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Effectiveness of agroecological practices in creating resilience to climatic variability in Colombia - The Amazon Chagra

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MSc International Environmental Studies

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DECLARATION

I, Alvaro Andrés Castañeda Sánchez, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work as not been previously submitted to any other university for award of any type of academic degree.

Date: 30/08/2019

Signature: Andrés Castañeda A.

Alvaro Andrés Castañeda Sánchez

“If anyone thinks he really knows something, he has not yet learned it as he ought.”

1 Corinthians 8:2

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Abstract

Indigenous farmers of the high Amazon region in Colombia are acknowledged for the development of traditional agroecological practices that are very open and dynamic. These self-sufficient food systems are known as “Chagra”, and consist of polycultures that integrate livestock, medicinal plants, fibre plants and silviculture and resemble in many ways the canopy levels and the diversity of the ecosystems that surround them. They have thrived for generations in difficult regions where high humidity and constant precipitation meet high slopes, vulnerable to erosion, as well as flat and poorly drained land where floods are frequent. The test of time is the best evidence of the potential of their practices in creating resilience to extreme climatic events. As the world faces global environmental changes and conventional productive food systems are becoming increasingly questioned, there are reasons to consider researching these alternative systems and producing data and empirical evidence that could lead towards reforming the global food system and creating one that is more robust, resilient and sustainable. There is evidence that the distribution of meteorological variables like rainfall is modulated by global climate drivers such as El Niño Southern Oscillation (ENSO). The purpose of this research is to compare the stability in the production of conventional agriculture with the stability of the Chagra during extreme ENSO related events. Data was gathered about the production of conventional and Chagra agriculture and about the context in which two indigenous groups, the ingas and the Kamentsá, develop the Chagra practice. There is evidence to suggest the Chagra does increase resilience and reduce vulnerability by protecting the soils and keeping a high level of biodiversity. However, more research is necessary and following research should include the design of long-term standardised data collection and isolation of other variables.

Key Terms: *Agroecology, Chagra, Integrated Agriculture, Food production, Resilience, Adaptive Management, Climatic Variability, El Niño Southern Oscillation, ENSO, Oceanic Niño Index, ONI, Kamentsá, Inga, Indigenous, Sibundoy Valley, Putumayo, Colombia, South America, Tropical latitude, Andes Mountains, Colombian Massif, High Amazon Basin, Montane Forest, Global Environmental Change, Combining knowledge*

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Introduction

There is a great amount of literature and studies both exploring and presenting the benefits of different traditional agroecological practices worldwide. Much has been written about the strategies that have lasted up to today as well as the historical, and sometimes prehistorical achievements of indigenous and traditional societies. However, not much has been done in comparing the effectiveness and the efficiency of such methods in dealing with climatic variability.

Clearly, all methods are valuable. But what if some are better than others? This question gains importance when considering that traditional practices could give direction towards the type of adaptive management approaches required to increase the resilience of a large portion of questionable conventional practices as the world faces the threats posed by the current trends of global environmental changes.

The purpose of this study is to compare one form of traditional agroecological production practice: the “Chagra” or “Jajañ”, by the indigenous communities of the high Amazon region in Colombia with conventional agricultural practices present in the surrounding areas. The production values obtained by each practice will be superimposed with the climatic data obtained using the ONI (Oceanic Niño Index) by NOAA and data provided by the Colombian Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) to determine whether there are significant variations in the production values during extreme El Niño and La Niña events.

Agricultural Practices and Sustainability

The last century has seen an increase of agricultural practices that are uncertain regarding their sustainability in the long term. There has been a worldwide surge of monocultures, GMO’s, fertilisers, pesticides, herbicides among others. These have increased the availability of food in many places but have also been pointed out as root causes for loss of biodiversity, loss of pollinators, loss of natural pest controllers, homogenisation of the landscapes, wearing down the soils, favouring erosion processes and creating disbalance. (Mejia G., 1995)

Some political organisations and NGO’s in different continents have taken part in condemning these procedures for their potential in keeping and sustaining social imbalances due to globalisation processes, seed control and land ownership among others. (Juarez P. *et al*, 2016)

For these reasons, scientists worldwide have taken on the task of searching for the best available techniques that may allow populations worldwide to get the best performance out of the crops we depend upon while increasing resilience and reducing those negative effects of conventional practices.

The Potential of Traditional Agroecological Practices

There is an increasing interest in the traditional knowledge of indigenous peoples that have managed to survive throughout time in regions characterised by fragile ecosystems, poor soils, and difficult environmental conditions. It has been argued that their persistence is the greatest indicator of their potential for sustainability.

The heterogeneity of small-scale agricultural practices displayed by traditional farmers offers numerous strategies developed to deal with climatic variability. Traditional farming systems are characterised by a high level of on-farm biodiversity, which has proven to be linked to resiliency to extreme climate. (Altieri, M. & Nicholls, C., 2017)

The ways in which traditional farmers adapt, as well as their methods to manage, maintain, and preserve the biodiversity of the territories on which their agroecosystems are located tend to be deeply linked to different aspects of their culture (Ganz, M. 2005). The knowledge behind traditional practices can provide guidelines for agroecological practices that work better with tropical regimes, ecosystems and climatic variability.

A definition of agroecology is the sustainable design and management of agricultural systems through the application of ecological concepts and principles (Ganz, M. 2005). Traditional farmers are pioneers in developing key agroecological strategies such as biodiversification, soil management and water harvesting. (Altieri, M. & Nicholls, C., 2017) Traditional agroecological systems of food production in tropical regions integrate cultivated crops and livestock, often mirroring and interlacing the surrounding ecosystems. (Ganz, M. 2005).

There are many ways in which conventional western agriculture in tropical regions can integrate polycultures to become more beneficial for the natural environment. Implementing a greater diversification of plants and fitting different forms of livestock production: bovine, ovine, porcine, poultry, fish farming among others, can increase agricultural input efficiency and could result in environmental benefits for all production systems (Clark & Tilman, 2017).

With as many different types of crops and produce as there are ways to implement agroecological practices, there is plenty of work ahead for researchers and farmers towards developing environmentally sustainable solutions able to satisfy human demand. Creating a more sustainable agricultural future may require the development of production systems that integrate the benefits of conventional, organic, conservation and traditional agroecological practices. (Clark & Tilman, 2017). These can be implemented in the design and management of modern agroecosystems that allow farmers to adopt strategies that increase resilience and provide economic benefits (Altieri, M. & Nicholls, C., 2017).

It is, however, necessary to acknowledge that there are ecological differences in the territories where traditional practices have been implemented. Also, the experience of farmers through generations cannot be improvised, and there are cases in which established methods are often handled intuitively by elders who respond to feedbacks from the environment. Such forms of adaptive management conform a challenge for people interested in creating sustainable agroecological packages.

Global Changes and Resilience

The last century has seen a great deal of changes on behalf of demographic growth and human activity. The impacts of development have increased dramatically and the rate at which humans are affecting the Earth systems is increasing significantly. The current socioeconomic trends are leading to an increase in demand of resources and goods affecting the natural systems that provide the land, water, air, food, wood, materials and energy and at the same time absorb the residues, waste and heat from all sorts of processes. (Steffen *et al.* 2015)

The rate at which humans are impacting the Earth system is now so significant, some scientists refer to it as the Great Acceleration: a period of logarithmically increasing changes that result from human growth and development. The extent of human activities has now reached a global scale, which is why some propose to call this epoch the Anthropocene, as the one following the Holocene in the Quaternary period within Geological Time. (Waters *et al.* 2016)

Agricultural development has also changed dramatically in the last century. There have been new technological advances in the fields of genetics, fertilisers and pesticides as well as better gear and machinery; accompanied by greater demand of territories and water, greater loss of biodiversity from those ecosystems removed for production and a decrease in the types of seeds used worldwide.

The current trends of global changes push for the need to explore efficient ways of agricultural development that are sustainable from an environmental point of view and can absorb possible environmental changes. Global changes may conform a major threat in the form of extreme events that may test the resilience of both conventional and traditional agriculture. Stochastic events that may result from environmental changes, mismanagement in agricultural practices or the sum of natural and anthropogenic causes may create perturbations and disturbances for which mankind is not prepared. Modelling possible events and adopting strategies that increase the capacity to respond, resist, learn and adapt becomes decisive.

Indigenous agricultural techniques in fragile ecosystems can provide great inspiration for farmers that provide the food we depend upon (Chaves, M. Vieco J.J., 1987). In fact, a growing number of conventional producers are challenging the widespread methods and are implementing agroecological practices. The last two decades have seen an increase in techniques such as agroforestry and silvopastoral livestock. Apt implementation of techniques requires a deep understanding of natural processes and the nature of environmental changes.

Climate, the challenge of the Tropics

Climate involves the atmospheric conditions that characterise a region. Temperature, precipitation as well as other parameters like evapotranspiration, humidity, wind speed and direction, solar radiation, luminosity and cloud formation help in defining the climate. Due to processes of rotation and translation of the Earth, as well as the lunar and solar cycles, altitude, latitude and probably other major forces, climate is dynamic; it displays cyclical ranges at many scales, some of which are better understood than others.

Climate is a major determinant in soil formation. It affects the variations in the water table which also affects the effective depth of the soils. It helps create conditions for soils to flood or get very dry which effects the form in which nutrients are available for plants and can impact their physical mechanical features and whether lumps of chemicals or hard impermeable horizons are formed. (IGAC, 2014)

Climatic variability ranges over many time and space scales from local to global, and from daily to monthly, annual to multi-annual, multi-decade and even multi-century time scales. Year-to-year variations in the weather patterns are often associated with changes in the wind, air pressure, storm tracks, and jet streams that encompass large regions at a global scale. El Niño and La Niña are two phases of a naturally-occurring global cycle of multi-annual scale known as ENSO (El Niño– Southern Oscillation) (McPhaden et al, 2006).

The El Niño phase presents periods of slow trade winds, which conform a low-pressure system that settles on the tropical Pacific Ocean causing exceptionally warm sea surface temperatures across the eastern tropical Pacific. During El Niño episodes tropical land systems tend to be more susceptible to droughts. The La Niña phase presents periods of fast trade winds which push the low-pressure system of the inter-tropical convergence zone (ITCZ) towards tropical continental areas causing rainier years and large flood events. (Peixoto & Oort, 1992).

Floods and droughts are the utmost expression of climatic variability in tropical regions where conventional agriculture is a significant victim of an extreme regime (Barbier, 2004). Colombia is located on the tropics and its climate is the result of the action of the ITCZ and the effect of global multiannual processes connected to the winds and sea currents (ENSO). Therefore, it is inevitable that any traditional agroecological development in the country has included adaptation measures to the action of floods and droughts caused by climatic variability. It is appropriate to study these forms of production objectively.

The Amazon Chagra

A great number of indigenous groups living in the Amazon could be catalogued as traditional and undeveloped by modern standards. It requires a closer look to acknowledge the complex adaptation of their systems to the environment they inhabit. (Chaves M. Vieco J.J., 1987)

The amazon crops, or "Chagras" as they are named, are crops characterised by polyculture, involve a great diversity of plant species per location and include a rotation of places as the soils start losing their capacity to produce. For this reason, traditional communities have more than one Chagra at a time, often they have three: One in a starting stage, another one at a suitable for production stage, and the last one is near abandonment. This rotation demands the indigenous to log new parts of the forest every so often to prepare for new Chagras. (Chaves M. Vieco J.J., 1987)

During the abandonment stage, the jungle retakes these territories and many types of plants grow on them again. After that, these areas are logged and burned or let to decompose depending on the group (culture). Turning it into an organic layer and a small source of fertiliser in which later, the group will plant seeds again.

For the indigenous person the Chagra is conceived as the "space where different species of animals and plants meet". "A place for easy and permanent access to them". An important element of their identity and a place to transmit knowledge and customs. In the Chagra "the thoughts and spirituality of the elders is found". (Agreda, 2016)

Chagras provide advantages regarding the use of light, rain and the potential to reduce erosion and soil degradation through rotation and use of organic compost. Taller plants receive more sunlight and direct rain, while the lower plants receive less light and water fall on them with less strength. A great advantage of the amazon polyculture has to do with less dispersal of diseases due to the distribution inside the Chagra.

Another advantage of the amazon Chagra has to do with the compatibility of this form of plantation with the naturally occurring fauna of the region. Indigenous people plant species that are not for human consumption but are known to attract animals because they provide food or shelter. This form of association attracts pest controllers, pollinators, herbivores and predators, which are at times hunted for human consumption.

There is also a greater advantage regarding soil erosion and the increase of the organic layer in a region characterised by a very positive hydric balance. The Chagra system has allowed the indigenous groups of the higher amazon regions to thrive despite the relative low fertility of the soils, often high slopes, high air humidity and high precipitations.

Due to the experiential nature of the Chagra development, there is little knowledge in relation of how it has evolved in relation to a few centuries ago. However, the method remains, and sustains whole communities with little variation in produce in relation to climatic variability. This makes it an interesting subject for study in relation to what conventional agriculture in these regions can potentially introduce, or what is already being used.

There are many ways in which conventional western agriculture in tropical regions can integrate polycultures to become more beneficial for the natural environment. The knowledge behind traditional practices could provide guidelines for agroecological practices that work better with tropical regimes, ecosystems and climatic variability.

The Kamentsá People

The Kamentsá people are an indigenous group that inhabits the high Amazon region on an area known as the Sibundoy valley in the department of Putumayo in the South of Colombia. (UNHCR, 2011) They share their territory with another indigenous group: The Ingas. There are about 4879 people in the tribe, of which about 2376 are males and 2503 are females. (DANE, 2005)

Kamentsá translates to: Native people with own thoughts and language. They have a great cultural heritage that starts with their language, the Camsá, a Language Isolate with no familiar roots within the Andes language families that has been preserved by creating a written language that uses Latin script and the development of Bilingual Schools. (Agreda, 2016)

They have great knowledge of medicinal plants which they trade throughout the country. They are protectors of the Central Forest Reserve. They manage their own Botanical Garden in collaboration with the Colombian Network of Botanical Gardens and have preserved the ancient development of the Chagra practice for generations.

The Inga People

The Inga people are an indigenous group with a broader distribution. Most of the group inhabits the Sibundoy Valley together with the Kamentsá, but they expand further towards the lower Putumayo into the Amazon Forest. To the west some inhabit the western Slope of the Andes that looks towards the Pacific coast in the Nariño department and a smaller group lives north towards the Cauca department and the Cauca river valley. (UNHCR, 2011) There are about 15700 people with about 7850 males and 7850 females. (DANE, 2005)

Like the Kamentsá, they are known for their traditional knowledge of medicinal plants and food plants. They are unique in the way they have developed processes of cultural exchange and acknowledgement of cultural diversity with other indigenous communities. (Arango R. & Sanchez E., 2004)

They tend to travel much and do trade which allows them to increase their knowledge of plants beyond the boundaries of their territory. When they find interest or use in different fruits, vegetables, medicinal herbs or trees, they are likely to introduce them into their own Chagras and culture.

They are highly organised and have been able to influence policies and government in the regions they inhabit. Like the Kamentsá, they are involved with the Colombian Network of Botanical Gardens and keep the Chagra tradition with greater dynamism.

Objectives:

1. Describing the environmental context in which the Chagra practice is developed by the Kamentsá and Inga communities in the high Amazon region in Colombia.
2. Exploring the effectiveness of the Chagra practice in tackling climatic variability by measuring the agricultural production of conventional and traditional practices during historic El Niño and La Niña events.
3. Prospecting the potential of agroecological practices within the Chagra that could be implemented in tropical modern large-scale projects to tackle climate variability.

Methods

1. Describing the environmental context in which the Chagra practice is developed by the Kamentsá and Inga communities in the high Amazon region in Colombia.

Any comparison between practices can only be possible in regions with similar environmental features (latitude, climate, soil). Knowledge of the environmental context allows the delimitation of similar areas and is useful to discern social from natural variables that may influence the outcome of an activity.

To address this objective, a literature review was required to identify traditional practices and locate them within the Colombian geography. It was necessary to access secondary information of Biophysical and social variables. Great part of the information was obtained through different government agencies that work at a national level, environmental corporations at a regional level and indigenous councils and government organisations at a local level.

Some of the data about the geology and lithology of the area of interest was obtained from the Colombian Geological Service (SGC formerly INGEOMINAS). Soil information was obtained from the Agustin Codazzi Geographic Institute

(IGAC). Meteorological and limnological information was obtained from the Colombian Institute of Hydrology, Meteorology and Environmental Studies (IDEAM). Biotic information was obtained from the Autonomous Regional Corporation of the Amazon Basin (CORPOAMAZONIA).

Some socio-economic information was found through programs of international organisations such as the United Nations and from the Kamentsá and Inga council as well as the Local major and government of Putumayo.

Remote sensing information like satellite imagery and radar data was obtained from American and Russian sources of geographic data such as Alaska Satellite Facility (ASF - NASA) and accessing the Bing blue-marble via SAS Planet. A digital elevation model was created to help visualisation of the region and other products were derived such as the surface hypsometry, hill shade, and slope. Geographic information was obtained from different government agencies such as (IGAC), (SGC), (IDEAM) and the Amazon Institute of Scientific Research (SINCHI).

2. Exploring the effectiveness of the Chagra practice in tackling climatic variability by measuring the agricultural production of conventional and traditional practices during historic El Niño and La Niña events.

To address this objective, there was literature review and a dataset about ENSO was obtained. Secondary information about historical agricultural production was accessed from Governmental institutions and the indigenous councils.

ENSO data was obtained in the form of historical Oceanic Niño Index (ONI) which is produced every three months by NOAA since 1950. Data from the Colombian Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) was over imposed.

Agricultural information was obtained from the National Statistics Administration Department (DANE), and from the Colombian Ministry of Agriculture

(MinAgricultura). A visit to the field was required to obtain mostly qualitative data. Traditional practice production data turned to be very scarce and not standardised. However, the practices were described by some farmers, and recent historical accounts were found about the effect of some landslides on conventional and Chagra practices in the Sibundoy Valley which turned out to be pertinent to the study.

A comparison was made between the stability in the production of conventional agricultural production in the nearby territory with extreme ENSO related events. A description of the practices was made to qualitatively assess the way in which practices handle equivalent effects.

3. Prospecting the potential of agroecological practices within the Chagra that could be implemented in tropical modern large-scale projects to tackle climate variability.

This objective required a literature review and a visit to those locations identified. Areas where production had less variations caused by strong ENSO episodes were prioritised. There was a literature review and a conversation with elders and members of the community. An analysis was made to identify how modern large-scale projects could implement these practices in an experimental way.

Results:

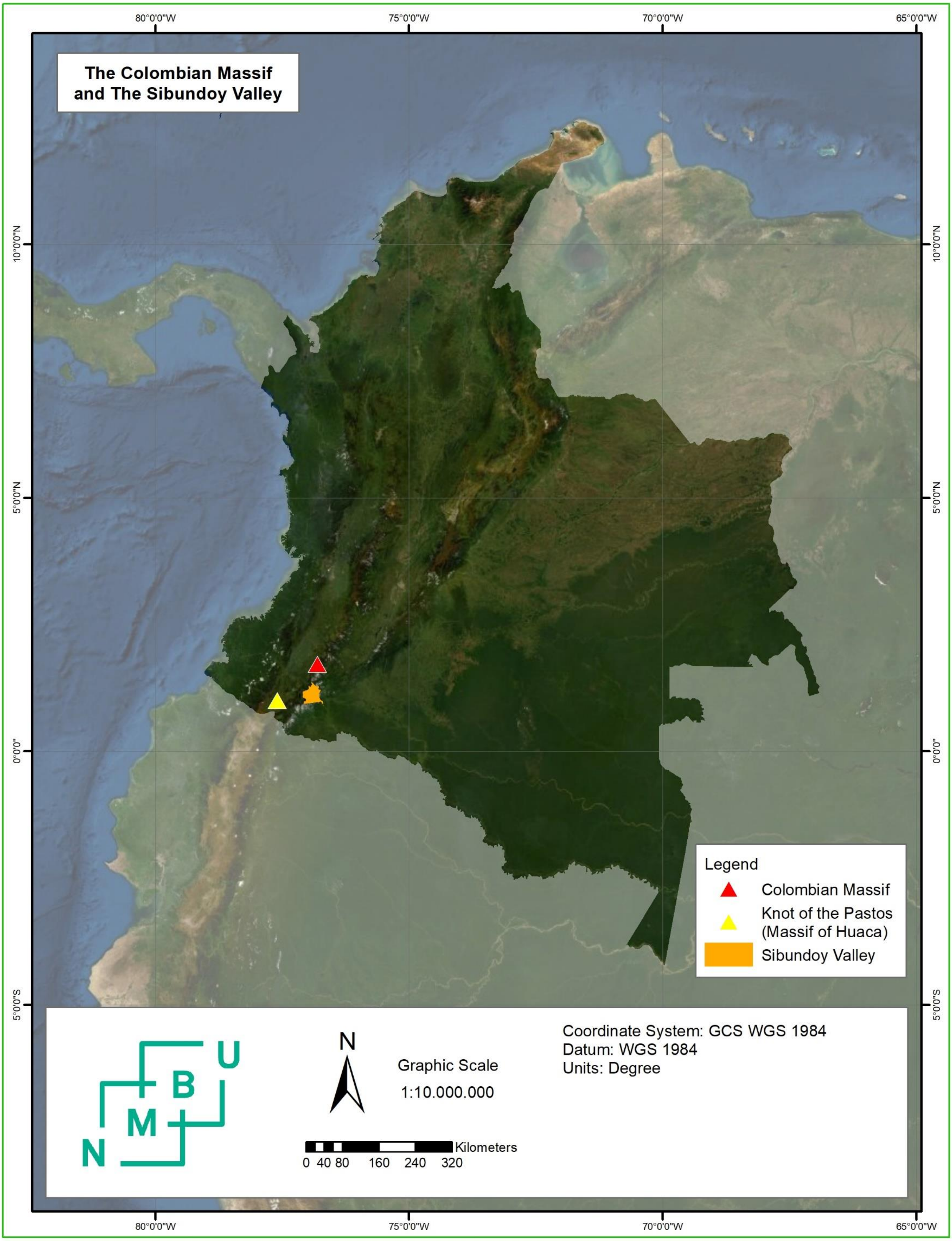
1. Describing the environmental context in which the Chagra practice is developed by the Kamentsá and Inga communities in the high Amazon region in Colombia.

To address this objective, a literature review was required to identify traditional practices and locate them within the Colombian geography.

The Colombian Massif:

The group of mountains that form the place where the Andes Range splits into the Central and Eastern Mountain Ranges of Colombia is known as the Colombian Massif. From there, water flows in all directions and five of the main Colombian river basins meet: The Magdalena and Cauca rivers flow towards the Caribbean slope, the Caquetá and Putumayo rivers are part of the great Amazon basin and the Patía river flows towards the Pacific slope. There are 38 lakes located within the labyrinth of mountains that compose the Colombian Massif and it has been catalogued as a limnological ark. (Alfredo T., 1978)

The area is identified as the source of 70% of the Colombian safe water for human consumption and irrigation and it hosts the largest freshwater reserve in equatorial areas worldwide. Due to the number of ecosystems present and the large amount of biodiversity it was designated by UNESCO as a Biosphere reserve. Finally, this ecoregion is also a referent for its multi-ethnic and pluricultural composition, as different indigenous, afro-descendent communities and mestizo farmers and cities are settled on it.



The Colombian Massif and The Sibundoy Valley

The Sibundoy Valley:

The Sibundoy Valley is situated in the southeast of Colombia, on the foothills of the Colombian Massif in the Amazon-Andes region on the north west part of the Department of Putumayo. It extends for 526 square kilometres out of which 85 are flat. The region belongs to the great Amazon basin, specifically the high basin of the Putumayo river.

Most inhabitants of the Sibundoy valley are indigenous and mixed with Spanish descendants who found their niche within the current trade system in the production and sale of medicinal plants, corn, (tumaqueño) beans, peas and milk. The place is an area of interest for traditional medicine and many guides and rituals have been exported at a global scale. Two main indigenous groups inhabit the Sibundoy Valley, the Kamentsá and the Ingas. According to the narrations of the elders, the flat part of the territory used to be an ancient lake and all the communities were settled on the northern edges of the lake. The soil studies confirm this knowledge.

The name Sibundoy was most likely given in ancient time by the ancestors of the Kamentsá people. The first written registers of the Sibundoy region start in 1535 when the Spanish captains: Hernando Cepeda, Juan Ampudia and Pedro de Añasco, reached the territory. Their accounts describe how the houses were well provided with corn and other foods. By 1935 the territory was known as “Las Casas” (the houses) but later, the capuchin monks changed the name to San Pablo de Sibundoy, in honour to the patron of the Parish of Sibundoy.

In time, the territories were Commissaries attached to the neighbouring city of Mocoa up until 1965, when the INCORA (Colombian Institute for Agrarian Reform) arrived to settle disputes of territorial property. By 1970, the territories went from being Commissaries to Intendencies. And by 1982 the territories were elevated to municipalities to increase their budget and the income received from the Nation in the form royalties.

The Sibundoy Valley is composed by four municipalities: Santiago, Colón, Sibundoy and San Francisco. Due to the short distance between the Urban centres, there are people of both ethnic groups distributed throughout the territory and in every town. The Sibundoy Valley is known for the high production of beans, corn and milk, which are exported to other towns and cities. Farmers that trade with agriculture belong to both the ethnic and the colonial mestizo communities.

The municipality of Santiago has a territory that extends 791.2km^2 with an Urban Centre of 0.4584km^2. It has over 9210 inhabitants of which 3135 are Urban (DANE, 2005). About 65% of the population are indigenous predominantly of the Inga people. In this territory the Inga governor oversees the indigenous council and the different intercultural meetings that take place. It has 26 rivers that flow towards the Quinchoa river. Agriculture is the main economic activity in the municipality with milk, beans and corn production.

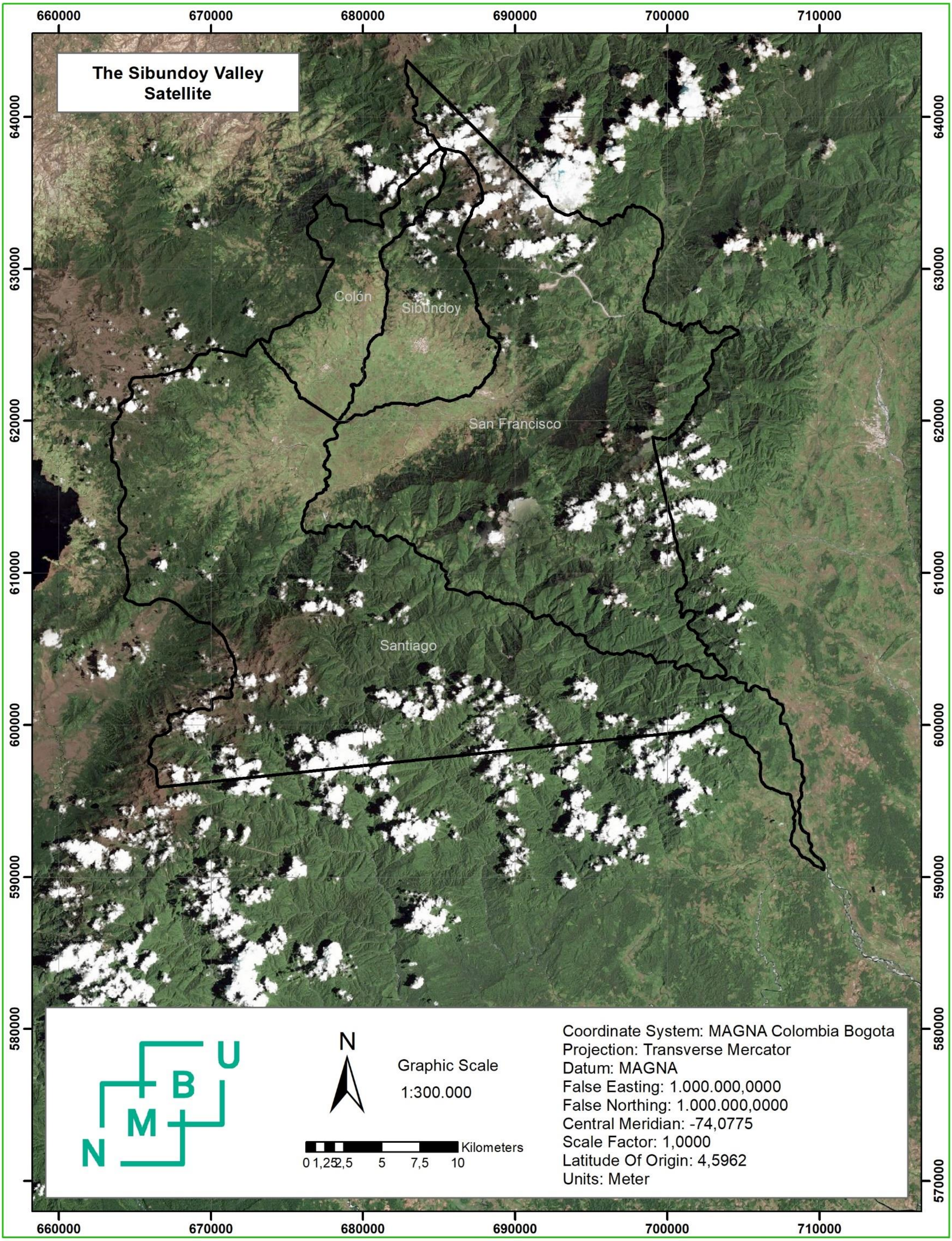
The municipality of Colón is the smallest in size and population in the Valley. It extends for 75.38km^2 with an Urban Centre of 1.21km^2. It has over 5170 inhabitants of which 2935 are Urban (DANE, 2005). About a 37% of the population are Inga people. Historically, the territory remained almost inhabited until about a century ago, when people from other regions of the country, particularly from the neighbouring department of Nariño followed by indigenous people that settled there. It has 27 rivers and streams and has gradually developed a great tourism industry due to its natural thermal waters. Agriculture is the main economic activity with milk, corn, tree tomatoes, beans, peas, apple and potatoes production.

Figure 1. View of the Municipality of Colón

The municipality of Sibundoy has an extension of 93km^2. It has about 13300 inhabitants of which 9150 are Urban (DANE, 2005). About 7% are indigenous. The municipality is a traditional Kamentsá territory. Its main urban centre is known as “the cultural capital of Putumayo” and it on its main square: “El parque de la Interculturalidad” (or Park of Interculturality), it has many references to the hallucinogenic medicinal plant Yagé, which is used in the production of the traditional drink Ayahuasca a central part in many rituals or “mingas”. It is the major commerce centre of the Valley. It has many restaurants and small hotels and in the last decade there has been an increase in tourism, many of which are foreign wanting to try the Ayahuasca with the guidance of the elders or “taitas”. Agriculture is the main economic activity with milk, beans, corn and apple production.

Figure 2. View of the Municipality of Sibundoy

The San Francisco municipality has an extension of 573.7km^2. It has more than 6810 inhabitants of which 3715 are Urban. (DANE, 2015) There are also Ingas and Kamentsá people distributed in the territory, but in smaller proportion. It is the centre for cattle activity in the region. The economy is based on trade and agriculture, being of major importance the milk and poultry, aquaculture, beans, peas and corn. There is also exploitation of timber and firewood. The region has mining activities of lime, marble, gold and brick.


The Sibundoy Valley
Satellite
Colón
Sibundoy
San Francisco
Santiago
660000
670000
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1:300.000
0 1,25 2,5 5 7,5 10
Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
Datum: MAGNA
False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter

Kamentsá:

The Kamentsá people are the original inhabitants of the Sibundoy valley. The centre of their society is the family group, which is a recurring topic in their literature.

Their economic organisation is based mainly in agriculture and in a smaller way in pastoralism. They also elaborate wooden carvings and handcrafts like bead collars. Women tend to do a similar job to nurses by helping with new-born children and healing pains with massage therapy. Their dress code is colourful with a predominance of red, green and pink. As mentioned before, they speak Spanish together with their native tongue.

The Kamentsá religion is a syncretism of traditional beliefs and Catholicism. They hold a predominant devotion for the sacred heart of Jesus and the Virgin Mary. In their belief all humans hold a spirit that comes from the Earth and people turn into seeds when they die. Their cosmovision and cultural foundation has to do with the world of plants and vegetables. The sacred Yagé (*Banispterosis caapi*) is primordial in their culture as a plant of knowledge, healing and medium to the spiritual realm, and the traditional chief and medic or “taita”, translates to “father”, has it on high regard among the other plants in his own garden. The knowledge of traditional medicine is one of their main cultural riches and is a value of trade with other indigenous communities. (Chaves M. & Vieco J.J., 1987)

Their music has spiritual meaning and is inspired by the Ayahuasca hallucinogen. It includes magic, singing, dance and theatre, which are important for every aspect of their religious practices. It has a function, a use and an intention, and for them it is not just a way of entertainment. A great deal of its importance has to do with identity as a community and keeping alive the tradition and language. The rhythm and genre are catalogued as “Andino” (Andean) and it features different instruments, many of which have been introduced by cultural exchange: It includes a variety of flutes, quena, zampoña, rondador, guitars, charango, tiple, bombo, maracas, armadillo and turtle shells and snail shells. (SINIC, 2018)

The Ingas

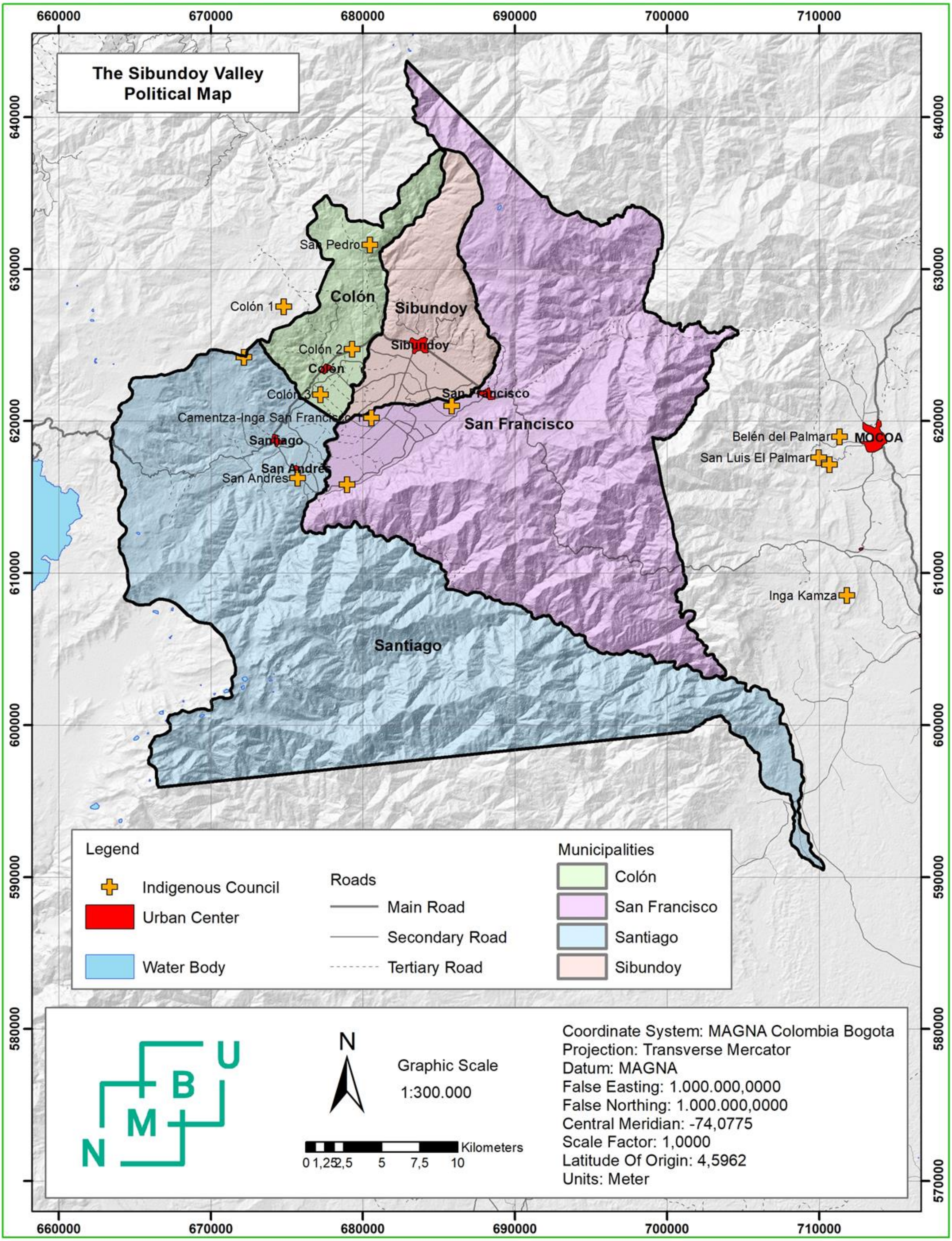
The Ingas were historically enemies of the Kamentsá people. They are descendants of the Incas, specifically Huayna Cápac (the young king), whose campaigns intended towards expanding the empire to the north. The first Ingas to settle were known as “mitimak-kuna” or military communities of farmers and merchants dedicated to trade outside of the empire and gathering of information for the Inca Empire.

For the Incas, the northern boundaries were virtually unexplored and highly unstable due to the warring nature of its inhabitants, (back then grouped as “pastos”). After crossing the territory of another group: The Cofán, they reached their upmost north in the Sibundoy Valley, where they founded a colony around the XVth century, setting the borders of the empire and with the purpose of controlling tributes. They set to dominate the Kamentsá and to confront the resistance of another group, the Kwaiker.

After the defeat of the Inca Empire on behalf of the Manco Inca Yupanqui and the Spanish Empire in 1533, the Ingas experienced an isolation period from the rest of the Quechua speaking people. The region was visited by different Spanish captains and was administrated by catholic missions from 1547. In the year 1700 they declared peace with the Kamentsá as their indigenous chief the “Cacique” Carlos Tamoabioy (now known as the “son of the thunder” in the indigenous tradition) declared, in his death bed, that their borders had been defined from ancestral times. (Chaves M. & Vieco J.J., 1987)

Their population is about 9700 people with about 6000 more distributed in other parts of the Andes mountains on the South West and in some main cities of Colombia. They are known for their high nomadism; they have the tradition of travelling afar and practice trade. Their language is Quechua, and like the Kamentsá, their economy is based on agriculture and pastoralism. They are also famous for their handcrafts and share with the Kamentsá in their traditional medicine. For the Ingas, the Yagé is also of high importance in the foundation of their cosmovision. Their dress code is characterised by the predominance of the colour purple. (Arango R. & Sanchez E., 2004)

Both groups face diverse pressure due to terrorist groups and drug traffic. Illegal organisations use the region as a corridor towards Ecuador, the Amazon and Orinoco basin, the Colombian massif and the Pacific coast. Up to date, countless indigenous leaders have been murdered for showing disapproval of illegal armed groups. (UNHCR, 2011)


The Sibundoy Valley
Political Map
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Camentza-Inga San Francisco
San Francisco
Santiago
San Andrés
San Andrés
Belén del Palmar
MOCOA
San Luis El Palmar
Inga Kamza
Santiago
Legend
Indigenous Council
Urban Center
Water Body
Roads
Main Road
Secondary Road
Tertiary Road
Municipalities
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Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
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Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter

Biophysical Variables

To reduce the number of variables any comparison between practices could only be possible in regions with similar environmental features (climate, soil). The Sibundoy Valley presents an advantage for this purpose as most agricultural activities take place in the areas nearby the urban centres (municipal heads) where soils tend to be the most fertile and the territory is predominantly flat.

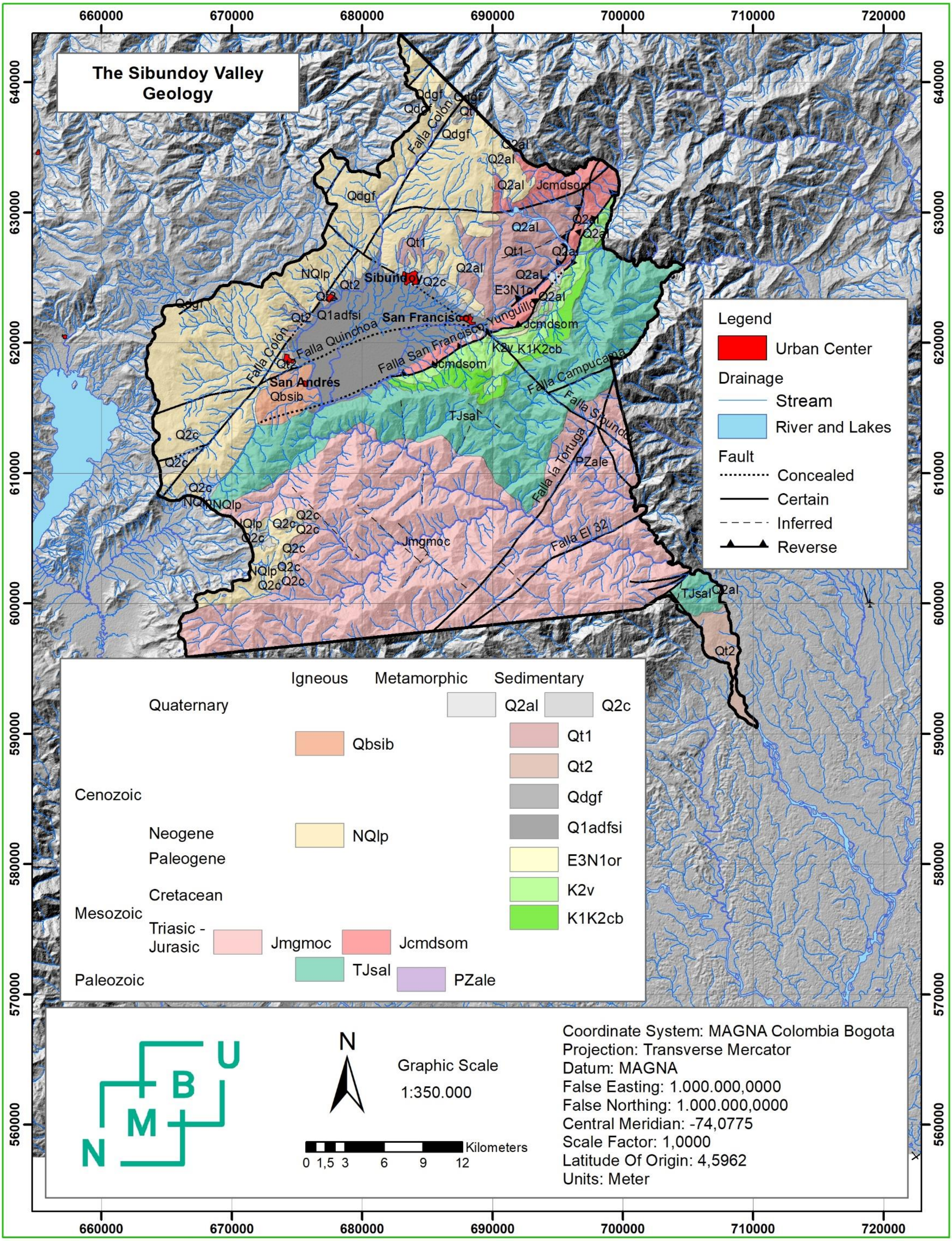
Geology and Lithology

The Sibundoy Valley is part of a very complex region at a tectonic level. It is located on notable geographic areas such as the Colombian Massif and the Knot of the Pastos, where the Andes splits into the three mountain ranges that integrate the Colombian Andean surface. (IGAC,2014)

The territory is set on a predominantly mountainous landscape. It lies on a substrate of continental sedimentary rocks that emerge on the transition region between the eastern plains and the western slope of the Andes Mountain Range, on formations of Igneous, Metamorphic and Volcanoclastic rocks.

The zone is affected by various reverse faults oriented in direction northeast southwest. Among these are the Colón fault, the Conejo fault, the Campucama fault, the Quinchoa fault, the San Francisco – Yunguillo fault and the Tortuga fault. While the El Carmen and the Sibundoy faults are oriented in a direction northwest, southeast.

The valley is rich in different deposits and minerals both metallic and non-metallic: There is Gold, Cadmium, Cobalt, Copper, Tin, Molybdenum, Titanium, Tungsten, Limestone, Diatomites, Evaporites, Gypsum, Mica and Marble. The area is also rich in Petroleum, which nowadays represents the main source of income from the nation to the region by concept of royalties.


The Sibundoy Valley Geology
Legend
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Drainage
Stream
River and Lakes
Fault
Concealed
Certain
Inferred
Reverse
Sibundoy
San Francisco
San Andrés
Falla Colón
Falla Quinchoa
Falla San Francisco - Yunguillo
Falla Campucana
Falla Sibundoy
Falla la Tortuga
Falla El 32
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Q2al
Q2c
Qt1
Qt2
Q1adfsi
Qbsib
NQlp
E3N1or
K2v
K1K2cb
Jcmdsom
Jmgmoc
TJsal
PZale
Igneous
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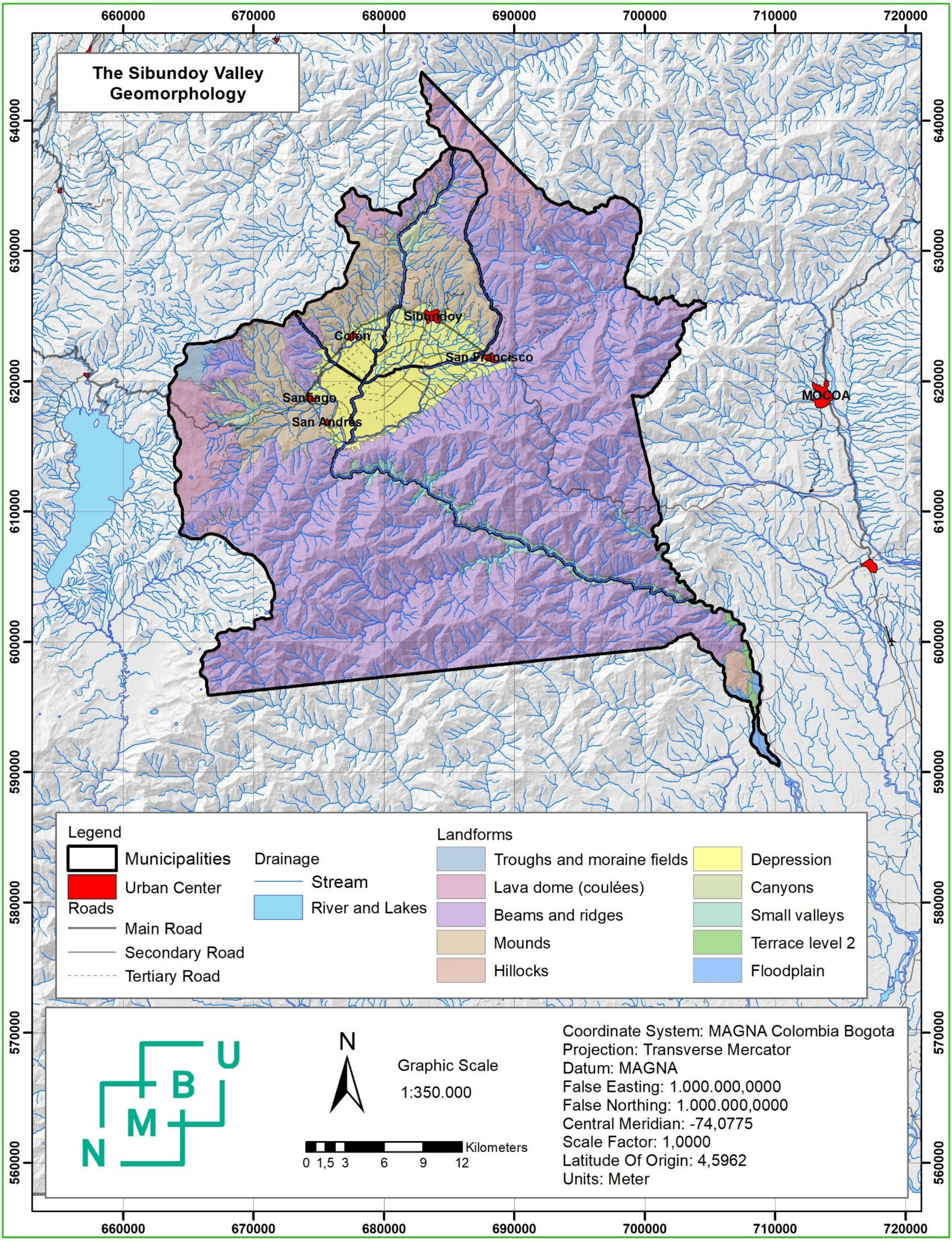
The Sibundoy Valley
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Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
Landforms
Troughs and moraine fields
Lava dome (coulées)
Beams and ridges
Mounds
Hillocks
Depression
Canyons
Small valleys
Terrace level 2
Floodplain
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Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
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False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter

Climate

Climate is an active factor in the formation of the soils and human settlements and development. It involves atmospheric conditions such as precipitation, temperature, evaporation, humidity, speed and direction of the winds, luminosity and cloud cover. Among the factors that condition the climate in the region are the Intertropical Convergence Zone (ITCZ), the effect of the interaction of the Atmosphere and the Pacific Ocean (trade winds, ENSO and the cold Humboldt current), the orography and latitudinal features which determine temporality and solar radiation. (IGAC,2014)

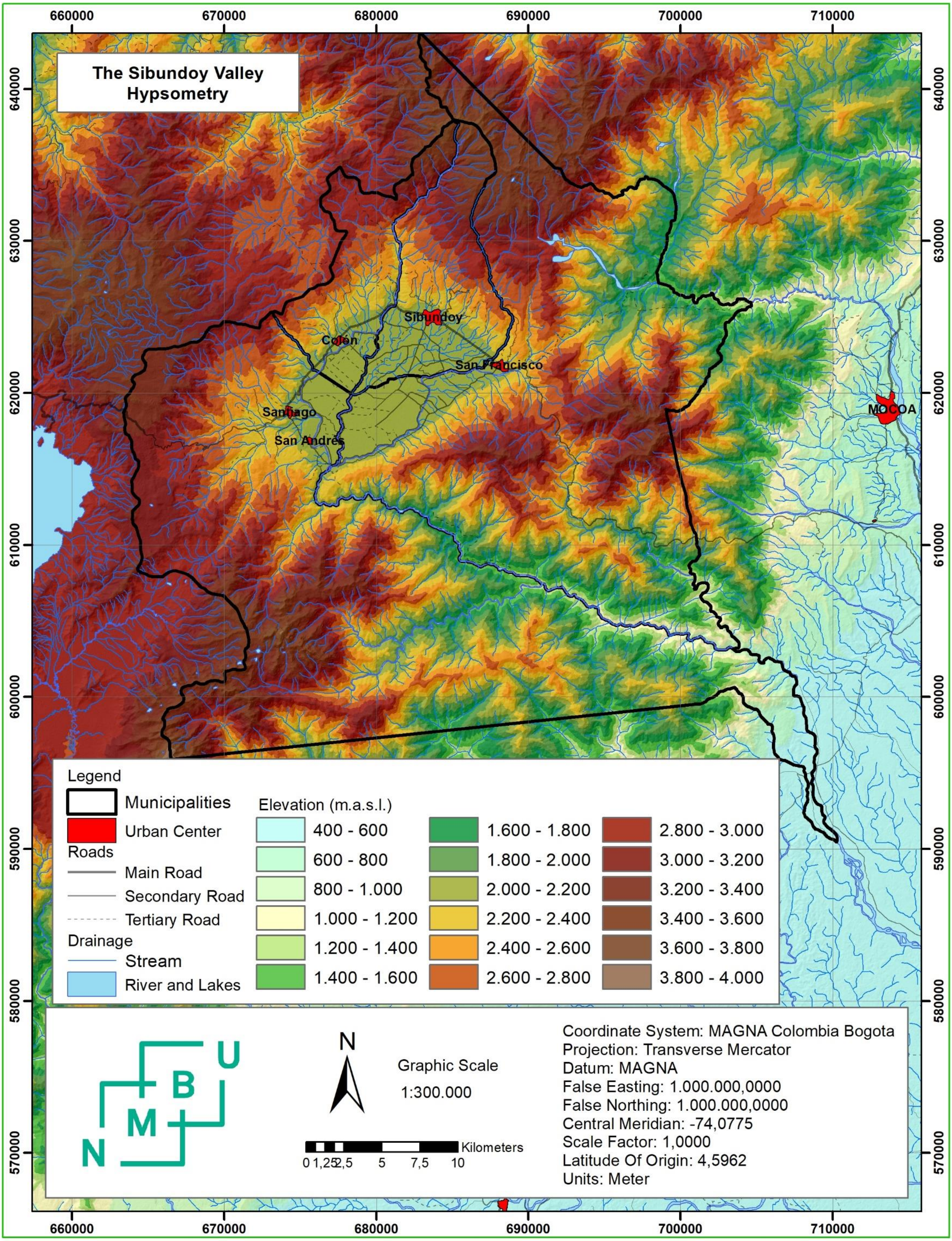
The Sibundoy Valley is characterised by a very cold and very humid regime in the mountainous parts with a warm and very humid regime in the lower parts where the Putumayo River heads towards the Eastern Amazonian Plains. The lands located above the 3600 m.a.s.l. have temperatures between 4°C and 8°C, they tend to remain covered by clouds with strong winds and low solar exposition. The lands located between the 3000 m.a.s.l. to 3600 m.a.s.l. have temperatures between 8°C to 12°C with high cloudiness, strong winds and low solar exposition. The lands between 2001 m.a.s.l. to 2000 m.a.s.l. have temperatures that oscillate between 12°C to 18°C. This is the thermic floor on which the Municipal Urban centres are located and where most agricultural activities happen. The warmer regions between 0 m.a.s.l. to 1000 m.a.s.l. and 1000 m.a.s.l. to 2000 m.a.s.l. conform a canyon shaped by the Putumayo river and a small part of the piedmont of the Andes Mountain Range. The annual temperature tends to be above 24°C and between 18°C to 24°C respectively. These regions present greaten solar exposure. (IGAC,2014)

According to the Thornwaite classification, the higher altitude parts present a Mesothermic Perhumid climate with average temperatures that range around 11,5°C and total multiannual precipitations of about 1328mm/year. The lower parts of the piedmont have average temperatures of about 25.3°C and precipitations of near 4829mm/year and are classified as Megathermic Perhumid. (CORPOAMAZONIA, 2012)

The precipitation contributions are constant throughout the year varying between 630mm/year in the driest years to 3500mm/year in the rainiest years. The precipitations present a monomodal regime in which July is the most humid month and January is the driest. The humid winds of the Amazon Rainforest form orographic clouds that cause the Valley to remain overcast throughout most of the year. The annual average of sun time is 855 hours (IDEAM, 2001). (See table 1)

Table 1. Average climatic Parameters for the high central depression of the Sibundoy Valley. (IDEAM, 2001)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Abs. Max. Temp (°C)	33.0	29.0	29.0	26.6	30.4	26.6	30.0	24.8	25.0	29.8	32.4	26.6	33.0
Med. Max Temp. (°C)	21.0	21.1	21.2	20.6	20.3	19.5	18.5	19.0	20.2	20.9	21.7	21.5	20.5
Media Temp. (°C)	15.8	15.9	16.0	15.8	15.7	15.2	14.5	14.7	15.1	15.6	16.2	15.9	15.5
Min. Media Temp. (°C)	10.2	10.6	10.6	11.3	11.5	11.1	10.3	10.0	9.9	10.0	10.7	10.5	10.6
Abs. Min. Temp (°C)	0.5	2.2	0.6	1.1	0.6	1.4	1.4	1.1	2.4	2.5	0.4	2.3	0.4
Rains (mm)	93	117	120	175	217	207	227	154	118	116	100	97	1741
Days of Rain (≥)	19	18	21	24	26	24	24	22	20	19	18	17	252
Sun Hours	92	67	62	54	67	52	57	64	71	81	103	115	885
Relative Humidity (%)	88	87	86	89	88	89	88	87	86	87	86	87	87.3


The Sibundoy Valley
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Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
Elevation (m.a.s.l.)
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Graphic Scale
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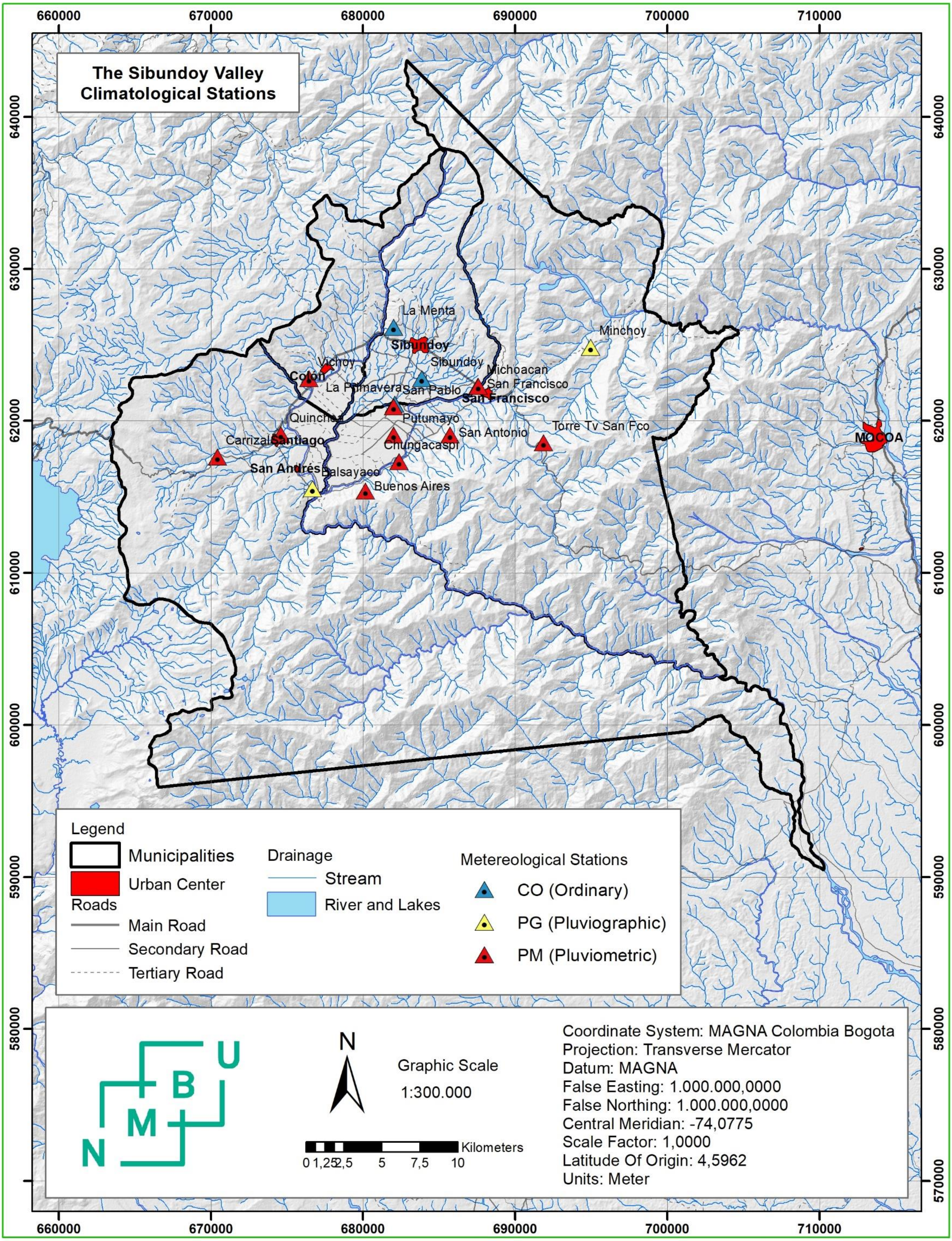
Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
Datum: MAGNA
False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter

In the next pages, the meteorological data of the Sibundoy Valley is presented. The information was obtained from the institution by the time of the study. The information was organised in tables to facilitate observation and analysis. (IDEAM, 2019)

Table 2. IDEAM Climatologic Stations in the Sibundoy Valley

CODE	CATEGORY	NAME	MUNICIPALITY	DEPARTMENT	ELEVATION	LONGITUDE	LATITUDE
47015040	CO	Michoacan	Colon	Putumayo	2118	76°53'1"W	1°10'44,1"N
47010170	PM	Vichoy	Colon	Putumayo	2119	76°59'0"W	1°11'0"N
47010050	PM	Chungacaspi	San Francisco	Putumayo	2197	76°55'48,9"W	1°8'2,6"N
44010040	PG	Minchoy	San Francisco	Putumayo	2300	76°49'1,5"W	1°12'7,6"N
47010010	PM	San Antonio	San Francisco	Putumayo	2152	76°54'0"W	1°9'0"N
47010090	PM	San Francisco	San Francisco	Putumayo	2844	76°53'0,2"W	1°10'44,2"N
47010180	PM	Torre Tv San Fco	San Francisco	Putumayo	2844	76°50'42"W	1°8'43,5"N
47010020	PG	Balsayaco	Santiago	Putumayo	2148	76°58'52,6"W	1°7'4,4"N
47010150	PM	Carrizal	Santiago	Putumayo	2495	77°2'14,3"W	1°8'12,3"N
47010080	PM	Quinchoa	Santiago	Putumayo	2117	77°0'0"W	1°9'0"N
47010060	PM	Buenos Aires	Sibundoy	Putumayo	2165	76°57'0"W	1°7'0"N
47015090	CO	La Primavera	Sibundoy	Putumayo	2093	76°55'57,7"W	1°10'5,9"N
47010070	PM	Putumayo	Sibundoy	Putumayo	2070	76°56'0"W	1°9'0"N
47010100	PM	San Pablo	Sibundoy	Putumayo	2159	76°56'0"W	1°10'0"N
47015010	CO	La Menta	Sibundoy	Putumayo	2067	76°56'0"W	1°11'0"N
47015030	CO	Sibundoy	Sibundoy	Putumayo	2100	76°55'0"W	1°11'0"N

The meteorological data available for the climatologic stations in the Sibundoy Valley is presented in the next set of tables. The information was organised to facilitate observation and analysis. (IDEAM, 2019)


The Sibundoy Valley
Climatological Stations
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La Menta
Minchoy
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Vichoy
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Michoacan
San Francisco
Quinchoa
Putumayo
Carrizal
Santiago
San Antonio
Torre Tv San Fco
Chungacaspi
MOCOA
San Andrés
Balsayaco
Buenos Aires
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Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
Metereological Stations
CO (Ordinary)
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False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter

Table 3. Precipitation (mm) per station

			PRECIPITATION (mm)												
NAME	MUNICIPALITY	ELEV	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC	ANNUAL
Michoacan	Colon	2118	107,7	125,6	134,8	180,1	208,4	209,2	210,8	143,7	111,4	95,7	102,9	119,3	1749,6
Vichoy	Colon	2119	107,6	105,4	116,6	172,9	223,0	241,3	240,7	169,4	110,9	119,7	111,4	99,8	1818,7
Chungacaspi	San Francisco	2197	103,5	118,7	142,3	190,3	268,9	349,9	471,8	295,5	198,0	129,6	116,3	107,8	2492,6
Minchoy	San Francisco	2300	184,0	202,0	186,9	259,4	339,2	336,0	364,5	280,5	230,8	159,2	171,4	160,3	2874,2
San Antonio	San Francisco	2152	93,5	106,0	137,9	173,2	256,6	222,1	219,8	179,8	138,2	126,4	116,0	101,0	1870,5
San Francisco	San Francisco	2844	159,5	191,2	231,2	258,6	277,0	390,2	420,0	288,2	246,4	154,9	153,1	157,1	2927,4
Torre Tv San Fco	San Francisco	2844	208,6	241,0	280,0	387,0	528,6	629,2	779,8	504,7	314,9	254,5	212,1	209,5	4549,9
Balsayaco	Santiago	2148	106,0	118,1	135,4	156,0	205,9	239,2	252,6	202,0	147,4	121,4	112,6	106,1	1902,7
Carrizal	Santiago	2495	175,0	171,8	190,8	250,7	300,8	311,8	302,3	230,9	170,6	148,9	164,6	147,0	2565,2
Quinchoa	Santiago	2117	99,9	114,3	137,9	159,1	181,9	179,5	190,7	124,3	102,1	105,9	103,1	83,0	1581,7
Buenos Aires	Sibundoy	2165	158,0	144,9	169,4	190,8	230,9	242,8	266,4	174,9	165,8	146,5	156,3	137,7	2184,4
La Primavera	Sibundoy	2093	93,2	117,0	119,8	174,6	216,5	207,3	227,2	153,7	118,0	115,9	99,9	97,1	1740,1
Putumayo	Sibundoy	2070	76,9	77,4	121,3	146,4	191,6	179,5	191,7	153,9	121,7	102,2	83,3	82,1	1528,0
San Pablo	Sibundoy	2159	47,2	71,0	78,8	126,0	138,2	151,9	165,0	117,7	80,5	73,7	77,2	84,1	1211,2
Sibundoy	Sibundoy	2100	99,7	95,3	121,3	156,4	190,5	182,4	192,7	136,3	120,2	120,7	119,0	101,9	1636,3

Table 4. Number of days with rain per station

			NUMBER OF DAYS WITH RAIN												
NAME	MUNICIPALITY	ELEV	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC	ANNUAL
Michoacan	Colon	2118	19	19	22	24	26	26	26	24	22	20	19	20	267
Vichoy	Colon	2119	17	16	18	21	23	24	25	22	18	17	16	16	233
Chungacaspi	San Francisco	2197	22	20	23	27	28	28	29	28	26	24	22	22	298
Minchoy	San Francisco	2300	22	21	22	24	26	26	27	25	24	22	23	23	287
San Antonio	San Francisco	2152	17	15	20	21	25	24	25	23	20	17	17	17	242
San Francisco	San Francisco	2844	12	13	15	17	19	21	21	18	15	12	11	12	186
Torre Tv San Fco	San Francisco	2844	23	21	24	27	29	29	29	28	25	25	22	24	306
Balsayaco	Santiago	2148	18	18	20	22	24	24	25	24	22	19	18	20	256
Carrizal	Santiago	2495	19	19	21	23	25	25	25	24	21	19	18	17	257
Quinchoa	Santiago	2117	14	15	17	20	20	21	22	17	17	15	12	12	201
Buenos Aires	Sibundoy	2165	15	14	16	18	21	20	22	19	17	15	15	16	208
La Primavera	Sibundoy	2093	19	18	21	24	26	24	24	22	20	19	18	17	252
Putumayo	Sibundoy	2070	16	15	19	20	22	23	23	23	21	19	18	17	237
San Pablo	Sibundoy	2159	11	12	13	16	18	18	19	16	14	12	11	12	172
Sibundoy	Sibundoy	2100	20	19	23	25	26	25	27	24	24	22	21	20	276

Table 5. Maximum year of occurrence (mm/year)

		MAX PRECIPITATION IN 2 4 HOURS / YEAR OF OCCURRENCE (mm /year)											
NAME	MUNICIPALITY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC
Michoacan	Colon	95,8 /1989	95,4 /1989	90,5 /1989	95,5 /1989	64 /2000	95,2 /1989	79 /1976	38,4 /1981	36,6 /1989	49,3 /1987	46 /1987	90,9 /1988
Sibundoy	Sibundoy	90,1 /1985	38,7 /1987	45,2 /1982	55,7 /1978	89,4 /1982	67,1 /1972	72,6 /1971	36,5 /1981	41 /1972	62,9 /1980	40,8 /1989	76,2 /1984
La Primavera	Sibundoy	35,7 /1993	33,9 /1993	47,7 /1993	53,6 /1984	66,1 /1988	76,3 /1988	70,8 /1986	47,3 /1988	38,1 /1988	65,8 /1987	43,7 /1988	31,1 /1998

Table 6. Mean temperature in Celsius degrees

			MEAN TEMPERATURE (°C)												
NAME	MUNICIPALITY	ELEV	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC	ANNUAL
Michoacan	Colon	2118	16,1	15,9	15,9	15,8	15,6	15,1	14,6	14,7	15,1	15,7	16,1	16,0	15,5
La Menta	Sibundoy	2067	15,7	15,8	15,9	16,0	15,6	15,0	14,4	14,7	15,1	15,9	16,1	15,9	15,5
La Primavera	Sibundoy	2093	15,8	15,9	16,0	15,8	15,7	15,2	14,5	14,7	15,1	15,6	16,2	15,9	15,5
Sibundoy	Sibundoy	2100	16,1	16,0	16,0	16,0	15,9	15,2	14,5	14,8	15,2	15,8	16,2	16,1	15,7

Table 7. Maximum mean temperature in Celsius degrees

			MAX MEAN TEMPERATURE(°C)												
NAME	MUNICIPALITY	ELEV	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC	ANNUAL
Michoacan	Colon	2118	21,7	21,6	21,3	21,3	20,7	20,4	19,4	19,8	20,1	20,9	21,7	21,4	20,8
La Menta	Sibundoy	2067	21,0	21,3	21,0	21,3	20,6	19,2	18,4	18,6	20,1	21,6	22,1	21,5	20,5
La Primavera	Sibundoy	2093	21,0	21,1	21,2	20,6	20,3	19,5	18,5	19,0	20,2	20,9	21,7	21,5	20,5
Sibundoy	Sibundoy	2100	20,9	20,8	21,0	20,8	20,4	19,4	18,6	18,7	19,7	20,9	21,3	21,1	20,3

Table 8. Minimum mean temperature in Celsius degrees

			MIN MEAN TEMPERATURE (°C)												
NAME	MUNICIPALITY	ELEV	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC	ANNUAL
Michoacan	Colon	2118	10,8	10,9	11,1	11,3	11,3	12,1	10,6	10,3	10,4	10,6	11,0	11,0	11,0
La Menta	Sibundoy	2067	9,9	10,1	10,4	10,8	11,3	11,0	10,7	10,1	10,2	10,4	10,0	9,8	10,4
La Primavera	Sibundoy	2093	10,2	10,6	10,6	11,3	11,5	11,1	10,3	10,0	9,9	10,0	10,7	10,5	10,5
Sibundoy	Sibundoy	2100	10,2	10,4	10,4	10,5	10,7	10,2	9,7	9,4	9,5	10,2	10,2	10,2	10,1

Table 9. Hours of sunshine per day

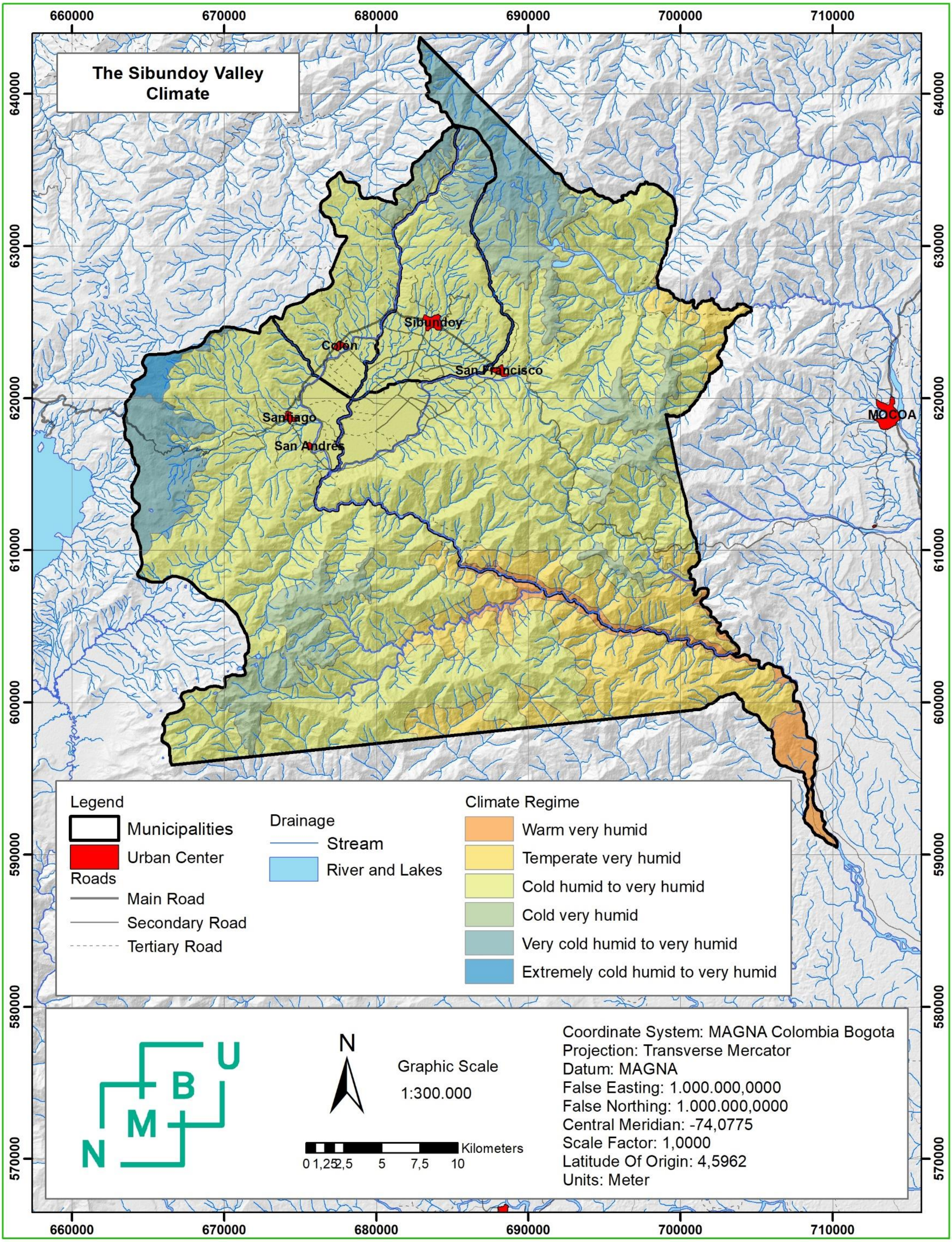
		SUNSHINE(Hours/day)												
NAME	MUNICIPALITY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC	ANNUAL
Michoacan	Colon	3,2	2,5	2,0	1,8	1,8	1,2	1,1	1,7	2,0	2,6	3,3	3,3	2,2
La Menta	Sibundoy	3,0	2,7	2,2	2,2	1,8	1,7	1,5	1,6	2,0	3,0	3,0	3,1	2,3
La Primavera	Sibundoy	3,0	2,3	2,0	1,8	2,2	1,7	1,8	2,1	2,4	2,6	3,4	3,7	2,4
Sibundoy	Sibundoy	3,7	2,7	2,6	2,4	2,6	2,0	2,0	2,1	2,4	3,3	3,5	3,5	2,7

Table 10. Relative humidity (%)

		RELATIVE HUMIDITY (%)												
NAME	MUNICIPALITY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC	ANNUAL
Michoacan	Colon	85	85	86	87	88	88	88	87	86	85	85	85	86
La Menta	Sibundoy	87	86	88	87	88	89	88	88	87	85	85	86	87
La Primavera	Sibundoy	88	87	86	89	88	89	88	87	86	87	86	87	87
Sibundoy	Sibundoy	84	84	84	85	86	86	86	86	85	83	83	84	85

Table 11. Evaporation (mm)

		EVAPORATION (mm)												
NAME	MUNICIPALITY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC	ANNUAL
Michoacan	Colon	81,2	69,4	68,0	63,8	55,8	49,5	42,5	51,4	61,1	75,2	83,2	73,3	774,2
La Menta	Sibundoy	72,2	65,7	73,8	64,6	68,2	61,6	61,6	61,1	68,8	84,0	86,6	79,6	847,6
Sibundoy	Sibundoy	85,0	74,8	76,4	67,3	66,0	57,4	54,8	55,3	65,5	82,2	87,9	82,0	854,6


The Sibundoy Valley
Climate
Sibundoy
Colon
San Francisco
Santiago
San Andres
MOCOA
Legend
Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
Climate Regime
Warm very humid
Temperate very humid
Cold humid to very humid
Cold very humid
Very cold humid to very humid
Extremely cold humid to very humid
NMBU
N
Graphic Scale
1:300.000
Kilometers
0 1,25 2,5 5 7,5 10
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
Datum: MAGNA
False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter
660000
670000
680000
690000
700000
710000
640000
630000
620000
610000
600000
590000
580000
570000

Hydrology

In general terms, the prevailing drainage pattern is dendritic with high density of drainages. The rivers tend to dissect canyons with high slopes. The piedmont has many alluvial fans with braided drainage patterns.

Figure 3. View of Quebrada Lavapies, north west of Sibundoy urban centre

The San Pedro river is an important river born in the highlands of the Municipalities of Colon and Sibundoy; it crosses the main inhabited fan region of the valley together with the Hidraulica River until they discharge into the Putumayo River. The Putumayo River is the main river in the valley. It is born on the high lands of the municipality of San Francisco and dissects the mountain towards the South-East as it flows towards the Amazon River.

Figure 4. View of San Pedro River on the central depression of the Sibundoy Valley

Due to the sedimentary nature of the Eastern slope of the Andes, the Putumayo River is characterised by “white waters” with a high content of electrolytes and a significant charge of particles in suspension from erosive processes in the mountain range. These differ with the “black waters” rivers born in the eastern plains of the Amazon, which have a low electrolytic content and a owe their black colour to the high content of humic substances. (CORPOAMAZONIA, 2012)

In the next pages, the hydrological data of the Sibundoy Valley is presented. The information was obtained from the institution by the time of the study. The information was organised in tables to facilitate observation and analysis. (IDEAM, 2019)

Figure 5. View of Quebrada Hidraulica

Table 12. IDEAM Limnologic Stations in the Sibundoy Valley

CODE	CATEGORY	NAME	MUNICIPALITY	DEPARTMENT	ELEVATION	LONGITUDE	LATITUDE
47017070	LM	El Eden	Santiago	Putumayo	2087	76°56'0"W	1°6'0"N
47017100	LM	Canal B	Santiago	Putumayo	2065	76°58'0"W	1°6'0"N
47017080	LM	Balsayaco-La Maria	Santiago	Putumayo	2065	76°58'0"W	1°7'0"N
47017140	LM	Pte Canal D	Colón	Putumayo	2123	76°57'0"W	1°11'0"N
47017050	LM	Sibundoy	San Francisco	Putumayo	2113	76°53'0"W	1°12'0"N

The data available for the limnologic stations in the Sibundoy Valley is presented in the next set of tables. The information was organised to facilitate observation and analysis. (IDEAM, 2019)

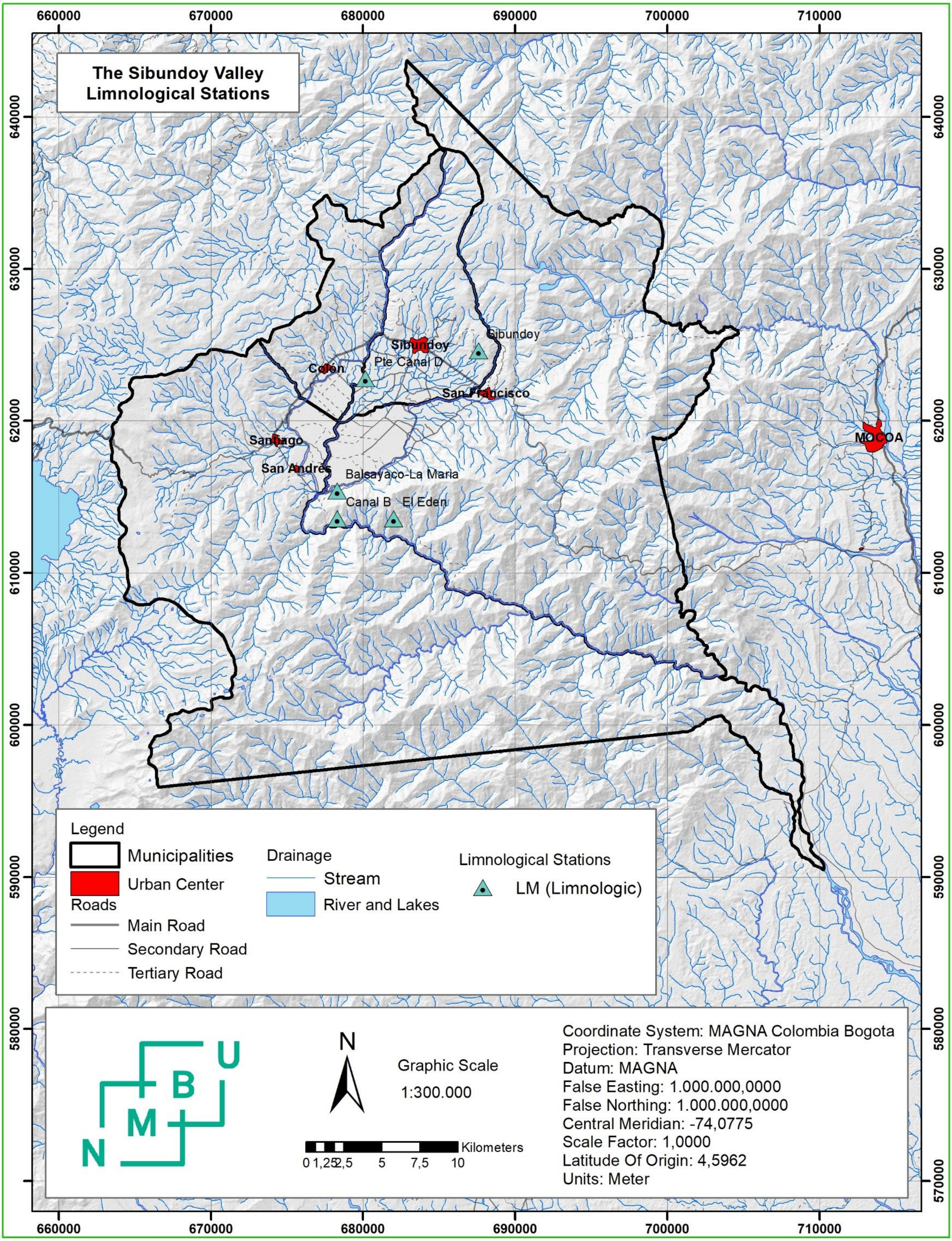

The Sibundoy Valley
Limnological Stations
660000
670000
680000
690000
700000
710000
640000
630000
620000
610000
600000
590000
580000
570000
Sibundoy
Colón
Pte Canal D
San Francisco
Santiago
San Andrés
Balsayaco-La Maria
Canal B
El Eden
MOCOA
Legend
Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
Limnological Stations
LM (Limnologic)
N
Graphic Scale
1:300.000
0 1,25 2,5 5 7,5 10
Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
Datum: MAGNA
False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter

Table 13. Median flow values (m3/se)

		MEDIAN FLOW VALUES (m^3/sec)												
NAME	STREAM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
El Eden	Putumayo	19,21	20,00	21,74	27,50	34,44	45,96	54,04	40,11	30,19	23,74	20,02	19,13	29,67
Canal B	Quinchoa	7,93	9,04	9,84	12,6	15,4	20,4	22,1	16,1	11,55	8,88	8,07	7,93	12,48
Balsayaco-La Maria	Putumayo	9,2	9,67	11,6	14,7	19	28,1	32,2	25,4	18,17	13,1	10,5	10	16,82
Pte Canal D	San Pedro	2,47	2,95	2,9	3,66	4,28	5,27	6,41	4,72	3,468	2,86	2,77	2,63	3,7
Sibundoy	San Pedro	3,13	3,06	3,99	4,56	5,25	7,81	9,8	7,69	5,641	3,56	3,23	2,99	5,06

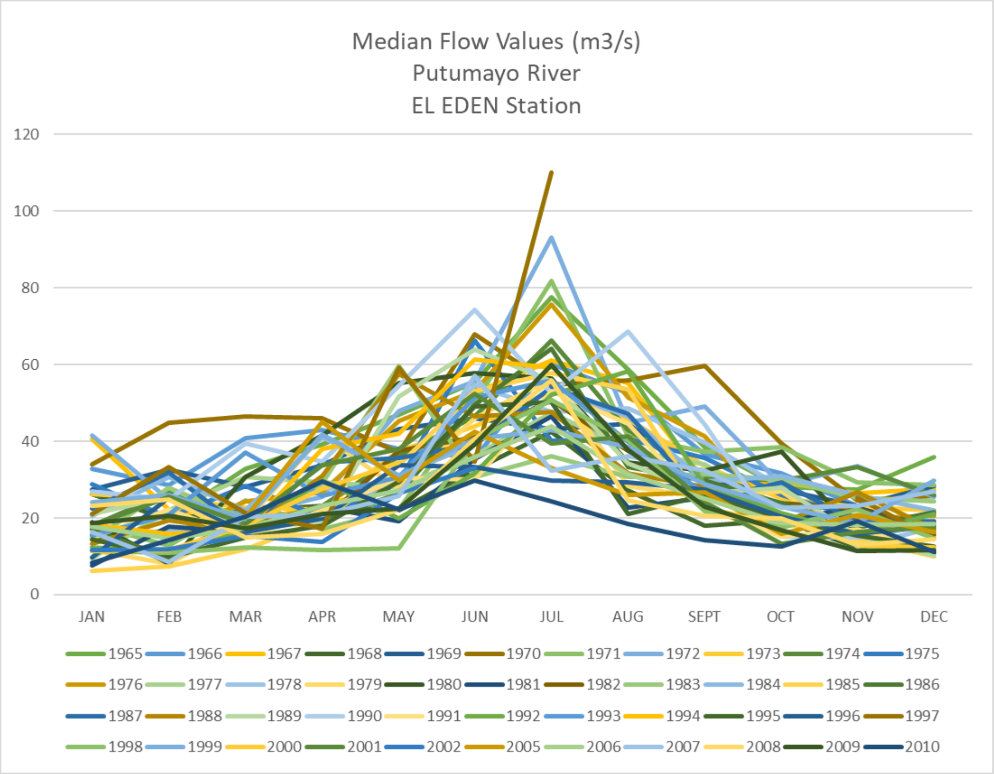
Table 14. Maximum flow values (m3/se)

		MAX FLOW VALUES (m^3/sec)												
NAME	STREAM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
El Eden	Putumayo	41,65	44,80	46,50	46,10	59,61	74,30	110,20	68,60	59,70	39,40	33,61	35,90	110,20
Canal B	Quinchoa	13,5	17,9	22,9	26,9	28,1	41,5	32,2	24,1	17,4	15,2	12,6	13	41,54
Balsayaco-La Maria	Putumayo	30,1	33,1	34,4	34,3	43,6	66,7	98,2	53,5	46,69	29,8	30	25,5	98,17
Pte Canal D	San Pedro	4,42	7,62	7,54	7,74	7,36	9,24	11,7	8,21	7,63	5,75	4,6	5,31	11,68
Sibundoy	San Pedro	6,94	6,84	7,39	10,1	7,64	14,5	27,9	32,1	16,94	5,05	6,83	5,65	32,07

Table 15. Maximum flow values (m3/se)

		MIN FLOW VALUES (m^3/sec)												
NAME	STREAM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
El Eden	Putumayo	6,31	7,33	11,92	11,70	12,10	29,72	24,43	18,40	14,34	12,60	11,44	9,99	6,31
Canal B	Quinchoa	1,85	1,69	4,53	7,01	6,69	8,94	11,6	4,73	5,078	4,12	3,26	3,03	1,69
Balsayaco-La Maria	Putumayo	1,36	1,07	1,9	2,52	3,39	4,78	4,17	3,06	3,1	1,31	1,7	0,76	0,76
Pte Canal D	San Pedro	1,26	0,96	1,48	1,79	2,09	2,83	2,58	1,8	1,382	0,6	0,9	0,79	0,6
Sibundoy	San Pedro	1,22	1,19	1,11	1,94	2,71	4,4	5,54	2,73	2,262	2,12	1,15	0,48	0,48

Next are some visualisations made using the flow data. It is unfortunate to find that none of the stations remain open by the time of the study.


Median Flow Values (m3/s)
Putumayo River
EL EDEN Station
0
20
40
60
80
100
120
JAN
FEB
MAR
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MAY
JUN
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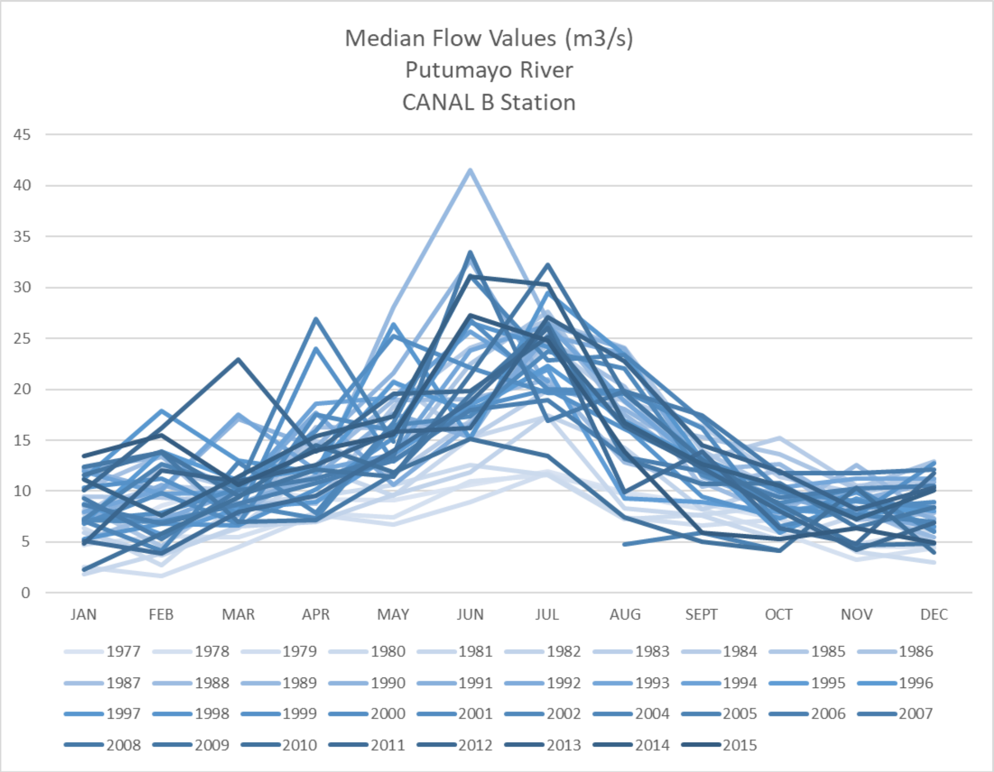
Median Flow Values (m3/s)
Putumayo River
CANAL B Station
0
5
10
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JAN
FEB
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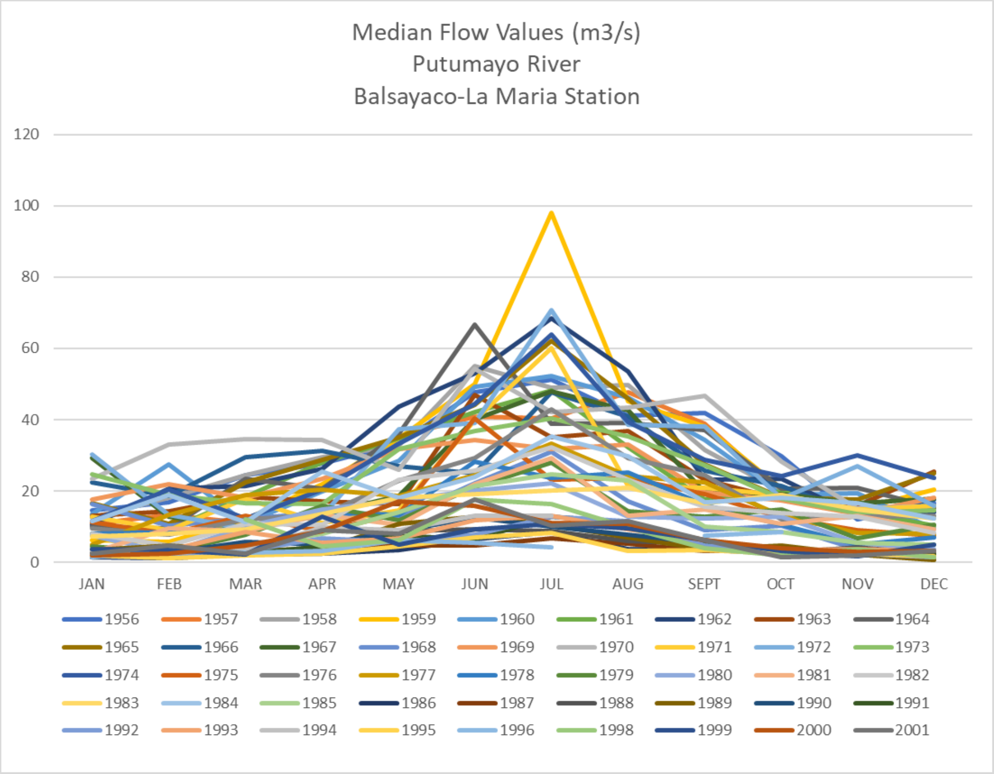
2014
2015


Median Flow Values (m3/s)
Putumayo River
Balsayaco-La Maria Station
120
100
80
60
40
20
0
JAN
FEB
MAR
APR
MAY
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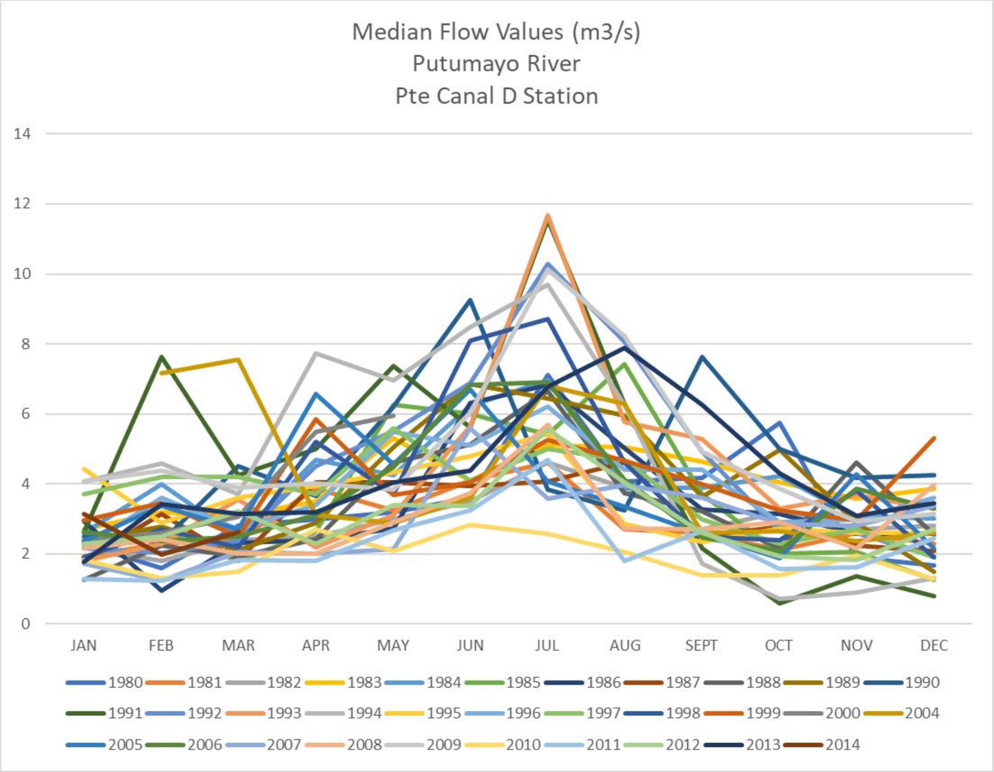
Median Flow Values (m3/s)
Putumayo River
Pte Canal D Station
14
12
10
8
6
4
2
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
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1981
1982
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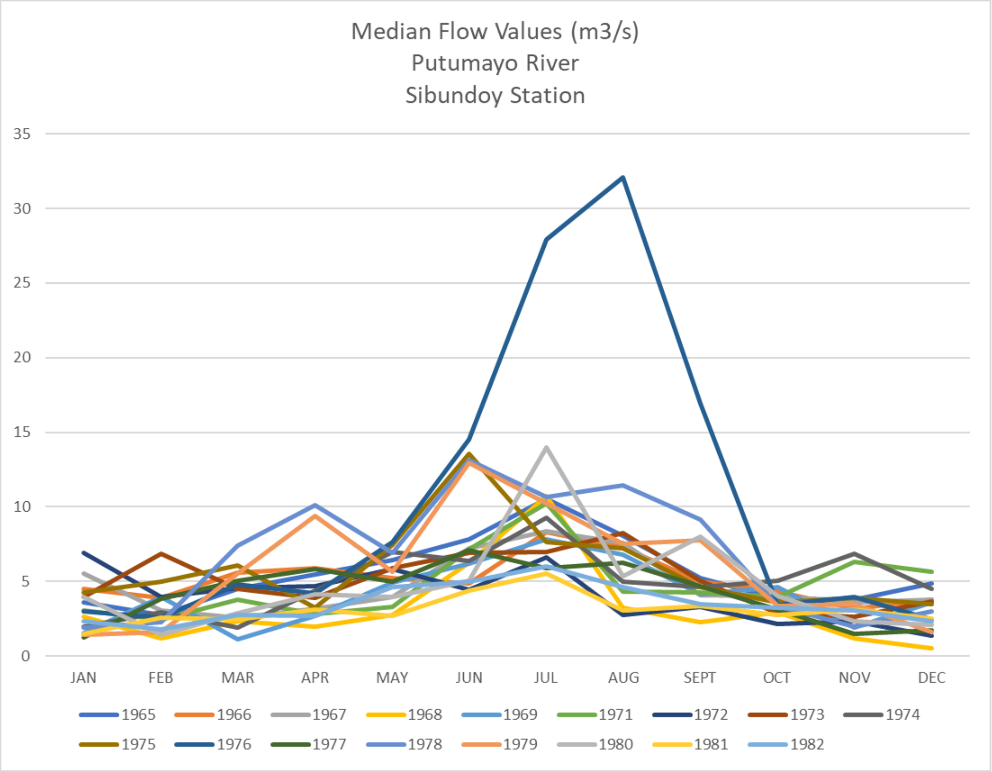
2010
2011
2012
2013
2014



Soils

The Sibundoy Valley presents a high diversity of soils that are often characterized by steep slopes and a high content of volcanic ashes. These tend to have high aluminium saturation, high acidity and low fertility. Nonetheless there is a flat area in the centre of the basin where all the municipal heads are located. This area conforms a depression that was formed by alluvial and lacustrine deposits in this landform most agricultural activities take place and the most fertile soils are found. (IGAC,2014)

For the interest of the study, the soils where agriculture takes place are described in detail. Both conventional and traditional agriculture useful for comparisons in the study take place in mountain soil areas with cold humid climate. These soils elevation ranges between 2000 to 2200 m.a.s.l. have an average temperature of about 15°C and annual precipitations close to 1750mm.

The soils in this region are originated from deposited organic materials, volcanic ashes and deposited igneous, sedimentary and metamorphic materials. In this agrogenic environment are units identified in the Soils Map with the codes MLA, MLB, MLC and MLI.

The different types of soils are set on different landforms with different slopes. The Slopes map is obtained from the radar topographic imagery digital elevation model available at Alaska Satellite Facility. (ASF, 2019)

Table 16. Types of slopes

SLOPE	PERCENTAGE	CODE
Flat to slightly flat	0 - 3	a
Slightly inclined	3 - 7	b
Moderately inclined	7 - 12	c
Strongly inclined	12 - 25	d
Slightly steep	25 - 50	e
Moderately steep	50 - 75	f
Strongly steep	>75	g

The soils coded **MLAa** are soils classified as Association: Hydric Haplofibrists; Fibric Haplohemists; Terric Haplofibrists. An association is defined a as a unit integrated by various dominant soils which never account for more than 25% of the unit. (IGAC,2014)

The soils allocated in the lowest part of the depression are classified as Hydric Haplofibrists. These have been developed from organic materials and are very poorly drained, these tend to flood for long periods of time. They tend to be strongly acid, with high cation exchange capacity, high carbon content, medium basic solution content, high aluminium saturation and low fertility. (IGAC,2014)

The main constrains for the use of these soils are flooding, poor drainage system, superficial water table and incipient decomposition of organic materials. (IGAC,2014)

Those soils allocated in the edges of the depression are classified as Fibric Haplohemists. These soils result from the deposition of organic materials. These tend to be shallow, constrained by the water table and poor drainage. They tend to be very acid, with high cation exchange capacity, high organic carbon content, high bases content, low aluminium saturation and low fertility. The main

constrains for use are the poor drainage, high water table and long-lasting flooding.
(IGAC,2014)

The soils allocated in areas that contact the terraces are classified as Terric Haplofibrists and have evolved from mineral and organic materials. They are superficial, constrained by the water basin, poorly drained and easily flooded. (IGAC,2014)

They tend to be strongly acid, with high cation exchange capacity, high organic carbon content, high content of bases, low base saturation and low to medium aluminium saturation. The main constraints for use are the medium lasting floods, poor drainage, superficial water table and little decomposition of the organic materials. (IGAC,2014)

The Association presents inclusions of Andic Eutrudepts soils, which are allocated in the banks of the rivers. These have been formed from alluvial sediments covered by thin layers of volcanic ashes; they are deep, well drained and present a medium to high fertility. (IGAC,2014)

They are acid, with high cation exchange capacity, high organic carbon content, high content of bases, high bases saturation and low aluminium saturation. The main constraint for use is the low content of phosphorous. (IGAC,2014)

The soils coded **MLBa** are classified as Association: Typic Udifluvents; Typic Fluvaquents; Hydric Haplohemists. (IGAC,2014)

These soils are mostly dedicated to grassland and cattle activities with few small areas dedicated to vegetable crops. The soils allocated in the terrace sectors are classified as Typic Udifluvents. These have been developed from fluvial lacustrine deposits. They tend to be deep, well drained and present a medium fertility. (IGAC,2014)

They are strongly acid, with medium cation exchange capacity, high organic carbon content, medium base saturation, low aluminium saturation. The main constraint for these soils is the low phosphorous content. (IGAC,2014)

The soils allocated on the edges of the lower parts are classified as Typic Fluvaquents. These have evolved from fluvial lacustrine deposits, are shallow, limited by the water table, thick texture and medium fertility. (IGAC,2014)

These soils present a medium strong acid reaction, a high cation exchange capacity, high bases saturation, low aluminium saturation and good water retention. The main constrains for use are the little depth, high water table and being poorly drained. (IGAC,2014)

The soils located in the low parts of the terrace are classified as Hydric Haplohemists. These have evolved from organic materials, are very superficial and constrained by the water table. They are very poorly drained, tend to flood and have a high organic content. (IGAC,2014)

They are strongly acid, with high cationic exchange capacity, high organic content. Low bases saturation, high aluminium saturation, high water retention and a high tendency to prolonged flooding. The main constrains for use of these soils are the little depth, high water table, poor drainage, prolonged flooding and low capacity for mechanic support. (IGAC,2014)

The soils coded **MLCa** and **MLCb** are classified as Association: Typic Udorthents; Typic Udifluvents; Andic Dystrudepts. (IGAC,2014)

These soils occupy the depression in the mountain and display a flat to slightly corrugated shape with slopes that range from 0 to 7%. These soils are formed from alluvial sediments. They are well drained, extremely acids with low bases saturation. Their chemical fertility is low. These soils are mostly used for grasslands for semi-intensive cattle production. There are also some small territories being used for vegetable and corn production. (IGAC,2014)

The soils allocated on the top part of the depression are classified as Typic Udorthents. They are formed from alluvial sediments, are shallow, limited by rock fragments. Well drained with thick textures. (IGAC,2014)

They are extremely acid with medium cationic exchange capacity. They have low organic carbon and low bases content and saturation. They have high aluminium saturation. They have low water retention. The main constraints for use are the little depth and the great amount of stones. (IGAC,2014)

The soils allocated on the middle part of the depression are classified as Typic Udifluvents. These soils are superficial with large stone fragments of different sizes. They have low fertility. (IGAC,2014)

These soils are strongly acid with high cationic exchange capacity. They present high organic carbon on the surface, low bases content and low bases saturation. The aluminium saturation is low. The main constraints for use are the low effective depth, low water retention and low fertility. (IGAC,2014)

The soils allocated on the middle part of the depression are classified as Andic Dystrudepts. These are developed from volcanic ashes. They are deep, well drained, with moderately thick textures and low fertility. (IGAC,2014)

They tend to be medium acid, high cationic exchange capacity, high organic carbon. Low bases content and low bases saturation. They have low fertility. The main constraints for use are the low availability of nutrients and the low retention of phosphates. (IGAC,2014)

The Association presents inclusions of soils classified as Fluvaquentic Enduaquepts. These are allocated in the lower parts of the depression. They have developed from alluvial sediments. They are superficial, limited by water table. Poorly drained with low fertility. (IGAC,2014)

They are strongly acid, with high cationic exchange capacity, high carbon content, medium bases content, with low bases saturation. The main constraints for use are low effective depth, poor drainage, high water table and low fertility. (IGAC,2014)

The soils coded as **MLIc**, **MLId** and **MLIe** are classified as Association Eutric Hapludands; Acrudoxic Placudands; Typic Fulvudands. (IGAC,2014)

These soils occupy some of the hillocks in the mountain passage. The topography of these soils ranges from wavy to strongly corrugated. These have developed from volcanic ashes set over lava flows and pyroclastic deposits. They range from moderately to deep; they are well drained and have low fertility. These types of soils tend to be used for agriculture and cattle production. (IGAC,2014)

The soils allocated on the low parts of the hillocks are classified as Eutric Hapludands. These have developed from volcanic ashes. They are deep, well drained with moderately fine textures and low fertility. (IGAC,2014)

They tend to be strongly acid, with high cationic exchange capacity, high organic carbon content, low bases content and saturation and high aluminium saturation. The main constraints for use are the high slopes, the high risk of erosion and mass movements, the strong acidity, low nutrients availability and high phosphate retention. (IGAC,2014)

The soils allocated on the middle parts of the hillocks are classified as Acrudoxic Placudands. They have developed from volcanic ashes, are moderately deep, and constrained by a hardened layer and low fertility. (IGAC,2014)

They tend to be strongly acid, with high cationic exchange capacity, high organic carbon content on the top 65 cm. They have low bases content and saturation and high aluminium saturation. They have high water retention. The constraints for use are the strongly steep slopes, the moderately effective depth, high erosion susceptibility, strong acidity, low nutrient availability and high phosphate retention. (IGAC,2014)

The soils allocated on the high parts of the hillocks are classified as Typic Fulvudands. These have developed from volcanic ashes set on lava flows. They are very deep, well drained, with moderately thick textures and low fertility. (IGAC,2014)

They are strongly acid, with high cationic exchange capacity, high organic carbon content. Low bases content and saturation. Very high aluminium saturation. The main constraint for use are the strong steep slopes, high erosion vulnerability, high aluminium content and saturation, strong acidity, low nutrient availability and high phosphate fixation. (IGAC,2014)

The Association presents inclusions of soils classified as Typic Placudands, which are allocated on the inferior part of the hillocks. They have developed from volcanic ashes. Are deep, well drained, with moderately thick textures and low fertility. (IGAC,2014)

They are strongly acid, high cationic exchange capacity, high organic carbon content, low bases content and saturation and high aluminium saturation. The main constraints for use are the highly steep slopes, high erosion susceptibility. High aluminium content and saturation, strong acidity, low nutrients availability and high phosphate fixation. (IGAC,2014)

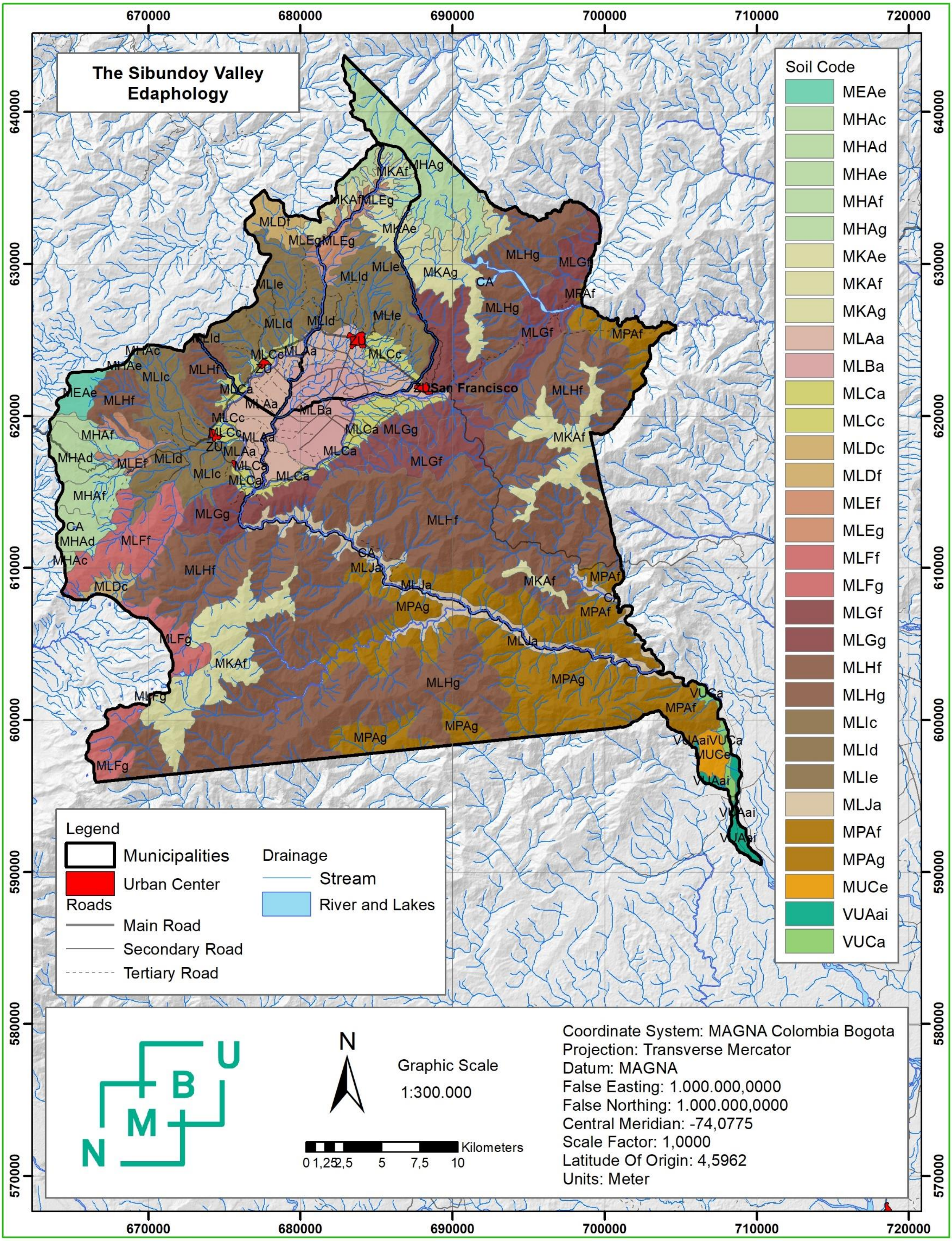
Table 17. Description of soil units in the agricultural portion of the Sibundoy Valley. (IGAC,2014)

UCS	UCS_S	LANDSCAPE	CLIMATE	TYPE OF SURFACE	LITHOLOGY	FEATURES	COMPONENTS	PERCENTAJE
MEA	MEAe	Mountain	Extremely cold humid to very humid	Crafts and moraine fields	Volcanic ash	Very deep soils, well drained, with medium textures, very strongly acidic, with very high aluminium saturation and low fertility	Consociation: Typic Melanocryands; Inclusions	90, 10
MHA	MHAc, MHAd, MHAe, MHAf, MHAg	Mountain	Very cold humid to very humid	Lava Domes (Coulées)	Volcanic ash	Very deep soils, well drained, moderately coarse textures, strongly acid reaction, high aluminium saturation and low fertility	Consociation: Typic Fulvudands; Inclusions	80, 20

UCS	UCS_S	LANDSCAPE	CLIMATE	TYPE OF SURFACE	LITHOLOGY	FEATURES	COMPONENTS	PERCENTAJE
MKA	MKAe, MKAf, MKAg	Mountain	Cold very humid	Rows and beams	Granodiorites, monzogranodiorites and volcanic ash	Deep and superficial soils, well to excessively drained, of fine and coarse textures, high and very high aluminium saturation, strongly acid, low fertility	Association: Andic Dystrudepts; Lithic Udorthents; Inclusions	45, 40, 15
MLA	MLAa	Mountain	Cold humid to very humid	Depression	Organic and fluvio-lacustrine deposits	Very superficial and superficial soils, well to very poorly drained, of moderately coarse and fine textures, moderately to very strongly acidic, moderate and high fertility	Association: Hydric Haplofibrists; Fibric Haplohemists; Terric Haplofibrists; Inclusions	35, 30, 30, 5
MLB	MLBa	Mountain	Cold humid to very humid	Depression	Fluvial lacustrine and organic deposits	Very shallow and deep soils, well drained, with moderately thick and coarse textures, with high aluminium saturation, strongly acidic to extremely acidic, low fertility	Association: Typic Udifluvents; Typic Fluvaquents; Hydric Haplohemists; Inclusions	40, 30, 25, 5
MLC	MLCa, MLCc	Mountain	Cold humid to very humid	Depression	Thick alluvial materials	Very shallow, deep soils, well drained, with moderately coarse textures, with high aluminium saturation, moderately to extremely acidic, low fertility	Association: Typic Udorthents; Typic Udifluvents; Andic Dystrudepts; Inclusions	35, 30, 25, 15
MLD	MLDc, MLDf	Mountain	Cold humid to very humid	Lava Domes (Coulées)	Volcanic ash	Deep and very deep soils, well drained, moderately coarse textures, with high aluminium saturation, moderate and strongly acidic, low fertility	Consociation: Acrudoxic Melanudands; Inclusions	80, 20
MLE	MLEf, MLEg	Mountain	Cold humid to very humid	Canyons	Volcanic ash and sandstones	Superficial and very deep soils, well drained, medium textures, high aluminium saturation, strongly acidic, low and high fertility	Association: Typic Placudands; Lithic Udorthents; Rocky outcrops	50, 40, 10
MLF	MLFf, MLFg	Mountain	Cold humid to very humid	Rows and beams	Volcanic ash	Deep, well-drained soils, moderately coarse textures, very strongly acidic, medium and very high aluminium saturation, low fertility	Consociation: Acrudoxic Fulvudands; Lithic Hapludands	90, 10
MLG	MLGf, MLGg	Mountain	Cold humid to very humid	Rows and beams	Volcanic ash, siltstone and mudstone	Deep, well-drained soils, moderately coarse textures, strongly and very strongly acidic, high aluminium saturation, low fertility	Association: Typic Hapludands; Typic Placudands; Lithic Udorthents; Rocky outcrops	35, 30, 30, 5

UCS	UCS_S	LANDSCAPE	CLIMATE	TYPE OF SURFACE	LITHOLOGY	FEATURES	COMPONENTS	PERCENTAJE
MLH	MLHf, MLHg	Mountain	Cold humid to very humid	Rows and beams	Volcanic ash, granodiorites and monzogranodiorites	Very shallow and deep soils, well and excessively drained, moderately fine textures, moderately thick and coarse, strongly to extremely acidic, medium to very high aluminium saturation, moderate and low fertility	Association: Eutric Pachic Fulvudands; Lithic Udorthents; Andic Dystrudepts; Inclusions	40, 30, 25, 5
MLI	MLIc, MLId, MLIe	Mountain	Cold humid to very humid	Hillocks	Volcanic ash	Very deep and deep soils, well drained, medium textures, strongly and very strongly acidic, high and very high aluminium saturation, low and moderate fertility	Association: Eutric Hapludands; Acrudoxic Placudands; Typic Fulvudands; Inclusions	40, 25, 25, 5
MLJ	MLJa	Mountain	Cold humid to very humid	Hollows	Recent heterogeneous alluvial deposits	Moderately deep soils, moderately drained, moderately fine textures, very high aluminium saturation, very strongly acidic, low and moderate fertility	Association: Typic Udifluvents; Fluvaquentic Dystrudepts	55, 45
MPA	MPAf, MPAg	Mountain	Temperate very humid	Rows and beams	Volcanic ash, granodiorites and monzogranodiorites	Very shallow and deep soils, well and excessively drained, moderately fine textures, moderately thick and coarse, strongly and very strongly acidic, medium to very high aluminium saturation, moderate and low fertility	Association: Typic Hapludands; Lithic Udorthents; Inclusions	50, 40, 10
MUC	MUCe	Mountain	Warm very humid	Hillocks and hills	Siltstone and Mudstone	Soils moderately deep and deep, well drained, moderately fine and medium textures, strongly and very strongly acidic, very high aluminium saturation, low fertility	Association: Andic Dystrudepts; Typic Dystrudepts; Inclusions	50, 40, 10
VUC	VUCa	Valley	Warm very humid	Terrace level 2	Ancient alluvial deposits with intercalations of arcillolites and volcanic ash	Very shallow and deep soils, very poorly drained, with organic matter in the process of decomposition, medium to very high saturation of aluminium, strong to very strongly acid, medium and low fertility	Association: Fluventic Dystrudepts; Histic Humaquepts; Sapric Haplohemists; Inclusions	35, 30, 25, 10

UCS	UCS_S	LANDSCAPE	CLIMATE	TYPE OF SURFACE	LITHOLOGY	FEATURES	COMPONENTS	PERCENTAJE
VUA	VUAai	Valley	Warm very humid	Flood plain	Heterogeneous alluvial deposits	Moderately deep and shallow soils, well and poorly drained, moderately coarse to moderately fine textures, moderately to strongly acidic, low and medium aluminium saturation, low to high fertility	Association: Dystriic Eutrudepts; Fluvaquentic Endoaquepts; Typic Dystrudepts; Inclusions	35, 30, 25, 10


The Sibundoy Valley
Edaphology
Soil Code
MEAe
MHAc
MHAd
MHAe
MHAf
MHAg
MKAe
MKAf
MKAg
MLAa
MLBa
MLCa
MLCc
MLDc
MLDf
MLEf
MLEg
MLFf
MLFg
MLGf
MLGg
MLHf
MLHg
MLIc
MLId
MLIe
MLJa
MPAf
MPAg
MUCe
VUAai
VUCa
San Francisco
CA
Legend
Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
N
Graphic Scale
1:300.000
0 1,25 2,5 5 7,5 10
Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
Datum: MAGNA
False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter
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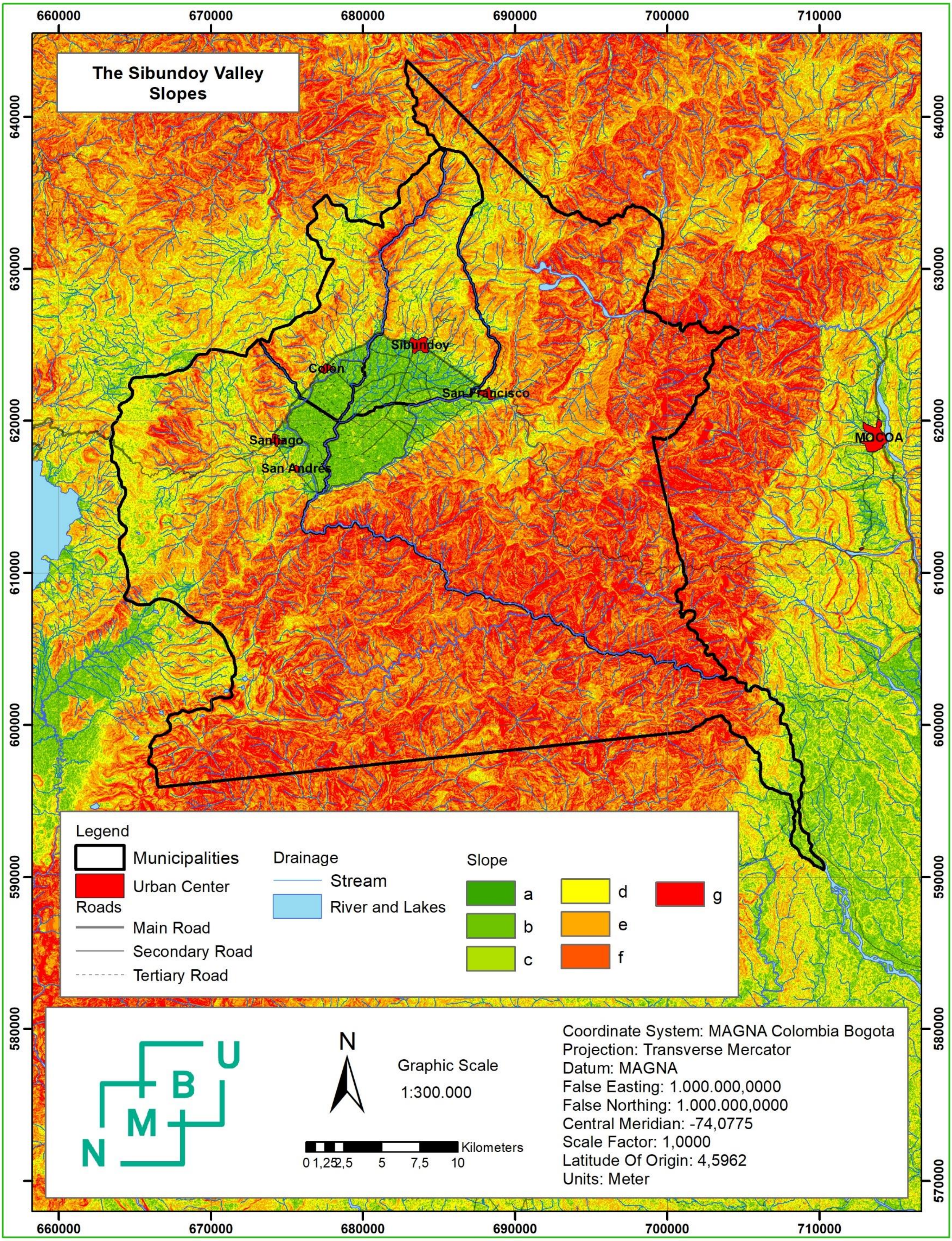
The Sibundoy Valley
Slopes
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630000
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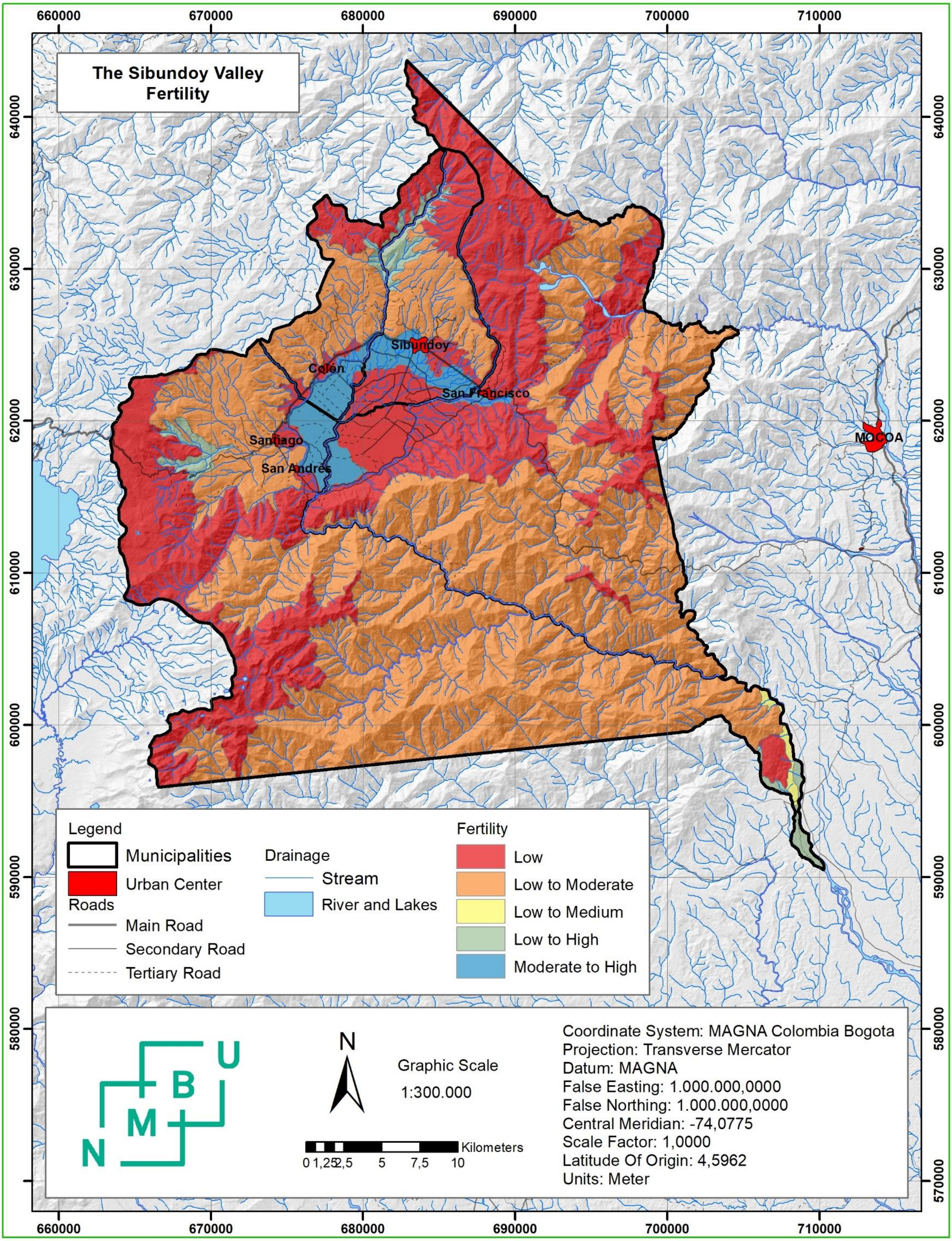
Sibundoy
Colón
San Francisco
Santiago
San Andrés
MOCOA
Legend
Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
Slope
a
b
c
d
e
f
g
NMBU
N
Graphic Scale
1:300.000
0 1,25 2,5 5 7,5 10 Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
Datum: MAGNA
False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter


The Sibundoy Valley
Fertility
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Sibundoy
Colón
San Francisco
Santiago
San Andrés
MOCOA
Legend
Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
Fertility
Low
Low to Moderate
Low to Medium
Low to High
Moderate to High
N
Graphic Scale
1:300.000
0 1,25 2,5 5 7,5 10
Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
Datum: MAGNA
False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter
NMBU

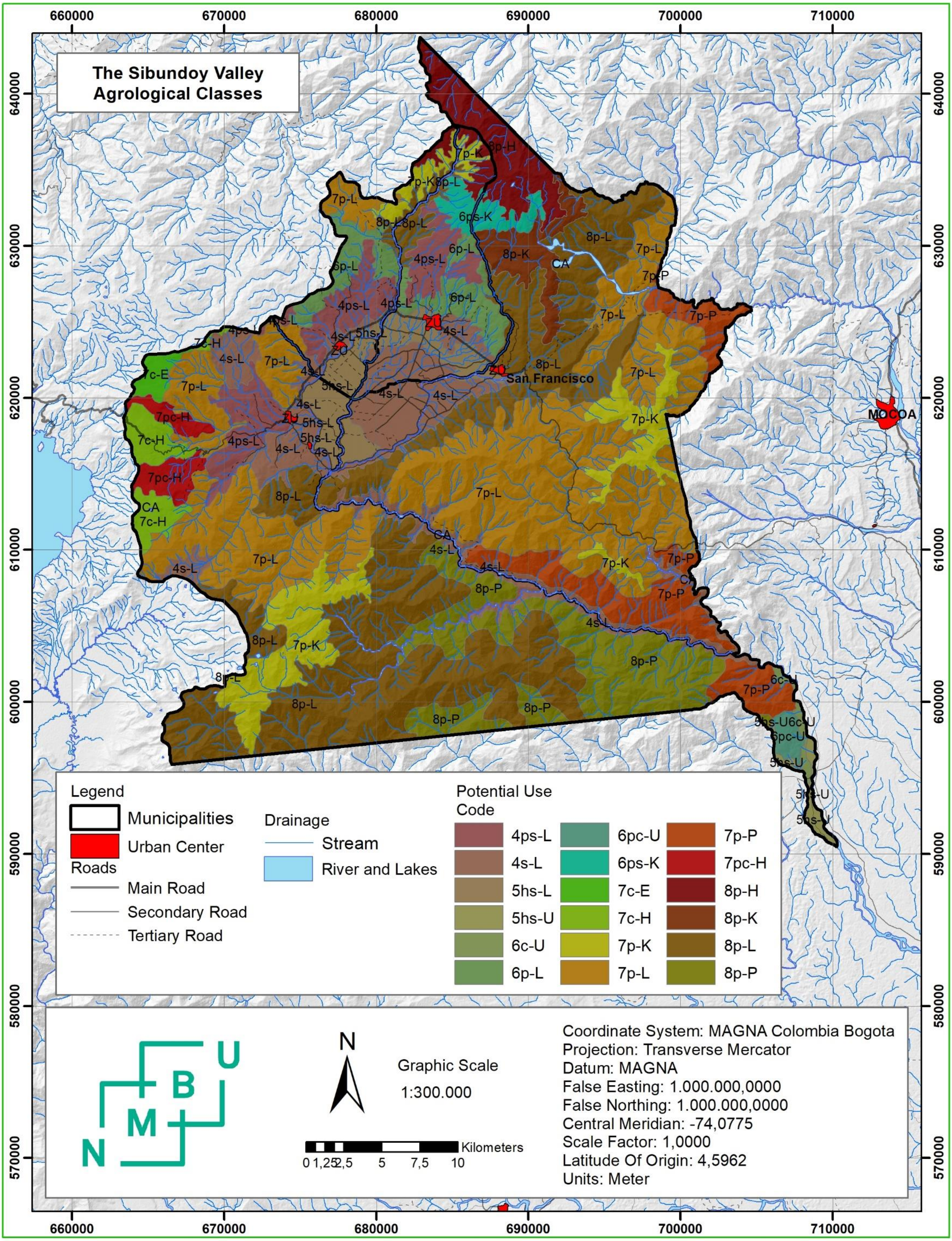
Table 18. Recommended use and management of the soils (Agrological Classes) based on the soil classification. (IGAC,2014)

CODE	CLASS	SUBCLASS	MANAGEMENT GROUP	UCS	DESCRIPTION	MAIN LIMITATIONS	RECOMMENDED USE	RECOMMENDED MANAGEMENT
4ps-L	4	ps	L	MLId	Humid cold weather; moderately undulating relief, deep, well-drained soils, medium textures, high and very high aluminium saturation, strong and very strongly acidic, low fertility	Inclined strongly inclined, high and very high saturation of aluminium, very strong acidity, low fertility	Extensive cattle ranching, silvopastoral systems, forest plantations or dense and semi-dense crops	Technified management of pastures and livestock, rotating paddocks and avoiding overburden and overgrazing; perform fertilizations according to soil fertility
4s-L	4	s	L	MLBa, MLCa, MLCc, MLDc, MLIc, MLJa	Humid cold weather; flat to moderately wavy relief; superficial and very deep, well-drained soils, moderately coarse textures, high aluminium saturation, moderate to extremely acidic, low fertility	Superficial soils, strong acidity, high aluminium saturation and low fertility are strongly inclined, high and very high aluminium saturation, very strong acidity, low fertility	Agriculture with some specific crops and semi-intensive livestock	Carry out the tillage under adequate humidity conditions; increase the level of fertility using chemical and organic fertilizers; use species and varieties of crops that are genetically improved and adaptable to edaphic conditions
5hs-L	5	hs	L	MLAa	Humid cold weather; slightly flat relief, very shallow soils, very poorly drained, with moderately coarse textures, high aluminium saturation, strongly acid, moderate fertility, very frequent flooding	Frequent flooding, poor drainage, very shallow soils, high aluminium saturation, strong acidity	Extensive cattle raising, with introduced pastures resistant to excess moisture, seasonal crops adapted to ecological conditions	Flood control, depletion of the water table, construction of subsurface and surface drainages; implementation of practices related to crop selection, fertilization and tillage in adequate humidity conditions
5hs-U	5	hs	U	VUAai	Very humid warm weather; flat relief, frequent floods; superficial to deep, well to poorly drained soils, moderately coarse to moderately fine textures, low to high aluminium saturation, moderately and strongly acidic	Frequent flooding, effective surface depth, high aluminium saturation, very strong acidity, low fertility, high rainfall throughout the year	Livestock with good management of grasses tolerant to excess moisture; the recommended use is the conservation of natural vegetation and the technical and selective exploitation of forests that still exist	It requires the construction of works that control floods, lower the water table and eliminate excess water
6ps-K	6	ps	K	MKAe	Cold weather very humid; slightly steep relief; deep, well drained soils, fine textures, high aluminium saturation, strongly acidic, low fertility	Slightly steep slopes, strong acidity, high aluminium saturation, moderate and low fertility	Silvopastoral systems, forest plantations and wildlife	Management of pastures and livestock, rotating pastures and crops; fertilization; construction of hillside ditches and implement live barriers

CODE	CLASS	SUBCLASS	MANAGEMENT GROUP	UCS	DESCRIPTION	MAIN LIMITATIONS	RECOMMENDED USE	RECOMMENDED MANAGEMENT
7c-E	7	c	E	MEAe	Extremely cold humid weather; slightly steep relief; well drained soils, very deep, medium textures, very strongly acidic, with very high aluminium saturation and low fertility	Low temperatures, high cloudiness, low solar brightness, strong winds, slightly steep slopes, very high aluminium saturation, strong acidity and low fertility	Conservation of natural vegetation, protective forests and wildlife	Maintain the vegetation cover of these ecological conditions, reforest, eliminate agricultural activities
6c-U	6	c	U	MUAd, MUCc, MUCd, LUBb, PUAa, PUBa, PUBb, VUBa, VUCa	Very humid warm weather; flat to strongly wavy relief; very shallow to deep soils, moderately coarse to fine textures, well drained, extremely to moderately acidic, medium to very high aluminium saturation and low fertility	Effective surface depth in some sectors, extreme to moderate acidity, medium to very high aluminium saturation, low fertility and excessive rainfall during the year	Semi-stable livestock, silvopastoral systems and protective forests	Technified management of grasslands and livestock, rotating paddocks and avoiding overburden and overgrazing, using pastures adapted to ecological conditions
6p-L	6	p	L	MLIe	Humid cold weather; slightly steep relief; deep, well-drained soils, medium textures, very high aluminium saturation, very strongly acidic, moderate fertility	Slightly steep slopes, very strongly acidic, with very high aluminium saturation and low fertility	Silvopastoral systems and protective forests	Technified management of pastures and livestock, rotating paddocks and avoiding overburden and overgrazing; sowing of introduced pastures of good nutritional quality; Pasture renovation and application of fertilizer crops
6pc-U	6	pc	U	MUAe, MUBe, MUCc, MUCe, MUDe, LUBc	Very humid warm weather; moderately broken relief; deep soils, well drained, medium to fine textures, moderate and very high aluminium saturation, strong and very strongly acid, moderate and low fertility	Slightly steep slopes, very high aluminium saturation, strongly acidic, low fertility, high precipitation during the year	Silvopastoral systems, protective forests, conservation and wildlife	Control of runoff waters, management of pastures; avoid overgrazing, plant trees for shade and shelter animals and maintain those that exist, encourage mixed grazing and avoid burning and clear felling
7c-H	7	c	H	MHAc, MHAd, MHAe	Very cold humid weather; moderately wavy to moderately broken relief; deep, well-drained soils, medium textures, strongly acidic, with high aluminium saturation, low fertility	Low temperatures, moderately inclined to slightly steep slopes, strongly acidic, with phosphorus fixation capacity, high aluminium content, low fertility	Protective forests, wildlife, conservation, silvopastoral systems	Reforest with native and / or exotic species; eliminate agricultural activities; avoid felling and burning

CODE	CLASS	SUBCLASS	MANAGEMENT GROUP	UCS	DESCRIPTION	MAIN LIMITATIONS	RECOMMENDED USE	RECOMMENDED MANAGEMENT
7pc-H	7	pc	H	MHAf	Very cold humid weather; moderately steep relief, soils derived from volcanic ash, deep, well drained, medium textures, strongly acid reaction, high aluminium saturation, low fertility	Limited by low temperatures, moderately steep slopes, susceptible to erosion and mass movements, strongly acid reaction, high aluminium content and low fertility	Protective forest, wildlife, conservation	Reforest with native or exotic species; suspend agricultural activities; avoid clear felling and burning
7p-K	7	p	K	MKAf	Cold weather very humid; strongly broken relief; surface to deep, well-drained soils, coarse textures, very strongly acidic, very high aluminium saturation and low fertility	Moderately steep slopes, surface soils, very strong acidity, very high aluminium saturation, low fertility	Protective vegetation, conservation of fauna and flora	Protection of natural resources such as fauna and vegetation cover, suspend agricultural activities
7p-L	7	p	L	MLDf, MLEf, MLFf, MLGf, MLHf	Humid cold weather; moderately steep relief; deep, well drained soils, medium fine and moderately thick textures, strong to extremely acidic, high and very high aluminium saturation, low fertility	Moderately steep slopes, low effective soil depth, very strong acidity, high aluminium saturation and low fertility	Protective-producing plantations, reforestation, wildlife	Plant native and / or foreign species adapted to ecological conditions
7p-P	7	p	P	MPAf	Very humid temperate climate; strongly broken relief; very shallow and deep, well and excessively drained soils, moderately fine and moderately coarse textures, strongly and very strongly acidic	Moderately steep slopes, high susceptibility to erosion, very strongly acid reaction, ability to fix phosphates, high aluminium content, and low fertility	Protective forest plantations, wildlife, conservation	Reforest with native or exotic species, suspend agricultural activities
8p-H	8	p	H	MHAg	Very cold humid weather; strongly steep relief; deep, well drained soils, medium textures, strongly acidic, with high aluminium saturation, low fertility	Low temperatures; steeply steep slopes; high susceptibility to erosion and mass movements; high aluminium saturation, strongly acid reaction, low fertility	Conservation of fauna and vegetation for land use coverage	Suspend agricultural activities, allow the regeneration of vegetation, reforestation with species adapted to the ecological environment, conservation of plant cover
8p-L	8	p	L	MLDg, MLEg, MLFg, MLGg, MLHg	Humid cold weather; strongly steep relief; surface soils to very deep, well to excessively drained, textures moderately fine to moderately coarse, strongly and very strongly acidic, medium to very high	Strongly steep slopes, high susceptibility to erosion and mass movements, superficial soils, excessive drainage, high aluminium saturation, strong acidity, low fertility	Conservation of natural vegetation, reforestation where the vegetation has been cut down	Avoid agricultural activities, maintenance of the plant cover typical of these ecological conditions

CODE	CLASS	SUBCLASS	MANAGEMENT GROUP	UCS	DESCRIPTION	MAIN LIMITATIONS	RECOMMENDED USE	RECOMMENDED MANAGEMENT
					saturation of aluminium			
8p-P	8	p	P	MPAg	Very humid temperate climate, strongly steep relief, very shallow and deep soils, well and excessively drained, of moderately fine and moderately coarse textures, very strongly acidic, very high aluminium saturation	Strongly steep slopes, very shallow soils, excessive drainage, high aluminium saturation, very high acidity, low fertility	Conservation of natural vegetation, reforestation where the vegetation has been cut down	Avoid agricultural activities, maintain the plant cover typical of these ecological conditions
8p-K	8	p	K	MKAg	Cold weather very humid; strongly steep relief; well-drained soils, deep to shallow, fine and moderately coarse textures, strongly acidic, high aluminium saturation and moderate fertility	Strongly steep slopes, high susceptibility to erosion and mass movements, high aluminium saturation, strong acidity, low fertility	Conservation of natural vegetation, reforestation where the vegetation has been cut down	Avoid agri+A1:I19cultural activities, maintain the plant cover of these ecological conditions, protective reforestation


The Sibundoy Valley
Agrological Classes
Legend
Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
Potential Use Code
4ps-L
4s-L
5hs-L
5hs-U
6c-U
6p-L
6pc-U
6ps-K
7c-E
7c-H
7p-K
7p-L
7p-P
7pc-H
8p-H
8p-K
8p-L
8p-P
San Francisco
MOCOA
CA
ZU
N
Graphic Scale
1:300.000
0 1,25 2,5 5 7,5 10
Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
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False Easting: 1.000.000,0000
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Biodiversity

Due to its location within the tropics and its connectivity with the Amazonian Rainforest, the Sibundoy Valley presents a high biological diversity of both fauna and flora. The Sibundoy Valley is broadly conformed by Montane Forests in the highlands that transition towards Pluvial Plain Forests in areas with lower altitude. The types of vegetation present are distributed mainly regarding the elevation above the sea level (m.a.s.l.) and the precipitation regimes. (CORPOAMAZONIA, 2012)

The Pluvial Plain Forests that conform the lower parts of the Sibundoy Valley (below 1000 m.a.s.l.) are made up of the "Western Hylaea", a mainland forest configuration of the Amazon Jungle characterised for being abundantly arboreous with some trees reaching heights of 40 metres and in average no less than 15 metres. These form a continuous canopy and tend to present tabular or stilt roots. These types of forest are present in regions prone to natural periodic flooding and soils of low fertility. (CORPOAMAZONIA, 2012)

The abundant arboreal vegetation is rich in Legumes, Bombacaceae, Myristicaceae, Solanaceae, Rubiaceae, Malvaceae and Lauraceae, among others; it has a high presence of lianas, palm trees, hygrophilous families such as Musaceae, epiphytes, orchids, etc. In fruit trees the Myrtaceae, Sapotaceae, Anacardiaceae, Lecitidaceae and Legumes stand out. (CORPOAMAZONIA, 2012)

Some species of special commercial importance are the Cedrela odorata, Swietenia macrophylla and Cedrelinga catenaeformis; legumes such as Trattinickia peruviana, Quassia simarouba, Virola spp, Hura crepitans, and the genera Ceiba, Bombax, Apeiba, Inga, Ochroma, and Clusia, among others. (CORPOAMAZONIA, 2012)

The Montane Forests are the most abundant and are present in the higher regions of the Sibundoy Valley (above 1000 m.a.s.l.). They are classified in relation to their elevation into: Sub Andean Forest (From 1000 m.a.s.l. to 2400 m.a.s.l.) and Andean Forest (From 2400 m.a.s.l. to 3800 m.a.s.l.). (CORPOAMAZONIA, 2012)

The Sub Andean Forest has less predominance of tabular root species, palm trees, epiphytes and lianas and a greater presence of small leaved trees and arboreal ferns. Some species such as Quercus granatensis, Juglans columbiensis and Podocarpus spp are of biogeographical interest. (IGAC, 2014)

The Andean Forests are characterised by the presence of fog and a high humidity. Trees are about 5-meter-high in average, mostly deciduous with small leaves and shafts covered by mosses and epiphytes. The genera Weinmannia, Brunellia, Clusia, Befaria, Eugenia, Ilex, Oreopanax, among others are of special importance. The vegetation in this region is typically adapted to the variations of temperature between day and night and respond well to the occasional frost. (IGAC, 2014)

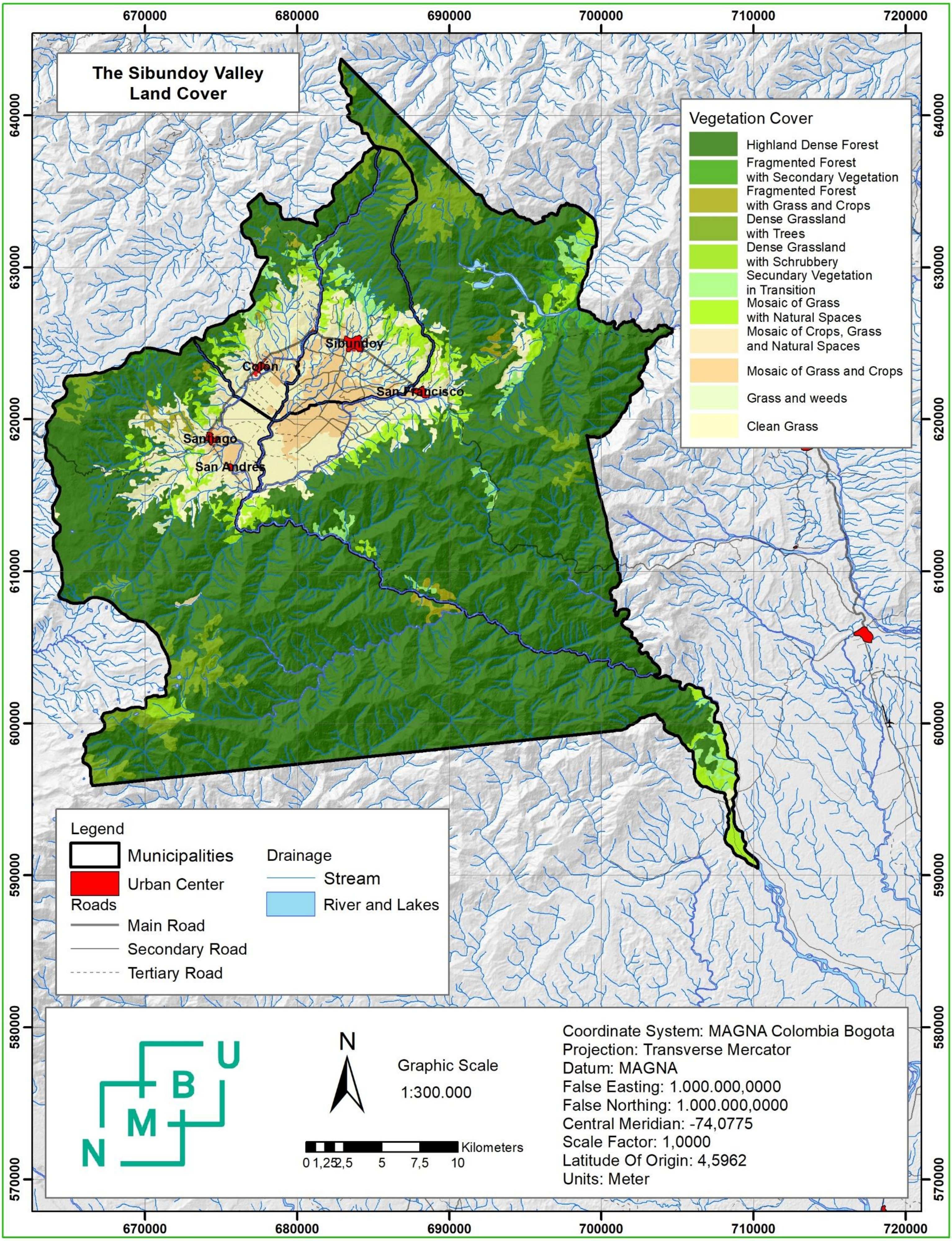
The high flatlands of the Valley, where most people are settled, has been mostly logged and replaced by grasslands and crops. The territories with high slopes which are harder to access tend to remain untouched and present mostly native species typical of the Andean Forest. (IGAC, 2014)

Above the 3000 m.a.s.l. in some sectors the Andean Forest transitions into Paramount vegetation, more common of higher grounds. These are adapted to temperatures that often go below 0°C, with frequent frosts. The humidity tends to remain high shaping a foggy landscape. The sky tends to remain overcast with little sun time and strong winds. The most abundant plants present are Asteraceae, Orchids and Gramineae with some arboreal vegetation that forms scrubs with disperse trees. (IGAC, 2014)

An interesting fact about the Sibundoy Valley is how rich it is from an ethnobotanist perspective. There is a great natural presence of hallucinogenic plants throughout its territory. In 1941, the American botanist Richard Evans Schultes found the highest concentration of hallucinogenic plants ever recorded with over one thousand six hundred trees within the Solanaceae family.

Traditional medicine is regarded as important for its inhabitants and the local healers make use of many types of flowers to treat infections and fevers, roots to kill parasites, tonics to treat nervous diseases, and herbal blends to cure labour pains. (CORPOAMAZONIA, 2012)

The vegetable coverage map was obtained from the Biodiversity Humboldt Institute and presents the vegetation coverage according to the Corine Land Cover methodology. (SINCHI, 2009)


The Sibundoy Valley
Land Cover
Vegetation Cover
Highland Dense Forest
Fragmented Forest with Secondary Vegetation
Fragmented Forest with Grass and Crops
Dense Grassland with Trees
Dense Grassland with Schrubbery
Secundary Vegetation in Transition
Mosaic of Grass with Natural Spaces
Mosaic of Crops, Grass and Natural Spaces
Mosaic of Grass and Crops
Grass and weeds
Clean Grass
Sibundoy
Colón
San Francisco
Santiago
San Andrés
Legend
Municipalities
Urban Center
Roads
Main Road
Secondary Road
Tertiary Road
Drainage
Stream
River and Lakes
NMBU
N
Graphic Scale
1:300.000
0 1,25 2,5 5 7,5 10 Kilometers
Coordinate System: MAGNA Colombia Bogota
Projection: Transverse Mercator
Datum: MAGNA
False Easting: 1.000.000,0000
False Northing: 1.000.000,0000
Central Meridian: -74,0775
Scale Factor: 1,0000
Latitude Of Origin: 4,5962
Units: Meter
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2. Exploring the effectiveness of the Chagra practice in tackling climatic variability by measuring the agricultural production of conventional and traditional practices during historic El Niño and La Niña events.

To address this objective, it was necessary to obtain secondary information of historical agricultural production. This historical information was found in Governmental institutions and records taken by the Kamentsá and Inga people.

Agricultural Production

Communities in the Sibundoy Valley base their economy on the agricultural sector, being commerce of great importance. Agrarian economy for local consumption is based on traditional agricultural produce. While commercial agrarian economy is based on beans, apples, milk and cattle. There are also tree tomato crops, malanga arracacha and a great amount of beans and corn.

Data about the agricultural production in the municipalities that form the Sibundoy Valley was obtained in the National Agriculture Survey. (DANE, 2017) The multiannual production of reported agricultural activities was obtained through the Gubernation of Putumayo from the Municipal Agriculture Evaluation made by the Ministry of Agriculture. (MinAgricultura, 2018)

The first dataset obtained in the agricultural census by DANE gives light to all the types of production in the Sibundoy Valley. The information was prepared and separated for presentation and analysis purposes.

Meat and Milk Production

Cattle

Table 19. Cattle heads and number of farms for indigenous and non-indigenous farmers

Municipalities	Total Farms	Cattle Heads	Indigenous Farms	Cattle Heads	Non-Indigenous Farms	Cattle Heads
San Francisco	691	5.847	148	684	543	5.163
Santiago	479	3.134	38	174	441	2.960
Sibundoy	313	3.199	157	1.562	156	1.637
Colón	302	3.382	29	335	273	3.047

Figure 6. Areas used for cattle production

Porcine

Table 20. Pig heads and number of farms for indigenous and non-indigenous farmers

Municipalities	Total Farms	Pig Heads	Fattened Pigs	Total	Indigenous Farms	Pig Heads	Fattened Pigs	Total	Non-Indigenous Farms	Pig Heads	Fattened Pigs	Total
Colón	13	40	177	217	5	9	9	18	8	31	168	199
Sibundoy	73	205	266	471	36	75	40	115	37	130	226	356
San Francisco	67	228	650	878	16	49	9	58	51	179	641	820
Santiago	85	139	118	257	20	28	45	73	65	111	73	184

Buffalos

Table 21. Buffalo heads and number of farms for indigenous and non-indigenous farmers

Municipalities	Total Farms	Buffalo Heads	Indigenous Farms	Buffalo Heads	Non-Indigenous Farms	Buffalo Heads
Colón	0	0	0	0	0	0
Sibundoy	0	0	0	0	0	0
San Francisco	0	0	0	0	0	0
Santiago	1	5	0	0	1	5

Equine

Table 22. Horse heads and number of farms for indigenous and non-indigenous farmers

Municipalities	Total Farms	Total Horses	Indigenous Farms	Horses	Non-Indigenous Farms	Horses
Colón	3	6	0	0	3	6
Sibundoy	33	59	15	28	18	31
San Francisco	62	120	6	8	56	112
Santiago	28	55	1	1	27	54

Ovine

Table 23. Sheep heads and number of farms for indigenous and non-indigenous farmers

Municipalities	Total Farms	Sheep Heads	Indigenous Farms	Sheep Heads	Non-Indigenous Farms	Sheep Heads
Colón	1	18	0	0	1	18
Sibundoy	2	11	1	9	1	2
San Francisco	1	1	0	0	1	1
Santiago	2	38	0	0	2	38

Figure 7. Sheep growing next to a Chagra, farmers use the manure as fertiliser

Caprine

Table 24. Goat heads and number of farms for indigenous and non-indigenous farmers

Municipalities	Total Farms	Goat Heads	Indigenous Farms	Goat Heads	Non-Indigenous Farms	Goat Heads
Colón	1	25	0	0	1	25
Sibundoy	2	19	1	1	1	18
San Francisco	0	0	0	0	0	0
Santiago	0	0	0	0	0	0

Poultry

Table 25. chicken heads and number of farms for indigenous and non-indigenous farmers

Municipalities	Total Farms	Poultry Inventory	Indigenous Farms	Poultry Inventory	Non-Indigenous Farms0	Poultry Inventory
Colón	159	38.401	26	313	133	38.088
Sibundoy	624	10.146	349	5.568	275	4.578
San Francisco	426	13.702	123	8.578	303	5.124
Santiago	631	21.090	109	7.415	522	13.675

Figure 8. Hen next to a container where they grow the native cuy

Aquaculture and Fishing

Table 26. Fish and number of aquaculture facilities for indigenous and non-indigenous farmers

Municipalities	Total Aquaculture	Total Fishing	Indigenous Aquaculture	Fishing	Non-Indigenous Aquaculture	Fishing
Colón	10	1	2	0	8	1
Sibundoy	5	2	2	2	3	0
San Francisco	16	17	0	4	16	13
Santiago	2	0	0	0	2	0

Agroindustry

Table 27. Agroindustry farms and Area for indigenous and non-indigenous farmers

Municipalities	Total Agroindustry Farms	Area (Ha)	Coffee Farms	Area (Ha)	Sugar Cane Farms	Area (Ha)	Cocoa Cane Farms	Area (Ha)	Other Agroindustry Farms	Area (Ha)
Colón	16	3	2	0	14	3	0	0	0	0
Sibundoy	3	4	0	0	3	4	0	0	0	0
San Francisco	115	142	22	46	0	0	89	92	4	4
Santiago	369	283	24	9	125	131	182	93	36	50

Municipalities	Indigenous Agroindustry Farms	Area (Ha)	Coffee Farms	Area (Ha)	Sugar Cane Farms	Area (Ha)	Cocoa Cane Farms	Area (Ha)	Other Agroindustry Farms	Area (Ha)
Colón	5	2	1	0	4	2	0	0	0	0
Sibundoy	3	4	0	0	3	4	0	0	0	0
San Francisco	28	34	3	7	0	0	23	25	2	1
Santiago	58	52	4	0	40	51	13	0	1	0

Municipalities	Non-Indigenous Agroindustry Farms	Area (Ha)	Coffee Farms	Area (Ha)	Sugar Cane Farms	Area (Ha)	Cocoa Cane Farms	Area (Ha)	Other Agroindustry Farms	Area (Ha)
Colón	11	1	1	0	10	1	0	0	0	0
Sibundoy	0	0	0	0	0	0	0	0	0	0
San Francisco	87	108	19	39	0	0	66	66	2	3
Santiago	311	231	20	9	85	80	169	92	35	49

Plantain and Tubers

Table 28. Tuber farms and Area for indigenous and non-indigenous farmers

Municipalities	Total Farms	Total Area (Ha)	Plantain Farms	Area (Ha)	Cassava Farms	Area (Ha)	Potato Farms	Area (Ha)	Other Tuber Farms	Area (Ha)
Colón	14	506	1	406	0	0	11	94	2	7
Sibundoy	19	27	0	0	1	0	0	0	18	27
San Francisco	392	615	339	432	4	17	31	126	18	40
Santiago	533	442	113	194	5	2	75	100	340	146

Municipalities	Total Indigenous Farms	Total Area (Ha)	Plantain Farms	Area (Ha)	Cassava Farms	Area (Ha)	Potato Farms	Area (Ha)	Other Tuber Farms	Area (Ha)
Colón	4	1	0	0	0	0	3	1	1	0
Sibundoy	8	14	0	0	1	0	0	0	7	14
San Francisco	162	170	146	165	0	0	7	4	9	1
Santiago	64	24	7	17	1	0	13	1	43	6

Municipalities	Total Non-Indigenous Farms	Total Area (Ha)	Plantain Farms	Area (Ha)	Cassava Farms	Area (Ha)	Potato Farms	Area (Ha)	Other Tuber Farms	Area (Ha)
Colón	10	505	1	406	0	0	8	93	1	7
Sibundoy	11	13	0	0	0	0	0	0	11	13
San Francisco	230	445	193	268	4	17	24	122	9	39
Santiago	469	418	106	177	4	2	62	99	297	141

Fruits

Table 29. Fruit farms and Area for indigenous and non-indigenous farmers

Municipalities	Total Fruit Farms	Total Area (Ha)	Banana Farms	Area (Ha)	Citric Farms	Area (Ha)	Pineapple Farms	Area (Ha)	Avocado Farms	Area (Ha)	Other Fruit Farms	Area (Ha)
Colón	106	56	0	0	0	0	0	0	9	44	97	12
Sibundoy	463	60	0	0	4	4	0	0	145	23	314	34
San Francisco	153	82	4	13	8	16	1	1	9	17	131	35
Santiago	363	194	5	1	79	58	0	0	19	29	260	106

Municipalities	Indigenous Fruit Farms	Total Area (Ha)	Banana Farms	Area (Ha)	Citric Farms	Area (Ha)	Pineapple Farms	Area (Ha)	Avocado Farms	Area (Ha)	Other Fruit Farms	Area (Ha)
Colón	8	1	0	0	0	0	0	0	8	1	98	56
Sibundoy	190	19	0	0	3	3	53	8	134	7	273	42
San Francisco	64	16	0	0	4	4	2	0	58	12	89	66
Santiago	47	19	4	1	3	1	0	0	40	17	316	175

Municipalities	Non-Indigenous Fruit Farms	Total Area (Ha)	Banana Farms	Area (Ha)	Citric Farms	Area (Ha)	Pineapple Farms	Area (Ha)	Avocado Farms	Area (Ha)	Other Fruit Farms	Area (Ha)
Colón	98	56	0	0	0	0	0	0	9	44	89	12
Sibundoy	273	42	0	0	1	1	0	0	92	14	180	27
San Francisco	89	66	4	13	4	12	1	1	7	17	73	23
Santiago	316	175	1	0	76	57	0	0	19	29	220	88

Cereals

Table 30. Cereal farms and Area for indigenous and non-indigenous farmers

Municipalities	Total Cereal Farms	Total Area (Ha)	Rice Farms	Area (Ha)	Yellow Corn Farms	Area (Ha)	White Corn Farms	Area (Ha)	Other Cereal Farms	Area (Ha)
Colón	227	98	0	0	11	4	215	94	1	0
Sibundoy	919	395	0	0	218	123	281	84	420	189
San Francisco	348	369	2	1	152	179	123	94	71	96
Santiago	704	680	0	0	483	523	173	120	48	36

Municipalities	Indigenous Cereal Farms	Total Area (Ha)	Rice Farms	Area (Ha)	Yellow Corn Farms	Area (Ha)	White Corn Farms	Area (Ha)	Other Cereal Farms	Area (Ha)
Colón	28	40	0	0	1	1	26	39	1	0
Sibundoy	498	145	0	0	97	61	129	41	272	44
San Francisco	176	156	0	0	81	89	62	41	33	27
Santiago	116	21	0	0	60	11	45	9	11	1

Municipalities	Non-Indigenous Cereal Farms	Total Area (Ha)	Rice Farms	Area (Ha)	Yellow Corn Farms	Area (Ha)	White Corn Farms	Area (Ha)	Other Cereal Farms	Area (Ha)
Colón	199	58	0	0	10	3	189	54	0	0
Sibundoy	421	250	0	0	121	62	152	43	148	145
San Francisco	172	213	2	1	71	90	61	53	38	69
Santiago	588	659	0	0	423	513	128	111	37	35

Flowers, Medicinal and Forest plantations

Table 31. Medicinal farms and Area for indigenous and non-indigenous farmers

Municipalities	Total Flower Farms	Total Area (Ha)	Vegetable Farms (Ha)	Area (Ha)	Medicinal Farms	Area (Ha)	Forest Plantations	Area (Ha)
Colón	1	5	267	153	1	2	17	6
Sibundoy	1	0	675	316	6	2	15	3
San Francisco	2	0	254	131	7	9	45	259
Santiago	1	2	623	560	58	21	147	357

Municipalities	Indigenous Flower Farms	Total Area (Ha)	Vegetable Farms (Ha)	Area (Ha)	Medicinal Farms	Area (Ha)	Forest Plantations	Area (Ha)
Colón	0	0	44	8	0	0	1	0
Sibundoy	0	0	265	107	1	0	6	1
San Francisco	0	0	106	76	3	4	8	21
Santiago	0	0	100	11	3	0	11	19

Municipalities	Non-Indigenous Flower Farms	Total Area (Ha)	Vegetable Farms (Ha)	Area (Ha)	Medicinal Farms	Area (Ha)	Forest Plantations	Area (Ha)
Colón	1	5	223	145	1	2	16	6
Sibundoy	1	0	410	209	5	2	9	2
San Francisco	2	0	148	55	4	4	37	238
Santiago	1	2	523	549	55	20	136	338

The following dataset was obtained via the gubernation of Putumayo and it presents an account made by the Ministry of Agriculture and Territorial Development (MinAgricultura, 2018). It contains information regarding the Species, the crop cycle (transient or permanent), the period of harvest, harvested area (hectares), production (tons) and performance (tons per hectare) of crops since 2007 when the new development and monitoring strategy was implemented. No standardised multiannual information was available for the Sibundoy Valley before that year. The information was prepared and separated for observation and analysis purposes.

Conventional Agriculture

Cereals

Table 32. Cereal production and performance per municipality

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
Colón	Traditional Corn	*Zea mays*	Dry Grain	Transient	2007	2007A	42	42	80	1,9
					2008	2008A	115	115	288	2,5
					2009	2009A	115	115	210	1,83
					2010	2010A	115	115	220	1,91
					2011	2011A	125	125	291	2,33
					2012	2012A	127	127	291	2,3
					2013	2013A	126	64	83	1,3
					2014	2014A	126	126	176	1,4
					2015	2015A	164	164	352	2,15
					2016	2016A	200	150	165	1,1
					2017	2017A	180	175	175	1
					2018	2018A	184	184	186	1,01
San Francisco	Traditional Corn	*Zea mays*	Dry Grain	Transient	2007	2007A	294	273	318	1,17
					2008	2008A	80	77	81	1,05
					2009	2009A	80	77	132	1,71
					2010	2010A	230	215	400	1,86
					2011	2011A	100	90	150	1,67
					2014	2014A	80	80	160	2
					2015	2015A	104	104	223	2,15
					2016	2016A	280	230	230	1
					2017	2017A	260	240	240	1
					2018	2018A	265	265	268	1,01
Santiago	Traditional Corn	*Zea mays*	Dry Grain	Transient	2007	2007A	210	189	378	2
					2008	2008A	120	118	236	2
					2009	2009A	120	118	236	2
					2010	2010A	100	98	196	2
					2011	2011A	101	98	196	2
					2012	2012A	140	85	255	3
					2013	2013A	60	35	46	1,3
					2014	2014A	83	83	107	1,3
					2015	2015A	107	107	230	2,15
					2016	2016A	120	110	132	1,2

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2017	2017A	100	90	99	1,1
					2018	2018A	103	103	114	1,11
Sibundoy	Traditional Corn	*Zea mays*	Dry Grain	Transient	2007	2007A	305	252	378	1,5
					2008	2008A	110	110	253	2,3
					2009	2009A	145	145	276	1,9
					2010	2010A	125	125	250	2
					2011	2011A	129	120	331	2,76
					2012	2012A	200	180	468	2,6
					2013	2013A	280	240	312	1,3
					2014	2014A	223	223	289	1,3
					2015	2015A	290	290	622	2,15
					2016	2016A	296	289	318	1,1
					2017	2017A	290	290	319	1,1
					2018	2018A	292	292	333	1,14

Figure 9. Choclo Corn

Fruit Trees

Table 33. Fruit production and performance per municipality

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
Colón	Avocado	*Persea americana*	Fresh Fruit	Permanent	2014	2014	4	4	32	8
					2015	2015	4	4	32	8
					2016	2016	4	4	32	8
	Grenadia	*Passiflora liguraris*	Fresh Fruit	Permanent	2008	2008	12	6	60	10
					2009	2009	12	6	60	10
					2010	2010	12	6	90	15
					2011	2011	15	11	220	20
					2012	2012	20	15	225	15
					2013	2013	19	14	210	15
					2014	2014	20	16	288	18
					2015	2015	27	24	432	18
					2016	2016	5	5	45	9
					2017	2017	14	2	18	9
					2018	2018	17	13	117	9
	Lulo	*Solanum quitoense*	Fresh Fruit	Permanent	2007	2007	19	19	95	5
					2008	2008	4	4	20	5
					2009	2009	4	4	20	5
					2010	2010	4	4	48	12
					2011	2011	10	10	160	16
					2012	2012	12	10	200	20
					2013	2013	12	9	117	13
					2014	2014	16	12	168	14
					2015	2015	13	13	182	14
					2016	2016	4	2	12	5,9
					2017	2017	4	4	21	6
					2018	2018	6	3	15	6
	Apple	*Malus domestica*	Fresh Fruit	Permanent	2007	2007	5	5	40	8
					2008	2008	1	1	8	8
					2009	2009	1	1	8	8
					2010	2010	1	1	8	8
					2011	2011	2	1	8	8
	Blackberry	*Rubus glaucus*	Fresh Fruit	Permanent	2016	2016	2	1	5	5
					2017	2017	7	2	10	5
					2018	2018	9	6	30	5
	Tamarillo	*Solamun betaceum*	Fresh Fruit	Permanent	2007	2007	6	5	50	10

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2008	2008	20	15	120	8
					2009	2009	20	15	120	8
					2010	2010	20	15	180	12
					2011	2011	26	19	228	12
					2012	2012	26	22	264	12
					2013	2013	24	19	228	12
					2014	2014	30	24	384	16
					2015	2015	32	30	480	16
					2016	2016	4	3	24	7,9
					2017	2017	7	4	28	8
					2018	2018	8	6	44	8
San Francisco	Avocado	*Persea americana*	Fresh Fruit	Permanent	2014	2014	3	3	18	6
					2015	2015	3	3	18	6
					2016	2016	7	5	30	6
					2017	2017	8	7	8	1,1
					2018	2018	10	8	10	1,2
	Grenadia	*Passiflora liguraris*	Fresh Fruit	Permanent	2009	2009	7	0	0	
					2014	2014	8	3	54	18
					2015	2015	12	8	144	18
					2016	2016	30	25	175	7
					2017	2017	34	29	197	6,8
					2018	2018	38	34	245	7,2
	Lulo	*Solanum quitoense*	Fresh Fruit	Permanent	2007	2007	80	76	380	5
					2009	2009	8	6	30	5
					2014	2014	9	9	117	13
					2015	2015	7	7	91	13
					2016	2016	9	7	14	2
					2017	2017	10	8	14	1,8
					2018	2018	12	10	15	1,5
	Apple	*Malus domestica*	Fresh Fruit	Permanent	2007	2007	3	2	26	13
	Blackberry	*Rubus glaucus*	Fresh Fruit	Permanent	2009	2009	4	0	0	
					2016	2016	4	3	6	2
					2017	2017	5	3	5	1,8
					2018	2018	6	5	10	2
	Tamarillo	*Solamun betaceum*	Fresh Fruit	Permanent	2007	2007	4	3	27	9
					2010	2010	8	4	144	36
					2011	2011	9	6	160	26,67

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2012	2012	10	8	180	22,5
					2014	2014	12	8	112	14
					2015	2015	29	27	378	14
					2016	2016	8	7	18	2,5
					2017	2017	9	8	18	2,4
					2018	2018	11	9	22	2,5
Santiago	Grenadia	*Passiflora liguraris*	Fresh Fruit	Permanent	2009	2009	13	3	36	12
					2010	2010	13	3	36	12
					2011	2011	16	4	48	12
					2012	2012	16	4	50	12,5
					2013	2013	16	16	200	12,5
					2015	2015	25	21	378	18
					2016	2016	32	26	182	7
					2017	2017	37	32	224	7
					2018	2018	47	31	214	7
	Lulo	*Solanum quitoense*	Fresh Fruit	Permanent	2007	2007	76	76	380	5
					2008	2008	70	46	228	4,96
					2009	2009	63	15	75	5
					2010	2010	70	46	228	4,96
					2011	2011	67	15	75	5
					2012	2012	133	50	325	6,5
					2013	2013	58	45	293	6,5
					2015	2015	50	50	650	13
					2016	2016	87	77	454	5,9
					2017	2017	67	67	402	6
					2018	2018	59	59	354	6
	Apple	*Malus domestica*	Fresh Fruit	Permanent	2007	2007	3	3	35	11,67
					2008	2008	5	3	35	11,67
					2009	2009	13	4	32	8
					2010	2010	13	4	32	8
					2011	2011	15	5	40	8
					2012	2012	15	5	40	8
	Blackberry	*Rubus glaucus*	Fresh Fruit	Permanent	2007	2007	5	4	27	6,75
					2008	2008	11	4	25	6,25
					2009	2009	16	3	23	7,5
					2010	2010	15	6	36	6
					2011	2011	18	4	30	7,5
					2012	2012	36	17	65	3,82
					2013	2013	11	9	18	2
					2015	2015	74	68	748	11

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2016	2016	148	145	1.233	8,5
					2017	2017	153	143	1.287	9
					2018	2018	173	141	1.269	9
	Tamarillo	*Solamun betaceum*	Fresh Fruit	Permanent	2007	2007	2	2	18	9
					2012	2012	61	30	270	9
					2013	2013	65	55	495	9
					2014	2014	65	55	495	9
					2015	2015	78	70	630	9
					2016	2016	154	150	1.200	8
					2017	2017	119	119	952	8
					2018	2018	115	115	920	8
Sibundoy	Avocado	*Persea americana*	Fresh Fruit	Permanent	2014	2014	5	5	60	12
					2015	2015	5	5	100	20
					2016	2016	5	5	100	20
	Grenadia	*Passiflora liguraris*	Fresh Fruit	Permanent	2007	2007	10	10	115	11,5
					2009	2009	8	7	70	10
					2010	2010	9	9	93	10,33
					2012	2012	25	18	216	12
					2013	2013	29	22	330	15
					2014	2014	31	17	306	18
					2015	2015	56	52	936	18
					2016	2016	128	106	848	8
					2017	2017	149	124	1.116	9
					2018	2018	158	149	1.341	9
	Lulo	*Solanum quitoense*	Fresh Fruit	Permanent	2007	2007	19	19	95	5
					2008	2008	14	14	60	4,29
					2009	2009	9	3	24	8
					2010	2010	9	12	60	5
					2012	2012	50	25	125	5
					2013	2013	13	13	65	5
					2014	2014	27	13	169	13
					2015	2015	21	21	267	13
					2016	2016	59	50	290	5,8
					2017	2017	59	52	308	5,9
					2018	2018	67	59	350	5,9
	Apple	*Malus domestica*	Fresh Fruit	Permanent	2007	2007	4	3	24	8
					2008	2008	4	1	7	6,5
					2009	2009	4	1	8	8

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2010	2010	4	2	16	8
					2011	2011	4	2	16	8
					2012	2012	5	3	21	7
	Blackberry	*Rubus glaucus*	Fresh Fruit	Permanent	2012	2012	3	3	33	11
					2014	2014	6	3	33	11
					2015	2015	8	6	66	11
					2016	2016	5	3	20	6,8
					2017	2017	7	4	29	6,8
					2018	2018	11	7	50	6,8
	Mountain pawpaw	*Vasconcellea cundinamarcensis*	Fresh Fruit	Permanent	2007	2007	10	10	150	15
	Tamarillo	*Solamun betaceum*	Fresh Fruit	Permanent	2007	2007	15	9	80	8,89
					2008	2008	24	15	140	9,33
					2009	2009	32	20	200	10
					2010	2010	24	15	140	9,33
					2012	2012	62	40	360	9
					2013	2013	32	19	171	9
					2014	2014	46	32	512	16
					2015	2015	50	45	712	16
					2016	2016	56	48	432	9
					2017	2017	61	55	492	9
					2018	2018	70	61	553	9

Tubers

Table 34. Tuber production and performance per municipality

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
Colón	Arracacha	*Arracacia Xanthorrhiza*	Fresh Tuber	Annual	2013	2013	3	2	30	16,8
	Potato	*Solanum tuberosum*	Fresh Tuber	Transient	2006	2006B	5	5	49	9,7
					2007	2007A	5	3	30	10
					2007	2007B	4	4	40	10
					2008	2008A	3	3	30	10
					2008	2008B	3	3	30	10
					2009	2009A	4	4	40	10
					2009	2009B	6	6	60	10
					2015	2015A	6	6	60	10
	Criolle Potato	*Solanum tuberosum*	Fresh Tuber	Transient	2010	2010A	4	4	40	10

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2010	2010B	6	6	60	10
					2011	2011A	5	5	50	10
					2011	2011B	7	7	65	10
					2012	2012A	5	5	50	10
					2012	2012B	7	7	70	10
					2013	2013A	6	6	60	10
					2014	2014A	6	6	60	10
	Yacon	*Smallanthus sonchifolius*	Fresh Tuber	Annual	2015	2015	2	2	40	20
San Francisco	Potato	*Solanum tuberosum*	Fresh Tuber	Transient	2007	2007B	1	1	10	10
					2008	2008A	3	3	38	12,67
					2008	2008B	3	3	36	12
					2009	2009A	3	3	24	9,5
					2009	2009B	3	3	35	11,8
					2010	2010A	4	4	9	2,5
					2010	2010B	5	5	11	2,5
					2011	2011A	4	4	9	2,13
					2011	2011B	4	4	8	2,05
					2016	2016A	2	2	2	1
					2017	2017A	2	2	4	1,9
					2018	2018A	2	2	4	1,97
	Yacon	*Smallanthus sonchifolius*	Fresh Tuber	Annual	2015	2015	4	4	80	20
Santiago	Potato	*Solanum tuberosum*	Fresh Tuber	Transient	2006	2006B	6	6	53	8,9
					2007	2007A	10	8	72	9
					2007	2007B	5	5	45	9
					2008	2008A	5	5	45	9
					2008	2008B	6	6	55	9,17
					2009	2009A	6	6	56	9,3
					2009	2009B	6	6	56	9,3
					2010	2010A	6	6	56	9,3
					2010	2010B	6	6	56	9,3
					2011	2011A	6	6	56	9,3
					2011	2011B	6	6	56	9,3
					2012	2012A	6	6	56	9,3
					2012	2012B	6	6	56	9,3
					2015	2015A	11	11	110	10
					2016	2016A	5	5	56	11,7

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2017	2017A	10	10	20	2
					2018	2018A	10	10	21	2,07
	Criolle Potato	*Solanum tuberosum*	Fresh Tuber	Transient	2013	2013A	6	4	40	10
					2014	2014A	11	11	110	10
	Yacon	*Smallanthus sonchifolius*	Fresh Tuber	Annual	2015	2015	1	1	10	20
Sibundoy	Arracacha	*Arracacia Xanthorrhiza*	Fresh Tuber		2013	2013	3	2	30	16,8
	Potato	*Solanum tuberosum*	Fresh Tuber	Transient	2006	2006B	3	3	27	9
					2007	2007A	9	6	60	10
					2007	2007B	6	6	60	10
					2008	2008A	5	5	50	10
					2008	2008B	4	4	48	12
					2009	2009A	8	8	80	10
					2009	2009B	6	6	60	10
					2010	2010A	8	8	80	10
					2010	2010B	6	6	60	10
					2011	2011A	8	8	75	10
					2011	2011B	8	8	45	6
					2012	2012A	6	6	56	9,3
					2012	2012B	5	5	47	9,3
					2015	2015A	11	11	110	10
					2016	2016A	3	3	30	10
					2017	2017A	3	3	5	1,8
					2018	2018A	3	3	6	1,81
	Criolle Potato	*Solanum tuberosum*	Fresh Tuber	Transient	2013	2013A	8	6	60	10
					2014	2014A	10	10	100	10
	Yacon	*Smallanthus sonchifolius*	Fresh Tuber	Annual	2015	2015	10	10	200	20

Leguminous

Table 35. Leguminous production and performance per municipality

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
Colón	Pea	*Pisum sativum*	Dry grain	Transient	2007	2007B	1	1	1	0,99
					2008	2008A	2	2	3	1,25
					2008	2008B	5	5	8	1,65
					2009	2009A	1	1	2	1,5
					2009	2009B	8	6	6	1,05
					2010	2010A	1	1	1	1,2
					2010	2010B	8	6	8	1,33
					2011	2011A	2	2	3	1,5
					2011	2011B	9	9	16	1,78
					2012	2012A	2	2	3	1,32
					2012	2012B	9	9	12	1,32
					2013	2013A	5	4	5	1,3
					2014	2014A	8	8	8	1
					2015	2015A	8	8	9	1,06
	Bean	*Phaseolus vulgaris*	Dry grain	Transient	2007	2007A	153	153	133	0,87
					2008	2008A	146	146	131	0,9
					2009	2009A	146	146	138	0,95
					2010	2010A	146	146	200	1,37
					2011	2011A	92	92	131	1,42
					2012	2012A	88	88	113	1,3
					2013	2013A	82	40	48	1,2
					2014	2014B	126	126	188	1,49
					2015	2015B	164	164	213	1,3
					2016	2016B	200	150	345	2,3
					2017	2017B	200	200	322	1,61
San Francisco	Pea	*Pisum sativum*	Dry grain	Transient	2007	2007B	1	1	1	1,32
					2008	2008A	4	4	6	1,57
					2008	2008B	4	4	7	1,65
					2009	2009A	2	2	2	1,2
					2009	2009B	4	4	6	1,38
					2010	2010A	1	1	2	1,5
					2010	2010B	1	1	2	1,67
					2011	2011A	1	1	2	2

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2011	2011B	1	1	2	2
					2014	2014A	15	15	15	1
					2015	2015A	15	15	16	1,06
					2016	2016A	2	2	4	1,8
					2017	2017A	10	10	8	0,84
					2018	2018A	10	10	9	0,85
	Bean	*Phaseolus vulgaris*	Dry grain	Transient	2007	2007A	319	298	279	0,94
					2008	2008A	80	78	70	0,9
					2009	2009A	79	77	96	1,25
					2010	2010A	220	200	360	1,8
					2011	2011A	200	190	330	1,74
					2011	2011B	150	140	240	1,71
					2014	2014B	80	80	111	1,39
					2015	2015B	104	104	135	1,3
					2016	2016B	255	248	570	2,3
					2017	2017B	250	245	377	1,54
Santiago	Pea	*Pisum sativum*	Dry grain	Transient	2007	2007B	2	2	3	1,65
					2008	2008A	3	3	5	1,65
					2008	2008B	3	3	7	2,2
					2009	2009A	4	4	4	1,05
					2009	2009B	5	5	4	0,86
					2010	2010A	4	4	5	1,2
					2010	2010B	5	5	4	0,86
					2011	2011A	6	6	9	1,64
					2011	2011B	6	6	10	1,82
					2012	2012A	7	6	12	2,15
					2012	2012B	6	6	13	2,21
					2014	2014A	15	15	15	1
					2015	2015A	15	15	16	1,06
					2016	2016A	20	18	45	2,5
					2017	2017A	20	20	19	0,93
					2018	2018A	20	20	19	0,95
	Bean	*Phaseolus vulgaris*	Dry grain	Transient	2007	2007A	145	144	219	1,52
					2008	2008A	100	98	91	0,93
					2009	2009A	100	98	100	1,02
					2010	2010A	120	118	137	1,16

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
					2011	2011A	123	112	182	1,63
					2012	2012A	145	100	126	1,26
					2013	2013A	127	100	130	1,3
					2014	2014B	83	83	132	1,59
					2015	2015B	107	107	139	1,3
					2016	2016B	120	110	253	2,3
					2017	2017B	100	100	161	1,61
Sibundoy	Pea	*Pisum sativum*	Dry grain	Transient	2007	2007B	1	1	1	0,99
					2008	2008A	5	5	6	1,16
					2008	2008B	4	4	4	0,99
					2009	2009A	3	3	3	1,07
					2009	2009B	6	6	6	1,07
					2010	2010A	3	3	4	1,2
					2010	2010B	6	6	4	0,7
					2011	2011A	5	5	5	1
					2011	2011B	7	7	6	0,94
					2012	2012A	8	7	15	2,15
					2012	2012B	6	6	13	2,15
					2013	2013A	5	4	5	1,3
					2014	2014A	17	17	17	1
					2015	2015A	17	17	18	1,06
					2016	2016A	5	4	10	2,5
					2017	2017A	4	4	3	0,89
					2018	2018A	4	4	4	0,91
	Bean	*Phaseolus vulgaris*	Dry grain	Transient	2007	2007A	294	284	235	0,83
					2008	2008A	144	144	126	0,88
					2009	2009A	162	11	28	2,5
					2010	2010A	162	22	30	1,38
					2011	2011A	165	12	20	1,67
					2012	2012A	196	166	232	1,4
					2013	2013A	320	180	216	1,2
					2014	2014B	223	223	392	1,76
					2015	2015B	290	290	377	1,3
					2016	2016A	296	285	713	2,5
					2017	2017B	305	290	507	1,75

Figure 10. Conventional Bean Plantation

Aromatic Plants

Table 36. Aromatic production and performance per municipality

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
Colón	Basil	*Ocimum basilicum*	Fresh leaf	Permanent	2008	2008	1	1	1	1
					2009	2009	1	1	1	1
					2010	2010	1	1	1	1
				Transient	2011	2011A	2	1	1	1
	Aromatic Plants		Fresh leaf	Permanent	2007	2007	3	3	20	6,67
San Francisco	Basil	*Ocimum basilicum*	Fresh leaf	Permanent	2009	2009	2	1	1	1
	Aromatic Plants		Fresh leaf	Permanent	2007	2007	3	3	20	6,67
					2009	2009	1	0	0	
Santiago	Aromatic Plants				2007	2007	5	5	28	5,6
Sibundoy	Basil	*Ocimum basilicum*	Fresh leaf	Permanent	2009	2009	25	20	20	1
					2010	2010	25	19	19	1

				Transient	2011	2011A	20	15	15	1
	Aromatic Plants		Fresh leaf	Permanent	2007	2007	8	8	52	6,5
					2009	2009	20	20	20	1
					2010	2010	20	18	18	1
				Transient	2011	2011A	18	15	15	1

Vegetables

Table 37. Vegetable production and performance per municipality

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
Colón	Chard	*Beta vulgaris*	Fresh fruit	Transient	2013	2013A	4	3	35	12,5
					2013	2013B	5	4	44	12,5
	Kale	*Brassica oleracea var. Acephala*	Fresh vegetable	Transient	2013	2013A	5	3	45	15,1
					2013	2013B	5	4	56	15,1
San Francisco	Chard	*Beta vulgaris*	Fresh fruit	Transient	2010	2010A	1	1	3	2,7
					2010	2010B	2	1	4	2,7
	Branch onion	*Allium fistulosum*	Fresh vegetable	Transient	2010	2010A	1	1	3	3
					2010	2010B	1	1	3	3
	Coriander	*Coriandrum sativum*	Fresh vegetable	Transient	2010	2010A	1	1	4	3
					2010	2010B	1	1	4	3
	Lettuce	*Lactuca sativa*	Fresh vegetable	Transient	2010	2010A	2	1	4	2,7
					2010	2010B	2	1	4	2,7
	Cabbage	*Brassica oleracea var. Capitana*	Fresh vegetable	Transient	2010	2010A	1	1	5	5
					2010	2010B	1	1	5	5
	Tomato	*Lycopersicum esculetum*	Fresh vegetable	Transient	2009	2009A	8	5	200	40
	Carrot	*Daucus carota*	Fresh vegetable	Transient	2010	2010A	2	1	14	11
					2010	2010B	2	1	15	11
Santiago	Chard	*Beta vulgaris*	Fresh fruit	Transient	2013	2013A	5	4	38	10,6
					2013	2013B	5	4	40	10,6
	Branch onion	*Allium fistulosum*	Fresh vegetable	Transient	2013	2013A	5	4	44	11
					2013	2013B	5	5	56	11,1
	Kale	*Brassica oleracea var. Acephala*	Fresh vegetable	Transient	2013	2013A	5	4	48	11,1
					2013	2013B	5	4	44	11,1
	Cucumber	*Cucumis sativus*	Fresh vegetable	Transient	2013	2013A	2	1	12	12
	Tomato	*Lycopersicum esculetum*	Fresh vegetable	Transient	2009	2009A	58	4	36	9
					2010	2010A	58	5	36	7,2
					2011	2011A	61	6	54	9
Sibundoy	Chard	*Beta vulgaris*	Fresh fruit	Transient	2013	2013A	5	5	63	12,5
					2013	2013B	5	4	44	12,5

Municipality	Crop	Scientific Name	Physical State Production	Crop Cycle	Year	Period	Sown Area (ha)	Harvested Area (ha)	Production (ton)	Performance (ton/ha)
	Branch onion	*Allium fistulosum*	Fresh vegetable	Transient	2013	2013B	2	2	20	10
	Kale	*Brassica oleracea var. Acephala*	Fresh vegetable	Transient	2013	2013A	5	5	76	15,1
					2013	2013B	5	4	56	15,1

Chagra Production

Traditional practice production data turned out to be very scarce and not standardised. Despite much of the literature about the Chagra pointing out at a well settled the method. Visits to the field proved the practice is far more dynamic than previously described and it was clear that it allows the inclusion of many foreign species that may be found to have any form of value to the owners.

The Chagra practice is a form of integrated polyculture that indigenous peoples of the Amazon region have practiced for generations. The main characteristic of a Chagra is a great diversity of plants grown in a small area. The purpose of the Chagra is self-sufficiency, although there is a surplus that indigenous trade in special markets held on Sundays at the main towns.

The method is dynamic and allows the inclusion of new species as travellers and trade bring new seeds that people find useful for medicine, fibre, wood or food. By the time of the study, one of the most recent acquisitions gaining interest was the avocado, which was introduced into the valley about 20 years ago and has become increasingly popular due to its flavour, uses and demand. Different farm animals are integrated. Starting with the native “cuy” (guinea pig) which is always present and the introduced hares, chickens, turkeys, sheep, cows and pigs. It is traditional for indigenous people to pick the manure of the animals they own and prepare an organic fertiliser. (Agreda, 2016)

Figure 11. Farmers selling the surplus of the Chagra in the market

The Chagra farms in the Sibundoy valley are a repository for many unique types of beans and corn as well as some medicinal plants that are mostly original of the region. The elders or taitas tend to keep robust botanic gardens in their houses and have a great array of medicinal plants, many of which are natural to the lower amazon region. It was interesting to notice they have introduced Eucalyptus in their plantations and use the sprouts for medicinal purposes.

The extension of a Chagra depends on the size of the land owned by a family. A small orchard inside the urban centre, where space is limited, can measure about 15m^2, but in average they tend to be slightly larger than 100m^2. In the rural areas, larger spaces are used for grazing of cattle and often have an area dedicated to corn and bean crops. When the corn is ripe, the sticks are left standing and bean is planted on it. In a way transitioning towards conventional agriculture.

Figure 12. Set up for cuy inside a Chagra

Some of the plants reported in the Chagras visited were the tranca bean, choclo corn, chachaporroto (big bean), sugar cane, guasimba, tumaqueño, cuna, ñame, col, sidra, chilli peppers, achira, curuba, reina, tree tomato, pumpkin, coriander, cabbage, carrot, onion, blackberry, moquillo, motilon, calendula, peppermint, densansé, rosemary, mint, cedar, neldo,, red eucalyptus and oak.

Figure 13. Beans growing on the sticks of the corn

ENSO data

ENSO data was obtained from NOAA in the form of historical Oceanic Niño Index (ONI). The method used to obtain the data is called NOAA Extended Reconstructed Sea Surface Temperature (SST) V5 (Also referred to as ERSST.v5 STT). And is produced by taking a monthly record and making an average with the two months that preceded.

ERSST.v5 STT is a global monthly analysis of the sea surface temperature set from 1854 to present which derives from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). The Version 5 is the result of improvements in spatial and temporal variability. The ERSST is suitable for long-term global and basin-wide studies. (Huang *et al*, 2017).

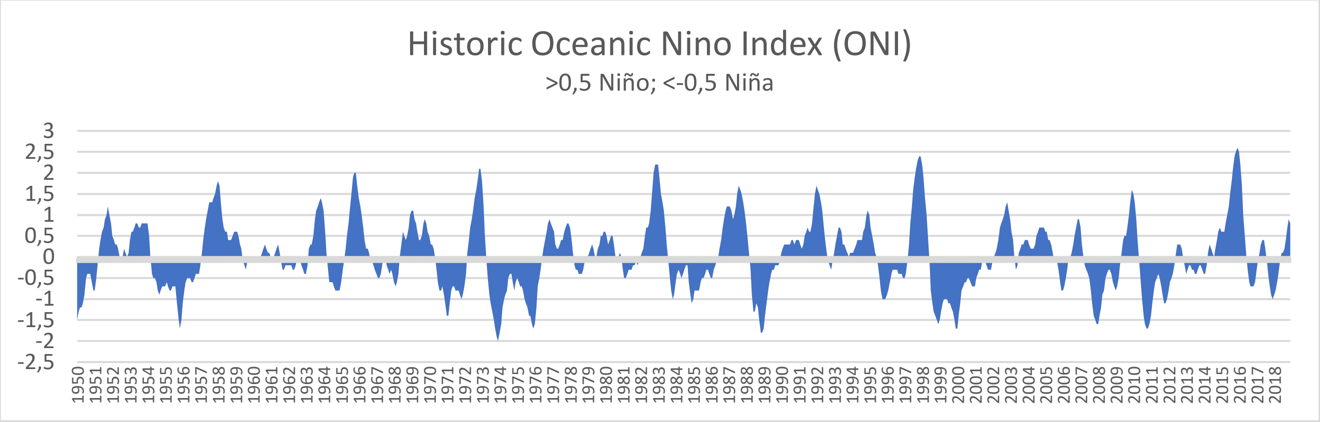
Periods that range around 0°C from -0,5°C to 0,5°C are considered “normal”. When the average temperature value for three months running ERSST.v5 STT in the Niño 3.4 region (5°N-5°S, 120°-170°W) is above 0,5°C, it is considered a Niño Anomaly or Niño event. When the temperature is below -0,5°C, it is considered a Niña Anomaly or Niña event. Warm and cold periods are presented in red and blue colours respectively. The colours display historical periods in which the threshold is met for minimum of 5 consecutive overlapping seasons.

Table 38. Oceanic Nino Index (ONI) (NOAA,2019)

Year	**DJF**	**JFM**	**FMA**	**MAM**	**AMJ**	**MJJ**	**JJA**	**JAS**	**ASO**	**SON**	**OND**	**NDJ**
1950	**-1,5**	**-1,3**	**-1,2**	**-1,2**	**-1,1**	**-0,9**	**-0,5**	-0,4	-0,4	-0,4	-0,6	-0,8
1951	-0,8	-0,5	-0,2	0,2	0,4	**0,6**	**0,7**	**0,9**	**1**	**1,2**	**1**	**0,8**
1952	**0,5**	0,4	0,3	0,3	0,2	0	-0,1	0	0,2	0,1	0	0,1
1953	0,4	**0,6**	**0,6**	**0,7**	**0,8**	**0,8**	**0,7**	**0,7**	**0,8**	**0,8**	**0,8**	**0,8**
1954	**0,8**	**0,5**	0	-0,4	**-0,5**	**-0,5**	**-0,6**	**-0,8**	**-0,9**	**-0,8**	**-0,7**	**-0,7**
1955	**-0,7**	**-0,6**	**-0,7**	**-0,8**	**-0,8**	**-0,7**	**-0,7**	**-0,7**	**-1,1**	**-1,4**	**-1,7**	**-1,5**
1956	**-1,1**	**-0,8**	**-0,6**	**-0,5**	**-0,5**	**-0,5**	**-0,6**	**-0,6**	**-0,5**	-0,4	-0,4	-0,4
1957	-0,2	0,1	0,4	**0,7**	**0,9**	**1,1**	**1,3**	**1,3**	**1,3**	**1,4**	**1,5**	**1,7**
1958	**1,8**	**1,7**	**1,3**	**0,9**	**0,7**	**0,6**	**0,6**	0,4	0,4	0,4	**0,5**	**0,6**
1959	**0,6**	**0,6**	**0,5**	0,3	0,2	-0,1	-0,2	-0,3	-0,1	0	0	0
1960	-0,1	-0,1	-0,1	0	0	0	0,1	0,2	0,3	0,2	0,1	0,1
1961	0	0	0	0,1	0,2	0,3	0,1	-0,1	-0,3	-0,3	-0,2	-0,2
1962	-0,2	-0,2	-0,2	-0,3	-0,3	-0,2	0	-0,1	-0,1	-0,2	-0,3	-0,4
1963	-0,4	-0,2	0,2	0,3	0,3	**0,5**	**0,9**	**1,1**	**1,2**	**1,3**	**1,4**	**1,3**
1964	**1,1**	**0,6**	0,1	-0,3	**-0,6**	**-0,6**	**-0,6**	**-0,7**	**-0,8**	**-0,8**	**-0,8**	**-0,8**
1965	**-0,6**	-0,3	-0,1	0,2	**0,5**	**0,8**	**1,2**	**1,5**	**1,9**	**2**	**2**	**1,7**
1966	**1,4**	**1,2**	**1**	**0,7**	0,4	0,2	0,2	0,1	-0,1	-0,1	-0,2	-0,3
1967	-0,4	-0,5	-0,5	-0,4	-0,2	0	0	-0,2	-0,3	-0,4	-0,3	-0,4
1968	-0,6	-0,7	-0,6	-0,4	0	0,3	0,6	0,5	0,4	**0,5**	**0,7**	**1**
1969	**1,1**	**1,1**	**0,9**	**0,8**	**0,6**	0,4	0,4	**0,5**	**0,8**	**0,9**	**0,8**	**0,6**
1970	**0,5**	0,3	0,3	0,2	0	-0,3	**-0,6**	**-0,8**	**-0,8**	**-0,7**	**-0,9**	**-1,1**
1971	**-1,4**	**-1,4**	**-1,1**	**-0,8**	**-0,7**	**-0,7**	**-0,8**	**-0,8**	**-0,8**	**-0,9**	**-1**	**-0,9**
1972	**-0,7**	-0,4	0,1	0,4	**0,7**	**0,9**	**1,1**	**1,4**	**1,6**	**1,8**	**2,1**	**2,1**
1973	**1,8**	**1,2**	**0,5**	-0,1	**-0,5**	**-0,9**	**-1,1**	**-1,3**	**-1,5**	**-1,7**	**-1,9**	**-2**
1974	**-1,8**	**-1,6**	**-1,2**	**-1**	**-0,9**	**-0,8**	**-0,5**	-0,4	-0,4	**-0,6**	**-0,8**	**-0,6**
1975	**-0,5**	**-0,6**	**-0,7**	**-0,7**	**-0,8**	**-1**	**-1,1**	**-1,2**	**-1,4**	**-1,4**	**-1,6**	**-1,7**
1976	**-1,6**	**-1,2**	**-0,7**	**-0,5**	-0,3	0	0,2	0,4	**0,6**	**0,8**	**0,9**	**0,8**
1977	**0,7**	**0,6**	0,3	0,2	0,2	0,3	0,4	0,4	**0,6**	**0,7**	**0,8**	**0,8**
1978	**0,7**	0,4	0,1	-0,2	-0,3	-0,3	-0,4	-0,4	-0,4	-0,3	-0,1	0
1979	0	0,1	0,2	0,3	0,2	0	0	0,2	0,3	**0,5**	**0,5**	**0,6**
1980	**0,6**	**0,5**	0,3	0,4	0,5	0,5	0,3	0	-0,1	0	0,1	0
1981	-0,3	-0,5	-0,5	-0,4	-0,3	-0,3	-0,3	-0,2	-0,2	-0,1	-0,2	-0,1
1982	0	0,1	0,2	**0,5**	**0,7**	**0,7**	**0,8**	**1,1**	**1,6**	**2**	**2,2**	**2,2**

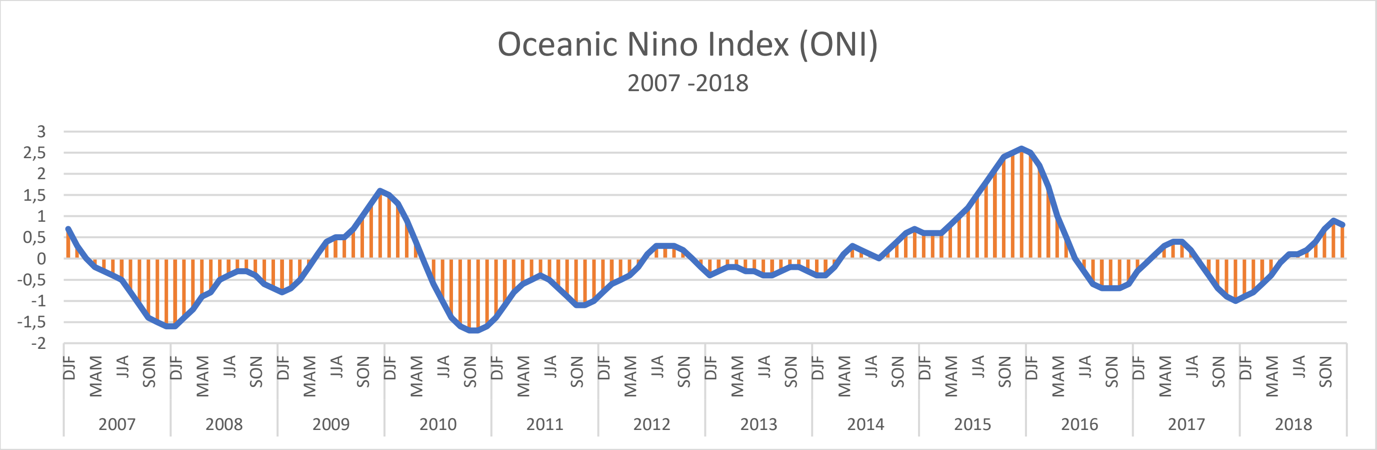
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1983	**2,2**	**1,9**	**1,5**	**1,3**	**1,1**	**0,7**	0,3	-0,1	**-0,5**	**-0,8**	**-1**	**-0,9**
1984	**-0,6**	-0,4	-0,3	-0,4	-0,5	-0,4	-0,3	-0,2	-0,2	**-0,6**	**-0,9**	**-1,1**
1985	**-1**	**-0,8**	**-0,8**	**-0,8**	**-0,8**	**-0,6**	**-0,5**	**-0,5**	-0,4	-0,3	-0,3	-0,4
1986	-0,5	-0,5	-0,3	-0,2	-0,1	0	0,2	0,4	**0,7**	**0,9**	**1,1**	**1,2**
1987	**1,2**	**1,2**	**1,1**	**0,9**	**1**	**1,2**	**1,5**	**1,7**	**1,6**	**1,5**	**1,3**	**1,1**
1988	**0,8**	**0,5**	0,1	-0,3	**-0,9**	**-1,3**	**-1,3**	**-1,1**	**-1,2**	**-1,5**	**-1,8**	**-1,8**
1989	**-1,7**	**-1,4**	**-1,1**	**-0,8**	**-0,6**	-0,4	-0,3	-0,3	-0,2	-0,2	-0,2	-0,1
1990	0,1	0,2	0,3	0,3	0,3	0,3	0,3	0,4	0,4	0,3	0,4	0,4
1991	0,4	0,3	0,2	0,3	**0,5**	**0,6**	**0,7**	**0,6**	**0,6**	**0,8**	**1,2**	**1,5**
1992	**1,7**	**1,6**	**1,5**	**1,3**	**1,1**	**0,7**	0,4	0,1	-0,1	-0,2	-0,3	-0,1
1993	0,1	0,3	0,5	0,7	0,7	0,6	0,3	0,3	0,2	0,1	0	0,1
1994	0,1	0,1	0,2	0,3	0,4	0,4	0,4	0,4	**0,6**	**0,7**	**1**	**1,1**
1995	**1**	**0,7**	**0,5**	0,3	0,1	0	-0,2	**-0,5**	**-0,8**	**-1**	**-1**	**-1**
1996	**-0,9**	**-0,8**	**-0,6**	-0,4	-0,3	-0,3	-0,3	-0,3	-0,4	-0,4	-0,4	-0,5
1997	-0,5	-0,4	-0,1	0,3	**0,8**	**1,2**	**1,6**	**1,9**	**2,1**	**2,3**	**2,4**	**2,4**
1998	**2,2**	**1,9**	**1,4**	**1**	**0,5**	-0,1	**-0,8**	**-1,1**	**-1,3**	**-1,4**	**-1,5**	**-1,6**
1999	**-1,5**	**-1,3**	**-1,1**	**-1**	**-1**	**-1**	**-1,1**	**-1,1**	**-1,2**	**-1,3**	**-1,5**	**-1,7**
2000	**-1,7**	**-1,4**	**-1,1**	**-0,8**	**-0,7**	**-0,6**	**-0,6**	**-0,5**	**-0,5**	**-0,6**	**-0,7**	**-0,7**
2001	**-0,7**	**-0,5**	-0,4	-0,3	-0,3	-0,1	-0,1	-0,1	-0,2	-0,3	-0,3	-0,3
2002	-0,1	0	0,1	0,2	0,4	**0,7**	**0,8**	**0,9**	**1**	**1,2**	**1,3**	**1,1**
2003	**0,9**	**0,6**	0,4	0	-0,3	-0,2	0,1	0,2	0,3	0,3	0,4	0,4
2004	0,4	0,3	0,2	0,2	0,2	0,3	**0,5**	**0,6**	**0,7**	**0,7**	**0,7**	**0,7**
2005	**0,6**	**0,6**	0,4	0,4	0,3	0,1	-0,1	-0,1	-0,1	-0,3	**-0,6**	**-0,8**
2006	**-0,8**	**-0,7**	**-0,5**	-0,3	0	0	0,1	0,3	**0,5**	**0,7**	**0,9**	**0,9**
2007	**0,7**	0,3	0	-0,2	-0,3	-0,4	**-0,5**	**-0,8**	**-1,1**	**-1,4**	**-1,5**	**-1,6**
2008	**-1,6**	**-1,4**	**-1,2**	**-0,9**	**-0,8**	**-0,5**	-0,4	-0,3	-0,3	-0,4	**-0,6**	**-0,7**
2009	**-0,8**	**-0,7**	**-0,5**	-0,2	0,1	0,4	**0,5**	**0,5**	**0,7**	**1**	**1,3**	**1,6**
2010	**1,5**	**1,3**	**0,9**	0,4	-0,1	**-0,6**	**-1**	**-1,4**	**-1,6**	**-1,7**	**-1,7**	**-1,6**
2011	**-1,4**	**-1,1**	**-0,8**	**-0,6**	**-0,5**	-0,4	**-0,5**	**-0,7**	**-0,9**	**-1,1**	**-1,1**	**-1**
2012	**-0,8**	**-0,6**	**-0,5**	-0,4	-0,2	0,1	0,3	0,3	0,3	0,2	0	-0,2
2013	-0,4	-0,3	-0,2	-0,2	-0,3	-0,3	-0,4	-0,4	-0,3	-0,2	-0,2	-0,3
2014	-0,4	-0,4	-0,2	0,1	0,3	0,2	0,1	0	0,2	0,4	**0,6**	**0,7**
2015	**0,6**	**0,6**	**0,6**	**0,8**	**1**	**1,2**	**1,5**	**1,8**	**2,1**	**2,4**	**2,5**	**2,6**
2016	**2,5**	**2,2**	**1,7**	**1**	**0,5**	0	-0,3	**-0,6**	**-0,7**	**-0,7**	**-0,7**	**-0,6**
2017	-0,3	-0,1	0,1	0,3	0,4	0,4	0,2	-0,1	-0,4	**-0,7**	**-0,9**	**-1**
2018	**-0,9**	**-0,8**	**-0,6**	-0,4	-0,1	0,1	0,1	0,2	0,4	0,7	0,9	0,8
2019	**0,8**	**0,8**	**0,8**									

When set on a continuous timeline, the Historic Oceanic Niño Index (ONI) reveals a great deal of climatic variability. Climate is always changing, therefore, one of the greatest challenges of scientists in this age has been to determine how much of that change, if any, is due to human development. During such a short time scope in climatic terms there is a visible gradual increase in the temperature of the extreme Niño anomalies, but there is no observable tendency on the Niña side.



Whether this is evidence of anthropogenic climate change belongs to a different discussion. However, as mentioned before, there has been a great deal of environmental changes caused by human development during the last few decades and nothing should be dismissed at this point. Much less when considering that there is not enough understanding of climate variability, and therefore, the effects of climate change are unpredictable and in the worst scenario could potentially endanger life on the planet.

Since most multiannual agricultural production reports start in 2007 and end in 2018, the fragment of ONI information used for the analysis covers that same period. The ONI data presents two phases of strong Niña anomalies from 2007 to 2009 and from 2010 to 2012 and a weak phase from late 2017 to early 2018. During the same period there have been two phases of strong Niño anomalies from 2009 to 2010 and from 2015 to 2016. By the end of 2015, the Niño presented the highest ONI average temperature ever recorded by reaching 2.6°C. There were two “normal” phases with temperatures ranging between -0.5°C and 0.5°C, there was a long phase from 2012 to early 2015 and a short one from 2016 to 2017.



A comparison was made between the stability in the production of conventional agricultural production in the Sibundoy Valley with extreme ENSO related events. Considering the amount of information available, only the crops with many years reported were chosen for that purpose.

When gathering historical climatic data to determine the climate and understand its variability, it is recommended to use periods of no less than 30 years for climatic analysis. However, a period of 30 years may not be enough to capture the full potential range of climatic variation. The stability of extreme events is likely not to be fully observable. (WMO, 2017)

The solar cycle is often the baseline for climatic studies with ranges of 11 years from solar min to max and 11 more from solar max to min. This means a 22 years cycle can reveal the behaviour during one whole solar cycle. To fully understand variation caused by the solar influence, it is required to have meteorological data of many solar cycles. (Landcheidt, 2000) Since most climatic stations worldwide have been setup during the last century. There is not enough multiannual information to fully comprehend the nature of climatic variation.

This conforms an issue in using local climatic datasets. Much of the information is incomplete as all climatological stations in the Sibundoy Valley were opened decades ago and many were closed not long after. In some zones of the Valley there is not enough data available for calculating a precise reference climatological standard and most climatic descriptions of the region are the result of extrapolation of altitudinal means with meteorological data.

There is evidence that the distribution of hydrometeorological variables such as local average or extreme rainfall is modulated by global climate drivers such as ENSO (Sun e*t al,* 2014) This is advantageous as the ONI dataset provides ongoing information from the year 1950. However, there is still much work to be done in fully understanding the ways in which ENSO controls the rainfall variability at a local level, particularly in remote areas where gathering up of climate data has not been done aptly.

Finding information regarding agricultural production proved to be another issue. Gathering of production data in the Sibundoy Valley used to be made informally for accounting purposes. Until recently, the gremial associations were not fully organised for greater purposes than loans and cooperation in the region. There have been great efforts on behalf of the different instances of government in terms of accounting for all that is produced by the agricultural sector in the last two decades. However, usable production data started to be gathered in a standardised manner since 2007. This means the data available is not significant from a climate scale and models regarding production and climate can only be seen a first approximation to the subject.

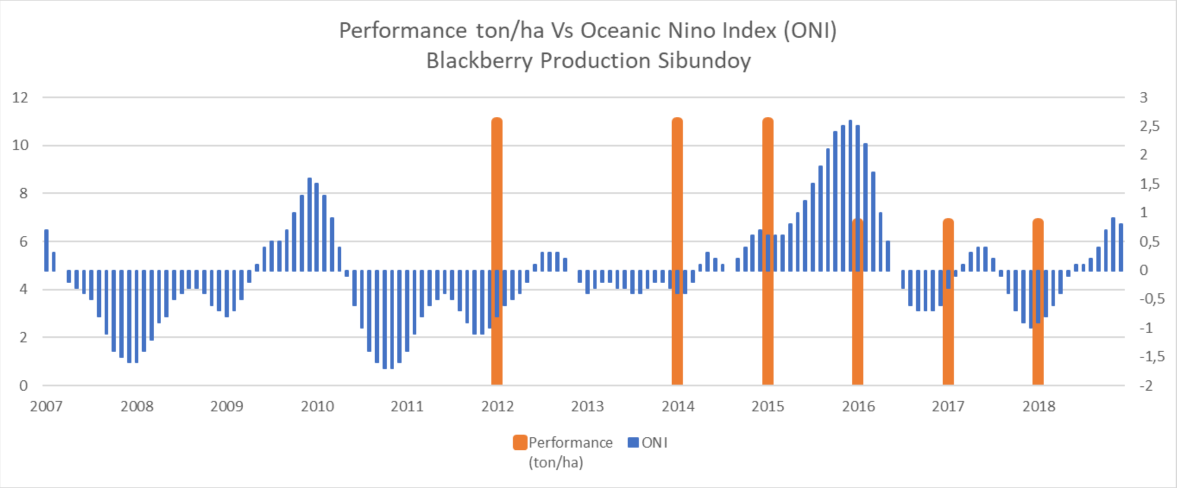
Some graphs were made to over-impose conventional agricultural annual production with ONI data. At first sight there seems to be a great increase in the performance of the crops during the long normal phase of 2012 – 2015. But that was not always the case. Almost all crops performed poorly during the second Niño phase and during the years after. This could indicate an adverse effect caused by a reduction in precipitations. However, it does not serve to understand why the performance decreased during the years after.

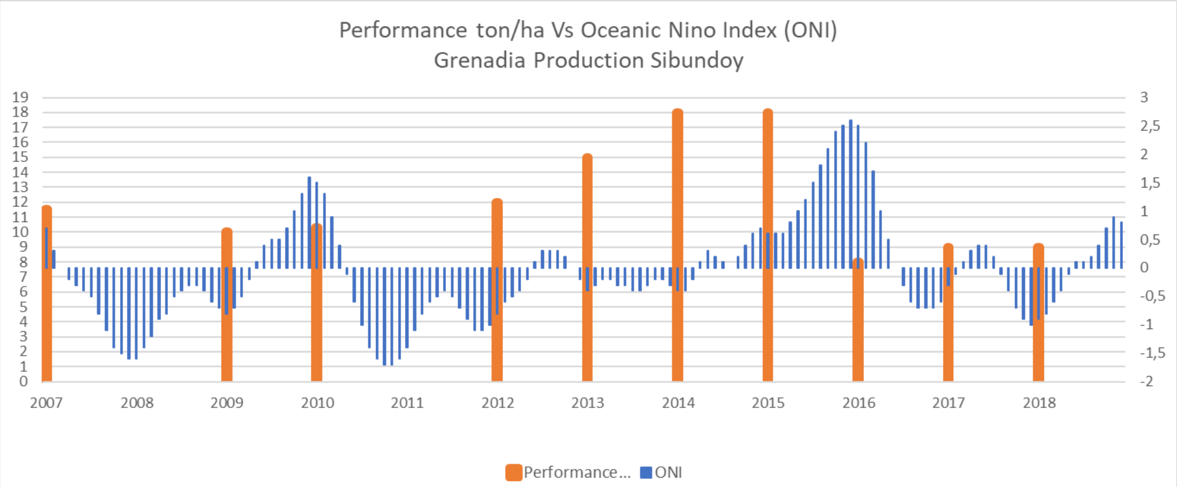
The potato production was remarkable as it remained constant with two harvests a year independently of the phase. However, there were many years when there was no production reported. The reliability of the information must be questioned as there was no description about how it was obtained or about why there were no reports during certain years. It does not seem feasible that all the producers in a municipality would stop producing during certain years.

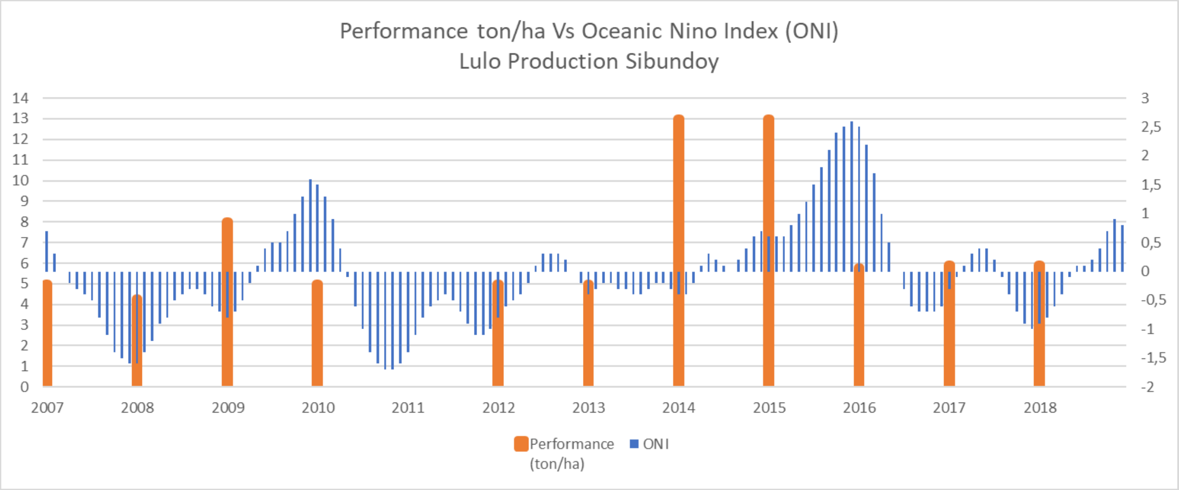
It should be expected that crops that require greater amounts of water would be better off during the Niña events when time is rainier and crops that grow better with less water would be better off during the Niño events. Nevertheless, that was not always the case. There are other variables affecting the results, and climatic data alone is not enough to understand such behaviour.

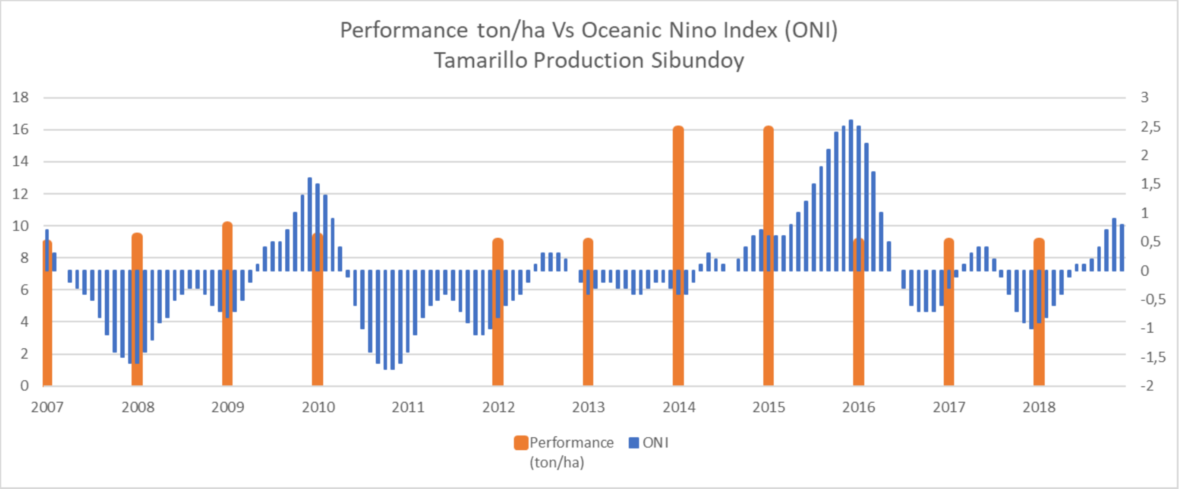
It seems clear that to fully understand the climate impact on crop production other variables need to be isolated. The information obtained was too general due to be presented at a Municipality scale. There is no data regarding the use of fertilisers and nuances about farms are not specified. It is not possible to differentiate a crop set on the north of the central depression from one set on the south or from one set on the edges where the slope increases.

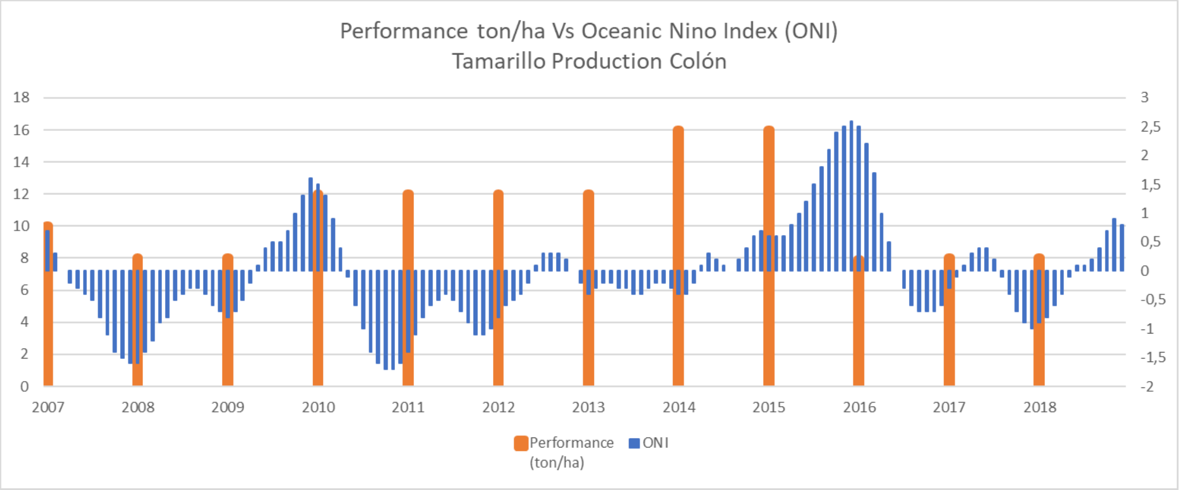
Fruit Production

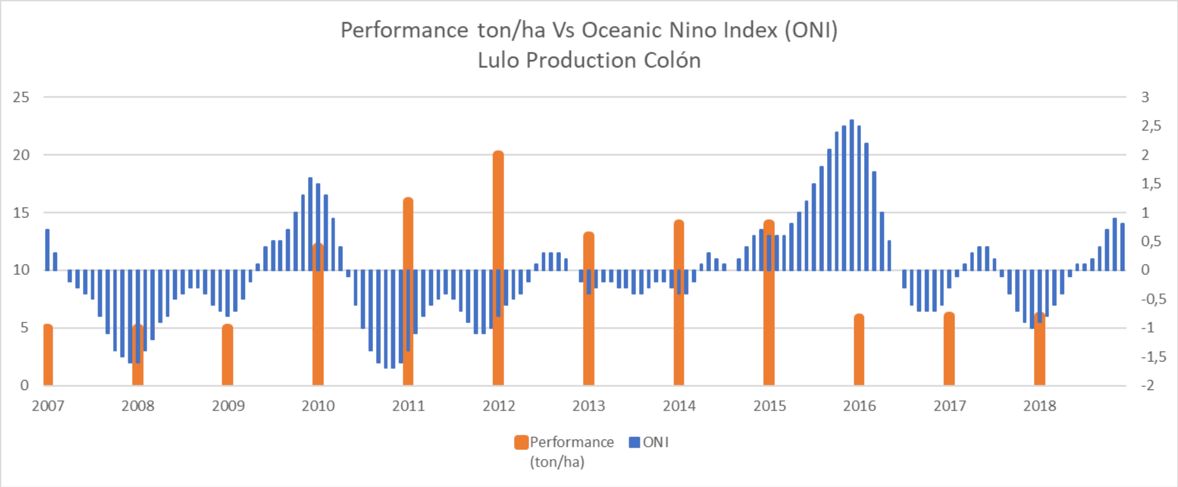


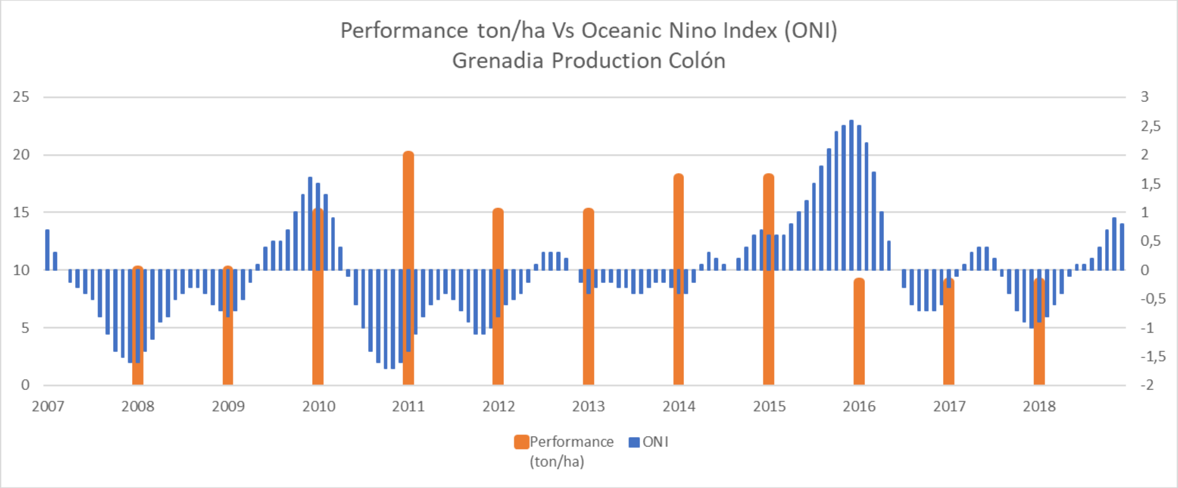


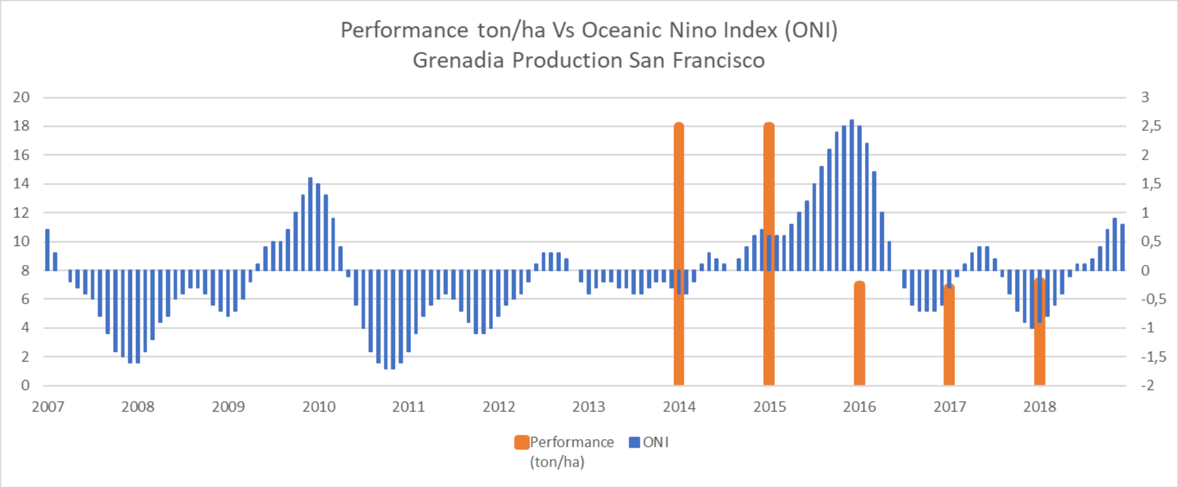

Performance ton/ha Vs Oceanic Nino Index (ONI)
Lulo Production Sibundoy

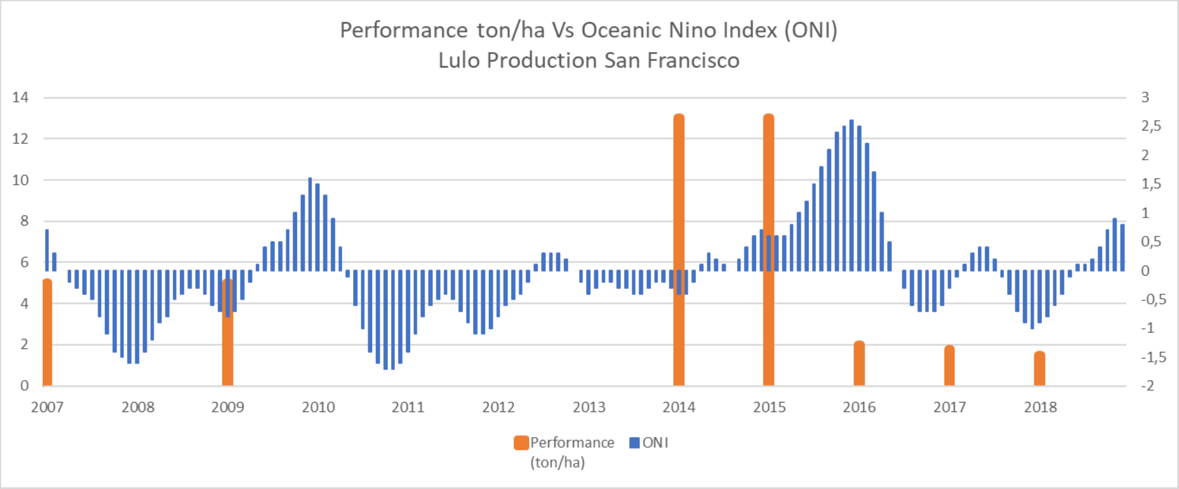

Performance ton/ha Vs Oceanic Nino Index (ONI)
Tamarillo Production Sibundoy

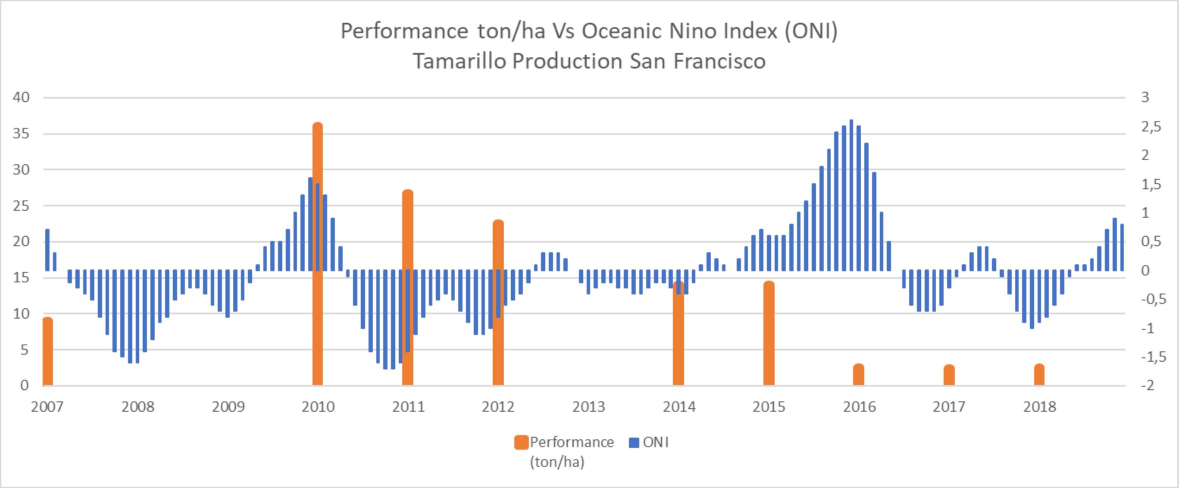

Performance ton/ha Vs Oceanic Nino Index (ONI)
Tamarillo Production Colón

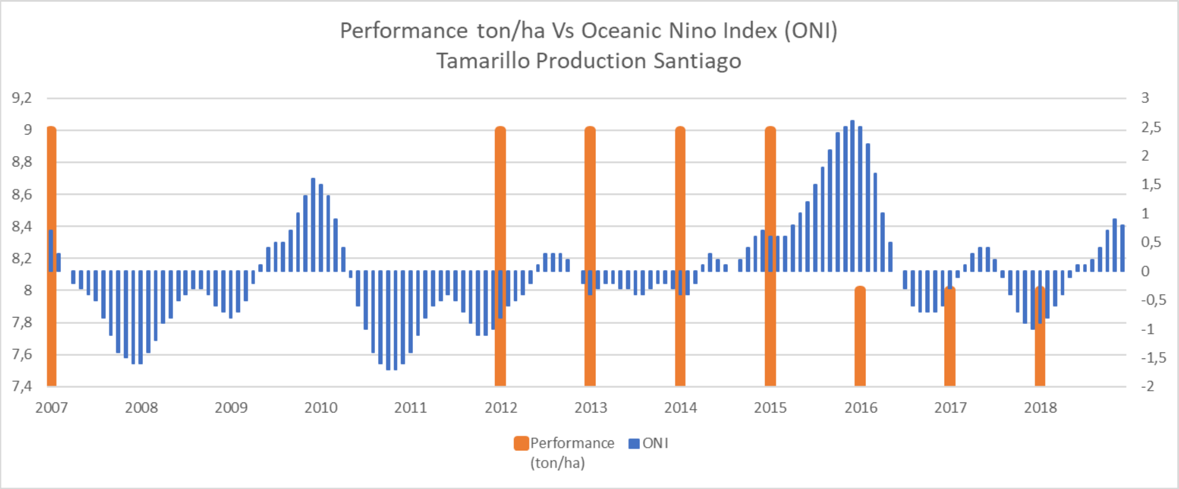

Performance ton/ha Vs Oceanic Nino Index (ONI)
Lulo Production Colón
25
20
15
10
5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI

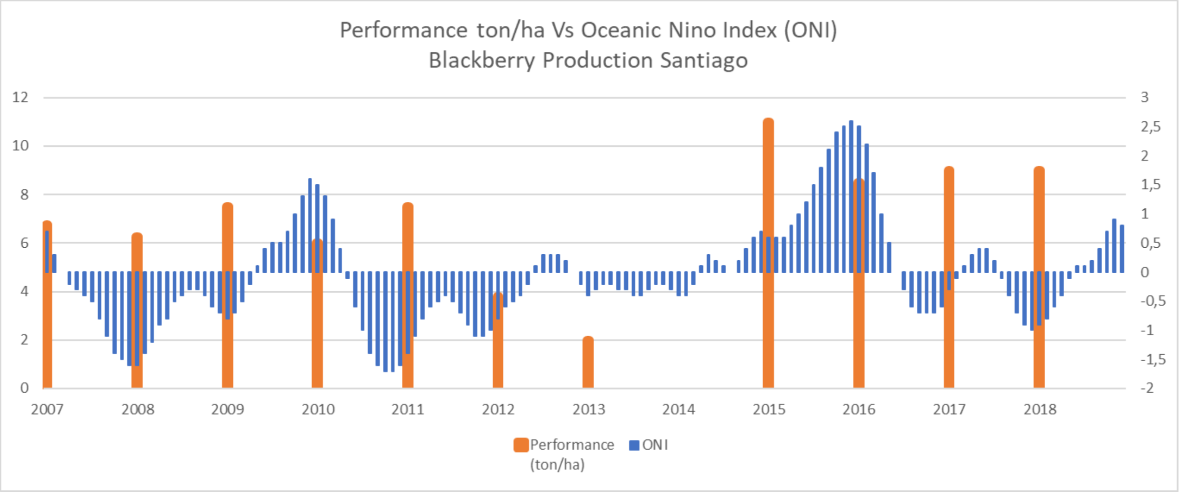

Performance ton/ha Vs Oceanic Nino Index (ONI)
Grenadia Production Colón
25
20
15
10
5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI

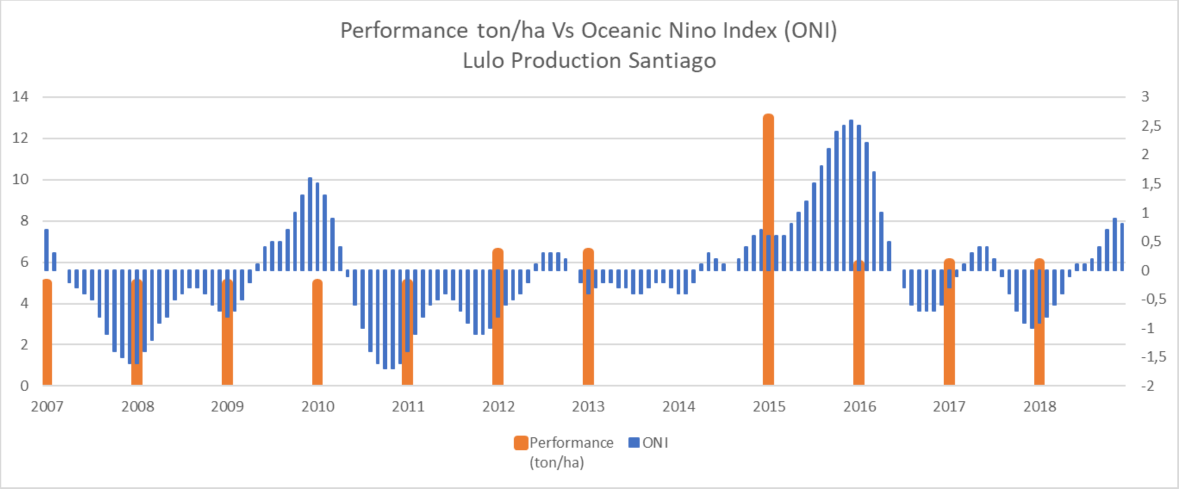

Performance ton/ha Vs Oceanic Nino Index (ONI)
Grenadia Production San Francisco
20
18
16
14
12
10
8
6
4
2
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI

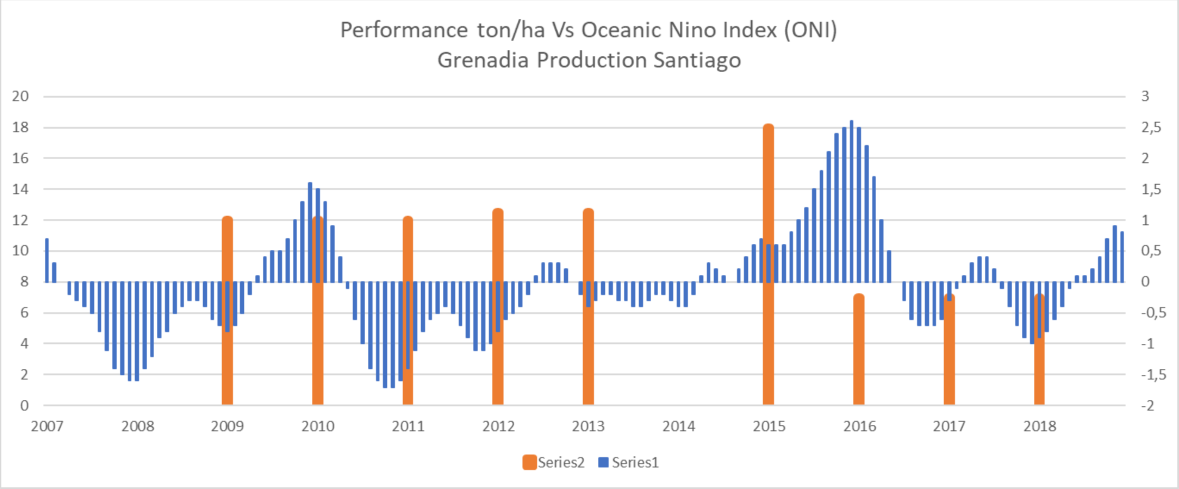

Performance ton/ha Vs Oceanic Nino Index (ONI)
Lulo Production San Francisco


Performance ton/ha Vs Oceanic Nino Index (ONI)
Tamarillo Production San Francisco

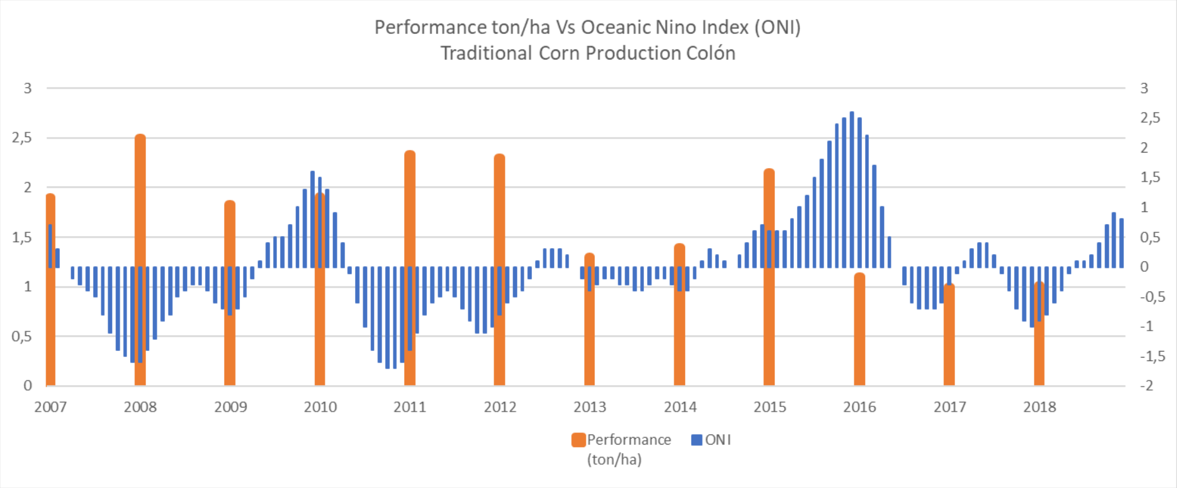

Performance ton/ha Vs Oceanic Nino Index (ONI)
Tamarillo Production Santiago

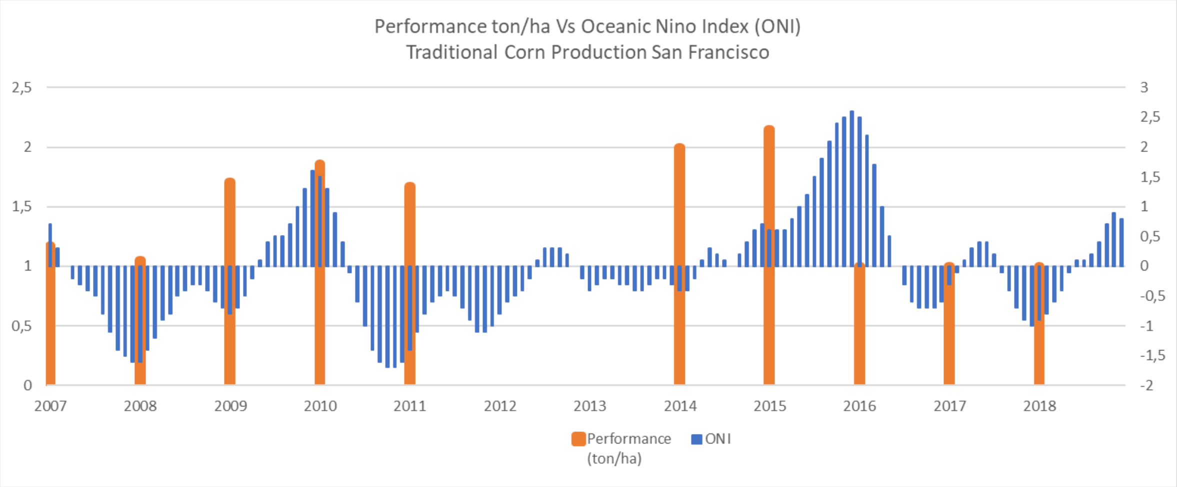

Performance ton/ha Vs Oceanic Nino Index (ONI)
Blackberry Production Santiago
12
10
8
6
4
2
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Lulo Production Santiago
14
12
10
8
6
4
2
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Grenadia Production Santiago
20
18
16
14
12
10
8
6
4
2
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Series2
Series1

Cereals


Performance ton/ha Vs Oceanic Nino Index (ONI)
Traditional Corn Production Colón
3
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Traditional Corn Production San Francisco
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
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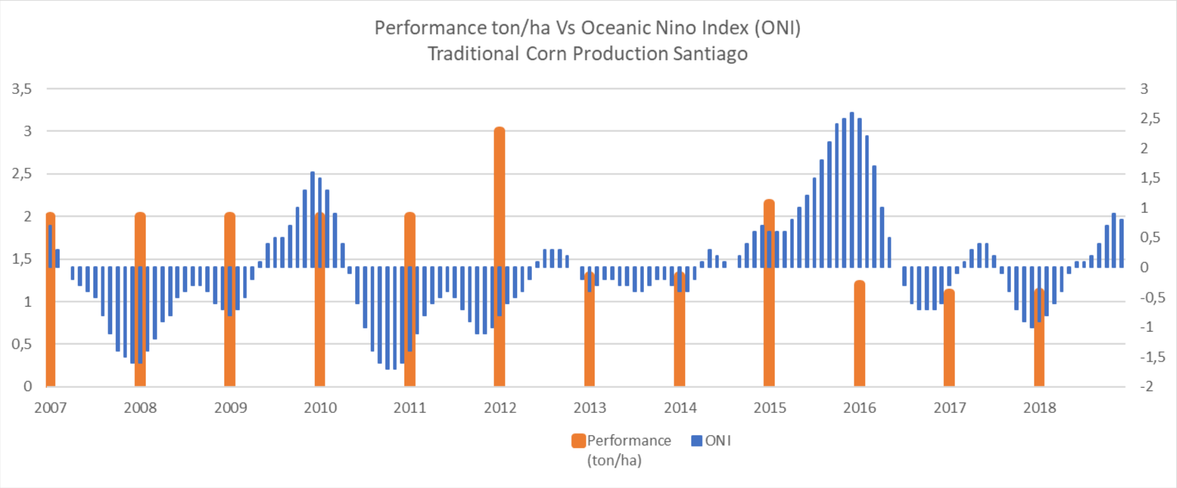
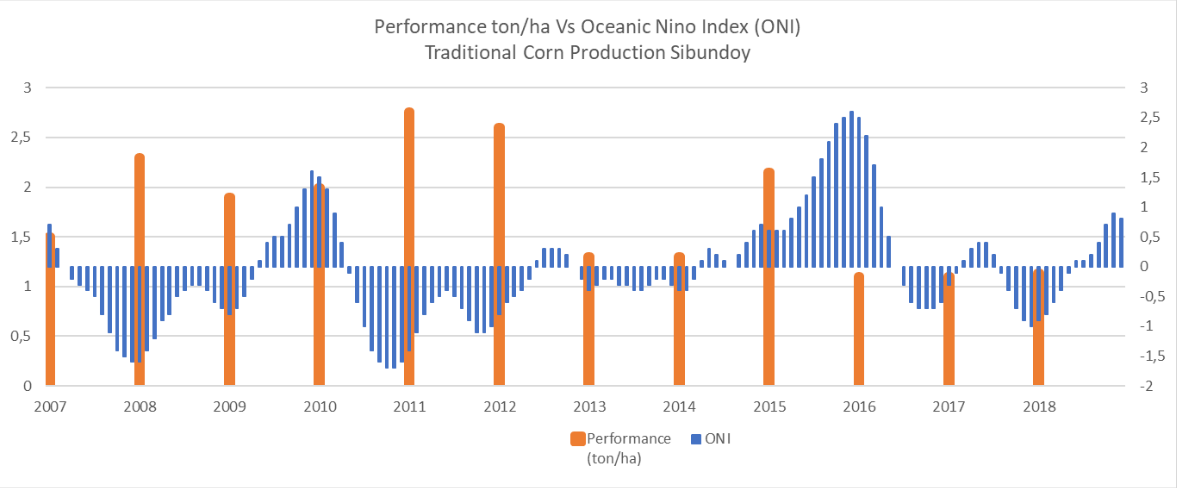
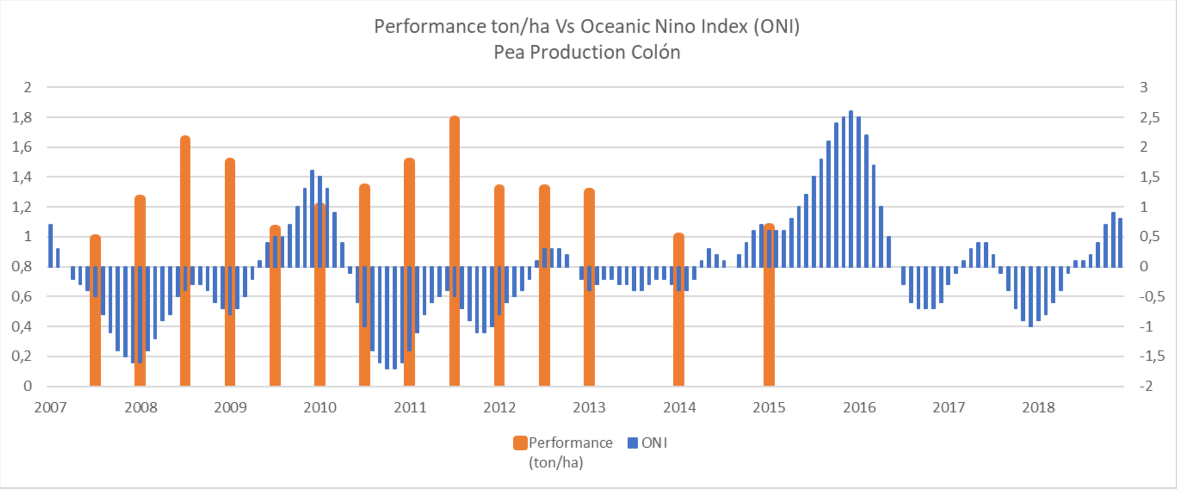
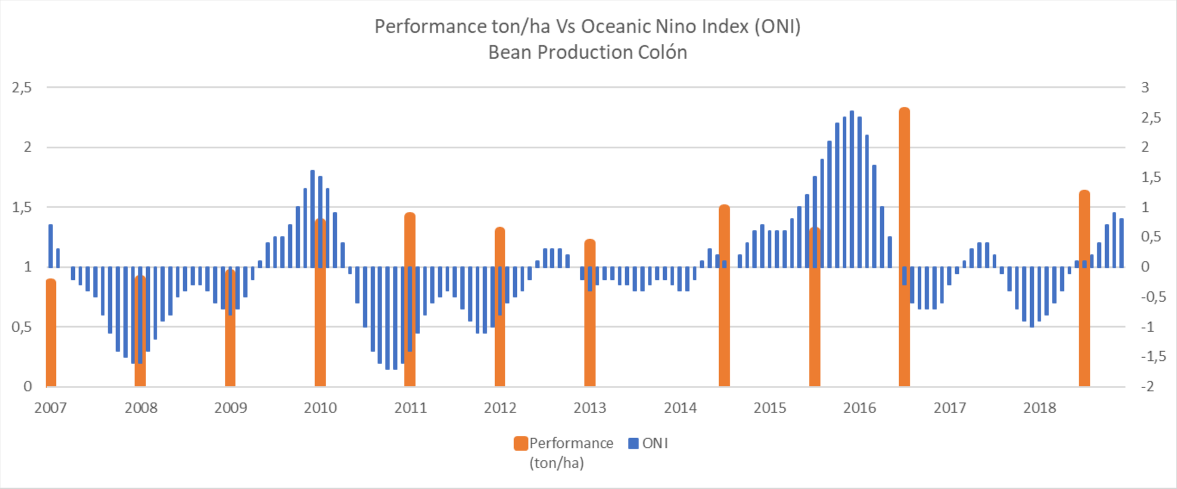
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Traditional Corn Production Santiago
3,5
3
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Traditional Corn Production Sibundoy
3
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
🟧 Performance (ton/ha)
🟦 ONI

Legumes


Performance ton/ha Vs Oceanic Nino Index (ONI)
Pea Production Colón
2
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
🟧 Performance (ton/ha)
🟦 ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Bean Production Colón
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
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2007
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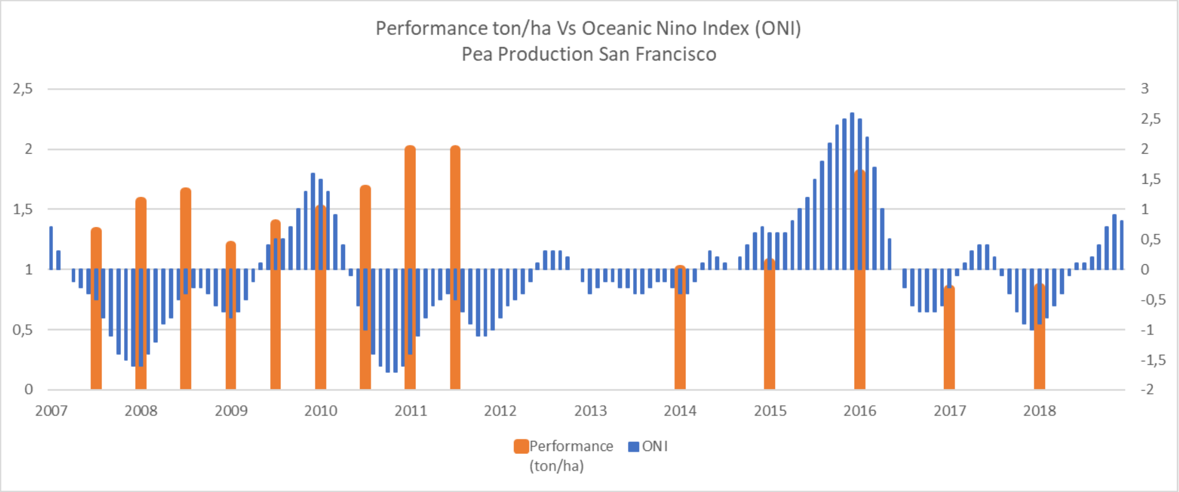
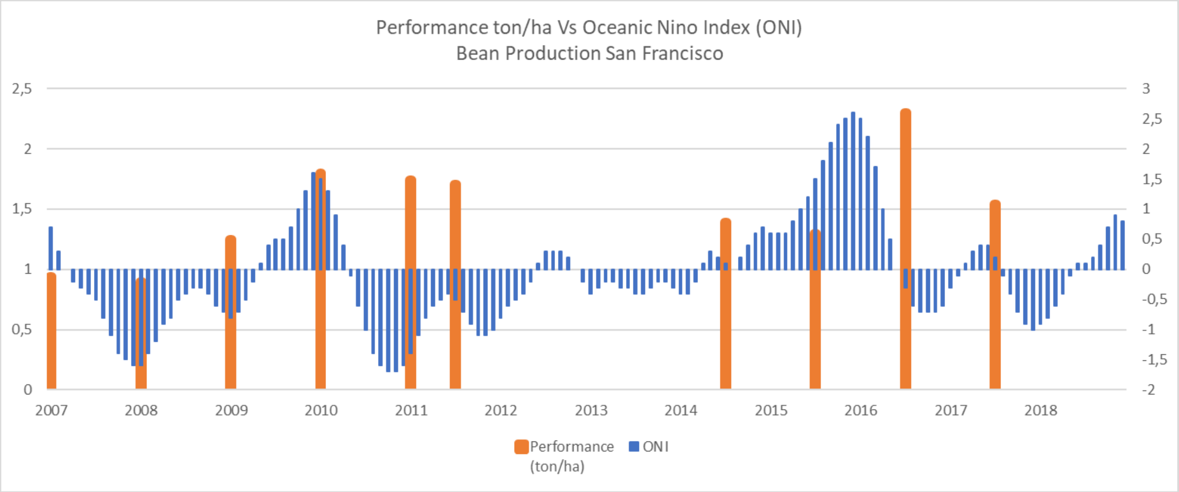
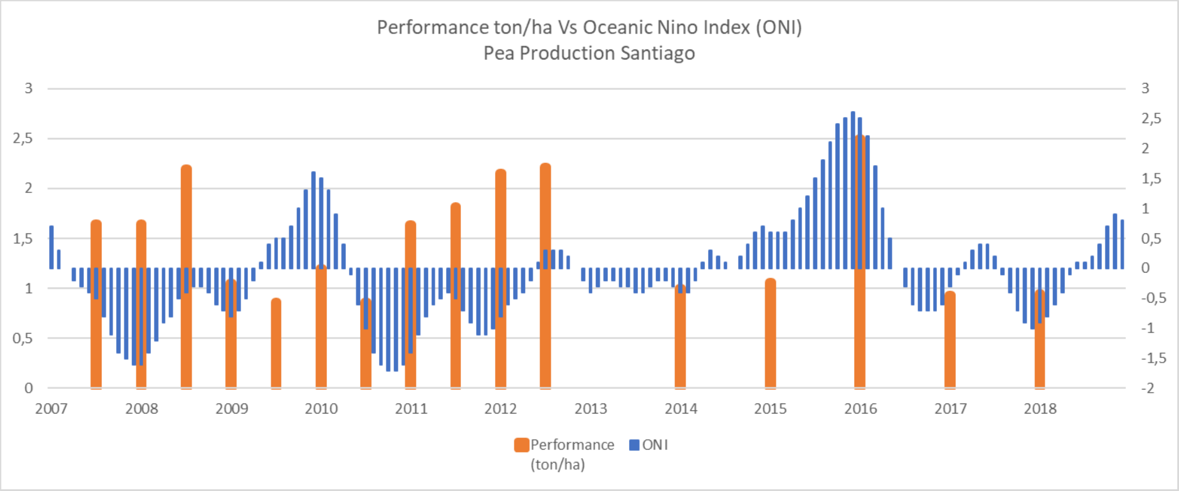
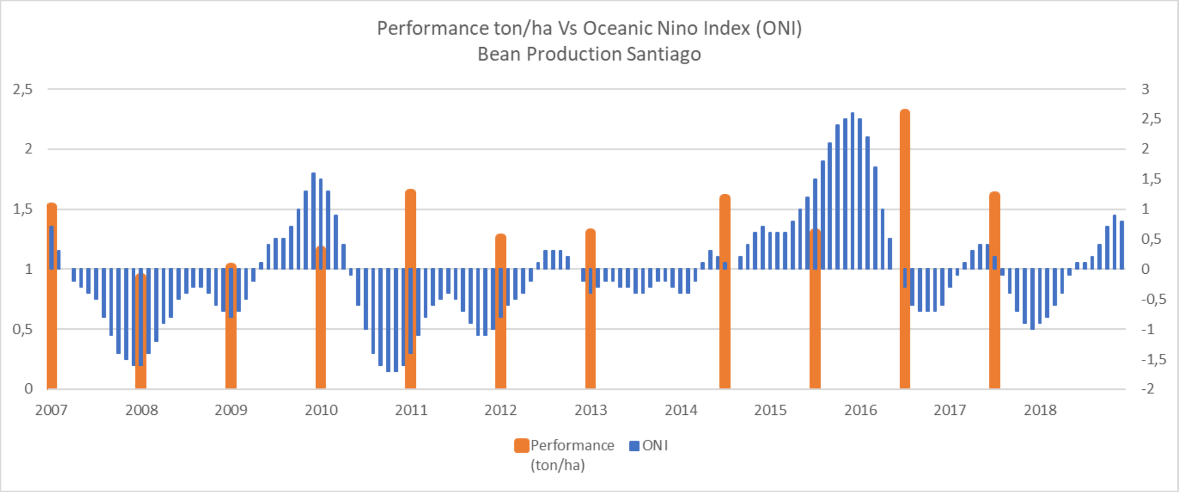
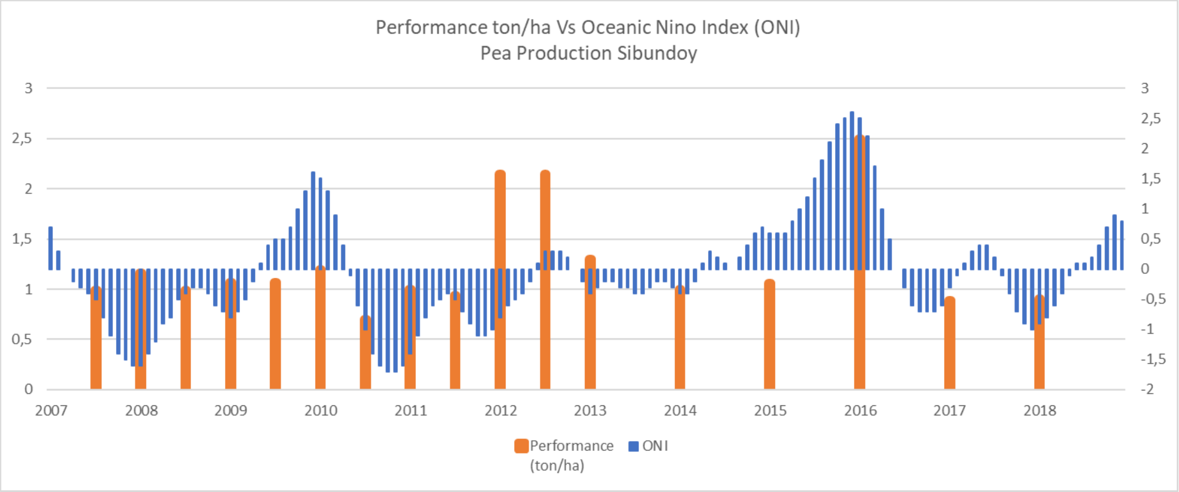
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
🟧 Performance (ton/ha)
🟦 ONI

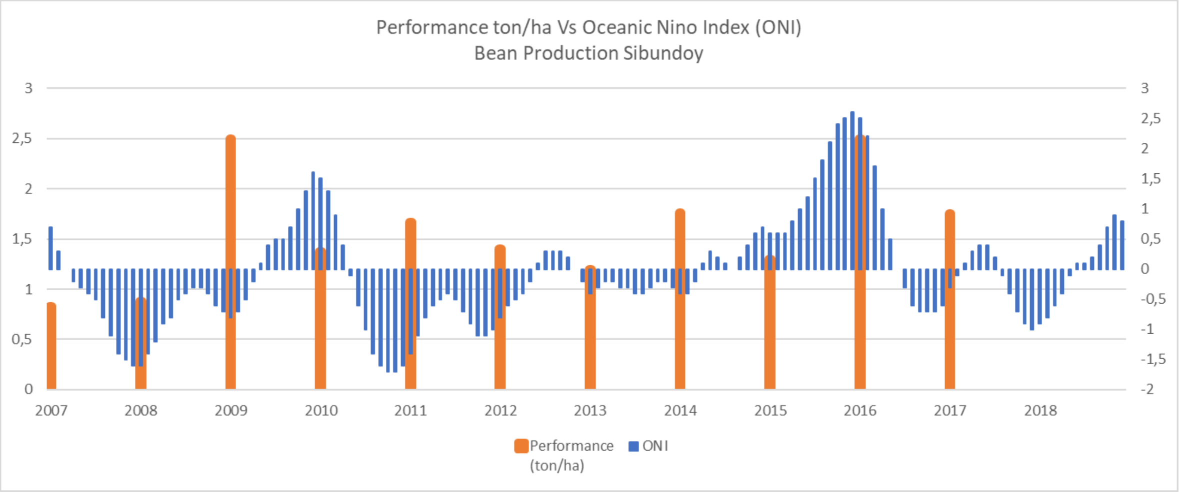

Performance ton/ha Vs Oceanic Nino Index (ONI)
Pea Production San Francisco
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Bean Production San Francisco
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI

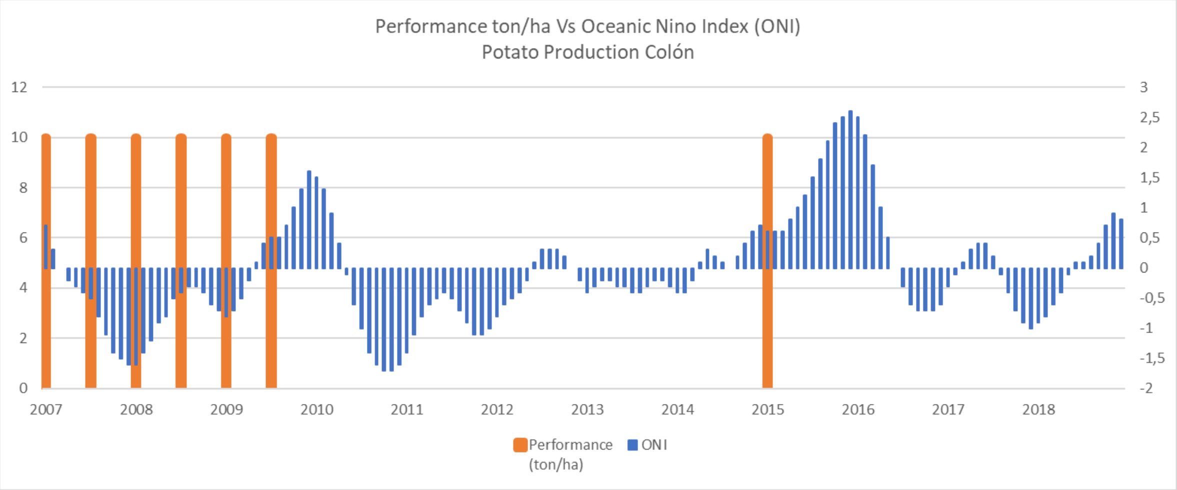

Performance ton/ha Vs Oceanic Nino Index (ONI)
Pea Production Santiago
3
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Bean Production Santiago
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI

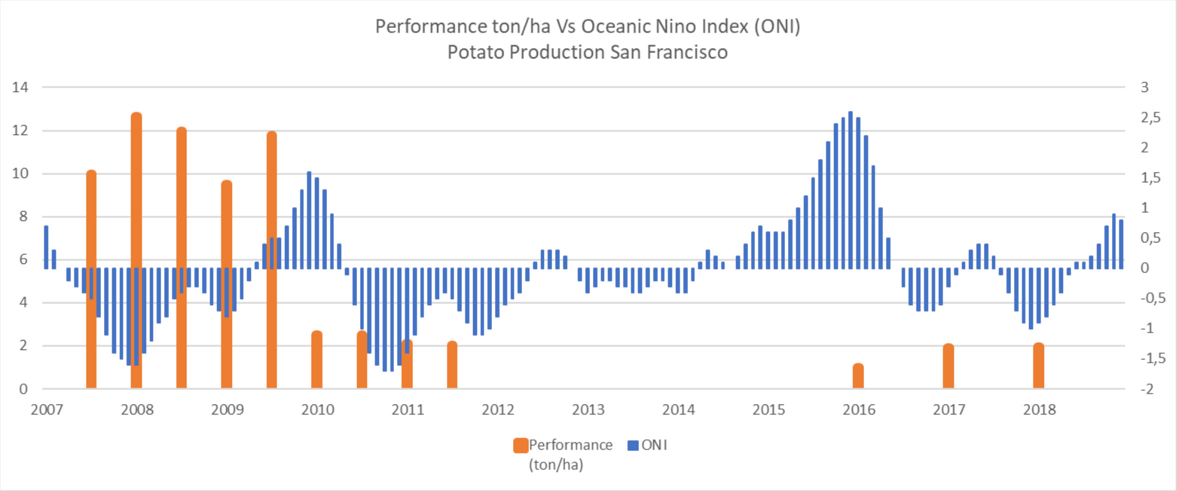

Performance ton/ha Vs Oceanic Nino Index (ONI)
Pea Production Sibundoy
3
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI


Performance ton/ha Vs Oceanic Nino Index (ONI)
Bean Production Sibundoy
3
2,5
2
1,5
1
0,5
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI

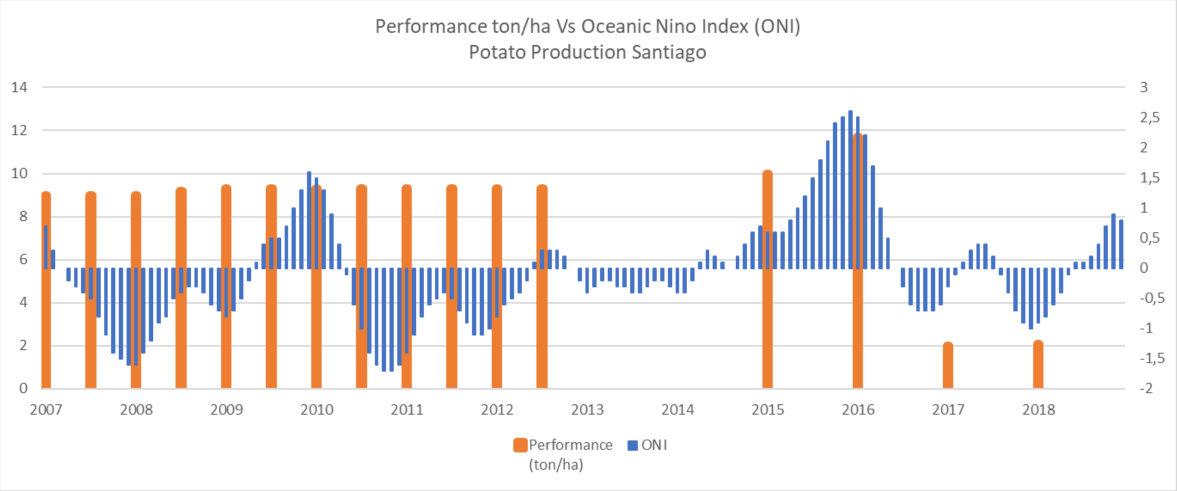
Tubers



Performance ton/ha Vs Oceanic Nino Index (ONI)
Potato Production Colón
12
10
8
6
4
2
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI



Performance ton/ha Vs Oceanic Nino Index (ONI)
Potato Production San Francisco
14
12
10
8
6
4
2
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI



Performance ton/ha Vs Oceanic Nino Index (ONI)
Potato Production Santiago
14
12
10
8
6
4
2
0
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
2007
2008
2009
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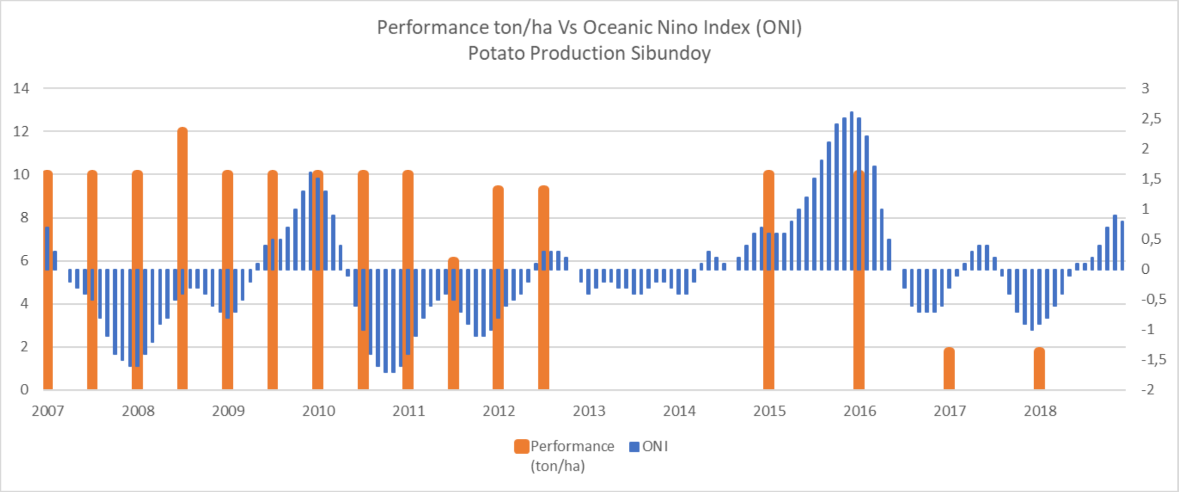
2014
2015
2016
2017
2018
Performance (ton/ha)
ONI



Regarding the Chagra practice it was disappointing to find that little has been done to monitor production for accounting purposes. Despite so much work done in descriptions of the benefits of the Chagra practice in the Amazon region and the large number of documents that refer to the Chagra and other integrated agroecological practices as an alternative for agricultural development and food production.

After visiting Chagras and talking to different producers, it became evident that due its nature of self-subsistence and perhaps due to the mindset that some alternative agriculture philosophers promote in which the process is more important than outcome or results, there was no accounting on any instance other than a few ones done at singular times by other researchers.

For that purpose, there was a meeting with producers in which the importance of creating a standard way of measuring production was discussed. A great reason to register production is the development of empiric evidence that may be useful not only to compare, but to improve the practice itself and to agree about what is the best way to implement it and to complement or eventually transform conventional agriculture. Another advantage of accounting has to do with knowledge of the resources of the region, which could help improve the sharing of information and finally lead to a more robust and efficient practice that can benefit the whole community.

Producers also showed concern regarding the use of seeds and referred to food sovereignty as important. It is evident that many producers are transitioning in one way or another towards conventional agriculture. Documenting production and working towards perfecting the Chagra practice could lead to a more efficient way of preserving it. It was quite surprising to discover the great amount of knowledge farmers hold regarding the types of plants and the different uses these have. Children not older than 15 years showed that they were quite prepared and were able to describe every plant in their Chagras. It is almost shameful to think that such knowledge goes unacknowledged by society in general and that it is not economically remunerated.

During the conversations they mentioned a story that conforms evidence that the Chagra practice has a positive effect in soil protection. The story was about the year 2000 when two tragedies struck the Sibundoy Valley. The first one, was a guerrilla attack on the town of Sibundoy that caused some deaths and generated panic on great sectors of the population. And the second one, was an above the average precipitation that caused many landslides particularly north of the central depression in the areas where the slope increases. During that time, more than fifty families lost their crops and were affected to the point of being offered relocation on behalf of the government. They were offered to move to smaller lots or to stay and change the way they were doing production.

At that time the personnel of CORPOAMAZONIA gave them advice regarding the way they were producing and led them to implement the practice of polyculture, they used the Chagra model of their neighbours and led them towards planting trees to protect the soil. They introduced the avocado into the region and the Chagra practice extended to non-indigenous farmers living on the slopes. This confirms what has been written regarding polyculture and its potential for erosion control. It should be noticed that during the year 2000 there was a great Niña event that started right after an intense Niño by midyear 1998, had its highest ONI value in 2000 (-1.7) and reached the normal" range (-0.5) by the beginning of 2001.

Conventional practices involve tillage which leaves the soil particularly exposed to erosion processes. In the Sibundoy Valley both bean and pea crops are especially vulnerable. The Chagra practice does not involve tillage which reduces the loss of nutrients and erosion problems. It also allows the canopy to provide a permanent supply of organic material to the soil enhancing the organic layer and providing an environment that can hold more water when there is an extreme dry season related to a strong Niño anomaly.

Regarding flood control, there is no evidence that the Chagra practice can help control flooding. Floods have greater relation with the landforms and precipitation regime rather than vegetation cover. However, having greater diversity means the Chagra has trees that are less affected, and most fruit trees survive when floods happen. There is also the possibility that the distribution inside the crops can have an effect in preserving smaller plants from devastating effects. However. more specific studies are required to reach empiric conclusions. Farmers in the lower parts of the central depression where there is a greater tendency to flooding tend to deal with it by prioritising fruit tree plantations and milk production.

3. Prospecting the potential of agroecological practices within the Chagra that could be implemented in tropical modern large-scale projects to tackle climate variability.

Agroecological practices in tropical regions, especially in South and Central America (and specifically in Colombia), present differences marked by the contrast of the history of the farmers and the great diversity of existing ecosystems. These derive in a great array of agroecosystems that vary according to the altitudinal, meteorological, geomorphological, hydrological and socioeconomical features of their territories. Therefore, it is important to acknowledge that there are many starting points for conversion of productive systems from the conventional methods and it is not possible to develop a unique proposal towards the transformation of the practices.

It seems important to notice that when it comes to implementing resilient and environmentally sustainable practices into existing productive systems, a new set of values is required. A mindset that considers becoming rich quick and increasing the yield at any cost, may not be open to transformation processes that prioritise the protection of biodiversity (seed diversity included), the soils and the water, even though there may be the interest of protecting their investment, business and livelihood in the long term.

The purpose of a large set of practices in conventional agriculture is to obtain the maximum yield per land by using transgenic species, pesticides, fertilisers and other modern technologies. (Mejia G., 1995) There is a sense of urgency in being extremely efficient, and there is often little connectivity with their surroundings and the interest of other farmers and society in general. It is also important to agree that different people have different values and think differently, therefore, waiting for the day that all farmers go through a personal transformation may appear utopian.

Recording data and improving the empirical knowledge of the benefits of agroecological practices towards resilience and sustainability from an environmental and economic point of view, may help reach those sectors where positivist approaches have greater impact in decision making. Thus, it is key to develop a greater understanding of climatic variability to begin with and to test the Chagra practice from many dimensions to gain credibility in contexts where these forms of knowledge are better appreciated.

Before seeking elements of the agroecological Chagra practice that could increase resilience to climatic variability, it is imperative to set goals that represent the advantages of its implementation and the interests of the farmers. Some wanted results should include economic viability, reduction of soil erosion, reduction in the loss of nutrients, increase in the organic layer of the soil, reduction of the loss of water in dry season, reduction of affectation due to floods, efficiency in use of resources, reduction in the use of pesticides and increase in biodiversity.

Increase of biodiversity may not be seen at first sight as a measure that increases resilience to climatic variability. However, not all species are affected equally to extreme climatic events, and even within a same species, genetic diversity allows parts of the populations to survive to changes and the trials of extreme climate. In terms of wild and domesticated species, Brazil is considered the country with the greatest diversity with approximately 55000 species, in second place is Colombia, with 45000 species. This is significant when considering that Europe has nearly 13000 species and North America has an estimated of 23000 species (Davis *et al*, 1986). Agroecological systems in tropical South America have the potential to become the source of genes that could ensure the adaptability of many different crops in the future.

The great number of factors that need consideration in a process towards implementing features of the amazon Chagra to the different crops grown conventionally in the nearby areas demand specific studies that grasp the needs of farmers in terms of harvest and efficiency, as well as a selection of goals that are appropriate to the biophysical context in which the productive system develops.

After visiting locations where people practice the Chagra, it became noticeable that they all share some common features such as the setup for the cuy farming and the chickens, there tends to be an area that is more intensely used for corn, there is a place set for medicinal plants, and the big trees tend to be located towards the boundaries. There are fruit trees randomly distributed and a great diversity of tubers, leguminous and vegetables with no apparent order except for preference of the farmers who know where to find them and use ease of access as the main criterion.

This tendency of random distribution is not very well understood and there are no studies that could indicate which are the best associations that could help plants grow better and increase the capacity to resist flooding processes. Again, this points towards controlled experiments that could direct the process that may lead to resources being used more efficiently.

The Sibundoy Valley has been influenced by the different groups of people that occupy it and the merchant and travelling nature of many of its inhabitants. During the field visit it became evident that all cultures are learning from each other and are influencing each other deeply. An interesting example is the tendency of indigenous people to refer to aspects of the Christian faith in their daily life, while on the other side of the scale, the colonial community is always joining the taitas in the practice of “mingas” or ritual praying sessions that belong to the indigenous tradition. In the same way, indigenous people tend to have transition areas with monoculture, while many colonial communities have introduced the polyculture, especially the ones located on the slopes surrounding the central depression.

There are clear benefits of the Chagra practice from many dimensions, however, a greater level of cooperation for commercial purposes and deeper understanding of the practice and its best configuration are required to reach the point where the economic benefits measure up with the environmental benefits. That would be the most advantageous scenario, as more people would be attracted to implementing the integrated polyculture and less people would transition towards conventional agriculture.

Conclusions

The Chagra practice is the traditional form of agriculture developed by indigenous peoples that have inhabited the Amazon region throughout generations. It is distinct from conventional production systems in containing a great diversity of species per area and in resembling the diverse ecosystems that surround it. It is a dynamic form of production always open to including new species that are considered valuable to the farmers. As a form of integrated agroecological practice it includes animals, and manure is used as fertiliser. Historically, it has been a self-subsistence arrangement that provides a surplus that farmers trade commercially.

The Inga and Kamentsá peoples inhabit the Sibundoy Valley. Their Chagra is adapted to the biophysical features of the Andes region of the high Amazon basin. The environmental context can be summarised as a mountainous landscape formed by igneous metamorphic rocks and great volcanic influence. The soils have high presence of volcanic ashes and sediments, yet they are often acid with low fertility. There is high humidity and abundant precipitations throughout the year. The vegetation is typical of the Amazon Andes, with great diversity of plants and an overwhelming amount of medicinal and psychotropic features. Most people are settled in a flat central depression that was formed by an old lake and tends to flood frequently. Politically, the territory is divided in four municipalities and indigenous communities have special representation and participation in the government through different indigenous councils.

There is still need of information to fully understand climatic variability. The Oceanic Nino Index (ONI) is the longest ongoing source of climatic information available for tropical latitudes, yet it is still short termed from a climatic variability scope. There is evidence that El Niño – Southern Oscillation (ENSO) modulates the distribution of local average and extreme rainfall in the tropics. Nevertheless, there is not enough local climatic data to calculate a precise reference standard within the Sibundoy Valley as there has not been a long-termed record of information and many meteorological stations have been closed.

Data for agricultural production was available at a municipality level since the year 2007 until the year 2018 which is barely enough to analyse for climatic variability purposes. Most crops had a greater performance during the years when the ONI showed normal conditions and performed poorly during the strong Niño anomaly. There is need of more specific information to deduce causality. In some cases, the reliability of the data was questionable. There was barely any data from the Chagra farmers and there was a testimonial of resilience during the year 2000 when a strong Niña took place causing many landslides. This event led the farmers living in areas with higher slopes to transition towards polyculture, increase silviculture and in every case, to implement the Chagra.

Some of the most perceivable benefits of implementing the Chagra practice have to do with increasing biodiversity, increasing the organic layer of the soil, reducing the use of pesticides, reducing soil erosion, reducing loss of nutrients, integrating livestock production and managing water more efficiently. The dynamism of the Chagra practice conforms a great example of the flexibility of integrated polycultures. The sensibility of farmers to feedbacks from both the environment and the crops displays an example of what an adaptive management in agriculture can look like.

There are many variables that need consideration when implementing practices within the Chagra to the wide array of crops that are grown conventionally. This demands for specific studies that grasp the challenges that different productive systems face, the context in which they develop and the needs of the farmers. More research is required to fully understand the effects of climatic variability in agricultural production. Controlled experiments could lead to better understanding of the ways agroecological practices perform before extreme climatic events and could lead to perfecting them. Empirical data could be influential towards transitioning from some of the unsustainable trends that involve conventional agricultural practices.

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