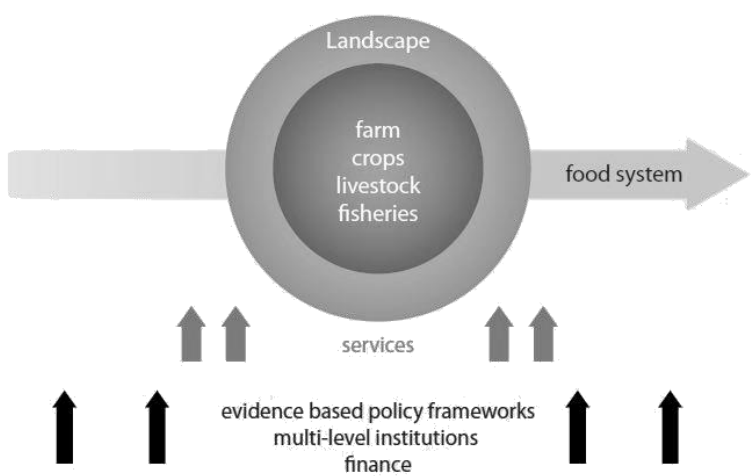

Figure 1. Elements considered in CSA approach. Source: FAO and CCAFS (2014a)

CSA is not a technology or a specific agricultural practice that can be carried out everywhere. It considers the social, economic, and environmental context that CSA will be implemented. CSA is an approach that requires site-specific assessments to identify technologies and agricultural production practices.

From CSA approach, it arises the climate-smart village (CSV) approach where different experimental and research sites are taking place for scaling up with the intervention of local communities, governments and international organisations for the adoption of CSA (Ramirez, 2016, CGIAR-CCAFS, 2017, Mora Montero, 2017a).

2.2. Climate-Smart Villages

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic partnership of CGIAR and Future Earth, led by the International Center for Tropical Agriculture (CIAT).

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), in collaboration with national programmes, is partnering with rural communities to develop Climate-Smart Villages (CSV) as models of local action that ensure food security, promote adaptation, and build resilience to climatic stresses. Researchers, local partners, farmers' groups and policymakers collaborate to select the most appropriate technological and institutional interventions based on global knowledge and local conditions to enhance productivity, increase incomes, achieve climate resilience and enable climate mitigation (Aggarwal et al., 2013).

The research program is working with various partners, including national governments and research institutions, testing a range of interventions in Climate-Smart Villages (CSVs) across Latin America, West Africa, East Africa, South Asia and Southeast Asia (CGIAR-CCAFS, 2017). CSVs are located in climate change "hotspots" as shown in figure 2.

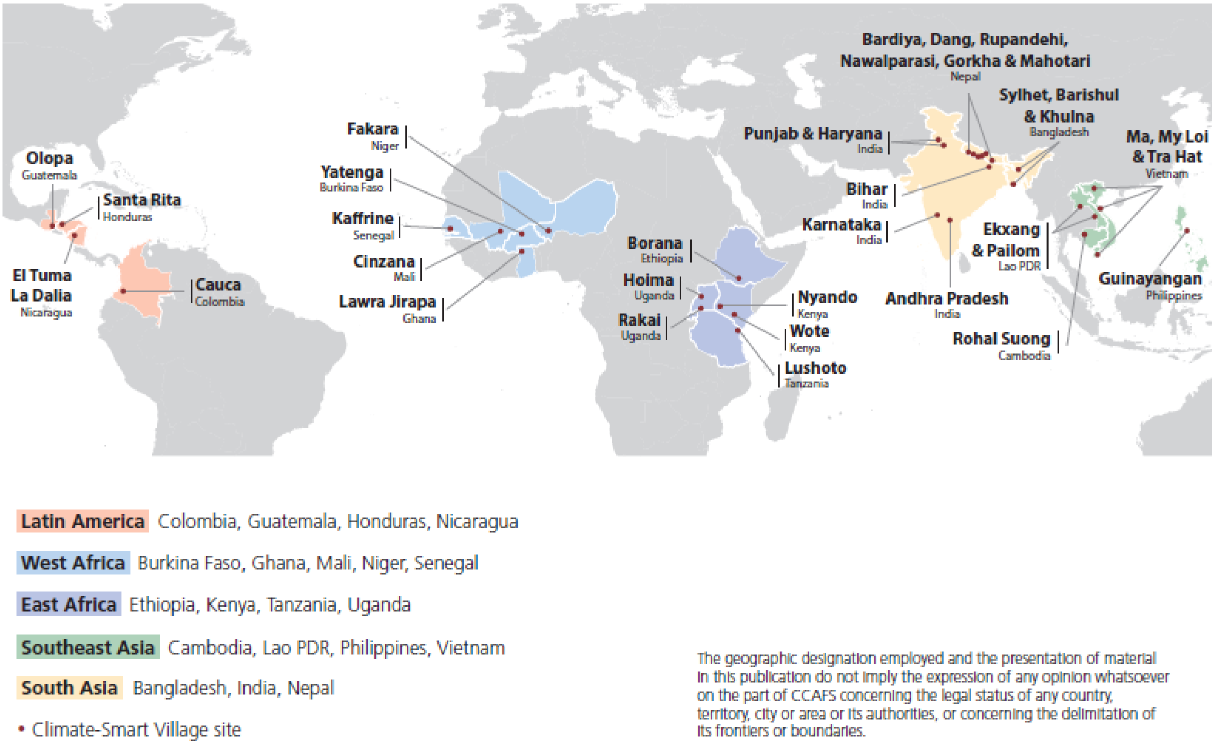

Figure 2. Location of the Climate-Smart Villages across the five focal CCAFS regions. Source: CGIAR-CCAFS (2016b)

The CGIAR Research Program on CCAFS is carried out with funding by CGIAR Fund Donors, Australia (ACIAR), Ireland (Irish Aid), Netherlands (Ministry of Foreign Affairs), New Zealand Ministry of Foreign Affairs, Switzerland (SDC), Thailand, The UK Government (UK Aid), USA (USAID), The European Union (EU). The Program is carried out with technical support from the International Fund for Agricultural Development (IFAD).

It also collaborates with local farmers, community-based organisations, national meteorological institutions, and private sector stakeholders.

The main objectives of the CGIAR Research Program on CCAFS as described by Mora Montero (2017a) are to:

1. Develop and test technologies, practices and systems of adaptation and mitigation for the poor people; and
2. Provide diagnostics and analysis that ensure cost-effective investments, the inclusion of climate change policies in agriculture and the linking of climate issues in agricultural policies,

from subnational to global levels, in a way that brings benefits to the poor people in rural areas.

CSVs provide venues where different stakeholders participate in the project planning and implementation to come up with adaptation and mitigation options to improve food security, nutrition and climate resilience (Gonsalvez et al., 2015). The components of a CSV are climate-smart technologies, climate information services, village development plans and local knowledge and institutions. CSV are located in regions where are considered to be affected negatively by climate change. CSV approach brings together farmers, policymakers, researchers and local organisations to work on a portfolio of different practices to adapt agriculture to climate change. Furthermore, CSV approach focuses in to identify the appropriate interventions, innovations and policies that are gender and socially sensitive.

According to Aggarwal et al. (2018), the CSV approach is an agriculture research-for-development (AR4D) to test, through participatory methods, technological and institutional options for dealing climatic variability and climate change challenges for food security. It aims to create evidence at local scales of what CSA options work best, where, why, and how, and use this evidence to draw out lessons for policymakers, agricultural development practitioners, and investors from local to global levels. CSV AR4D promotes local, incremental adaptation and transformative options while building local capacities to continue to innovate, experiment, and adapt.

As stated by Aggarwal et al. (2018), the strategy of the CSV approach is to evaluate portfolios of options in addition to individual CSA options, and have robust action research to:

1. Understand the effectiveness of a variety of CSA options, to enhance productivity, raise incomes, build climate resilience, increase adaptive capacity, and reduce GHG emissions.
2. Develop solutions in anticipation of future climate change impacts.
3. Understand the socio-economic, gender, and biophysical constraints and enablers for adoption.

4. Test and identify successful adoption incentives, finance opportunities, institutional arrangement, and scaling out and up mechanisms while ensuring alignment with local and national knowledge, institutions, and development plans.

2.2.1. Setting up a Climate-smart village

To set up a CSV it is necessary to follow the following steps:

1. Selecting the location based on its climate risk profile, land-use options, and the implication of farmers and local government to participate and collaborate in the project.
2. Working with communities such as farmers, researchers, rural-advisory services and village officials to ensure the success of CSV.
3. Conducting a baseline survey by the researchers to know the current socio-economic situation, resources available, average production and income, vulnerability and risk management approach of village household.
4. Prioritising interventions by the stakeholders and test which climate-smart technologies and practices will suit better to the village. Farmers are encouraged to be involved in focus group discussions to express their opinions.
5. Building capacity encouraging farmers to get involved in the different practices by giving them a set of tools (machinery, newly improved seed, and index-based insurance) and approaches in advance.
6. Monitoring and evaluating the progress through a daily diary of farmers' activities that are analysed by researchers after the crop season (using identified indicators such as resilience, income, equity, farm production, among others).
7. Disseminating outcomes by publishing videos on success stories and testimonials from the pilot villages, and by presenting results in the nearby villages.

2.2.2. Climate-smart village activities

CSA practices have multiple dimensions and levels of climate-smartness. The six main key interventions in CSV activities are weather smart, water smart, carbon smart, nitrogen smart, energy smart and knowledge smart (Aggarwal et al., 2013, WorldBank et al., 2014).

There are key questions that help to assess which type of climate smartness of the different CSA practices (WorldBank et al., 2014).

- Weather-smart, the question refers if there is a reduction in climate-related risks as droughts, floods, among others when implementing CSA practices.
- Water-smart, it refers if it enhances water availability and water use efficiency.
- Carbon-smart, it refers if the CSA practice enhances soil carbon stock and reduce carbon emissions.
- Nitrogen-smart, it refers if it enhances soil nitrogen stock and reduces nitrogen-based gases emissions.
- Energy-smart, it refers if it promotes energy use efficiency and it promotes alternative energy use.
- Knowledge-smart, it refers if it promotes local knowledge and social networks for increasing producers' adaptive capacity to climate change.

For example, water-smart practice refers when there is an increase in water retention, and therefore an improve resilience. Carbon-smart, when practices contribute to the mitigation of GHG emissions through carbon management. Knowledge-smart, when the relevant CSA activities help farmers to adapt to climate change such as giving them improved seeds for climate extremes. Figure 3 shows the different smartness categories for evaluating CSA practices.

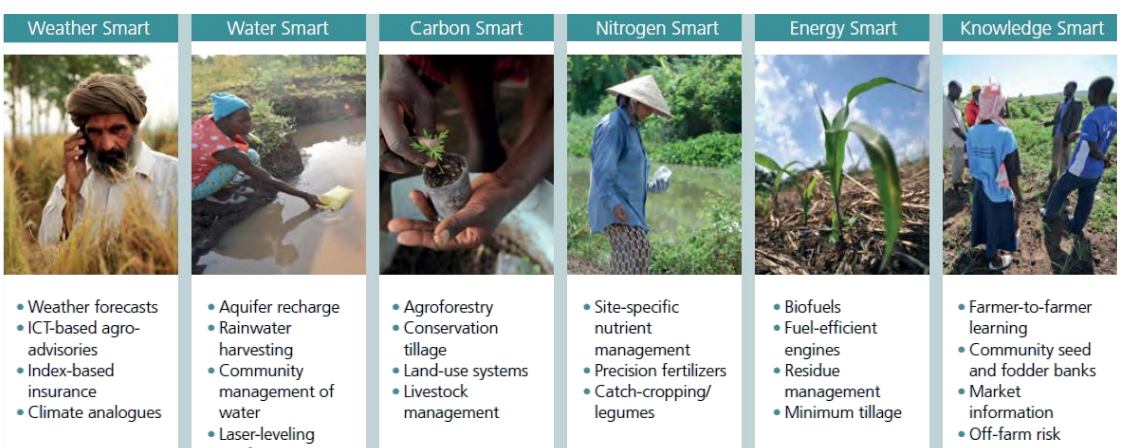

Figure 3. Examples of Climate Smart Village activities. Source: Aggarwal et al. (2013)

2.2.3. Monitoring plan

The CSV monitoring plan is a methodology developed to guide regional teams and researchers at different levels in CSA evaluation activities across the 5 CSV regions (Latin America, West Africa, East Africa, South Asia and Southeast Asia). The CSV monitoring plan includes specific indicators that track changes occurring at the plot, farm and household levels and test the hypothesis that farmer's experimentation and implementation of CSA options leads to positive biophysical and socio-economic changes at these levels (Bonilla-Findji et al., 2017a).

The CSV monitoring plan is organised to cover four research objectives (Bonilla-Findji et al., 2017a, Jarvis et al., 2017):

1. Evaluate CSA options effects on productivity, adaptation, and mitigation (versus conventional practices).
2. Assess the CSA farm performance (synergies and trade-offs).
3. Assess changes in Household Food, Livelihood Security, Adaptation indicators (adopters and non-adopters).
4. Assess CSA adoption, dissemination, and dis-adoption trends (enabling and constraining factors).

These four objectives aim to address the following key research questions in the CSV agro-ecological and socio-economical contexts:

- What are the intrinsic synergies and trade-offs (among CSA pillars) related to the implementation of CSA portfolios at plot and farm levels (vs conventional)? (Related to objective 1 and 2).
- What are the perceived (gender disaggregated) effects of CSA options implementation on Household's Food/Livelihood Security and Resilience (production, income generation, food security, adaptive capacity)? (Related to objective 3).

- Who is winning/losing with CSA? What are the effects of CSA options on labour, control over resources and participation in decision making? (Related to objective 3).
- Which are the main adoption and dis-adoption factors in a given CSV? (Related to objective 4).

The comparison of cross-site and regional CSA practices will allow examining which options work best (in most places), where (under which conditions) and for whom (gender disaggregation).

2.2.3.1. Implementation monitoring plan

The CSV monitoring plan shall be implemented at an annual frequency. Each objective has a specific responsibility (Bonilla-Findji et al., 2017a).

- Objective 1, it is under the responsibility of Project leaders that are taken CSA practices and services on field evaluations. Project leaders will have to submit their evaluations annually as part of the CCAFS Annual reporting in MARLO[1].
- Objective 2, it shall be undertaken and reported annually by the CSV regional coordination teams and will be implemented using a "CSA Cool-farm calculator tool[2]." Farm evaluations will have to be submitted as part of the CCAFS Annual reporting in MARLO.
- Objectives 3 and 4, they shall be undertaken and reported annually by the CSV regional coordination teams using the ICT based "5Q-Smart Monitoring." The implementation of these objectives should be planned for each site at the same time of the year, and it would be ideal if it is following by the most critical hunger months.

2.2.3.2. Common indicators to be tracked

Objective 1 has the following main indicators to evaluate CSA practices.

[1] MARLO (Managing Agricultural Research for Learning and Outcomes) is an online platform assisting CGIAR Research Programs, Platforms and Centers in their strategic results-based program planning and reporting of research projects. It covers the project cycle from planning to reporting and learning.
[2] CSA Cool-Farm tool is a farmer calculator that calculates the carbon footprint per production unit.

Table 1. Main indicators CSA practice performance. Source: Bonilla-Findji et al. (2017a)

Pillar	Indicator *(compared to control/ conventional practice)*	Metrics
Productivity	Yield	*Crop/Livestock production unit per Ha*
	Cost/Benefit Analysis	(Yes or No)
Adaptation	Inter-annual variation of yield	Coefficient of Variation (Standard variation of the mean)
	Reduction in yield losses	%
	Water use efficiency (when applicable)	*Ratio*
	Nutrient use efficiency	*Ratio*
Mitigation	Amount of carbon sequestered	*CO_2 eq per ha/kg*
	Amount of GHG emitted	*CO_2 eq per ha/kg*

Objective 2 has the following main indicators to evaluate synergies and trade-offs of CSA practices implemented at Farm level. To use this tool properly farmers will have to provide specific data that is easily quantified by a farmer such as the size of the family, the CSA practices currently tested, areas of the main crops, number of animals, amount of fertilisers used and management of crop residues.

Table 2. Main indicators CSA Farm Performance. Source: Bonilla-Findji et al. (2017a)

Pillar	Indicator	Metrics
Productivity	Caloric ratio of the farm (%)	Caloric supply/Caloric demand x 100
	Fodder ratio of the farm (%)	Fodder supply/Fodder demand x 100
	Cost benefit ratio (%)	Benefit/Cost x 100
Adaptation	Biodiversity index (%)	Based on Gobbi, J., Casasola, F., 2003.
	Water balance (%)	Water supply/water demand x 100
	Nutrient balance (%)	Nutrient supply/nutrient demand x 100

Mitigation	Emission/Sequestration of CO2	CoolFarmTool

Objectives 3 and 4 use 5Q-Smart Monitoring approach which gives feedback mechanisms using short surveys to collect information by asking structured and simple questions to farmers. Objective 3 includes the main indicators tracked at household level disaggregated by gender (table 3) and objective 4 examines the CSA adoption and dis-adoption trends and related factors (financial, technical/operational and social) that enable its implementation (table 4). The questions are mostly designed to elicit Yes/No answers. The first year the survey should be face to face but those in following years can be automated phone-call based 5Q surveys (Bonilla-Findji et al., 2017a, Jarvis et al., 2017).

The CSV 5Q-Smart Monitoring tool includes five modules:

- M0. Registration Module – Demographic baseline
- M1. Climate shocks
- M2. Climate services
- M3. Livelihoods security and financial services
- M4. Food security
- M5. Climate-smart options

Table 3. Main indicators to be tracked at household level (gender disaggregated). Source: Bonilla-Findji et al. (2017a)

CSA Pilar	Theme	Indicator
PRODUCTIVITY	Food Security	1. Food Insecurity Access Scale Score (HFIAS) 2. Degree of un fulfilment of basic needs 3. Self-consumption “diversification” (related to changes made in crop/livestock production both climate-induced and autonomous) 4. Perceived CSA effect on variety of products consumed (related to CSA practice)

		5. Share of main food source
	Livelihood Security	6. Perceived CSA effect on yield 7. Perceived CSA effect on additional income generation
ADAPTATION	Food Security Stability	1. Positive changes in HFIAS 2. Δ HHs' degree of basic needs fulfilment 3. Δ in Perceived CSA effect on access to sufficient food 4. Δ in Perceived CSA effect on variety of self-consumed products 5. Δ HH's External food dependency
	Coping Strategies (Absorptive capacity)	6. Δ HHs coping strategies (climate shock-induced) (sell assets; using saving/credit; reduce expenses etc.)
	Risk Mitigation actions (Adaptive capacity) - HH undertaking climate-induced or autonomous changes - (Transformative capacity)	7. Δ HH's changes in cropping/livestock activities (climate shock-induced or autonomous). (Changing mgt practices, farm infrastructure, crops) (Changed herd size, pasture/ feed management, sold, relocated, migrated the herd, livestock) 8. Δ HH's (climate shock-induced/autonomous) crop or livestock changes (substitution, diversification or stopping/abandoning) 9. Δ (HH's perceived) Change in ability to confront/recover from a future climate shock associated to changes made in cropping/livestock activities (climate-induced or autonomous changes) 10. Δ (HH's perceived) Change in ability to confront/recover from future climate shock related to CSA options

		11. Δ (HH's perceived) Capacity to undertake radical changes (climate-induced or autonomous) (grew/breed crops/livestock that never had before) 12. Δ (HH's perceived) Off-farm income generation source/dependency 13. Δ Farmers Ag-related income 14. Δ (farmers perceived) Effect of CSA on-farm/off-farm income share 15. Δ Farmers Saving capacities 16. Δ Farmers Investment capacities
	Knowledge and learning	17. Δ in Farmers receiving value chain training, per source
	Gender equity	18. Perceived CSA effect over labour time 19. Perceived effect over access/control over CSA generated resources 20. Participation in CSA implementation (Adoption/dis-adoption) decision making

Table 4. Indicators tracked in relation to CSA implementation/adoption trends. Source: Bonilla-Findji et al. (2017a)

CSA adoption/ dis-adoption trends and enabling factors	
Awareness and interest	1. Farmers' CSA options awareness 2. CSA interest from “non-adopters
Shocks	3. (Perceived) Frequency of non-climate related shocks reducing Hh incomes 4. (Perceived) Frequency of climate-related shocks reducing Hh incomes
Implementation/ dis-adoption frequency and motivations	5. HHs/farmers implementing CSA 6. HHs/farmers dis-adopting CSA

	7. HHs drivers of CSA implementation (climate-shock, proactive adaption to future shocks, markets, learning...) 8. HHs motivation for CSA dis-adoption 9. Farmers access to weather information services (per type and channel) 10. Farmers capacity/incapacity to use weather information 11. Reasons of inability to use weather information 12. Farmers CSA knowledge sources 13. Farmers receiving CSA/ CIS training
Financial enablers	14. Farmers access to credit for ag. activities (per type, source and motivation) (e.g. to recover from/prevent climate event? Make changes in crop/livestock activities? 15. Farmers access to insurance (per source and motivation, type of risk covered) 16. Farmers receiving loans, price bonus, delivery contracts from buyers/providers
Farmer to farmer dissemination	17. CSA farmer-to-farmer dissemination beyond the HH

2.4.Colombia CSA Country Profile

The CGIAR Research Program on Climate Change, Agriculture and Food security and CIAT in partnership with the World Bank Group and CATIE developed CSA Country Profiles to give an overview of the agricultural challenges in countries around the world, and how CSA help them adapt to and mitigate climate change (WorldBank et al., 2015). The regions that currently have completed CSA country profiles are Latin America and the Caribbean (Argentina, Colombia, Costa

Rica, El Salvador, Grenada, Mexico, Peru, Nicaragua and Uruguay), Africa (Kenya, Rwanda, Senegal, Mozambique, Tanzania, Zambia and Uganda), Asia (Sri Lanka, Bangladesh, Pakistan, Bhutan, Nepal and the Philippines) and Europe (Moldova).

2.4.1. Colombia: Country Context

Colombia is located between latitudes of 4 °S to 12 °N and has a typically tropical climate with wet weather. Colombia's climate is described in three climate zones: the tropical zone (24-27 °C), the temperate zone (18 °C between 1000 m and 2000 m), and the cold zone (13 -17 °C above 3000 m) (Karmalkar et al., 2010).

Figure 4: Colombia political map. Source: WorldMapStore (2017)

Due to the influence of trade winds and the Intertropical Convergence Zone (ITCZ), a bimodal regime with rainy periods is present in Colombia. The first rainy period is in March-April-May (MAM) and the second in September-October-November (SON). Rainfall on Colombia's coast averages 1000 mm per year, being heavier on the west coast and in the Andean area. In the north, there is only a long rainy season from May to October with average annual rainfall of 1070 mm (Karmalkar et al., 2010, Puertas Orozco et al., 2011).

The climate variability of Colombia is being influenced by the El Niño-Southern Oscillation (ENSO) and its opposite phase, "La Niña." ENSO is particularly noticeable in Colombia in the Pacific North, in the Andean region and the Caribbean region. "El Niño" events are associated with decrease in precipitations and river streamflow's, and warmer conditions during the late wet-season; in contrast, "La Niña" is associated with heavier precipitation, floods and colder conditions (IPCC, 2001, Karmalkar et al., 2010, Puertas Orozco et al., 2011, SIAC, 2017).

2.4.2. Agriculture

The main agricultural productions systems that smallholder farmers are involved with in Colombia are potato, maize, sugarcane, plantain, cassava, beans, tobacco, cocoa, coffee, vegetables, fruits, and other minor crops. In contrast, large agribusinesses produce commercial crops such as sugarcane, banana, flowers, palm oil, rice, cotton, sorghum, and soybean (WorldBank et al., 2014, WorldBank et al., 2015). The livestock grown in Colombia is mostly meat cattle, dairy cattle, poultry and pork (WorldBank et al., 2014)

As reported by Ramirez-Villegas et al. (2012), in the warmer regions located from sea level to 1000 m of elevation the crops planted are cacao, sugarcane, coconut, banana, plantain, rice, cotton, tobacco, cassava and as a livestock cattle for meat. In temperate regions, from 1000 up to 2000 m, the crops planted are coffee, flowers, maize, fruit, and some vegetables. Moreover, in the cooler regions, from 2000 to 3000 m, the crops produced are potatoes, wheat, barley, cold-climate vegetables, flowers, dairy cattle, and poultry.

According to the WorldBank et al. (2014), the most important production systems in Colombia are livestock, sugarcane, coffee, rice, plantain, maize, and potato as are contributing to the country's economic development and food security. Also, livestock (beef and cattle) contributes to the country's agricultural National Gross Domestic Product (GDP).

Agriculture in Colombia has been an important factor of the Colombian economy contributing between 10-14% of GDP. Moreover, in Colombia, agriculture is a support for food and nutritional security (Ramirez-Villegas et al., 2012).

According to Ramirez-Villegas et al. (2012), "Colombian agriculture features inequality, and diversity of farming systems, vulnerabilities, rates of occupation, deforestation rates and trends, crop management, and organizational levels."

2.4.2.1. Agricultural land-use

Land-use distribution in Colombia is unequal. Colombia ranks 11th worldwide land-use distribution in relation where the unequal distribution land in countries (WorldBank et al., 2015). Around 39% of Colombia's land is used for agriculture (pasture and cultivation, 37% and 2%, respectively), with forestry occupying 54% of the land (WorldBank, 2009). The following figure 5 represents the major environmental constraints related to agricultural potential.

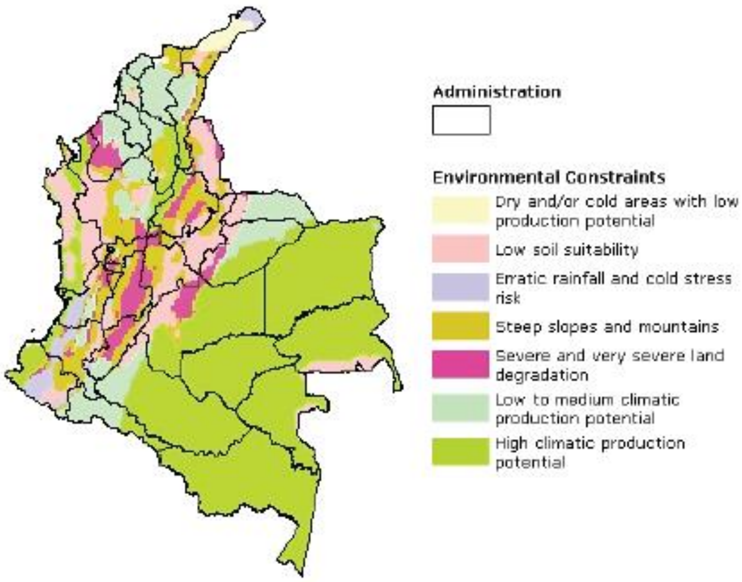

Figure 5. Baseline map of the major environmental constraints related to agricultural potential. Source: WorldBank (2009)

In 2005, according to WorldBank (2009), land-use in Colombia was mainly forestry, pasture, arable and other (54%, 37%, 2% and 7%, respectively) as shown in figure 6.

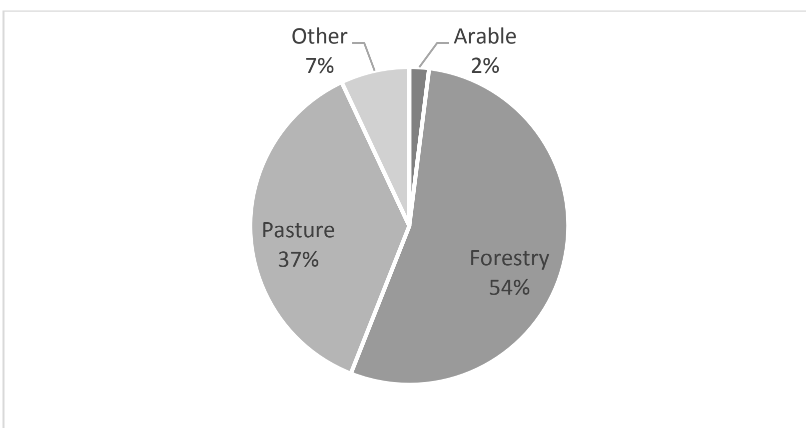

Figure 6. Land-use in 2005. Source: WorldBank (2009)

As shows figure 7, the main crop grown is coffee, followed by maize, rice and sugarcane (17%, 13%, 12% and 10%, respectively) (WorldBank et al., 2015). Moreover, in the Andean region, the predominant crops are plantain, cassava, corn, fruit and vegetables. In contrast, in the department of Valle del Cauca, sugarcane, soybeans, rice and sorghum are predominant and are using a high degree of mechanisation (WorldBank et al., 2014).

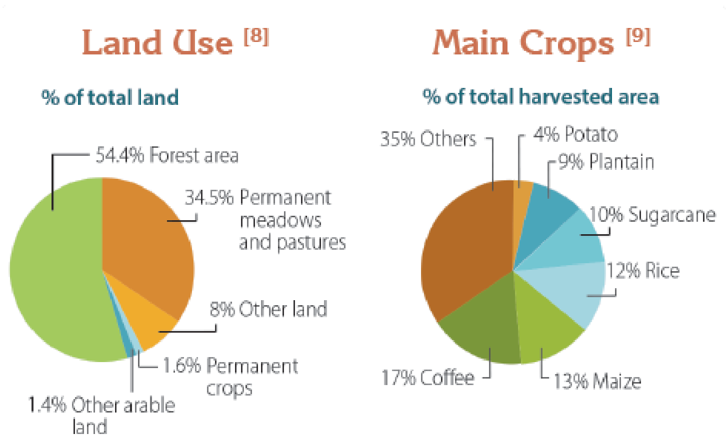

Figure 7. Land-use in Colombia in 2011. Source: WorldBank et al. (2015)

Approximately 60% of the water use in Colombia is used for agricultural activities (IPCC, 2001, WorldBank et al., 2015). Water resources have high pressure in the Andean, Central and the Caribbean regions. Pastures require 27% of water available from agricultural land-use, annual crops 14%, and permanent crops 13%.

2.4.3. Greenhouse gas emissions

In Colombia, the main sectors that contribute to the GHG emissions are energy, agriculture, land-use change and forestry, waste and industrial processes. Among these sectors, the GHGs most emitted are CO_2, CH_4, N_2O, HFCs and SF_6. Figure 8 shows the total GHG emissions during the period 1990 – 2012 in $MtCO_2e$ as reported in the Third National Communication (IDEAM, 2017).

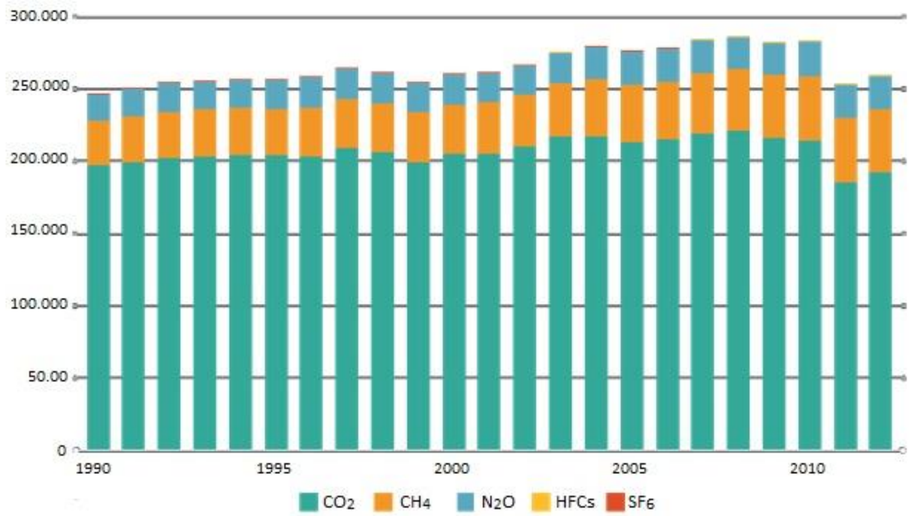

Figure 8. Total GHG emissions in Colombia 1990 – 2012 in Mt CO_2 e. Source: IDEAM (2017)

Figure 9 shows a total of GHG emissions during the period 1990 – 2014 according to CAIT (CAIT, 2017). It shows that in 1990, the total of CO_2e was 270 Mt being energy 54 Mt, agriculture 52 Mt, land-use change and forestry 150 Mt, waste 7.9 Mt and industrial processes 3.2 Mt.

In 2004, the total of CO_2e was 300 Mt being energy 63 Mt, agriculture 55 Mt, land-use change and forestry 170 Mt, waste 11 Mt and industrial processes 5.5 Mt. In 2014, the total of CO_2e was 182 Mt being energy 89 Mt, agriculture 54 Mt, land-use change and forestry 20 Mt, waste 12 Mt and industrial processes 8.3 Mt.

Figure 9.Total CO_2 GHG emissions in Colombia during the period 1990 – 2014 according to CAIT data source. Source: CAIT (2017)

However, according to the United Nations Framework Convention on Climate Change (UNFCCC) data source takes into consideration energy, agriculture, waste and 'other' as the main sectors that contribute to GHG emissions. Figure 10 represents the GHG emissions in Colombia during the period 1990 – 2004, divided by sector. In 1990, the total of CO_2e was 110 Mt being energy 51Mt, agriculture 55 Mt and waste 7.4 Mt. In 2004, the total of CO_2e was 140 Mt being energy 66 Mt, agriculture 69 Mt and waste 10 Mt (CAIT, 2017).

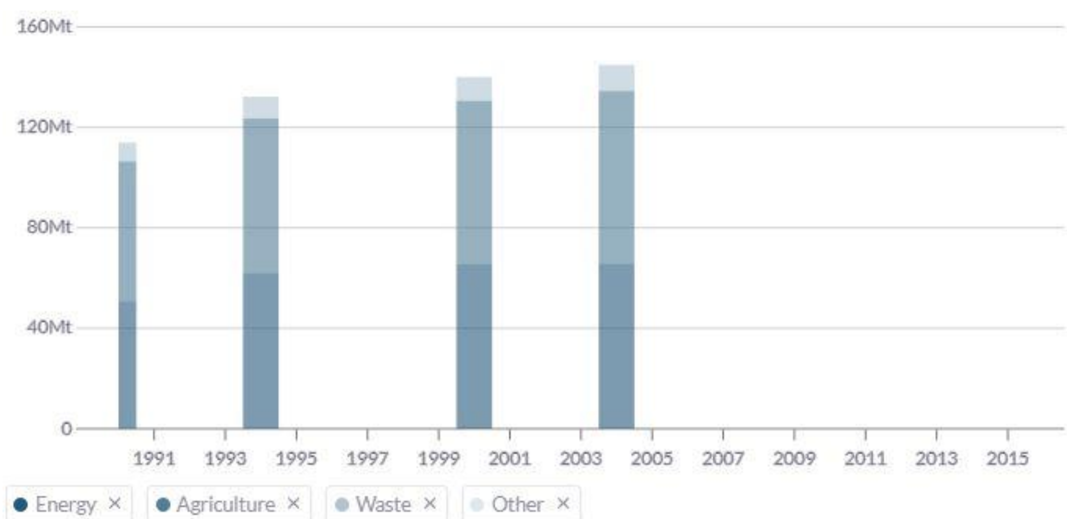

Figure 10. Total CO_2 GHG emissions in Colombia 1990 – 2004 according to UNFCCC data source. Source: CAIT (2017)

Furthermore, according to WorldBank et al. (2015) agriculture was the main sector that contributed 38% (68.5 Mt CO_2 equivalent) to the total GHG emissions in 2004. Figure 11 shows the total GHG emissions by sectors, and agriculture GHG emissions broken down in the different practices that contribute to the GHG emissions. In 2004, 50.8% of total agricultural GHG emissions were from crops, and 49.2% were from livestock (WorldBank et al., 2015).

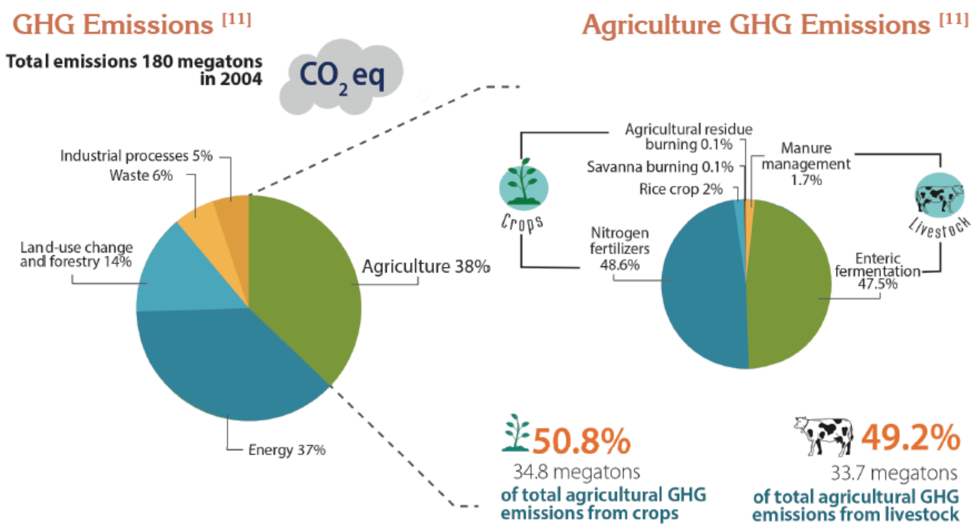

Figure 11. Total GHG emissions and Agriculture GHG emissions in Colombia in 2004. Source: WorldBank et al. (2015)

According to WorldBank (2009), in 1990 83.4% of total methane emissions were from livestock compared to the 85.8% in 1994. Methane emissions come from enteric fermentation from farm animals and the handling of animal manure. Moreover, the total nitrous oxide emissions originated from the use of cropland and fertilisers in 1990 and 1994 were 98.3% and 98.5%, respectively.

2.4.4. Current climate trends

According to Karmalkar et al. (2010), the mean annual temperature in Colombia does not show a specific trend since 1960. However, in every season between 1960 and 2006, the frequency of hot days and nights has increased by 76 and 73.5 days, respectively (21% of days and 20% of nights). The rate of increase is strongly in June, July and August for hot days and in September, October and November for hot nights. In contrast, the frequency of cold days and cold nights has decreased by 26.6 and 26.7 days, respectively (7.3% of days and 7.3% of nights). The rate of decrease is rapid in June, July and August for cold days and September, October and November for cold nights.

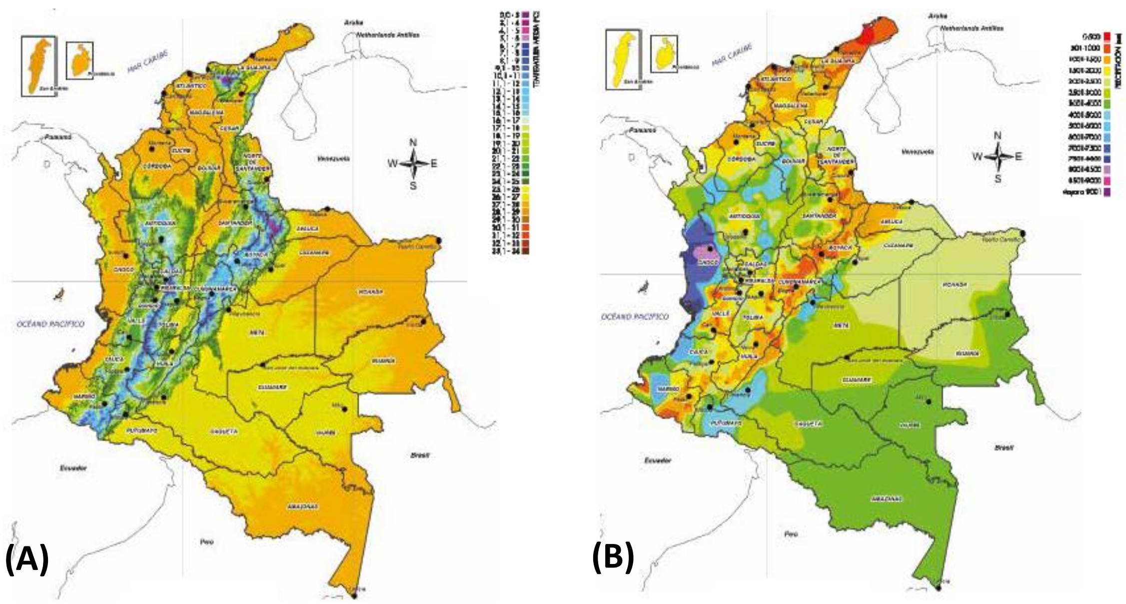

Figure 12. Average annual temperature (A) and precipitation (B) 1976-2005. Source: IDEAM (2015)

Furthermore, since 1960, the mean rainfall in Colombia shows an increase per decade in March, April, May by 6.8 mm per month (2.9%). However, there is a decrease of 3.1 mm (1.3%) per decade in June, July and August (Karmalkar et al., 2010).

According to the IPCC (2001), rainy seasons have been occurring earlier in recent years than 25 years ago. Furthermore, in the main rivers, Cauca and Magdalena Rivers, there is a decreasing trend in the river streamflow. Deforestation also accounts for decreasing trends in river discharges. ENSO events are affecting negatively the lowland areas (Amazon, Orinoco and Parana River) and the mouth of Magdalena River among others with the flooding associated with sea-level rise.

2.4.5. Future climate trends

According to Karmalkar et al. (2010), the mean annual temperature in Colombia is expected to increase by 1.1 to 2.5 °C by the 2060s, and 1.5 to 5.4 °C by the 2090s. All scenario projections show increases in the frequency of hot days and nights. It is projected that hot days will occur on 21-24% of days by the 2060s, and 25-70% of days by the 2090s. It is expected that in September, October and November the hot days will increase rapidly taking place on 36-89% of nights by 2090s. Besides, all scenario projections show decreases in the frequency of cold day and nights.

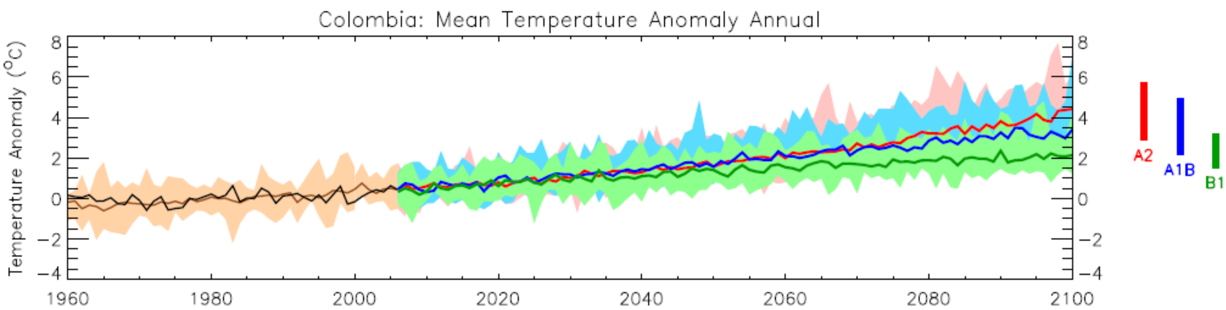

Figure 13. Trends in annual mean temperature for the recent past and projected future in Colombia. Source: Karmalkar et al. (2010)

The third National Communication on Climate Change to the UNFCCC (IDEAM, 2015) stated that if the levels of GHG emissions increase the average annual temperature could increase by 2.14 °C by 2100.

Moreover, projections of mean annual rainfall in Colombia show increases in rainfall. By the 2090s, annual projections fluctuate between -11 to +19% of rain and 5-day rainfalls tend to increase in scenario projections changing by -13 to +33 mm (Karmalkar et al., 2010).

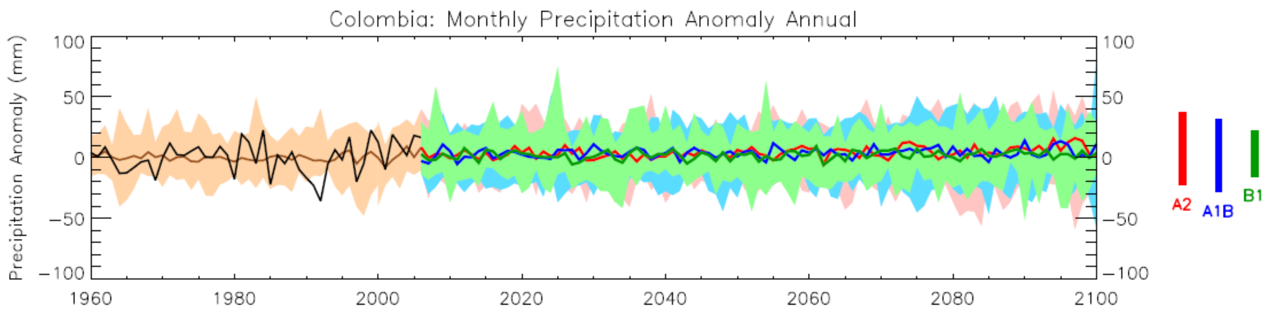

Figure 14. Trends in annual precipitation for the recent past and projected future in Colombia. Source: Karmalkar et al. (2010)

On the one hand, of precipitation is expected to decrease by 10 – 30% by 2071-2100 in 27% of the national territory (Amazonas, Vaupés, south of Caquetá, San Andrés and Providencia, Bolívar, Magdalena, Sucre and north of Cesar). On the other hand, it is expected for the same period an increase of precipitation by 10 – 30% in 14% of the national territory (Nariño, Cauca, Huila, Tolima, Eje Cafetero, west of Antioquia, north of Cundinamarca, Bogotá and centre of Boyacá) (IDEAM, 2015).

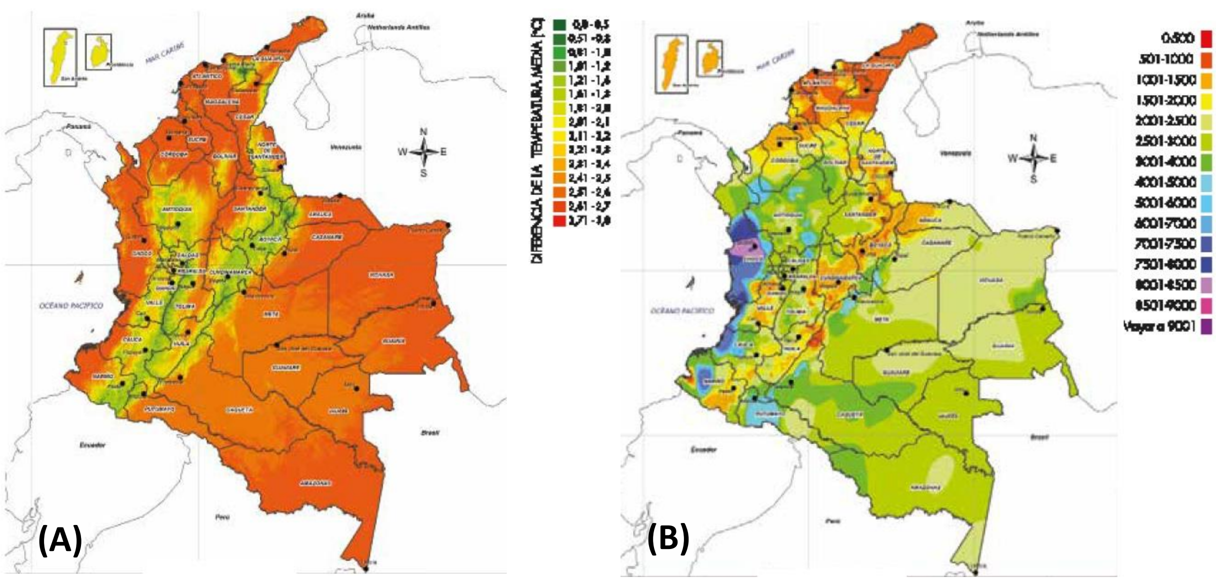

Figure 15. Change of temperature (A) and precipitation (B) between scenario 2071-2100 compared to the average reference precipitation 1976-2005. Source: IDEAM (2015)

According to the WorldBank et al. (2015), the Second National Communication of Colombia to the UNFCCC, projected changes under the A2 climate scenario, including:

- Increase of 1.4 °C in annual temperature by 2040.

- Increases in temperature would result in prolonged and intense drought seasons and proliferation of pests.
- Reduction in average annual rainfall of 10% or more affecting the water availability in some departments.

As stated by Karmalkar et al. (2010), there is a disagreement in different model simulations about the projected changes in the amplitude of future "El Niño" events in Colombia.

2.4.5.1. Future climate trends in Cauca

Climate change scenario projections show that the Cauca region will increase the temperature above 2.5 °C, and precipitation will tend to decrease by 2050 (Mora Montero, 2017b).

According to Minambiente (2016), the scenario projections for temperature show that by 2040-2070 and 2071-2100 it would be an increase in average temperature by 0.5 °C – 1 °C. Towards 2070 and 2100 these changes and increases could oscillate to an increase in temperature that can reach from 1.4 °C in the Andean Region and 2.6 °C in Pacific Region by 2100.

Furthermore, Minambiente (2016) stated that the changes in precipitation in the next 30 years tend to concentrate in the Pacific region, and with less incidence to the centre, south and north regions of Cauca with an average by 16% more of precipitation. Towards 2070 and 2100 this increasing tendency remains on the Pacific Coast. By 2100, the increase of precipitation could be an average of 18% compared with equivalent values from the period 1976-2005.

Figure 16 shows A) the difference of temperature between scenario 2071-2100 compared to the average reference temperature 1976-2005 and B) the change of precipitation between scenario 2071-2100 compared to the average reference precipitation 1976-2005.

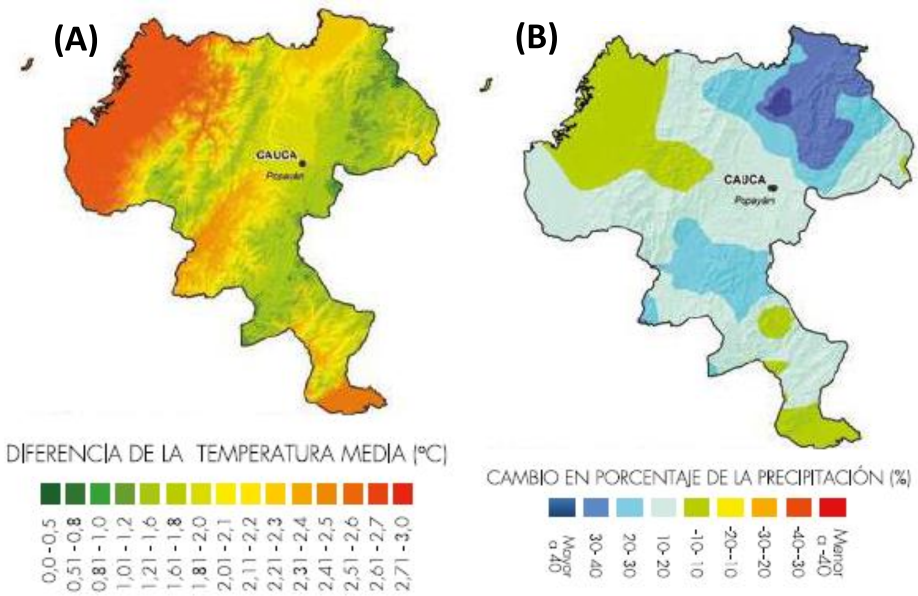

Figure 16. Climate change Scenarios for the Cauca Department. (A) Temperature, (B) Precipitation Source: Minambiente (2016)

2.4.6. Climate change impacts

Climate change impacts in Colombia are expected to affect the altitudinal limits of forest and agriculture, reducing the life zone and possibly causing the disappearance (or displacement) of current fauna and flora (IPCC, 2001, Minambiente, 2016). The rise in sea level will also affect people living in coastal towns and cities as it has been estimated that the sea level could increase by 40-60 cm by 2050-2060 compared to the period 1961-1990 (WorldBank, 2009, IDEAM, 2015).

Climate change will affect the agricultural socioeconomic of Colombia (Ramirez-Villegas et al., 2012). Crops associated with food security (maize, beans, plantain and yucca) will be the ones more affected by the climate change in the Andean region (Mora Montero, 2017b). Losses in coffee, fruit, cocoa, and bananas will be affected as well, and changes may occur to the distribution of pests and diseases; non-technically developed smallholders are likely to be increasingly vulnerable as a result of these changes (Ramirez-Villegas et al., 2012).

As reported by Minambiente (2016), “La Niña” event in 2010-2011 affected more than 49.000 families with agricultural losses. Also, “El Niño” event in 2015 caused significant decreases in the quantity and quality of products such as maize, beans and vegetables.

According to IDEAM (2015), Minambiente (2016), Ramirez-Villegas et al. (2012) and WorldBank (2009), increased temperature and changes in land use will increase desertification processes, decrease the productivity of agricultural land and lead to loss of water resources (e.g. the disappearance of snow cover in the high mountains). Also, decreases in precipitation patterns will intensify desertification processes and loss of water resources affecting human health, agricultural and forestry production, economy and regional competitivity. Increases of precipitation can increase the possibility of landslides, the affection of rural aqueducts and damage to road infrastructure on mountain areas, as well as the risk of floods in flat areas of the country, and salinisation of agricultural lands.

Furthermore, as stated by Ramirez-Villegas et al. (2012) the expected climate change impacts, its respective crops impacted, and adaptation measures for Colombian agriculture are the ones described in table 5.

Table 5. Expected climate change impacts, crops likely to be impacted and adaptation measure. Source: Ramirez-Villegas et al. (2012)

Expected Impacts	**Crops likely to be impacted**	**Adaptation measures**
Changes in crop phenology and the subsequent impact on product flow to markets and supply chains	Coffee, *Musa* crops, upland rice, maize, soybeans, common beans, fruit trees	Changes in harvest and sowing dates. Infrastructural changes for perennial crops (irrigation, drainage).
Flooding of agricultural lands due to increases in sea level and salinisation of underground water	African oil palm (Pacific coast), *Musa* crops (Urabá)	Re-location of activities according to new territorial ordering plans. Walls and barriers construction to prevent salinisation and protect coastal ecosystems.
Changes in pests and diseases: increases and displacement to new regions	Coffee (above 1,500 m.a.s.l.), *Musa* crops (above 500 m.a.s.l.), potatoes above 2,500 m.a.s.l., cassava, fruit trees	Find out pest and disease resistant and/or tolerant materials. Implementation of monitoring and early-warning systems in order to

		implement sustainable management.
Intensification of land degradation processes and desertification	Potatoes and cassava in Andean mountain hillsides	Increase soil resilience by improved and sustainable agronomic management (i.e. optimised used of inputs and barriers to avoid soil erosion).
Increased vulnerability of small producers to climate variability and climate change	All crops (sectors with significant dispersion within the country should be addressed in the first place)	Creation of adaptation subsidies and an agricultural insurance system for mountain hillside producers and for arid areas. Big producers and the government should invest in research, extension and technology transfer to support smallholders
Risk of loss (extinction) of not currently ex-situ conserved or underrepresented plant genetic resources	Prioritization of activities that require genetic improvement: fruit trees, avocado, *Musa* crops, coffee, potatoes	The government should stimulate the better conservation of plant genetic resources and should provide funding for such purpose. National and international institutions within the country should perform analyses on high-risk areas, incomplete collections and organise collecting missions.
Gradual loss in crop and pasture suitability and productivity, including the possible abandonment of current crop lands	Sugarcane, coffee (above 1,500 m.a.s.l.), potatoes (below 2,500 m.a.s.l.), Musa crops (below 500 m.a.s.l.), citric fruit trees (highlands), livestock	Locate heat-resistant varieties in relevant gene banks. Currently, conserved plant genetic resources should be queried in order to determine the likely gene sources and to further establish genetic improvement strategies.

The changes in temperature and precipitation can impact significantly to the production and earnings from the coffee fields as is the fourth department producer of this crop (Minambiente, 2016).

2.4.7. Institutions and policies for CSA

Colombia became a party of the Kyoto Protocol in 2001 and a party of the United Nations Framework Convention on Climate Change (UNFCCC) in 1995. Colombia submitted its Third National Communication in 2010. Since 2001, Colombia has started to take many adaptation and mitigation measures in relation to climate change (Ramirez-Villegas et al., 2012, WorldBank et al., 2015).

Colombia has different strategies that try to analyse the potential changes in the climate. It studies the vulnerabilities and creates instruments for the management such as the Colombian Low-Carbon Development Strategy (ECDBC, Spanish acronym), the National Strategy for Reducing Emissions from Deforestation and forest Degradation (ENREDD+, Spanish acronym), and the Climate Change National Adaptation Plan (PNACC, Spanish acronym) all included in the 2011 CONPES 3700 Institutional Strategy to Articulate Climate Change Policies and Actions in Colombia (Minambiente, 2016, WorldBank et al., 2015). Moreover, the National Development Plan 2014-2018 “Todo Por un Nuevo País” contains different climate change management measures and mention the need to consolidate a National Climate Change Policy (Minambiente, 2016). Also, the Integrated National Adaptation Project (INAP) was intended to define and implement prevention and adaptation measure to climate change (WorldBank, 2009).

According to Minambiente (2016), Government of Cauca, an Autonomous regional corporation of Cauca (CRC) and the Ministry of Environment and Sustainable Development (MADS) developed the Integral Territorial Climate Change Management Plan for Cauca 2040 (PIGCCTC) to promote a long-term vision and to have a resilient and low-emission department.

The primary institutions engaged in CSA according to WorldBank et al. (2015) are presented in figure 17[3].

[3] Acronyms of the institutions are listed on page 3

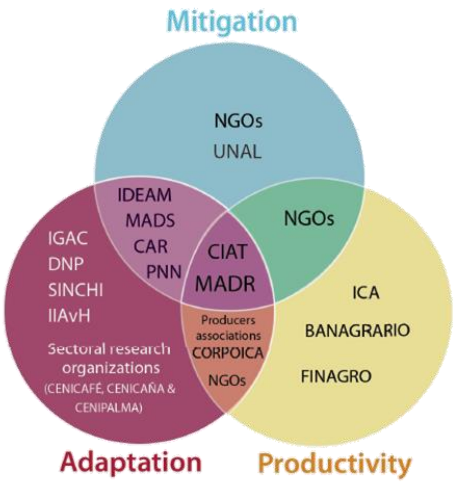

Figure 17. Primary focus of Institutions Engaged in CSA. Source: WorldBank et al. (2015)

The environmental policies that enable CSA and enhance agricultural productivity, adaptation and mitigation are represented in figure 18.

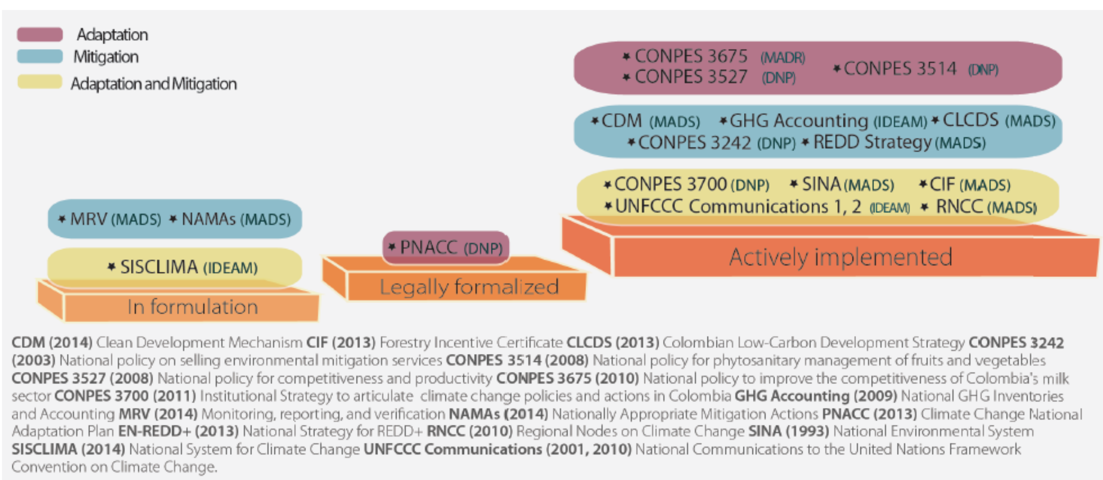

Figure 18. Enabling Policy Environment for CSA. Source: WorldBank et al. (2015)

2.5. Cauca Climate-Smart Village

Cauca is a department with a higher climatic vulnerability in Colombia. In 2014, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) started to implement CSV in Latin America. Cauca CSV has been implemented in 14 sites located in the northwest of Popayán, the capital city of Cauca Department (CGIAR-CCAFS, Mora Montero, 2017b).

Figure 19. Cauca CSV location. Source: Mora Montero (2017b)

This project has been developed in association with Ecohabitats Foundation; a non-profit organisation specialised in participatory processes of adoption and mitigation to climate change with rural communities located in Popayán. CSV is based on an Innovation Platform from which a participatory process is generated to strengthen the ability of small producers to adapt to climate change and variability. Farmers, technical assistants, researchers, private industry and government, test and adopt the different practices, technologies, services and institutional mechanisms that contribute to productivity, adaptation and mitigation (Mora Montero, 2017a).

The Cauca CSV covers 59% of the Palace river sub-basin area, with an extension of 10.295 hectares and home to 500 families; it is in the Cauca river upper basin. Cauca CSV is found between 1.550 and 1.700 m above sea level (m.a.s.l.) (Ramirez, 2016, Twyman, 2016). Between 2015 and 2016, 80 families have been involved in the Cauca CSV pilot (Ramirez, 2016).

As reported by Bonilla-Findji et al. (2017c), the altitude of the Cauca CSV AR4D site is 1760 m.a.s.l., size of the farms are between 2 and 5 Ha, 1491 of total households (HH), 9% are women headed HH, the crops produced are coffee, sugar cane, beans and vegetables and the animals are pigs and hen.

The following figure 20 shows where the different villages are based, and the village baseline study in Los Cerrillos.

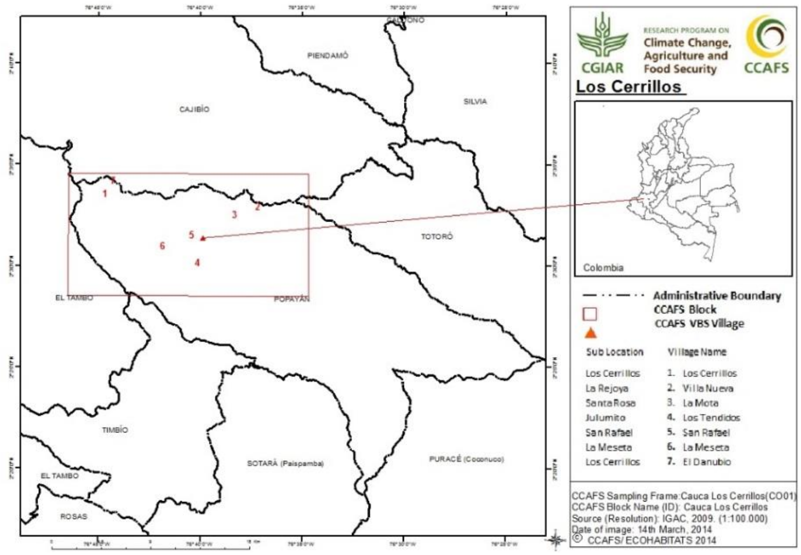

Figure 20. Location Los Cerrillos in Cauca. Source: Paz and Ortega (2014)

2.5.1. Cauca CSV social and biophysical characteristics

According to Ramirez (2016), Ecohabitats Foundation in 2015 stated that in Cauca CSV 89% of the population is mestizo peasant and 11% is Afro-Colombian or indigenous. The education level in the area is limited, at list one of the members of the house finished primary school (37%) and secondary school (47%). 26% of the houses have access to properties that are less than 1 hectare, 61% of them to areas between 1 and 5 hectares, and 12% to areas larger than 5 hectares.

The coverage and land use in Cauca department, in 2010, was 73% of the area was represented in 40% forests, 19% pastures and 14% secondary vegetation. The 27% remaining was covered with heterogeneous agricultural areas, crops, planted forests, lagoons, glaciers, urban areas, natural and artificial inland water, grasslands among others (Ramirez, 2016).

Moreover, the coverage and land use in Cauca CSV is similar to the Cauca department regarding forests and pastures being 76% of the territory, similar to the 73% for the whole department. The remaining 24% is distributed in two main groups, 16% of which includes coffee crops (12%), sugarcane (2%) and other crops (1,3%), and 8% consisting of roads and paths, lakes, houses, rivers, greenhouses and infrastructure (Ramirez, 2016).

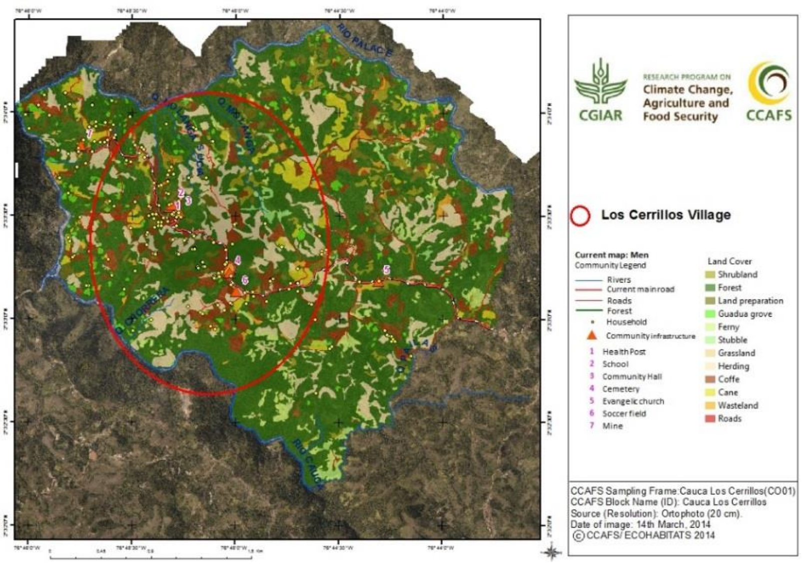

Figure 21. Land cover in Los Cerrillos Village. Source: Ortega and Paz (2014)

Regarding the climate, Cauca CSV is located in the Popayan plateau on lands with slopes between 12 and 25%. The territory presents a range of temperature between 15 and 25 °C, precipitation between 2.300 and 3.000 mm per year. It is characterised by having a raining period between October and May, with monthly average precipitation of 228 mm, and a dry season with low volumes of rain between June and September with monthly average precipitation of 89,5 mm. Figure 22 summarises the monthly multiannual precipitation between 1971 and 2014 (Ramirez, 2016).

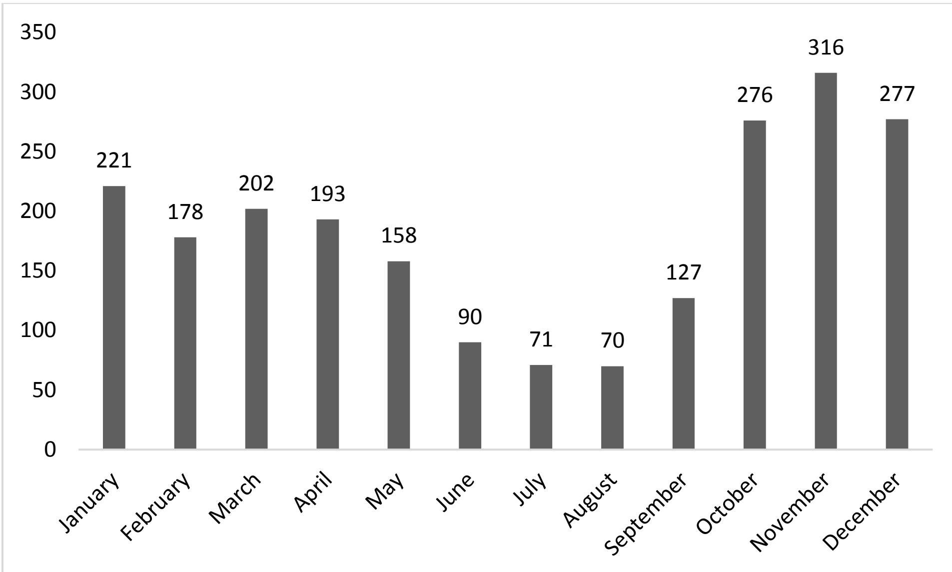

Figure 22. Monthly multiannual precipitation 1971-2014. Source: Ramirez (2016)

2.5.2. Productive systems and practices

In Cauca CSV, the predominant crops are shade-grown coffee, unshaded coffee, and intercropped shade coffee with sugarcane.

According to Ramirez (2016), in 12 sites in Cauca CSV, there is a coffee tradition being the predominant crop either with shade-grown coffee with fruit trees (citrus, avocado, guamo), banana and timber or unshaded monoculture coffee (full-Sun). The most sown variety is Castillo (85% of the region), and the other 15% a mix between Castillo, Colombia and Caturra, which are preferred for their pest and disease resistance.

2.5.3. Cauca CSV socioeconomic analysis

This block refers to the surveys realised to the producers where the socioeconomic characteristics of the producers, the cost-effectiveness of adaptation measures, and were the externalities where identified.

2.5.3.1. *Socioeconomic characteristics of producers*

As stated by Ramirez (2016), the results of 14 families surveyed are that more than 80% have coffee crops, firstly, 35% of the field is shaded monoculture coffee, secondly, 24% are unshaded monoculture, thirdly, 12% are shade-grown coffee with sugar cane, and finally, 6% have unshaded coffee with sugar cane. Barely 6% of the families have monoculture sugar cane.

Moreover, 12% of the field is intercropped with unshaded coffee and shade-grown coffee, and 6% are fields with semi-shade grown coffee (figure 23).

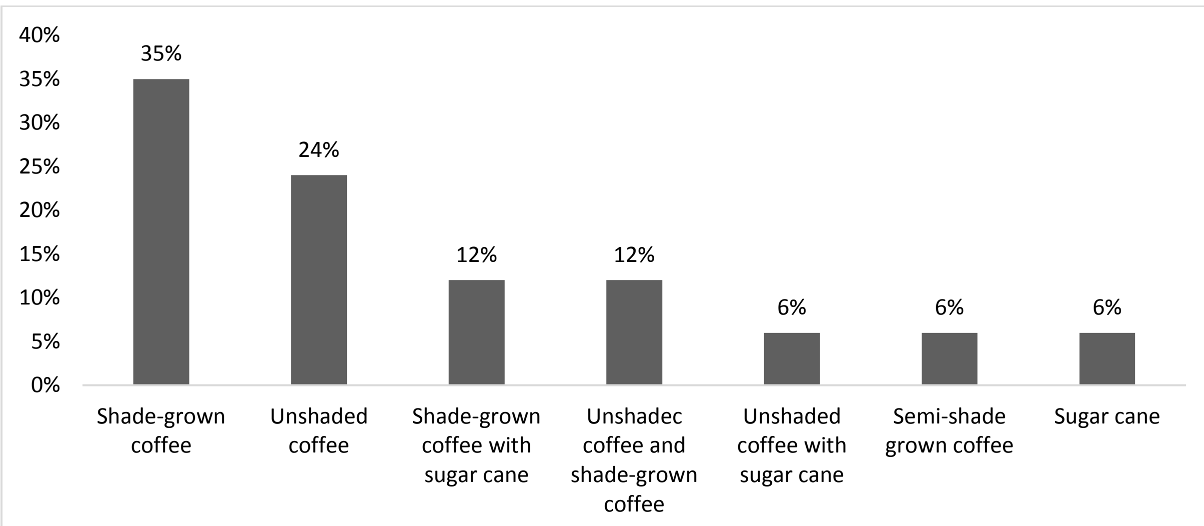

Figure 23. Frequency of the productive systems in Cauca CSV. Source: Ramirez (2016)

Furthermore, the results of Ramirez (2016) are in accordance with the 2015 study of Ecohabitats which found that the predominant productive systems in Los Cerrillos were coffee crops with variation in the type of the culture such as shade-grown coffee or unshaded monoculture.

Moreover, 93% of the 14 producers surveyed have finished primary school, and one of the people surveyed is a professional and was a teacher. All the respondents are older than 40 years old: 43% are between 40 and 50 years old, 36% are between 50 and 60 years old, 14% are between 60 and 70 years old, and 7% are older than 70 years old (figure 24) (Ramirez, 2016).

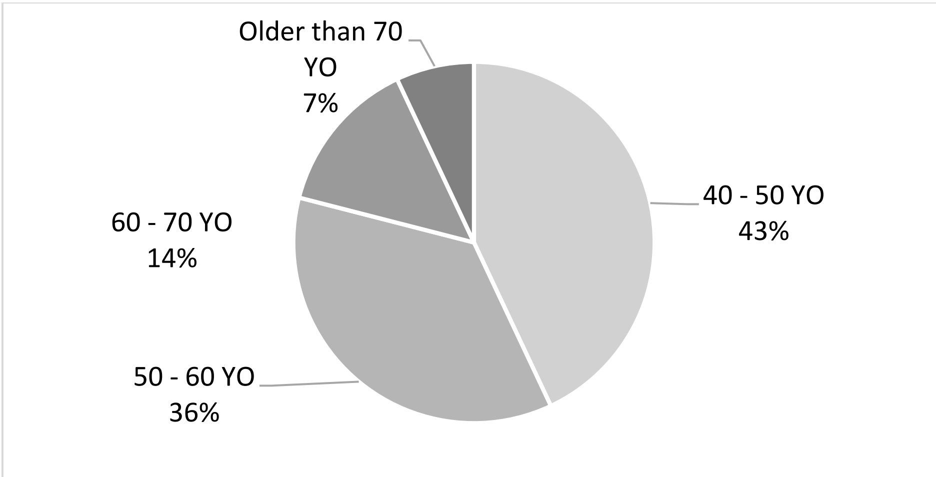

Figure 24. Age of the respondents in Cauca CSV. Source: Ramirez (2016)

According to Ramirez (2016), these results are relevant to understanding that the owners of the fields are not young people, but 43% of the owners are between 40 and 50 years old. This suggests they will be taking care of the fields for a long time as the life expectancy in Colombia is 71 and 77 for men and women, respectively.

Also, 70% of the respondents are associated, and 21% are not associated. Among the associated respondents, 43% are members of "Agricod Cooperativa de café de la vereda El Danubio", 14% of Asoagro, 7% of Asancerillos, 7% of Asopanela and 7% of Provitec (figure 25) (Ramirez, 2016).

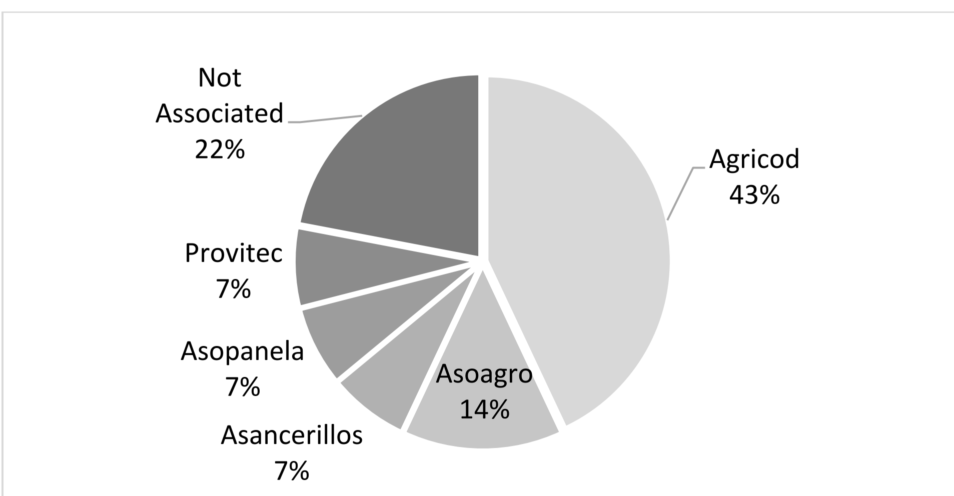

Figure 25. Membership of associations of producers surveyed in Cauca CSV. Source: Ramirez (2016)

According to Ramirez (2016), being members of an association has allowed the respondents to undertake stronger challenges such as the one that Agricod undertook to produce unique coffee for export, improve its power of negotiation by selling its products, and undertaking social projects in favour of all the community.

Among the 14 producers surveyed, 12 of them on their fields have vertical and rectangular gardens with vegetables. The vegetables that are grown in Cauca CSV are carrot, cucumber, chard, radish, parsley, beet, cabbage, lettuce, tomato, welsh onion (scallions), celery, spinach, and cilantro (Ramirez, 2016).

2.5.3.2. Cost-effectiveness of adaptation measures in the shade-grown coffee and unshaded coffee

The financial evaluation of the adaptation measures has been corroborated with the different surveys made in November 2016 in Cauca CSV. Through these surveys, it has been identified that the fields that have shade-grown coffee without any adoption measures obtain yields 10% smaller than those of shade-grown coffee that has implemented the adaptation measure. In contrast, the fields that have unshaded coffee and did not adopt any adaptation measures obtain yields 30% lower compared to the producers that did implement them in their unshaded coffee fields when facing the dry season (Ramirez, 2016).

The highest drought impact on the unshaded coffee fields that did not implement any adaptation measures is due to the highest vulnerability compared to the ones that are shade-grown coffee without adaptation measures. According to Ramirez (2016), unshaded coffee requires a more considerable amount of fertilisers, contributing to the fall of yields if the application of fertilisers is not appropriated.

2.5.3.3. Identification of externalities

Externalities are the indirect effects generated through the implementation of CSA practices on natural resources, especially in biodiversity, in the quality of soil and water, flora, fauna and reduction of GHG emissions (Ramirez, 2016).

According to Ramirez (2016), drought is the major hazard that farmers are noticing on their coffee and sugarcane productivity. A reason for this, most of the adaptation measures are focused on how to deal with this phenomenon.

Drought and higher temperature due to heat waves in summer generates a loss of soil moisture that the rains have provided, and harms the development of the crop, decreasing yields, eliminating beneficial insects, increasing erosion and soil degradation (Ramirez, 2016).

Furthermore, soil degradation has important implications for mitigation and adaptation to climate change. Since the loss of biomass and organic matter from soil releases carbon into the atmosphere and affects the quality of the soils and its capacity to keep water and nutrients (Ramirez, 2016).

As reported by Ramirez (2016), in Cauca CSV since 2015, it has been introduced seven CSA practices for the provision of water: artisan "ariete", reservoir, camandula water pump, water harvesting in paddocks, portable micro-spray, rainwater harvesting and drip irrigation.

Furthermore, the different families of Cauca CSV use organic fertilisers to produce vegetables and coffee crops. The organic fertiliser is made from vermicomposting, livestock manure, poultry manure, coffee husk and pulp, leaves and bagasse cane, litter, pastures, inputs that are produced on the same farm and whose preparation has required training given by instructors from the Ecohabitats Foundation.

There are different socio-economic and environmental benefits from 1) indirect benefits of the adaptation measures for the management of water, 2) external benefits from biofactory and use of organic fertilisers, 3) benefits of the organic family garden, and 4) benefits of multi-layer fringes (Ramirez, 2016).

1. Socio-economic benefits from drip irrigation: saving water, increase of crop yields and reduce soil salinisation. Environmental benefits from rainwater harvesting: decrease

of soil erosion, conservation of natural resources such as soil, water, and biodiversity, increases in agricultural productivity, and ensure food security.

2. Socio-economic benefits: saving fertilisation costs, reduce the toxic risk for humans and animals, use of familiar hand labour, and knowledge gain of how to manage the fields sustainably. Environmental benefits: increase of soil biodiversity, better soil structure, a decrease of using fossil combustibles as there is a change from chemical inorganic fertilisers to organic fertilisers contributing to mitigate GHG, and a decrease of soil and water pollution.
3. Socio-economic benefits: ensure food security all the time as is a staggered production, women are the ones that oversee this activity, and the excess production generates an added income. Environmental benefits: use of organic fertilisers decrease soil and water pollution, an increase of soil biodiversity, and a decrease of GHG emissions.
4. Socio-economic benefits: trees produce fruits and fodder, foliage used as fodder, and protect cultivation and animals from the wind. Environmental benefits: multi-layer fringes give green manure, doffer and firewood through pruning, act as biological corridors for flora and fauna, function as live barriers to control erosion, conserve moisture in hillside areas, reduce speed of water and decreases wind speed on hillsides, and an increase of carbon capture through trees in the multi-layer fringes.

3. Methodology

In this section, the methodology used to evaluate the data from Cauca-CSV in order to achieve this Masters in Climate Change, Agriculture and Food Security (MScCCAFS) thesis objective of developing an instrument to support local stakeholders and practitioners in their planning and decision-making processes to promote and scale out CSA will be explained.

The data analysed is from a Gender-sensitive Smart Household Monitoring instrument to assess CSA performance and outcomes. These surveys took place on March 2018 in seven locations (El Danubio, La Mota, Las Mercedes, Los Cerrillos, Los Tendidos, San Antonio, and San Rafael) in Cauca-CSVs. Seven trained enumerators from the seven different locations surveyed smallholder farmers engaged in different CSA practices in Cauca-CSV.

3.1.CSV Monitoring Plan

The CSV Monitoring Plan (Bonilla-Findji et al., 2017b, CSIR-SARI, 2017) was designed in 2017, and it is an ICT-based Smart Household Monitoring Instrument to identify the range of household typologies that are experimenting with CSA options and generating gender disaggregated evidence on:

- CSA adoption trends (within different types of households identified)
- Frequency of climate-related shocks and/or out-migration, coping strategies and risk mitigation actions,
- Practice-specific motivations, enabling/limiting adoption factors,
- Perceived impacts on gender equity/empowerment aspects (labour time, control over resources, participation in decision making) and on,
- Perceived performance and outcomes of specific CSA options on households' livelihood/food security and resilience.

The household monitoring will be implemented through the cost-effective, efficient and scalable Geo farmer application system which enables to organise all collected data (geospatial information and survey responses) in one central database. It is an application which integrates means of interactions for effective feedback and monitoring of experimental testing of agricultural practices. Local facilitators can use a smartphone application to register farmers' responses, execute surveys, asking structured and simple questions to farmers, and collect geographical point information. These structured questions are linked to a set of indicators to evaluate the performance of CSA options at household and community levels. Indicators cover aspects related to Food & Livelihood Security; Resilience and Coping Strategies, Risk Mitigation actions and capacities; knowledge and learning and gender aspects.

At the community level, indicators will allow tracking the occurrence of climate and non-climate shocks, CSA options awareness, access and implementation, enabling/constraining factors and dissemination mechanisms. Supplementary variables will also be collected mainly in order to understand drivers of adoption or dis-adoption such as climate shocks, access to training and knowledge diffusion mechanisms. In an initial registration module of the surveys, individual farmers were asked questions about some their household socio-economic characteristics that will then be used to identify the different household types present in the CSV. Surveys will be repeated in yearly intervals to improve monitoring of change. Cauca-CSV survey was the first time that took place. Experts for monitoring will be able to access a web-dashboard to create and manage surveys, provide information on CSA options and access results from surveys. Changes observed in the indicators will inform all stakeholders involved in activities on CSVs.

3.2. Analysis of the data

The data from the surveys was given on a Microsoft Excel file. Modules 0 to 5 – M0. Registration Module (demographic baseline), M1. Climate Shocks, M2. Climate Services, M3. Livelihood security and Financial services, M4. Food Security, M5. Climate-smart option – were organised in different Microsoft Excel sheets. Before analysing the data, some steps were taken:

1. Raw data was reviewed.
    a. To facilitate the review, the surveyed smallholder farmers were ordered from highest to lowest according to the variable address. This made easier to know who belongs to the same farm.

b. Each module (M0-M5) was reviewed separately using locality as a filter. Checking the modules by locality made easier to find errors as each smallholder from a specific locality was surveyed from the same enumerator.

c. The answers were reviewed while checking the Question Tree "CSV-5Q Implementer" to check which questions need to be answered depending on the structure of the survey and its previous answers.

2. Indicators were calculated.

   a. Each indicator (table 3 and table 4) relates to one or a few questions from the survey. Before calculating the indicators, it is necessary to identify which questions related to each indicator.

   b. Once the specific questions had been identified, then the metrics and the formulas in words for each indicator were written down.

   c. Each indicator has to take into consideration disaggregated gender, head households, CSA implementers and non-implementers, the different CSA practices implemented in Cauca CSV, and climate events that affected the smallholder farmers when required for the indicator. Also, each indicator was calculated as a global result for Cauca CSVs and for each Cauca CSV site.

   d. Indicators were calculated as a percentage. Before getting the final result of each one, it was calculated how many people answered each question for Cauca CSVs and for the seven different sites – disaggregated by gender and head households when required.

   e. To calculate indicators related to the Household Food Insecurity Access Scale (HFIAS) was used the "*Household Food Insecurity Access Scale (HFIAS) for Measurement of Household Food Access: Indicator Guide*" section 5.3 – HFIAS Score (Coates et al., 2007).

3. Graphs were done with the software TIBCO® Spotfire® Desktop 7.5.0.

4. Results

This section presents the results of the Cauca-CSV surveys in order to achieve this MScCCAFS thesis objective of developing an instrument to support local stakeholders and practitioners in their planning and decision-making processes to promote and scale out CSA will be explained.

4.1. General data and characteristics of farmers

The survey from the monitoring plan was taken in 7 villages from Cauca CSV, El Danubio, La Mota, Las Mercedes, Los Cerrillos, Los Tendidos, San Antonio and San Rafael. 262 participants were surveyed (131 men and 131 women). 164 households were listed to be surveyed, but among all the households listed only 86% (N =141)[4] of them responded as head of the household. 51.1% of the household in the survey were male-headed (Table 6).

Each household in the survey was required to have at list one head of household plus another member of the household, i.e. spouse to be able to participate. Not filling correctly the question affected the calculation of the indicators as most of them required the answer head of the household.

Table 6. Survey participants

	Farmers	Couples	Men	Women	Households	Heads of Households	Head of HH - female	Head of HH - male
El Danubio	30	10	15	15	20	20	11	9
La Mota	39	16	18	21	23	22	12	10
Las Mercedes	37	14	18	19	23	22	8	14
Los Cerrillos	61	24	30	31	37	36	18	18
Los Tendidos	38	16	19	19	22	21	13	8
San Antonio	24	4	11	13	19	16	6	10
San Rafael	33	13	20	13	20	4	1	3
Total	**262**	**97**	**131**	**131**	**164**	**141**	**69**	**72**

[4] The survey is made as a question tree typology survey, and it has 33 questions out of 346 that every survey participant must been answered. 45.5% of the required questions were not answered by the total of the participants.

Of the survey participants (that answered the question, N =163) 92.6% belong to the ethnic group mestizo peasant, 0.6% to Nasa, and the rest did not specify (6.8%).

The majority of the survey participants (66%) were born between 1940 and 1970 (68 and 38 years old), with few participants (4.6%) born after 1990 (28 years old and younger) (Figure 26)[5].

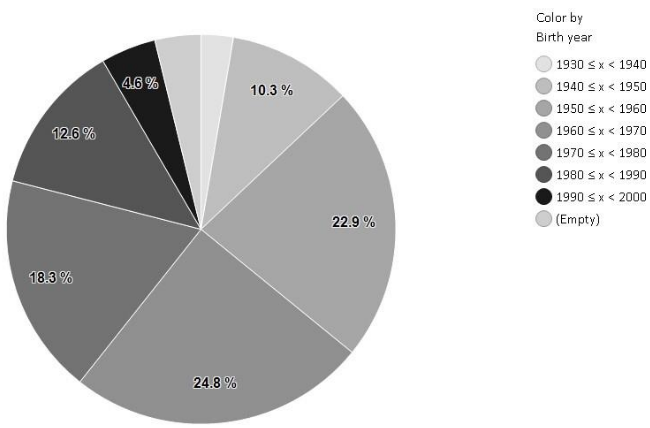

Figure 26. Participant's birth year

Of the participants surveyed (N = 262) more females had more formal education (secondary, technical and university) than males (Figure 27).

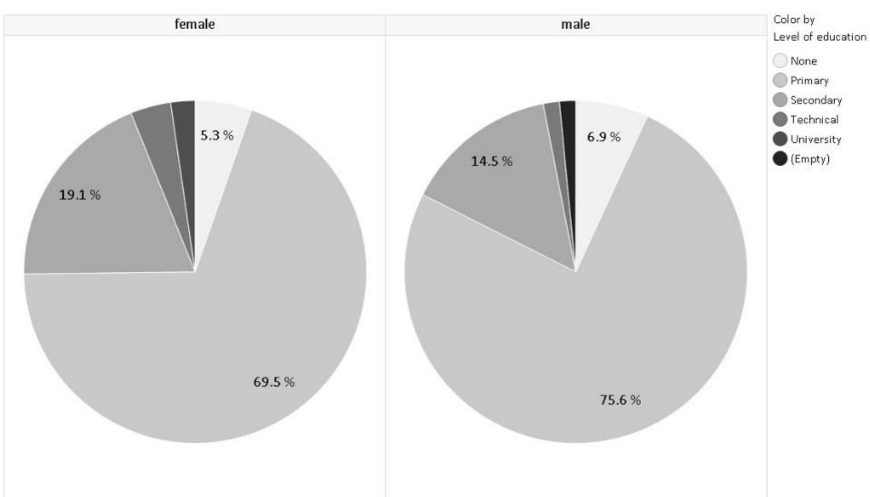

Figure 27. Level of education

[5] Empty represents survey participants who did not answer the question related with the graph

Of the people that answered the survey question related to the number of people living in the same house (N =98), the household size in Cauca CSV is between 2 and 4 people (Figure 28).

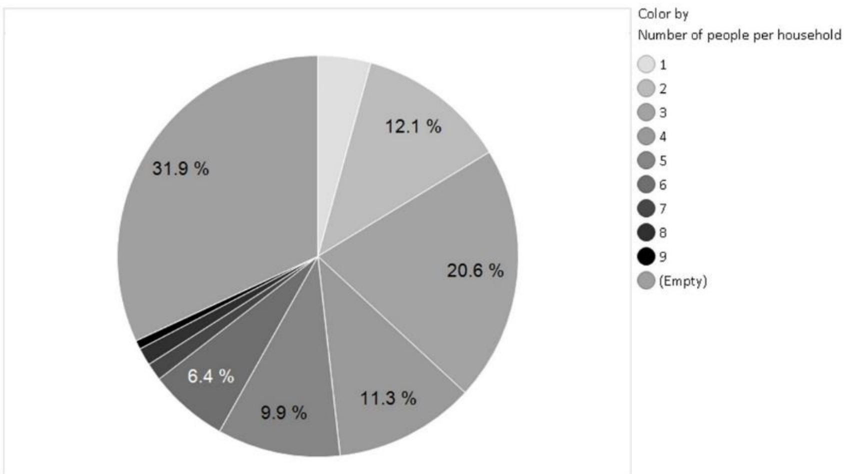

Figure 28. Number of people per household

El Danubio, Los Cerrillos and Las Mercedes (20, 22 and 1 households, respectively) did not answer the related question (31.9% of households did not answer).

The crops grown in the household farm (N =161 households answered) are mostly coffee and sugar cane.

Table 7. Crops grown in the household farm

Crops	Households that grown the crop	%
Shade-grown coffee	85	52.8
Unshaded coffee	66	41
Sugarcane	98	60.9
Vegetables	23	14.3
Herbs/species	4	2.5
Other	60	37.3

The total productive area of the household farm is 20.3% for households that have less than 1 Ha, 77.1% for households that have between 1 and 5 Ha, and 2.6% for households that have more than 5 Ha.

Among the survey participants, 68 of them (42.2%, N =161) are owners of the land that they cultivate.

4.2. Livelihoods

The main source of income of the survey participants (N =262) is on-farm activities (77.9% farmers and 74% households) (Figure 29 and Appendix A indicator 19).

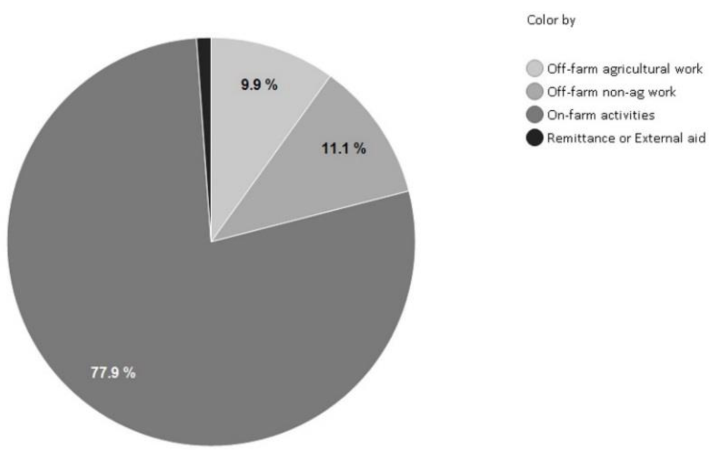

Figure 29. Main source of income

Among the 7 different villages that participated in the survey, for all of them the main source of income is on-farm activities (Figure 30).

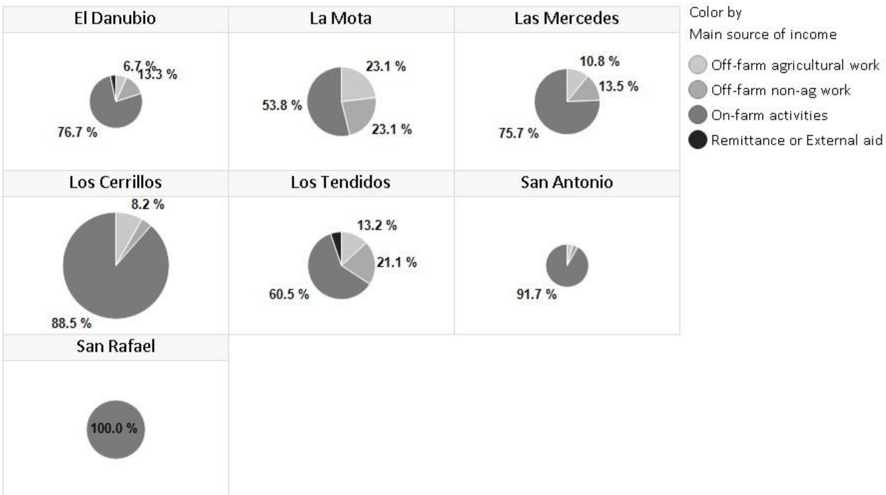

Figure 30. Main source of income per villages

4.3. Climatic events

44.2% of the survey participants (N = 259) were affected by a climate event. Irregular rains (46%) and frost and hail (45%) were the climate-related shocks more common that lead to a reduction in household incomes followed by droughts (28%) and heat waves (11%) (Appendix A – indicator 6).

Irregular rains (N =136) was the climate extreme event that affected mainly 3 of the 7 villages leading to a more significant reduction of the household incomes, droughts (N =117) 2 of 7, and frost and hail (N =65) affected 1 of 7. Las Mercedes was the only village that was affected in the same way by irregular rains and frost and hail (Figure 31).

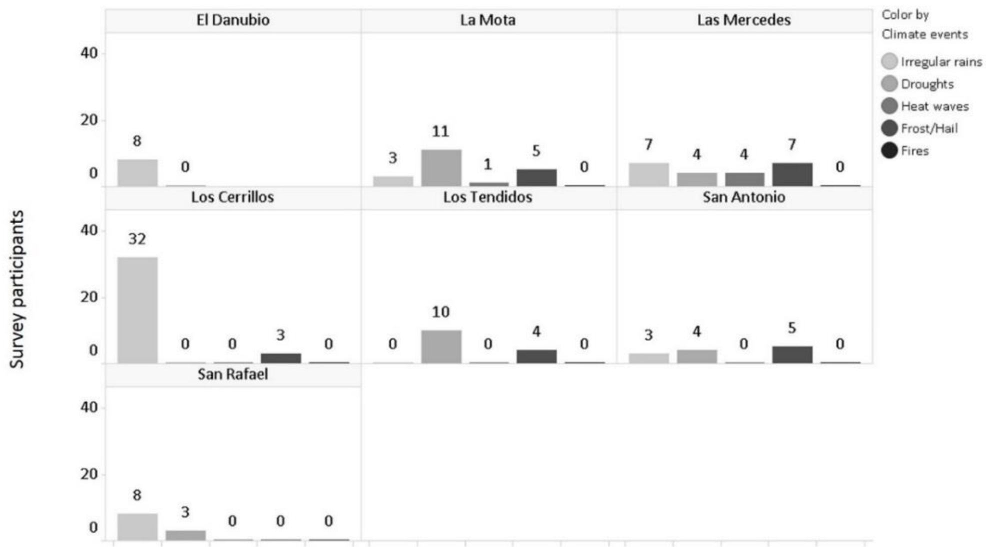

Figure 31. Climate events per villages

4.4. Coping strategies

The climate shock-induced coping strategy most used in Cauca CSV for irregular rains, droughts, heat waves, and frost and hail are use savings or borrow money followed by reducing expenses.

Figure 32 represents the coping strategies used for irregular rains (N =61 for each variable – coping strategy) among survey participants that are adopting CSA practices and non-adopters.

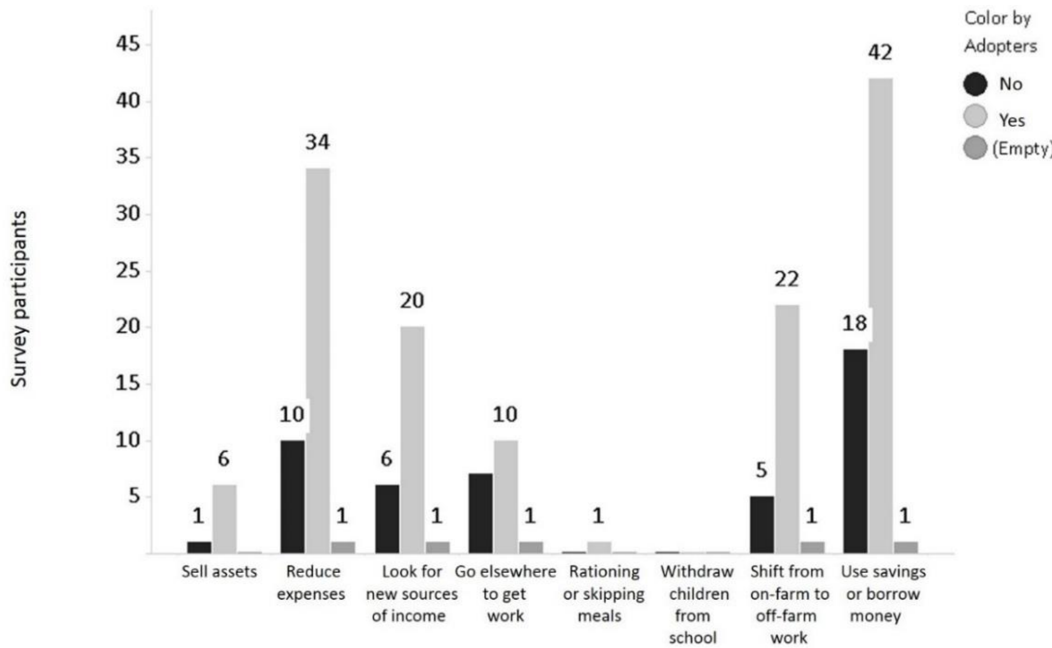

Figure 32. Coping strategies used for irregular rains.

4.5. Risk mitigation actions and autonomous changes

To begin with risk mitigation actions, households that are implementing CSA practices and undertaking climate-shock induced changes in cropping activities (N =28) mostly undertook changes in management practices of cropping systems (43%) and changes in farm infrastructure (36%). Of 4 households implementing CSA practices that respond the question related to undertaking climate-shock induced changes in their livestock activities 67% sold, relocated or migrated the herd and 33% changed livestock. 29% of the households have a perception of improved ability to confront or recover from a future climate shock associated to changes made in cropping and livestock activities (N =135) (Appendix A – indicators 7a, 9a and 11a).

Secondly, households implementing CSA practices and undertaking autonomous changes in their cropping activities (N =22), changed their management practice of current cropping system, changed their farm infrastructure and changed crops (36%, 36%, 21%, respectively). 2 households (N =2) sold, relocated and migrated the herd as autonomous changes in their livestock activities (Appendix A – indicator 7b and 9b).

4.6. CSA Practices

Of the survey participants 48.9% (128) farmers (N =262) and 51.9% (76) households (N =158) are implementing CSA practices. In Cauca CSV, 22.9% (60), 12.6% (33) and 9.9% (26) farmers are implementing 1, 2 and 3 CSA practices, respectively. (Table 8).

Table 8. Number of practices that survey participants are implementing

Practices	Farmers	Men	Women	Households
0	134	72	62	82
1	60	30	30	37
2	33	11	22	20
3	26	12	14	13
4	8	5	3	5
5	0	0	0	0
6	1	1	0	1
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0

Table 9 includes the CSA practices implemented in Cauca CSV: drought-tolerant biofortified beans, organic fertiliser, home garden, windbreak barriers, crop residue retention/ incorporation, water harvesting, irrigation, ferrocement tanks water storage and Camandula water pump.

The most widely CSA practices implemented by the heads of the households are organic fertiliser (30%), water harvesting (30%) and home garden (26%) (Appendix B – indicator 5). Drought-tolerant biofortified beans has been implemented by 6% of the head households in Cauca CSV (Appendix B – indicator 5). Windbreak barriers, crop residue retention/ incorporation, irrigation, ferrocement tanks water storage and Camandula water pump have been implemented by a small number of farmers who were surveyed. Moreover, the answer rate for those last CSA practices mentioned was meagre (only six survey participants answer out of the 262).

Table 9. CSA practices implemented

	Famers (N =262)[6]	Men	Women	Heads of households (N = 141)
Drought-tolerant biofortified beans	16	10	6	9
Organic fertiliser	79	43	36	42
Home garden	64	31	33	37
Windbreak barriers	1	0	1	0
Crop residue retention/incorporation	3	1	2	0
Water harvesting	76	37	39	42
Irrigation	1	1	0	0
Ferrocement tanks water storage	1	1	0	1
Camandula water pump	1	1	0	0

Among the 48.9% farmers implementing some CSA option, the number of men and women implementing CSA practices is equitable. The practices that more women are implementing are drought-tolerant biofortified beans, home garden and water harvesting (6.8%, 28.2% and 31.6%, respectively) compared to 6.4%, 24.8% and 31.2% implemented by men. In contrast, the survey shows that organic fertiliser has been implemented with 30.8% of women and 34.4% for men (Figure 33).

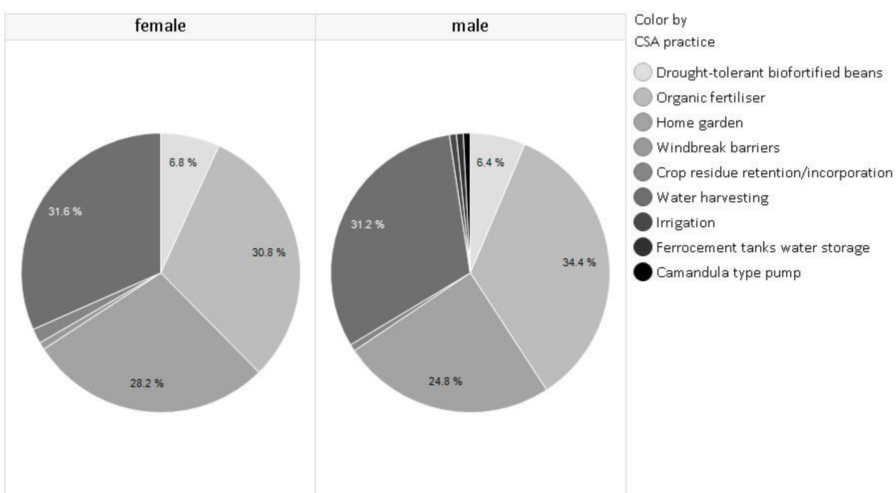

Figure 33. CSA practices implemented disaggregated by gender

[6] Windbreak barriers, crop residue retention/ incorporation, irrigation, ferrocement tanks water storage (N =6)

Figure 34 details the CSA practices implemented in the 7 different sites of Cauca CSV. Among the villages, the CSA practices widely implemented are drought-tolerant biofortified beans, organic fertiliser, home garden and water harvesting.

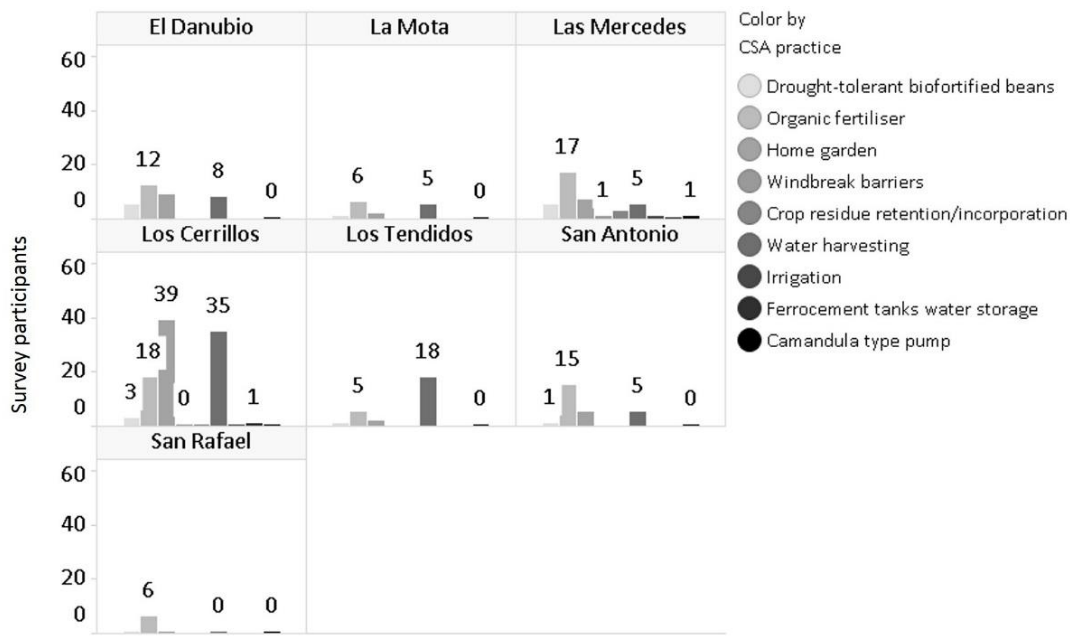

Figure 34. CSA practices implemented in the different villages

Las Mercedes is the village that is implementing more practices by farmers compared to the other villages. Las Mercedes is implementing drought-tolerant biofortified beans (5 farmers), organic fertiliser (17 farmers), home gardens (7 farmers), windbreak barriers (1 farmer), crop residue retention/ incorporation (3 farmers), water harvesting (5 farmers), irrigation (1 farmer) and Camandula water pump (1 farmer).

Furthermore, among the 7 villages surveyed, 4 of them (El Danubio, La Mota, Los Tendidos and San Antonio) are implementing 4 CSA practices, Los Cerrillos is implementing 5 CSA practices and San Rafael one.

4.6.1. Drivers of CSA implementation

Table 10 shows the factors that cause the survey participants to implement the different CSA practices. A significant number of survey participants are implementing CSA practices because they learned from CCAFS and Ecohabitats Foundation (123).

Also, CSA options were implemented to adapt to future climate shocks (38), because of new market opportunities (15), and in response to a climate event (14). 45 farmers stated that the drivers of implementing the different CSA practices were other not mentioned in the survey.

Table 10. Drivers of CSA implementation

	In response to a climate event	To adapt to future climate shocks	Because of new market opportunities	Because of learning from CCAFS/ Ecohabitats	Other
Drought-tolerant biofortified beans	0	4	3	6	2
Organic fertiliser	4	15	10	20	28
Home garden	2	9	0	49	2
Windbreak barriers	8	9	1	44	12
Crop residue retention/ incorporation	0	0	0	1	0
Water harvesting	0	1	0	0	0
Irrigation	0	0	0	1	0
Ferrocement tanks water storage	0	0	0	1	0
Camandula water pump	0	0	1	1	1

4.6.2. Dis-adopting CSA practices

Figure 35 represents the farmers that stopped implementing CSA practices. Organic fertiliser was the CSA option that more survey participants dis-adopted (10.6% farmers and 12% households, N =161) and they cited it required a lot of work (9 farmers and 9 households, N =18) as a reason to not continue implementing the practice (Appendix B – indicator 8).

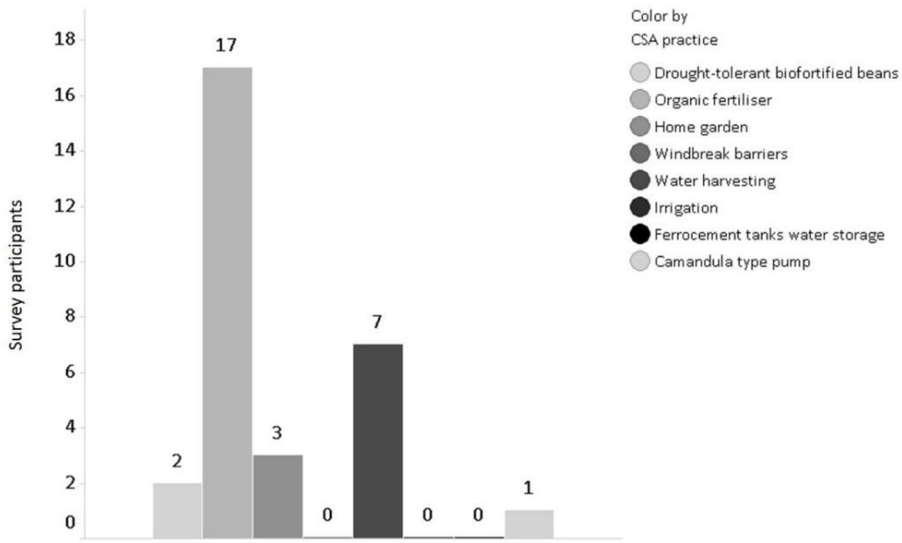

Figure 35. Survey participants dis-adopting CSA practices

4.6.3. Climate informatics services (CIS)

Only a small number of survey participants (N =262), 7 farmers (2.7%), 3 men and 4 women from Las Mercedes, had access to weather information services. The majority of the respondents had access to storm or extreme weather warning (3), and 1 respondent had access to the weather forecast and another one to seasonal forecast (Appendix B – indicator 9).

The channel that the survey participants received weather information services was mainly via radio, TV or loudspeaker (3 men), 1 men via cell phone or internet and 1 woman via other channels. Among the survey participants, 108 (N =161) have their own cell phone.

Among the 5 farmers that respond to have access to weather information services through different channels, 4 of them were capable of using weather information services, storm or extreme weather warning, weather forecast and seasonal forecast (2, 1, and 1, respectively), and 1 was not able to use weather information because did not know what decisions to change (Appendix B – indicator 10).

Only 2 farmers received climate information service (CIS) training from CCAFS-Ecohabitats Foundation (Appendix B – indicator 13).

4.6.4. CSA training

Table 11 details farmers CSA knowledge sources. The majority of the survey participants that are implementing CSA practices (Table 9) learnt about CSA options from CCAFS training and demonstrations (150), 38 from training by technical assistance by other institution, 28 from self-learning and 19 survey participants from a family member or neighbour.

The survey participants receive more training and learn more about the following CSA practices: drought-tolerant biofortified beans, organic fertiliser, home garden and water harvesting.

Of the 15 survey participants that answered the related question with drought-tolerant biofortified beans, 67% received training and demonstration from CCAFS, for organic fertiliser 30% (N =77), home garden 94% (N =62) and water harvesting 74% (N = 74) (Appendix B –indicator 12).

The common CSA practices that farmers learn from self-learning and a family member or neighbour are organic fertiliser (18% and 10%, respectively) and water harvesting (12% and 14%, respectively) (Appendix B –indicator 12).

Table 11. Farmers CSA knowledge sources

	From CCAFS training/ demonstrations	Training by Technical assistance by other institution	Self-learning	From a family member or neighbour
Drought-tolerant biofortified beans	10	3	2	0
Organic fertiliser	23	32	14	8
Home garden	58	3	0	1
Windbreak barriers	0	0	1	0
Crop residue retention/ incorporation	1	0	2	0
Water harvesting	55	0	9	10
Irrigation	1	0	0	0

Ferrocement tanks water storage	1	0	0	0
Camandula water pump	1	0	0	0

Furthermore, figure 36 shows CSA farmer-to-farmer dissemination beyond the household in Cauca CSV. Of the 9 CSA practices implemented, 7 have been disseminated farmer-to-farmer.

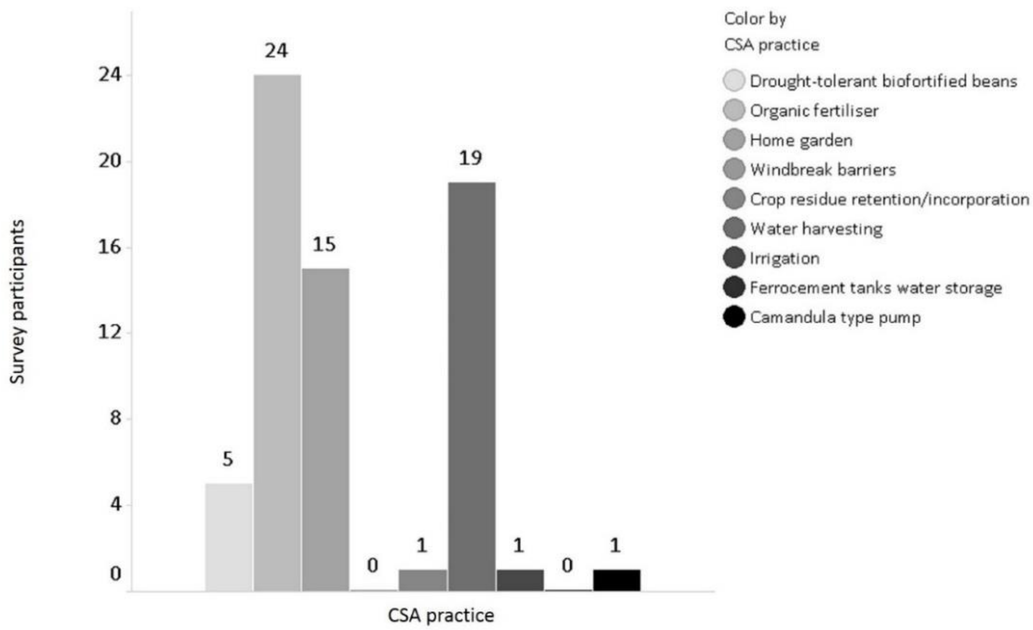

Figure 36. Farmer-to-farmer dissemination beyond the household

For organic fertiliser, 24 survey participants are disseminating their knowledge beyond the household (31.1%, N =77), for water harvesting 25.6% (N =74), and for home garden 24.2% (N =62) (Appendix B – indicator 17).

Las Mercedes is the village that has more farmer-to-farmer dissemination beyond the household, 7 different practices (drought-tolerant biofortified beans, organic fertiliser, home garden, crop residue retention/incorporation, water harvesting, irrigation, Camandula water pump).

4.7. Financial enablers

Firstly, of 262 survey participants, 42% men and 36% of women had access to loan or credit for agricultural activities.

Figure 37 details the source or where the survey participants borrowed money for the loan or credit the money (N =102). The vast majority (84.3%) obtained the money from a bank as a formal credit – 87% men and 81% women, with a few from cooperative or microcredit institution (8.8%) and family and friends (4.9%) (Appendix B – indicator 14).

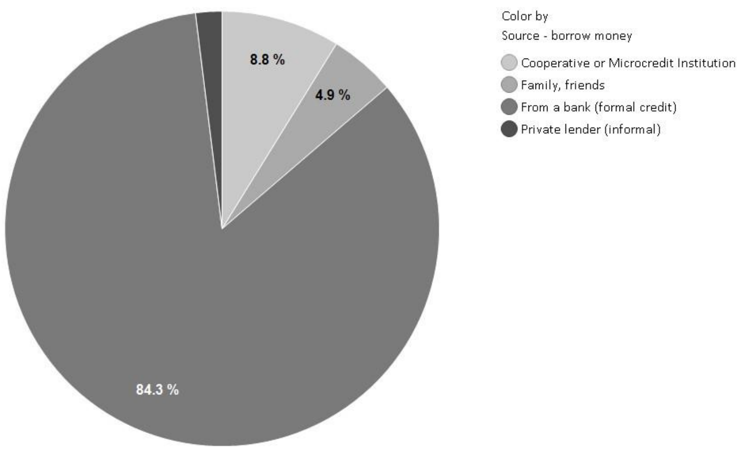

Figure 37. Source of the credit for agricultural activities

From the farmers that used a loan or a credit (N =102), the purpose of it was to help recovery from or to be better prepared against a climate-related shock (83.5%) – 78% men and 89% women (Appendix B – indicator 14).

The use of the loan or credit for agricultural activities was mostly (73.5%, N =102) to change or improve management practices – purchase management or production inputs followed by to make infrastructure investments (11.8%) (Figure 38).

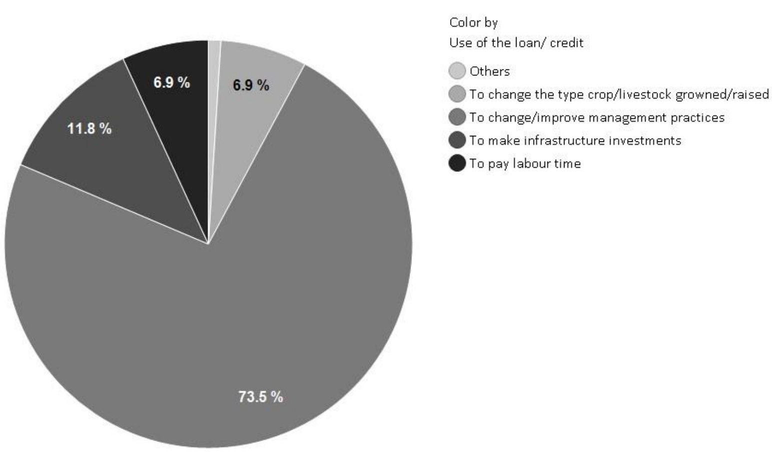

Figure 38. Use of the loan or credit for agricultural activities

The majority of the survey participants (86.3%) obtained a loan for more than 1 year – long term and 13.7% loan for less than 1 year – short term (N =102) (Appendix B – indicator 14).

Secondly, of 262 survey participants, 2.3% (6) survey participants (2% men and 3% women) had access to insurance, and they had or bought any insurance to cover losses in their production. 5 survey participants – 2 men and 3 women (N =6) obtained the loan or credit with the purpose to help recover from or to be better prepared against a climate-related shock. For the 6 survey participants (2 men and 4 women) the risk covered by the insurance was crop risk (Appendix B – indicator 15).

Thirdly, of 262 survey participants, 3% of the men received loans from their buyers, or from their providers of inputs or equipment. Also, 10% of men and 12% of women (N =262) received a price bonus or price subsidy, to stimulate them to produce in a climate-friendly manner. 8% men and 9% women (N =262) received a formal delivery contract to sell their products (Appendix B – indicator 16).

4.8. Livelihood security and Resilience

4.8.1. Food Security

Of 164 households surveyed in Cauca CSV, 156 households are food secure (95.1%) while a marginal number of households are food insecure (4.9% - 8 households).

Table 12 details the households that are food insecure in Cauca CSV. El Danubio is the village where the 15% of the households (3) stated that between August and November 2017 the head household or someone in their households did not have access to enough food.

Table 12. Food insecurity in the villages' households

	Households that stated food insecurity (access)	N
El Danubio	3	20
La Mota	1	23
Las Mercedes	1	23

Los Cerrillos	1	37
Los Tendidos	1	22
San Antonio	1	19
San Rafael	0	20

The HFIAS Score measures the degree of food insecurity (access) in the households between the period August-November in 2017. The maximum scores for each household that related to having some degree of food insecurity (access)[7] are 6, 8, 6, 1, 2, 27, 2 and 4 being 27 the higher score and 0 the minimum score. Higher the score is, the more food insecurity (access) the household experienced.

The indicator, average HFIAS Score was calculated following Coates et al. (2007):

$$Average\ HFIAS\ Score = \frac{Sum\ of\ HFIAS\ Scores\ in\ the\ sample}{Number\ of\ HFIAS\ Scores\ (households)\ in\ the\ sample}$$

$$Average\ HFIAS\ Score = \frac{6+8+6+1+2+27+2+4}{8} = 7$$

As mentioned above, 27 is the higher score that means more food insecurity. In this case, the indicator related to the HFIAS Score in Cauca CSV for the year 2017 is 7 that means that among the 8 households the food insecurity (access) is low.

Table 13 shows the four different categories of food insecurity access (food secure, mildly food insecure access, moderately food insecure access and severely food insecure access) that the Household Food Insecurity Access Prevalence (HFIAP) indicator categorises households.

"A food secure household experiences none of the food insecurity (access) conditions, or just experiences worry, but rarely. A mildly food insecure (access) household worries

[7] There are three levels of frequency-of-occurrence response options: rarely (once or twice), sometimes (three to ten times), and often (more than ten times) between August and November 2017. Those three levels are changed into number to calculate the HFIAS being 1, 2 and 3, respectively.

about not having enough food sometimes or often, and/or is unable to eat preferred foods, and/or eats a more monotonous diet than desired and/or some foods considered undesirable, but only rarely. However, it does not cut back on quantity nor experience any of three most severe conditions (running out of food, going to bed hungry, or going for a whole day and night without eating). A moderately food insecure household sacrifices quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. However, it does not experience any of the three most severe conditions. A severely food insecure household has graduated to cutting back on meal size or number of meals often, and/or experiences any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating), even as infrequently as rarely"(Coates et al., 2007).

Eight head households stated that they did not have access to enough food between August and November 2017. Among those head households, 2 households are food secure, 2 mildly food insecure access, 3 moderately food insecure access, and 1 severely food insecure access.

Table 13. Household Food Insecurity Access Prevalence indicator

HFIAP		Households
	Food secure	2
	Mildly Food insecure Access	2
	Moderately Food Insecure Access	3
	Severely Food Insecure Access	1

4.8.1.1. Food security stability

Of the 8 households that did not have enough access to food, 3 of them were implementing CSA practices, and 5 of them were not implementing CSA practices. The positive changes in the HFIAS Score when implementing CSA practices is 4, and 8.8 for the non-implementers (Appendix A – indicator 1).

The perceived CSA effect on access to enough food in Cauca CSV by the farmers is high (Table 15). For drought-tolerant biofortified beans, organic fertiliser, home garden and waster harvesting the perceived CSA effect by farmers is 87%, 88%, 95%, and 84% respectively (Appendix A – indicator 2).

Table 14. Perceived CSA effect on access to enough food

	Perceived CSA effect on access to enough food	N
Drought-tolerant biofortified beans	13	15
Organic fertiliser	68	77
Home garden	59	62
Windbreak barriers	0	1
Crop residue retention/ incorporation	0	3
Water harvesting	62	74
Irrigation	1	1
Ferrocement tanks water storage	1	1
Camandula water pump	1	1

Table 16 shows the perceived CSA effect on the variety of self-consumed products by farmers, where most farmers surveyed that are implementing CSA practices see themselves with a high perception of variety of self-consumed products. In the case of drought-tolerant biofortified beans the perception is 93% by farmers, organic fertiliser 96%, home garden 97% and water harvesting 81% (Appendix A – indicator 4).

Table 15. Perceived CSA effect on variety of self-consumed products

	Perceived CSA effect on variety of self-consumed products	N
Drought-tolerant biofortified beans	14	15
Organic fertiliser	73	76
Home garden	60	62
Windbreak barriers	0	1
Crop residue retention/ incorporation	2	3
Water harvesting	60	74

Irrigation	1	1
Ferrocement tanks water storage	1	1
Camandula water pump	1	1

4.8.2. Production/income

The perception of the CSA effect on the yield and production for all 9 CSA practices it increased (Table 17). The perception by women is higher compared to the men in organic fertiliser (77% versus 55%), home garden (94% versus 77%) and water harvesting (68% versus 65%), while drought-tolerant biofortified beans women and men perceived an increase in production in the same way (60%) (Appendix A – indicator 7).

The fact that a few farmers could not say how the production affected on their production it is a good thing. This it means that farmers are starting to implement more and more those practices such as drought-tolerant biofortified beans (40% men and 20% women), organic fertiliser (24% men and 9% women), home garden (5% men and 3% women), and water harvesting (5% men and 5% women) (Appendix A – indicator 7).

Table 16. CSA effect on yield/production

	Production decreased	I cannot say because I was new	No effect on production	Production increased	N
Drought-tolerant biofortified beans	0	4	2	9	15
Organic fertiliser	5	13	9	50	77
Home garden	2	3	4	53	62
Windbreak barriers			1		1
Crop residue retention/ incorporation			1	2	3
Water harvesting	2	4	19	49	74
Irrigation				1	1
Ferrocement tanks water storage				1	1
Camandula water pump				1	1

The perception of CSA effect on additional income generation by farmers is greater than 70% for drought-tolerant biofortified beans (73%), organic fertiliser (73%), home garden (92%), and water harvesting (70%). Farmers use the additional income to purchase food (45%, 61%, 84% and 85%, respectively) (Appendix A – indicator 8).

4.8.3. Adaptive capacity

Table 18 details the perception of the household's improved ability to confront/recover from a future climate (shock) related to CSA option. For those CSA practices that the head household survey participants answered the related questions to the improved ability to confront or recover from a future climate shock, the answer value is greater than 85%.

For drought-tolerant biofortified beans, all the head households' participants that answered the question (N =8) perceived an improved ability. For organic fertiliser, home garden and water harvesting the head household's perception is 86%, 97% and 98%, respectively (Appendix A – indicator 12).

Table 17. Household's improved ability to confront/recover from a future climate (shock)

	Household's improved ability to confront/recover from a future climate	N
Drought-tolerant biofortified beans	8	8
Organic fertiliser	36	42
Home garden	34	35
Windbreak barriers	0	0
Crop residue retention/ incorporation	0	0
Water harvesting	39	40
Irrigation	0	0
Ferrocement tanks water storage	1	1
Camandula water pump	0	0

4.9. Gender and Social differentiation

4.9.1. Labour time

Table 19 details the different 9 CSA practices labour time disaggregated by gender. Men spent more time implementing organic fertiliser, home garden and water harvesting (45%, 39% and 30%, respectively) compared to women (43%, 35% and 22%, respectively). Compared to men, more women spent the same amount of time implementing organic fertiliser, home garden and water harvesting (54%, 55% and 59%, respectively) (Appendix A – indicator 25).

A minority of farmers are spending less time implementing CSA practices. However, the survey participants that the labour time decreased when implementing CSA practices are mostly men.

Table 18. CSA practices labour time

	Spent less time		Spent more time		The same amount of time		N
	Men	Women	Men	Women	Men	Women	
Drought-tolerant biofortified beans	1	1	4	5	3	1	15
Organic fertiliser	1	3	18	16	19	20	77
Home garden	2	4	13	10	12	21	62
Windbreak barriers						1	1
Crop residue retention/ incorporation	1					2	3
Water harvesting	8		13	6	13	28	74
Irrigation			1				1
Ferrocement tanks water storage	1						1
Camandula water pump	1						1

4.9.2. Access and control over income/resources generated

The observed effect over access and control over CSA generated resources is generally higher for women surveyed on organic fertiliser (82% versus 68% of men), home garden (90% versus 36% men) and water harvesting (92% versus 48% of men). In contrast, drought-tolerant biofortified beans 75% of men had a higher perception of the access and control over this practice compared to the 33% of women (Appendix A – indicator26).

4.9.3. Participation in CSA implementation decision making

The next three table refer to the participation of men and women in CSA implementation (adoption and dis-adoption) decision making.

Firstly, Table 19 details for each CSA practice the number of farmers – disaggregated by gender if they were involved in the participation process to decide about implementing a practice. In Cauca CSV, most of the households are taking together the decisions related to the different practices. Even though most of the households are deciding together, for drought-tolerant biofortified beans and organic fertiliser more men are deciding alone (70%, 49%, respectively) compared to 17% and 28% of women. In contrast, home garden and water harvesting are women the ones deciding (27%, 21%, respectively) compared to 13% and 11% of men (Appendix A – indicator 27). However, there are a few women that are not included in the decision-making process.

Table 19. Participate process

	No, I did not participate in the decision		**Yes, I decided alone**		**Yes, it was a joined decision**		
	Men	**Women**	**Men**	**Women**	**Men**	**Women**	**N**
Drought-tolerant biofortified beans		1	7	1	3	4	16
Organic fertiliser	1	3	21	10	21	23	79
Home garden		1	4	9	27	23	64
Windbreak barriers						1	1

Crop residue retention/ incorporation			1	1		1	3
Water harvesting	1		4	8	32	31	76
Irrigation			1				1
Ferrocement tanks water storage			1				1
Camandula water pump			1				1

Secondly, Table 20 details who is the person in charge of doing the most work when implementing CSA practices. Only a few survey participants did nothing while men are the ones mostly doing most of the work in drought-tolerant biofortified beans (90% compared to 17% of women), organic fertiliser (88% compared to 36% of women), and water harvesting (51% compared to 36% of women). For the home garden, nearly the same number of men and women stated that are doing most of the implementing work (48% compared to 42% of women) (Appendix A – indicator 27).

Even though men were the ones doing most of the work, many women were also helping with the implementation of the different CSA practices.

Table 20. Person in charge of doing most of the work

	No, I did nothing		**No, I just helped**		**Yes, I did most**		
	Men	**Women**	**Men**	**Women**	**Men**	**Women**	**N**
Drought-tolerant biofortified beans		1	1	4	9	1	16
Organic fertiliser	1	1	4	22	38	13	79
Home garden		2	17	16	15	14	64
Windbreak barriers				1			1
Crop residue retention/ incorporation				2	1		3
Water harvesting	2		18	23	19	14	76
Irrigation					1		1
Ferrocement tanks water storage			1				1
Camandula water pump					1		1

Thirdly, Table 21 details the survey participants that participate in the process of the decision to stop implementing any CSA practices. The answer rate on this question is low, and this is a reason for only the survey participants that stated that they did implement some CSA practices before in their households.

Generally, men are the ones that decide to stop implementing CSA practices, but women have some voice as well even though more women answered that are not participating in the decision process compared to men.

Table 21. Decision to stop implementing CSA practices

	No		Yes		
	Men	**Women**	**Men**	**Women**	**N**
Drought-tolerant biofortified beans		1	2		3
Organic fertiliser	1	4	8	5	18
Home garden		1	1	1	3
Windbreak barriers					-
Crop residue retention/ incorporation					-
Water harvesting		4	2	1	7
Irrigation					-
Ferrocement tanks water storage					-
Camandula water pump				1	1

5. Discussion

This section provides a discussion of the results from the surveys of the CSV monitoring plan.

5.1. Adaptation

Adaptation has been recognised as a vital component of policy response for reducing the negative impact of climate change (Deressa et al., 2009, Gbetibouo, 2009, Balew et al., 2014, Khatri-Chhetri et al., 2017). Furthermore, McCarthy et al. (2011) stated that improving the resilience of agricultural systems is essential for climate change adaptation. In Cauca CSV 48.9% of the farmer participants on the survey were adopting CSA practices.

McCarthy et al. (2001) define adaptive capacity as the ability of a system to adjust to climate change (including variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Moreover, as stated in Gbetibouo (2009) and Deressa et al. (2011), adaptation to climate change requires that farmers perceive changes on the climate and respond to climate change identifying different adaptation options that will work on the specific geographical location and implement those CSA practices.

5.2. Farm-level adaptation

Decisions that farmers took to adapt to climate change and implement different adaptation options are influenced by several household socioeconomic factors that include: age, gender of the head of the household, education, household size, farm size, private property, subsistence farmers, access to climate information services, access to free extension services and access to credit.

The age of farmers has a significant effect regarding adoption. Different studies linked the age of farmers to their farming experience stating that experienced farmers are more likely to adopt new practices as their better knowledge and a higher perception of the changing climate (Nhemachena and Hassan, 2007, Deressa et al., 2009, Deressa et al., 2011, Khatri-

Chhetri et al., 2017). The results from the Cauca CSV survey showed that older farmers are the main ones adopting new CSA practices.

In contrast, Gbetibouo (2009) highlighted that older farmers are more likely to be risk-averse and less flexible than younger farmers. Moreover, Westermann et al. (2015) stated that young farmers are more open-minded to implement new practices.

Gender of the head of the household is location-specific. Some studies indicate that female-headed households are more likely to adapt to climate change and take adaptation options as much of the agricultural work is done by women (Nhemachena and Hassan, 2007).

However, other studies indicate that female-headed households are less likely to take up new adaptation practices as they may have limited access to resources due to traditional barriers. In consequence, male-headed households would be the ones that will adapt more easily to climate change as they will get information about new practices more readily (Deressa et al., 2009).

According to Cauca baseline study back in 2014, all the female head-household interviewed in Cauca CSV were divorced, single or widowed (Paz and Ortega, 2014). In Cauca, CSV was almost surveyed the same number of female-headed households (69) and male-headed households (72). Furthermore, Diana Deere et al. (2012) highlighted in her study the partial view of gender inequality inside a household as it does not take into account the position of men and women within households. One of the requirements of the survey was to interview a head household and the opposite gender of the headed-household to have home gender equality among the survey. Because of this requirement, during the survey, 97 couples were interviewed with respect to the 262 survey participants.

Education is an essential factor regarding adoption of CSA practices. Several studies stated that there is a positive relationship between higher levels of education on farmers and headed-households and the adoption of CSA practices (Deressa et al., 2009, Deressa et al., 2011, Balew et al., 2014, Taneja et al., 2014). In Cauca CSV, women are the ones that have a higher level of education (secondary, technical and university) than males. However, most of the participants surveyed only have a primary level of education.

Furthermore, CGIAR-CCAFS (2018a) highlighted that young people in Cauca CSV want to pursue a career related to agriculture to be able to gain agriculture knowledge at a university that can help to improve their quality of life in their CSV territory.

Household size is a factor that different studies concluded that did not significantly increase the probability of adaptation (Deressa et al., 2009, Gbetibouo, 2009). However, bigger household size increases the likelihood of adaptation, and this is associated with households with more labour (Deressa et al., 2011, Balew et al., 2014). In general, Cauca CSV households have between 2 and 4 people. Nevertheless, the question related to household size had a low answer rate. Cauca baseline in 2014 identified that between 1 and 6 people lived in the households (Ortega and Paz, 2014).

Farm size it does not depends explicitly on the size itself; it also depends on the specific characteristics of the farm (Deressa et al., 2011). Deressa et al. (2009) and Gbetibouo (2009) highlighted that largescale farms would tend to adopt CSA practices earlier than small-scale farm as farm size is usually associated with greater wealth. Most of the survey participants have a medium-scale farm between 1 and 5 Ha.

Private property increases the probability of investing in different adaptation practices. Tenure means farmers have proper property rights, and they will be able to change their land to adapt to climate change (Nhemachena and Hassan, 2007, Gbetibouo, 2009). Among the survey participants, most of them are not the legal owner of the land. Even though, a meeting held the 10th of August with people related to Cauca CSV[8] stated that most of the families are not leasing lands as they have their own properties.

[8] Luis Ortega (Ecohabitats), Molly Green (Internship Ecohabitats), Waldina Bermúdez- Cauca CSV farmer specialised in organic production and the leader of organic fertiliser, Valentina Santa Cruz - Leader of the Rural Youth Environment Node, Alfredo Chará - Agricod Association and the person in charge of the installation and monitoring of the meteorological stations in Cauca CSV, Ana Cecilia Vargas - Commercialization and technic assessment in Ecohabitats, Jimmy Mañunga - President Association of Northwestern communal actions of Popayan, David - Cauca CSV farmer, and Anton Eitzinger - CIAT-DAPA.

Subsistence farmers are those farmers that usually produce one staple food crop such as sugarcane and coffee that Cauca CSV farmers are growing. It is to say, their income comes from on-farm activities. Nhemachena and Hassan (2007) highlighted that subsistence farmers are more likely to incorporate other crops in their lands adapted to climate change than changing to new crops. In Cauca CSV most of the farmers their source of income is from on-farm activities. This means that farmers spent more time on the farm and compared to those farmers that work off-farm will have more time available on farming activities and adopting new practices (Gbetibouo, 2009).

Access to climate informatic services is a factor that shows a higher probability of taking up adaptation measure regarding climate change. Lack of CIS access or limitations in information increases failure associated with adaptation measures (Nhemachena and Hassan, 2007, Balew et al., 2014).

Furthermore, CIS must be gender addressed. Men and women have different needs related to climatic information received (Huyer et al., 2015). Cauca baseline in 2014 highlighted that most of the participant did not receive CIS (Ortega and Paz, 2014), and four years after only 2.7% of the survey participants received weather information services.

Access to free extension services increases the probability of farmers of taking up new CSA practices to adapt to climate change. Extension services provide a significant source of information on climate change and agricultural advice for farmers. Different studies stated that farmers with access to extension services will be more aware of climate change and will have a higher probability in adopting new measures (Nhemachena and Hassan, 2007, Deressa et al., 2009, Gbetibouo, 2009, CGIAR-CCAFS, 2018a). Also, extension services must be gender addressed to ensure a higher adaptation to climate change (Huyer et al., 2015). Women usually are the ones with more mobility difficulties as they are the ones that are taking care of the household and sometimes they need their husband approval (Gumucio et al., 2017).

Gbetibouo (2009) stated that farmers learn about the best adaptation options in three ways: firstly, learning by doing, secondly, learning by copying, and thirdly, learning from instruction.

As mentioned above, farmers receiving information and workshops about how to adapt to climate change will increase a higher adaptation to it.

Most of the farmers implementing in Cauca CSV received training and demonstrations by CCAFS or by other institutions. Every time more women are participating in those training. Also, farmer-to-farmer dissemination beyond the household will help for scaling out as farmers from Cauca CSV are already doing. Furthermore, CGIAR-CCAFS (2018b) highlighted that both men and women, adults and children, are going to the farmers' schools.

Access to credit and level of adoption have a positive relationship as availability to credit eases the different constraints and allow farmers to buy different needed inputs in the far to adapt to climate change (Deressa et al., 2009, Gbetibouo, 2009, Balew et al., 2014).

In Cauca CSV among the survey participant 42% of men and 36% of women have access to loan or credit for agricultural activities. Among those farmers, most of them borrowed the money from a bank for a more than one year.

Furthermore, Deressa et al. (2009) and Balew et al. (2014) stated that institutions, policymakers and development practitioners must play an important role in promoting the use of adaptation practices to reduce the negative impact of climate change.

5.3. CSA practices implemented

Khatri-Chhetri et al. (2017) stated that any practice that enhances at least one of the three CSA pillars (adaptation, mitigation and productivity) in agriculture under climate change and variability it can be considered as a CSA practice.

Among the 9 CSA practices implemented in Cauca CSV, organic fertiliser, water harvesting, home garden and drought-tolerant biofortified beans are the adaptation measure more adopted by farmers.

Literature regarding different CSA practices implemented to adapt to climate change by smallholders is scarce. The practices cited related to Cauca CSV are water harvesting, irrigation, water storage, crop resilience to heat and drought, (Nhemachena and Hassan, 2007, Deressa et al., 2009, Taneja et al., 2014, McCarthy et al., 2011). Ramirez (2016) on his cost-benefit analysis on CSA practices cited organic fertiliser and home garden. Recently CGIAR-CCAFS (2018a) and (CGIAR-CCAFS, 2018b) cited drought-tolerant beans, organic fertiliser, home garden and water harvesting.

Organic fertiliser has significant importance for food security in Cauca CSV and reducing greenhouse gas emissions. A few farmers are using organic fertiliser on their farms to grow organic crops such as coffee, cherry tomatoes and vegetables in the home gardens (Ramirez, 2016, CGIAR-CCAFS, 2018a). Also, within the CSV project, it has been instructing farmers how to prepare organic fertiliser (Ramirez, 2016, CGIAR-CCAFS, 2018b). Cauca CSV is in the process of changing from chemical products to organic.

Water harvesting is a source of additional water when a period of drought arrives (CGIAR-CCAFS, 2018b). Moreover, Taneja et al. (2014) highlighted that the major impact of climate change on agriculture would be experienced in the form of water stress. Drought was the climate event that more affected Cauca CSV, and a reason for this it shows that a significant number of smallholders adopted water harvesting as adoption to climate change.

Home garden is a CSA practice that ensures food security in Cauca CSV and extra cash on smallholders’ households. Home garden improves the variety of food that households eat (CGIAR-CCAFS, 2018b).

Drought-tolerant biofortified beans ensure families of Cauca CSV to have food even when the rain decreases. Also, it ensures food security in the households (CGIAR-CCAFS, 2018a). As are biofortified those beans are a source of iron and zinc. Cauca CSV farmers are asking more drought-tolerant biofortified beans to try in their farms, and they are starting to grow a small number of land (between 10 and 15 beanstalks).

Results show that farmers implementing CSA practices perceived a positive effect on the variety of their self-consumed products.

5.4. Limitations for scaling CSA and recommendations

This section englobes the different limitations found while doing this research project to help scale out CSA among smallholder farmers in Colombia and its correspondent recommendations.

Low rate answer in some questions such as the head of the household, household size, on the survey made some of the results not real. Some of the Cauca CSV farmers (Waldina Bermúdez and Ana Cecilia Vargas), and the leader of the Rural Youth Environment Node (Valentina Santa Cruz) stated on a meeting on the 10^{th} of August that the low rate for the head of households related question could be a psychologic problem to not understand the question. Also, it could be related with a social problem that the spouse even doing all the work at the household the husband is the one that has the word.

Furthermore, the results show that during the survey there was a surveyors' problem. Some of the villages for specific questions have a low rate answer. During the meeting held in Popayán the 10^{th} of August the participants agreed that the survey training done by Ecohabitats Foundation some of the surveyors did not go.

Moreover, Luis Ortega from Ecohabitats Foundation stated that for the next surveys the surveyors would be young people from the Rural Youth Environment Node appropriately trained. It is important that surveyors understand the question that is asking the participants and review if the answer that the survey participant is giving is correct.

Also, for the next survey, the participants of the meeting agreed that some questions should be more specified such as organic fertiliser that should specify that is the organic fertiliser made through Ecohabitats Foundation. Would be a great idea to add a picture or short video to make easy the question of understanding. Also, specify irrigation as it seems that irrigation could present some confusion if it is related to the home garden as watering plants or is drip irrigation.

Having accurate results will help to improve CSV monitoring and the planning tool for farmers for scaling out.

Limited access to the Internet is a factor that is not helping to increase the number of farmers adopting new climate-smart practices (Westermann et al., 2015). Through the Internet, they could receive CIS to know when a climate event will hit a specific area when are the best times to grow crops. The main problem is that there is a marginal number of people receiving CIS in Cauca CSV even though most of them own a cell phone. One of the reason could be a poor Internet connection.

Information and communication technologies (ICTs) to reach more farmers (Westermann et al., 2018), and social networks (Martinez-Baron et al., 2018) should be promoted to ensure a higher adaptation to climate change.

Language should be addressed correctly for a better farmers understanding and ease scaling out CSA. Farmers trust more the information received from another farmer than from institutions (meeting 10th of August).

Benefits are often not appreciable until five years or more, but costs are borne immediately (McCarthy et al., 2011). Farmers usually want to see results the same year, and some CSA practices take longer than expected.

Appropriate literature concerning the scaling up and out of CSA is still scarce.

6. Conclusion

Global population is increasing, and consequently food demand to ensure food security. Climate change is a major issue that affects the global population, and agriculture is being significantly impacted due to changes in rainfall patterns, increases in temperature, and intensity of extreme weather events such as droughts and floods.

Adaptation to climate change is one of the main strategies to minimise the adverse effects of the changing climate on agriculture. The climate-smart agriculture (CSA) approach endeavours to sustainably increase agricultural production and incomes while adapting and building resilience to climate change, and reduce, where possible, greenhouse gases emissions. From this approach the CGIAR Research Program on Climate Change, Agriculture and Food Security developed Climate-Smart Villages (CSV) as models of local action that ensure food security, promote adaptation, and build resilience to climatic stresses.

This research thesis analysed the data collected through the CSV monitoring system in Cauca, Colombia that will be to design an instrument prototype in the next weeks to scale out CSA to support local stakeholders and practitioners need for planning and decision-making processes. Cauca is a vulnerable region, and it will be negatively impacted by climate change increasing temperatures and decreases in precipitation, and consequently increases on droughts.

The study found that the CSA practices related to water shortage and increases in organic food production are the ones most preferred by smallholder farmers such as water harvesting, organic fertiliser and home garden. Smallholder farmers prefer those practices that ensure food security all year and increases their income due to the selling of the products. Also, to have a higher adoption of smallholder farmers to climate change will be needed to promote climate informatics services around farmers.

To address the instrument correctly to help smallholders and practitioners to scale CSA for next surveys will be essential to improve the surveys of the CSV monitoring system and its surveyors to be able to analyse accurate data.

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Appendices

Appendix A: Indicators tracked at household level (gender disaggregated)

Appendix B: Indicators tracked in relation to CSA implementation/adoption trends