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CLIMATE CHANGE ADAPTATION IN HIGHLAND ECUADOR: INTERSECTIONS OF GENDER, GEOGRAPHY, AND KNOWLEDGE IN FARMING COMMUNITIES

Dinka Natali Caceres Arteaga
Universidad Central del Ecuador

DINKA NATALI CACERES ARTEAGA
Candidate

LATIN AMERICAN STUDIES
Department

This dissertation is approved, and it is acceptable in quality and form for publication:

Approved by the Dissertation Committee:

K. MARIA D. LANE, Chairperson

BENJAMIN P. WARNER

CLAUDIA B. ISAAC

LAURA L. HARJO

ADRIANA RAMIREZ DE ARELLANO

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by

DINKA NATALI CACERES ARTEAGA

Environmental Engineer, Universidad Internacional SEK, 2002
Management for Local Sustainable Development, Universidad Politécnica Salesiana, 2002
Master of Environmental Law, Universidad Alfredo Perez Guerrero, 2013

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To Micaela, Camilo, Aida y Lucho, with all my heart.

This is for you, and thanks to you.

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Doctor of Philosophy, University of New Mexico, 2020

ABSTRACT

This dissertation uses a feminist political ecology perspective to explore the socioeconomic impacts of climate change in Ecuador, especially but not limited to the agriculture sector. It is based on the use of mixed methods that allowed the participation and validation of the local population, surpassing their role as beneficiaries to co-authors of this research.

The significance of this study relies on the position the local population holds in the fields of human geography, under a community local-planning perspective, as they attempted to collaborate in the process of adaptation to climate change by presenting analysis and calculation of an index of adaptive capacity at the national level, by establishing future climate models at the local level for the first time in Ecuador, and by showing that agroecology is a viable adaptation alternative.

The collection of primary information was carried out through participatory observation, interviews with key actors, and surveys of a representative sample of families working in agriculture.

The tangible outcomes are three articles. The first is, "What the future holds? Historical climate analysis and projection of future climatic scenarios for the Andean canton of Pedro Moncayo, Ecuador," whose main objective is to identify the evidence of change in certain climatic elements, such as precipitation and temperature at the local scale. It presents a historical analysis of the period from 1981-2017 and the formulation of climatic scenarios under the RPC4.5 and RPC6 scenarios for the 2020-2050 period. This study aims to be a contribution to vulnerable communities in their planning and capacity-building processes.

The second article, "Gendered impacts of the adoption of agroecological practices as a climate change adaptation mechanism in four Highland communities in Pedro Moncayo, Ecuador," shows the different perceptions of women and men on the impact of the use of agroecology on gender roles, and challenges to access water resources and irrigation infrastructure.

The third article, "Adaptive capacity to climate change in Ecuador's farming population," proposes an adaptive capacity index (ACI) adjusted to the context of populations dedicated to agriculture in Ecuador and proves how the use of an intersectional approach improves the visibility of vulnerable groups.

Table of Contents

LIST OF FIGURES

ARTICLE 1 WHAT DOES THE FUTURE HOLD? HISTORICAL CLIMATE ANALYSIS AND PROJECTION OF FUTURE CLIMATIC SCENARIOS FOR THE ANDEAN CANTON OF PEDRO MONCAYO, ECUADOR

ARTICLE 2 SOCIO ECONOMIC AND GENDERED IMPACTS OF THE ADOPTION OF AGROECOLOGICAL PRACTICES AS A CLIMATE CHANGE ADAPTATION MECHANISM IN FOUR HIGHLAND COMMUNITIES IN PEDRO MONCAYO, ECUADOR

ARTICLE 3: ADAPTIVE CAPACITY TO CLIMATE CHANGE IN ECUADOR'S FARMING POPULATION

LIST OF TABLES

INTRODUCTION

Women have historically suffered from discrimination, limiting their rights, access to education, health, justice, land, and credit, among other issues. They face social, economic, and political barriers that have diminished their capacity to adapt to climate change. Women in Ecuador are not the exception. It is important, however, to remember that women are not only vulnerable but also are potential change makers. Ecuadorian women living in rural areas are reservoirs of ecological knowledge, and they know their lands, their rivers, and their Pacha Mama.[1] A real, participatory, and inclusive gender approach inserted into climate change policies will allow women who have the potential to become meaningful change makers in their communities to increase their adaptation capacities. This is the central premise of this dissertation and is my long-term expectation.

This study analyzes the gender situation in Ecuador under the scenario of climate change. Gaps found in the literature review suggest that gender inclusion in climate change adaptation is highly relevant and might produce positive impacts on adaptation capacity. Additionally, international efforts of world leaders gathered at the United Nations and the Sustainable Development Goals have established that equality between women and men is needed, and that the road to that equality point is not an easy one (Esquivel & Sweetman, 2016).

The literature also points out that a study focused only on gender is not enough for designing public policies because women cannot be taken as a similar standard group.

[1] Pacha Mama is an Andean conception of mother Earth, the one that feeds their children and demands respect.

There are other equally important aspects, such as sex, race, ethnicity and age. This dynamic is called intersectionality and is a central aspect of my research.

An important aspect of this research is the use of geographical information systems and models of climate change to identify future climate change scenarios; social, economic, and environmental impacts of average and extreme variations of the present and future climate; and methods for adaptation to the identified impacts.

As this project proposes an explorative interdisciplinary approach that combines two streams of social sciences (Geography and Environmental Studies, Community and Regional Planning), qualitative research methods will provide a comprehensive research framework. Three articles have been developed in this project:

- The first article generates updated qualitative and quantitative scientific documentation of the impacts of and adaptation measures to variability and climate change in Pedro Moncayo from 1965-2017. A spatial data analysis was used to help answer the following research question: How has climate varied in Pedro Moncayo and what could be expected in the future?

- The second article involves an empirical study in agricultural communities of Pedro Moncayo canton, situated on the Andean region of Ecuador. The article, through developing workshops and surveys in the area of this canton, looks for the analysis of socioeconomic and cultural changes due to the use of agroecological practices and their impact on women and men as two different groups. This article addresses the following research question: How the use of agroecological practices as a mechanism of climate change adaptation has transformed the socioeconomic conditions of agricultural communities in Pedro Moncayo?

- The third article explores how intersectionality, understood as the convergence of social identities, such as gender and ethnicity, is relevant in the study of the adaptive capacity to climate change adjusted to the context of populations dedicated to agriculture in Ecuador. The article aims to answer the following research question: What is the adaptive capacity of populations linked to agriculture in Ecuador in 2014?

Background

Climate change is a major problem worldwide. In recent decades, scientific research and the political treatment of the theme in search of solutions have focused attention on the most relevant forums at the global, regional, and national levels.

The central problem is the intensification of the greenhouse effect (GHE) by anthropogenic causes, described for the first time in 1824 by Jean Baptiste Fourier. The naturally occurring GHE makes life on the planet possible by increasing the average temperature from -18°C to 15°C.

The possibility of an intensification of this effect was raised between 1896 and 1908 by Svante Arrhenius, who at that time found that the increased burning of coal for industrial activities would lead to an increase in the concentration of CO_2 in the atmosphere, allowing a warming of the system (Fankhauser, 2013). The concentration of CO_2 in the atmosphere in the preindustrial era was approximately 270 ppm (parts per million by volume). According to the World Meteorological Organization, the concentration of CO_2 in 2018 was 407.8 ppm, which is 147% above the preindustrial level (World Meteorological Organization, 2019).

The inaugural World Climate Conference in 1979 was the first global forum to address global warming; no consensus for responses was reached. However, participants at the conference recognized the global problem, as shown later by the creation of an Advisory Group on Greenhouse Gases in an international conference of organizations of the United Nations in 1985.

With the diffusion of the GHG emission data, especially from the Hawaiian volcano Mauna Loa, which in 1995 already recorded 335 ppm, the scientific community and United Nations organizations began to take initial actions for the scientific and political treatment of the issue via the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1998 and the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992.

Ecuador

"*Ecuador is a constitutional, social, democratic, sovereign, independent, unitary, intercultural, pluri-national and secular State of rights and justice. It is organized as a republic and governed in a decentralized manner*." (Article I, Constitution of the Republic of Ecuador).

Located in South America, Ecuador has a population of 16.2 million. Projections indicate it could reach 23 million by 2050.

The climate conditions in Ecuador are influenced by various factors, including its location on the Equator, the Andes Mountain Range, the Amazon, and the Pacific Ocean. The country has three continental physiographic regions: coastal, inter-Andean and the Amazon, and the Galapagos Islands. This variety leads to different types of weather, with high temperatures in the Amazon and coastal regions and low temperatures in the inter-Andean region, where altitudes reach 6,000 meters. Rainfall is abundant and continuous in the Amazon region and of lesser intensity in the inter-Andean and coastal regions.

Ecuador's main economic activity is petroleum extraction and exportation, followed by agriculture, which represented 8% of the gross domestic income (Ministerio de Agricultura y Ganaderia, 2019). Between 2004 and 2018, the contribution of agriculture to the gross domestic product in Ecuador remained between 8% and 9%, while the employment of activities related to this sector reached 13% of the population aged 15 and older, during the year 2019 (Instituto Ecuatoriano de Estadísticas y Censos, 2019).

These two elements, among others, are directly affected by both the impact of climatic variations as well as by the response measures that developed countries are taking to reduce GHG through declines in oil consumption. These impacts, coupled with the sharp drop in oil prices and the occurrence of El Niño and La Niña weather events, especially those between 1982-1983, 1997-1998, and 2015-2016, further exacerbate the socioeconomic situation of the country as a whole and specifically that of low-income families living in the countryside who depend on subsistence agricultural production.

Ecuador is a party to the UNFCCC, the Kyoto Protocol (KP), and the Paris Agreement. It has presented its first three National Communications on Climate Change, in 2000, 2010 and 2017, the Biennial Updated Report in 2017 and the Nationaly Determined Contribution in 2019. The First National Communication focused on demonstrating that Ecuador is highly vulnerable to climatic variations and is affected by the potential response measures of developed countries, which is framed in Articles 4.8 and 4.9 of the UNFCCC and Article 3.14 of the Kyoto Protocol (Ministerio del Ambiente, 2000).

The Second National Communication presented information to demonstrate the initiatives and actions taken by the country, not only to reduce impacts but also to reduce their GHG emissions without any mandatory commitment to the UNFCCC (Ministerio del Ambiente, 2011).

The Third National Communication presents the efforts made and results obtained between 2011 and 2015, and is based on the identification of national priorities and interests considered in the National Plan for Good Living 2013-2017 (Ministerio del Ambiente del Ecuador, 2017).

The Biennial Updated Report presents an update of the Second National Communication, including the Technical Annex of results obtained by Ecuador in reducing emissions from deforestation between 2008 and 2014 (Ministerio del Ambiente del Ecuador, 2016).

The Nationaly Determined Contribution -- NDCwas presented in 2019 and includes the First Communication of Adaptation of Ecuador, summarizing relevant aspects of the Third National Communication of 2017, preparatory phases of the NDC, and of the National Adaptation Plan in formulation (Ministerio del Ambiente del Ecuador, 2019).

The First National Communication on Adaptation includes information about National Circumstances, Impacts, Risks and Vulnerabilities, National Priorities, Support and Implementation Needs, Efforts and Implementation Plans centered on the Organic Code of the Environment, 12 Barriers, Challenges and Gaps, and Information of how the planned measures support compliance with the SDGs.

The three National Communications highlight evidence of increased temperature and precipitation variation in all regions of the country. As of January 2020, Ecuador is preparing its Fourth National Communication and Second Biennial Updated Report, as well as working on the implementation of the National Determined Contribution.

The Constitution of the Republic of Ecuador, in Article 414, establishes that "the State shall adopt adequate and cross-cutting measures for climate change mitigation by limiting greenhouse gas emissions, deforestation, and atmospheric pollution; [the State] shall take measures for the conservation of forests and vegetation, and shall protect the population at risk."

Under this legislation, a number of national policies have been adopted, by which the mitigation and adaptation to climate change and the implementation of the National Strategy on Climate Change are declared to be state policy.

Several pilot projects have been implemented in Ecuador, especially at large watersheds and/or small agricultural sectors of higher socioeconomic vulnerability, where the issue of gender is very important, although that issue is not addressed directly. The Third National Communication establishes that the Climate Change Subsecretary, with the support of other relevant actors in the subject, to establish criteria on gender mainstreaming to be considered in projects.

Article 280 of the Constitution of the Republic of Ecuador establishes that the National Development Plan is the instrument to which public policies, programs, and projects will be subject. Its observance is mandatory for the public sector, and it serves as a guideline for other sectors. Article 43 of the Organic Code Public Planning and Finance establishes that, "The Plans of Territorial Ordinance are the instruments of development planning that have the objective to order, make compatible, and harmonize the strategic development decisions regarding human settlements, economic-productive activities, and natural resource management as a function of territorial qualities, through the definition of guidelines for the manifestation of the long term territorial model established at the level of the respective government."

Ecuadorian regulations indicate, directly or indirectly, that national, regional, and local development and planning instruments must consider climate change and risk management.

The provincial, cantonal, and municipal Plans of Development and Territorial Ordinance are the planning instruments prescribed by the constitution, by the Organic Code of Territorial Organization, Autonomic and Decentralization, and by the Organic Code Public Planning and Finance.

In other words, the PDOTs are the instruments by which the national plan and budget are translated to the provincial, municipal, and parochial levels. The Decentralized Autonomous Governments (GADs) are responsible for their preparation and execution.

The importance of climate change's inclusion in the PDOTs is officially indicated by the Ministerial Resolution of the Ministry of the Environment No. 137, of May 19, 2014, in which are "established the general guidelines for the incorporation of Climate Change in local planning by the Decentralized Autonomous Governments through plans, programs, and Climate Change strategies, for their subsequent officialization as Climate Change Plans by the Ministry of the Environment" (Ministry of the Environment, 2014).

The Organic Code of the Environment -- COA, in force since April 2018, updates and restructures the legal framework of Ecuador's environment, in which climate change is classified as a responsibility of the Decentralized System of Environmental Management under the responsibility of the Environmental Ministry.

The Ministry of Environment, as the National Environmental Authority, has the attribution, among others, of defining the national strategy and plan to confront the effects of climate change based on national and local capacity

The COA's Fourth Book of Climate Change aims to:

> "establish the legal and institutional framework for planning, articulation, coordination and monitoring of public policies aimed at designing, managing and executing at local, regional and national levels, adaptation and mitigation actions of climate change in a transversal, timely, effective, participatory, coordinated and articulated manner with ratified international instruments for the State and the principle of common but differentiated responsibility. National policies in this area will be designed to prevent and respond to the effects of climate change and contribute to global efforts to address this anthropogenic phenomenon" (Art. 247).

Study Area

Pedro Moncayo Canton is located in Pichincha Province and is characterized by social, economic, and environmental diversity, which is highlighted by a grand evolution of the floriculture industry and a diminishing of the agricultural industry.

The social, economic, and environmental impacts caused by climate events in Ecuador are the result of extreme climate events. However, studies and research on the matter are generally focused on the average monthly and annual values of precipitation and temperature.

In this same sense, the PDOTs presented by the provincial and cantonal governments, include vague references to average precipitation and temperature values and lack documentation of the principal climatic impacts, including those by extreme events, that affect their territories.

Specifically, the PDOT of the government of Pedro Moncayo Canton, updated in 2015 and 2018 with a 2025 horizon, includes only references to precipitation and average temperature during the period of 1985-2009, lacks an identification of the impacts of climate change, and does not consider the mandatory guidelines issued by the Ministry of the Environment to include climate change (Gobierno Autonomo Descentralizado Municipal de Pedro Moncayo, 2018).

The guidelines issued by the National Planning Secretariat for the preparation of the PDOTs consider relevant the inclusion of information utilizing geographic information systems (GIS).

Literature review

The following literature review examines the scientific knowledge of climate change as well as its political process, based on the fact that uncertainties play an important role in the definition of future scenarios, but this cannot stop decision makers from working on adaptation measures. A special focus is made on adaptation capacity as the key concept for my research.

The following section focuses on political ecology as an aptly positioned theory to address the climate change impact on rural communities under a gender scope, that are highly dependent on natural resources.

Climate Change

Considerations

Scholarly understanding of climate change's causes and impacts has focused on the characteristics of globality, longevity, irreversibility, and uncertainty. Climate change is global, indifferent to where GHGs occur and spread through the atmosphere, heterogeneously generating impacts around the planet. It is long-term because increases in temperature and rising sea level are expected for the next decades and centuries (Wagner & Weitzman, 2015).

Among the major uncertainties, the temporal evolution of GHG emissions is included because changes in the climate system, and concomitantly changes in its impacts, depend on the emissions. The projections depend on the socioeconomic development and climate policies to be adopted. In this regard, the Intergovernmental Panel on Climate

Change (IPCC) presents four Representative Concentration Pathways (RCPs), depending on which temperature increments between 1.5°C and 4.5°C would be generated by the end of this century (IPCC, 2014). On the other hand, the uncertainties in relation to spatial and temporal scales of climate models are important, especially for developing countries and countries located in tropical and mountainous regions.

Burke et al. (2015) specified the existence of two sources of uncertainty: first, the imperfect knowledge of future trajectories of the variables that can affect the climate system (mainly GHG emissions), and second, the imperfect knowledge of how changes in these variables will affect climate change.

The greenhouse effect (GHE) of natural origin, which is necessary for life on the planet, has intensified as a result of the contribution of emissions generated by human activity. This level, as well as its current and future impacts, might not be reversible. Past and current emissions remain in the atmosphere for a long time and generate impacts beyond measures that can be taken to reduce them.

Dangerous Anthropogenic Interference in the Climate System

The ultimate objective of the UNFCCC is to achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner (UNFCCC, 1992).

The relevant question: What is the dangerous level of emissions that can interfere with the climate system, and what is meant by adaptation?

The "dangerous level" can be relative, depending on the type of system or element of the system in question. However, an increase of more than 1.5°C to 2.0°C in the global average temperature has been cited as having dangerous implications if exceeded (Intergovernmental Panel on Climate Change, 2014; Meinshausen et al., 2009). In this regard, the IPCC in its Fifth Report on Impacts, Adaptation and Vulnerability identifies risks of the Five Integrative Reasons for Concern (RFCs) that could be generated by exceeding certain values of the average global temperature.

The RFCs are unique and threatened systems, extreme weather events, distribution of impacts, global aggregate impacts, and large-scale singular events (IPCC, 2014).

The Paris Agreement on Climate Change, signed in December 2015, sets an ambitious objective to limit the global average temperature increase to well below 2°C or even 1.5°C above preindustrial levels, recognizing that in this way, the impacts of climate change could be significantly reduced; the climate accord also called for "Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production" (UNFCCC, 2015).

The long-awaited Conference of the Parties 25 held in Spain in December 2019, left a sense of emptiness in society, which demanded a greater commitment to reduce GHG emissions, leaving the issue of market use for compliance purposes unfinished.

Governance

The governance of climate change is a complex issue. An important and shared appreciation indicates the need to consider at least three interrelated factors: the multiple scales of political decision making involved, the fragmented and blurred roles of state and nonstate actors; and the deep nature of many of the processes of production and consumption (Bulkeley & Newel, 2015).

Operatively, the official political governance of climate change is led by the Conference of Parties as rector and deciding body of the UNFCCC, and the scientific governance by the Intergovernmental Panel on Climate Change. In both areas, decisions are made by governments. In that respect, criticisms of this centralism point to alternatives. For example, considering global processes--production, trade and consumption--through which GHG emissions are generated displays the need for an important role of transnational corporations and consumers. The emissions of greenhouse gases of some oil companies are higher than those of several developed countries (Bulkeley & Newel, 2015).

Institutional relationship between science and politics

Science and politics at a global level have maintained a close relationship. The global policy defined in the framework of the United Nations through its principal legal instruments, such as the UNFCCC, the Kyoto Protocol, and Paris Agreement, has used the periodic reports of the IPCC.

The IPCC has also developed assessments in response to specific requests from the Conference of Parties, such as attributing climate change to human activity.

The reduction of the uncertainty of this attribution through time as shown in the language of the IPCC (in 1995 “more likely than not”; in 2001, “likely”; in 2007, “very likely”; and by 2013 “extremely likely”) has generated strong support for greater action and decision from the UNFCCC (Wagner & Weitzman, 2015).

One of the objectives of the Paris Agreement adopted in December 2015 makes clear reference to the dangerous level of an increase in global average temperature of 1.5°C to 2.0°C established by the IPCC (UNFCCC, 2015).

The research results of the scientific community are published in referenced journals, with limited access to most of the developing countries. These documents, in turn, are mainly supported by other publications of the same type, without considering or without knowledge of research in developing countries, which is not widespread in indexed journals.

Without ignoring the existence of criticism, principally by skeptics, of the elements and contents of the IPCC reports, these have marked an important development, especially in developing countries, for which these reports have become the main source of information and decision making in the face of the limited availability and access to scientific literature from the developed world. The IPCC reports are widely accessible, free of charge, and are presented in several languages.

In developing countries, relevant sources of reference and citation include publications of the IPCC, UN agencies, regional institutions, NGOs, and other entities as well as the country's reports presented before the UNFCCC, such as the National Communications, Biennial Updated Reports (BURs), Nationally Determined Contribution (NDC).

Vulnerability and Adaptation to Climate Change

The rapid increase in the consumption of goods and services worldwide directly and indirectly generates GHG emissions, which increases their concentration in the atmosphere, intensifying the GHE and heating of the planet.

This heating results in variations in the climate system that can generate negative and even positive impacts in social, economic, and environmental systems; the heating also can produce and/or increase the vulnerability of weaker systems.

In this context, adaptation emerges as an alternative response to reduce the impacts of climate change and climate variability, evaluations that require historical, current, and future data of the climate system with the least possible uncertainty and scales that allow the attainment of local-level assessments.

In the context of social, ecological, climatic, and risk sciences, those terms have been defined and used according to their requirements, resulting in differences in language and interpretation as well as in results of operations. Specifically in the field of climate change, authors such as Nuñez (2016), O'Brien et al. (2007), and Fünfgeld et al. (2012) cited approximations of other authors and highlighted the need for a clear understanding of the definitions.

Relevant Definitions for the Research

The definitions presented below fundamentally are used by the United Nations institutions responsible for climate change and disaster risk management to respond to scientific evaluations, and are widely used by developing countries such as Ecuador.

Adaptation: is an adjustment in natural systems or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous, and planned adaptation.

Adaptation assessment: is the practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility.

Adaptive capacity, as related to the impact of climate change: is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Resilience: is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Vulnerability: is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Adaptation

With the advancement of science and the implementation of adaptation projects worldwide, there have been several interpretations and contexts on adaptation (Nuñez, 2016; Adger, Arnell, & Tompkins, 2004; Berrang-Ford et al., 2015; IPCC, 2012).

At least four questions allow researchers to clarify the broader context of adaptation: “Adapt to what?” “Who or what adapts?” “How does adaptation occur?” “How good is the adaptation?” By analyzing several definitions of these questions, it is found that most of them differ in the three questions, including not clarifying how adaptation occurs. Adaptation refers to both the process and the outcome and can be passive or reactive, spontaneous or planned (Smit, Burton, Klein, & Wandel, 2000).

Nunez (2016) identified at least 10 references to What adaptation refers to?, 12 references to Who or what adapts? and 10 references in relation to Adaptation to what? (Table 1).

Specifically, within climate change, the development of adaptation and related concepts also respond to political decisions by the United Nations, specifically to articles of the UNFCCC that led to this development.

The scholar has developed four groups of thought and methodologies in this framework: (a) estimate of the degree to which adaptation can moderate or reduce impacts modeled resulting from different climate change scenarios; (b) identification of the best adaptation measures that can be used to reduce impacts; (c) evaluation of the adaptive capacity of social, geographical, and economic systems; and (d) practical application of adaptation in geographical areas and communities.

Table 1. References to Adaptation Considerations

What the adaptation refers to	**Who or what adapts?**	**Adaptation to what?**
A process. A process of deliberate change. A dynamic social process. A decision-making process. An adjustment. A continuous stream of activities, actions, decisions, and attitudes. Responses or actions. Actions. An outcome. Changes.	A system (household, community, group, sector, region, country). Vulnerable systems. Human and natural systems. Ecological, social, or economic systems. Socioecological systems. Society. A behavioral or economic structure. An individual, group and institution. Individuals, groups, and governments. People. Organism.	Climate. Changes of climate. Climate variability. Observed or expected changes in climatic stimuli. Changing condition, stress, hazard, risk, or opportunity. Environmental changes and their impacts. External stimuli and stress. Current or future predicted change. Actual and expected impacts of climate change. The surrounding environment.

In the first three schools of thought, the process of adaptation is not addressed specifically. The practical application of adaptation is an approach that is developing little by little and responds to the characteristics of the system as evaluated locally.

The first group of thought assumes adaptation conventionally and focuses on measuring its effect in relation to expected impacts, such as how much the cost of impacts is reduced because of the adaptation. In the second group, adaptation measures are evaluated, such as cost-benefit, cost effectiveness, and multicriteria procedures. In the third group of thought, the relative ability to adapt serves as a comparison and prioritizes actions toward systems of lower adaptive capacity. The fourth group of special interest for this investigation is related to the adaptive capacity of the communities and to specific initiatives for their adaptation (Smit et al., 2006).

The interaction of climate-related threats with vulnerable systems with low adaptive capacity can lead to severe and even irreversible impacts (IPCC, 2014). This reality prompted the identification of common response means between communities of climate change and risk management (led by the United Nations International Strategy for Disaster Reduction UNISDR).

Both communities and schools of thought have common elements, but conceptual differences also exist in various terms used in the two fields (Papathoma-Kohle, Glade, & Catrin, 2016). This new approach was reflected in the publication of the Special Report of Working Groups I and II of the IPCC, "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (IPCC, 2012) which served as the basis for the Fifth Evaluation Report Group 2 of the IPCC 2014 (IPCC, 2014).

In a study in 2012, the IPPC reported this: "disaster risk management and adaptation to climate change focus on reducing exposure and vulnerability and increasing resilience to the potential adverse impacts of climate extremes, even though the risks cannot fully be eliminated" (IPCC, 2012)

While all definitions respond to a specific purpose and context, the one raised by the IPCC in 2014 is used for the purpose of this "Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."

Vulnerability

Similarly in the case of adaptation, in relation to vulnerability, a wide range of definitions has addressed the requirements of different scientific areas. For example, Nunez (2016), while discussing adaptation in the context of health, identified 11 definitions that varied according to the scientific field in which they were developed--disaster, sociology, environment, climate, and health-economics.

Authors such as O'Brien et al. (2004), Adger (2006), Cutter (2008), IPCC (2012), and Nunez (2016) tried to explain the causes of the similarities and differences between the definitions of vulnerability. It is interesting how Cutler et al. (2006) suggested three ways to understand this situation: (1) vulnerability as a result of embedded social characteristics -- the research taking this position focuses on availability of assets and diverse levels of susceptibility (exposure is considered as given), (2) vulnerability as a result of diverse levels of exposure; and (3) vulnerability as a complex concept that conveys both biophysical and social components inherent of a specific location or place.

The IPCC Report of 2014 mentioned that population patterns (growth pattern and age, individual characteristics such as sex, health, education, and income) and the environment (geographical location, health, and public structure) impact human vulnerability. The IPCC, in its 2012 assessment of risk and climate change included social, environmental, and economic characteristics as factors that drive vulnerability.

In the case of definition of vulnerability assessments, differences are found. O'Brien et al., (2007) designed and implemented a tool to identify the interpretation of different types of vulnerability studies. The application of this tool in two studies of vulnerability in Mozambique showed one of them framed in outcome vulnerability (OV) and the second in context vulnerability (CV), with differences in their elements, results, and response measures.

The OV is considered as an end-point approach and presents the results of the impact of climate change on a given sector, reduced by the measures to be adopted. This interpretation has been used by the IPCC in its reports. CV, meanwhile, reduces vulnerability to positively alter the environment in which climate change and climate variability occurs.

Adaptive Capacity

The vulnerability of any system is a function of the exposure and sensitivity of that system to hazardous conditions and the ability or capacity or resilience of the system to cope, adapt or recover from the effects of these conditions. The expositions and sensitivity are responses from the interaction of social and environmental forces, while forcing social, cultural, political and economic influence the adaptive capacity. A system with a greater ability to adapt will have less vulnerability, while it will be greater with a higher exposure and sensitivity (Smit et al., 2006).

Adaptive capacity, like other elements of vulnerability, is dynamic and therefore susceptible to variations among communities, countries, social groups, and other entities..

According to Bahadur et al., (2013), a review of scientific literature suggests that the relationship of resilience with concepts such as vulnerability and adaptive capacity is still poorly defined, whereas vulnerability and resilience are similar concepts for some authors. For other authors, they are opposed, and a third group considers them to be separate concepts, which points out similar confusion between resilience and adaptive capacity. The decision of Paris Agreement notes that the three concepts are separate or at least related (UNFCCC, 2015).

Advancement in Adaptation

International research centers, UN organizations, and groups of scientists developed the first evaluations of adaptation on a global level with grids of hundreds of kilometers and focused on relevant sectors, such as agriculture, water resources, fisheries, and forests. The IPCC, in its 1990 and 1992 reports, was among the first to extensively transmit these assessments in a summarized and systemized way.

Progress on adaptation has been evaluated by several authors. It was very well cited by Lesnikowski (2015), who also referred to the existence of initiatives of international organizations (United Nations Development Program [UNDP], UNFCCC, European Environmental Agency [EEA]) to collect, organize, and make these advances available, mainly at the project level, still leaving an important gap regarding the state of adaptation globally.

These publications have been published in international indexed journals and developed by scientists and research centers in developed countries. However, a wealth of experience and work also has been carried out in developing countries that for various reasons have not been published in indexed journals and are therefore either unknown or unused by the scholars of developed countries.

These experiences of developing countries are included in summary form in the National Communications on Climate Change, which each country delivers to the UNFCC periodically.

In this regard, Lesnikowski et al. (2015) developed a systematic approach of 117 National Communications submitted by countries to the UNFCCC between 2008 and 2012, including 4,104 adaptation initiatives. The authors found that progress on actual adaptation interventions--including infrastructure projects, regulations, public outreach campaigns, and surveillance and monitoring--is limited, and the adaptation efforts at a national level are primarily occurring with groundwork actions such as impact and vulnerability assessments, adaptation research, and the development of conceptual tools to guide adaptation.

Given that adaptation occurs differently--policies and planning, capacity building, physical or social interventions, behavioral changes, and others--as well as at different temporal and spatial scales, it is not an easy task to measure the progress of adaptation, such as through a reference matrix (IPCC, 2014). It is also difficult to successfully measure adaptation when no accepted definition on successful adaptation exists. Some authors cited by Leiter (2015), Palutikof et al., (2013), Adger et al., (2015), and Wilbanks and Kates (1999) suggested considering temporal and spatial scales to measure the progress of adaptation.

Importance for Developing Countries

Adaptation is very important for reducing the impacts of climate change around the world. In developing countries, it has a remarkable relevance, for several reasons, such as geographic location, high and low adaptive capacity.

Most developing countries are located in tropical and subtropical areas, where increased temperature and potential changes in rainfall patterns could exacerbate current conditions of high temperatures and erratic inter and annual distribution of precipitation.

In many countries, specific sectors, such as agriculture, of their economy are especially susceptible to the vagaries of climate change, and that leaves entire regions and their residents highly vulnerable.

In general, adaptive capacity to address current climate anomalies in developing countries is low, a scenario that can be aggravated by climate change (Millner & Dietz, 2015).

The Paris Agreement and Adaptation to Climate Change

The Paris Agreement of December 2015 established a new post-2015 global climate regime, in the context of the United Nations, to take effect in 2020. The Paris Agreement on adaptation includes various commitments and processes in which the words "vulnerability, adaptation, and resilience" are used.

According to Article 7, the Paris Agreement establishes a global goal on adaptation to enhance adaptive capacity, strengthen resilience, and reduce vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of holding temperature increases well below 2°C and making efforts to limit them to 1.5°C.

Each member country of the Paris Agreement should prepare and submit an adaptation communication to the UNFCCC, which may include its priorities, implementation and support needs, plans and actions, without creating additional burden for developing country parties. Adaptation efforts of developing countries will be recognized for funding established by the Paris Agreement (UNFCCC, 2015).

While the pact does not directly designate the definitions to be used, they typically refer to the official definitions of the UNFCCC and IPCC (UNFCCC, 2015).

Climate change and agriculture

Climate change is a problem of global scale, heterogeneous, contains an asymmetric and unequal condition, and whose effects are differentiated at the local level (Barcená et al., 2018). Several factors intermingle to generate in the affected population a greater or lesser capacity to adapt to climate change, including the level of development, poverty, access to technology, political power, and representation in the face of national and international negotiations (Warner, 2015).

The scientific documentation generated during the past two decades has highlighted the agricultural sector in developing countries as one most affected by the current and future impacts of climate system variation (Fischer, Shah, Tubiello, & Velhuizen, 2005; Food and Agriculture Organization, 2007)--due mainly to the lack of capital to implement adaptation measures and exposure to extreme weather-related events (Lopez & Hernandez, 2016).

According to the Intergovernmental Panel on Climate Change -- IPCC, in low latitudes, climate change has negatively influenced the processes of desertification and food security, particularly with corn, the growth rate of animals, and in other areas, while positive changes have occurred in high-latitude nations (IPCC, 2019).

A potential loss of arable land is estimated by the end of the century to be between 1% and 21%, affecting crops, local economies, and food security in Central America and part of the Andean region. In the tropical areas of South America and east of the Andes, an increase in temperature during the growing season is very likely to affect agricultural productivity and human well-being (IPCC, 2014).

Likewise, climatic models predict "the damages will be shared disproportionately by small third world farmers, and particularly farmers who depend on unpredictable rainfall regimes" (Altieri & Nicholls, 2008, p. 9). This impact would be due, among other reasons, to the low access to technologies, inputs, information, and monetary resources to adopt adaptation measures (Birthal, Khan, Negi, & Agarwal, 2014).

Faced with this problem, rural populations have developed strategies to take care of their fields and to maintain and/or improve agricultural production. These strategies constitute an important element for the construction of public policy according to a nation's needs. However, few works on the subject have been carried out in the Andean region (Herrador-Valencia & Paredes, 2016; Cáceres-Arteaga, Ayala, Rosero, & Lane, 2018).

Political Ecology

The use of the term “political ecology” dates to 1935 when it was written in academic literature by Frank Throne (Throne, 1935). However,“it was established as a specific discipline and a new field of inquiry and social conflict in the early sixties and seventies triggered by the irruption of the environmental crisis” (Leff, 2012).

This environmental crisis, also known as “reactionary environmentalism of the First World’ (Stott & Sullivan, 2000) was constructed around rebellious scholarly works such as “Silent Spring” (Carson, 1962), “The Population Bomb” (Ehrlich & Ehrlich, 1969), “A Blueprint for Survival” (Goldsmith, 1972), “The Limits to Growth” (Meadows, Meadows, & Randers, 1972), and “Small is Beautiful” (Schumacher, 1973).

Despite the fact that “political ecology” had appeared in studies such as “Ownership and Political Ecology” (Wolf, 1972) and “A Critique of Political Ecology” (Enzensberger, 1974), some scholars found it hard to accept it as new discipline or approach (Peet & Watts, 1996; Keys, 2005).

By the 1990s and the beginning of the new century, political ecology had emerged as a respected new field of study, having human geography and cultural ecology as backgrounds (Steward, 1955; Walker, 2005).

One of the initial approximations of political ecology indicates that it “surged as a new way to understand how environmental and political forces interact to effect social and environmental changes through the actions of various actors at different scales” (Stott & Sullivan, 2000).

However, there were some concerns about its contributions. One of the still persistent concerns is the lack of clarity about the "ecology" of political ecology (Walker, 2005), as developing "politics without ecology" would ultimately become environmental politics (Basset & Zimmerer, 2004). It can be distinctively analyzed by geographers for studying human-environmental relations (Zimmerer & Bassett, 2003; Robbins, 2012) and specifically, climate change political and scholarly debates (Sultana, 2014; Neumann, 2005; Liverman, D., 2015).

For this to be done, a transdisciplinary approach is needed, especially considering that one of the most significant shortcomings of political ecology is the lack of collaboration across natural and social science divide in climate change research" (Moser, S. C., 2010; Wainwright, 2010).

A critical assessment of capitalism as a driver of climate change and persistent inequalities that reinforce vulnerability is another relevant challenge (Tschakert, 2012).

Political ecology and climate change

Initially, political ecology was reluctant to engage in studies of climate change. The primary reason seemed to be epistemological differences, unwillingness to participate in hard-core climate science, and a lack of consensual definitions of vulnerability and adaptation (Tschakert, 2012). As a result, gaps within this scenario have appeared.

Those gaps are produced as a result of a poorly defined scale related to the study of the impacts of climate change and the reinforcement of the capability of adaptation of vulnerable communities (Moser, S. C., 2010).

The ultimate pronunciation of political ecology states that it “provides powerful insights into understanding the causes, consequences, and responses to climate change from local to global scales. In return, climate change connects political ecology back to some of its origins in efforts to understand hazard vulnerability and the intersections between poverty and environmental degradation, but also goes forward into highly politicized debates about the future of development, energy and land use” (Liverman, D., 2015).

For the purpose of this research, the adaptation aspect of climate change will be analyzed in detail.

Political ecology’s pervasive blindness to gender – feminist political ecology

Gender is conceptualized as a “meaning system” and is proven to be a critical factor in shaping access to and control over resources, environmental decisions, and technologies (Schubert, 2005; Rocheleau, Thomas-Slayter, & Wangari, 1996).

Multidisciplinary scholars maintain that a gendered analysis shapes society-nature relations and consequently is “fundamental to understanding resource access, use and degradation around the world” (Goldman & Schurman, 2000) and to guarantee a more accurate assessment of environmental change at the scale at which decisions are made (MacGregor, 2010).

Feminist political ecology, a field for understanding human-environment interactions, was pioneered by Dianne Rocheleau in 1996, drawing on insights from political ecology, cultural ecology, and feminist geography to explore structures and processes of social change.

Definitions of feminist political ecology indicate that it

> "treats gender as a critical variable in shaping resource access and control, interacting with class, caste, race, culture and ethnicity to shape processes of ecological change, the struggle of men and women to sustain ecologically viable livelihoods, and the prospects of any community for sustainable development" (Rocheleau, Thomas-Slayter, & Wangari, 1996).

Feminist political ecology goes beyond the causes to the study of changes on hoods, landscapes, and property regimes that result (???) from environmental and political-economic decisions. For examples in existing literature, see Hovorka (2006); for context, see Jarosz) (1999), Paul and Gezon (2006), Truelove (2011), and Sultana (2011). In this sense, feminist political ecology seems to be the most appropriate conceptual framework to understand the dynamics of climate change on vulnerable groups seeking adaptation process at local scales.

A first challenge under this approach is to confront the lack of studies and attention given to gender under climate change scenarios (MacGregor, 2010; Terry, 2009). Some of the few that do, lack data and evidence (Arora-Jonsson, 2011).

Another important challenge is the dearth of research linking gender inequalities to environmental justice (Reed & George, 2011; Angostino & Lizarde, 2012; Banerjee & Bell, 2007; Terry, 2009). Demands have come from global networks, civil society, and grass-roots organizations that propose that climate change is a rights issue during the first

Climate Justice Summit in 2002. "It affects our livelihoods, our health, our children and our natural resources" (Angostino & Lizarde, 2012).

People around the world who are calling for climate justice to redress the systemic crises of today's development distinguish the uneven burden on countries of the South, as well as the historical responsibility of the first-world countries in the level of emissions of greenhouse gases (Angostino & Lizarde, 2012).

"No climate justice without gender justice" (MacGregor, 2010), was a rallying cry of feminist groups from the Bali Climate Conference in 2007, ranging from organizations such as Women's Environment and Development Organization (WEDO) to grassroots initiatives clamoring for gender-equality concerns to be fully integrated into international agreements (Terry, 2009).

It should not be surprising, considering that neither the United Nations Framework Convention on Climate Change (1992) nor the Kyoto Protocol (1997), that the most important international treaties mentioned "women" or "gender" (Skutsch, 2002; Terry, 2009).

In other words, "the threats posed by global warming have failed to impress on policy-makers the importance of placing women at the heart of their vision of sustainable development" (Denton, 2002). This can be understood within the frame of the "masculinization of environmentalism," meaning that men in charge of climate change as scientific and economic experts, entrepreneurs, policymakers and spokespeople (MacGregor, 2010).

Aurora Johnson, analyzing climate change discourses, states that women in the North are positioned as "virtuous" and that women in the South are "vulnerable": "The only thing that these two groups share is the fact that women are not part of decision-making bodies as are the men in their societies, and that is to the detriment of women" (Arora-Jonsson, 2011, p. 744).

There is a tendency to see women in the context of their vulnerabilities as ". . . helpless, voiceless and largely unable to manage herself and her family without the help of UN development agencies funded and staffed by the North" (MacGregor, 2010) --rather than on their agency and knowledge limits the ability of creating innovative adaptation strategies (Buechler & Hanson, 2015; Terry 2009).

An empirical study in Ecuador analyzed "whether and how international climate change mitigation financing relates to gender" (Hildahl, 2010). It evaluated an SGP bio-digester project in the Intag zone and concluded that "the promotion of gender overall is low on the agenda, strategic gender interests are mainly not advanced through the project, nor does it differentiate among women and in turn excludes marginalized women. Overall, this case study reinforced existing gender inequalities" (Hildahl, 2010).

Until recently, the power of gender gave the impression of having lost its "critical edge" by the "domestication" of gender in development policy (Cornwall, 2007), which means gender was defined as a "technological problem" to be fixed (Loftsdóttir, 2011; Mollett & Faria, 2012).

There was and still is a notable tendency to produce "manuals and procedures" to treat the "gender problem," which reduces the power of gender from politics to simple steps among adaptation and development initiatives (for examples, see UICN; UNDP; WEDO; CCGA, 2007; UNDP, 2009).

However, feminist political ecology seems to have taken steps forward with respect to gender and climate change debates, going ". . .from gendered vulnerabilities to fragmented identities and intersectionality, focusing on adaptive capacity rather than impacts" (Tschakert, 2012).

There is an incredible potential on the impact that Feminist Political Ecology and other feminist geographical studies could have in the current climate change political and scholar debates (Sultana, 2014; Harris, 2015; Hanson & Buechler, 2015). Policies must guarantee that the gender approach and analysis are incorporated in order to avoid contributing to existing gender inequalities (Nelson, Meadows, Cannon, Morton, & Martin, 2002), and for that, the quality and quantity of academic work might be significant. This constitutes the aim of my own research as well.

Sherilyn MacGregor argued that "shedding light on the gender dimensions of climate change will enable a more accurate diagnosis and a more promising cure than is possible with a gender-neutral approach" (MacGregor, 2010, p. 124).

It is important to note that this gendered approach is also embedded in a wide landscape of other issues and identities (Valentine, 2007), meaning that an intersectional vision is also crucial in confronting climate change. Critics of the gender approach point out that other social categories--class age, and ethnicity--are just as important as gender and thus should not be neglected.

Intersectionality is defined “as the way in which any particular individual stands at the crossroads of multiple groups” (Minow, 1997) and,

> “it is used to name and describe hidden acts of multiple discrimination and how they obfuscate damaging power relations, and it also brings to the fore how they construct, while paradoxically obviating, identities of the self” (Fernandes, 2003).

As for climate change, its effects, such as the rise in sea level with the risks that this implies, changes in climate patterns with more frequent extreme events, loss of species and ecosystems, water contamination, and other undesirable issues, have a differential impact as a result of factors such as gender, geography, ethnicity and income group (Angostino & Lizarde, 2012). Additionally, the impacts of climate change are “shaped by roles, responsibilities, and entitlements associated with various markers of social status and expectation, including gender, class, and caste” (Carr & Thompson, 2014).

A study by Valentine (2007) said:

> “…where studies within feminist geography have looked at intersectional types of issues, they have tended to limit their analyses to the relationships between particular identities such as class or gender rather than addressing the full implication of the above theorization of intersectionality. . . .” (Valentine, 2007).

A specific critic approaches race as an understudied area in political ecology. A postcolonial intersectionality analysis is argued, understanding it as a “concept that moves beyond US-based racial and gender hierarchies to acknowledge the way patriarchy and racialized processes are consistently bound up in national and international development practices” (Mollett & Faria, 2012).

Scales

One of the major theoretical debates in human geography since the 1990s has been referred to as the politics of scales, and even though some aspects of scales have already been mentioned (see the climate change section), a more accurate application under the lens of political ecology at a more complex social-ecological level is required.

The idea of creating scales is a political act, and there is no inherently neutral way to scale challenges such as climate change, which scales the problem without having a solution and asks for cities to adapt to climate change without knowing how to mitigate its causes.

There are several approaches to creating scales. In agriculture, for example, the proposed combination goes from global (climate change, variability, extreme events, and unpredictability), to country (urbanization, migration) and to the local level (poverty, property rights, market access) (Hazell & Wood, 2008).

However, a closer look at local and household levels proposed by feminist political ecologist Rocheleau (1996, 2008) presents an opportunity to go deeper into multiple types of knowledge.

It might go beyond this by making scales less visible (Elmhirst, 2011) and even dissolving scalar boundaries (Tschakert, 2012) in order to highlight the multiple and dynamic connections between the smallest (body) to the biggest (cities and nations). (Nightingale, 2010).

There are proposals for using feminist political ecology as it '. . . may further reflect on how to 'unfix' scales, bringing the disembodied global more directly to the everyday intimacies of the 'other'--other places, other people, other times" (Tschakert, 2012).

Overview of the articles

This dissertation consists of three articles that address three distinct topics related to climate change adaptation: historical and future climatic scenarios, agroecology as a climate change adaptation mechanism in the Andean canton of Pedro Moncayo, and the calculation of the adaptive capacity at a national level.

The first article, co-authored with Oscar Ayala, Darwin Rosero, and Maria Lane, used historical information of climatic variables such as temperature and precipitation for the period 1981-2016, registered by 126 meteorological stations of the Meteorological and Hydrological National Institute situated around Pedro Moncayo canton. Using this information, six maps were constructed to present the variability of precipitation and temperature from 1981 to 2017.

A second product of this research was the construction of future climatic scenarios for the period 2030-2050 under two climatic scenarios, RCP 4.5 and RCP 6. The results show that Pedro Moncayo canton is likely to experience warmer days and colder nights, conditions that will pose a genuine challenge for all of the agricultural activities carried out in the area and that constitute the economic life of their populations. These results were socialized with authorities of the Municipality of Pedro Moncayo and the area directors of this institution.

The effect of temperature and precipitation in sectors such as agriculture, health, livestock, and tourism need to be understood in order to design appropriate public policies. Because this is the first study of future scenarios at the local level in Ecuador, it is expected to become a relevant element in local planning, which by legal mandate must now include plans and programs for mitigation and adaptation to climate change. It is also expected that this study will be replicated in other local scenarios, real and viable projects will be formulated, and the adaptive capacity of these population will increase. This article was published in November 2018 in a special edition of the Journal of Geography of Central America, Vol. 3, No. 61E.

As a result of the previous study and given the vulnerability of the agricultural sector to climate change, the following article of this dissertation, co-authored with Maria Lane, aimed to empirically establish the socioeconomic and gendered perceptions of the impact of agroecological practices as a climate change mechanism on 150 agricultural families participating in an agroecological project of the Municipality of Pedro Moncayo. An exploratory sequential method was employed through the use of quantitative tools, such as surveys, as well as through the use of qualitative tools, such as in-depth interviews and participatory observation, which contrasted and complemented the information.

The findings demonstrate perceptions and impacts differentiated by gender, which is directly related to culturally established responsibilities by gender. Women are responsible for both productive and reproductive work, while men face social pressure as providers and heads of household. Agroecology becomes an alternative for older adults, both men and women, as well as for women of a young age, for whom the economic income, yet limited, translates to freedom and autonomy in their homes and personal lives.

At the end of this research, the agroecology project that was being funded by an international nongovernmental organization has come to an end, so it is expected that the results of this research will serve as input for the design of new projects that will continue to support these families and their communities.

The final article includes the intersectionality approach as a methodological proposal for a better understanding of adaptive capacity. After field work and a careful literature review, this research co-authored with Maria Lane, was used to design an adaptive capacity index for agricultural workers in Ecuador. It shows how being a female and indigenous reduces the adaptive capacity, and being mestizo and having an important financial income, increases the adaptive capacity. With those findings, this article is expected to serve as a guide for public policies on climate change that is inclusive for vulnerable people.

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ARTICLE 1 WHAT DOES THE FUTURE HOLD? HISTORICAL CLIMATE ANALYSIS AND PROJECTION OF FUTURE CLIMATIC SCENARIOS FOR THE ANDEAN CANTON OF PEDRO MONCAYO, ECUADOR

Abstract: The natural and anthropogenic variations of climate systems are increasingly evident. Climate change has become the central theme of research for decision making at all levels. The principal objective of the current research is to identify the evidence of change in certain climatic elements, such as precipitation and temperature at the local scale in Pedro Moncayo, Ecuador. The study uses records from 1981-2017 produced by 126 meteorological stations of the National Institute of Meteorology and Hydrology closest to the study area. Geographical Information Systems were used for statistical analysis and geographical representation. This is the first study that presents climate scenarios at local scale in Ecuador, It aims to be a contribution for the scientific community, but especially for vulnerable communities in their planning processes and strengthening their adaptation capacity.

Key words: climate change, historical variability, scales, Ecuador

Resumen: Las variaciones naturales y antropogénicas de los sistemas climáticos son cada vez más evidentes. El cambio climático se ha convertido en el tema central de la investigación para la toma de decisiones a todo nivel. El objetivo principal de esta investigación es identificar la evidencia de cambios en ciertos elementos climáticos, como la precipitación y la temperatura a escala local en Pedro Moncayo, Ecuador. Se utilizó información brindada por las 126 estaciones meteorológicas del Instituto Nacional de Meteorología e Hidrología más cercanas al área de estudio y sus registros desde 1981 hasta 2017. Sistemas de Información Geográfica (SIG) se utilizaron para el análisis estadístico y la representación geográfica. Este es el primer estudio que presenta escenarios climáticos a escala local en el Ecuador, y pretende ser un aporte para la comunidad científica, pero sobre todo para las comunidades vulnerables en sus procesos de planificación y fortalecimiento de su capacidad de adaptación.

Palabras clave: cambio climático, variabilidad histórica, escalas, Ecuador

Introduction

The natural and anthropogenic variations of climate systems are increasingly evident. Climate change has become the central theme of research for decision making at the global, regional, national, and local levels.

The best summary of the research and publications generated by the scientific community is published as Reports of the Intergovernmental Panel on Climate Change - IPCC. These reports, among other evidence, indicate an increased frequency in extreme climate events, highlighting the probability that this situation will continue in the future. This signals that the main problem is not necessarily variation in average monthly values, but in annual values.

Thinking about vulnerability, adaptation and adaptation capacity, special attention will also need to be given to scales. There is uncertainty as to how local populations and eco-systems will be affected by and adapt to these changing conditions at various spatial scales, particularly in the vulnerable regions of the Global South (Roy, 2018).

Ecuadorian regulations indicate that national, regional, and local development and planning instruments must consider climate change and risk management on their provincial, cantonal, and municipal Plans of Development and Territorial Ordinance - PDOTs.

In May 2014, Ecuador's Ministry of Environment established general guidelines for its Decentralized Autonomous Governments to incorporate climate change in local planning through plans, programs, and climate change strategies, for their subsequent officialization as Climate Change Plans (Ministerio del Ambiente, 2014).

Despite this, the consideration of actual and future climate on the PDOTs is scarce and insufficient to sustain decision-making processes. National documents, such as the three *National Communications on Climate Change* presented by Ecuador before the United Nations Framework Convention on Climate Change -UNFCCC in 2000, 2011, and 2017, summarize evidence of changes in Ecuador's climate systems at the national scale and highlight the increasing frequency of extreme climate events. However, the studies were carried out at the national scale, compromising their use for analyzing climate change effects, impacts, and adaptation capacity at local levels.

The Decentralized Autonomous Government of Pedro Moncayo Canton updated its PDOT in March 2015 with a 2025 horizon, including limited references to historical precipitation and temperature averages during 1985-2009. Relying on historical data from only 6 meteorological stations, the PDOT does not include future climate change scenarios and does not consider the mandatory guidelines issued by the Ministry of the Environment to include climate change in long-term planning.

To remedy this problem, this paper offers a scale-sensitive approach to climate data in Pedro Moncayo. It presents the scientific evidence and support needed by the local government to plan for climate change effects, obtain resources necessary for effective preparation, and increase the canton's adaptation capacity.

Area of study

Pedro Moncayo is located in the Inter-Andean region, northeast of the province of Pichincha, with altitudes that vary between 1730 and about 4300 meters above sea level. It forms part of the Esmeraldas river basin, which includes the Guayllabamba, San Pedro, Pita, Pisque and Blanco rivers that flow into the Pacific (see Figure 1). It occupies an area of 339 km2 with a population of 37.802 in 2014.[2]

The majority of the Pedro Moncayo territory is devoted to agriculture (58.1%) and shrub and herbaceous vegetation (30.6%). (Gobierno Autónomo Descentralizado de Pedro Moncayo, 2015). It is characterized by social, economic, and environmental diversity, with a recent boom in the floriculture industry at the expense of agriculture.

[2] Projection made by SENPLADES, based on the Population and Housing Census, INEC 2010

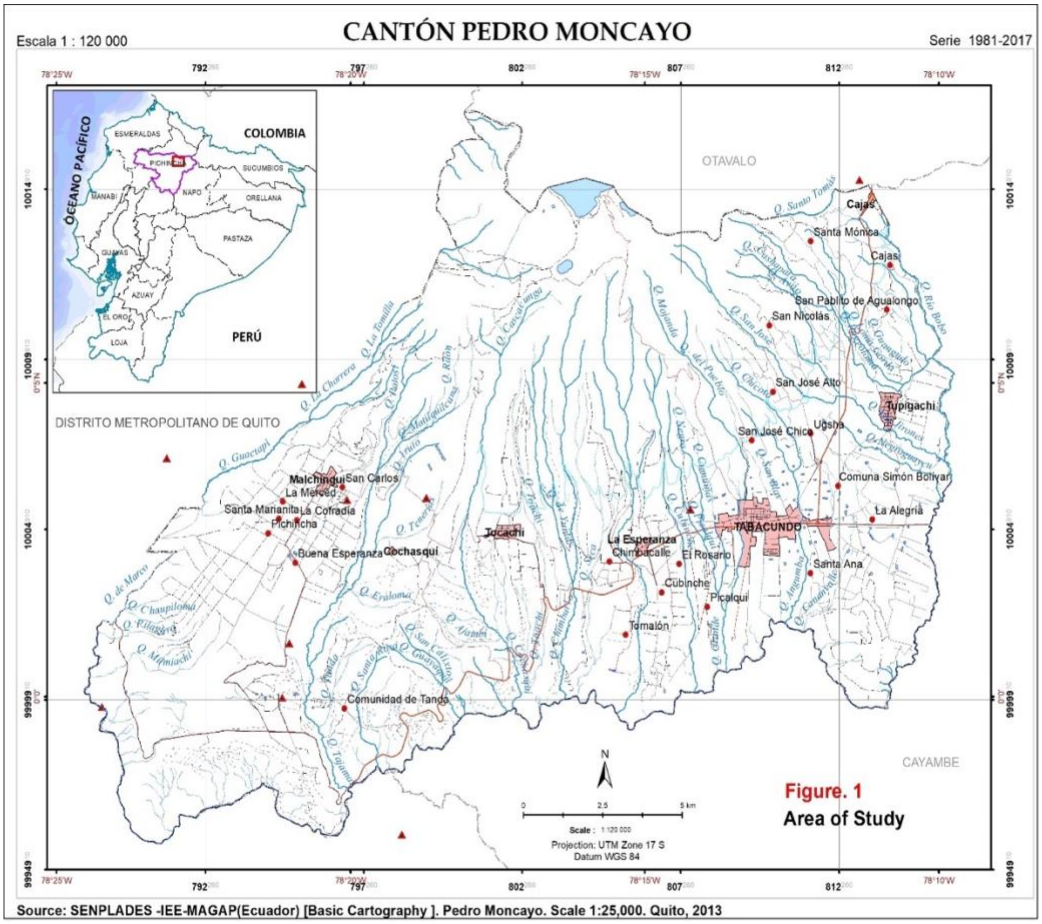


Figure 1: Area of Study

Climate Change: Impacts, Uncertainty and Adaptation

Scholarly understanding of the causes and impacts of climate change has focused on the characteristics of globality, longevity, irreversibility and uncertainty. It is global, indifferent to where the Green House Gas emissions - GHG occur and spread through the atmosphere, heterogeneously generating impacts in the world. It is long-term because increases of temperature and sea level are expected for the next decades and centuries (Wagner, 2015). This contributes to the problem of irreversibility.

The greenhouse effect of natural origin, which allows life on the planet, has intensified with the contribution of emissions generated by human activity. This intensified level, as well as its current and future impacts, may not be reversible. Past and current emissions remain in the atmosphere for a long time and generate impacts beyond the measures that can be taken to reduce them.

Among the major uncertainties, the temporal evolution of GHG emissions is key. Changes in the climate system depend on changing GHG emissions, which in turn depend on the socio-economic development and climate policies to be adopted. To acknowledge this, the IPCC presents four scenarios[3], showing temperature increases ranging between 1.5°C and 4.5°C by the end of this century (IPCC, 2014). Beyond this, there are important uncertainties in the spatial and temporal scales of climate changes and impacts, especially for developing countries and those located in tropical and mountainous regions. Critically, climate models provide little certainty about how local populations will be affected by and adapt to climate conditions (Roy, 2018). There are two primary sources of uncertainty: first, imperfect knowledge of future trajectories of variables that can affect the climate system (mainly GHG emissions); second, imperfect knowledge of how changes in these variables will affect climate change (Burke et al., 2015).

[3] The fifth Assessment Report (AR5) of the IPCC established four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. These scenarios, called Representative Concentration Pathways (RCPs) include a scenario of low emissions (RCP 2.6), two intermediate (RCP 4.5 and RCP 6.) and the one with the highest expected emissions (RCP 8.5). The first and the last are referred to as the optimistic and pessimistic scenarios.

The ultimate objective of the UNFCCC is:

> to achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. (United Nations Framework Convention on Climate Change, 1992)

The relevant question then is: what is the dangerous level of emissions that can interfere with the climate system, and what is meant by adaptation?

The "dangerous level" can be relative, depending on the type of system or element of the system in question. However, an increase of more than 1.5°C to 2.0°C in the global average temperature has been highlighted as having dangerous implications if exceeded (IPCC, 2014; Meinshausen, 2009). The report identified risks of five integrative Reasons for Concern - RFCs that could be generated by exceeding certain values of the average global temperature: unique and threatened systems, extreme weather events, distribution of impacts, global aggregate impacts, and large-scale singular events

The Paris Agreement on Climate Change, signed in December 2015, sets an ambitious objective of limiting the global average temperature increase to well below 2°C or even 1.5°C above preindustrial levels. It recognizes that climate change impacts could be reduced significantly, while also "Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production." (Conference of the Parties, 2015)

This focus on adaptation acknowledges that increased heating produces climate variations that can generate both negative and positive impacts, but that they typically produce and/or increase the vulnerability of weaker systems. Adaptation thus emerges as an alternative response to reduce the impacts of climate change and variability. The IPCC defines climate adaptation as: "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2014). Others have refined this definition (Nuñez, 2016, Arnell, Tompkins & Adger, 2004, Berrang-Ford et al 2015, IPCC, 2012), noting that it refers to both process and outcome, and can be passive or reactive, spontaneous or planned (Smit, Burton, Klein, & Wandel, 2000).

To make plans for adaptation, planners require historical, current and future climate data with the least possible uncertainty, and they need these data at scales that support local-level assessments. To this end, this research presents the main characteristics of the current climate and future projections for the Canton Pedro Moncayo as an important contribution to its planning needs.

Methodology Framework

The World Meteorological Organization, following a longstanding norm in the scientific community, uses statistics as a basic methodological tool for consolidating meteorological data into temporal and spatial series. This study used statistical interpolation to improve both the spatial and temporal certainty for climate data in the study area.

Pedro Moncayo has only a few meteorological stations within the canton, yet there are many other nearby stations in neighboring cantons and throughout the region. For this study, 126 meteorological stations were identified from outside Pedro Moncayo in order to improve the mapping of spatial and temporal distribution of precipitation and temperature.

The meteorological stations were referenced on topographic maps of the Ecuadorian Military Geographical Institute at a scale of 1:50000. All monthly, quarterly, and annual series from 1981-2010 and 1981-2017, with variations in percentage terms (precipitation) and anomalies (temperature), were rendered in a Geographical Information System to generate maps of precipitation and temperature. The 1981-2017 series are used to identify the temporal and spatial distributions of precipitation and temperature.

By comparing with the 1981-2010 series, which is considered standard by the World Meteorological Organization, we generate variation statistics showing increased or decreased precipitation and temperature (anomalies). For temperature maps, a Shuttle Radar Topography Digital Terrain Model (30-meter resolution) was used. Missing data were completed with CHIRPS series from the Climate Hazard Group or, in the case of temperature, with NASA series from the Prediction of Worldwide Energy Resource Climatology Resource for Agroclimatology and Global Modeling and Assimilation Office - GMAO.

To make future predictions, climate change scenarios were generated for Pedro Moncayo based on those prepared by Ecuador's National Institute of Meteorology and Hydrology (and other institutions) and included in the *Third National Communication on*

Climate Change. RCPs of 4.5 and 8.5 were considered.[4] The comparison of current and future climate allowed us to project variations for the period 2031-2050.

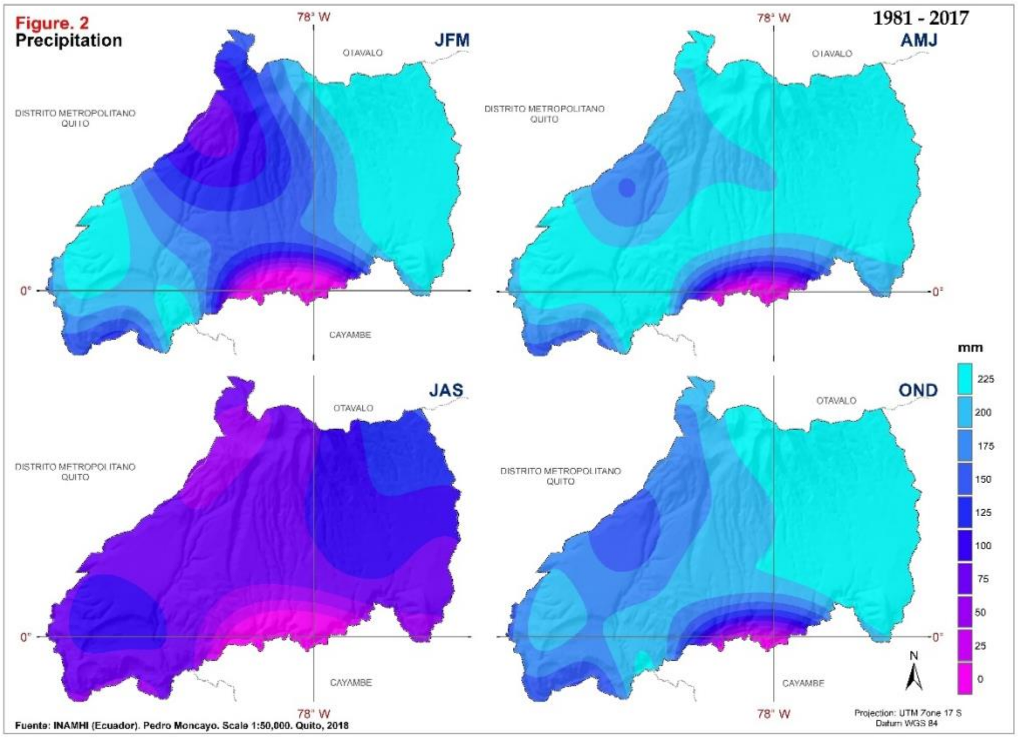
Results

The climate in Ecuador as well as in Pedro Moncayo has changed in the last decades, which is perceived by the people and corroborated by the national statistics. An increase in frequency of extreme events is the common denominator, even when analyses are produced and presented at national level. At the canton level, the limited number of meteorological stations has given only very general climate signals. By adding spatially interpolated data from stations outside the canton and changing the temporal scale of the data, we gain a much more detailed view of the distribution and variations in both temperature and precipitation.

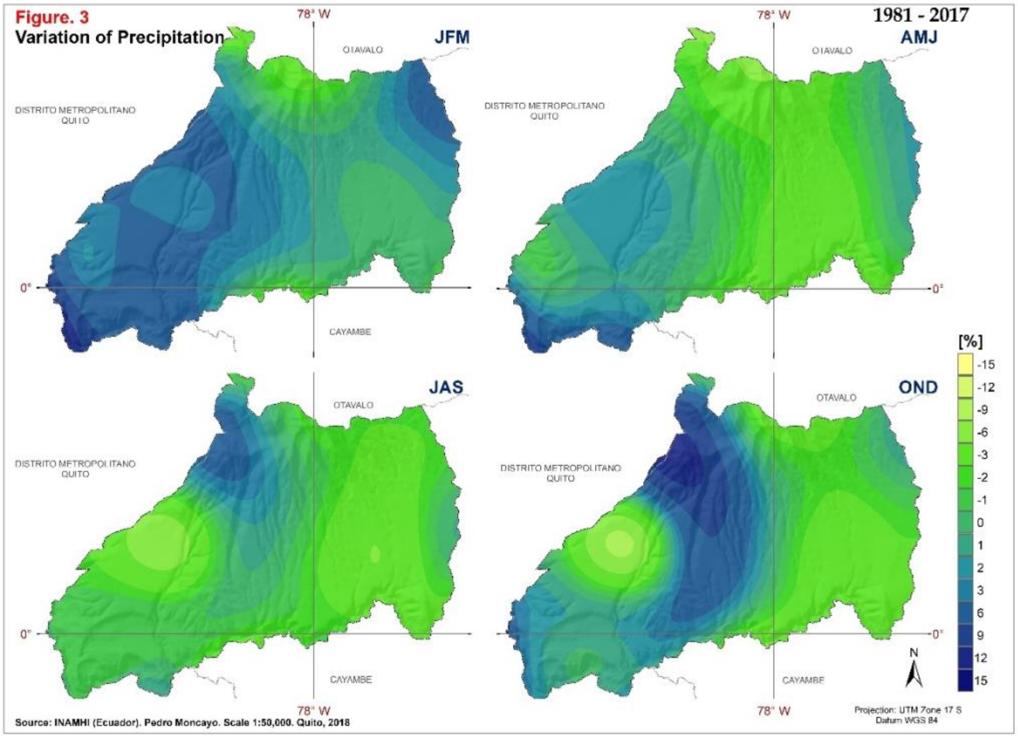
Precipitation

The climate of Pedro Moncayo, in general, is typical of the Ecuadorian highlands with a bimodal distribution: a maximum peak between the months of March and April and a secondary peak in October, along with a dry season between the months of June and September. The quarterly distribution of precipitation shows greater rainfall towards the flanks of the Andean Cordillera in the east and southeast. The south-central zone has the least precipitation during all four quarters of the year, with the lowest rainfall during the quarter of July to September (see Figure 2).

[4] Refer to footnote 6.



The geographical or spatial distribution of the precipitation variation (expressed in percentages) for the period 1981-2017 in relation to the normal (1981-2010), is heterogeneous with increases and decreases in certain areas in the four quarters, with a greater tendency to increase between January and March, especially in the southwest, which is reversed between July and September when the tendency to decrease is predominant. (see Figure 3). This means that in general terms, the precipitation in a larger part of the canton has increased between January to March and has decreased between July and September.



Temperature

The thermal regime of Pedro Moncayo responds to its orographic characteristics and location on the equatorial line. The average temperature has slight variations during the year, but there are important differences between day and night. The maximum midday temperature increases from the northeast to the southwest, where values are highest. On a quarterly basis, although the same geographical distribution is maintained, the highest values of the maximum temperature (up to 24-25°C) are recorded between July and September (see Figure 4). In terms of anomalies for the period 1981-2017, there is a generalized slight decrease in the maximum temperature, in greater magnitude in the northeast, especially between the quarter of July to September (see Figure 5).

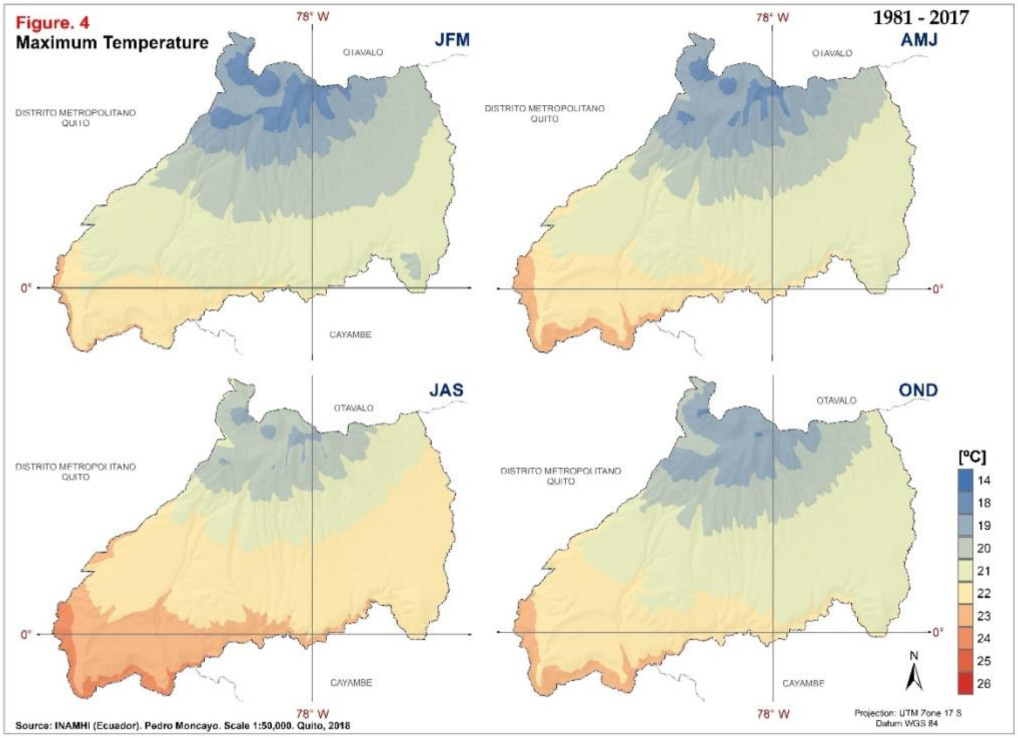


Figure. 4
Maximum Temperature
1981 - 2017
JFM
AMJ
JAS
OND
78° W
0°
OTAVALO
CAYAMBE
DISTRITO METROPOLITANO QUITO
[ºC]
14
18
19
20
21
22
23
24
25
26
N
Projection: UTM Zone 17 S
Datum WGS 84
Source: INAMHI (Ecuador). Pedro Moncayo. Scale 1:50,000. Quito, 2018

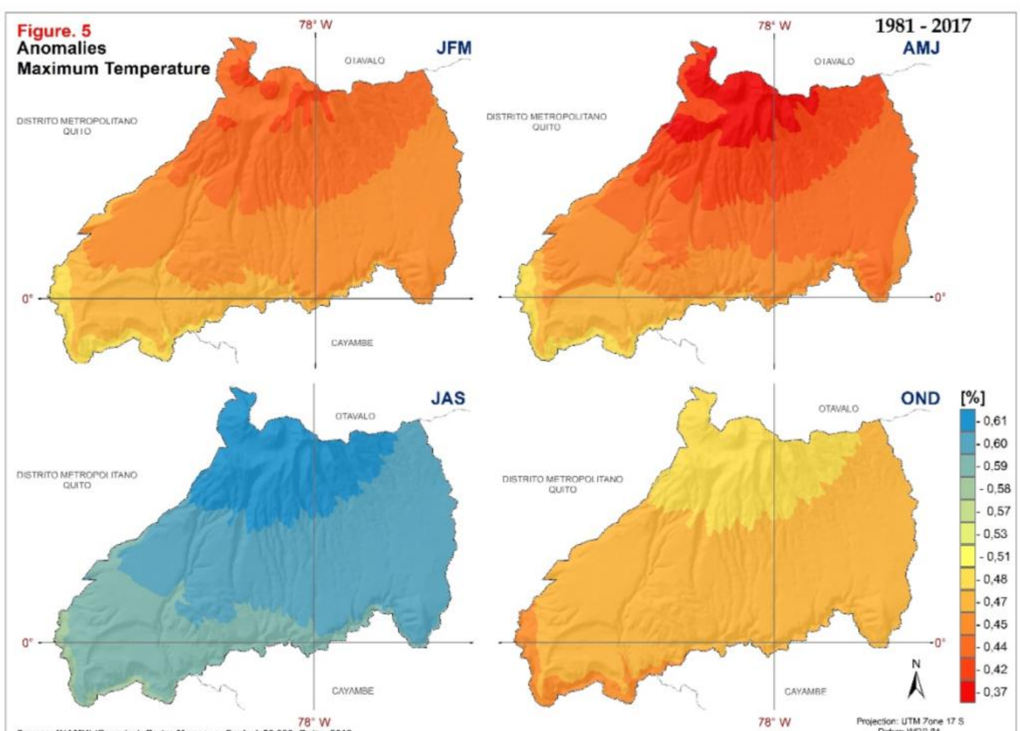
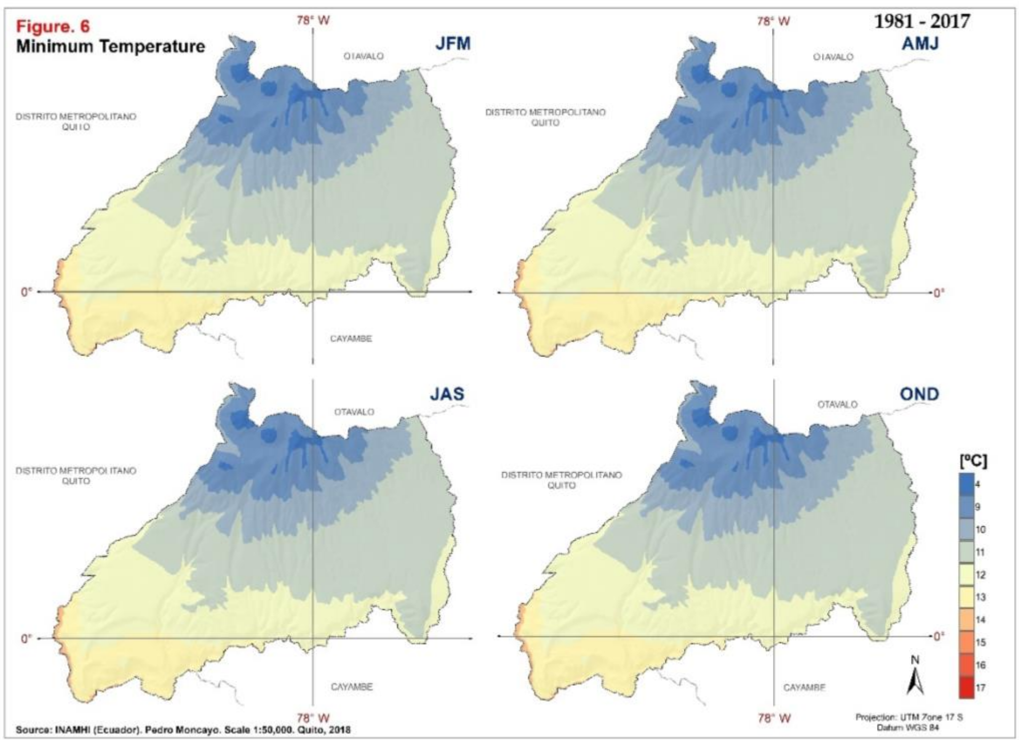
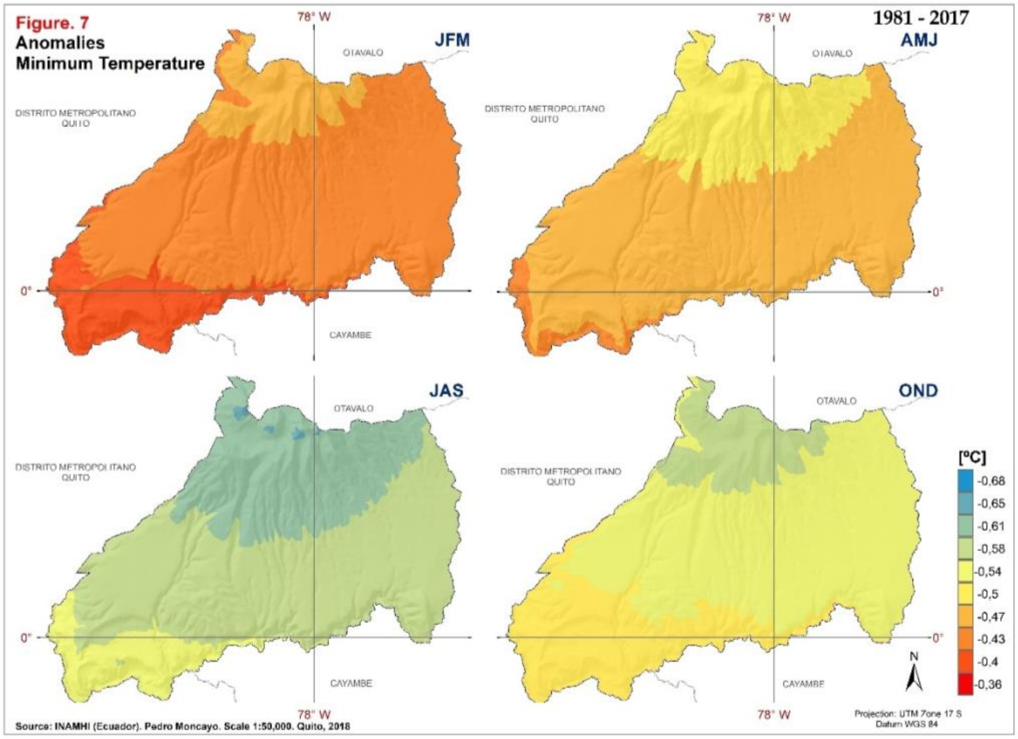


Figure. 5
Anomalies
Maximum Temperature
1981 - 2017
JFM
AMJ
JAS
OND
78° W
0°
OTAVALO
CAYAMBE
DISTRITO METROPOLITANO QUITO
[%]
0,61
0,60
0,59
0,58
0,57
0,53
0,51
0,48
0,47
0,45
0,44
0,42
0,37
N
Projection: UTM Zone 17 S
Datum WGS 84
Source: INAMHI (Ecuador). Pedro Moncayo. Scale 1:50,000. Quito, 2018

The minimum nighttime temperature decreases from the west to the higher parts of the northeast, where the lowest values are recorded (4-9°C) (see Figure 6). The anomalies of minimum temperature, although slight, are greater in the northeaster. The biggest negative anomalies occur in the months between July and September, which is climatologically considered as the dry season (see Figure 7).





Current climate vs Future climate

The maps presented in this section show the spatial and temporal distribution of the variation between current and future climate. The current climate is represented by the average value of the period 1981-2017 and the future climate by the scenarios built for the period 2031-2050 under the 4.5 and 8.5 Representative Concentration Pathways (RCP) [5]

By using the intermediate scenario (RCP 4.5) and the pessimistic scenario (RCP 8.5), we seek to cover the expected variation under extreme emission scenarios. RCP 2.5 is not used because, despite the fact that it is the objective of the Paris Agreement that will come into force as 2020, it seems very unlikely considering the actual circumstances (Aida Arteaga, 2017).

5 Refer to footnote 6.

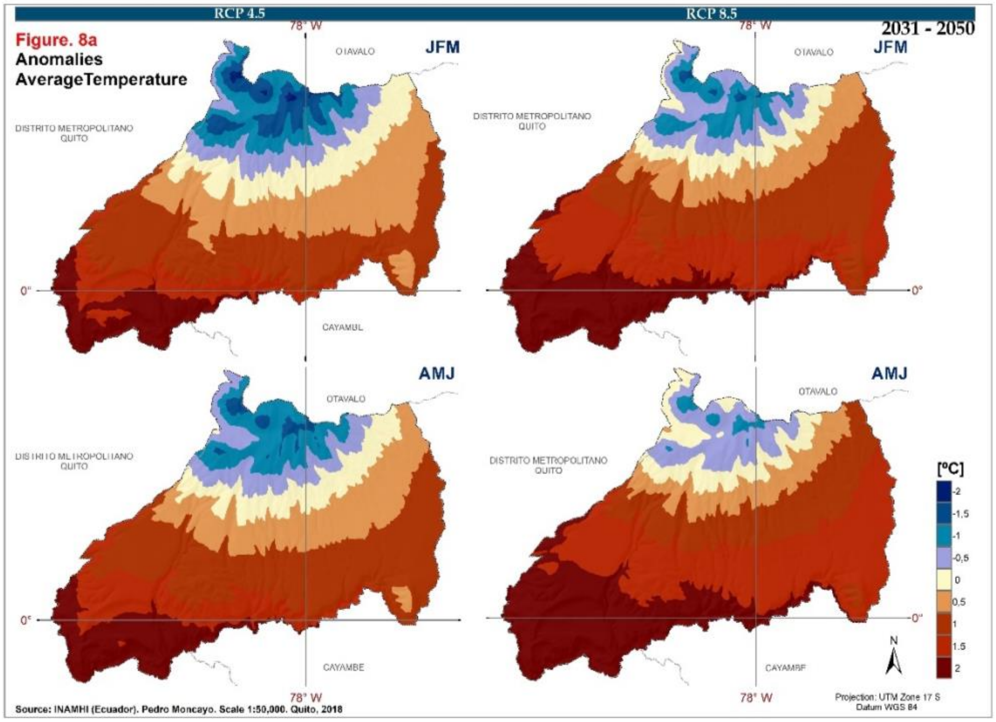
It should be noted that the current climate used in this research is different to that used for the Third National Communication on Climate Change presented by Ecuador before the UNFCCC. This difference is fundamentally based on three aspects: period considered, source of the database and methodology. This analysis is based on data from 126 meteorological stations located in and around the Canton Pedro Moncayo for the period 1981-2017.

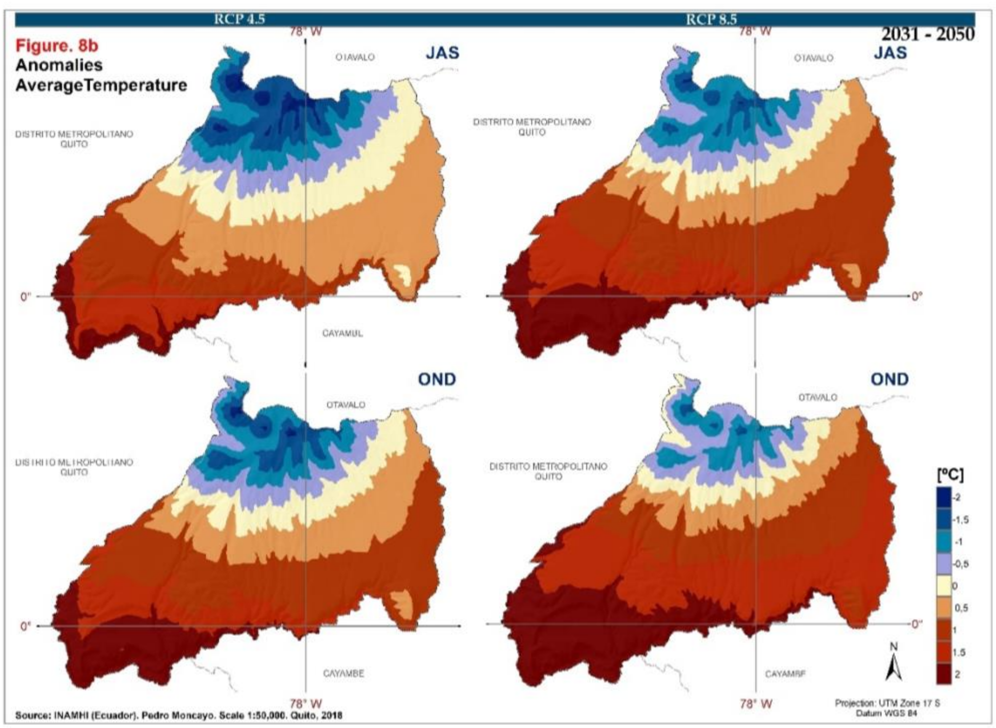
Temperature

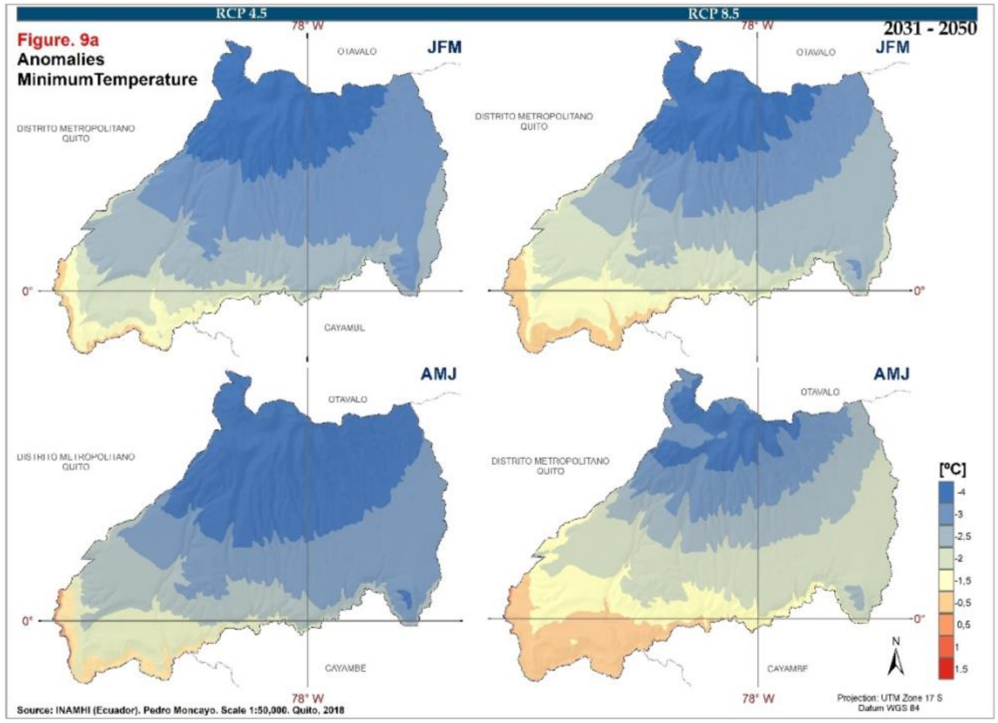
To identify quarterly trends, we calculated the anomaly of the average temperature between current climate (1981-2017) and future climate (2030-2050) expressed in degrees centigrade.

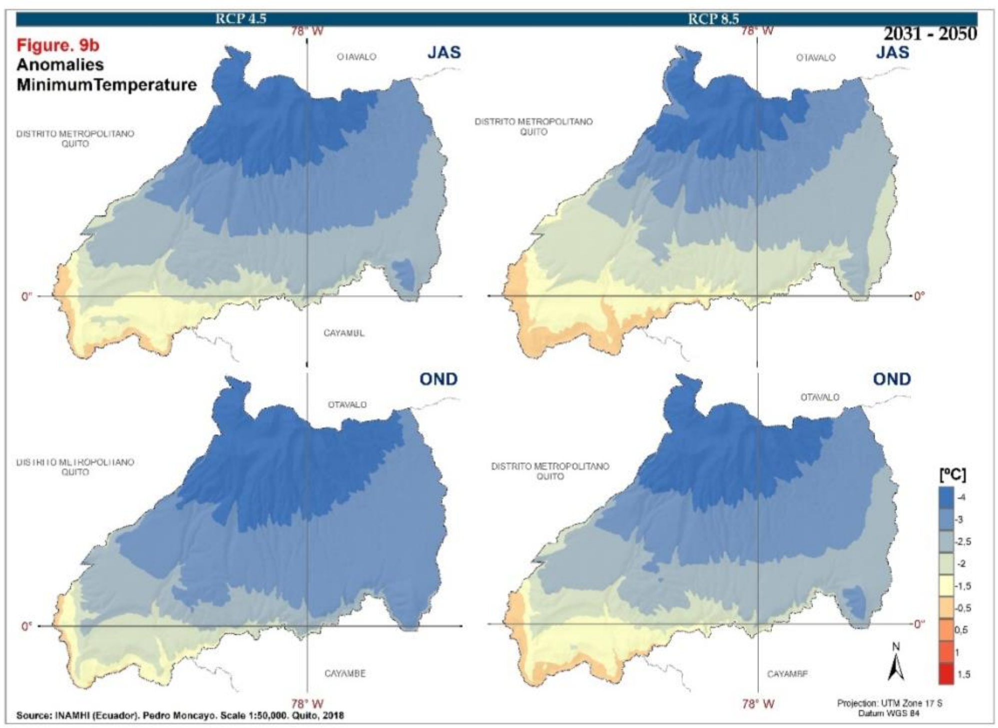
Under RCP 4.5, there is a decrease in the average temperature in the northern center and an increase in the rest of the canton in all the quarters. From quarter to quarter there are no major variations in the values of the anomalies (see left side of Figures 8a and 8b). Under RCP 8.5, the same geographical distribution of the anomalies is maintained, with a greater magnitude of the increase in temperature and less of the decrease in the north center of the canton (see right side of Figures 8a and 8b).

Under RCP 4.5 the minimum temperature decreases practically throughout the territory of the canton, with greater intensity in the northern center, especially in the quarter from July to September (see left side of Figures 9a and 9b). Under RCP 8.5 the minimum temperature decrease is maintained, but with a smaller magnitude, especially in the July-September quarter (see right side of Figures 9a and 9b).

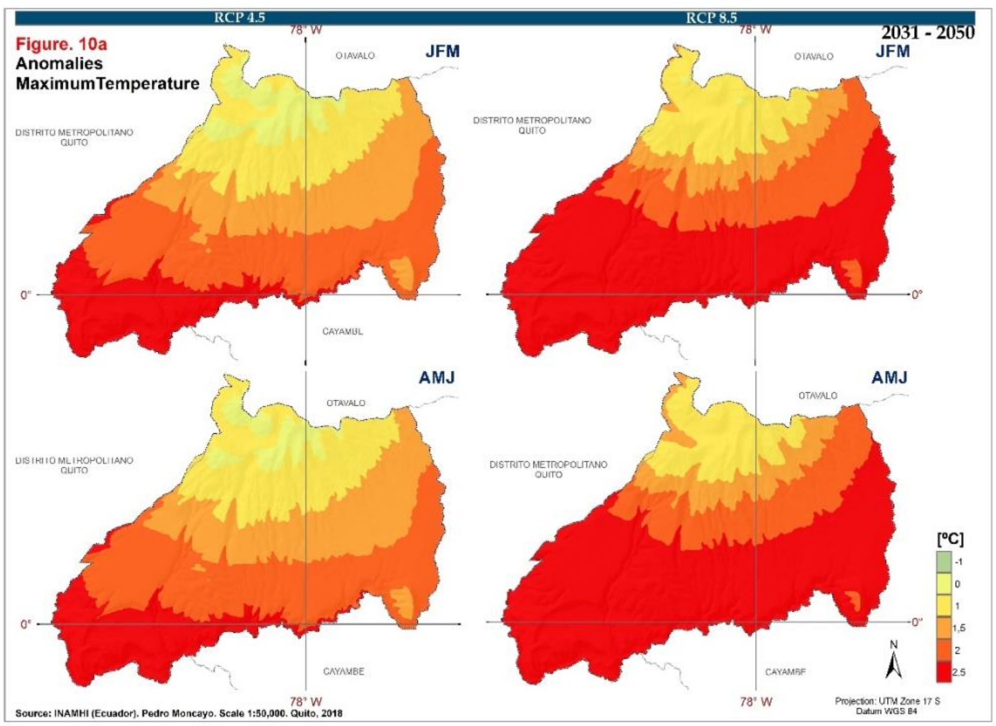

RCP 4.5
RCP 8.5
2031 - 2050
Figure. 8a
Anomalies
AverageTemperature
JFM
AMJ
OTAVALO
DISTRITO METROPOLITANO QUITO
CAYAMBE
78° W
0°
[ºC]
-2
-1,5
-1
-0,5
0
0,5
1
1,5
2
N
Projection: UTM Zone 17 S
Datum WGS 84
Source: INAMHI (Ecuador). Pedro Moncayo. Scale 1:50,000. Quito, 2018

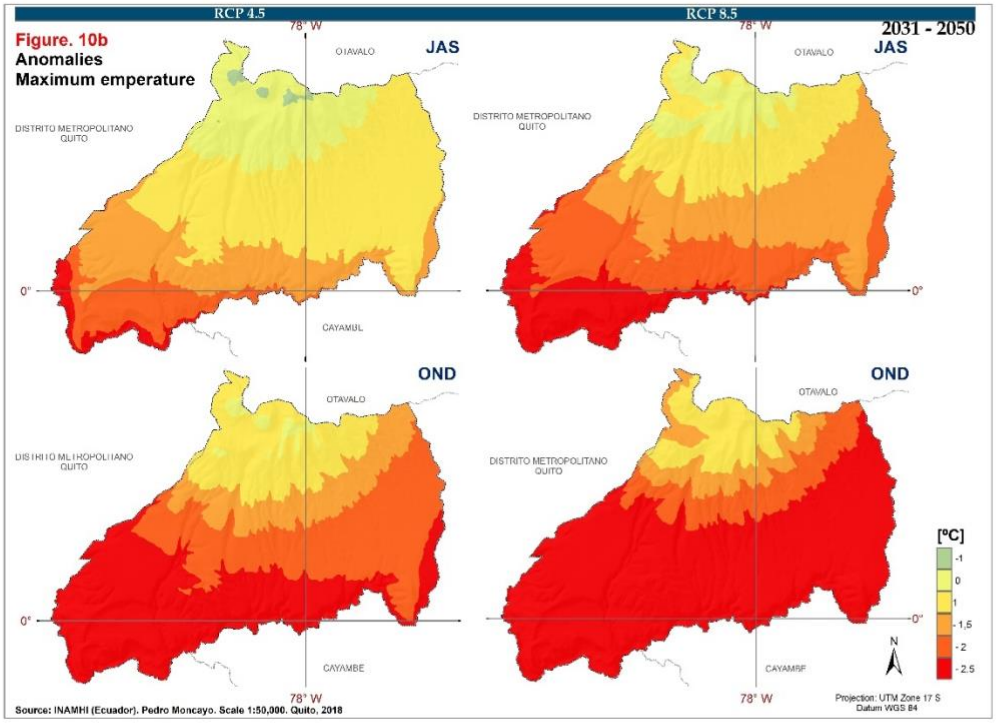

RCP 4.5
RCP 8.5
2031 - 2050
Figure. 8b
Anomalies
AverageTemperature
JAS
OND
OTAVALO
DISTRITO METROPOLITANO QUITO
CAYAMBE
78° W
0°
[ºC]
-2
-1,5
-1
-0,5
0
0,5
1
1,5
2
N
Projection: UTM Zone 17 S
Datum WGS 84
Source: INAMHI (Ecuador). Pedro Moncayo. Scale 1:50,000. Quito, 2018


RCP 4.5
RCP 8.5
2031 - 2050
Figure. 9a
Anomalies
MinimumTemperature
JFM
AMJ
78° W
0°
OTAVALO
DISTRITO METROPOLITANO QUITO
CAYAMBE
[°C]
-4
-3
-2,5
-2
-1,5
-0,5
0,5
1
1,5
N
Projection: UTM Zone 17 S
Datum WGS 84
Source: INAMHI (Ecuador). Pedro Moncayo. Scale 1:50,000. Quito, 2018


RCP 4.5
RCP 8.5
2031 - 2050
Figure. 9b
Anomalies
MinimumTemperature
JAS
OND
78° W
0°
OTAVALO
DISTRITO METROPOLITANO QUITO
CAYAMBE
[°C]
-4
-3
-2,5
-2
-1,5
-0,5
0,5
1
1,5
N
Projection: UTM Zone 17 S
Datum WGS 84
Source: INAMHI (Ecuador). Pedro Moncayo. Scale 1:50,000. Quito, 2018

The maximum temperature under RCP 4.5 also increases practically throughout the entire territory, with a greater magnitude throughout the south, especially in the quarter from October to December. During the quarter from July to September, the increase is mainly concentrated in the southeast (see left side of Figures 10a and 10b). Under RCP 8.5, the generalized increase is of greater magnitude throughout the canton and throughout the year, with the exception of the central northern area. The increase is of smaller magnitude between the months of July and September (see right side of Figures 10a and 10b).

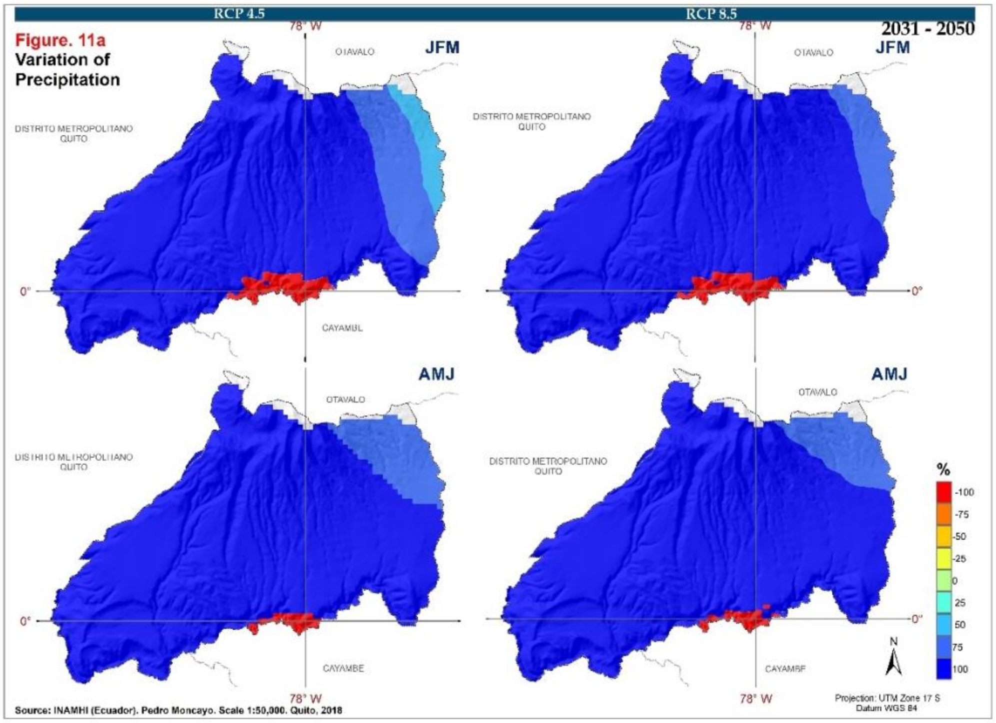


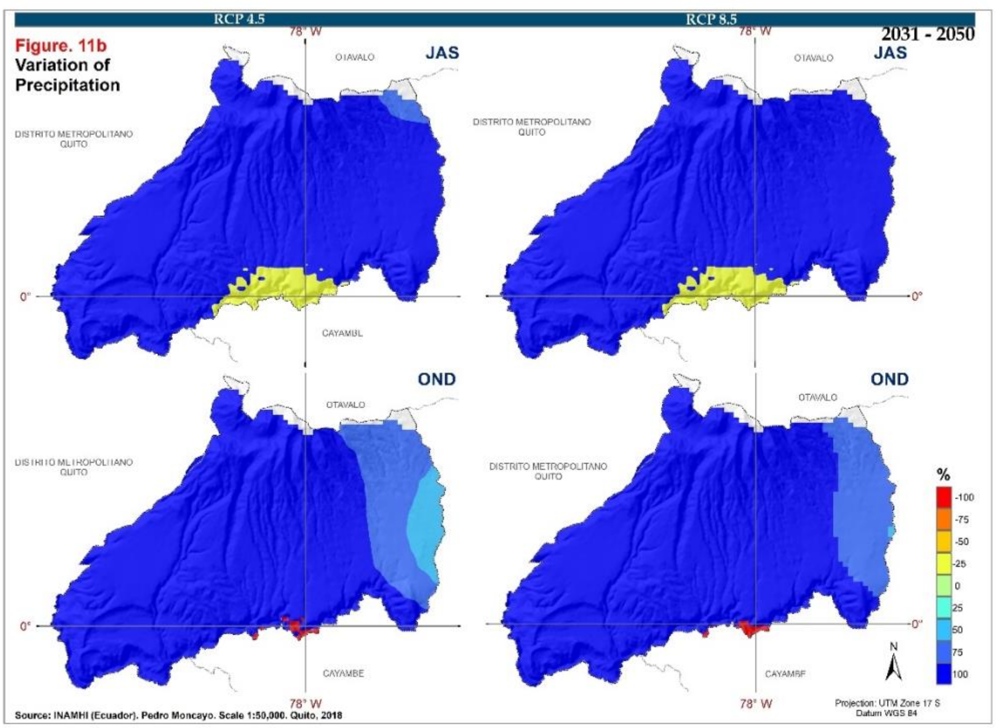


Precipitation

To identify quarterly trends, we calculated the variation of quarterly precipitation between current climate (1981-2017) and future climate (2031-2050) by percentage. The predicted percentage variation is predominantly positive, showing increased precipitation in almost the entire territory, with the exception of a small area south of the canton's center.

During the four quarters and under RCP 4.5, the geographical distribution of the percentage variation is maintained, with a greater quantitative significance between January and March. (see left side of Figures 11a and 11b). Under RCP 8.5, both the spatial and temporal distribution (between the quarters) are maintained without major changes. (see right side of Figures 11a and 11b).


RCP 4.5
RCP 8.5
2031 - 2050
Figure. 11a
Variation of Precipitation
JFM
AMJ
OTAVALO
DISTRITO METROPOLITANO QUITO
CAYAMBE
78° W
0°
%
-100
-75
-50
-25
0
25
50
75
100
N
Projection: UTM Zone 17 S
Datum WGS 84
Source: INAMHI (Ecuador). Pedro Moncayo. Scale 1:50,000. Quito, 2018


RCP 4.5
RCP 8.5
2031 - 2050
Figure. 11b
Variation of Precipitation
JAS
OND
OTAVALO
DISTRITO METROPOLITANO QUITO
CAYAMBE
78° W
0°
%
-100
-75
-50
-25
0
25
50
75
100
N
Projection: UTM Zone 17 S
Datum WGS 84
Source: INAMHI (Ecuador). Pedro Moncayo. Scale 1:50,000. Quito, 2018

Discussion

This analysis indicates a homogeneous geographic distribution of precipitation, nighttime temperature, and daytime temperature, with slight variations between the quarters. Topography plays a fundamental role in this finding. Between 1981 and 2017, however, precipitation variation is temporally heterogeneous, with increases and decreases in several areas. The period between January to March (rainy season) shows an increase in precipitation, while decreases have occurred in the dry-season months of July to September. Maximum temperature has decreased slightly, especially in the northeast. Minimum temperature has diminished slightly, especially in the dry season.

In the future, this study predicts an increased average temperature (with the exception of the north center), a decrease of the minimum temperature, and an increase of the maximum temperature. That is, we expect slightly colder nights and hotter days. Under a pessimistic emissions scenario (RCP 8.5), the situation varies slightly in terms of magnitude. For quarterly precipitation, this study predicts a generalized increase in precipitation in all quarters, with the exception of areas of the northern center, a situation that is basically maintained even under a pessimistic scenario of GHG emissions.

It is important to emphasize that the future scenarios predicted in this paper differ from those presented by Ecuador in its *Third National Communication on Climate Change* to the UNFCCC, especially in terms of magnitude. There are two important reasons for these differences. First, and remarkably important, is the use of an appropriate local-level scale of analysis. Second, the current climate data used in this study are somewhat different, as a result not only of the scale of analysis, but also the time period, the database source, and the methodology. The study of the scenarios presented in the *National*

Communication uses the period 1981-2005, considers a total for the whole country of 137 stations with rainfall data and about 30 with temperature data. The methodology used in the present investigation considers in depth the issue of orography and altitude, using a terrain digital terrain model and making corrections for missing data.

This is a critical finding, showing that the magnitude and, in some cases even the direction (+/-), of the expected variations are different depending on which data series/scale is used for present climate.

We are convinced that the best mechanism to confront climate change and increase the adaptation capacity of communities is to provide meaningful predictions at local scales that can be used as the basis for detailed planning. This paper demonstrates both the difficulty and the promise of this approach, pointing toward a need for more research on this topic, conceptually and empirically. For the case of Pedro Moncayo canton, we have produced results that will support the articulation of local mechanisms to deal with the present and future climate conditions. This promises great benefit to those communities living and dealing with climate change.

Acknowledgements

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ARTICLE 2 SOCIO ECONOMIC AND GENDERED IMPACTS OF THE ADOPTION OF AGROECOLOGICAL PRACTICES AS A CLIMATE CHANGE ADAPTATION MECHANISM IN FOUR HIGHLAND COMMUNITIES IN PEDRO MONCAYO, ECUADOR

Abstract

Although there is no clear and consensual definition of agroecology, its role as an adaptation mechanism to climate change, with benefits to food sovereignty, production, and community well-being, has been shown and widely discussed. The gendered impacts of agroecological practices on communities and their perceptions of climate change, however, have received little attention. This paper examines the differing perceptions of men and women in several Andean communities in Pedro Moncayo, Ecuador, focusing on their reaction to the socioeconomic and environmental changes seen in their communities due to the use of agroecological practices as a climate change adaptation mechanism. The results show how the implementation of agroecology increases adaptive capacity of these communities, especially for women.

Keywords: climate change, gender, agroecology, Ecuador

Resumen

A pesar de que no existe un claro consenso en la definición de agroecología, su rol como mecanismo de adaptación al cambio climático, con beneficios para la soberanía alimentaria, producción y bienestar comunitario, ha sido ampliamente evidenciado y discutido. Sin embargo, los impactos de género de las practicas agroecológicas en comunidades y sus percepciones sobre cambio climático, no han recibido mayor atención.

Este artículo estudia las diferentes percepciones de hombres y mujeres en varias comunidades andinas de Pedro Moncayo, Ecuador, enfocándose en sus reacciones a los cambios socio económicos y culturales vistas en sus comunidades debido al uso de prácticas agroecológicas como un mecanismo de adaptación al cambio climático. Los resultados muestran como la implementación de la agroecología incrementa la capacidad de adaptación de estas comunidades, especialmente de la mujer.

Palabras clave: cambio climático, género, agroecología, Ecuador

> "Gender inequalities constitute one of the structural problems of the Ecuadorian socio-economic system. It is necessary to develop and strengthen the technical capacities of authorities, decision makers and technical personnel..., as well as of counterpart actors, in gender analysis, gender approach and gender theory related to climate change"
> (Ministerio del Ambiente de Ecuador, 2017, pg. 487).

> "Gender is now a reviewed research topic for the IPCC because of the differential impacts of climate change and climate policy on women."
> (Gay-Antaki & Liverman, 2018, pg. 2060).

Introduction

Gender refers to socially constructed categories describing women and men, and it is shaped by the cultural notions of masculinity and femininity (Dankelman, Introduction: exploring gender, environment and climate change, 2010). Gender is highly relevant for policymaking since it points toward differentiation among the reproductive, productive, community management and political roles that are played by men and women in society (Burns, 2017). Gender is conceptualized as a "meaning system" and has proven to be a critical factor in shaping access to, and control over, resources, environmental decisions, and technologies (Schubert, 2005; Rocheleau, Thomas-Slayter, & Wangari, 1996) and, in contrast to sex, gender can change over time and according to social class, religion, ethnicity, region, or country (Nagel, 2016). Multi-disciplinary scholars maintain that gender shapes socionatural relations and is consequently fundamental to understanding resource access, use and degradation around the world (Goldman & Schurman, 2000) and is critical to guaranteeing a more accurate assessment of environmental change at the scale where decisions are made (MacGregor, 2010) (Buechler & Hanson, 2015). Siliprandi and Zuluaga (2014), citing Deere (2002), established that a gendered perspective has enhanced the analysis of rural populations and agricultural development initiatives such as agroecology.

In this study, we are particularly interested in understanding the socioeconomic and gendered impacts of the use of agroecological practices as a potential mechanism for rural adaptation to climate change. Agroecology emerged at the end of the 1970s in response to the environmental movement and the ecological crisis. Although the term was new, agroecology was often presented as a "rediscovery" of peasant knowledge about ecology and agriculture, through oral transmission and conservation techniques (Molina, 2011). Recent attention to the science and practice of agroecology acknowledges it is as old as the origins of agriculture (Busconi 2017). Modern agroecological movements leverage this long history to recover and support alternatives to the predominant production and consumption model (Neira & Montiel, 2013). In five main centers in Latin America -- Brazil, the Andean Region, Central America, Mexico, and Cuba -- agroecology has become a phenomenon in which social and political movements, scientific research, and the production of technologies combine in an innovative process linked to progressive governments and to peasant and indigenous resistance movements (Altieri & Toledo, 2011).

This study focuses on Andean highland communities in Ecuador, where an indigenous movement has reacted strongly against the agrofood-system crisis through uprisings in 1990, 1994, and 2000 (Toledo, 2012). Agroecology is an important part of this resistance, as it provides an intercultural link and a collective way of developing a constructive social change scenario. Recently recognized in the Constitution of Ecuador, agroecology is not only a scientific discipline but also a way of escaping certain economic and technological structures, and it shows an intrinsic relationship between food sovereignty and the solidarity economy (Gortaire, 2017). Food sovereignty -- the right of people to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems (European Coordination Vía Campesina, 2018) – is conceived as a precondition to genuine food security (Lee, 2007 adapted from Via Campesina, 1996: 1).

According to Altieri & Toledo (2011), agroecology provides the principles for rural communities both to achieve food sovereignty and to design resilient agroecosystems capable of withstanding variations in climate. The use of polycultures and agroforestry systems also situates indigenous knowledge as a key source of information on adaptive capacity to climate change. The use of agroecological practices such as crop diversification, seed saving to maintain local genetic diversity, animal integration, soil organic management, water conservation and harvesting help agricultural systems to become more resilient to climate change (Nicholls C. I., 2013), to recover and value some local knowledge and strengthen the autonomy of farmers (Zuluaga & Aura Luz Ruiz, 2013). Terms like "traditional knowledge," "indigenous technical knowledge," "rural knowledge," and "ethnoscience" have often been used interchangeably "to describe the system knowledge of a rural ethnic group that has originated locally and naturally… information is extracted from the environment through special systems of cognition and perception that select the most useful and adaptable information, and then successful adaptations are preserved and transmitted from generation to generation by oral or experiential means…" (Altieri, 1991: 2). Most research on agroecology focuses on its ecological resiliency, but little has been written about the ways it allows peasants and rural communities to establish leadership on social, political and environmental issues. (Altieri M. A., Nicholls, Henao, & Lana, 2015).

There has been little attention to gender roles within agroecological systems, and food sovereignty, even though some AE-based social movements, like La Via Campesina, explicitly hold gender equality as stated values (Patel, 2012). Few studies have analyzed the relationship between gender and food sovereignty (Park, White, & Julia, 2015), and some others of agroecology and food sovereignty (Oliver, 2016), but none have examined the particular relationships between gender, food sovereignty and specific agroecological practices (Kerr, Hickey, Lupafya, & Dakishoni, 2019).

Given that agroecology has received new attention as an adaptation mechanism for climate change (Gortaire, 2017; Colectivo Agroecológico del Ecuador, 2017), and that it is now common knowledge that climate change impacts and adaptations have a gendered dimension (Nagel, 2015; Djoudi, y otros, 2016; Dankelman, 2010; MacGregor, S., 2010; Arora-Jonsson, 2011), it is critical that we analyze agroecological practices from a gender perspective.

Agriculture constitutes the most important source of employment for women living in rural areas in most developing countries (Howland et.al., 2019), however they have less access than men to productive resources such as assets, inputs, knowledge, land, fertilizer, improved seeds, education, financial services, technologies and opportunities (Peterman et. al, 2014; Sheanan and Barrett, 2014; Gutiérrez-Montes et al., 2018; IICA, 2018). Closing these inequalities, known as the gender gap in agriculture, could increase agricultural production in the developing world by between 2.5% and 4%, on average (Food and Agricultural Organization, 2011)

This research presents the socioeconomic and gendered impacts of an Ecuadorian project that sought to revitalize agroecological practices in four Andean highland communities of Pedro Moncayo. Our study shows that policy support for agroecological practices has helped legitimize ancestral and indigenous knowledge while also positioning women as repositories of knowledge; and that it promotes technological advances that improve harvesting, seed adaptation and care, production of surpluses, and harvest irrigation and management through trainings involving both men and woman. When combined, these activities constitute climate change adaptation practices. Both men and women perceived agroecology as an important means to achieve nutritional security and sovereignty even though they agree it produced insufficient income. Women were emphatic about the positive ways agroecological practices contribute to the development of their families, especially in terms of health and increased independence they gained by earning additional income. In this way, agroecology challenges gender disparities: it has allowed women to participate in spaces beyond their reproductive roles, to produce and reproduce knowledge, to be part of community organizations, and to become leaders.

Area of Study

Ecuador, located in South America, is a megadiverse country that has four distinct ecoregions within its territory: the marine coast, the Andean highlands, the Amazon, and the Galapagos Islands. With a great variety of climates and microclimates across its 256,370 square kilometers, Ecuador is considered one of the 17 most mega-diverse countries on the planet. It also has a high cultural diversity, with the following population groups officially recognized: mestizo, montubio, indigenous, white, Afro-Ecuadorian / Afro-descendants, and "others".

The activities of agriculture, livestock, hunting and forestry generate the most employment in Ecuador, with 24.97% of the population employed in these sectors in 2015 and 28% in 2018. According to the 2010 Census, 48.6% of the indigenous population, 16.4% of the Afro population and 16.7% of the mestizo population were engaged in these activities. (Instituto Ecuatoriano de Estadísticas y Censos - INEC, 2010). "Historically, land ownership and distribution has been highly concentrated and unequal in Ecuador, with the majority of peasantry having insufficient access to land to meet family subsistence needs throughout the year" (Brassel, Herrera, and Laforge, 2008, cited on Tilzey 2019, pg. 639). Poverty due to Unsatisfied Basic Needs shows the indigenous population as the poorest, with a difference of 32.6% with mestizos in 2010.

Pedro Moncayo is located in the Inter-Andean region, in northeastern Pichincha province, Ecuador. It occupies an area of 339 km^2 and in 2014 had a population of 37,802. The indigenous population makes up 26% of the total population, while 68% are mestizo, with the remaining 6% identified as White, Black, and mulatto. The poverty level in Pedro Moncayo is higher than the national average, reaching 80% in rural areas (INEC, 2010). Indigenous populations have the highest poverty rates, with differences of 20.2% over the afro population and 24.9% over the mestizo population in 2010.

Over the past 20 years, the rural population has decreased by 10% due to heavy migration toward urban areas. With the arrival of numerous international flower companies, the surplus value of productive land increased in Pedro Moncayo, often separating producers from their land. There were also changes in agricultural production, as residents had previously grown products mainly for self-consumption, with any surplus intended for commercialization. Now that much of the population is dependent on salaried employment and farmers have left their lands (Pinchao, 2013). As people searched for employment and a better quality of life, migrants who have left Pedro Moncayo have mostly chosen other nearby cantons in the Pichincha province, especially Quito, which boasts a large urban center that makes it attractive in terms of employment and educational opportunities. (Gobierno Autónomo Descentralizado de Pedro Moncayo, 2018).

An estimated 57% of the land of Pedro Moncayo is devoted to agriculture, with most farming taking place at elevations between 1,730 and 4,300 meters. Floral production constitutes the most competitive and profitable activity of the region, generating employment for 59% of the population. According to the Survey of Surface and Continuous Agricultural Production, there were 86 floriculture farms registered in Pedro Moncayo in 2016, ranging in size from 0.75 to 28 hectares. Although there is little public information available about these firms, most of them are international and controlled by investors from outside Ecuador. Most of the floriculture operations are concentrated in Tabacundo Parish, and they export their products to the US, Russia, and Europe.

Floriculture has been widely questioned due to its impacts on the environment and the health of the population (Breilh, 2007; Acosta, 2010), as well as on indigenous rights to land and water (Hidalgo, Boelens, & Vos, 2017). According to the canton's 2018

Territorial Development Plan, excessive use of agrochemicals in large-scale floral operations has led to an increase in disease, primarily cancer. Likewise, the growth of a land market and competition with foreign floral producers threatens the rural population and worsens local food security and sovereignty (Gobierno Autónomo Descentralizado de Pedro Moncayo, 2018).

Figures 1 and 2 show how land use and land cover have changed over the past three decades (from 1990 to 2016), particularly highlighting the massive growth of land devoted to agroexport companies, the floral industry and agriculture. These indirectly indicate increased pressure on natural resources, especially water and land.

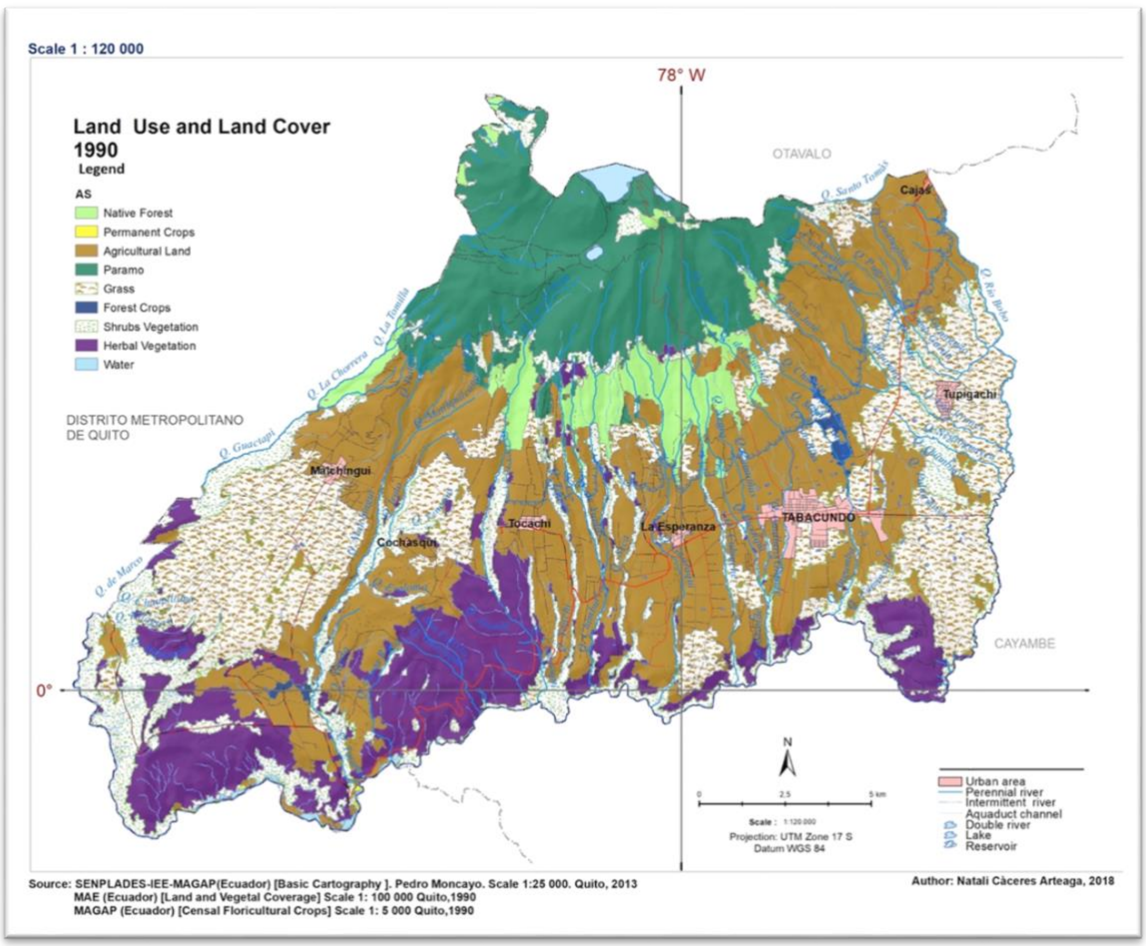

Figure 1: Land Use and Land Cover, 1990

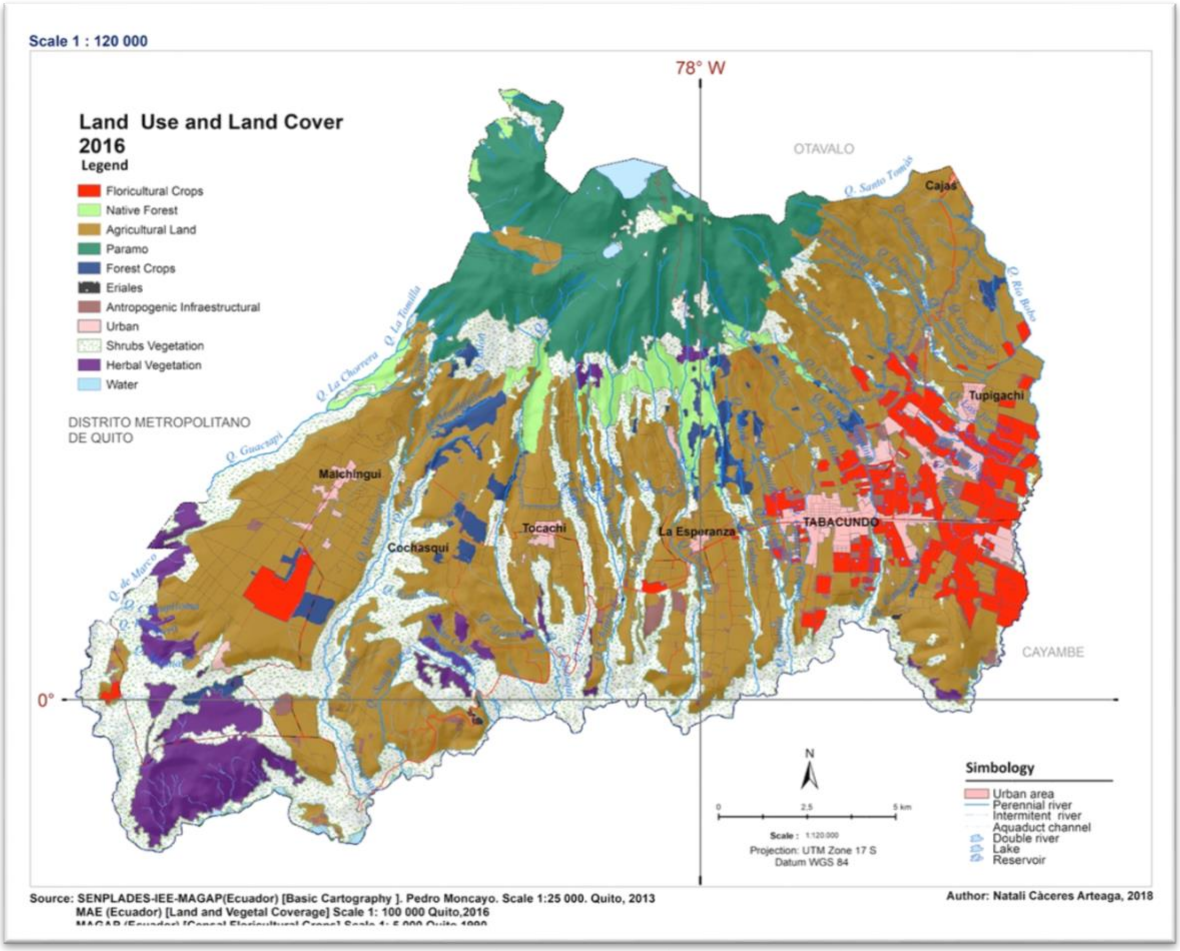

Figure 2: Land Use and Land Cover, 2016

In addition, climate change presents one of the current threats to sustainable farming in the Andes (Perez, C. et. al 2010, pg. 71) and constitutes a significant challenge for both the biophysical and socioeconomic systems in Pedro Moncayo, particularly threatening productive agricultural areas. A recent analysis of future climate change scenarios for Pedro Moncayo — the first and only such canton-level meteorological study in Ecuador — shows that the area is likely to face colder nights and warmer days, with its southernmost areas likely to experience severe dryness. Because the economy of this area is entirely dependent on the irrigated agriculture and floriculture industries, predicted increases in dryness threaten both subsistence farming and commercial operations that provide employment throughout the canton (Cáceres-Arteaga et al., 2018).

The development plan of the Municipality of Pedro Moncayo, updated in 2018, established that irrigation water for agriculture must come from the micro-basin of the Chimba River in Cayambe. However, only 22.5% of the productive land located in this area currently has adequate water for irrigation. Water access is intermittent, depending on the location of irrigation systems or on families' ability to invest in constructing water storage infrastructure. Water harvesting practices, such as well-drilling and reservoir construction, are now under development in several rural areas (See figure 3).

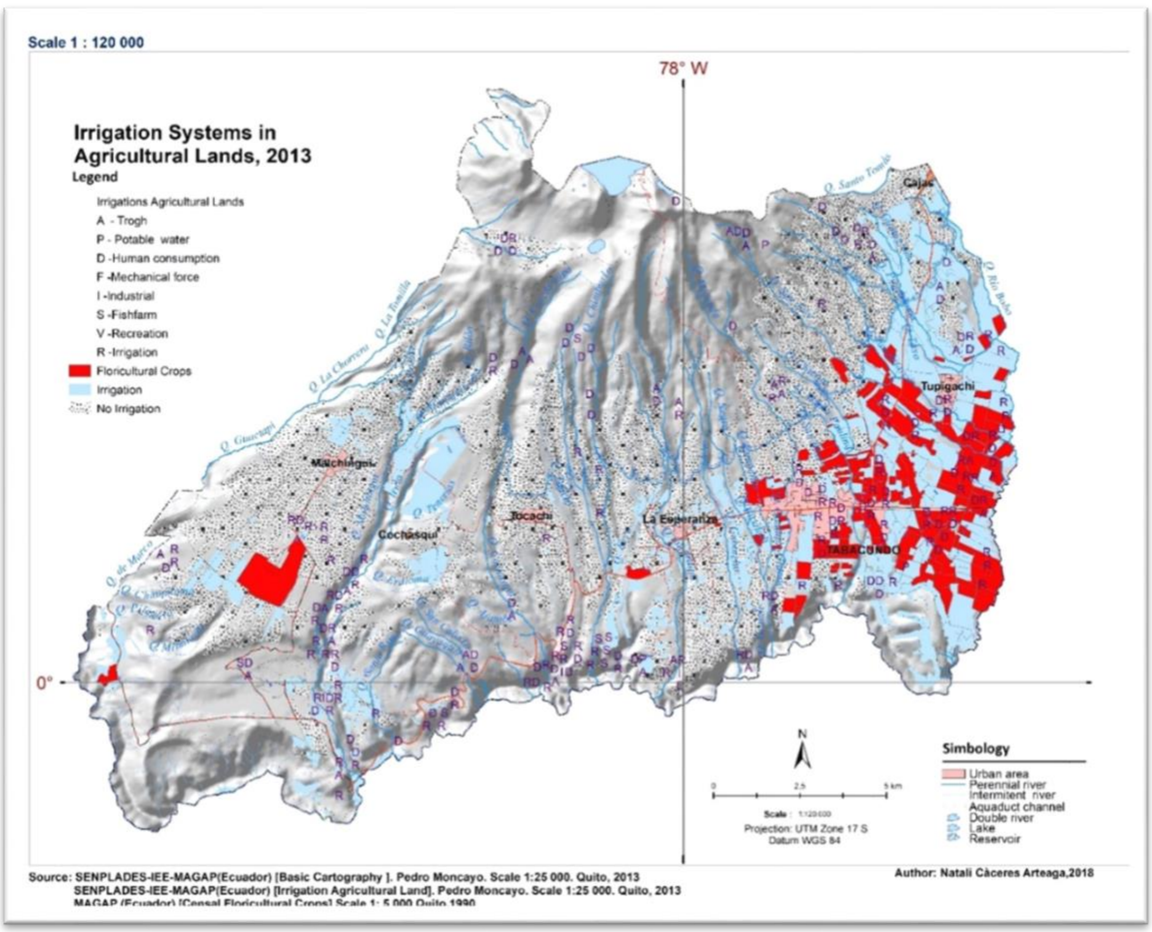

Figure 3: Irrigation Systems in Agricultural Lands, 2013

The Agroecological Project

To improve subsistence producers' ability to adapt to climate change impacts while simultaneously increasing their market engagement, the municipality of Pedro Moncayo is currently implementing an agroecology project for 150 families living in the parishes of Tabacundo, La Esperanza, Tocachi, and Tupigachi. The project is part of a cantonal process initiated in 2009 to consolidate agroecological fairs and support organizations of small producers working under the support of international NGOs.

The municipality extended the project through demonstrative group trainings on farms where neighboring families participated, thus covering nearly the entire canton. Families were trained on farm design to help them adapt to climate change impacts, including spatial considerations such as where to put a reservoir, how to distribute crops, how to arrange a composter, which crops to rotate, and how to optimize irrigation and water harvesting systems. The training explicitly associated ancestral knowledge with new technology, through activities and instruction on how to prepare and improve natural fertilizers, for example. Training groups included more women than men, because the program worked to schedule training events at times that would not interfere with family activities. Overall, the program has enjoyed broad participation and has succeeded in helping families minimize productivity losses through the implementation of agroecological practices for adapting agriculture to climate change.

Data and Methods

This study used a mixed-methods approach to address the following question: How has the use of agroecological practices as a mechanism of climate change adaptation transformed the socioeconomic conditions of agricultural communities in Pedro Moncayo? Both quantitative and qualitative methods were needed to address multiple aspects of this complex question, ranging from residents' perceptions of the causes, trends, impacts, and indicators of climate change to participating families' experience of the social impacts of using agroecological practices as a climate change adaptation mechanism.

An exploratory sequential design first used in-depth interviews as a qualitative method to develop a sensitive, context-specific survey, which was then deployed to conduct quantitive tests.

Base data sources

Base data was acquired from various official sources, including (a) the National Institute of Statistics and Census (INEC), which provided information about poverty due to NBI; (b) the National Planning Secretariat (SENPLADES), Spatial Ecuadorian Institute (IEE) and the Ministry of Agriculture (MAGAP), which provided both the 2013 base map for Pedro Moncayo at a 1:25,000 scale and the 2013 Irrigation and Agricultural Land map at a 1:25,000 scale; (c) the Ministry of the Environment (MAE), which provided information about land cover at a 1:100,000 scale for 1990 and 2016; (d) MAGAP, which provided the map of Floricultural Crops at a 1:5,000 scale for 1990 and 2016; and (e) the

Territorial Order and Development Plan, updated in March 2018, which provided both socioeconomic and political information.

Data collection

The first research phase was a qualitative exploration of the challenges faced by farmers due to climate change and their role as peasants. In this phase, 15 in-depth interviews were conducted with key stakeholders from the municipality, social organizations, local authorities and farmers' leaders. A total of 8 women and 7 men were interviewed, including elected officials from Pedro Moncayo (2), technical personnel from the municipal staff (2), farmers and participants from local agroecology fairs (5), leaders from relevant social organizations and movements (3), and technical instructors or professors (3). The interview included questions such as: Do you think there have been changes in the weather, such as temperature or rainy seasons? Have these changes affected agriculture in any way? What would be the main challenge that farmers currently have? In what aspects has it helped you to participate in the Project? Do you think that agroecology helps to better manage these climate changes? How? Based on testimonies and responses to this initial exploration from key informants, a survey was designed and pre-tested with 10 farmers from the canton to improve the validity and reliability of the instrument. The survey was revised after the pilot test to remove possible misunderstandings.

The second research phase consisted of a quantitative exploration that included 119 surveys obtained from a random selection with a confidence level of 95% and a margin of error of 5%. From a list of families participating in the project, the first family was randomly selected, and, from that first survey, the neighborhood was searched for the next closest family that was part of the project. The number of respondents from each parish was proportional to the number of participants of the agroecological project in that parish. The average age of women was 54, and men, 58, indicating a trend for adult men and women in agriculture. However, it is a bimodal distribution, with most people falling into one of the older or younger age groups.

The questionnaire contained 29 questions related to (a) perceptions of climate change trends and impacts, (b) perceptions of the impacts of agroecological practices on life quality, and (c) demographic profile. The average time to respond to the survey was 10 minutes. It was administered by the first author between December 2018 and March 2019.

Data analysis

Survey data were analyzed to understand the relative roles of women and men working with agroecological practices on their farms and how agroecological practices influence these roles and responsibilities. We first studied whether gender division arises in daily schedules and responsibilities. Second, we investigated the overall contribution of both genders to income and financial decision-making processes. Third, we identified socioeconomic and environmental impacts of agroecology, as well as the social transformations and changes resulting from the implementation of agroecological practices across the four parishes. The variables used for the analysis are listed in Table 1.

Results

We present the results of the study below in three sections: social impacts, economic impacts and environmental impacts of the use of agroecological practices as a climate change adaptation mechanism.

Table 1. Impacts and Variables

Impacts	Variables
Social impact	Access to a higher quality of health Access to education Quality of family life (family time) Access to health services Access to education and/or training Family diet and therefore health Participation in the community
Economic impact	Economic income Production Volume Market spaces Sell products as healthy/organic products
Environmental impact	Ability to cope with climate change
Individual challenges	Greater requirements of working time Access to water for limited irrigation Greater requirement of people to work the chakra Strong economic investments Climate change Crop pests Low income from the sale of products
Community benefits	Improvement in bargaining power vis-à-vis local authorities Improvement in community leadership relationships Access to marketing spaces Avoiding intermediaries Infrastructure in the community
Community challenges	Access to water for irrigation Access to seeds Access to tools for cultivation Access to markets for the sale of products Conflicts within the community Climate Change

Social impacts

a) Revitalization of ancestral knowledge

The use of agroecological practices on the farms of Pedro Moncayo canton is nothing new. In fact, 100% of those surveyed said they learned from their parents and grandparents how to manage their farms in ways consistent with what is now called "agroecology," while 57% reported that they obtained additional knowledge from their communities. Most recently, 86% of women and 74% of men surveyed said they supplemented this knowledge via training provided by the municipality of Pedro Moncayo.

> "The Municipality established the training schedules in a way that we women can participate without leaving our families unattended. This has been great since now we participate, learn and also share knowledge, and this is not anymore a thing for men only" (Female Farmer, 28 years old).

> "People from the Municipality came to explain to us, for example, why it is important that we continue to exchange seeds and save all varieties of beans, or herbs for when children get sick or have stomachache. As mothers and grandmothers, we have always done that, but now we see that there are some plants that are more difficult to find, or young women who doesn't know how to use them, so we also teach them that knowledge. We learn and we teach too, even to the people who come to buy the plants, we have to explain to them how to use it" (Female Farmer, 57 years old).

This has promoted the entry of women into public spaces, becoming important actors in the agroecological fairs, explaining directly to buyers the nutritional quality of agroecological products and the environmental impact of agroecological practices.

All interviewees agreed that previous generations were respectful of the environment and that much of what they are encouraged to practice today has been done for a very long time. Many of them said they believe that caring for the land, the use of organic surpluses and the harvesting of water are more urgent today because climate change has caused environmental conditions to change.

> "It is important for us and for our children and grandchildren to keep the water cleaned, without using those chemicals to improve the production of crops. We can use organic surpluses for that, and that way we don't lose the fertility of our lands, so our grandchildren can keep eating healthy, clean. It should be our legacy for them" (Female Farmer, 68 years old)

These results show how families now use their ancestral knowledge and complement it with modern practices created to face new challenges.

b) Nutrition and family diet

Survey participants reported that the greatest benefit was improvement of the family diet, as production is destined first for self-consumption and then for sales. This is the main reason why 95% of men and women stayed faithful to agroecological production. Women in charge of preparing family meals were emphatic on this point, as in this representative comment:

> "Look, if you knew everything that they put into the food you eat, you would never eat, or worse, give it to your kids. That food is not only poison but also has no taste. It doesn't cook well. It's like eating plastic. I even save the eggs from my chickens to give to my grandkids so that they can grow well. I don't care about having to work in the hot sun to be able to give them something good to eat like we had in the past…" (Female Farmer, 59)

Despite this acknowledged improvement in nutrition, the low agroecological farming incomes have not allowed families to improve in terms of access to healthcare. In terms of education, women explained that their training provided by the Municipality has given them better skills for working their lands and also, have allowed them to stay closer to their kids and support them with school activities.

c) Access to education and health

Some 83% of the women surveyed and 80% of the men had not perceived any improvement in terms of access to or quality of healthcare. Findings also suggest little change in access to education during the past five years.

Access to education was perhaps one of the main indicators of this problem. A total of 56% of the women surveyed had not completed primary education, although in many cases they attended the first two or three years. In the case of men, this percentage was only 10%. (See Table 2)

However, women aged 30 to 55 reported that their children were being better educated because they could now spend more time with them and help them with their homework. Some 68% of the women surveyed had determined that their quality of life had improved. Likewise, they reported having more income to purchase educational materials, which had clear emotional value to some interviewees.

Table 2. Demographic Profiles of Respondents, by parish

	Tocachi		Tabacundo		Tupigachi		La Esperanza		Total		
	male	female	male	female	male	female	male	female	male	female	total
	(n = 7)	(n = 2)	(n = 28)	(n = 53)	(n = 10)	(n = 17)	(n = 1)	(n = 1)	(n = 46)	(n = 73)	(n = 119)
Age											
44 and up	7	2	22	35	10	12	1	1	40	50	90
25 to 44	0	0	6	18	0	5	0	0	6	23	29
Ethnicity											
Mestizo	7	2	24	41	6	12	1	1	38	56	94
Indigenous	0	0	4	12	4	5	0	0	8	17	25
Family Status											
Married	7	1	27	42	10	13	1	1	45	57	102
Widow	0	1	0	5	0	4	0	0	0	10	10
Single	0	0	0	5	0	0	0	0	0	5	5
Civil union	0	0	1	0	0	0	0	0	1	0	1
Divorced	0	0	0	1	0	0	0	0	0	1	1
Education											
Primary	3	0	19	22	8	3	1	0	31	25	56
None	4	2	3	25	2	11	0	1	9	39	48
High school	0	0	6	6	0	1	0	0	6	7	13
No answer	0	0	0	0	0	1	0	0	0	1	1

For women older than 55, personal education was not a priority, as they considered their age to be a barrier to finding training programs. Both men and women, however, reported that they participated in the agroecological trainings offered by the Pedro Moncayo municipality and it has improved their abilities and skills to work on their lands and sell their products.

d) Division of labor and daily duties

Women´s roles and their percentage of responsibilities showed a situation of structural inequality. According to those surveyed, care for children (55.4%), grandchildren (20.3%), sick people (43.2%), and senior citizens (71.6%) were the exclusive responsibility of women, as was the preparation of family meals (98.6%). Work outside of agriculture, in the floral industry (4.3%), and private-sector activities (19.6%) were exclusive to men. The only shared space between men and women was agricultural work on farms: cleaning, irrigation, sowing, and preparation of products for sale. However, the sale of farm products at agricultural fairs was exclusive to women; certain men accompanied them but only on certain occasions. Activities at the community level, such as meetings and *mingas*, were another space of participation of both men (67.4%) and women (86%). (See Figure 4)

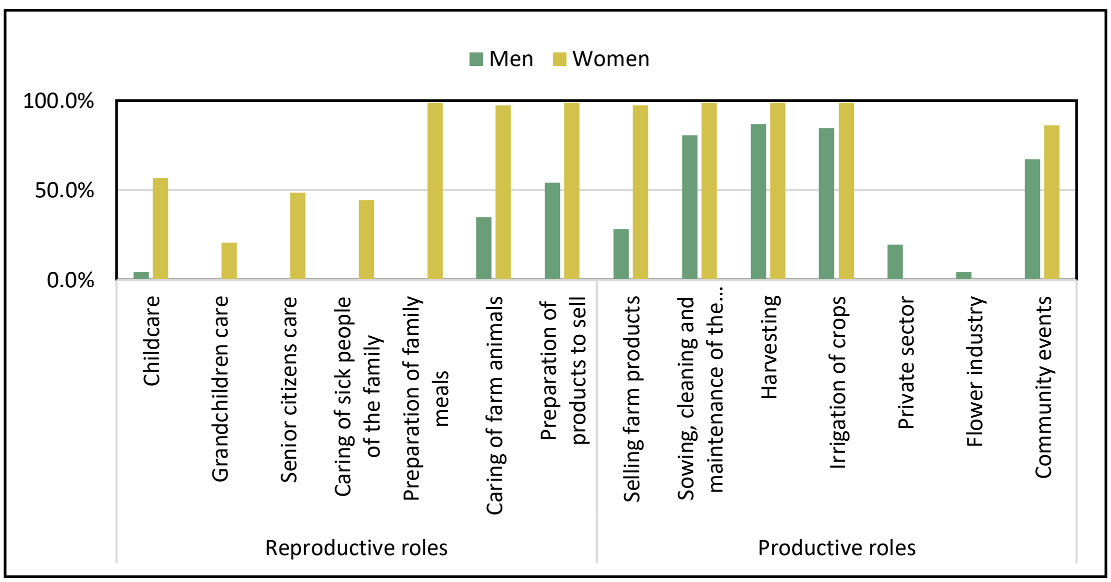

Figure 4: Percentage of Participation in Daily Activities by Gender

Economic impacts

a) Market spaces

One of the main challenges in the productive cycle has always been marketing. In Pedro Moncayo, like many Andean agricultural zones, middlemen reduce the bargaining capacity of producers. Without permanent market spaces for direct sales to consumers, it is difficult to imagine the survival of rural economies. The municipality's agroecology program has induced fundamental change by designated a space for an agroecological fair every Friday. This has allowed producers a better and more permanent income, without losing profits to middlemen. Some 72% of those surveyed said they believed that the municipally-provided market space was one of the main advantages of production under agroecological parameters.

Notably, the sale of agricultural products is done almost exclusively by women. Only 28% of men said they participated in the fairs versus 100% of the women. Examining this from a gendered perspective, we can see that this activity has brought much more than economic benefits.

> "Some of us used to work on the flower plantations, and we decided to quit and become free. Now we manage our time in a better way so we can be with our kids, share some time with the family, and have our own income which gives us freedom. This is all about freedom to choose what is best for us" (Female farmer, 28 years old)

When asked about the personal benefits of this activity, women gave various answers, including "independence," "generating my own income," "traveling to other cities and selling what I produce," "knowing people," "having free time and personal space," "eating out with friends," "not depending on my husband," and "not asking for permission or waiting for him to give me money." This is similar to the gendered impact of increased income in other sectors of the economy as well (Deere & Alvarado, 2016) (Abbots, 2013). At the community level, those surveyed agreed that agroecology has helped their community to produce in higher volume, although low market prices continued to be a weakness.

b) Head of Household

Overall, both men and women in Pedro Moncayo considered men as heads of household, providers, resource owners, and decision makers. However, that does not mean decisions are made only by men. (See Table 3)

Table 3. Head of Household

Legal status	Women			Men		
	Self	My husband	My father	Self	My wife	My father
Single	3%	-	4%		-	-
Married	1%	77%	-	96%	2%	-
Divorced	1%	-	-		-	-
Widow	14%	-	-		-	-
Legal union	-	-	-	2%	-	-

This socially established and normalized order characterizing masculinity in adulthood exerts a huge pressure over them, especially those who have less-stable jobs, are poor, and when their rural livelihoods are undermined as a result of climate change. With fewer resources, which causes a crisis to their self-esteem, they are no longer able to fulfill their socially assigned roles as providers (Skinner, 2011). This little-analyzed aspect of gender studies, which requires more attention, surfaced in interview comments such as the following.

> “We men have to keep the house and find work from where there isn't any because they see us as a little man, and one also gets depressed when there

> is no work, but you cannot show that weakness, but imagine what they would say about me if they saw me sad or crying. Just as women work at home, we have to work outside, and bring money to live" (Male Farmer, 57 years old).

c) Land ownership and decision-making processes

The status of women and men was quite different with respect to land ownership. Only 16% of the women reported being landowners, and their marital status varied from single, widowed, and divorced. Among married women, 100% recognized shared tenancy of the land with their husbands, compared to 83% of married men who reported that they shared land with their wives. Some 17% of married men reported that they were sole landowners, despite being married.

The trends in recognizing women's roles remains true for the analysis of household economic support. Only single, divorced, or widowed women were labeled as the main source of household income, while 43% affirmed that their spouses were the primary means of support, and 30.5% reported that income between spouses was similar. The opposite occurred with men, where 56% declared themselves to be the main supporters, and 45.6% considered that the income between spouses was similar. Only 2% of men recognized that their spouse was the primary supporter.

Some 70% of men and women recognized that decisions about income earned through the agroecological production were principally made jointly within marriages. This is the case especially for married people who also work together on the farm. In the case of men, the other 30% claimed that they make the decisions about family income. In the case of women, the remaining 30% were split: 5% responded that the decisions were made by their husbands, and 25% responded that the decisions were made by them alone.

Of the 25% of decision-making women, 85% were single, divorced, or widowed. This is to say that women exercised the decision-making power only when there was no man in the family. (See Table 4). However, independently of who makes the decisions about income from agroecological production, women have reported a sense of increased independence and autonomy because they are the ones earning the money.

Table 4. Decisions About Income

Men			Women		
Myself	My wife and I	My wife	Myself	My husband and I	My husband
30%	70%	0%	25%	70%	5%

Environmental impacts

A total of 100% of the surveys showed that men as well as women, both on a personal and community level, named climate change and water access as the most serious problems that necessitate the use of agroecological practices. The time required for field labor, the necessity of having more people to work the plots of land, and the requirement of significant economic investment (principally to install irrigation systems and for sowing), have been categorized as midlevel problems. This was because in most cases, it was the woman who worked the farm from Monday to Friday. The family help — the husband and children — arrived on weekends.

To understand the changes perceived by farmers, it is necessary to clearly understand the prevailing environmental conditions and how these conditions problematize (and sometimes completely inhibit) agricultural activity. Perceptions of climate change are homogeneous and do not vary between gender, age, or ethnicity.

The days were perceived as hotter (97.5%), the nights as colder (71.6%), and there was increased uncertainty about when seasonal rains would begin (88%), in comparison to the past. There was a duality in water access, with 40% of those surveyed reporting access to water for irrigation and 43% reporting a lack of access. In both cases, there was an acknowledged dependency on rainwater, with increasing dryness clearly creating an aggravating factor for agriculture.

According to the IPCC, when a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event (Intergovermental Pannel on Climate Change - IPCC, 2013). Survey participants were asked to identify three extreme events that have occurred with more frequency over the past five years, and the results show that strong winds and drought were a problem in all four parishes. The third most-cited event varied depending on the location and different physical factors in each zone: Tabacundo also suffers from increased frost, Tupigachi and Tocachi from increased heatwaves, and La Esperanza from more frequent sandstorms. (See Table 5)

Table 5. Most Frequent Extreme Climate Events

Parishes	Veranillos	Crop freeze events	High winds	Droughts	Hail
Tabacundo	-	83%	99%	96%	-
Tupigachi	64%	-	96%	96%	-
Tocachi	100%	-	100%	100%	-
La Esperanza	-	-	100%	100%	100%

Under this adverse climatic scenario, the inclusion of agroecological practices has been very useful, according to survey participants. The main benefit that farmers found was the adaptive capacity to face climate change. Some 90.8% of those surveyed, without geographical, ethnic, or age differences, said the correct use of agroecological practices, such as green fences, had avoided crop loss and had reduced evaporation. For example:

> “We have had to plant trees and build green fences to take care of the crops. Our grandparents and parents almost did not have to do this because the winds were not so strong. Now if we don't plant trees they fly and the plants are damaged, the soil becomes poor and then does not produce well” (Male Farmer, 65 years old).

> “Our strength to confront the climate is better, bigger… we have implemented agroecological practices and agroforestry to avoid frost, drag erosion and water misuse. Now there is more variety for insects’ control, little birds that have come to the trees, it was decided which trees to plant. Not all trees that were used as fences should be vegetative, but we try to use trees that also produce, and thus optimize and maximize the space….my 14 year old son has done a lot of this work with me, and now he knows more” (Female Farmer, 49 years old)

Conclusions

This study illuminates some of the socioeconomic impacts of climate change adaptation mechanisms like agroecology in rural communities. The analysis of participants’ perceptions reveals several important dynamics that explain the key role of agroecology in Andean communities vulnerable to climate change.

Climate change is perceived as a real threat to the productive systems of Pedro Moncayo, especially in terms of access to water resources. The unequal use and distribution of this resource exacerbates the vulnerability to this threat.

The reproduction and care of seeds, the elaboration of organic surpluses, and the harvesting of water have allowed rural populations to better face climate change and at the same time practically eliminate the use of chemicals. By avoiding environmental contamination and loss of fertility, agroecological practices clearly function as an adaptation method to climate change.

In addition, this study aims to open a discussion of gendered experiences in agroecology in the Ecuadorian Andes and how they have challenged gendered dimensions of traditional agriculture that delegate women the responsibility for both productive and reproductive work, while also assigning social pressure to men as providers and heads of household.

Despite long workdays filled with both domestic and productive tasks, women have found an adequate mechanism in agroecology to assure the health of their families as well as their personal development. As explained by Elmhirst & Hidalgo (2017), citing Jarosz (2011), women show motivations that are not primarily economic but are associated with social goals and desires to live a satisfying and meaningful work life.

The rescue of indigenous and local knowledge has made clear the role of women as reservoirs of knowledge. From preparing the land to selling the products, reproduction and interchange of seeds, preparation of food and caretaking for sick members of the family, women have shown how they can preserve and transmit this knowledge to following generations.

There is a high level of awareness among both men and women about the importance of agroecology in nutritional security and sovereignty. Agroecology in Pedro Moncayo is linked to the perception of how to live well and live a full life and to what is known in the Andean culture as *Sumak Kawsay*[2] (Houtart, 2011).

The possibility of generating and controlling income has improved self-esteem in women, while also empowering them to make decisions inside the family, participate in community organizations, and assume leadership roles. By facilitating commercial spaces specifically for agroecological producers, the Pedro Moncayo municipality has been key to the development of agricultural activity and the inclusion of women as direct sellers. This has decreased the interference of middlemen and guaranteed a fairer price for the farmers. This transition of women from private to public spaces is a major step toward gender equality.

The access to education and training, the ability to generate an income, and the participation in community organizations are key factors of adaptive capacity. We can conclude here that as these elements have been achieved in Pedro Moncayo, especially by women, their adaptive capacity to climate change has been also increased.

In the future, some key public policies should be designed based on the positive results of this experiment. Community leaders and local authorities should work together to ensure a community certification for agroecological production, thus guaranteeing better access to sales and income for farming communities. A better income will have a direct impact on access to health and education, whih also improves adaptive capacity to climate change.

Additionally, there should be mechanisms to replicate the experiences of training and sharing knowledge in other communities, in a way that helps people understand not only that agroecology is a suitable mechanism for climate change adaptation but also that its implementation might have a positive impact on gender equality and food sovereignty.

Notes

1. *Sumak Kawsay* or *Buen Vivir* is a new concept included in the Constitution of the Republic of Ecuador in 2008, which proposes a life in harmony with nature and a critique of capitalist development. (Asamblea Nacional Constituyente, 2008; Altmann, 2013; Bretón, Cortez & García, 2014; Macas, 2010; Acosta, A., 2013; Cortez, 2011).

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ARTICLE 3: ADAPTIVE CAPACITY TO CLIMATE CHANGE IN ECUADOR'S FARMING POPULATION

Abstract

This article explores how intersectionality, understood as the convergence of social identities such as gender and ethnicity, is relevant in the study of the adaptive capacity to climate change. The study proposes an adaptive capacity index (ACI) adjusted to the context of populations dedicated to agriculture in highland Ecuador. Using an analysis of nonlinear main components and the information available in the 2014 Living Conditions Survey, an ACI of 1.43 on a scale with a maximum of 5 was found nationwide. The results show that the greatest difference is present between the population possessing a higher level of education and those with no educational level. The study also found that urban populations have a greater adaptive capacity than residents of rural areas, that men have a greater adaptive capacity than women, and that residents of homes with a male head-of-household have higher adaptive capacity that residents in homes with a female head-of-household. In ethnic self-identification, the greatest difference is present between indigenous populations and mestizo populations, with the mestizos possessing a greater adaptive capacity. This suggests that public policies designed with an intersectional approach can help improve an agricultural population's adaptative capacity, particularly benefiting the most vulnerable groups.

Key words: adaptive capacity, climate change, intersectionality, agriculture, Ecuador

Resumen

El presente artículo explora como la interseccionalidad, entendida como la convergencia de identidades sociales tales como la etnicidad y el sexo, es relevante en el estudio de la capacidad adaptativa al cambio climático. El estudio propone un Índice de

Capacidad Adaptativa (ICA) ajustado al contexto de poblaciones dedicadas a la agricultura en el Ecuador. Usando análisis de componentes principales no lineales y la información disponible en la Encuesta de Condiciones de Vida del año 2014, se encontró un ICA de 1.43 sobre 5. Los resultados muestran que la mayor diferencia está presente entre la población con nivel superior y aquellos sin nivel educativo. La población urbana tiene mayor capacidad adaptativa que aquella reside en el área rural; los hombres también tienen mayor capacidad adaptativa que las mujeres y también quienes residen en hogares con jefatura masculina. En la auto identificación étnica, la mayor diferencia está presente entre los indígenas y mestizos, a favor de los mestizos. Esto demuestra que la inclusión del enfoque de interseccionalidad puede ayudar a mejorar la capacidad de adaptación a partir del diseño de políticas públicas focalizadas en los grupos más vulnerables.

Palabras clave: capacidad adaptativa, cambio climático, interseccionalidad, agricultura, Ecuador

Introduction

Climate change is a heterogeneous, global problem that produces asymmetric and unequal conditions, the effects of which are differentiated at the local level (Barcená, et al., 2018). Populations are not uniformly vulnerable. The rise in sea level, changes in climate patterns and more frequent extreme events, loss of species and ecosystems, water contamination, and other climate-related changes have a differential impact as a result of various factors such as geography and income, and they are also shaped by roles, responsibilities, and entitlements associated with markers of social status and expectation, including gender, class, and caste (Thomas et al., 2019; Angostino & Lizarde, 2012; Carr & Thompson, 2014). Additionally, the level of development, poverty, access to technology, and political power and representation in national and international negotiations are factors that intermingle to generate in the affected population a greater or lesser capacity to adapt to climate change (Warner & Weitzman, 2015).

In social terms, climate change exacerbates inequalities that already exist, as its consequences "are expected to fall disproportionately on developing countries, and typically will hit the poorest communities within them the hardest" (Jones, et al., 2010, p. 2). According to the Intergovernmental Panel on Climate Change -- IPCC (2014), those most affected by climate change will be the poorest and most disadvantaged on the planet.

In economic terms, studies show the agricultural sector is one of the most vulnerable and likely to be the most affected through changes in temperature, precipitation patterns, and increased occurrences of extreme events such as drought and flood (Kokic et al., 2005; Mendelsohn, 2009). The Fifth Assessment Report of the IPCC establishes that in the past 30 years, climate change has contributed to global agricutural production declining by 1-5% per decade (Porter et al., 2014). By 2080, agricultural output in developing countries is expected to decline by 20%, while output in industrial countries is expected to decrease by 6% (Cline, 2007; Fischer et al., 2005; Nicholls, 2013).

In communities across Latin America, the livelihoods of small farmers have been undermined by climate change (Warner, 2016). Their geographic location, low levels of income, high dependence on agriculture, and a limited capability to secure alternatives for living make them especially vulnerable populations (Altieri & Nicholls, 2013).

According to the Third National Communication on Climate Change, Ecuador is one of the most vulnerable countries to climate change. Agriculture and water availability are among the repercussions of the accelerated retreat of tropical glaciers, sea level rise, and the intensification of climatic variability phenomena, mainly associated with El Niño and La Niña (Ministerio del Ambiente, 2017; Cadilhac et al., 2017).

The volume of scientific publications available worldwide for adaptation to climate change and vulnerability has grown. However, the publications from developing countries still represent a small fraction of the total (Field, 2014). According to Cadilhac et al., (2017), one of the main research needs in Ecuador is for methodologies and indicators on adaptation. Ecuador's National Climate Change Strategy identifies adaptation as one of the strategic areas pursuing the reduction of social, economic, and environmental vulnerability (Ministerio del Ambiente, 2012).

This study works within this frame, seeking to contribute information related to the capacity to adapt to climate change in communities dedicated to agriculture. The study seeks to address the following questions:

- What elements should be included in an index to measure the adaptive capacity to climate change for agricultural populations in Ecuador?
- What was the adaptive capacity of populations linked to agriculture in Ecuador in 2014?

To answer these questions, we adopted 4 determinants of adaptive capacity (economic resources, technology, information and skills, and infrastructure) as put forth by Smit and Pilifosova (2001). Using these determinants, we developed an indicator framework grounded in a systematic review of scientific literature that considered approaches assessing adaptive capacity at national and local levels around the world, with a particular focus on farmers. Subsequently, we developed an agricultural sector index for assessing the adaptive capacity of farmers in Ecuador, constraining the final framework by the availability of data in the National Survey of Living Conditions of 2014. Finally, we analyzed the results of the index through geographical regions in Ecuador, in urban and rural spaces, using an intersectional approach to social identities such as gender and ethnicity.

This paper has five sections. The first section introduces the problem and the goals of the research. The second one reviews literature on key concepts related to adaptive capacity. The third section looks at the socioeconomic and environmental conditions of Ecuador as the study area. The fourth section presents the data and methods used to identify and select the set of indicators, as well as the construction of the index. The fifth section presents the results of the application of the Adaptive Capacity Index in the study area showing how categories of identity such as sex, head of household and ethnic self-identity intersect into a low adaptive capacity of the population dedicated to agriculture. It shows how the lack of education, access to technology and living in rural areas have an impact on their adaptive capacity.

Adaptive Capacity: conceptual framework

After the Intergovernmental Panel on Climate Change (IPCC) – the worldwide technical institution of the United Nations Framework Convention on Climate Change – released its First Assessment Report in 1990, research was focused on the vulnerability of particular sectors and regions, but social drivers or uneven distribution of risk received little attention (Thomas et al. 2019). A decade later, by 2001 the IPCC Third Technical Report identified adaptive capacity as one of the three components of vulnerability: exposure, sensitivity, and adaptive capacity (Smit & Wanderl, 2006) (See Figure 1).

Systems are considered more or less vulnerable depending on two factors: the severity of the specific stressful event, and the degree of adaptive capacity (Wall & Marzall, 2006). It means that the increase of adaptive capacity will reduce the vulnerability of a system and vice versa (see figure 1).

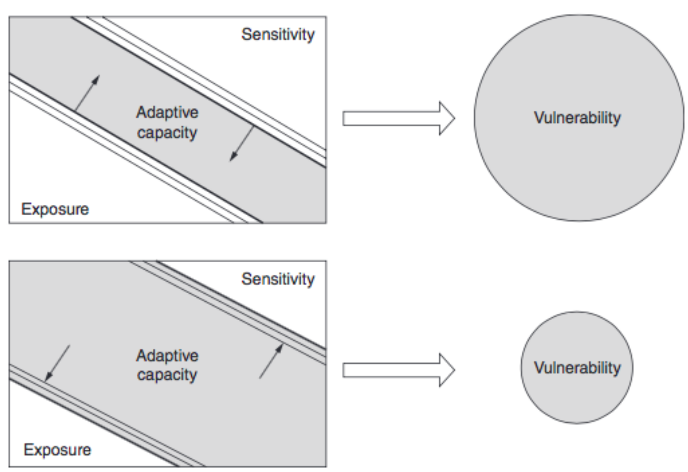

Figure 1: Vulnerability (Thomas, K., et al. 2019)

Adaptive capacity was then defined as “a practical means of coping with changes and uncertainties in climate, including variability and extreme events” (Smit & Pilifosova, 2001, p. 879). The Fourth Technical Report stated that “the capacity to adapt is dynamic and influenced by economic and natural resources, social networks, entitlements, institutions and governance, human resources and technology” (Adger et al., 2014, p. 719). Most recently, the Fifth Report presented adaptive capacity as “the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences” (Pachauri, 2014, p. 118).

All of these reports link the concept of adaptive capacity to the assessment of drivers or determinants (See Table 1).

Table 1: Determinants of Adaptive Capacity (Smit & Pilifosova, 2001)

Determinants	Description
Economic resources	Assets, capital resources, financial means, measures of wealth or poverty.
Technology	Availability, access and use of technologies, level of technology used, skills to develop adaptive capacity
Information and skills	Access to information for decision making human capital in households.
Infrastructure	Availability and access to infrastructure, health centers, roads, public services.
Institutions	Efficacy and institutional efficiency, ability to manage events associated with climate change.
Equality	Access and distribution of equitable resources within a group.

Since then, the concept of adaptive capacity has been used in varying contexts and at varying spatial scales. It is dynamic as it changes over time, from country to country, community to community, from households and individuals (Smit & Wanderl, 2006), and under three dimensions: generic, impact specific, and sector specific. The generic dimension studies the ability of a system to respond to the general climate change stimuli; the impact-specific dimension studies the ability of the system to respond to a particular climate change stimulus; and the sector-specific dimension studies the capacity of a particular economic sector, such as agriculture, to adapt to general impacts of climate change within a model region (Abdul-Razak & Kruse, 2017).

Considering the vulnerability of the agricultural sector around the world, studies have used the sector-specific dimension to analyze and build an index of adaptive capacity of agriculture at national and local levels (See Table 2). These studies are geographically located mostly in Africa (3) and Australia (3), with one case each in North America (1) and Asia (1). No records show studies in Europe, Central America, and Latin America. Most of the studies are regionally scaled and some are national.

Intersectionality

Although an important volume of literature shows that climate change is not gender neutral (Dankelman, 2010; Reggers, 2019; MacGregor, 2010; Djoudi, et al., 2016; Ravera & Arandia, 2017; Schwerhoff & Konte, 2020), research on what determines the adaptive capacity of men and women remains limited (Davies & Thornton, 2011). From the studies detailed in Table 2, only two studies consider gender as a category of analysis. None address ethnicity. Both gender and ethnicity are important categories of identity for the use of intersectionality as a method of analysis, as presented in this study.

Table 2: Index for Adaptive Capacity on Agriculture--Case Studies

Author(s), year of publication	Place / scale	Determinants used
Wall and Marzall (2006)	Herrington, Canada	Social, human, institutional, natural, and economic resources
Sietchiping (2006)	Northwestern Victoria, Australia	Sociocultural, economic, and institutional and infrastructure
Swanson, Hilley, Venema, and Grosshans (2007)	Praine region, Canada	Economic resources, technology, information, skills and management, infrastructure, institutions and networks, equity
Sheng, Nossal, Zhao, Kotic, and Nelson (2008)	Regions, Australia	Human, social, natural, physical, and financial capital
Nelson, Kokic, Crimp, Martin, Meinke, Howden, Voil and Nidumolu (2010)	Rural communities, Australia	Human, social, natural, physical, and financial capital
Defiesta and Rapera (2014)	Dumangas, Philippines	Human resources, physical resources, financial resources, information, and livelihood diversity
Ibrahim (2014)	Meatu and Iramba Districts, Tanzania	Human, natural, financial, physical and social capital
Abdul-Razak and Kruse (2017)	Northern region, Ghana	Economic resources, social capital, awareness and training, technology, infrastructure and institutions
Alhassan, Shaibu, Kuwornu, and Osman (2018)	Tolon and Central Gonja districts, Ghana	Human, natural, physical, financial, social, information accessibility, and livelihood diversity

Coined by Kimberle Crenshaw in 1989 as a postcolonial and antiracist position, intersectionality is a concept focused on understanding the interconnected relations between structural identities of race, class, gender, ethnicity, culture, and sexuality (Kaijser & Kronsell, 2014).

It is defined as the way in which a particular individual stands at the crossroads of multiple groups (Minow 1997), states that social categories (i.e., 'race'/ethnicity, gender, class, sexuality, and ability) are constructed and dynamic (Djoudi et al., 2016), and starts from the premise that people live multiple, layered identities derived from social relations, history, and the operation of structures of power (Symington, 2004).

Kaijser and Kronsell (2014) presented a strong argument for using intersectionality in an analysis of climate change:

- It provides a critique of existing power relations and institutional practices relevant for climate issues.
- It can generate alternative knowledge crucial in the formulation of more-effective and legitimate climate strategies.
- It highlights new linkages and positions that can facilitate alliances between voices that are usually marginalized in the dominant climate agenda.
- It allows the analysis of which social categories are represented in or absent from the climate change dynamics.

The interaction of gender, agricultural development, and climate change has made progress in recent years in the identification of research questions and development of new research approaches.

What are men's and women's adaptation options and strategies? What are the differences in their capacity to adapt? What are the characteristics and causes of gender differentials in vulnerability and adaptive capacity to weather-related risk? Why? Where? How? (Kristjanson et al., 2017).

An additional important aspect to consider is rurality. In Ecuador, rural areas are defined as "all those geographical areas where the population lives dispersedly in the countryside and in towns and small cities of up to 15,000 inhabitants, whose production systems are mainly linked to the valorization of natural resources , be it primary production (agriculture, livestock, fishing, mining, afforestation), transformation and service activities for these primary activities, and the enhancement of landscapes and natural conditions (tourism, recreation)" (Cuesta Molestina, et al., 2017, p. 10).

However, in this study, the understanding of the rural goes beyond the definition above, visualizing it as a dynamic socio-economic entity, located in a geographical space not necessarily of political limits, where different actors conflict, and where living conditions and access to basic services keep the agricultural population vulnerable.

All of these aspects are extremely relevant to understand the dynamics of the agricultural sector in Ecuador, a country that is considered highly vulnerable to climate change, as presented in the following section.

Study Area

Ecuador, located in South America, occupies a continental area of 284.470 km_2, 7.900km2 of insular area, and has a population of 17.5 million. Its name is derived from the equinoctial line or Equator, the maximum parallel of land that crosses from east to west.

The country has four distinct ecoregions: the marine coast, the Andean highlands, the Amazon, and the Galapagos Islands, all of which provide a vast biodiversity and make Ecuador one of the 17 most megadiverse nations on the planet despite its small size. (See Figure 2). Ecuador also has a high cultural diversity, with the following population groups officially recognized: mestizo, montubio, indigenous, White, Afro-Ecuadorian/Afro-descendants, and “others.”

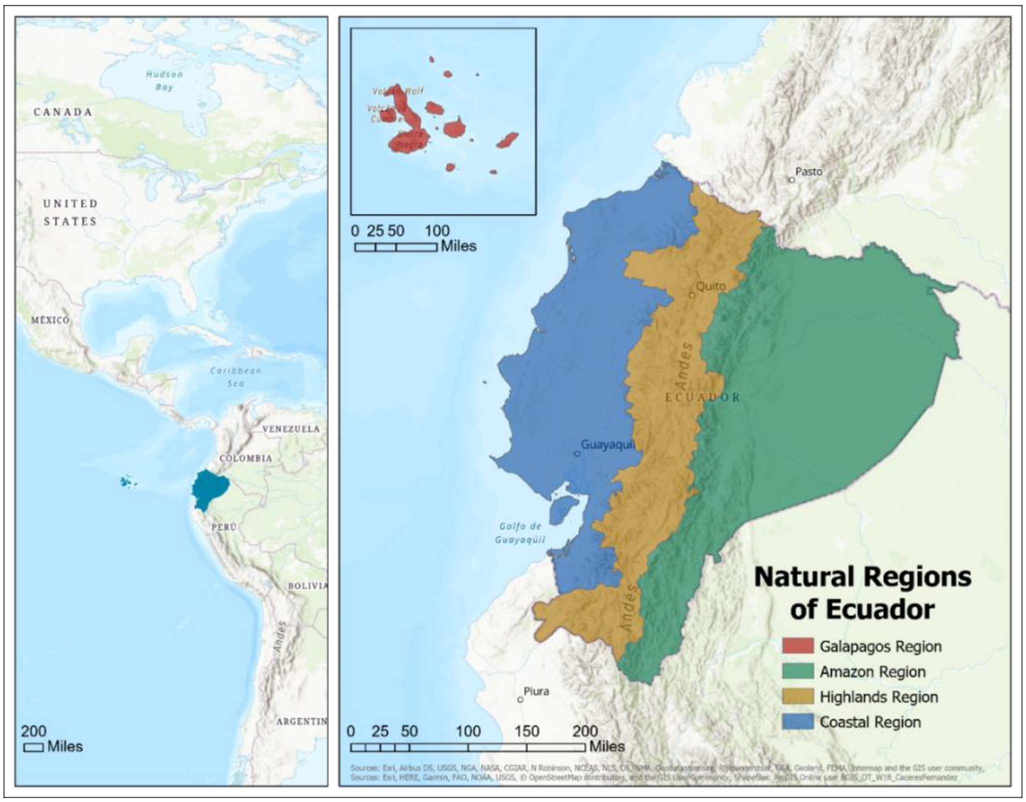

Figure 2: Natural Regions of Ecuador

A climate change study in Ecuador analyzed historical data through the end of the 1990s using14 meteorological stations in the coastal and inter-Andean regions, finding that the average temperature rose up to 1.6ºC in the high urban area and 1.5ºC in the high rural area, while in the marine urban area, a permanent temperature change of between 0.5ºC and 1ºC was found.

Data about precipitation have been irregular, yet seem to show declines, especially in the coastal region (Cáceres et al., 1998). In 2017, the Third National Communication of climate change presented climate projections for Ecuador. The results show an increase in the average temperature for the period 2011-2040 between 0.6$_{o}$C and 0.75$_{o}$C, presenting the largest increments in the Costa region (0.7$_{o}$C - 0.9$_{o}$C), in the Amazon (0.75$_{o}$C - 0.9$_{o}$C) and in the Galapagos Islands (0.75$_{o}$C - 1$_{o}$C).

For the period of 2041 – 2070, the increase would be 0.9oC to 1.7oC, with the biggest changes being those of the Amazon (1.3$_{o}$C - 2.1$_{o}$C) and the Galapagos Islands (1.2$_{o}$C - 2.5$_{o}$C). Finally, by 2071-2100, the average temperature would increase between 0.9$_{o}$C and 2.8$_{o}$C, for the country, however, the Amazon and Galapagos would have higher increments, in the order of 1.3$_{o}$C to 3.5$_{o}$C and 1.2$_{o}$C to 4.4$_{o}$C, respectively.

All these scenarios represent a big challenge for the economy of Ecuador. The productive economic structure in the country is not diverse and has focused historically on primary extraction activities, such as petroleum and agriculture. This constitutes a challenge for the Ecuadorian economy, considering that the protections of the Internal Domestic Gross by 2100 estimate that by 2025, the petroleum era in Ecuador will have ended (Comisión Económica para América Latina y el Caribe, 2012) and the agricultural sector in Ecuador is highly vulnerable to climate change (Comisión Económica para América Latina y el Caribe, 2012; Yerovi, et al., 2018).

The activities of agriculture, livestock, hunting, and forestry generate the most employment in Ecuador, with 28% of the population working in these sectors in 2018. According to the 2010 Census, 48.6% of the indigenous population, 16.4% of the Afro population and 16.7% of the mestizo population were engaged in these activities (Instituto Ecuatoriano de Estadísticas y Censos, 2010).

Additionally, the agricultural sector contributes to other economic activities and constitutes an important link in the productive chain for commerce, transport, services, agribusiness, tourism, and other areas of employment.

Being such a relevant economic sector for the country, agriculture has been affected by drought, frost, and extreme weather events that inflict reduction and losses in future agricultural production (Ministerio del Ambiente del Ecuador, 2017; Ministerio del Ambiente del Ecuador, 2019; Pineda & Willems, 2016; Cadilhac, et al., 2017).

This sector has suffered significant declines in its productive activity, due to the high incidence of climatic and meteorological factors. The occurrence of the El Niño – Southern Oscillation caused significant losses in the agricultural GDP. In the period 1982-1983, the Central Bank of Ecuador reported lossed of 13.65%; for 1992-1993, they were 51%, making that period one of the most critical for the nation’s economy; and in 1997-1998, the loss in agricultural GDP was 3% (Noboa, et al., 2012).

Local evidence indicates, for example, that in 2015, the loss of planted area of transient crops declined by 52.79% due to climatic events such as drought (38.09%), frost (10.29%), and floods (4.31%) (Lopez, Lopez, & Leon, 2017). An analysis of 1,060 cocoa farmers in the province of Manabi indicated high (45.53%) and very high (6.43%) vulnerability (Macias et al., 2019). Variations in temperature and precipitation contribute to a reduction in crop yield in the province of Azuay--i.e., crops such as corn, beans, potatoes, and peas (Chindon, et al., 2017).

In the Valencia canton, with 17.41% of its area dedicated to banana cultivation, research identified the rainy season (56%), intensity of rainfall and winds (33%), and pests and diseases (11%) as the primary elements affecting banana production (Piedrahita et al., 2016).

Data and methods

Base data sources

The base data for the study was acquired from the 2014 Survey of Life Conditions, a multipurpose survey that gathered information on the different aspects and dimensions of household well-being, developed by the National Institute of Statistics and Census (INEC). The objective of the survey was "to study the economic impacts and living conditions of the Ecuadorian population from the perspective of household surveys" (Instituto Ecuatoriano de Estadisticas y Censos, 2015, p. 14).

This instrument was selected for its wealth of information. It also has other sections that were not included in previous iterations, such as a section focused on generalized self-efficacy from which an Adaptive Capacity Index was built, which is explained later. As background, it is important to note that the Survey of Life Conditions was administered in 1995, 1998, 1999, 2006, and 2014.

Being this the first time that an Adaptive Capacity Index is built for Ecuador, and for agricultural sector, is undoubtedly its valuable contribution to the discussion of adaptation to climate change at all levels. However, it is important to mention that the Survey of Living Conditions, while providing relevant information, was not designed with a focus on climate change and is not intended to provide any type of intersectional analysis. For this study, we have adapted the data for use in these new ways.

Target population

For this study, the population analysis represents economically active people linked to the agricultural sector and who are 15 or older.

Data analysis

For data analysis, nonlinear principal component analysis (NLPCA) was used, which allows the processing of ordinal or nominal variables. The procedure assigns a quantification on a numerical scale to each category. That is to say, the variables are re-coded to give them numerical properties according to their characteristic, discarding any bias or arbitrariness, and that in the case of ordinal variables the method preserves the hierarchy of the categories (Konig, 2002).

Sheng, et al (2008) used principal component analysis to formulate an adaptation index for Australian rural communities, making use of official statistical information from the Ministry of Agriculture. First, five individual index are obtained from the use of the principal component analysis for dimensions associated with human, social, natural, physical and financial capital. Then, with these five indexes they used the principal component analysis for the second time to formulate the adaptive capacity index.

For this study, a similar exercise is performed, but using the analysis of nonlinear main components. This technique guarantees:

i) compatibility with the conceptual framework,

ii) interpretability, and

iii) practicality in the construction of the index.

Proposal Model of Determinants for the Adaptive Capacity

For the Adaptive Capacity Index calculation, this study takes 4 out of 6 determinants as put forth by Smit & Pilifosova (2001) as a framework for identifying the indicators for this study. Institutions and Equality were not used as determinants due to the lack of information available. See Table 3

Building an Index of Adaptive Capacity

The development of the adaptive capacity index (ACI) has two stages. First, indexes are constructed for each of the four determinants. Second, the ACI is constructed from the four metrics obtained. In both cases, the analysis of non-linear main components is used to assign the corresponding scores to each category and in each variable.

The ACI is constructed in such a way that the highest value represents the best adaptive capacity of an individual and is obtained by the linear combination of the scores obtained with the analysis method of non-linear main components.

Algebraically, the index is obtained by:

$$ICA = \sum_{i=1}^{k} p_i$$

Where p_i is the score assigned by the principal component analysis to the determinant index k, with k = 1,2,3,4.

The sample size for that population is 5002 records, which allows inferences to be made at various levels of disaggregation. With the methodology indicated, the four indices that are the input for the ACI construction were built. In all cases, a varimax rotation with Kaiser Normalization was used.

Table 3: Proposal Model of Determinants for the Adaptive Capacity

Determinant	Description	Indicators	Source of Indicator	Indicator assumptions/relevance
Economic resources	Assets, capital resources, financial means, measures of wealth or poverty	Consumption poverty, subjective poverty and perceptions of quality of life and economic situation, welfare	(Egyir, Ofori, Antwi, & Ntiamoa-Baidu, 2015) (Abdul-Razak & Kruse, 2017) (Swanson, Hilley, Venema, & Grosshans, 2007)	Greater economic resources increase adaptive capacity, while the lack of financial resources limits adaptation options. Low adaptive capacity has been attributed to widespread poverty, as those with few resources and little access to power are more vulnerable, and less able to afford all requirements that can result from extreme climate events.
		Access to health care (private and public)	(Berry, Hogan, Ng, & Parkingson, 2011)	Health is an essential component of the capacity to adapt to climate change and psychological health is an essential component of resilience
Technology	Availability, access and use of technologies	Use of internet and technological equipment (computers, tablets, smart phones)	(Borraz, 2012) (Ospina & Heeks, 2012)	ICTs can collaborate on climate change monitoring, involving citizen participation, and creating early warning mechanisms for extreme events and better management of natural disasters.
Information and skills	Access to information for decision making, human capital in households	Self-efficacy - ability to get over unexpected situations, handle difficult situations and find alternatives to solve a problem	(Grothmann & Patt, 2005)	Motivation and perceived abilities are important determinants of human action, and could increase adaptive capacity as people is more focus on taking actions
		Participation in community organizations, and/or farmer-based organizations	(Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009)	Participation in farmer-based organizations positively influences adaptation to change, as they act as conduits for information, allows collaborative initiatives to overcome collective challenges and increases community negotiation power.
		Literacy	(Maddison, 2006) (Brooks, Adger, & Kelly, 2005)	Higher literacy rates increase adaptive capacity by increasing people's capabilities, skills, access and understanding of information, and higher productivity.

Table 3: Proposal Model of Determinants for the Adaptive Capacity (cont.)

Determinant	Description	Indicators	Source of Indicator	Indicator assumptions/relevance
Infrastructure	Availability and access to infrastructure, health centers, roads, public services.	Quality of residence and basic services	(Thathsarani & Gunaratne, 2018)	Quality of residence and ownership of physical assets increases adaptive capacity. Lighting, especially electric energy as a public service, has a positive impact on to the adaptive capacity.
		Access to housing	(Zhang, Rockmore, & Chamberlin, 2007) (Adger, Brooks, Bentham, Agnew, & Eriksen, 2004)	Good quality of roads increases the ability of rural populations to access markets and reduce transaction costs, facilitate migration and remittances, and effective evacuation if needed
		Water pump and irrigation equipment	(Egyir, Ofori, Antwi, & Ntiamoa-Baidu, 2015) (Alhassan, Shaibu, Kuwornu, & Osman, 2018)	Access to irrigation infrastructure increases adaptive capacity to extreme events like droughts.

Results

Economic resources

One of the most widely accepted premise about climate change is its impact on poor populations. Poverty, more than any other indicator limits adaptive capacity as people rely on climate-sensitive activities such as agriculture. It also limits their access to better home conditions, access to information and TICs, opportunities to develop skills and education.

In Ecuador, the official data establishes that 79% of the Economically Active Population (EAP) linked to agricultural activities in 2014 was in the rural area of the country. If we analyze and compare the information of this population within each determinant and compare the indicators with the national behavior in the economic dimension, 46% of the population linked to agriculture is poor by consumption. This proportion is more than double that of the national indicator.

The perception of poverty is also higher in the population dedicated to agricultural activities. 61% reside in households whose head of household considers himself poor or subjectively very poor. This proportion is 23 points higher than the rest of the EAP. A positive perspective on the improvement in the standard of living is much lower in the population dedicated to agricultural activities, as well as the perception of living well with respect to the family economic situation.

In relation to access to social benefits, 22% at some time accessed the human development bond. Although more than half of that of the EAP at the national level does not have any health coverage, in the case of the population that performs agricultural activities, 6 out of 10 do not have access to social or private security.

In short, the agricultural EAP has worse conditions in the economic determinant when compared to the national characterization.

Table 4: Descriptive Distribution -- Economic Resources

Indicators		National EAP	Agriculture EAP
Poverty by consumption	Poor	21.9%	46.1%
	Not poor	78.1%	53.9%
Subjective poverty	Very poor	4.0%	7.9%
	Poor	34.4%	53.3%
	More or less poor	46.3%	36.3%
	Not poor	15.4%	2.5%
Perception of living standards	Worsened	14.0%	15.4%
	Same	70.8%	75.9%
	Improved	15.2%	8.7%
Perception of the family economic situation	Live poorly	9.7%	14.1%
	Live more or less well	76.9%	77.4%
	Live well	13.4%	8.5%
Receives welfare	Yes	15.4%	21.5%
	No	84.6%	78.5%
Access to health insurance	None	54.2%	60.3%
	IESS, Voluntary/rural insurance	10.1%	20.2%
	IESS, General Insurance	34.0%	18.8%
	Private Health Insurance	1.7%	0.7%
Total		100%	100%

Based on the official data presented in Table 4, the calculation of the adaptive capacity for the Economic resource determinant reached 11.3/25 as is shown in Table 5.

The best adaptive capacity is present in the urban area, in men and mestizos, which means that women and indigenous people living in rural areas face bigger challenges to confront climate change.

Table 5. Results of the Economic Resources Index

		Range 0-25		Sample
		Index	VC	
Total		11,27	0,01	5002
Area	Urban	12,66	0,01	492
	Rural	10,9	0,01	4510
Region Natural	Highlands	11,3	0,01	2372
	Coast	11,48	0,01	1367
	Amazon	10,09	0,01	1254
Sex	Male	11,64	0,01	3315
	Female	10,4	0,01	1687
Ethnic Self-identity	Indigenous	10,1	0,01	1461
	Afro-Ecuadorian	11,21	0,03	176
	Mestizo	11,59	0,01	2836
	Other	11,25	0,01	529
The estimator is robust if it has a sample of at least 200 cases and a Coefficient of Variation (CV) less than 0.15				

Technology

Information and Communication Technologies (ICTs) constitute an important tool on climate adaptation. It is argued that the use of ICTs could reduce the lack of appropriate information and knowledge-sharing mechanisms among rural communities, especially dedicated to agriculture. (Borraz, 2012).

For climate change awareness and monitoring, Ospina & Heeks (2012) establish that the use of ICTs such as cellphones can facilitate the dissemination of climate change messages among vulnerable people which contributes to the understanding of climate impacts and increase adaptive capacity.

As of 2014, the use of technological goods and services in the population linked to agricultural activities in Ecuador is marginal. In the specific case of the internet, only 8% used this service, compared to the national proportion, there is a difference of 30 points.

Similarly, the use of smartphones is reduced to an 8% of population in agriculture in comparison with 26% at national level. These differences on access to technology presented on Table 6 puts on evidence an unequal situation with negative impacts not only on adaptation to climate change but especially on living conditions.

Table 6. Descriptive Distribution -- Technology

Indicators		National EAP	Agriculture EAP
Smartphone use	No	74.0%	92.4%
	Yes	26.0%	7.6%
Internet use	No	62.4%	92.1%
	Yes	37.6%	7.9%
Computer use	No	53.7%	87.5%
	Yes	46.3%	12.5%
Tablet Use	No	88.6%	97.7%
	Yes	11.4%	2.3%
Total		100%	100%

Based on the official data presented on Table 6, the calculation of the adaptive capacity for the Technology determinant reached an alarming 1.1/17 as is shown in Table 7, which makes this determinant the biggest challenge for adaptive capacity in Ecuador. The urban area has the best rating in this regard, but it remains on dangerous levels.

Information and Skills

The literature says relationships through networks and associational community life increase adaptive capacity as people act as conduits for information, allowing collaborative initiatives to overcome collective challenges and increasing community negotiation power (Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009).

Table 7. Results of the Technology Index

		Range 0-17		Sample
		Index	VC	
Total		1,1	0,05	5002
Area	Urban	2,04	0,09	492
	Rural	0,85	0,05	4510
Region	Highlands	1,2	0,07	2372
	Coast	1,09	0,08	1367
	Amazon	0,64	0,1	1254
Sex	Male	1,2	0,06	3315
	Female	0,84	0,1	1687
Ethnic Self-Identity	Indigenous	0,66	0,12	1461
	Afro-Ecuadorian	0,95	0,21	176
	Mestizo	1,31	0,06	2836
	Other	0,78	0,14	529
The estimator is robust if it has a sample of at least 200 cases and a Variation Coefficient of less than 0.15				

The official data presented in Table 8 shows that participation in community organizations, and/or farmer-based organizations are marginal at the national level and in the population dedicated to agricultural activities, which threatens their adaptive capacity. At national scale, the level of education of the head of household presents higher rates on attendance to high school and higher, meanwhile, head of household related to agriculture have 65% with primary education and 12% with no education. The illiteracy rate in the population linked to agricultural activities is almost three times that of the national indicator. This is alarming, considering that the literature stipulates that the higher the level of education make high adaptive capacity as it increase knowledge and ability to be aware and prepare for future climate impacts (Brooks et al, 2005; Madisson 2006; Wall & Marzall, 2006).

Table 8. Descriptive Distribution -- Information and Skills

Indicators		National EAP	Agriculture EAP
Thanks to his qualities he has been able to overcome unforeseen situations	Never	2.4%	3.5%
	Rarely	25.9%	33.6%
	Often	40.5%	37.8%
	Always	31.2%	25.2%
Whatever happens he is able to handle difficult situations	Never	2.1%	3.0%
	Rarely	24.5%	31.3%
	Often	40.8%	37.3%
	Always	32.6%	28.5%
In the face of a problem, he can think of several alternatives on how to solve it	Never	1.7%	2.3%
	Rarely	20.8%	28.1%
	Often	40.3%	38.0%
	Always	37.2%	31.6%
Participation in community organizations, and/or farmer-based organizations	No	98.1%	96.6%
	Yes	1.9%	3.4%
Educational level of head of household	None	5.6%	12.3%
	Primary	42.9%	65.0%
	High school	33.6%	20.6%
	Higher	17.9%	2.1%
Literacy	No	4,6%	12.6%
	Yes	95.4%	87.4%
Total		100%	100%

Based on the official data presented in Table 8, the calculation of the adaptive capacity for the information and skills determinant reached 9.97/10 as is shown in Table 9. The categories of urban area, coastal region and men present a better index in this determinant. Mestizos have the best qualification with respect to the other ethnic groups, especially when compared with indigenous.

Table 9. Results of the Information and Skills Index

		Range 0-20		Sample
		Index	VC	
Total		**9,97**	0,01	5002
Area	Urban	10,57	0,01	492
	Rural	9,82	0,01	4510
Region	Highlands	9,74	0,01	2372
	Coast	10,21	0,01	1367
	Amazon	9,92	0,01	1254
Sex	Male	10,25	0,01	3315
	Female	9,35	0,01	1687
Ethnic Self-Identity	Indigenous	8,8	0,01	1461
	Afro-Ecuadorian	10,07	0,03	176
	Mestizo	10,3	0,01	2836
	Other	9,91	0,02	529
The estimator is robust if it has a sample of at least 200 cases and a Coefficient of Variation (CV) less than 0.15.				

Infrastructure

41% of EAP linked to agricultural activities resides in homes whose floor has the lowest quality conditions (table, untreated wood, cane, earth or other material). This proportion is more than double if we compare it with the national EAP. Also, the poor materials of the walls of the house are double in the population linked to agriculture (other material, uncoated cane, wood and adobe or tapia).

Regarding the type of lighting, there are no relevant differences in the behavior of the national and agricultural EAP, but not in the way in which garbage is eliminated. In this case, the gap in access to municipal garbage collection service is 33%. This would force 39% of the households in which the agricultural EAP resides to burn their garbage.

59% of the EAP at the general level resides in homes with sewage systems. This proportion is almost three times higher than that of the agricultural EAP. Access to conventional telephone service is almost four times lower in the agricultural population, and water through the public network is 30 points lower in agricultural households, and one fifth access water through a well.

11% of the population linked to agriculture pays for water for consumption or irrigation, this proportion is somewhat smaller than that of the general population. Considering that irrigation infrastructure is highly relevant for adaptive capacity of agricultural communities especially facing extreme events like droughts, the results shows less than 1% of the population with these assets. It means that the farming families are highly dependent on rain for the growth of their products (Egyir, et al., 2015).

78% of the PEA related to agriculture resides in homes whose access is not road, paved or paved street, this proportion at national level is 45%.

Table 10. Descriptive Distribution of Infrastructure

Indicators		National EAP	Agriculture EAP
Apartment floor	Other	0.1%	0.2%
	Land	4.2%	9.1%
	Cane	0.4%	1.1%
	Wood / untreated wood	14.0%	30.5%
	Cement / Brick	41.2%	47.5%
	Marble / Faux marble	0.7%	0.1%
	Ceramic / tile / vinyl	31.2%	9.3%
	Duel / parquet / faux wood	8.2%	2.2%
Walls	Other	0.1%	0.3%
	Uncoated cane	5.1%	11.5%
	Bahareque cane and coated reed)	1.3%	3.2%
	Wood	5.4%	14.4%
	Adobe / tapia	4.0%	7.3%
	Asbestos / cement	3.8%	1.6%
	Block / brick	72.8%	59.0%
	Concrete	7.4%	2.8%
Type of lighting	None	0.2%	0.6%
	Candle, lamp, lighter, gas	1.0%	3.3%
	Public electric company	98.6%	95.1%
	Solar panels	0.1%	0.5%
	Private power plant	0.1%	0.4%
How to dispose of garbage	Throw it in the street, ravine, lot	2.3%	6.9%
	Throw it into the river, canal	0.3%	1.0%
	Burn it	13.4%	39.0%
	Bury it	1.4%	3.8%
	Other	0.2%	0.3%
	Municipal Service	82.5%	49.1%
Type of hygienic service	Does not have	5.6%	15.9%
	Latrine	2.5%	6.2%
	Toilet and blind well	6.2%	14.4%
	Toilet and septic tank	26.6%	41.1%
	Toilet and sewer	59.1%	22.4%
Conventional telephone service	No	59.6%	89.0%
	Yes	40.4%	11.0%
Where water is obtained	Other	1.3%	2.9%
	Watershed	2.9%	10.0%
	Well	6.6%	19.8%
	Trolley / Tricycle	2.7%	2.7%
	Other source by pipe	8.7%	18.8%
	Public network	77.8%	45.8%
Spent on water / Irrigation system	No	86.1%	89.3%
	Yes	13.9%	10.7%
Main access to housing	Other	0.1%	0.0%
	River / Sea / Lake	0.3%	1.0%
	Path / Trail	6.1%	17.1%
	Gravel / dirt street	33.4%	52.8%
	Cobblestone	5.4%	7.3%
	Paved road or highway	54.8%	21.6%
Has water pump	No	99.0%	97.2%
	Yes	1.0%	2.8%
Has irrigation equipment	No	99.8%	99.5%
	Yes	0.2%	0.5%
Total		100%	100%

Based on the official data presented in Table 10, the calculation of the adaptive capacity for the Infrastructure determinant reached 17.71/50 as is shown in Table 11. The biggest difference appears between urban and rural areas and ethnic self-identification of mestizos and indigenous. This is the only index in which women get a higher score.

Table 11. Results of the Infrastructure Index

		Range 0-50		Sample
		Index	VC	
Total		**17,71**	0,00	5002
Area	Urban	20,81	0,01	492
	Rural	16,9	0,00	4510
Region	Highlands	19,21	0,01	2372
	Coast	17,07	0,01	1367
	Amazon	13,83	0,01	1254
Sex	Male	17,31	0,01	3315
	Female	18,63	0,01	1687
Ethnic Self-Identity	Indigenous	15,84	0,01	1461
	Afro-Ecuadorian	17,21	0,02	176
	Mestizo	18,58	0,01	2836
	Other	16,55	0,01	529
The estimator is robust if it has a sample of at least 200 cases and a Coefficient of Variation (CV) less than 0.15.				

Adaptive Capacity Index for Agriculture

The Adaptive Capacity Index for Agriculture in Ecuador is 1.43/ 5 at the national level. The differences between urban and rural are appreciable, between indigenous and mestizos, and there is a bias in favor of men. See Table 14 and 15

Nationally, adaptive capacity is lower in rural areas compared to urban areas. The lowest adaptive capacity in the population related to agriculture is found in that without any level of education (1.0), is an indigenous person living in the rural area (1.19), his place of residence is the Amazon. On the contrary, that is, a better adaptive capacity is found in the urban population with medium (1.86) and higher (2.16) level of studies, urban mestizo (1.72) and, of the urban part of the inter-Andean region.

Considering sex, men slightly exceed women in their adaptive capacity, slightly higher in the rural part. Similar situation is observed when analyzing the head of household.

At the regional level, the Amazon appears with the least adaptive capacity, both at the urban and rural levels, while the Andean region registers a better adaptive capacity (above the national average), and both in its urban and rural part. In all three regions, adaptive capacity is lower in the rural area.

Indigenous people have a lower capacity than Afro-Ecuadorians (1.40) and mestizos. These differences remain in the rural part, while in the urban part, the differences are minor.

People with a higher level of education (1.89) have a greater adaptive capacity than those without any level of education (1.0), a difference markedly at the urban level than at the rural level.

Table 12. Index of Adaptive Capacity by Determinants

		Economic Resources 0-5		Technology 0-5		Information and skills 0-5		Infrastructure 0-5		Sample
		Index	VC	Index	VC	Index	VC	Index	VC	
Total		**2.25**	**0.01**	**0.32**	**0.05**	**2.49**	**0.01**	**1.77**	**0**	**5002**
Area	Urban	2.53	0.01	0.6	0.09	2.64	0.01	2.08	0.01	492
	Rural	2.18	0.01	0.25	0.05	2.45	0.01	1.69	0	4510
Region	Highlands	2.26	0.01	0.35	0.07	2.43	0.01	1.92	0.01	2372
	Coast	2.3	0.01	0.32	0.08	2.55	0.01	1.71	0.01	1367
	Amazon	2.02	0.01	0.19	0.1	2.48	0.01	1.38	0.01	1254
Sex	Male	2.33	0.01	0.35	0.06	2.56	0.01	1.73	0.01	3315
	Female	2.08	0.01	0.25	0.1	2.34	0.01	1.86	0.01	1687
Head of household	Male	2.29	0.01	0.31	0.05	2.54	0.01	1.76	0.01	4189
	Female	2.05	0.01	0.39	0.12	2.27	0.02	1.81	0.01	813
Ethnic self-identification	Indigenous	2.02	0.01	0.19	0.12	2.20	0.01	1.58	0.01	1461
	Afro-Ecuadorian	2.24	0.03	0.28	0.21	2.52	0.03	1.72	0.02	176
	Mestizo	2.32	0.01	0.39	0.06	2.58	0.01	1.86	0.01	2836
	Other	2.25	0.01	0.23	0.14	2.48	0.02	1.66	0.01	529
Level of education	None	1.96	0.02	0.01	0.54	1.30	0.03	1.62	0.01	497
	School	2.22	0.01	0.15	0.08	2.55	0.01	1.75	0.01	3205
	Highschool	2.43	0.01	0.82	0.06	2.79	0.01	1.87	0.01	1200
	Superior	2.71	0.03	1.12	0.12	2.90	0.03	2.11	0.03	100

Table 13. Index of Adaptive Capacity

		Total			Urban			Rural		
		Index 0-5	VC	Sample	Index 0-5	VC	Sample	Index 0-5	VC	Sample
Total		**1,43**	**0,01**	**5002**	**1,69**	**0,01**	**492**	**1,37**	**0,01**	**4510**
Region	Highlands	**1,48**	0,01	2372	1,80	0,02	215	1,41	0,01	2157
	Coast	**1,43**	0,01	1367	1,62	0,02	239	1,37	0,01	1128
	Amazon	**1,20**	0,01	1254	1,61	0,04	35	1,18	0,01	1219
Sex	Male	**1,46**	0,01	3315	1,68	0,02	366	1,40	0,01	2949
	Female	**1,36**	0,11	1687	1,70	0,02	126	1,29	0,01	1561
Head of household	Male	**1,45**	0,01	4189	1,69	0,01	396	1,39	0,01	3793
	Female	**1,36**	0,01	813	1,68	0,03	96	1,27	0,02	717
Ethnic self-identification	Indigenous	**1,22**	0,01	1461	1,63	0,06	36	1,19	0,01	1425
	Afro-Ecuadorian	**1,40**	0,02	176	1,62	0,04	28	1,30	0,03	148
	Mestizo	**1,51**	0,01	2836	1,72	0,02	374	1,44	0,01	2462
	Other	**1,37**	0,03	529	1,57	0,04	54	1,34	0,01	475
Level of education	None	**1,00**	0,01	497	1,16	0,04	27	0,98	0,02	470
	School	**1,40**	0,01	3205	1,59	0,02	284	1,36	0,01	2921
	High school	**1,65**	0,02	1200	1,89	0,02	158	1,56	0,01	1042
	Superior	**1,89**	0,01	100	2,16	0,04	23	1,74	0,03	77

Conclusions

An adaptive capacity framework is useful for analyzing systems and variables so that a deeper understanding of the components and the way that they relate to each other can be achieved (Smit & Wanderl, 2006) (Williamson, Hesseln, & Johnston, 2012). Being this the first study on adaptive capacity to climate change in Ecuador, the most valuable contribution represents the possibility of using the evidence presented in the designing of adaptive strategies and its impact on the agricultural population.

The low values of the Adaptative Capacity Index indicate a low adaptive capacity of the population dedicated to agriculture in Ecuador, with differences in the context of region, sex, head of household, ethnic self-identity and level of education.

The highest record corresponds to people with a level of education of high school or superior, especially in urban areas. It is validated by authors like Maddison (2006), and Brooks et al., (2005) who determined that higher literacy rates increase adaptive capacity by increasing the capabilities of people, the adoption of new skills, a better access and understanding of information, and with that a higher productivity.

Lack of access to education, technology and information, being a women, being indigenous, having a female head of household, live in rural areas, in the amazon region, are the constant variables for low adaptive capacity to climate change. These results reflect and are validated by the reality of agriculture in Ecuador.

Relevant literature establish that indigenous groups and women are more vulnerable to the effects of climate change (Caretta & Borjeson, 2015) (Gomez & Moreno-Sanchez, 2015).

It is corroborated by the results of this study, as farmers identified as indigenous present the lowest scores on each one of the determinants used (economic resources, technology, information and skills and infrastructure), and also in the results of the ACI. The same results are found for female head of household and female, with a slightly difference on urban areas.

These findings are highly relevant for public policy design, showing the usefulness of intersectionality and corroborating its value as an approach to climate change adaptation studies (Kaijser & Kronsell, 2014).

As planning is a political act, these more vulnerable groups such as women, families with a female head of househol,d and indigenous populations are in need of some affirmative actions. These can be scholarships for educational programs, trainings and internships, developed both in Spanish and indigenous languages. On the economic aspect, access to credit for productive activities is needed, as well as financial support for small cooperatives and community saving organizations. Since the technology determinant has the lowest score, the government could implement access to internet through the state agencies with accessible plans, as well as equipment for community organizations accompanied by training on relevant software. For infrastructure, there is a huge need for irrigation systems that are accessible to local communities, which could be solved through projects by local authorities.

We recommend the information presented by this study to be deepened at the local and community level to establish measures and strategies more in line with the local reality as adaptive capacity is determined by relationships of a number of different factors at different scales (Vincent, 2007; Hill & Engle, 2013). The indicators listed in this study for the agriculture sector may not be replicated exactly for local communities, although the logic behind the selection could take the framework and approach presented here.

For example, for agricultural communities in Pedro Moncayo, the use of agroecological practices should be listed as a main indicator since it has proven to be a relevant mechanism for adaptation. The participation in community systems that provides access to credit for their members, the maintenance of local traditional knowledge for preserving seeds, and the preservation of ancestral practices of medicine are some other indicators of adaptation capacity that could be included. Access to health insurance is one of the most challenging aspects, especially for women living in rural areas.

Finally, although this quantitative approach has been valuable in the calculation of the Adaptive Capacity Index, it is recommended that future research on this topic makes use of mixed methods that allow complementing the quantitative approach with qualitative elements that provide a better understanding of the reality, and involve stakeholders at the formative stage of the research process.

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CONCLUSIONS

Relevant findings

Article 1: What the future holds? Historical climate analysis and projection of future climatic scenarios for the Andean canton of Pedro Moncayo, Ecuador

The current research filled an important gap in the main official planning documents of Pedro Moncayo canton, the Development and Territorial Planning Plans of the years 2015, and its update in 2018. These plans include only general references of the monthly precipitation and temperature values of the 1985-1989 period at six meteorological stations.

The research not only updated the periods of the series but also carried out an adequate statistical treatment, including the filling of missing gaps with internationally recognized techniques and sources to identify the main features of climatic variability. A geographical information system was used to generate monthly, quarterly, and annual maps of variation of precipitation and anomalies of temperature for the periods 1981-2010 and 1981-2017.

For the first time at local level in Ecuador, climate change scenarios were generated for Pedro Moncayo based on material in the *Ecuador Third National Communication on Climate Change.* Representative Concentration Pathways of 4.5 and 8.5 were considered. A comparison of current climate with future climate led to the creation of project variations for the period 2031-2050.

A Shuttle Radar Topography Digital Terrain Model (30-meter resolution) was used for temperature. Missing data were completed with Climate Hazards group Infrared Precipitation with Stations (CHIRPS) dataset or, in the case of temperature, with a NASA series from the Prediction of Worldwide Energy Resource Climatology Resource for Agroclimatology and Global Modeling and Assimilation Office -- GMAO.

The local climate of the Pedro Moncayo canton has varied consistently with national, regional and global features. People's perception was corroborated by the analysis of the data prepared for this investigation. Observed was a homogeneous geographic distribution of precipitation and of nighttime and daytime temperatures, with slight variations between the quarters. A heterogeneous temporal distribution of precipitation was observed, with increases and decreases in several areas.

Two geographical areas with different quantitative characteristics of precipitation were identified at the quarterly level: greater rainfall near the flanks of the Andean Cordillera in the east and southeast and less rainfall in the south-central zone, with the lowest rainfall during the quarter of July to September.

In general terms, the precipitation in a larger part of the canton has increased between January through March (especially in the southwest) and has decreased between July through September.

Due to its orographic characteristics and location on the equatorial line, slight variations in average temperature were recorded during the year, but important differences were recorded between day and night.

Increases of the maximum midday temperature were observed from the northeast to the southwest, with the highest values (up to 24-25°C) between July and September. A general slight decrease was observed in greater magnitude in the northeast, especially between the July to September quarter.

Decreases in minimum nighttime temperature were observed from the west to the higher parts of the northeast, where the lowest values (4-9°C) were registered. The biggest decreases occurred between July through September, which is climatologically considered to be the dry season.

One of the most relevant findings was that the future local scenarios differ from those at national level presented to the UNFCCC by Ecuador in its Third National Communication on Climate Change. This can be understood as an appropriate local-level scale of analysis with current climate data using an updated period (1981-2017), source, and methodology (depth consideration of orography and altitude, using a terrain digital model and making corrections for missing data).The scenarios included in the National Communication on Climate Change used the period 1981-2005 for 137 meteorological stations for the entire country in comparison with the 126 meteorological stations used just for Pedro Moncayo.

This is a critical finding, showing that the magnitude and, in some cases even the direction (+/-), of expected future climate could be different, depending on which data series/scale and methodology are used for present climate.

Expected in the future are an increase in precipitation in all quarters (except in areas of the northern center), in the average temperature (except in the north center), in maximum temperature, and a decrease of the minimum temperature.

Quarterly increases of precipitation in almost the entire canton was estimated, with the exception of a small area south of the canton's center.

During the four quarters and under both RCP scenarios, the geographical distribution of increases of precipitation is the same, with a greater quantitative significance January through March.

An increase in the average temperature under RCP4.5 (except in the northern center) and RCP 8.5 scenarios in all quarters was identified. No major variations were recorded from quarter to quarter. Recorded under RCP 8.5 were estimated anomalies with a greater magnitude of the increase and a lesser magnitude of the decrease in the north center of the canton.

A decrease of the minimum temperature, throughout the territory, was identified under the RCP4.5 and RCP 8.5 scenarios. Under the RCP 4.5 scenario, the greater intensity was estimated in the northern center, especially in July through September. Using RCP 8.5, the decrease was smaller, especially in the July-September quarter.

An increase of the maximum temperature under RCP 4.5 and RCP 8.5 was observed throughout almost all of the territory. Under RCP 8.5, the generalized increase was of greater magnitude, except in the central northern area.

More research on this topic, conceptually and empirically is needed. This research demonstrates both the difficulty and the promise of this approach.

Article 2: Socioeconomic and gendered impacts of the adoption of agroecological practices as a climate change adaptation mechanism in four Highland communities in Pedro Moncayo, Ecuador

The research analyzes the perceptions of the inhabitants of the Andean communities of Pedro Moncayo canton related to changes that occurred when using agroecological practices as a response to climate changes and their socio-economic and gendered impacts.

The quantitative exploration was conducted with 119 surveys obtained from a random selection with a confidence level of 95% and a margin of error of 5%. The content of the survey was a result of a qualitative exploration based on in-depth interviews. The survey contained 29 questions related to (a) perceptions of climate change trends and impacts, (b) perceptions of the impacts of agroecological practices on life quality, and (c) demographic profile.

Climate change and water access were named by 100% of women and men as the most serious problems necessitating the use of agroecological practices.

Perceptions of climate change were homogeneous and did not vary by gender, age, or ethnicity. The days were perceived as hotter (97.5%), the nights as colder (71.6%), and increased uncertainty was recorded about when seasonal rains would begin (88%), in comparison to the past.

As for water access, there was a duality. Some 40% of those surveyed reported access to water for irrigation, and 43% reported a lack of access to water. In both cases, there was an acknowledged dependency on rainwater, with increasing dryness clearly an aggravating factor for agriculture.

Strong winds and drought were the two of three extreme events that have occurred with more frequency over the past five years in all four parishes. The third most-cited event varied, depending on the location and different physical factors in each zone: increased frost in Tabacundo, increased heatwaves in Tupigachi and Tocachi, and more frequent sandstorms in La Esperanza.

The inclusion of agroecological practices has been very useful, according to survey participants because of the adaptive capacity to face climate change. Some 90.8% of the respondents, without geographical, ethnic, or age differences, said the correct use of agroecological practices, such as green fences, had avoided crop loss and had reduced evaporation.

However, the use of agroecological practices on the farms of Pedro Moncayo canton is nothing new. In fact, 100% of those surveyed said they had learned from their parents; 57% reported that they obtained additional knowledge from their communities and, and 86% of women and 74% of men obtained supplementary knowledge via training provided by the municipality of Pedro Moncayo.

Ancestral knowledge, jointly with the newly acquired knowledge, has allowed them entry into a different market with buyers who were more aware not only of the nutritional quality of agroecological products but also of the environmental impact of agroecological practices.

There is a structural inequality in the gendered division of labor and daily duties. Access to education was one of the main indicators of this problem; 56% of the women who participated in the study had not completed primary education while for men, only 10% had completed primary education.

The women are responsible for care of children (55.4%), grandchildren (20.3%), sick people (43.2%), and senior citizens (71.6%). Also, women are responsible of preparation of family meals (98.6%) and for the sale of farm products at agricultural fairs. The only shared space between men and women was agricultural work on farms: cleaning, irrigation, sewing, and preparation of products for sale.

Only 16% of the women reported being landowners. Among married women, 100% recognized shared tenancy of the land with their husbands, compared to 83% of married men who reported that they shared land with their wives. Some 17% of married men reported that they were sole landowners, despite being married.

Only single, divorced, or widowed women were labeled as the main source of household income, while 43% of the women surveyed affirmed that their spouses were the primary means of support, and 30.5% reported that income between spouses was similar. The opposite occurred with men, where 56% declared themselves to be the main supporters, and 45.6% considered that the income between spouses was similar. Only 2% of men recognized that their spouse was the primary supporter.

Some 70% of men and women recognized that decisions about income earned through agroecological production were principally made jointly within their marriage. This was especially for married couples who work together on the farm.

There is a different perception of 30% of women and men in relation to decision of income earned through agroecological production. The men claimed that they make the decisions about family income, while the 25% of women responded that the decisions were made by them alone. Of the 25% of decision-making women, 85% were single, divorced, or widowed. This says that women exercised the decision-making power only when there was no man in the family. More research could focus on that situation.

Men and women in Pedro Moncayo considered the male partner as the head of household, provider, resource owner, and decision maker. However, that does not mean decisions are made only by men.

In social terms, survey participants reported that the greatest benefit of the use of agroecological practices was an improvement of the family diet, as production is destined first for self-consumption and then for sales.

Family’s low agroecological farming incomes have not led to improvements in education or access to healthcare. Some 83% of the women and 80% of the men responded that they had not perceived any improvement in access to or quality of healthcare.

Little change in access to education during the past five years was determined, while women aged 30-55 reported that their children were being better educated because as mothers, they were able to spend more time with the children and help them with their homework.

Three of four persons surveyed believed that the municipally provided market space was one of the main advantages of agroecological practices. The market space allowed producers a better and more permanent income, without losing profits to middlemen. The sale of agricultural products is carried out almost exclusively by women.

It is important to note that the study’s surveys were effective in gathering data about the socioeconomic impacts of agroecological practices, but the depth and richness of personal accounts gleaned from the in-depth interviews was more suited to the purpose of this study. By giving women a safe place to discuss their conflicting roles during an anonymous interview, the interview methods allowed participants to express the independence achieved by having their own income.

Gendered impacts of the use of agroecology as a mechanism for addressing climate change remains to be studied. Other variables, such as ethnicity and age, also need special attention. Further and deeper research is needed at the national level (see Section 6.3.1).

Article 3: Adaptive capacity to climate change in Ecuador's farming population

The study proposes an adaptive capacity index (ACI) adjusted to the context of populations dedicated to agriculture in highland Ecuador. With that purpose, the study used 4 determinants of adaptive capacity: economic resources, technology, information and skills, and infrastructure. (Smit & Pilifosova, 2001).

Using an analysis of nonlinear main components and the information available in the 2014 Living Conditions Survey, an ACI of 1.43 on a scale with a maximum of 5 was found nationwide.

The results show a notable difference between urban (1.69/5) and rural áreas (1.37/5). This is highly relevant considering that, in Ecuador, the official data establishes that 79% of the Economically Active Population (EAP) linked to agricultural activities in 2014 was in the rural area of the country.

Geographically speaking, the Amazon región has the lowest score on urban and rural áreas, and on econmic resources, technology and infraestructure. Fort he information and skills determinant, the Highlands scored the lowest index. In all three regions, adaptive capacity is lower in the rural area.

The study used an intersectional approach to analyze the results of the Index, showing that there are differences on sex and ethnicity. When complemented with level of education, the following results were found:

- The lowest adaptive capacity was established for the population related to agriculture without any level of education (1.0), is an indigenous person living in the rural area (1.19), his place of residence is the Amazon.
- The higher adaptive capacity was established for population is found in the urban population with medium (1.86) and higher (2.16) level of studies, urban mestizo (1.72) and, of the urban part of the inter-Andean region.
- Considering sex, men exceed women in their adaptive capacity, except on urban areas where women scored slightly higher than men.
- When analyzing the head of household, the male head of household presents a higher total index, as well as on urban and rural areas.
- Considering ethnicity, indigenous people have a lower capacity than Afro-Ecuadorians and mestizos.

This suggests that public policies designed with an intersectional approach can help improve an agricultural population's adaptative capacity, particularly benefiting the most vulnerable groups.

When analyzing the individual Index for determinants, the Technology scored the lowest index (0.32) with a significant difference with Infrastructure (0.77), Economic resources (2.25), and Information and skills who scores the highest index (2.49).

The higher adaptive capacity for the Economic resources is present in the urban area, in men and mestizos, which means that women and indigenous people living in rural areas face bigger challenges to confront climate change.

The use of technological goods and services in the population linked to agricultural activities in Ecuador is marginal. In the specific case of the internet, only 8% used this service. This is relevant considering that literature establishes that information and communication technologies could reduce the lack of information and knowledge, especially in disaster related episodes. Investment in technology and targeted infrastructure should be an important long-term adaptation strategy.

Literature says that people's relationship with each other through networks and the associational life in their community increase the adaptive capacity as they act as conduits for information and allows collaborative initiatives, however people participating on community organizations are less than 4%. This is noticeable a challenge for communities facing climate challenges.

The results of the Information and skills index show how the categories of urban area, coastal region and men present a higher index in this determinant. Mestizos have the best qualification with respect to the other ethnic groups, especially when compared with indigenous.

Only 11% of the population linked to agriculture pays for water for consumption or irrigation, this proportion is somewhat smaller than that of the general population. Considering that irrigation infrastructure is highly relevant for adaptive capacity of agricultural communities especially facing extreme events like droughts, the results shows less than 1% of the population with these asset. It means that the farming families are highly dependent on rain for the growth of their products.

These results converge with information of literature review, especially showing the vulnerability of indigenous groups and women working on agriculture. These findings are highly relevant as it allows to design public policies for specific actors.

We recommend the use of mixed methods and local scale for future research.

Other issues raised by this research

The planning and execution of the research allowed for the identification of gaps, shortcomings, and challenges that directly and indirectly increase local vulnerability to climate change and reduce the local and national capacity of Ecuador to respond to natural and anthropogenic climate variations.

The reduction of the quality, quantity, access, and availability of meteorological data in recent years is a reality that today has no solution, at least in the short term. The National Institute of Meteorology and Hydrology -- INAMHI is in a dire situation due to significant cuts of its human, technological, and economic resources due to the economic and political crisis of the country and especially as a result of the limited importance given to this area of study.

In the 1980s, about 1,000 weather stations existed in Ecuador. Today, that number has declined to a few hundreds, of which only a few tens have been operational in recent years.

This, along with a lack of maintenance of the stations, a lack of calibration and replacement of their instruments, a reduction of personnel trained in meteorological observations, among other causes, have considerably reduced the quality of the meteorological information available to Ecuador and presents a big challenge for research.

Also experiencing significant reductions are the access and availability of meteorological data processed under international standards. The last Meteorological Yearbook includes statistically treated data up to 2014.

The data generated by automatic weather stations has not been processed, and access to it has been very limited, while the data generated by a large number of privately owned weather stations are not accessible and are not always shared with the INAMHI.

Local vulnerability to climate change increases in tandem with the ability to respond to current and future climatic events, also as a result of the low response capacity of the decentralized autonomous governments - GADs.

Variability and climate change in the planning and action of the GADs, especially with the local ones (cantonal and parish levels) are not considered with the relevance or priority this challenge deserves. Despite the existence in recent years of national guidelines for consideration of climate change at local level, especially in development plans and territorial planning, the issue is treated as a secondary matter. Climate issues are not a direct responsibility of the GADs, which means climate issues are generally worked by environmental departments that have limited qualified personnel and other responsibilities and priorities to address.

Only a few local governments, such as the Province Government of Pichincha, the Municipality of the Metropolitan District of Quito, the Municipality of Esmeraldas, and Guayaquil are the only entities that have designed climate change plans and strategies.

The annual budget of the GADs, already limited, generally does not include assignments for climate issues, and the initiatives that some local governments have implemented have been supported by climate change projects led by the Ministry of Environment and/or international aid.

Current climate change impacts and vulnerability are generally relegated to those expected for the future, when science predicts that the best strategy to adapt to climate change is to face current impacts and vulnerabilities.

A limited number of professional people in Ecuador have specialized in the field of climate change at the undergraduate and postgraduate levels, and the nation's system of higher education does not have under graduate academic programs that focus on climate issues. Academic programs for graduate lever are scarce, and those that exist focus more on future approaches.

Participation and presence in decision making and analysis of climate issues of the academy, private sector, and civil society are limited and sporadic. The Interinstitutional Committee on Climate Change, responsible for the issue at the national level, is conformed only by public-sector entities.

The availability and access to national and international scientific publications, as well as to initiatives on climate variability and change and to national in international negotiations, is scarce and, the existing one is dispersed and not always open access.

Future research and initiatives

As a result of this research process that began in 2015, topics for future research have been identified, as well as initiatives that can be planned and executed to address gaps and challenges described in this study. Some of them are:

- Studies on strategies and adaptation activities carried out by local communities working on agriculture, in rural areas, under a gendered and intersectionality approach.

- Studies on historical and future climate change scenarios at the local level.
- Studies on the inclusion of climate change on public policies

Proposal: Ecuadorian Observatory of Climate Change

There is no doubt about the need for joint initiatives to support government actions in its priorities and initiatives, as well as the need of open spaces from academia and civil society to generate spaces for exchanging knowledge and experiences, discussion and analysis of relevant topics, access and scientific use of data, among others. I believe these needs can be achieved by creating an Observatory of Climate Change.

In recent years, a series of similar initiatives have been implemented, under different perspectives, names and goals, most of them with a governmental approach. Some are Health and Climate Change Observatory (Spain), Pyrenean Climate Change Observatory, Regional Climate Change Observatory of the Murcia Region (Spain), Sustainable Development and Climate Change Observatory of La Rabida (Spain), Climate Change Observatory (Peru), Climate Change Observatory in Catapaca (Chile), Climate Observatory (UTPL, Ecuador), Climate Change Observatory on the coast of Quintana Roo (Mexico), National Climate Change Observatory (Argentina), Climate Change and Resilience Observatory (Dominican Republic), and the Observatory of Indigenous Rights and Climate Change (Costa Rica).

In Ecuador, there is no open access space where actors from the public, private, civil society, indigenous, academy, media, and other sectors can participate and obtain technical and scientific information and support, in part because the data and results from research are disperse and not always accessible.

The Climate Observatory of the Technical Private University of Loja has a regional scope in Ecuador (only Loja, El Oro, and Zamora provinces). It aims to provide society with climate information that will inform decision making and promote sustainable practices.

The academy has a fundamental role in generating scientific research, in addition to the connection to society. In this sense, the creation of an Ecuadorian Observatory of Variability and Climate Change, which would be an effort combining the interests, priorities, and resources of the main actors of the public and private sectors, society, pueblos and indigenous nationalities, national and international academia and media, is proposed.

The participation and support of the Ministry of Environment, as a national focal point, and the Ministry of Foreign Affairs and Human Mobility, as well as of the GADs would be one of the priorities. International aid would be welcomed for this initiative.

For this purpose, a project proposal is being prepared. I believe that, considering the economic dynamics of Ecuador, Central University of Ecuador, the faculty of agricultural sciences, with its two undergrad programs on agriculture and tourism, would be a suitable space for developing the observatory. The proposal would define political, technical, and economic requirements, generated by consensus among the actors interested in the proposal.