UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Administración y Economía

Designing a Choice Experiment: Water Resources and Best Management Practices for Livestock Production in Mejía, Ecuador

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RESUMEN

Este documento diseña un experimento de elección para entender y valorar las preferencias de los ganaderos en Mejía, en la adopción de prácticas de conservación del agua conscientes con el medio ambiente. A través de una revisión de la literatura, entrevistas con expertos y entrevistas con ganaderos, se identificaron las principales prácticas ganaderas perjudiciales para el medio ambiente y sus respectivas soluciones. La técnica de experimentos de elección se implementa con el fin de generar potenciales escenarios con diferentes prácticas ganaderas que pueden ser adoptadas por un ganadero y para evaluar las compensaciones entre atributos. Se proponen tres diseños de experimentos de elección diferentes, que incluyen cinco prácticas ganaderas, con dos niveles cada una, y un atributo de costo de implementación, con tres niveles. Se propone un modelo logit condicional para el análisis de datos. El objetivo adicional de esta investigación es proporcionar información pertinente a los responsables de la formulación de políticas públicas en lo que respecta a las preferencias de los ganaderos por una variedad de prácticas agroecológicas.

Palabras clave: Experimentos de elección, Mejía, Prácticas Ganaderas, Economía Ambiental, Conservación del Agua

ABSTRACT

This paper designs a choice experiment to understand and quantify livestock farmers preferences in Mejía, related to the adoption of environmentally-conscious water conservation practices. Through a literature review, interviews with experts, and interviews with livestock farmers, the main environmentally damaging livestock practices and their respective solutions were identified. Choice Experiment technique is implemented in order to generate potential scenarios with different husbandry practices that may be adopted by a farmer and to evaluate trade-offs between attributes. There are three different choice experiment designs proposed, which include five livestock practices, with two levels each, and an implementation cost attribute, with three levels. A Conditional Logit model is proposed for the data analysis. The further aim of this research is to provide relevant information to public policy makers in regard to farmers preferences for a variety of agro-ecological practices.

Key words: Choice Experiment, Mejía, Livestock Practices, Environmental Economics, Water Conservation

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INTRODUCTION

Environmental economics and sustainable development

Environmental economics has the aim of modifying destructive human behavior through economic incentives while maximizing welfare. “Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations, 2015). It aims to maintain economic advancement and progress while protecting the long-term value of the environment (Emas, 2015). For many years, economic development and nature conservation were seen as distinct and separate problems; until 1970’s where sustainability appeared on the international political agenda (Perman, 2003). By using economic tools, early theorists of sustainable development demonstrated that policies that protect the environment could also promote innovation and profit, such as the theories proposed by Arthur Pigou, Michael Porter, and Claas van der Linde. This implies that a trade-off is not necessary, and that win-win situations may be achieved for the environment and the economy. In other words, since current and future development depends natural resources, is in people’s best interest to preserve them.

Relevance of the Study

Water is a scarce resource that satisfies multiple needs, and since it is essential for life, everyone is a stakeholder, and consequently, a proper conservation of sustainable water management is imperative. Globally, 70 percent of freshwater is used for agriculture and this figure is estimated to increase (Food and Agriculture Organization of the United Nations, 2014a) Therefore, there is a growing pressure on water supplies and water quality. Particularly, the livestock sector is an important user of water resources as well as one of the largest sources of water pollution. This is clearly evident in Ecuador, where the agricultural and livestock presence has adversely affected water quality (Guerra, 2018). It is necessary to find a win-win situation for the environment and the economy, since livestock supports livelihoods and food security of 1.3 billion people around the world.

Our study area is Mejía canton found in the Ecuadorian Andes. Without any understanding of the productive dynamics that affect free-access goods (i.e. water) in Mejía, their inadequate management may result in a "Tragedy of the Commons" scenario. About a third of Mejía's territory is intended for livestock use. Mejía is the largest producer of dairy in the country, with 300,000 liters of milk per day, which represents 20 percent of the national production (Ministerio de Agricultura Ganadería y Pesca, 2015b) Thus, livestock activity has economic importance in the area.

Objectives

This manuscript is part of a project,[1] which attempts to value farmers' preferences over water conservation practices in livestock production in Mejía. More specifically, the general objective of this dissertation is to design an experiment that allows us to generate potential scenarios with different husbandry practices that may be adopted by a farmer. In doing so, choice experiment technique is implemented. In this case, the experiment will contain bundles of husbandry practices. Each bundle has a set of attributes and the levels of each attribute vary across bundles. The aim is to deepen the analysis of adoption of proper practices related to water conservation. In addition, there is also a need for more work related to the adoption of "good husbandry practices" in relation to the conservation of water resources in Latin America through a Choice Experiment; one study is developed by (Yehouenou & Grogan, forthcoming), where farmers' preferences over water conservation practices were estimated in Florida, United States.

[1] The title of this project is "Agricultural and Livestock Activities along San Pedro and Pita Rivers: Preferences over Best Management Practices and Conservation of Water Resources", funded by the School of Economics at the Universidad San Francisco de Quito.

The specific objectives of our research are:

1. Determine the best livestock practices related to water conservation through interviews with livestock production experts (i.e. professors from the USFQ[2] and farmers).
2. Analyze the effect of these selected husbandry practices on water resources based on existing literature.
3. Using previous references, understand farmers' preferences of adopting such environmentally-friendly practices. Given that these practices not only represent environmental benefits in the short and long run, but also increase productivity and efficiency in the use of resources.
4. Design a Choice Experiment with agro-ecological (and sustainable) practices in Mejía.
5. Based on the design, propose different hypotheses that can be tested in the next phase of this project.

The paper proceeds as follows. The next section provides background on livestock practices and water resources. The third section summarizes previous literature. The fourth section explains the underlying theoretical framework of the study and the methodology. The next section explains the proposed practices (attributes and levels). Followed by preliminary results and hypothesis and the last section concludes.

[2] USFQ: University of San Francisco of Quito

BACKGROUND

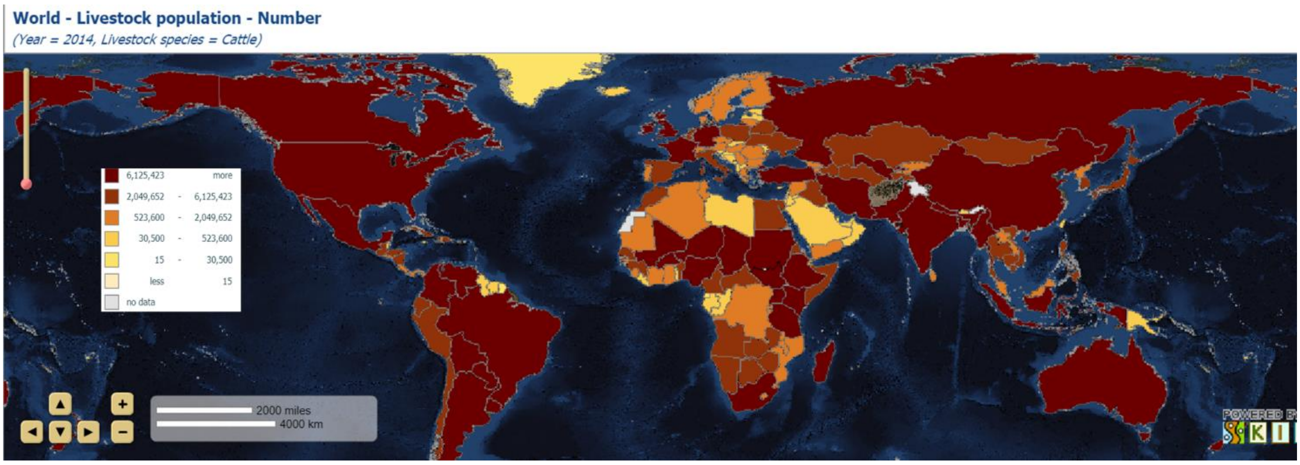
Livestock production

Livestock production in the world and Latin America.

There are varieties of animal species used for livestock production that differ in importance through the world's regions. Efficient livestock production requires good management practices and animal welfare. Livestock activities contribute to 40 percent of the global value of agricultural output (Food and Agriculture Organization of the United Nations, 2014b). As Figure 1 shows, livestock is highly significant in every continent.

Figure 1

Number of Cattle per Country

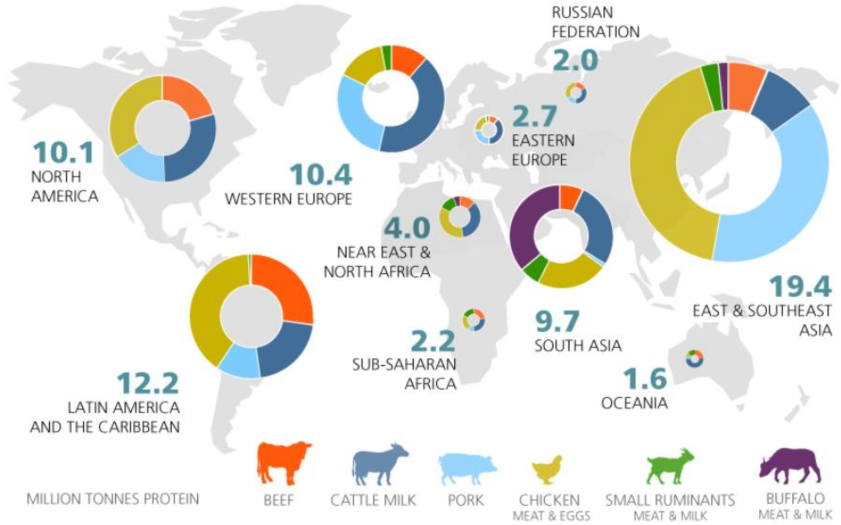


Source: FAO

According to FAO (2014a), livestock sector increases at high growing rates, becoming an engine of the agricultural economy, and therefore an important employment generator. In the past few decades, the livestock industry has been changing, due to demand and supply shocks. There is a booming demand for food derived from animals due to population growth, rising income, and changes in lifestyle. In numbers, this means that global demand is projected to increase by 70 percent to feed a population estimated to reach 9.6 billion by 2050. On the other hand, there is also a growth in production due to: major technological innovations, structural changes, livestock stocks increase, and greater productive efficiency. These growth and transformations offer opportunities for agricultural development, poverty reduction and food security gains (Food and Agriculture Organization of the United Nations, 2014a). In livestock, there is a strong relationship between human, animal, and environmental health.

Figure 2

Livestock Production by Region



Source: FAO

As Figure 2 shows, the most important region for livestock production is East and Southeast Asia, whereas Latin America and the Caribbean (LAC) region comes second, with chicken and beef production representing more than half of the total production. The estimated value of annual production in this region is about $79 billion, in which cattle represents $380 million (Practical Action, 2017). As reference, LAC livestock production has an annual growth rate of 3.7 percent and represents 46 percent of the total agricultural GDP. In the region, five countries account for 75 percent of the total livestock production[3] (Food and Agriculture Organization of the United Nations, 2016a). In the last decade, beef meet exports from the LAC region duplicated, and other livestock exports rose significantly (Practical Action, 2017).

[3] These five countries are: Brazil, Argentina, Mexico, Uruguay, Colombia and Chile

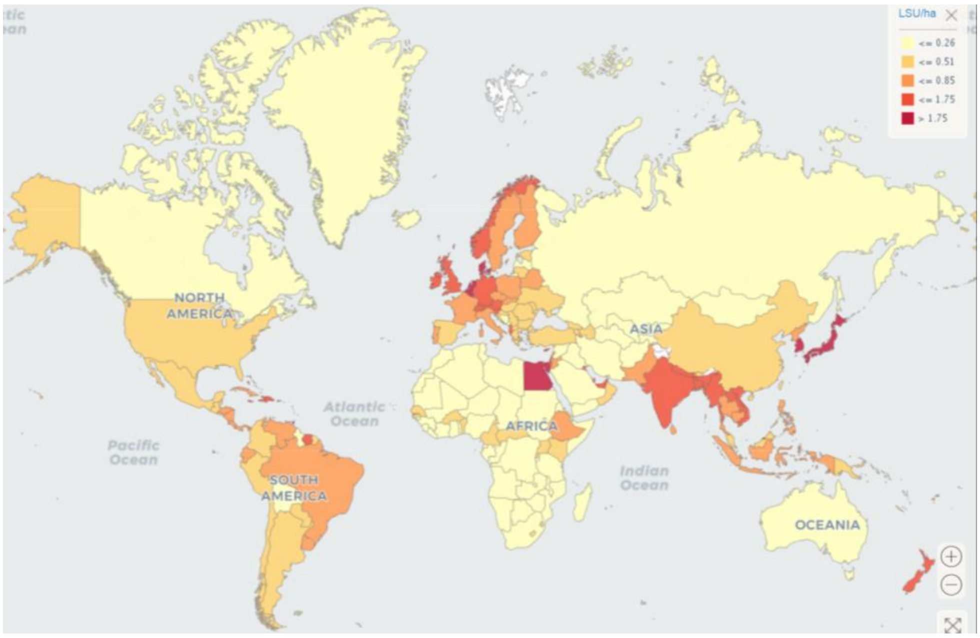
Also, livestock supports the livelihoods and food security of almost 1.3 billion people in the world, specifically the food security for 70 percent of the world's rural poor (Food and Agriculture Organization of the United Nations, 2014a). Livestock production systems are especially significant for farmers in developing countries, where more than half a billion people depend on livestock for their livelihood (International Livestock Research Institute, 2020). Livestock is not only an income generator, but it also acts as collateral for savings and as transport. Moreover, this sector performs critical development functions through its contribution to nutritious diets, economic growth, and livelihoods (Food and Agriculture Organization of the United Nations, 2016b).

Livestock is the world's largest user of land resources; the total land area occupied by pasture is 26 percent of the ice-free terrestrial surface. Feed crops are grown in one-third of total cropland, while grazing land and cropland dedicated to the production of feed represent almost 80 percent of all agricultural land (Food and Agriculture Organization of the United Nations, 2014a). Figure 3 shows the importance of agriculture in each country as an average of the livestock units (LSU) per hectare from 1994 to 2017, both Europe and Latin America have the highest ratio.

LAC region has an agricultural surface of 709,000,000 hectares. Of the total, 151,000,000 ha is arable land, 22,000,000 ha is destined to permanent crops and 536,000,000 ha is permanent meadows and pastures. The total LSU in this region are 286,976,379, with 87 percent found in South America. Moreover, LAC holds a total livestock production of 105,3821.1 thousand heads, from which 58,228.3 thousand are heads of cattle (Cepal, 2020).

Figure 3

Density of Major Livestock Types + Total in the Agricultural Area LSU/ha (Avg. 1994 – 2017)

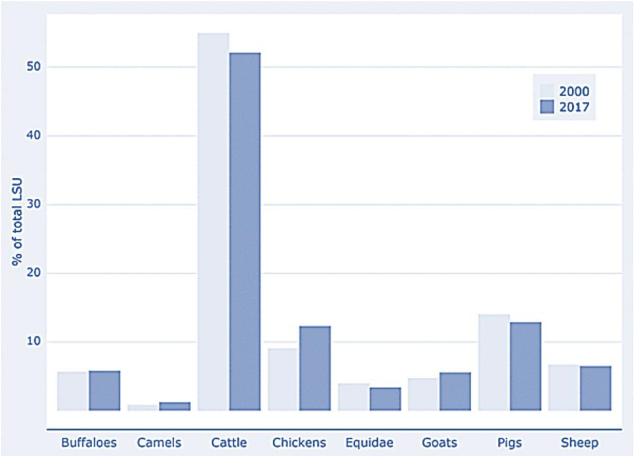


Source: FAOSTAT

When livestock units per hectare are disaggregated into the different ruminant and non-ruminant species, cattle occupy more than five times the space than other livestock species (see Figure 4). Cattle are the most common large ruminant, usually raised to produce milk, meat, hides and to provide power. When expressed in absolute animal numbers, in 2017 there were nearly 1.5 billion heads of cattle, which normalized in LSU represents 970 million cattle (FAO, 2019). In terms of quantity, milk is the most important livestock product worldwide. There is a variety of cattle raising systems, for example: capital intensive, labor intensive, specialized, double-purpose, multi-purpose, grass-based, feed-lot, mixed crop-livestock, extensive pastoral and others (Food and Agriculture Organization of the United Nations, n.d.).

Figure 4

Share of Total Livestock Units (in percent) by Species



Source: FAO

Livestock systems have a significant impact on the environment, including air, land, soil, water and biodiversity. Most of the impacts are indirect and not immediately observed, resulting in an underestimation of the impacts of the livestock production on the resources. Thus, the livestock-environment interactions are not easy to understand given its amplitude and complexity. Livestock industry accounts for one tenth of global human water use and is one of the largest sources of water pollution (Food and Agriculture Organization of the United Nations, 2013). As this sector grows so does its pressure on the world's natural resources, where, water sources are becoming scarce; pollution is increasing, degradation threats grazing land, deforestation increases due to grow in animal feed, and locally adapted animal genetic resources are being lost (Food and Agriculture Organization of the United Nations, 2013). It is important to evaluate and address the possible risks that livestock development may specifically cause for the environment in order to guarantee the industry's sustainability.

LAC is one of the richest regions worldwide in terms of natural resources. There are some common challenges that the region faces but differ in magnitudes in the sub-regions. Within such challenges are: low production efficiency; improvement of the quality and safety of products in the sector; increase in flexibility to respond to any structural change in the agricultural sector; sustainable management of natural resources; and a reconciliation between livestock production and the natural environment for the conservation of biodiversity (Molina & Díaz, 2017). More than 70 percent of the pastures of the region present a moderate to severe level of degradation, which has a significant impact on natural resources (Food and Agriculture Organization of the United Nations, 2016a). The LEAD initiative has highlighted the main environmental livestock problems that affect the region, which are the following: 1) land degradation due to overgrazing; 2) deforestation as a consequence of the expansion of grasslands and the conversion of forests into croplands for feed production; 3) pollution-related problems associated with the regression of mixed farming systems; 4) the rise of intensively exploited livestock systems; and 5) waste management (Molina & Díaz, 2017).

Fortunately, there are different international agencies helping the development of sustainable livestock production. For instance, FAO's livestock program promotes sustainable development for ruminants (Food and Agriculture Organization of the United Nations, 2013)[4] Also, the World Bank "supports countries to manage their growing demand for animal protein in ways that are significantly less harmful for the environment and contribute significantly less to climate change". It is currently investing $1.4 billion in active investments in livestock, of which 55 percent of new projects are been designed to yield climate change mitigation and adaptation co-benefits. The World Bank is also preparing guides and publications to share knowledge on best practices in sustainable livestock management (The World Bank, 2019).

[4] See the Livestock Environmental and Assessment Partnership that focuses on the development of broadly recognized sector specific guidelines (metrics and methods) for measuring and monitoring the environmental impact of the livestock sector.

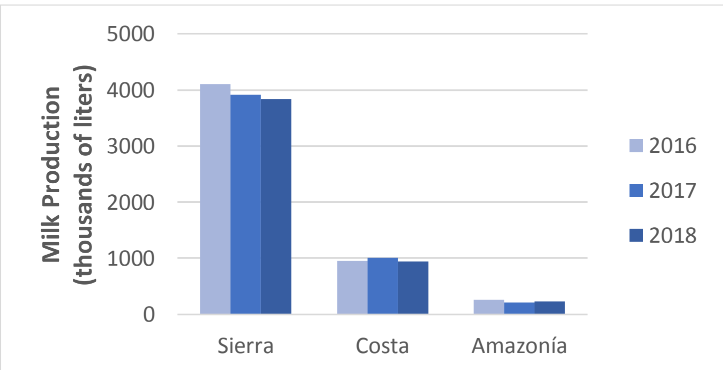
Livestock production in Ecuador.

The agriculture sector has represented about 10 percent of Ecuador's GDP for the last two decades, which meant $10,020.2 million in 2018 (Cepal, 2020). More specifically, livestock accounted for 1.5 percent of Ecuador's GDP in 2017 (Food and Agriculture Organization of the United Nations, 2017), in which milk cattle contributes the most. The agricultural sector supplies 95 percent of the food consumed within Ecuador, and 46 percent of the industry product is part of the factors of production of other industries. The agricultural sector is a source of monetary liquidity, as 40 percent of the foreign currency inflow has come from this industry the past 20 years. It also has a positive trade balance, since there are very few imports needed. Thus, this industry is key to guaranteeing food security and sovereignty for all Ecuadorian generations (Ministerio de Agricultura Ganadería y Pesca, 2015a).

In 2018, the national milk production was 5 million liters from 823,528 cows (INEC, 2018). The mountain region of Ecuador called Sierra has the highest milk production and the highest milk productivity, with a significant advantage in comparison to the other regions (see Figure 5). Pichincha province, where the study area is, contributes with a 15.7 percent of the total production in this region, with a yield of 10.4 liters per cow. Furthermore, milk exports have increased since 2014.

Figure 5

Milk Production by Regions (thousands of liters)



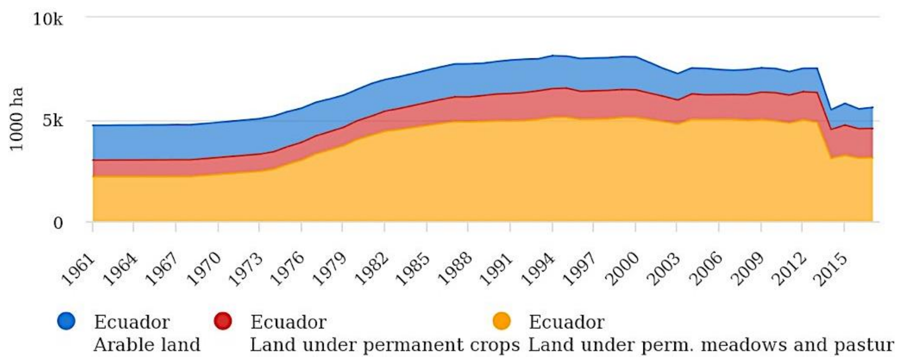
Source: INEC

Ecuador has 36.2 percent of its total population in rural areas, where agriculture is the highest employment sector with around 28 percent of total employment in 2018 (Cepal, 2020). The agricultural sector employs 7 percent of the economically active urban population and 62 percent of the economically active rural population, in which the majority is self-employed; of whom about 25 percent are women and 75 percent are men. It is important to note that more than half of the rural population in the country lives in poverty conditions, and the behavior of the agricultural sector directly affects their wellbeing and rural development (Ministerio de Agricultura Ganadería y Pesca, 2015a).

According to AGSO[5], land ownership in Ecuador is divided in small producers (i.e. from 1 to 20 ha), medium producers (i.e. from 20 to 100 ha) and big producers (i.e. more than 100 ha). Technology use is scarce in small producers, while big producers have a more technologically- advanced production. Most of cattle raising farmers in the country are small. Furthermore, agricultural land represents around 20 percent of total land (see Figure 6), where arable land is 1,033,000ha; permanent crops is 1,431,000ha, and permanent meadows and pastures is 3,126,000ha (Cepal, 2020). Refer to for a map of Ecuador's agricultural aptitude.

Figure 6

Agricultural Area in Ecuador (1961-2017)



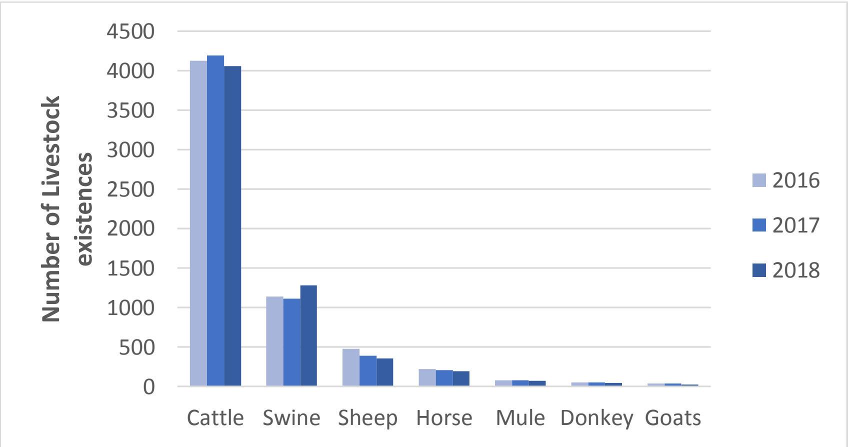
Source: FAOSTAT

[5] AGSO: Asociación de Ganaderos de la Sierra y el Oriente (Association of Ranchers from Sierra and Oriente)

Ecuadorian livestock production holds around 4 million cows in the country, making it the predominant ruminant and non-ruminant specie, as shown in Figure 7. Within the national livestock production the most common system is the double-purpose production representing 69 percent, then specialized milk-only production systems represent 19 percent, and specialized meet-only production systems represent 12 percent (Ministerio de Agricultura Ganadería y Pesca, 2015a). According to INEC (2018), the Sierra region has the highest number of bovines, where the province of Pichincha is the main producer. Also, the most common breed in each region is "Mestizos" (cross-breeds), leading it to be the predominant breed in the country[6]. Moreover, 70 percent of the bovine livestock are females and 30 percent are males.

Figure 7

Livestock Existence



Source: INEC

Ecuador has an important agricultural productive capacity due to its biophysical condition. Even though its potential to take advantage of the land in productive activities (agriculture, agroforestry, livestock) is high, 79 percent of this territory has not been exploited at its maximum. Moreover, 66 percent of the land has land use problems, which means that areas that suitable areas for a certain use are being used for a different end. The overuse of soils has caused erosion, deforestation, and an increase in agricultural areas in areas of natural

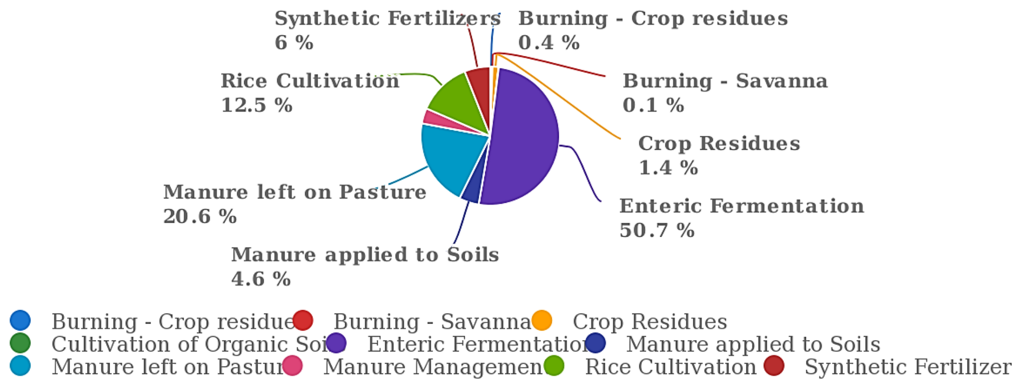
[6] See Appendix A for more information

forests, moors, and areas of natural water production. The agricultural frontier in Ecuador has expanded, which means that land that is not naturally for agricultural activities is being used for this purpose (Ministerio de Agricultura Ganadería y Pesca, 2015b).

For 2016, Ecuador's total agriculture CO2eq emissions where 11,578.7gigagrams. Figure 8 shows emissions by sector, in which those that are cattle related, add up to approximately 30 percent of the total emissions. Furthermore, the fertilizer use intensity is 55 tons per 1,000 hectares of agricultural land (2017). While fertilizer consumption is 34,253 tons per year (2017) (Cepal, 2020) (See Figure 9).

Figure 8

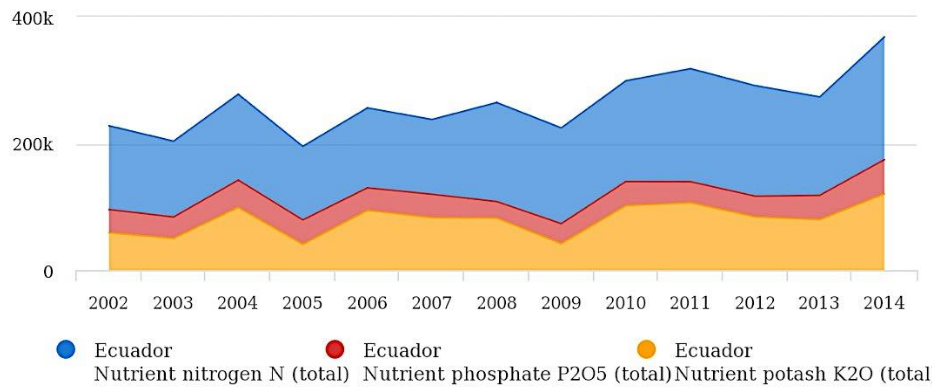
Emissions by Sector (CO2 equivalent) (Average 1990-2017)



Source: FAOSTAT

Figure 9

Fertilizers Consumption in Nutrients



Source: FAOSTAT

Ecuador has around 20 multilateral environmental agreements. Ecuador is part of the Global Agenda for Sustainable Livestock since January 2019. An important project initiative is Climate Smart Livestock in Ecuador, which is a partnership between the government and FAO. Moreover, one of the local priority policies in the agricultural sector is the ISPA practice[7]. ISPA promotes healthy soils, effective management of water resources, the use of good seeds from different variety and high performance, the integral management of plagues, the integration of crops, grassland, trees and livestock. For this to be achieved there is a need of policies targeted to territorial development and agricultural policies.

Water resources

Water resources in the world and Latin America.

Fresh water accounts for 3.5 percent of water on Earth, which represents only 22,300 ml^3. Of total freshwater, 69 percent is locked up in ice and glaciers and 30 percent is in the ground, this means just 1 percent of freshwater is easily accessible. Thus, water is a scarce resource, yet necessary for human and animal survival. It is important to note that throughout history water management has always been an important element for development.

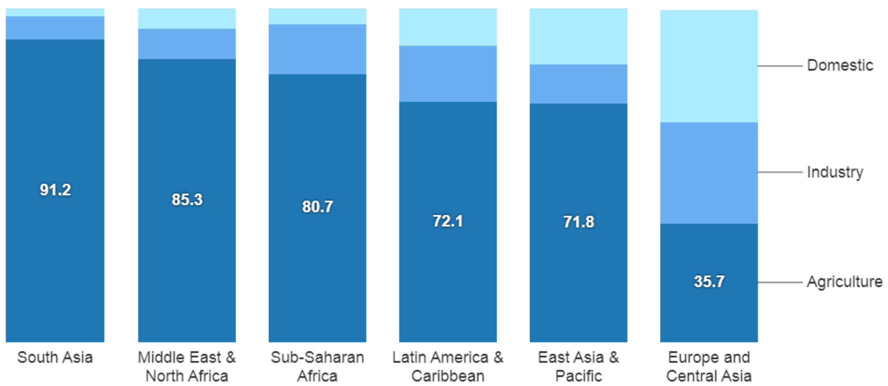
Human consumption of water per year is estimated to be around 3,600 km^3. Due to geography, climate, engineering, regulation, and competition for resources, water distribution varies among the regions with some being more abundant and other facing droughts and debilitating pollution (National Geographic, n.d.). “More than half of the world's water supply is contained in just nine countries: the United States, Canada, Colombia, Brazil, the Democratic Republic of Congo, Russia, India, China and Indonesia.” Water availability varies from place to place and over time. The availability of water affects the tight and abundance of vegetation, which is a primary source for foods for people and animals (Freeman, 2007). Globally, 70

[7] ISPA: Intensificación Sostenible de la Producción Agricola (Sustainable Intensification of Agricultural Production)

percent of freshwater is used for agriculture. “By 2050, feeding a planet of 9 billion people will require an estimated 50 percent increase in agricultural production and a 15 percent increase in water withdrawals” (Khokhar, 2017). As shown in the figure 10, in most of the world’s regions more than 70 percent of water is used for agricultural purposes.

Figure 10

Share of Freshwater Withdrawals by Sector (percent) in 2014



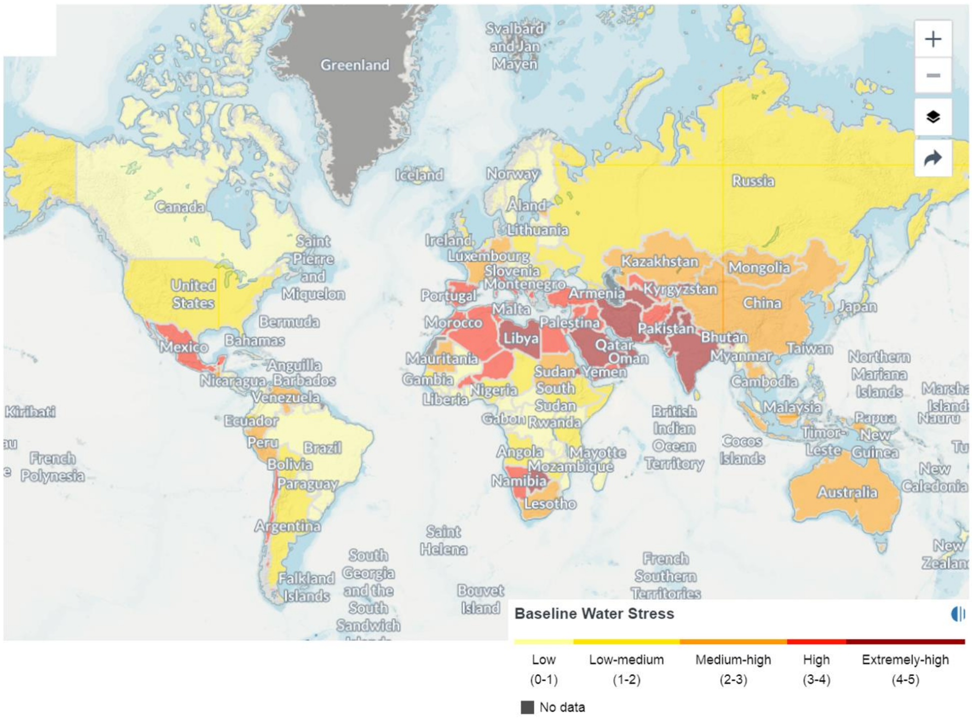
Source: World Bank

Water is a scarce resource that satisfies multiple necessities and since it is essential for life, everyone is a stakeholder. Thus, conservation and proper and sustainable water management is particularly important. The main problem is that while the amount of freshwater on the planet has remained constant over time the population has exploded, which means that competition for water increases every year. Water use has grown at more than twice the rate of population increase in the last century (National Geographic, n.d.). “The challenge is how to effectively conserve, manage, and distribute the water available” (National Geographic, n.d.).

According to the European Environment Agency, water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. It is estimated that by 2025, due to use, growth, and climate change, around 1.8 billion people will live in water scarcity areas, with two-thirds of the world's population living in water-stressed regions (National Geographic, n.d.). The region that faces the highest water stress is the Middle East and North Africa, whereas the Americas faces the lowest water stress (see Figure 11)[8].

Figure 11

World Water Stress



Source: Water Resources Institute

Another significant problem is that more than 80 percent of wastewater goes back into nature untreated, regardless of the polluting source. Moreover, 50 percent of the population in developing countries is exposed to polluted water sources. When the natural capacity to purify pollutants in water is exceeded, some of the most important consequences are: loss of biodiversity, decrease in livelihoods, deterioration of natural food sources, threats for health and well-being are, and extremely high cleaning costs for rivers.

LAC region has one third of the world's freshwater resources and only 10 percent of the human population, which means 22,929m^3 of water per person per year, significantly higher than the global average. However, water resources in the region are unevenly distributed,

[8] Refer to Appendix B for more information on Water Stress in LAC region.

resulting in some areas with water abundancy and others very arid. Latin America produces only 11 percent of the food in the world but has huge growth potential because land and water are abundant. However, due to lack of governance, lack of infrastructure, shortage of human, institutional and financial capital, and inefficient water use this growth is limited (Almar Water Solutions, 2019). Furthermore, the primary sector is an important polluter in the region due to activities such as: mining, oil extraction, agriculture, etc.

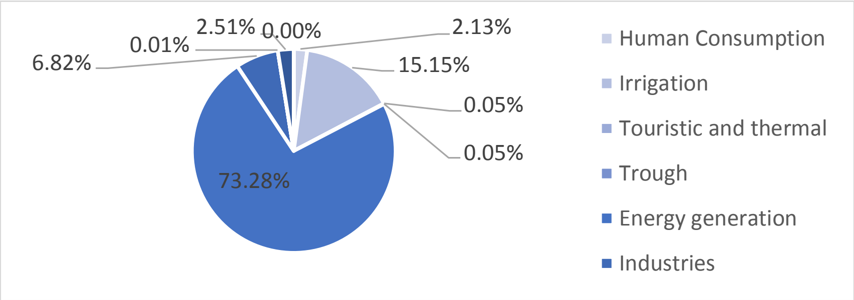
Water resources in Ecuador.

Ecuador has abundant water in relation to present and future requirements (Galárraga-Sánchez, 2000). However, although it is sufficient, water is unevenly distributed through the different geographic regions. Water resources in Ecuador come from two watersheds that originate in the Andes. 80 percent of the population occupies the Pacific watershed (west), which only has 14 percent of the water; while the other 20 percent of the population occupies the Amazon watershed (east) that has 86 percent of the water (Galárraga-Sánchez, 2000).The national territory is divided into nine river basin districts (refer to Appendix C). Ecuador has thrity one hydrographic systems, which are subdivided into seventy-nine basins. According to Senagua, The hydrographic region of the Pacific Ocean represents 124,563.83 km^2, while the Amazon hydrographic region represents 131,806.17 km^2.

Currently, the total volume of water resources in Ecuador is of 376,018 hm^3, which is divided in surface water resources, 361.747 hm^3, and groundwater resources, 14.272 hm^3. According to ARCA, in 2005 the amount of available water in Ecuador was 432.000 hm^3/year, which may be as low as 146.000 hm^3 in a dry season. The average per capita available water in 2017 was 26,000 m3/year, figure that has been decreasing since 2005 and will keep decreasing as population rises and polluted water resources can't be used anymore. This volume is around eight times more than the Latin American average of 3,1000 m3/year. In 2018, an average Ecuadorian consumed more than 40 percent more water than the average of the region because it has more resources but also due to the lack of water-consciousness. However, this does not apply to all provinces or to every part of each province (Alarcón, 2018). Most of Ecuador's available freshwater is used for energy generation, followed by irrigation (see Figure 12).

Figure 12

Water Uses

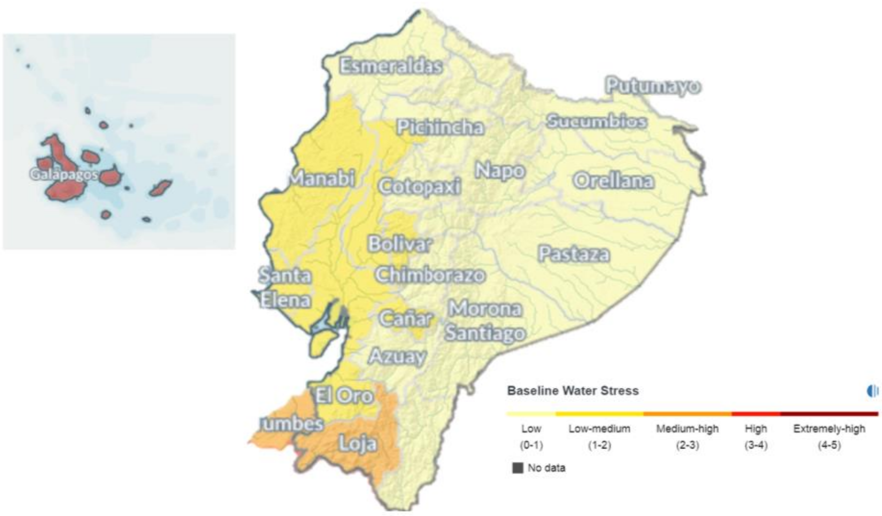


Source: SENAGUA

Ecuador has a low to medium water stress, occupying the 81st place out of 167 in the world (with 1 being the highest). As seen in Figure 13, Galapagos has the highest water risk, followed by Loja which has a medium to high water stress. There are eight provinces, mostly in the coastal zone, that have low to medium water stress; while the remaining fourteen provinces have a low water stress (Refer to Appendix D).

Figure 13

Ecuador's Water Stress

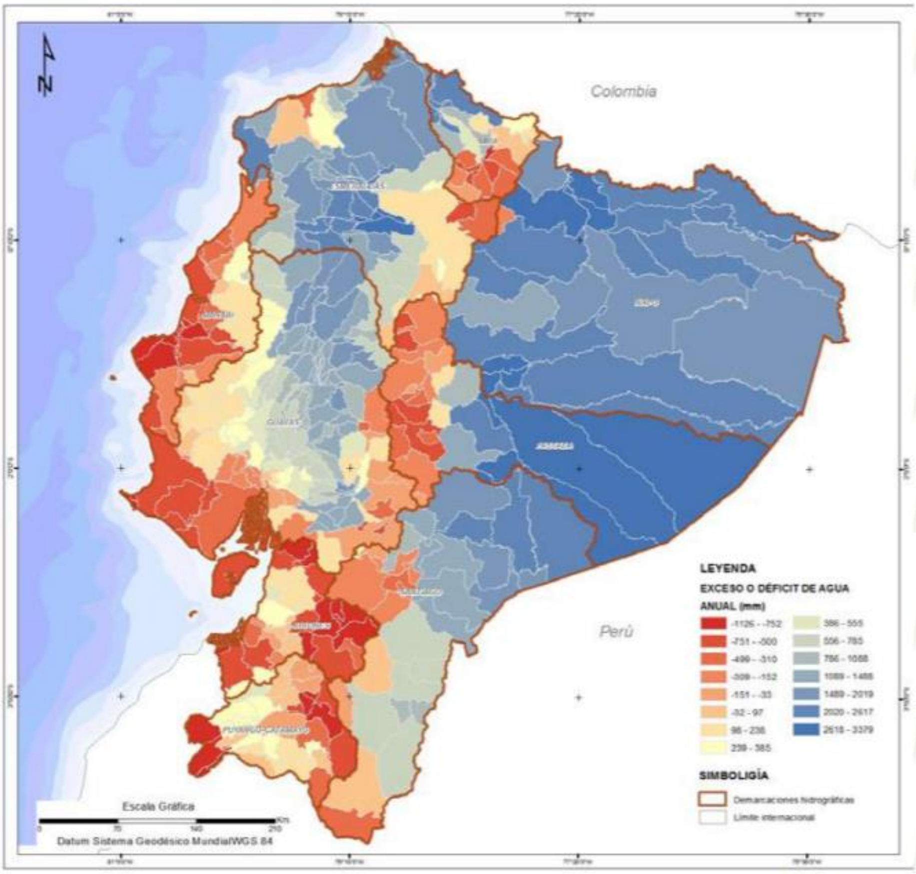


Source: Water Resources Institute

Figure 14 shows National Hydrological Balance, which determines the availability and/or water deficit per watershed. Areas with excess annual amount of water in the soil are mainly in the Sierra (north-center) and in the Amazon; whereas water-deficit areas are in the Andes Mountains, the coastal area and the south of the country.

Figure 14

Water Deficit



Source: SENAGUA

Ecuadorian water legislation

Constitution of the Republic of Ecuador 2008.

Ecuador was one of the first countries to recognize that Nature has rights, including water resources. The Constitution establishes its existence and maintenance must be respected. According to Art 12, the human right to water is fundamental and indispensable. Water constitutes a strategic national heritage for public use, inalienable, imprescriptible, seized and essential to life. Moreover, according to Art 411 the state will ensure the conservation, recovery and integral management of water resources, watersheds and ecological flows associated with the hydrological cycle. Any activity that may affect the quality and quantity of water, and the balance of ecosystems, will be regulated. Ecosystem sustainability and human consumption will be a priority in the use and use of water. Furthermore, the right to a healthy and ecologically balanced environment is recognized, it is in the public interest to preserve the environment. For which the State will promote the use of environmentally clean technologies and alternative non-polluting and low-impact energies, but it prioritizes the right to water.

Organic Law of Water Resources, Uses and Water Use.

The first water law in Ecuador was issued in 1972, but it became obsolete in the face of the country's needs and population growth. Due to the 2008 Constitution, a new legal body was issued on 2014, which is the Organic Law of Water Resources, Uses and Water Use (LORHUyA, in Spanish). There are four important components in LORHUyA, which are: integrated management, water resource planning, ecological flow, and nature's rights. This Law has two main purposes:

1. To guarantee the human right to have clean, sufficient, acceptable, accessible and affordable water for personal and domestic use in quantity, quality, etc. This implies free access, no discrimination and equitable access to water distribution and redistribution.
2. To regulate and control the authorization, management, preservation, conservation, restoration of water resources throughout Ecuador.

All types of water (surface, ground, and atmospheric) are recognized and are considered a national and strategic heritage, and essential for food sovereignty. The provision of the public water service is exclusively public or for the community, privatization is prohibited and only certain powers are allowed to be delegated to the private sector (art 1). Overall, this law addresses the right for water conservation, protection of water supply sources, flow regulation, areas of water abstraction, and regulates de uses and advantages of this resource.

This law creates the National Strategic Water System, which is a set of processes, entities and instruments to organize and coordinate the integrated management of water resources (art. 15). It is composed of: the Unique Water Authority (SENAGUA), the Intercultural and Plurinational Water Council, the Executive Function Institutions, the Water Regulation and Control Agency (ARCA), the Decentralized Autonomous Governments (DAG), and the Watershed Councils. SENAGUA is responsible for the integrated management of water resources by river basin systems (art. 8). Water authorities establish water rates. Furthermore, the responsibility for the sustainable management, protection and conservation of water sources is not only of the authorities aforementioned; but of all users, communes, villages and the owners of the premises where sources of water are found, therefore owners of the premises or users of the water must abide by this law (art 12).

There are areas of water protection that are the territories where there are water sources declared as in the public interest for maintenance, conservation and protection, which supply human consumption. Where land use affects the protection and conservation of water resources, the authorities shall establish and delimit areas of water protection in order to prevent and control water pollution. It aims to prevent water pollution and the State has the obligation to formulate public policies to guarantee the human right to water.

Water is used for basic activities essential for life and in accordance with art. 86 the priority of water use is: 1) human consumption; 2) Irrigation that guarantees food sovereignty includes the water trough, aquaculture and other activities of domestic food production; 3) ecological flow and 4) productive activities. The productive use of water requires the administrative authorization of the SENAGUA and Irrigation for agricultural production, aquaculture and agro export industry is the first priority.

Norm INEN 1108.

This legislation establishes the limits of concentration of elements and compounds for the different types of water uses: drinking water, domestic use, irrigation, industrial, etc. To evaluate water quality, five parameters are taken into consideration: physical quality, chemical quality, bacteriological quality, biological quality and radiological quality. It is an obligation to leave a sanitary protection zone from water supply sources, in which some activities regarding livestock are prohibited:

- Use of fertilizers, pesticides, organic fertilizers and minerals applied by sprinkling them from a light plane within 300 meters of the riverbank
- Grazing within 100 meters width, measured from the maximum water level.
- Livestock trough need to have a distance of at least 100 meters, measure by the maximum water level; and planning of drainage of dirty water outside the sanitary protection zone
- No cattle raising ranches in a distance less than 500 meters, measured from the maximum water level in the reservoirs.

LITERATURE REVIEW: CHOICE EXPERIMENT AND AGRICULTURAL PRACTICES

Choice Modelling is used either to estimate the willingness to pay or the willingness to accept. Extensive literature exists on Choice Experiments (CEs), both on the theoretical underpinning and methodological development. This methodology is used in consumer demand literature, transport economics, health care economics, tourism, agricultural economics, and environmental economics. Its use in the latter one is mainly for ex-ante policy incentives and subsidy schemes analysis. Studies to elicit farmers' preferences have appeared the past decade. Most of the CE's have been applied in the developed world, but the application in the developing world has increased, especially in India and China regarding environmental economics. Increasingly, this methodology is been used to assess the adoption of sustainable agricultural practices and environmental conservation of certain sites. On the other hand, is also used to value water resources, such as estimation of the value of improvements in river quality. Relevant studies for this paper, include CE's regarding farmers' preferences in their adoption of a variety of agricultural or land management practices, especially those pertaining about controlling water pollution. Also, environmental research in Ecuador or Latin America.

Alcon et al., (2014) evaluates farmers' acceptance of policy strategies to increase water supply reliability in a water scarce river basin in Spain. The results suggest that farmers are willing to pay double water prices to ensure water supply reliability, through government supply guaranteed programs. Additionally, Hanley et al., (2006), in the EU used choice modelling to estimate the value of improvements in ecological status in all EU waters through integrated catchment management. The results suggest that people really care about river ecology, aesthetics and banksides equally because they are all valid indicators of a healthy river. Moreover, in India, Barton & Bergland (2010) used a CE to evaluate a hypothetical irrigation water pricing regime. Their findings show that farmers preferred the status quo.

Furthermore, in India, Chellattan Veettil et al. (2011), applied a CE to investigate farmers' preferences for and the efficiency of a given pricing method based on WTP estimates, and measure the economic values of the water-rights attributes. The results show that farmers never prefer the existing pricing system. Moreover, in China, Aregay et al. (2016) studied the preference heterogeneity for Integrated River Basin Management (IRBM), where the results show that there is significant support for integrated ecological restoration. Furthermore, in South Africa, Saldias et al., (2016), analyzed farmers' preference of water reuse frameworks for irrigation. The CE findings show that water reuse is acceptable to farmers in the area and that they prefer options that guarantee good quality water and low levels of restrictions on use practices. Additionally, Tarfasa & Brouwer (2013) examined the WTP for improved water supply services through a CE in Ethiopia, were they find that households are willing to pay up to 80 percent extra for improved levels of water supply over and above their current water bill. In Ecuador, there have been a few water projects, however CE methodology is not applied, and they have more of a scientific aspect. For instance, Naciph (2016) analyses water quality of the San Pedro River and proposes a water treatment design. Quilmbaqui (2017) analyses the concentration of major elements in 18 rivers in Pichincha. Moreover, Borja (2018) evaluates the microbial and chemical load in rivers from the province of Pichincha in Ecuador. Additionally, Amendaño (2018) made a proposal for the water resource management for sustainable development in Mejía. Finally, Guerrero (2019) created an intervention model for the conservation of water resources applying fuzzy logic in the micro-basins of the Pita and Psyche rivers.

In what refers to farmers' preferences our main reference paper is Yehouenou & Grogan, (n.d.) forthcoming paper, which investigates cost-share program attributes that would affect producers' willingness to enroll in the program to fund the adoption of best management practices to improve water quality and decrease water use. Findings suggest that farmers prefer cost/share programs with shorter contract lengths, self-monitoring, and administration by agricultural agencies. Furthermore, Pan et al., (2016) employed a CE in China to investigate farmers' livestock pollution control policy. Their findings show that the biogas subsidy, technical support, pollution fees, and manure market are significant factors of preference over alternative policy designs for manure handling; and preference heterogeneity for livestock pollution control policies. Also in China, Pan et al. (2016) analyzes farmers' preference and valuation of livestock pollution control policy instruments at household-scale, medium scale and large-scale. The results show that all policy instruments effectively increased the manure eco-friendly treatment ratio for medium-scale farms, while this was not effective for household-scale farms. Household-scale and medium-scale farms had the highest preference for the biogas subsidy policy, while large-scale farms had the highest preference for the manure price policy. Furthermore, in Tajikistan, Goibov et al., (2012) estimate farmers' preferences on non-market values of agro-environmental attributes and their changes within the study area. Their findings suggested that preference heterogeneity exists, which implies that a decision for land allocation under different crops is jointly associated with other socio-economic and environmental factors. Additionally, Villanueva et al. (2015) also evaluated farmers' preferences toward AES in a case study of olive groves in Spain. The findings show that almost half of the farmers would be willing to accept it up to 2 percent for low monetary incentives, while the rest would do it for moderate-to-high monetary incentives; they also find that it is unlikely that farmers would participate collectively with the incentive of the up to 30 percent EU-wide bonus. Moreover, Ben-Othmen & Ostapchuk, (2019), analyzed the factors that influence French farmers' preferences and motivations have to join an AES involving grasslands restoration. The findings show, that farmers have a positive attitude towards a collective participation. Additionally, Espinosa-Goded et al. (2012) investigates farmers' preferences for different design options in a specific AES aimed at encouraging nitrogen fixing crops in Spain. The results show farmers have a strong preference for maintaining their current management strategies, however significant savings in cost or increased participation can be obtained by modifying some AES attributes. Furthermore, in Germany, Feil et al. (2016), analyzes farmers' preferences for farm-level collaborative arrangements, where the results show that farmer's preferences increase the closer their age is, the more years of acquaintance exists and the more similar their production activities are. Also in Germany, Latacz-lohmann and Schreiner (2018) examine the determinants of farmers' acceptance of alternative agricultural policy packages. The findings were that two thirds of respondents were in favor of the continuation of direct payments, 40 percent were in favor of higher standards in the environment and animal welfare in return for continued direct payments, while 23 percent wanted direct payments to continue without having to do anything in return. Finally, most were against a state safety net through market intervention. Moreover, Ward et al. (2016) study the farmers' preferences for Conservation Agriculture (CA) technologies in Malawi. The results indicate current farm level practices largely influence willingness to adopt the full CA package. Furthermore, in the US, Yeboah et al. (2015) examine agricultural landowners' decisions to participate in a conservation program involving filter strips. Findings indicate that shorter contract durations, enhanced rental payments, and education of the program efficiency would enhance participation. Moreover, Cai et al., (2019), examine what determines farmers' adoption of sustainable manure treatment technologies in livestock production. The findings show that there are two key factors influencing farmers' decisions to adopt multiple SMTT, off-farm and environmental awareness. It also revealed that there is no impact of the subsidy of the adoption of biogas technology, but the subsidy on composting technology does have an impact on adoption. Additionally, Meemken et al., (2017) used a CE to analyze how farmers in Uganda evaluate actual and hypothetical features of sustainability standards. Results indicate that farmers have positive attitudes toward sustainability standards, while they dislike bans of productivity-enhancing inputs, also, they appreciate agricultural training and special female support. In France, Jaeck and Lifran (2014) examine farmers' preferences for both cropping and management practices. The findings show that most rice growers would adopt environmentally friendly practices.

In Latin America, Cerda, (2013) assessed public economic preferences for biodiversity conservation and water supply and analyzed the factors influencing those preferences in Chile. The results show that visitors of the Peñuelas National Reserve are willing to pay to protect the selected attributes. Furthermore, in Brazil, Lemeilleur et al. (2019) investigate the incentives of coffee farmers to participate in certification schemes that require improved agricultural practices. The findings reveal that both cash and non-cash payments are likely to incentive farmers' participation; and that besides price premium, incentives as long term contracts and provision of technical would encourage producers to adopt eco-certification schemes.

In Ecuador, Blare and Useche (2015) examine the value men and women place on cacao agroforests through a CE. The results reveal that both men and women positively value the associated crops in the agroforests but place a lower value on their agroforests, as the natural biodiversity increases. Also, Blare and Useche (2019), estimated the value that smallholders place on the conservation of cacao agroforests. The results show that households were willing to give up some profit to conserve agroforests especially if they had managed the plot longer; and when women were included in the management of a plot. Additionally, in southern Ecuador, Raes et al., (2017) investigate farmers' preferences to participate in payment contracts to adopt silvopastoral systems. The findings show that farmland area, agricultural income and landowners' perceptions of environmental problems provide a partial explanation for the heterogeneity observed in the choices for specific contracts, therefore participation might increase if contracts were targeted at specific groups of farmers. Moreover, in the Galapagos National Park, Perez Loyola et al. (2019) aim to monetize the benefits of the attributes that the national park offers to tourist, the results demonstrate that tourists place the highest WTP on increased protection of animal species and garbage reduction. In the Ecuadorian Andes, (Barrowclough et al., 2016)investigate farmer attitudes toward how a hypothetical set of conservation agriculture practices will affect yield, labor use, erosion and cost. Results show producers are most concerned with future yields, planting labor and overall cost; and farmers provide support for conservation agriculture out-reach to highlight practices that increase long-run production and reduce the time and technical skills associated with planting. Also, in the Andes, Cranford and Mourato (2014), through a CE find that credit-based payments for ecosystem services are promising and have multiple desirable qualities of an incentive.

In Ecuador, there have been a few livestock analysis projects, mainly dissertations, however CE methodology is not applied. For instance, Vaca (2019) is the only research that analyses methodologies for the evaluation of the influence of the agricultural and livestock sector activities in water quality. Furthermore, Guncay (2018) made a proposal for the implementation of Good Livestock Practices in the process of reproduction of beef cattle on the “Tropicales” farm. Finally, Paredes (2015), made an environmental audit of compliance with the good adaptive practices carried out in livestock demonstration units in Papallacta. Despite the vast literature on adoption of environmentally conscious practices, in Latin America, no work has considered the effects of the adoption of environmentally conscious practices with an emphasis of water resource conservation through a CE methodology in which farmer’s preferences are considered.

STUDY AREA

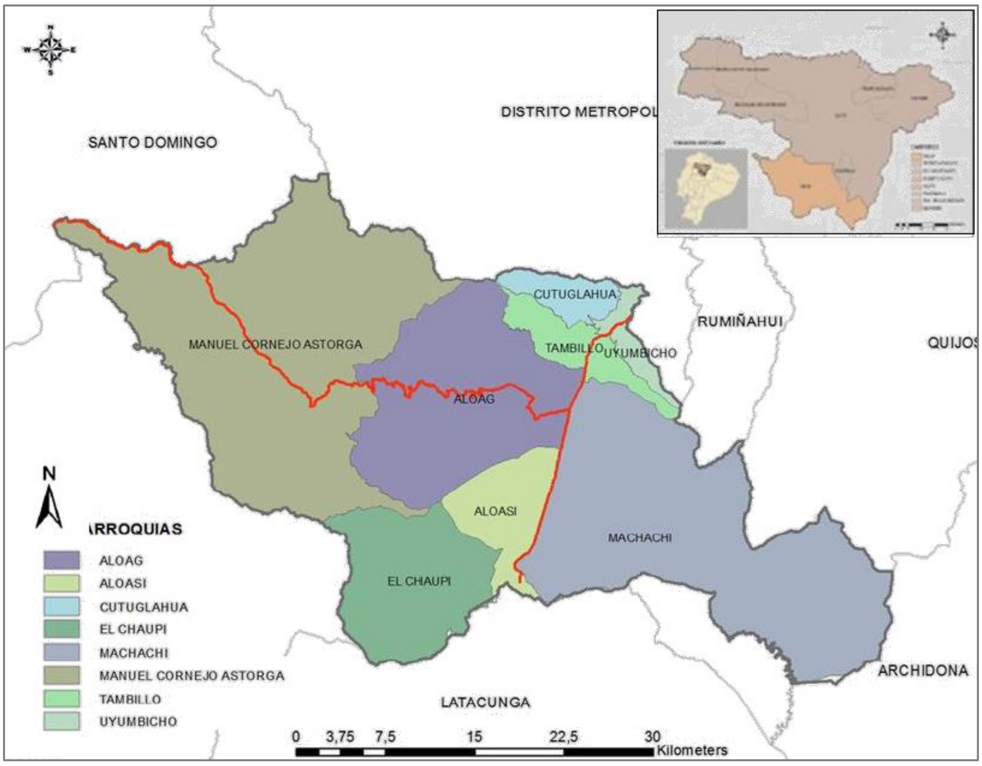
Mejía

General social and economic information.

Mejía is located in the southeast of the Province of Pichincha, south of Quito, at an altitude between 1200 and 5126 mamsl with an area of 1,426.46 km^2. Figure 15 shows a map of Mejía and its geographical limits. Its only urban parish is Machachi, while its seven rural parishes are: Alóag , Aloasí, Manuel Cornejo Astorga (Tandapi), Cutuglagua , El Chaupi , Tambillo, and Uyumbicho. Mejía has a total urban area of 20.9 percent, while its rural area represents 79.1 percent (Gestión de Comunicación MA, 2017).

Figure 15

Map of Mejía



Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

As seen in Table 1, Mejía's total population in 2010 was 81,335, were 79.7 percent was rural and 20.3 percent was urban. Its population is composed of 51.1 percent females and 48.9 percent males. In 2010, 25,600 people were economically active people, from which 7,751 were involved in agricultural activities (including: agriculture, livestock, forestry and fishery), representing 21.5 percent, while in 2014 it rose to 29.22 percent, demonstrating the sector's importance. Mejía's capital, Machachi, has the highest population with 31,705 citizens; it is followed by Cutuglahua and Aloasi, with 19,220 and 11,117 respectively. The least populated area is Manuel Cornejo Astorga with 4,214 citizens. Furthermore, 35 percent of Mejía's population is between 15 and 34 years, which implies that given they are young they might be inclined to apply more environmentally conscious agricultural practices.

Table 1

Area and Population of Mejía

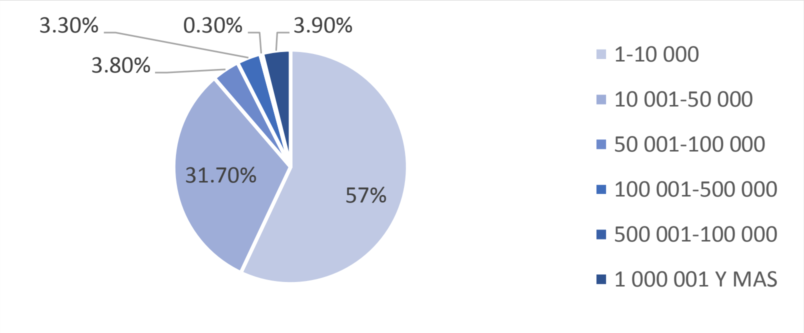
Parish	Zone	Area (km^2)	Population in 2010	Population in 2014
Aloag	Rural	235.47	9,237	10,602
Aloasi	Rural	66.34	9,686	11,117
Cutuglahua	Rural	28.36	16,746	19,220
El Chaupi	Rural	138.30	1,456	1,671
Machachi	Rural	467.99	11,108	31,705
	Urban		16,515	
Manuel Cornejo Astorga (Tandapi)	Rural	480.60	3,661	4,214
Tambillo	Rural	46.32	8,319	8,548
Uyumbicho	Rural	21.19	4,607	5,288

Source: (GAD Pichincha and GAD Mejía, 2015)

On the other hand, income is distributed as follows (see Figure 16), 57 percent of Mejía's citizens earn from $1 to $10,000. While 31.7 percent earn from $10,001 to $50,000, and 11.3 percent earn more than $50,001. Moreover, according to the Unmet Basic Needs 54.03 percent of Mejía's population is poor, while extreme poverty is 20.23 percent (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015).

Figure 16

Income Distribution

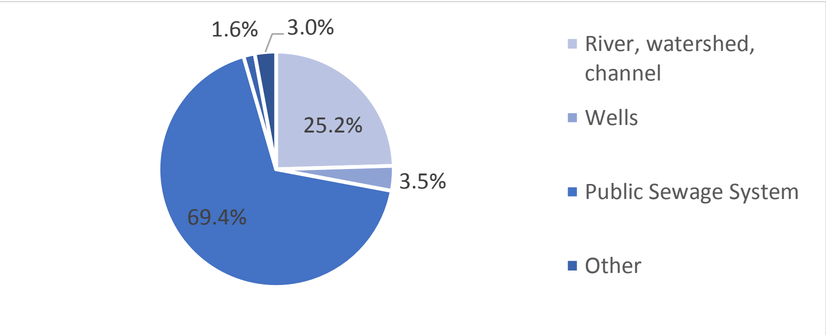


Source: GAD Pichincha

As seen in Figure 17, 69.4 percent of Mejía's population receives their water from the public sewage system. While, 25.2 percent receive their water from the river, a watershed or through a canal, exemplifying the importance of unpolluted hydrological resources for this community. Moreover, in Mejía 45.60 percent of people drink their water exactly as it reaches their home, once again illustrating the importance of unpolluted freshwater.

Figure 17

Water Supply of Mejía



Source: GAD Pichincha

Overall Mejía's educational system has an acceptable service. Only about 37 percent of the population in Mejía has a superior education title. About 20 percent have only 7 years of school, while around 15 percent have 13 years of school. Additionally, there is a 7 percent illiteracy rate on the canton. On the other hand, the medical system is below acceptable levels due to lack of doctors, medical infrastructure and equipment (GAD Mejía, 2015).

Machachi is located at the southern end of the valley that forms the San Pedro River at 2945 mamsl. The past decade Machachi grew to the periphery, the urban area expanded around 13 percent to the rural area. Its main economic activities are the production of mineral water, agriculture, livestock, and transportation because of the high potential it has due to climate, fertile soils, and geographical location. Moreover, there are around 2,800 people involved in agricultural, livestock, forestry and fishery activities in this parish, representing 22.3 percent. In Machachi, total land use with an agricultural approach is 12,548.5 ha, representing 32.3 percent of the parish territory (Robayo, 2018).

Livestock in Mejía.

In Pichincha, gross domestic agricultural production accounts for 12.74 percent of total national agricultural production. For livestock production farmers hold breeding of double-purpose cattle (meat and milk), sheep, goats and smaller ruminants. Cattle raising is mainly intended for milk and meat, but more than 80 percent is dairy production (Ministerio de Agricultura Ganadería y Pesca, 2015b).

The richness of the volcanic soils and the abundant presence of water resources in the canton characterize it as a highly agricultural region. In Mejía primary activities prevail, providing agricultural and livestock products too much of the country, therefore it is considered as a zone of food security (GAD Mejía, 2015; Robayo, 2018). People in agricultural activities are not only dedicated to production but also to the commerce of these products to a small, medium and large scale (Robayo, 2018). Mejía has the oldest dairy cattle in Ecuador that maintains a high genetic value. Holstein, Brown Swiss, Jersey, and Norman breeds have been and are the basis where much of the livestock from all over the country originated. Mejía has risen as a symbol of milk production nationwide due to its capacity of production per hectare. It has the biggest milk production in the country, where around 300,000 liters per day are produced, which represents 20 percent of the national production, and there are farms that even reach a capacity of 40 liters of milk per day per hectare. The canton is divided into hundreds of farms that currently reach an average production ranging from 17.8 to 25 liters of milk per day per cow (Centro de la industria láctea del Ecuador, 2015). It represents 7 percent of the country's bovine population, producing around 860,000 liters of milk daily for Quito (GAD Mejía, 2015).

Livestock herds are handled semi-intensively in medium and large farms and extensively on small plots (less than 5 ha) or for wild cattle. The semi-intensive system for bovine population management requires a high initial investment for the construction of stables and corrals and for the acquisition of milking machinery and equipment. The diet in this system is based on forage mixtures plus balanced feed. On the other hand, the extensive system for bovine population management is the most common in the province. In this system, the animals stay long periods in small paddocks, which leads to the animal selecting the grass to eat and producing a high percentage of waste due to trampling (GAD Mejía, 2015).

In the canton, the grazing areas have a low animal load, representing about 0.5 cattle per hectare, when there are around 56,000 cows. The traditional ones are producers whose characterization of the livestock herd is given by crossbreed animals or no breed ones. Management does not aim to improve the production or quality. On the other hand, the semi-technified or technified producers, are the ones who have designed their production to constantly supply the dairy industry, therefore, they manage their livestock herds with professionals to ensure milk quality. Moreover, they have irrigation systems for constant pasture production and use balanced food on a constant basis (GAD Mejía, 2015).

Land use.

The canton has three different areas according to altitude: the valley, the paramo and the western jungles (refer to Appendix E). All these conditions, such as climate, precipitation, land capacity, and soil properties allow Mejía to be the most important milk producer in the country. The cows' productivity reaches a world record being at 2600 to 3300mamsl. Furthermore, there are three relatively homogenous zones in Mejía (refer to Appendix F). The first zone is the cattle raising area, which is located in the central part of the canton. Its latitude ranges from 2800to 3350mamsl, being in Tambilo, Aloag, Aloasi, and El Chaupi parishes. Most producers are small with a semi-intensive system. On the other hand, the second zone is the agricultural production area, which is located in the center east and surrounding Machachi. Finally, the third zone is a combined (agricultural and livestock) production area, located in the north-west. Its latitude ranges from 1000mamsl to 2000mamsl. The cattle raising is mainly for milk, with an extensive system and almost no technology (GAD Mejía, 2015).

As Table 2 shows, of the total land-use area of the canton (105 571.74 ha), the largest percentage, 57.46 percent, is land for conservation and protection purposes, with a total area of 60 665.68 ha, and encompasses all-natural vegetation such as forests and scrub. On the other hand, an important part of the territory, 32.85 percent (34 680.88 ha), is intended for livestock use; where natural pasture can be found, and in some places, it is technically managed.[9]

Table 2

Land Use in Mejía

Use	Surface (hectares)	Percentage (%)
Agricultural	2,206.96	2.09%
Mixed Agricultural and Livestock	2,768.79	2.62%
Water	152.75	0.14%
Anthropic	3,108.83	2.94%
Poultry	21.64	0.02%
Conservation & Production	556.11	0.53%
Conservation & Protection	60,665.78	57.46%
Livestock	34,680.88	32.85%
Protection or Production	1,304.43	1.24%
Unproductive Lands	105.56	0.10%
Total	105,571.73	100.00%

Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

[9] For a more graphic explanation, refer to the map in Appendix G

According to MAGAP (2010), of the 96,937 hectares of arable land, more than 50 percent (59,962 ha) is destined to dairy-produced livestock (GAD Mejía, 2015). Around 38 percent of the land is occupied by agricultural activities (refer to Appendix H). Of the total land-use area (105,572 ha), a large part of the territory is intended for livestock use, representing 32.85 percent (34,681 ha). Also, natural pastures amount 32,541 ha and cultivated pastures amount 5,322 ha (GAD Mejía, 2015) (see Table 3). Together natural and cultivated pastures maintain approximately 350,000 cattle distributed in 3,185 livestock production units.

Table 3

Agro Land Use in Mejía

Occupation	Land Use	Surface (hectares)	Percentage of total	Percentage of Agro
Agro	Agriculture	4,975.75	4.71%	12.54%
	Livestock (cultivated pasture)	34,680.88	32.85%	87.41%
	Poultry	21.64	0.02%	0.05%
No Agro Use	Not applicable	65,893.47	62.42%	0%
Total		105,571.74	100.00%	

Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

Environment information and environmental damage in Mejía.

Mejía has six protected areas, declared so by the Ministry of Environment. Moreover, the main ecosystems in Mejía are mainly humid forest, very humid forest, and rainforest. Forests and pasture occupy most of the land, followed by paramo areas. On the other hand, bodies of water occupy 0.14 percent of the land coverage. 28,000 ha of Mejía are paramo ecosystems (moors), which is in the mountain, higher than the forest and lower than the peak (2800-4800 mamsl). The paramo has a variety of water resources such as: rivers, wetlands, waterfalls, etc. This ecosystem importance relies on its hydrological properties and its action on the water system, since for every square meter this ecosystem can produce up to one liter of water per day (Guerrero, 2019). Paramos regulate the hydrological cycle as the soil absorbs the water as a sponge and releases gradually. Paramos have the ability to intercept, store and regulate surface and underground water flows, and store carbon in their soil. However, changing the use of paramo land for agricultural activities alters its hydrological behavior, and consequently its water retention and regulation capacity (FONAG, 2019). Paramo's soil is formed by a combination of soil, decomposed plants, and therefore has a high content of organic matter and is rich in carbon. When the soil does not have enough organic matter, soil compacts and land erodes, which causes nutrients to flow down in water and with the wind. A compacted floor no longer stores water and the paramo loses its ability to regulate it.

Table 4 shows the degree in which the different ecosystems in Mejía are disturbed. The rainforest is the most altered, with 2.18 percent being very altered, 8.20 percent being mildly altered and 58.89 percent being slightly altered. Followed by the paramo herbaceous, which has 0.37 percent very altered, 16.24 percent mildly altered, and 2.92 percent slightly altered. Whereas, the scrub has only 9 percent of alteration overall. Both the paramo bushy and the herbaceous vegetation are the least altered.

Table 4

Ecosystem Disturbance Levels in Mejía

		Alteration Surface	
Plant Formation	Degree	Hectares	Percentage
Rainforest	Very altered	1334.58	2.18%
	Mildly altered	5021.67	8.20%
	Slightly altered	36055.12	58.89%
Scrub	Very altered	4020.19	6.57%
	Mildly altered	1734.74	2.83%
	Slightly altered	63.18	0.10%
Paramo (moor) bushy	Very altered	381.95	0.62%
	Mildly altered	97.76	0.16%
	Slightly altered	0.00	0.00%
Paramo (moor) herbaceous	Very altered	224.93	0.37%
	Mildly altered	9944.05	16.24%
	Slightly altered	1787.61	2.92%
Herbaceous vegetation	Very altered	121.10	0.20%
	Mildly altered	435.00	0.71%
	Slightly altered	0.00	0.00%

Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

Among the anthropic activities that have caused alterations in water and soil resources are: agriculture, livestock, fishing, timber exploitation and human settlements. Agriculture produces a significant alteration of the physical and chemical conditions of water and soil, due to the use of chemical inputs with toxic properties and due to the application of fertilizers and/or agrochemicals in the soil. The introduction of livestock areas near water sources results in water contamination with animal feces. Also, the decrease in water sources flow has been mainly caused by the exploitation of natural forests (GAD Mejía, 2015).

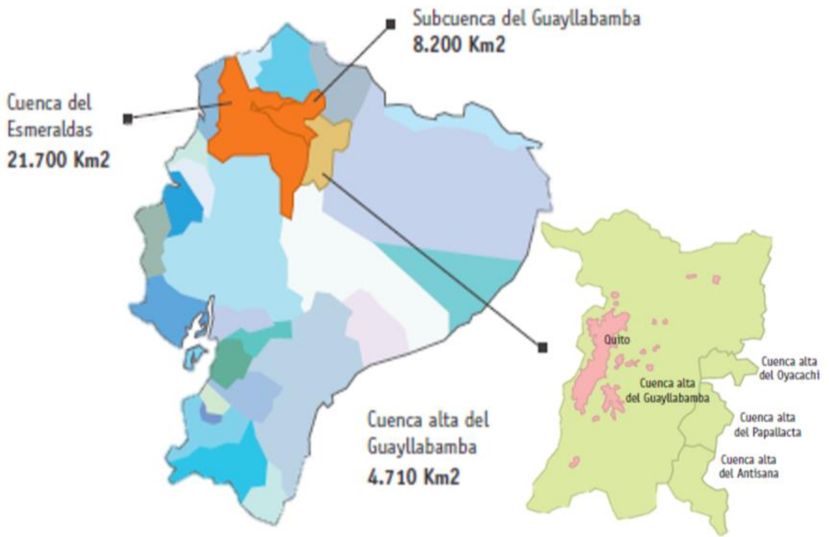
Water resources

Esmeraldas River Basin.

Esmeraldas River Basin district is one of the nine river basin districts in Ecuador and belongs to the Pacific Watershed (see Figure 18). According to Plan Nacional de Agua (2016), the Esmeraldas river basin has the following characteristics: average annual precipitation of 70,271 hm^3, annual runoff of 41,983 hm^3, average capacity of long-term underground water resources of 7,790 hm^3 and a total volume of water resources 43,131 hm^3.

Figure 18

Esmeraldas River Basin Map



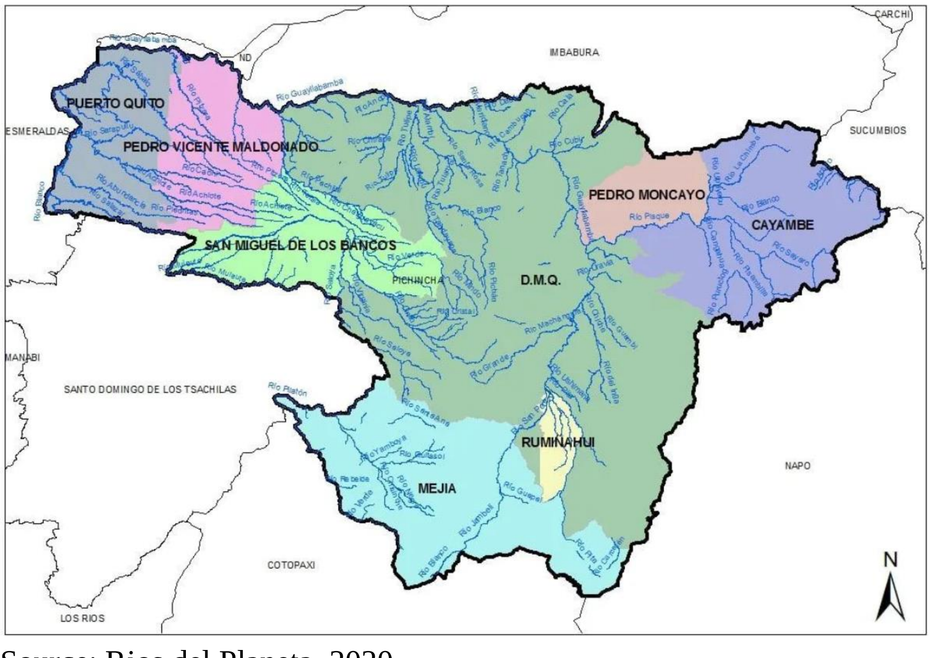
Source: FONAG, 2019

Guayllabamba Sub-River Basin.

The Guayllabamba Sub-river Basin (see Figure 19), constitutes the highest part of the Esmeraldas river basin, located in the inter-Andean alley, in Pichincha. This basin encompasses 2.5 million inhabitants (FONAG, 2019). “The basin has an area of 5524 km^2 where five cantons settle: Mejía, Rumiñahui, Cayambe, Pedro Moncayo and Metropolitan District of Quito. The Andean high rivers originate from paramo ecosystems (De la Paz, 2012). In what regards the land use of the Guayllabamba river basin are: human settlements, natural forest, a minimum percentage of quarries, bodies of water, hydroelectric plants, area intended for agriculture, lava flow, greenhouses, scrub, snow helmets, swamps, herbaceous moorland/pajona, burning, eucalyptus forests, and bare soil (Muñoz Villacreses, 2016).

Figure 19

Guayllambamba River Map



Source: Rios del Planeta, 2020

In Pichincha the most important rivers, with much-used flows in agricultural works, are: Guayllabamba, San Pedro, Pita, Pisque, Blanco (Ministerio de Agricultura Ganadería y Pesca, 2015b). According to Borja (2018), Pichincha rivers do not have acceptable levels in physicochemical, microbial, and metal parameters, for consumption, agricultural use, industrial use, or recreational activities. The availability of water resources decreases due to pollution, changes in land use, deforestation, increasing urbanization and pressure on rural areas. Some of the problems that FONAG identifies within this area are water sources degradation, poor management of watersheds, lack of governance, overexploitation of water, wrong culture, and knowledge on water handling.

Water in Mejía.

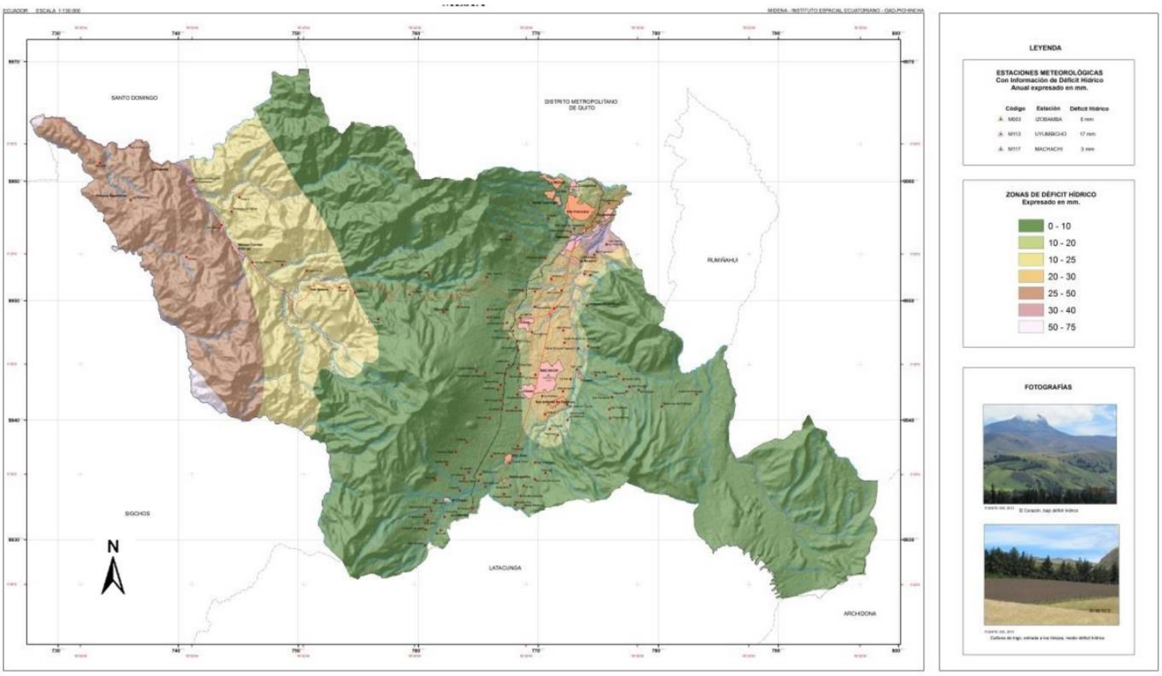
A variety of rivers pass through Mejía that mainly come from the mountains that surround it. In hydrographic terms, the canton is divided into two sub-basins: the Guayallabamba River and the Blanco River[10]. The micro-basin of the San Pedro River is in the eastern sector, belonging to the Guayllabamba River sub-basin, the same one that is fed by the thaws and watersheds of the Rumiñahui, Sincholagua, Pasochoa, Ilaló and Cotopaxi volcanoes. In the western sector, the Blanco River sub-basin originates with the thaws of the western mountain range, among them: Rucu Pichincha, Atacazo, Corazón and Illinizas (GAD Mejía, 2015).[11]

Most watersheds that provide water to many communities are unprotected. The main uses of water are troughs, domestic, hydroelectric plants, industries, fisheries, and irrigation. As Figure 20 shows, around a third of Mejía has the lowest water deficit index (0-10), mainly the central area. The east part has a water deficit from 10-20, which is still low. On the other hand, the west part is the highest water deficit area that goes from 10-25 and increases from 25-50 towards the border. Finally, in the middle of the center area there is also a medium water deficit.

[10] For a detailed list of rivers in Mejía refer to Appendix I
[11] For a detailed map of the hydrografic Division y Micro river basins in Mejía, refer to Appendix J.

Figure 20

Water Deficit Areas



Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

METHODOLOGY

Non-market valuation and choice experiment theory

When analyzing environmental goods, non-market valuation is applied, which is the monetarization of goods and services without market prices. This type of valuation considers total economic value: use value, option value and non-use value. There are two types of valuation methods: stated preference methods and revealed preference methods. The former derives the value by using survey attempts to elicit the respondents' willingness to pay (WTP) for preserving that good, while the latter is based on actual observable market choices that allow resource values to be directly inferred. While revealed preference data have the advantage of capturing actual choice decisions, important variables that are driving the decisions might remain unobservable (Tietenberg & Lewis, 2015). Since non-market valuation quantifies external benefits and costs, it can help to efficiently allocate resources and foster participatory public decision-making (Cerda, 2013).

Stated preference methods: Choice Experiment.

Within stated preference methods, contingent valuation (CV) and choice experiment (CE) are widely used for valuation of non-market goods and services. In general, CV studies describe the environmental change to be valued, while CEs describe modifications to the attributes of the item to be valued. Whereas CV presents a respondent with a "yes/no" question, CE presents the respondent with a menu of options of different environmental services at different prices (Cerda, 2013). CEs allow for the ex-ante study of economic benefits or costs generated by non-market goods and services – in this research the adoption of sustainable farming practices – in order to evaluate policies and programs that have not been widely introduced or adopted (Ortega et al., 2016). CEs aim to analyze WTP by asking the respondents' to choose among alternate bundles of goods. Each bundle has a set of attributes and the levels of each attribute vary across bundles; attributes can be quantitative or qualitative.

CEs construct a hypothetical market by presenting respondents with a series of ‘choice sets’ comprised of paired alternative plans (i.e. ‘Plan A’, ‘Plan B’) (Akter et al., 2016). There always has to be a plan in which the individual does not choose anything new, called the status quo option.

Individuals are asked to choose their preferred alternative from several options in a choice set, and they are usually asked to respond to a sequence of such choices (Sitompul et al., 2016). Varying the attribute levels across alternatives allows understanding of what shapes individual preferences and the relative importance of each attribute (Cerda, 2013). The objective of repeating the choice task is to infer which attributes influence the choice and analyze the implicit ranking of these attributes. Since CE is a field experiment, control is done by providing meaningful variation in attribute levels. One of the attributes has to be a price or cost term in order to estimate the WTP through marginal utilities (Hanley et al., 2006).

Although, as other non-market valuation techniques, CEs suffer from hypothetical, strategic or information bias (Hanley et al., 2006), this tool presents different advantages. The most notable advantage of the CE technique is that it allows attribute trade-offs and thus separate estimation of the value of individual attributes of a product or program (Akter et al., 2016). CE’s also allow the inclusion of attributes that are difficult to observe or that are missing in real markets (Gelaw et al., 2016). Furthermore, it can generate multiple value estimates from a single application, which is useful for decision-makers dealing with natural resource planning. Moreover, CEs provide results that are consistent with standard welfare economics by calculating implicit prices (Aniseh & Daniel, 2016; Ortega et al., 2016). Additionally, CE minimizes framing effects by simultaneously presenting a pool of other goods, which allows respondents to automatically consider complementary and substitution effects when making a decision (Sitompul et al., 2016). Compared to CV, CEs has the potential to provide greater information about peoples' preferences and avoids embedding effects and yea-saying biases that arise in CV (Cerda, 2013; Saldias et al., 2016).

Interviews

A crucial preliminary step is to identify the pertinent properties of the goods to be valued, and therefore a clear understanding of the specific attributes to be assessed. For a proper CE valuation, it is all about an appropriate definition of attributes and levels (Cerda, 2013). Interviews with experts in the field and farmers in the study area were conducted, to contribute to an adequate definition and description of the pertinent characteristics of the area to be valued. This led to a comprehensive definition of the husbandry practices to be analyzed and proposed.

Theoretical model

Choice Experiment is based on two theoretical economic arguments: Lancaster's 1966 New approach to consumer theory and Random Utility Theory (RUT) as its econometric basis developed by Thurstone's 1927 and further extended by McFadden's 1974 Random Utility Theory as its econometric basis. The underlying assumption when estimating farmers valuation of different livestock practices depends on the specific characteristics of these practices (including the implementation cost) (Christensen et al., 2011). Lancaster's theory establishes that consumers derive satisfaction/utility not from the goods themselves, but from the attributes/characteristics they provide. Therefore, when a consumer chooses a bundle over another, the trade-off is not just between two bundles, but it is between the different attributes of the two bundles.

McFadden's Random Utility Maximization (RUM) model is the underlying structural model encompassing discrete choice behavior (Akter et al., 2016). RUT is based on the assumption that individuals make choices according to a deterministic part along with some degree of randomness (Christensen et al., 2011). Here individuals are assumed to choose a single alternative that maximizes their utility from a set of available alternatives. Therefore, the model divides indirect utility into an observable and an unobservable component for each respondent (Akter et al., 2016). The former is a function of a vector of attributes and respondent characteristics. Thus, the utility for individual “s” and alternative “i” is:

$$U_{is} = V_{is} + \varepsilon_{is}$$

$$U_{is} = V(Z_i, S_s) + \varepsilon_{is}$$

Where:

- $V(Z_i, S_s)$ is the determinist element (observable)
- ε_{is} is the stochastic (random) element (unobservable) (error term), which includes: unobserved taste variations, unobserved attributes, and measurement errors. Meaning that it can result from the uniqueness of preferences of the individual or from the analyst’s incomplete information about the individual.
- U is the utility level
- Z is the vector of attributes/characteristics of good i
- S are the socioeconomic characteristics of individual s

The error component implies that predictions cannot be made with certainty. Choices made among alternatives will be a function of the probability that the utility associated with a particular option is higher than that associated with other alternatives (Kikulme et al., 2011). Therefore, people make a choice by comparing the utilities of the different alternatives given to them. To estimate the utilities from different alternatives the individual has to calculate the probabilities for each alternative i.

Econometric strategy.

In the present model, farmers are considered to be utility-maximizing individuals who choose the alternative with the highest utility. A farmer will therefore only participate in the scheme when the expected utility is higher than the utility obtained from current status. Following Goibov et al. (2012), the status quo option is considered in the model and thus, the observable term in the utility function is:

$$V_{is} = \mu(\beta + \beta_1 Z_1 + \beta_2 Z_2 + \cdots + \beta_n Z_n + +\alpha_1 S_1 + \alpha_2 S_2 + \cdots + \alpha_m S_s)$$

Where

- β is the ASC (alternative specific constant), representing the utility of zero payment option (status quo) (Goibov et al., 2012)
- $Z_1, Z_2, \dots, Z_n$ is vector of attributes/characteristics of good i
- $\beta_1, \beta_2, \dots, \beta_n$ represent the vector of parameters for the attributes (i.e. livestock practice options).
- $S_1, S_2, \dots, S_m$ are the socio-economic characteristics of the farmers.
- $\alpha_1, \alpha_2, \dots, \alpha_m$ represent the vector of parameters for the socio-economic characteristics of the farmers.
- μ is a scale parameter, which is assumed to be greater than zero, and is inversely proportional to the standard deviation of the error terms.

The probability that alternative "i" will be chosen over other alternative "j" is:

$$Prob\left(U_{is} \geq U_{js}\right) = Prob\left(V_{is} + \varepsilon_{is} \geq V_{js} + \varepsilon_{js}\right) = Prob\left[\left(\varepsilon_{is} - \varepsilon_{js}\right) \geq (V_{js} - V_{is})\right]$$

Assuming that $\varepsilon^*_{ijs} = \varepsilon_{is} - \varepsilon_{js}$ is identically and independently distributed as Gumbel distribution (double exponential distribution), the probability results in the Conditional Logit Model such that:

$$p_{is} = \frac{\exp[V_{is}]}{\sum \exp[V_{js}]}$$

The conditional logit model assumes that the parameters are homogenous across the population (Martin-Ortega et al., 2011) this means they are invariant across individuals. Also, it assumes the independence of irrelevant alternatives property (Luce's axiom) (Christensen et al., 2011). This shows that the relative probabilities of selecting between two options will remain unchanged by the introduction or removal of other options (Goibov et al., 2012). The model's probability is computed using Maximum Likelihood Estimation (Horne, 2006). Finally, a measure of economic value can be calculated for each practice options attributes using the following equation (Goibov et al., 2012):

$$CS = \frac{\ln \sum_k e^{Vki} - \ln \sum_k e^{Vk0}}{\mu}$$

$$W = -\left(\frac{\beta attribute}{\beta monetaryattribute}\right)$$

The WTP can be shown to be the marginal rate of substitution of any attribute to the cost attribute. When the linearity assumption holds, this is known as the implicit price (Chellattan Veettil et al., 2011). These average values for the individuals in the sample can be set in ranking structure determining the preferences of attributes and levels (Christensen et al., 2011).

Choice experiment design

The CE profiles were created in Stata with the dcreate command,[12] with a fractional factorial design using D-Efficiency (D optimality). One of the main features of fractional factorial designs are that statistical properties are known in advance of experimentation which allows informed decisions about the size of the experiment and limit the tradeoff of lost critical

[12] This command was written by Arne Risa Hole, Department of Economics, University of Sheffield.

information (Gunst & Mason, 2009). D-efficiency minimizes the variance and covariance matrix of the estimated parameters in the conditional logit model. The search for an optimal design is best characterized as maximizing the D-score, subject to available information, the D-Score for this design was 3.78%. The full factorial design has 96 possible combinations. This design included 18 choice sets blocked into 3 groups of 6[13] (Refer to Appendix K). Each respondent would receive 6 blocks and for each set, the respondent would choose between Plan A, Plan B or Status Quo.

[13] Following Yehouenou and Grogan.

LIVESTOCK PRACTICES FOR THE CHOICE EXPERIMENT ANALYSIS

Good Livestock Practices

Good Livestock Practices (GLP) are a series of guidelines that seek to ensure animal health to produce healthy and safe products and by-products for the consumer, and to protect the environment and people working on farmers. This aims to apply available knowledge, to sustainably use natural resources to produce food in a safe and healthy way, and which in turn is aimed at economic viability and social stability. GLP are about knowledge, planning, understanding, measuring, managing, and registration aimed at achieving social, productive, and environmental objectives (Guncay, 2018). Both FAO and OIE have published international GLP. These guides are intended to help authorities to assist stakeholders, to fully assume their responsibilities at the animal production stage of the food chain, by addressing socioeconomic, animal health, and environmental issues in a coherent manner (Food and Agriculture Organization of the United Nations & World Organization for Animal Health, 2009). Recommended good practices are under these headlines: 1) General Farm Management, 2) Animal Health Management, 3) Veterinary medicines and biologicals, 4) Animal feeding and watering, 5) Environment and Infrastructure, and 6) Animal and Product Handling.

Best Management Practice (BMP) according to Florida Department of Agriculture and Consumer Services, (2008) is a practice or combination of practices determined by the coordinating agencies. These are based on research, field-testing, and expert review, to be the most effective and practicable on-location means, including economic and technological considerations, for improving water quality in agricultural and urban discharges. BMP should reflect a balance between water quality improvement and agricultural productivity.

In most countries GLP are of voluntary fulfillment. Agricultural regulation institutions in countries usually work together with FAO and OIE. In Ecuador, the public agency AGROCALIDAD has established GLP guidelines, with two different manuals, one for milk cattle and one for beef cattle; both include the same main components (refer to Appendix L). This manual defines good quality water as contaminant-free water, contaminants such as chemicals or their residues, microbiological products, and health-damaging microorganisms (“Guía de Buenas Prácticas Pecuarias en la producción”, 2016; “Guía de carácter voluntario”, 2010).

The lack of effective processes to conserve, protect, and distribute the water resource has become a threat where the agricultural, livestock, land use, and human action exert pressures on the environment affecting water sources (Rosales, 2012). Although the ministerial agreement 394 (2013) of MAGAP, establishes incentives for adopting good environmental and livestock practices in Ecuador, farms do not adopt them. Art. 7, of the Ministerial Agreement 394, states that there would be a bonus of $0.02 and of $0.01 per liter of raw milk for those that implement good livestock practices or sanitary quality requisites, respectively. The prices of the liter of milk in that regard depending on the quality and certifications can range from approximately $0.43 to $0.53. The public bodies responsible for verifying and controlling the payment of this surplus and the farm conditions are MAGAP and AGROCALIDAD. Currently, there are 458 production units with the certification, from which 216 are husbandry units (Agrocalidad, 2020).

Selection of cattle raising practices for the choice experiment

To select the husbandry practices for the CE, 18 interviews were held with different farmers and experts.[14] Twenty cattle raising practices for improvement were identified. These were grouped in terms of the practice objective and the practice itself (see Table 5).

Table 5

Proposed Practices

Practice Number	Main Practice	Detailed Practices
P1	Grazing systems	Higher Efficiency and Assignment of Space Occupancy Pasture Management, rotational grazing system Rational Viosin Grazing system
P2	Agricultural frontiers	Limit agricultural frontiers Create buffer zones
P3	Use of animal waste	Biodigester Land application of animal waste Liquid Manure storage ponds, pits and tanks Create wetlands
P4	Antibiotics use	Optimize antibiotics use Hire technicians
P5	Avoid damaging land	No agricultural burning No cracks in the land
P6	Efficient use of water resources	Water Reuse Systems Water Channeling and Irrigation Water Treatment or Sanitation Projects Drinking troughs
P7	Proper Manure Management and Recycling systems	Individual reycling system Shared recycling system Minga

For the purpose of the CE, six main practices were selected.[15] The criteria used to choose the practices proposed was: 1) minimum cost; 2) relevance of the practice in terms of solving problems related to water resources; 3) easiness of implementation; and 4) time of implementation.

[14] The interviews were recorded.
[15] For a detailed calculation of the costs for each of these practices, refer to Appendix M

Table 6

Selected Practices for the Choice Experiment

Practice Number	Attributes	Levels
P1	Improved grazing systems	1. Rational Viosin Grazing Systems (Intensive rotational system) 2. Mix of organic fertilization + chemical fertilization (30-70) (Intensive rotational system)
P2	Agricultural frontiers: Buffer zones	1. Buffer zone with wood fences 2. Buffer zones with native vegetation and temporal fences
P3	Treatment of animal waste	1. Biodigesters 2. Oxidation Ponds
P4	Efficient water use: Irrigation Systems	1. Micro sprinkler system 2. No micro sprinkler system
P5	Proper Manure Management and Recycling systems	1. Individual recycling system 2. Shared recycling system

Grazing systems.

What are grazing systems.

A grazing system is a combination of soil, plants, animals, social and economic features with a controlled harvest of vegetation and management of practices that manipulate livestock to systematically control periods of grazing and rest (Launchbaugh, n.d.; Rouquette & Aiken 2020). There are two main types of grazing systems, continuous and rotational grazing. Continuous grazing is a system where livestock is allowed with an unrestricted, uninterrupted access to the same pasture (specific unit of land) for the entire grazing season or year (*Grazing Systems*, n.d.). The advantages of this system are easier management and lower input costs. Whereas the drawbacks are that improper continuous grazing can be a detriment to all forage resources and can lead to natural resource degradation like soil erosion, degraded water quality, loss of forage stands, and/ or increased weed competition (Florida Department of Agriculture and Consumer Services, 2008). On the other hand, the rotational grazing is a system where the pasture is divided into smaller paddocks and these paddocks are grazed in a planned sequence, where they have a rest period for recovery and re-growth. The advantages of this system are improved pasture longevity, more timely use of forage, increased forage production, increased performance, and can increase overall profitability (*Grazing Systems*, n.d.). The grazing period is the number of days during which a pasture is grazed (Launchbaugh, n.d.). The rest period is the time required for pastures to recover the foliar. The selection of these periods is based on the production of forage and its nutritional content. The nutritional content of the pasture is determined by plant-specific factors, by environmental factors, and by management factors (Vera, 2017).

Importance of grazing systems.

Cattle have different nutritional requirements, depending upon the class of animal and general age of the herd, sex of the animal, desired weight and pregnancy. Optimum forage growth needs to consider production goals in order to have the optimum nutrient value from the pasture (Florida Department of Agriculture and Consumer Services, 2008). For the livestock to produce a high-quality milk and meat, there must exist good quality and quantity of pasture (see Table 7). A cow must eat everyday a tenth of its weight in green forage. The better the quality of the pasture, the more nutrients it has and, thus, the less supplemental feeding the cow need (Reyes, 2015). Voluntary forage consumption is determined among other factors by digestibility, palatability, nutritional content, and the physiological status of the animal.

Table 7

Nutritional Requirements for a Double-Purpose Cow

Nutrient	Daily requirement
Protein	820 g
Energy	14 Mcal
Calcium	20 g
Phosphorus	16 g

Source: Vera, 2017

When properly managed grazing systems have a variety of benefits, and thus may help managers to achieve their objectives related to rangeland, livestock production, and ecosystem structure and function. Such systems work to maintain sustainable and productive pastures, resulting in an effective herd management and preventing pollution problems (Florida Department of Agriculture and Consumer Services, 2008; Frost & Mosley, n.d.). For example, good management of grazing systems may help soil watershed protection, manage forage value of plants, improve range condition, mitigate negative impacts of grazing, improve wildlife habitat, provide for multiple uses, and improve livestock production. Furthermore, these systems may increase forage production quantity or quality over time, make better use of whole resource, and increase opportunities to observe livestock and reduce health or distribution problems. Additionally, plant community composition may have a positive effect by evening the grazing intensity among plants, by evening out competition between plants and by providing a specific season of rest or deferment to benefit some plants.

Main problem.

In Mejía, rotational grazing systems are most common for milk cattle; whereas depending on the area, either rotational or continuous grazing systems are used for beef cattle. The main problem found in rotational grazing is the use of chemical fertilizer for the pasture to grow faster. The use of fertilizers can accelerate the degradation of natural resources (Vaca, 2019; Florida Department of Agriculture and Consumer Services, 2008), causing, for instance, soil erosion, ground and surface water pollution. The more fertilizer is applied the more soil erosion occurs which means soil nutrients are broken and dragged down by the bodies of water. When ground coverage is removed, the amount of water infiltrated as groundwater decreases. Water instead goes as runoff, which increases soil erosion and affects water quality by traveling with more materials, nutrients, and pollutants. Moreover, chemicals penetrating the soil may reach and consequently pollute groundwater. Chemicals travelling in the water may affect other plants and animals, that live in the water or that drink from it. Also, these polluters provoke eutrophication[16], generating high levels of surface biomass and lack of oxygen in deep water, and again, affecting water quality. In addition, removal of ground coverage also happens with continuous grazing because of cattle weight, paws, and continuous walking.

Proposed practice.

To counter the problems mentioned above, pasture and rangeland water quality needs to be effectively managed by having a proper distribution of cattle, along with the strategic placement of supplemental feeding, mineral stations, and alternative water sources away from surface waters. This should be complemented by installing fences and subdividing large pastures to exert more control over the frequency and timing of grazing. The two levels proposed are: 1) Rational Viosin Grazing (RVG): intensive rotational grazing system with no fertilization, short occupancy periods, a rest period of 50 to 60 days, and a high animal load; 2) traditional rotational grazing system with a mixture of organic fertilization (30 percent) and chemical fertilization (70 percent), with a rest period of 30 days, and a low-medium animal load. Note that even though the rest period is generically established, this period would depend on the plot and pasture growth, in order to assure that the cattle eat when the pasture has its highest protein intake. Furthermore, if the farm has high performance cattle, in either system they would need supplemental feeding (not considered in our case).

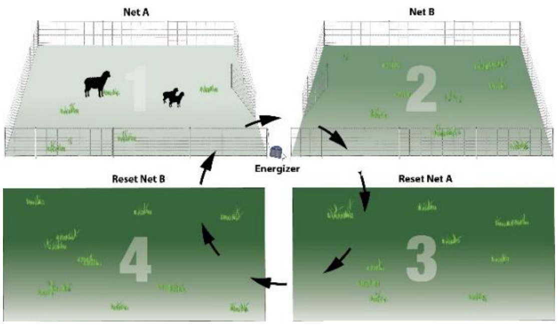
Even though the implementation costs of the RVG system are almost double than the other option, its maintenance cost is lower by around $100, since in the traditional system farmers have to buy chemical fertilization, which is expensive. In either of the proposed systems, there would be savings due to lower use of chemical fertilization for the mixed system, and no-use for the RVG one; however, savings would be more significant in the latter. Another

[16] Eutrophication: which is the accelerated growth of aquatic flora

important result of adopting either of these systems is that it improves soil's life resulting in an increase in fertility, which means that there will be more amount of pasture per unit area with a better protein intake (Reyes, 2015). Furthermore, while cattle will eat a young and digestible plant every day; the forage plant is given the opportunity to develop and recharge its energy reserves after each grazing; and lastly, the soil is evenly recycled from feces and urine, which are an excellent organic fertilizer. Finally, the cattle produce more milk due to a lower energy wear since they are walking less time than in continuous grazing.

Figure 21

RVG System and Rotational Grazing System



a) RVG System b) Rotational Grazing System

Source: (Terán, 2015) Source: (Putnam, 2020)

Agricultural frontiers: buffer zone.

Definition and importance of buffer zones.

Buffer zones for this context are assigned areas near the river that need to be left with no cattle, no production, no houses. According to Florida Department of Agriculture and Consumer Services (2008), there are three main types of conservation buffers, field borders, filter strips and riparian buffers. Buffer zones prevent husbandry activities to occur close to the bodies of water, especially rivers, protecting both surface and ground water; as well as reduce excessive amounts of sediment, organic material, nutrients, and pesticides in surface water sheetflow. This allows riverside vegetation to start growing, which helps to purify and filter the polluted water that goes back in the river. Thus, buffer practices assure the improvement of water quality and therefore make it easier to treat and clean the water. Furthermore, buffer zones help to preserve soil coverage and reduce soil erosion by preventing cattle trampling.

Main problem.

The agricultural border has been growing over the years (Maiguashca, 2014), which is a problem if cattle get close to the water resources. One of the problems that buffer zones aim to counteract is cattle feeding close to bodies of water, which increases the number of bacteria in the water and results in microbiologic pollution (Vaca, 2019). Furthermore, the removal of natural vegetation generates soil erosion, increased turbidity and sedimentation in waterbodies. Therefore, in order to prevent this environmental degradation the amount of land that is cleared of natural vegetation should be limited (Florida Department of Agriculture and Consumer Services, 2008). Another problem that buffer zones aim to offset is the weakening of the land and soil coverage and vegetation removal due to cattle trampling; which, as mentioned before, saturates soil's load capacity, decreases infiltration, resulting in runoff and leaching. In addition, this compacts the soil's organic matter, not allowing it to absorb and purify the water in the same capacity (Vaca, 2019). Furthermore, some plants, especially in the paramo, do not resist when stepped on or broken.

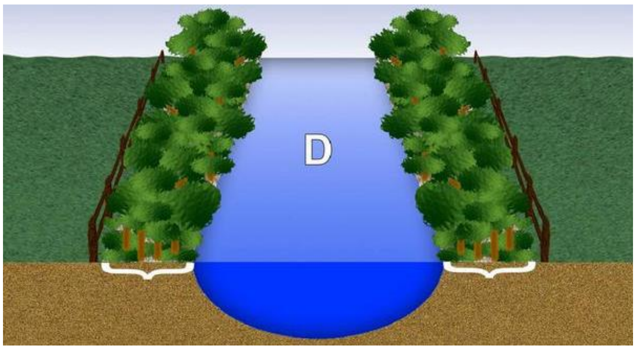
Proposed practice.

The proposed practice is to establish an acceptable agricultural frontier (buffer zone) that ranches should have with the different bodies of water, especially rivers. The buffer zone would be according to the damp perimeter that the river has (maximum width river has). The ideal buffer zone would be the same width as the river. A generic number established is around 25 meters from the river, however this is an arbitrary number, since not all bodies of water are the same or required the same agricultural frontier.

The present research proposes two buffer options. The first option is a buffer zone with native vegetation that obstructs entry; Mejía’s native vegetation species to be used could be: Polylepis, Romerillo, Ginoxis, pajonales, arbustos chuquiragua, Loricaria, Cedrillos, Arrayanes, Alisos, Valea Stipularis and Pumamaqui[17]. Each of these plants costs $0.40 and 20 units are needed to create the buffer zone. This option requires a temporary simple fence[18] to allow the plants to grow. The second option is a buffer zone with no vegetation but denoted with wood fences, in literature this is known as exclusion fencing. The advantage of the second option is its immediate application, but it is about four times more expensive than buffer zones with vegetation. By creating either a natural or an artificial barrier either of these options helps to reduce the occurrence of animals standing in water, streambank erosion problems, and water quality degradation. This aims to control the disturbance cause, by preventing livestock from entering isolated areas, damaging plants, and contaminating water sources with their waste.

Figure 22

Buffer Zones



Source: (Osmond & Burchell 2017)

Treatment of animal waste: biodigesters and stabilization ponds.

What are biodigesters

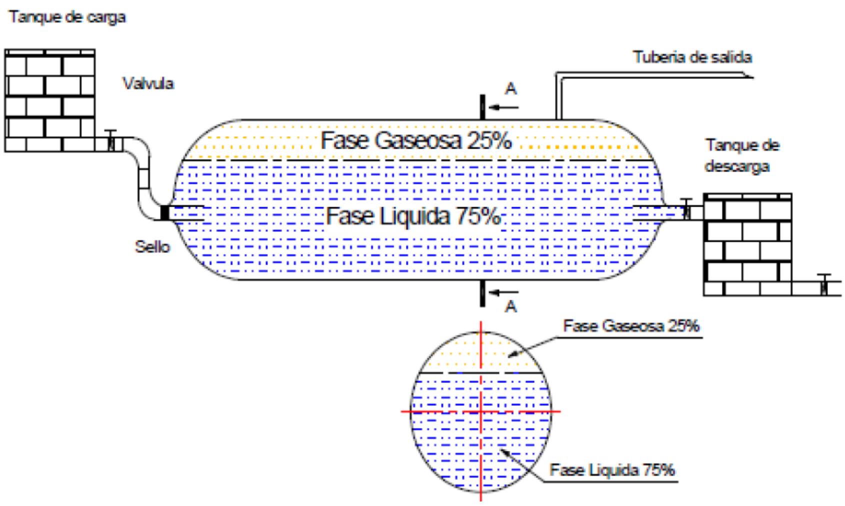
Biodigesters are a closed, hermetic, airtight and waterproof container in which the digestion of organic waste matter by fungi and bacteria takes place by dissolving it in water,

[17] Vegetation Species were proposed by an expert
[18] With wood poles and wire

resulting in the production of biogas and biofertilizer (boil) through fermentation (Merriam-Webster, n.d.) The fermentation process is anaerobic[19] and the bacteria found in fecal material are responsible for decomposition are methanogenic (i.e., they produce methane, also known as biogas). The biodigester has an entry for manure, a space for its decomposition, an outlet with control valve for gas (biogas), and an outlet for the already processed material (biofertilizer) (see Figure 23). There are four main steps: 1) Animal waste is mixed with water in the biodigester feeder; 2) In the biodigester, bacteria break down the manure, transforming it into methane gas; 3) Methane gas can be channeled to power a generator or heater; 4) Leftovers serve as a biofertilizer. Fungi and bacteria that are inside must be cultivated, so the product does not come out immediately, in cold climates as in Mejía the process takes around 45 days.

Figure 23

Biodigester



Source: Chungandro, 2010

What are stabilization ponds (oxidation ponds).

Stabilization ponds are large, shallow ponds designed for wastewater treatment through the interaction of sunlight, bacteria, and algae. They aim to reduce the organic content and

[19] Anaerobic: process takes place without oxygen

remove pathogens from wastewater. Algae grow using energy from the sun, carbon dioxide, and inorganic compounds released by bacteria in wastewater. Through photosynthesis algae release oxygen needed by aerobic[20] bacteria found in manure. In the pond, bacteria break down the manure, and leftovers serve as biofertilizer. Fungi and bacteria that are in the pond must be cultivated, so the product does not come out immediately. In order for the process to be faster a mechanical aerator is used to supply more oxygen, the process takes around 12 to 15 days, in comparison to 25-35 days without extra oxygen (Britannica, n.d.). The complex interactions of mechanisms (bacteria, temperature, ultraviolet radiation and photo oxidative reactions) result in the removal of pathogenic bacteria and viruses.

Figure 24

Stabilization Ponds

Importance of biodigesters and oxidation ponds.

These systems aim to treat animal dung instead of wasting this resource by throwing it out and polluting water. By using cow waste, farmers can get back some nutrients and reuse them. Biodigesters and oxidation ponds solve the water quality problem to some extent, by not just letting the polluted water go down stream. This way the polluted water is able to be treated before it keeps going through the different bodies of water until it cannot be used. Its importance lies in the use of waste (manure) to produce renewable and low-cost energy. For

[20] Aerobic: Process takes place with oxygen

the biodigester there are two outcomes: fertilizer and gas, while for the ponds there is only fertilizer. The processed manure is an organic, odorless, fly-less, pathogen-free fertilizer rich in nitrogen, phosphorus, and potassium. By producing a nutrient-rich fertilizer, these practices reduce the need for agricultural inputs. Also, adding manure to soils reduces their deterioration, increases their productivity, and makes it less vulnerable to pests, erosion, and drought. On the other hand, for biodigesters, the methane produced, rather than entering the atmosphere, is used for domestic activities (cooking, heating water), which, by converting it to carbon dioxide, decreases its global warming potential.

Biodigesters and oxidation ponds reduce the environmental impacts generated by the shredding of animal waste in an improper manner to pastures and bodies of water, which leads to pollution. In the second place, by producing biofertilizer, farms no longer need to buy and apply chemical fertilizers, implying savings and environmental preservation. And for biodigesters, in the third place, by producing biogas, farms save costs by not purchasing gas for the kitchen or the water heater. On the other hand, the advantage of stabilization ponds over biodigesters is they are able to treat 100 percent of the manure and take significant less time to produce biofertilizers.

Main problem.

The waste generated in livestock is composed of food residues, phytosanitary residues, antibiotics, debris of packaging and solid and liquid faeces. The environmental impact of livestock waste on soil is not as harmful, since they are only toxic when the nitrate content in the soil is close to 4 g/kg; whereas, water and air do have a negative impact (Yépez, 2014). Manure management is a significant concern due to possible release of coliform bacteria, phosphorous or nitrogen to ground and surface waters through leakage and runoff (Florida Department of Agriculture and Consumer Services, 2008). The main problem is that the most significant pollutant in livestock farms are leachates generated by husbandry activities, especially in the stables, which usually end up in bodies of water. Improper use or mishandling of these residues causes several problems including but not limited to, odor, nitrate production, water quality and pollution problems. Damage to surface waters is caused by nitrogen and phosphorus significantly present in livestock waste, which can be transported in runoff to surface waters in dissolved form, or they may be attached to sediment particles. Both elements can contribute to the eutrophication of waterbodies. On the other hand, ground water may become contaminated by leaching of nitrate or dissolved phosphorus. Fecal coliforms are another source of water quality impairment. While high numbers do not result in eutrophic conditions, they can pose a health hazard to animals and humans. Furthermore, bacteria in manure are a possible source of parasite infection and may cause diseases and health impacts such as dysentery, a variety of infections (Yépez, 2014).

Table 8 shows how much waste is produced by cows per day. Usually, manure's disposal process includes open liquid management systems, especially in lower technified and therefore more dispersed farms. This necessarily implies a further blurring towards streams, lagoons, course of derived rivers or apparently minor slopes, which in the end influences the water quality of surrounding sources (Vaca, 2019).

Table 8

Waste Produced by Cattle Type

Cattle Type	Age (months)	Waste Produced (pee + faeces kg/day)	Waste Produced only in the Stable (pee + faeces kg/day)
Calf	3-6	7	2.5
Cow	24+	28	7
Milk Cow	24+	45	10

Source: (Yépez, 2014; Arellanes, 2018)

Proposed practice.

The proposed levels of this practice is for the farmer to implement either a biodigester or a stabilization pond. Farmers have two alternatives for the implementation of biodigesters:

1) make its own biodigester, as it is relatively easy and much cheaper than buying one, with a cost of around $1200, and 2) buy a new one, with a cost of $3000. In regard of the pond construction, farmers would need a local contractor to do so, with an overall estimated cost would be $2560.

How to make a biodigester.

In terms of location, a suitable place for a biodigester is close to the stables and in a fair distance to the house (at least 10m). It should be close to the stables to save time and distance of transporting manure to the mixture-making area. The site where the biogas is to be used must not be more than 150 m apart from the biodigester because, beyond this distance, gas pressure decreases. Moreover, it should not be close to trees with very deep and extended roots that can damage the biodigester and have a place where there is some shade throughout the day. The first step is to manually excavate the pit (preferably in a flat terrain). The pit depends on the dimensions of the biodigester, but it should be made so the biodigester is 75 percent in the ground and 25 percent exposed. It is optional to put a fence around the pit so that the cattle do not damage the biodigester (Angel, 2016; Laboratorio Multimedia XBalam, 2013).

Biodigesters are constructed of polyethylene plastic and geomembranes either of PVC of polyethylene. Biodigesters usually have a cylindrical and elongated form. The parts of this system are PVC or polyethylene geomembrane, a charge tank, a discharge tank, an output for biogas, its different ducts and traps. The load and discharge tanks should ideally be about 1 m away of the biodigester each. A double polyethylene sleeve is needed, one layer of plastic is extended on the floor. To achieve the double layer a person must enter inside the first polyethylene tube, dragging the second inside it. Once the two layers are over-placed, they should be aligned so that there are no wrinkles or air left. When the two layers are overlapped, the gas outlet is built in the middle of the biodigester. To build this outlet, adapters, solid plastic discs, and rubber discs are needed, assuring that the whole is sealed. In the sides, the entrance and outlet tubes are attached. The polyethylene is bent accordingly from the ends to the central, sealing the sides of the plastic with tape, to avoid a possible leakage. The biodigester is put inside the pit, making sure the tubes are outside and fixed (Angel, 2016; Laboratorio Multimedia XBalam, 2013).

In areas with lower temperatures, a greenhouse or a thermal insulation system must be constructed, to avoid a decrease in biogas production decreases. Biogas production requires a temperature of 35°C, for which it is necessary to build a plastic cover as a micro tunnel that protects the biodigester from changes in the environment. Metal rods, wood, PVC pipes, and plastic are used to install the micro tunnel. A transportation PVC tube for the biogas needs to connect the biodigester to the house. Following Chungandro (2010), the biodigester proposed here would measure 10 m^3 and have a capacity of 125 kg. For comparison, a stabilization pond is equivalent to two biodigesters (for 20 cows) (Angel, 2016; Laboratorio Multimedia XBalam, 2013).

How does the biodigester work?

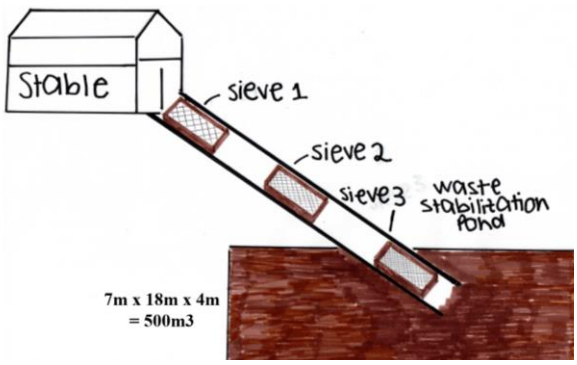
Animal waste from the stable is collected, a farmer can pick it up manually or this can go straight to a tube that leads to the cargo tank where the farmer will prepare the mixture and put it in the charge tank. The mixture is 1 part of water and 1 part of cow dung, which means 10 kg each, which should be mixed until the product is completely dissolved. It would take six days for the 125 kg of manure capacity for the biodigester to be filled. Then the biodigester is loaded with the liquid mixture at 75 percent to leave space for gas to be produced and stored. The mixture is left for a retention time depending on the ambient temperature of the place; at higher temperature the retention of the organic matter will be better, while at lower temperatures the retention time is longer. Given the conditions of Mejía, the biodigester must be retained from 30 to 45 days. After the retention period there would be a production of methane gas (biogas) and a production of biofertilizer. The biofertilizer should be put in the discharge tank to be used as fertilizer in the pastures later. On the other hand, the gas outlet goes on top of the biodigester with a pipe duct. A series of tubes, construction traps and passkey are used to carry the biogas to the house. Every month it should be checked that everything is fine and that there are no leaks. The biodigester must be used constantly or a process of putrefaction sets in within the container. A final consideration is that if the animals have been given antibiotics, at least four days should be allowed to go by before using the manure.

How does the stabilization ponds work?

Stabilization Ponds require a daily routine that starts in the stables. The manure from the stable is washed and combined with water (1 to 1 relation of water to manure), and this goes through a ramp towards the pond. Stage 1 has a sieve that catches the largest solids, whereas stage 2 has a sieve that catches the medium-sized solids, and stage 3 has a sieve that catches the smallest solids. After that, the liquid left goes to the stabilization pool where the process of making biofertilizer starts.

Figure 25

Stabilization Pond System



Efficient use of water resources: irrigation systems.

What is sprinkler irrigation.

Irrigation is the artificial application of controlled amounts of water to plants, land or soil at needed intervals. In agricultural activities, effective irrigation influences the entire growth process, in the case of livestock, of pastures. The key to maximizing irrigations efforts is uniformity[21]. An irrigation system is defined as a system of supplying land with water by different means (Victoria State Government, n.d.). Irrigation water can come from groundwater, surface water and non-conventional sources. There are three basic methods of irrigation: surface, sprinkler and drip. Sprinkler irrigation aims to create artificial rainfall by putting water in the field through a pipe system where the water is under pressure. Water is distributed through a system of pipes, usually by pumping, which control the intensity. Then, water is sprayed into the air through sprinkler, so that it breaks up into small water drops that fall to the ground (Brouwer, et al., n.d.). Micro sprinkler irrigation is a modification of the traditional sprinkler system that sprays water within walking distance of the plant, in a localized way, and involves less pressure. On the other hand, surface irrigation is the application of water to the fields at ground level, by either flood, furrow, borders or basin. Finally, drip (trickle) irrigation is a system where water is led to the field through a pipe, and through tubes water is supplied slowly, drop by drop to the plants (Brouwer et al., n.d.).

Importance of irrigation systems.

Irrigation is important because of the benefits it brings and when rainfall is not sufficient the pasture must receive additional water from irrigation. It allows to grow more and better quality pastures since these would not have water stress. Consequently, irrigation would mean a lower reliance on supplemental feeding. It also allows more flexibility in the operations since water is available at all times. Therefore, it additionally tolerates more animals per hectare and a more intensive grazing system. Irrigation is also insurance against seasonal variability, climate changes and drought. It helps to use areas that would otherwise be less productive or unproductive (too dry to grow pasture) and therefore increases the available terrain to grow pasture or keep livestock. Moreover, they avoid the construction of ditches and canals, which

[21] Uniformity here means that there is around the same amount of water all through the pasture or terrain

results in an increase in the useful crop/pasture land. Additionally, if chemical or biofertilizer is applied it helps them to be watered into the grand to maximize the benefits of applications. On the other hand, the potential problems of irrigation are under-watering and over-watering and their respective consequences (Victoria State Government, n.d.). Finally, irrigation systems function as artificial rain, but the sprayed droplets by crashing into the soil surface might cause erosion (Brouwer et al., n.d.; Food and Agriculture Organization, 2008).

Main problem.

In Mejía the status quo, is either no irrigation, or irrigation by floods or gravity. Irrigation by floods and gravity has significant drawbacks, starting with the huge amounts of water applied that contribute to leach soluble nutrients, mainly in soils of mild texture. The main problem with flood and gravity irrigation systems is that the construction of grooves and canals might cause soil transport and soil erosion. Also, since in this type of systems, the water table is near or above the surface, the risk of ion contamination, such as nitrates and sulfates, is relatively high, especially if high doses of fertilizers are used.

Proposed practice.

The proposed practice is a dummy variable (yes/no adoption) of micro-sprinkler irrigation system, that would be built by a contractor. This system consumes less water than the traditional sprinkler system, and it is mainly used for broad spacing crops, where localized irrigation is much more efficient. Micro-sprinkling system avoids risk of erosion since the drops produced are small. Moreover, as the wetness is relatively slow and localized, this system prevents leaching from soluble nutrients. Since irrigation is localized, it prevents diseases from spreading and if the water is contaminated the polluted area is reduced. As far as water quality is concerned, this system is susceptible to the presence of suspended solids since it may plug the holes of the micro sprinklers. In terms of irrigation efficiency, the micro sprinkler system is more efficient than the traditional one (see Table 9). The amount of water applied through the flow/time ratio of the micro sprinklers or drippers can be controlled well (Food and Agriculture Organization, 2008).

Table 9

Water Efficiency

Irrigation Type	Water Efficiency
Flood	40-65 %
Sprinkler	80-85 %
Micro-sprinkler	85-90 %
Drip	90-95 %

Source: FAO, 2008

Figure 26

Micro Sprinkler Irrigation

Source: (Agrotendencia, n.d.)

Proper waste management and recycling systems.

Definition and importance of proper waste management.

Waste management is collection, segregation, transportation, and disposal of waste product (Rinkesh, n.d.). Proper waste disposal is critical because certain types of wastes can be hazardous and can contaminate the environment if not handled properly. These types of waste also have the potential to cause disease or get into water supplies. When waste is disposed properly, special liners are used to prevent toxic chemicals from leaking out and precautions are taken so that any trash-burning related methane is safely contained (The Full Service

Environmental Contractors, 2014). Proper waste management avoids that waste reaches waterways and different bodies of water, which may pollute these in different forms. An empty chemical container can be hazardous since residues are always left inside.

Currently, there is some communitarian work (also known as "mingas") in Mejía to collect trash found in paths, ditches, rivers, etc. FONAG [22] propelled these activities due to the amount of garbage registered and collected. The mingas were consolidated with the signing of a cooperation agreement between Mejía's municipality and FONAG. In general, community work is part of the social capital of water management in Ecuador. Water management, especially in rural areas depends, in many cases, on the voluntary work of people seeking to improve access to water in their communities. According to MAGAP's manual of good agricultural practices (2010), there is a procedure for recycling these containers according to their content and particularity. This practice was implemented in the Salachi community in Cotopaxi and had positive results.

Main problem.

Chemical fertilizers containers, antibiotics tools (such as syringes), and antibiotic containers may reach waterways (directly or indirectly) and consequently pollute the water, affecting its quality, as well as harm living organisms found in it. Usually farmers eliminate these containers as common garbage, however this procedure is not adequate given the presence of chemicals that may damage the environment and may affect human health. The field visits of the present research to Mejía showed an improper waste management or recycling place. Some farmers mentioned that the disposal is developed by pouring leftover chemical fertilizers or antibiotics down the sink, down a sewer or in an irrigation ditch. The problem is that even though there are guidelines established by MAGAP, it is not applied and pollution

[22] FONAG: Fondo Para la Protección del Agua (Water Fund for Water Protection)

occurs because people are leaving the containers in the place of use, or worse, throwing them into the water channels. According to FONAG, Mejía's citizens do not know the impact of littering on the hydrant basins and its effect on people's quality of life due to inadequate management of the final disposal of organic and inorganic waste. Additionally, there is an extended law for the producers (of chemical fertilizers and antibiotics), which allows the buyer to return these containers to the premises so that producers are the ones who manage this hazardous waste. However, farmers do not really apply this and the supplier does not encourage this practice either.

Proposed practice.

The proposed practice is to install four color-coded containers, green, blue, and gray (see Figure 28). The containers have a capacity of 120 liters and a measurement of 94 x 48 x 56 centimeters. The price for each container is $60. The two levels proposed are: an individual recycling system or a shared recycling system. Even though each farm will have their own containers, the pickup truck cost would be either assumed individually or shared among five farms. The pickup truck would collect garbage every three months and it costs $25.

Figure 27

Color Garbage Disposal Cans

Source: (Mecalux, n.d.)

Cost attribute

For the cost attribute, only the implementation costs are considered for the design of the CE; since net maintenance cost is important, but a significantly lower figure. For the grazing systems, buffer zones, and irrigation practices, the implementation cost is established per hectare; whereas for the treatment of animal waste and the proper waste management and recycling systems, there is a total implementation cost regardless the number of hectares or bovine heads (Refer to Appendix M). The cost attribute has three proposed levels of subsidy by the government; 1) 25 percent, 2) 40 percent and 3) 60 percent. The maximum subsidized level was established according to an actual insurance-subsidy of 60 percent (Agencia de Regulación y Control Fito y Zoosanitario, 2018). The minimum subsidized level was established according to a 25 percent subsidy given to rice and corn small farmers in 2017 (Ministerio de Agricultura y Ganadería, 2016). Finally, a medium subsidized level was imperative. However, farmers will face the share of implementation costs or the percentage they will assume in the adoption of these practices, as levels of this cost attribute: 1) 40 percent, 2) 60 percent and 3) 75 percent. Furthermore, it is important to note that the government provided agricultural kits in the Coastal area since 2015, with a total investment of around $35 million. Since the implementation cost is significant, the subsidy might not be enough to encourage adoption for the different environmentally conscious practices, however there are credit options with preferential interest rates. These credits were announced by MAGAP in February 2019, specifically for banana, palm and livestock production. Specifically, the credit options are from BanEcuador,[23] the amount would reach $500,000 with an 8-year term and a 3-year grace period (Ministerio de Agricultura y Ganadería, 2019). This present research follows Yehouenou and Grogan (forthcoming), where they attempt to establish subsidy percentages as the cost levels.

[23] BanEcuador is a financial institute providing credits to agricultural activities.

DESIGN RESULTS AND HYPOTHESIS

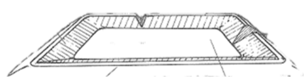
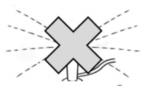
Choice Experiment design options

Our study proposes three different CE design options to present to the farmers. Each design has a total of five attributes (husbandry practices), each with two levels. The monetary attribute is the share of the implementation cost faced by a farmer, and it has three levels. A focus group is needed to evaluate attributes and levels proposed, and the most appealing design.

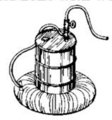
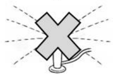
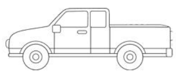
Design 1 - CE Design with descriptions

PRACTICE NUMBER	ATTRIBUTES	LEVELS
P1	Grazing systems	Mix of organic fertilization + chemical fertilization (30-70) (Intensive rotational)
P2	Agricultural frontiers: Buffer zones	Buffer zones with native vegetation and temporal fences
P3	Treatment of animal waste	Biodigesters (2 of 10m3 for 20 cows)
P4	Efficient Irrigation Systems	Micro-sprinkler
P5	Proper Manure Management and Recycling systems	Shared recycling system
P6	Implementation Cost Share	25%

Design 2 - CE Design with pictures

PRACTICE NUMBER	ATTRIBUTES	LEVEL
P1	Grazing systems	
P2	Agricultural frontiers: Buffer zones	
P3	Treatment of animal waste	
P4	Efficient Irrigation Systems	
P5	Proper Manure Management and Recycling systems	
P6	Implementation Cost	75%

Design 3 - CE Design with descriptions and pictures

PRACTICE NUMBER	ATTRIBUTES	LEVEL
P1	Grazing systems	 **Mix of organic + chemical fertilization**
P2	Agricultural frontiers: Buffer zones	 **Buffer zone with wood fences**
P3	Treatment of animal waste	 **Biodigesters**
P4	Efficient Irrigation Systems	 **No Micro-sprinkler**
P5	Proper Manure Management and Recycling systems	 **Individual recycling system**
P6	Implementation Cost	40%

Preliminary results and hypothesis

Overall, these proposed husbandry practices were chosen given their prevention potential from animal and human negative impacts through water resource conservation in Mejía, which in the end results in an increase in welfare of all inhabitants in this area. Table 10 shows the hypothetical effect on welfare that each attribute would have, with all of them being positive except for implementation costs. This is hypothesized because although the implementation cost of these best husbandry practices is significant, the maintenance cost is relatively low to null (except for the grazing systems) (Refer to Appendix M). An apparent benefit is that the monthly savings in comparison to status quo. For instance, traditional rotational grazing system has an estimated maintenance monthly cost of $450, while the RVG system and mix systems have lower maintenance costs, higher yields and resources preservation. In regard of buffer zones, ranchers do not have established agricultural frontiers, and therefore, the status quo does not have a maintenance cost. The adoption of buffer zones results in an implementation cost of $55/ha with native vegetation or $212/ha with wood fence. However, the maintenance cost is equal to that in the status quo. Biodigesters or stabilization ponds bring high costs in their construction but, compared to the status quo, they generate savings, avoiding the expenses on chemical or organic fertilizers. In addition, they may provide an incentive for potential commercialization of organic fertilizer between producers in the zones. Another required practice is the efficient use of water, and micro-sprinkling irrigation can reach that objective, with an implementation cost of around $1,200, and no monthly cost. Finally, both individual and shared recycling practices generate costs of $240 for implementation of colored disposal containers while they differ in the monthly recollection cost, $25 and $5 respectively.

Table 10

Practice's Effect on Welfare

Practice Number	Attributes	Levels	Effect on Welfare
P1	Grazing systems	1. Racional Viosin Grazing Systems (Intensive rotational system) 2. Mix of organic fertilization + chemical fertilization (30-70) (Intensive rotational system)	Positive
P2	Agricultural frontiers: Buffer zones	1. Buffer zone with wood fences 2. Buffer zones with native vegetation and temporal fences	Positive
P3	Treatment of animal waste	1. Biodigesters 2. Stabilization Ponds	Positive
P4	Efficient Irrigation Systems	1. Micro-sprinkler 2. No micro-sprinkler	Positive
P5	Proper Waste Management and Recycling systems	1. Individual recycling system 2. Shared recycling system	Positive
P6	Implementation Cost share	1. 40% 2. 60% 3. 75%	Negative

The levels in yellow in Table 10, are hypothesized to be the chosen ones. Even though the ideal grazing system would be RVG system, most farmers would probably prefer the mixed system. This could happen for two reasons, first there might be some resistance in not using chemical fertilizer at all, and second it takes at least six months for the pasture to get used to the change of chemical to organic fertilizer in order to produce better yields. Therefore, farmers could consider as first approach a mixed system, and maybe in the future change that to an RVG system. Complementarily, for treatment of animal waste, farmers are likely to be more inclined to biodigesters because they are cheaper than stabilization ponds and because farmers may have a resistance in for replacing chemical fertilizer with organic one. Even though, stabilization ponds treat 100 percent of manure, farmers with this resistance may not see the benefits of this tradeoff. Likewise, farmers are more likely to prefer buffer zones with native vegetation since it is a lower investment and better preservation properties for water resources than only a wood fence. However, the tradeoff will not be immediate, since plants will take some time to grow. Furthermore, depending on farmers' status quo, they would adopt the micro sprinkler irrigation. If farmers have traditional sprinkler irrigation, they would probably not adopt the micro-sprinkler irrigation, since it would represent an additional investment and would leave the other machines/system unused. Whereas, if farmers have canals or ditches to channel water to the pastures, they are less constrained to adopt the micro-sprinkler irrigation, since previous investment will not be lost, and benefits would outweigh the costs. Finally, the shared recycling system would probably be preferred over the individual one, since there are lower costs and same benefits, but also because of the strong social capital or cohesion.

CONCLUSIONS

The demand for livestock is likely to increase in the future due to increases in global population growth and supply factors. This dissertation designs a choice experiment in order to investigate farmers preferences for environmentally conscious livestock practices, and the values they place on improvement of water resources. The overall picture is that the more hectares that are farmed in an environmentally friendly way the greater the environmental benefits. We hope to demonstrate that farmers as primary uses of agricultural land and water resources are concerned about the effects of water use on the environment.

When analyzing environmental resources, non-market valuation techniques are used in order to consider total economic value. Stated preference methods have the advantage of exposing the driving variables of a decision, that would otherwise be difficult to observe or that are missing in real markets. Within, stated preference methods, CE not only calculates WTP, but more importantly, it has attribute trade-offs. This allows a separate estimation of the value of individual attributes of a program of practices by presenting the respondent with a menu of options of different environmental services at different prices. Thus, CEs provide more information about people´s preferences than other methods of valuation. CEs allow for the ex-ante study of economic benefits or costs generated by the adoption of sustainable farming practices, therefore providing an evaluation tool for policies and programs that are not widely adopted. The aim is to quantify external benefits and costs, which can help to efficiently allocate resources and foster participatory public decision-making.

One of the biggest limitations of any stated preference method is that it involves eliciting responses from individuals in constructed, hypothetical markets, rather than the study of actual behavior (Hanley et al., 2006); thus, a hypothetical bias can arise. Another limitation is that there could be strategic bias, which means that the individual would choose according to what it is the most convenient for him/her. Additionally, this method may be a problem for respondents who have low literacy levels and little experience with surveys, where a problem of information bias may arise.

This study is relevant, as it proposes environmentally-conscious solutions with an appropriate practical context and preferences, policies, and monetary incentives for the proper use and conservation of water resources. Mejía is a symbol of milk production nationwide due to its capacity of production per hectare. It has the biggest milk production in the country, which represents 20 percent of the national production. Thus, it not only contributes to Ecuador's food security but also the agricultural sector supports the livelihoods of 7,751 people in Mejía, representing almost 30 percent of the employed people in the Canton. The livestock sector is an important user of water resources and as well one of the largest sources of water pollution. About a third of Mejía's territory is intended for livestock use. Adoptions of the proposed practices have not yet started in the area hence it is a suitable place to conduct this type of research since it can provide policy makers with useful inputs for future policy reforms and adoption incentives.

The CE design proposed will be used for data collection in Mejía. The attributes and levels proposed are based on literature review, experts' opinion and interviews with farmers. However, focus groups with farmers in Mejía are needed to evaluate in-situ the attributes and levels and the CE designs proposed. Further research is needed for the credits and subsidies of the cost attributes. After the evaluation, comes the data collection in Mejía with the goal being around 250 surveys at the minimum. The analysis of this data will be done with a conditional logit model. The importance of this research relies on providing relevant information to public policy makers in regard to farmers preferences for a variety of agro-ecological practices.

Conditional logit model has the advantage of simplicity of estimation but the disadvantage that it has restrictive assumptions. Firstly, it assumes the IIA which means the relative probabilities of two options being chosen are unaffected by introduction or removal of other alternatives, the problem is that if this property is violated then Conditional Logit Model results will be biased (Pan et al., 2016). Moreover, conditional logit model assumes homogenous preferences across farmers, since a single parameter estimate is generated for each choice attribute. Farmers could be considered heterogeneous or homogenous, in this study homogeneity is assumed due to the fact that they are in the same area, usually have around the same background, and the alternative practices being proposed have been chosen on a minimum cost parameter so income differences should not be as significant. However, accounting for heterogeneity increases the estimates´ accuracy and reliability, unbiased preferences´ estimates and helps policies in terms of equity and socio economic variables (Pan et al., 2016).

REFERENCES

Angel, J., G. [TvAgro]. (2016, October, 11). *Construcción y Características de Biodigestores – TvAgro por Juan Gonzalo Angel* [Video]. YouTube. https://www.youtube.com/watch?v=2LgyAwbLXIs

Agencia de Regulación y Control Fito y Zoosanitario. (2018). *Plan de Contingencia para Fiebre Aftosa en el Ecuador*. http://www.agrocalidad.gob.ec/wp-content/uploads/Plan-de-contingenacia-Fiebre-Aftosa05062018-ilovepdf-compressed.pdf

Agrocalidad. (2020). *Agrocalidad trabaja en la implementación de buenas prácticas agropecuarias a escala nacional*. http://www.agrocalidad.gob.ec/agrocalidad-trabaja-en-la-implementacion-de-buenas-practicas-agropecuarias-a-escala-nacional/

Agrotendencia, (n.d.). *Microaspersión*. https://agrotendencia.tv/agropedia/glosario/microaspersion/

Akter, S., Krupnik, T. J., Rossi, F., & Khanam, F. (2016). The influence of gender and product design on farmers' preferences for weather-indexed crop insurance. *Global Environmental Change*, *38*, 217–229. https://doi.org/10.1016/j.gloenvcha.2016.03.010

Alarcón, I. (2018). En Ecuador se gasta 40% más agua que el promedio de la región | El Comercio. *El Comercio*. https://www.elcomercio.com/tendencias/ecuador-gasto-agua-cifras-latinoamerica.html

Alcon, F., Tapsuwan, S., Brouwer, R., & Miguel, M. D. De. (2014). A choice experiment of farmer ' s acceptance and adoption of irrigation water supply management policies A choice experiment of farmer ' s acceptance and adoption of irrigation water supply management policies. *EAAE 2014 Congress 'Agri-Food and Rural Innovations for Healthier Societies*, 1–12.

Almar Water Solutions. (2019). *Water Challenges and Opportunities in Latin America*. https://smartwatermagazine.com/news/almar-water-solutions/water-challenges-and-opportunities-latin-america

Amendaño, E.N. (2018) *Propuesta de gestión del recurso hídrico de la vertiente La Merced para el desarrollo sostenible, provincia de Pichincha, cantón Mejía parroquia Cutuglagua* (Publication No. 15286) [Tesis previa la obtención del título en Magister en Planificación y Ordenamiento Territorial para el Desarrollo] Repositorio PUCE

Aniseh, S., & Daniel, C. (2016). *Adaptive Capacity to Climate Change : Insights from Coffee Farmers in Nicaragua Ortega , Methodology * Results * Conclusions * Data *. July 2015*, 2–3. https://doi.org/10.22004/ag.econ.235729

Arbeláez, L. [Agricultura al día MADR]. (2017, November, 21). *Agricultura al Día - ¿Qué es un biodigestor, cómo funciona y cuáles son sus ventajas?* [Video]. YouTube. https://www.youtube.com/watch?v=DyQfQIzoDaI

Aregay, F. A., Yao, L., & Zhao, M. (2016). Spatial preference heterogeneity for integrated river basin management: The case of the Shiyang river basin, China. *Sustainability (Switzerland)*, *8*(10). https://doi.org/10.3390/su8100970

Barrowclough, M., Stehouwer, R., Alwang, J., Gallagher, R., Barrera Mosquera, V. H., & Domínguez, J. M. (2016). Conservation agriculture on steep slopes in the Andes: Promise and obstacles. *Journal of Soil and Water Conservation*, *71*(2), 91–102. https://doi.org/10.2489/jswc.71.2.91

Barton, D. N., & Bergland, O. (2010). Valuing irrigation water using a choice experiment: An individual status quo modelling of farm specific water scarcity. *Environment and Development Economics*, *15*(3), 321–340. https://doi.org/10.1017/S1355770X10000045

Ben-Othmen, M. A., & Ostapchuk, M. (2019). *Farmers' preferences for grassland restoration: Evidence from France*. *2230-2019–1944*. http://ageconsearch.umn.edu/record/289701

Blare, T., & Useche, P. (2015). Is there a choice? Choice experiment to determine the value men and women place on cacao agroforests in coastal Ecuador. International Forestry Review, 17(4), 46–60. https://doi.org/10.1505/146554815816086390

Blare, T., & Useche, P. (2019). Differences in women's and men's conservation of cacao agroforests in coastal Ecuador. *Environmental Conservation*, 46(4), 302-309. doi:10.1017/S0376892919000237

Borja, P.F. (2018) *Evaluation of the microbial and chemical load rivers from the province of Pichincha in Ecuador* (Publication No. 7349) [Trabajo de Titulación presentado como requisito para la obtención del título de Ingeniera en Procesos Biotecnológicos] Repositorio USFQ

Brouwer, C. Prins, K. Kay, M. & Heibloem, M. (n.d.). *Irrigation Water*. Food and Agriculture Organization of the United Nations. Retrieved May 5, 2020, from http://www.fao.org/3/s8684e00.htm#Contents

Cai, J., Zhang, L., Tang, J., & Pan, D. (2019). Adoption of multiple sustainable manure treatment technologies by pig farmers in rural China: A case study of Poyang Lake Region. *Sustainability (Switzerland)*, *11*(22). https://doi.org/10.3390/su11226458

Cepal. (2020). *CEPALSTAT Bases de Datos y Publicaciones*. https://estadisticas.cepal.org/cepalstat/Portada.html

Cerda, C. (2013). Valuing biodiversity attributes and water supply using choice experiments: A case study of la Campana Peñuelas Biosphere Reserve, Chile. *Environmental Monitoring and Assessment*, *185*(1), 253–266. https://doi.org/10.1007/s10661-012-2549-5

Chellattan Veettil, P., Speelman, S., Frija, A., Buysse, J., Mondelaers, K., & van Huylenbroeck, G. (2011). Price Sensitivity of Farmer Preferences for Irrigation Water-Pricing Method: Evidence from a Choice Model Analysis in Krishna River Basin, India.

Journal of Water Resources Planning and Management, *137*(2), 205–214. https://doi.org/10.1061/(ASCE)WR.1943-5452.0000103

Chungandro, K.R. (2010). *Diseño y construcción de un biodigestor para pequeñas y medianas granjas.* (Publication No. 2734). [Proyecto previo a la obtención del título de Ingeniero Mecánico, Escuela Politécnica Nacional]. Repositorio EPN.

Christensen, T., Pedersen, A. B., Nielsen, H. O., Mørkbak, M. R., Hasler, B., & Denver, S. (2011). Determinants of farmers' willingness to participate in subsidy schemes for pesticide-free buffer zones-A choice experiment study. *Ecological Economics*, *70*(8), 1558–1564. https://doi.org/10.1016/j.ecolecon.2011.03.021

Constitución de la República del Ecuador, (2008, October, 20). Registro Oficial No. 449.

Cranford, M. & Mourato S. (2014). Credir-Based Payments for Ecosystem Services: Evidence from a Choice Expermiment in Ecuador. Elsevier inc.

De la Paz, M. C. (2012). *Evaluación de la calidad de agua e integridad ecológica de ríos altoandinos manejados por el FONAG*.

Emas, R. (2015). *Brief for GSDR 2015 The Concept of Sustainable Development: Definition and Defining Principles*. Sustainable Development Goals. https://sustainabledevelopment.un.org/content/documents/5839GSDRpercent202015_SD_concept_definiton_rev.pdf

Espinosa-Goded, M., J. Barreiro-Hurlé and E. Ruto. 2010. What do farmers want from agri-environmental scheme design? A choice experiment approach. *Journal of Agricultural Economics* **61** (2): 259– 73.

Feil, J.-H., Anastassiasdis, F., Mubhoff, O., & Kasten, P. (2016). Analysing farmers preferences for collaborative arrangements: an experimental approach. German Asoociation of Agricultural Economists (GEWISOLA), 51, 325–337. https://doi.org/DOI: 10.22004/ag.econ.262081

Florida Department of Agriculture and Consumer Services. (2008). *Water Quality Best Management Practices for Florida Cow/Calf Operations*. http://lshs.tamu.edu/docs/lshs/end-notes/water quality bmps for florida cow calf operations-1943370498/water quality bmps for florida cow calf operations.pdf

FONAG. (2019). *FONAG*. FONAG. http://www.fonag.org.ec/web/

Food and Agriculture Organization of the United Nations. (n.d.). *Livestock Systems*. Food and Agriculture Organization of the United Nations. Retrieved April 2, 2020, from http://www.fao.org/livestock-systems/global-distributions/cattle/en/

Food and Agriculture Organization of the United Nations. (2008). Factores que se deben considerar para seleccionar el sistema de riego más adecuado. *El Desarrollo del Microriego en América Central*. http://www.fao.org/3/aj470s/aj470s02.pdf

Food and Agriculture Organization of the United Nations. (2013). *Livestock and Environment*. Animal Production and Health. http://www.fao.org/ag/againfo/themes/en/environment.html

Food and Agriculture Organization of the United Nations. (2014a). *Livestock and Animal Production*. Animal Production and Health. http://www.fao.org/ag/againfo/themes/en/animal_production.html

Food and Agriculture Organization of the United Nations. (2014b). *Tackling climate change through livestock*. Animal Production and Health. http://www.fao.org/ag/againfo/resources/en/publications/tackling_climate_change/index.htm

Food and Agriculture Organization of the United Nations. (2016a). *Ganadería de América Latina y el Caribe puede jugar rol clave en el logro de los Objetivos de Desarrollo Sostenible*. Food and Agriculture Organization of the United Nations. http://www.fao.org/americas/noticias/ver/en/c/421098/

Food and Agriculture Organization of the United Nations. (2016b). *Livestock and Income Generation*. Animal Production and Health. http://www.fao.org/ag/againfo/themes/en/income_generation.html

Food and Agriculture Organization of the United Nations. (2017). *Ecuador advances towards climate-smart livestock*. Food and Agriculture Organization of the United Nations. http://www.fao.org/in-action/agronoticias/detail/en/c/1025398/

Food and Agriculture Organization of the United Nations, & World Organization for Animal Health. (2009). *Guide to good farming practices for animal production food safety*.

Freeman, S. (2007). *The World's Water Supply*. How Stuff Works. https://science.howstuffworks.com/environmental/earth/geophysics/h2o1.htm

Frost, R., & Mosley, J. (n.d.). *Grazing Systems*. Gobal Rangelands. Retrieved May 6, 2020, from https://globalrangelands.org/topics/uses-range-and-pasture-lands/grazing-systems

Galárraga-Sánchez, R. H. (2000). *Informe Nacional sobre la gestión del agua en el Ecuador*. https://www.cepal.org/DRNI/proyectos/samtac/InEc00100.pdf

Gelaw, F., Speelman, S., & Van Huylenbroeck, G. (2016). Farmers' marketing preferences in local coffee markets: Evidence from a choice experiment in Ethiopia. *Food Policy*, *61*, 92–102. https://doi.org/10.1016/j.foodpol.2016.02.006

Gestión de Comunicación MA. (2017). *Mejía*. Pichincha Gobierno Provincial. https://www.pichincha.gob.ec/cantones/Mejía

Gobierno Autónomo Descentralizado Municipal del Cantón Mejía. (2015, November, 03). *Actualización del Plan de Desarrollo Y Ordenamiento Territorial.* Gobierno Autónomo Descentralizado Municipal del Cantón Mejía.

Goibov, M., Schmitz, P. M., Bauer, S., & Ahmed, M. N. (2012). Application of a Choice Experiment to Estimate Farmers Preferences for Different Land Use Options in Northern Tajikistan. *Journal of Sustainable Development*, *5*(5).

https://doi.org/10.5539/jsd.v5n5p2

Grazing Systems. (n.d.). University of Kentucky College of Agriculture, Food and Environment. Retrieved May 6, 2020, from https://grazer.ca.uky.edu/content/grazing-systems

Guerra, J. M. (2018). *Influencia del uso del suelo sobre la calidad ecológica de la cuenca del río San Pedro*. UDLA.

Guerrero, A.S. (2019). *Modelo de Intervención para la conservación del Recurso Hídrico aplicando lógica difusa en las microcuencas de los ríos Pita y Pisque*. (Publication No. 20386). [Trabajo de titulación, previo a la obtención del título de Ingeniera Geógrafa y del Medio Ambiente, ESPE Universidad de las Fuerzas Armadas]. Repositorio ESPE.

"Guía de carácter voluntario referente a la Certificación de Buenas Prácticas Pecuarias (BPP). Resolución 111 Agrocalidad. (2010)

"Guía de Buenas Prácticas Pecuarias en Ganadería de leche para pequeños productores. Resolución 0276 de Agrocalidad. (2016).

"Guía de Buenas Prácticas Pecuarias en la producción de ganado bovino de carne". Resolución 0244 de Agrocalidad. (2016)

Guía de carácter voluntario referente a la Certificación de Buenas Prácticas Pecuarias (BPP). Resolución 111 Agrocalidad. (2010)

Guncay, H.F. (2018). *Propuesta para la implementación de las buenas prácticas pecuarias (BPP) en el proceso de reproducción de bovinos de carne en la granja "Tropicales"*. (Publication No. 14426). [Trabajo de titulación, previo a la obtención del título de Ingeniero Agropecuario, ESPE Universidad de las Fuerzas Armadas]. Repositorio ESPE.

Gunst, R. F., & Mason, R. L. (2009). Fractional factorial design. *Wiley Interdisciplinary*

Reviews: Computational Statistics, *1*(2), 234–244. https://doi.org/10.1002/wics.27

Hanley, N. D., Wright, R. E., & Alvarez-Farizo, B. (2006). Estimating the economic value of improvements in river ecology using choice experiments: An application to the water framework directive. *Journal of Environmental Management*, *78*(2), 183–193. https://doi.org/10.1016/j.jenvman.2005.05.001

Horne, P. (2006). Forest owners' acceptance of incentive based policy instruments in forest biodiversity conservation - A choice experiment based approach. *Silva Fennica Monographs, 40*(1), 169–178. https://doi.org/10.14214/sf.359

INEC. (2018). Tabulados ESPAC 201.[Data set] Instituto Nacional de estadísticas y censos. https://www.ecuadorencifras.gob.ec/estadisticas-agropecuarias-2

Instituto Ecuatoriano de Normalización. (2014, January). *NTE INEN 1108 Agua Potable, Requisitos*. Instituto Ecuatoriano de Normalización.

International Livestock Research Institute. (2020). *International Livestock Research Institute*. International Livestock Research Institute. https://www.ilri.org/

Jaeck, M. and Lifran, R. (2014), Farmers' Preferences for Production Practices: A Choice Experiment Study in the Rhone River Delta. J Agric Econ, 65: 112-130. doi:10.1111/1477-9552.12018

Khokhar, T. (2017). *Chart: Globally, 70% of Freshwater is Used for Agriculture*. World Bank Blogs. https://blogs.worldbank.org/opendata/chart-globally-70-freshwater-used-agriculture

Kikulme, E. M., Birol, E. Wesseler, J. & Falck-Zepeda, J. (2011). A latent class approach to investigating demand for genetically modified banana in Uganda. *Agricultural Economics.* 42(5). https://doi.org/10.1111/j.1574-0862.2010.00529.x.

Laboratorio Multimedia X Balam [XBalamUV]. (2013, December, 13). *Biodigestor.*[Video]. YouTube. https://www.youtube.com/watch?v=QbQIc-csNvw

Latacz-lohmann, U., & Schreiner, J. (2018). *Assessing farmers ' preferences for the future of the Common Agricultural Policy : insights from of a discrete choice experiment in Germany*. *September*, 16–18.

Launchbaugh, K. (n.d.). *Grazing Systems*. Retrieved May 6, 2020, from https://www.webpages.uidaho.edu/range456/Hand_outs/graze_system.pdf

Lemeilleur, S., Subervie, J., Presoto, A. E., de Castro Souza, R., & Saes, M. S. M. (2019). Coffee farmers' motivations to comply with sustainability standards. *Journal of Agribusiness in Developing and Emerging Economies*, *à paraître*, à paraitre. https://halshs.archives-ouvertes.fr/halshs-02278751

Ley de Recursos Hídricos y Aprovechamiento del Agua. (2014, August, 6). Registro Oficial No. 305

Maiguashca, J.A. (2014). *Generación de metodología para proyectar el incremento de la frontera agrícola en el Cantón Mejía, usando SIG y Teledetección.* (Publication No. 3637). [Tesis de grado presentada como requisito para la obtención del título de Magister en Sistemas de Información Geográfica, Universidad San Francisco de Quito]. Repositorio USFQ.

Martin-Ortega, J., Giannoccaro, G., & Berbel, J. (2011). Environmental and Resource Costs Under Water Scarcity Conditions: An Estimation in the Context of the European Water Framework Directive. *Water Resources Management*, *25*(6), 1615–1633. https://doi.org/10.1007/s11269-010-9764-z

Mecalux, (n.d.). *Basurero de color para reciclaje.* https://www.logismarket.cl/ecosas/basurero-de-color-para-reciclaje/3160056905-p.html

Meemken, E. M., Veettil, P. C., & Qaim, M. (2017). Toward Improving the Design of Sustainability Standards—A Gendered Analysis of Farmers' Preferences. *World Development*, *99*, 285–298. https://doi.org/10.1016/j.worlddev.2017.05.021

Merriam-Webster. (n.d.). *Biodigester*. Merrian-Webster. Retrieved April 2, 2020, from https://www.merriam-webster.com/dictionary/biodigester

Ministerio de Agricultura Ganadería y Pesca. (2015a). La Política Agropecuaria Ecuatoriana Parte 1. In *Ministerio de Agricultura, Ganadería, Acuacultura y Pesca*.

Ministerio de Agricultura Ganadería y Pesca. (2015b). *La Política Agropecuaria Ecuatoriana Parte 2*.

Ministerio de Agricultura y Ganadería. (2016). *Registran a productores en Proyecto Plan Semillas para Agrocadenas Estratégicas*. Ministerio de Agricultura y Ganadería. https://www.agricultura.gob.ec/registran-a-productores-en-proyecto-plan-semillas-para-agrocadenas-estrategicas/

Ministerio de Agricultura y Ganadería. (2019). *MAG y BanEcuador anuncian créditos para desarrollar el sector agropecuario*. Ministerio de Agricultura y Ganadería. https://www.agricultura.gob.ec/mag-y-banecuador-anuncian-creditos-para-desarrollar-el-sector-agropecuario/

Molina, B., & Díaz, T. (2017). *FAO: La ganadería y sus desafíos en América Latina y el Caribe*. Organización de Las Naciones Unidad Para La Agricultura y La Alimentación (FAO). https://www.agronewscastillayleon.com/fao-la-ganaderia-y-sus-desafios-en-america-latina-y-el-caribe

Muñoz Villacreses, V. L. (2016). *Efectos de la Ley de Aguas en 1972 en el manejo de los recursos hídricos del alta montaña en Ecuador* (Issue June). Pontifica Universidad Católica del Ecuador.

Naciph, K. A. (2016) *Water Quality Analysis of the San Pedro River and Proposal of a Water Treatment Design for its use as a Water Source for a Communitarian Irrigation Project* (Publication No. 6127) [Trabajo de Titulación presentado como requisito para la obtención del título de Ingeniera Ambiental] Repositorio USFQ

National Geographic. (n.d.). *Clean Water Crisis Facts and Information*. National Geographic. Retrieved April 2, 2020, from https://www.nationalgeographic.com/environment/freshwater/freshwater-crisis/

Ortega, D. L., Waldman, K. B., Richardson, R. B., Clay, D. C., & Snapp, S. (2016). Sustainable Intensification and Farmer Preferences for Crop System Attributes: Evidence from Malawi's Central and Southern Regions. *World Development*, *87*, 139–151. https://doi.org/10.1016/j.worlddev.2016.06.007

Osmond. D. & Burchell, M. (2017, July, 26). Agricultural Riparian Buffers. NC STATE EXTENSION. https://content.ces.ncsu.edu/agricultural-riparian-buffers

Pan, D., Zhou, G., Zhang, N., & Zhang, L. (2016). Farmers' preferences for livestock pollution control policy in China: A choice experiment method. *Journal of Cleaner Production*, *131*, 572–582. https://doi.org/10.1016/j.jclepro.2016.04.133

Paredes, T.P. (2015) *Auditoría ambiental de cumplimiento a las buenas prácticas adaptativas realizadas en las unidades demostrativas pecuarias en la parroquia Papallacta (Publication* No. 10899) [Tesis previo a la obtención del título en Magister en Auditoría Ambiental] Repositorio ESPE

Perez Loyola, R., Wang, E., & Kang, N. (2019). Economic valuation of recreational attributes using a choice experiment approach: An application to the Galapagos Islands. *Tourism Economics*. https://doi.org/10.1177/1354816619885236

Perman, R. (2003). *Natural Resources and Environmental Economics*. Harlow: Pearson Education Limited.

Putnam, J. (2016). *Practical Pasture Configurations for Rotational Grazing.* Premier1Supplies. https://www.premier1supplies.com/sheep-guide/2016/09/pasture-configurations-for-rotational-grazing/

Practical Action. (2017). *Análisis y perspectivas de la ganadería en América Latina.* Practical

Action. http://infolactea.com/otros/analisis-y-perspectivas-de-la-ganaderia-en-america-latina/

Precio de la Leche Cruda, Acuerdo 394 Ministerio de Agricultura, Ganadería, Acuacultura y Pesca, (2013)

Raes, L., Speelman, S., & Aguirre, N. (2017). Farmers' Preferences for PES Contracts to Adopt Silvopastoral Systems in Southern Ecuador, Revealed Through a Choice Experiment. *Environmental Management*, *60*(2), 200–215. https://doi.org/10.1007/s00267-017-0876-6

Reyes. J.H. (2015). *Análisis de la innovación en productos agrícolas y ganaderos como incorporación de nueva tecnología para la transformación de la matriz productiva en Ecuador.* (Publication No. 6216). [Tesis de grado presentada como requisito para la obtención del título de Licenciado en Administración de Empresas, Universidad San Francisco de Quito]. Repositorio USFQ.

Rinkesh. (n.d.). *What is Waste Management and Methods of Waste Disposal? - Conserve Energy Future*. Conserve Energy Future. Retrieved April 2, 2020, from https://www.conserve-energy-future.com/waste-management-and-waste-disposal-methods.php

Río Guayllabamba: Mapa y todo lo que necesita conocer. (2020, January, 16). Ríos del Planeta. Retrieved April, 02, 2020, from https://riosdelplaneta.com/rio-guayllabamba/

Robayo, I.F. (2018). *Propuesta de reordenamiento de uso de suelo rural en la parroquia de Machahi para la conservación de tierras agrícolas y ganaderas.* (Publication No. 15583). [Disertación previa a la obtención del Título de Ingeniera Geógrafa en la planificación territorial, Pontificia Universidad Católica del Ecuador]. Repositorio PUCE.

Rosales, A. (2012). *Evaluación de un programa de voluntariado comunitario como herramienta de educación, manejo y restauración de ríos urbanos.* (Publication No. 2271). [Tesis de grado presentada como requisito para la obtención del título de Ecología y Manejo de Recursos mención en Comunicación Ambiental, Universidad San Francisco de Quito]. Repositorio USFQ.

Rouquette, M. Pas, Jr. & Aiken, G.E. (2020). *Management Strategies for Sustainable Cattle Production in Southern Pastures.* Elsevier Inc.

Saldias, C., Speelman, S., Van Huylenbroeck, G., & Vink, N. (2016). Understanding farmers' preferences for wastewater reuse frameworks in agricultural irrigation: Lessons from a choice experiment in the western cape, South Africa. *Water SA*, *42*(1), 26–37. https://doi.org/10.4314/wsa.v42i1.04

Sitompul, R., Brouwer, R., Sopaheluwakan, J., & van Beukering, P. (2016). Farm household preferences and evaluation of land use change policies for agro-forestry plantations in Central Kalimantan, Indonesia: A choice experiment. *International Journal on Advanced Science, Engineering and Information Technology*, *6*(2), 210–216. https://doi.org/10.18517/ijaseit.6.2.742

Tarfasa, S., & Brouwer, R. (2013). Estimation of the public benefits of urban water supply improvements in Ethiopia: A choice experiment. *Applied Economics*, *45*(9), 1099–1108. https://doi.org/10.1080/00036846.2011.613793

The World Bank. (2019). *Moving towards sustainability: The Livestock Sector and the World Bank*. The World Bank. https://www.worldbank.org/en/topic/agriculture/brief/moving-towards-sustainability-the-livestock-sector-and-the-world-bank

Tietenberg, T. & Lewis, L.(2015) *Environmental & Natural Resource Economics* (pp 243-245). Harlow: Pearson Education Limited

United Nations. [United Nations]. (2015, September,11). *What is Sustainable Development?* [Video]. YouTube. https://www.youtube.com/watch?v=3WODX8fyRHA

Vaca, M.E. (2019). *Metodologías para la evaluación de la influencia de actividades agropecuarias en la calidad del agua.* (Publication No. 17107). [Disertación previa a la obtención del Título de Magíster en Planificación y Ordenamiento territorial para el desarrollo, Pontificia Universidad Católica del Ecuador]. Repositorio PUCE.

Vera, J.L. (2017). *Períodos de descanso y fertilización de a mezcla forrajera Brachiaira brizantha – Pueraria phaseoloides en la época seca.* (Publication No. 13849). [Trabajo de titulación, previo a la obtención del título de Ingeniero Agropecuario, ESPE Universidad de las Fuerzas Armadas]. Repositorio ESPE.

Victoria State Government. (n.d.). *About Irrigation*. Agriculture Victoria. Retrieved April 2, 2020, from http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/irrigation/about-irrigation#

Villanueva, A. J., Gómez-Limón, J. A., Arriaza, M., & Rodríguez-Entrena, M. (2015). The design of agri-environmental schemes: Farmers' preferences in southern Spain. *Land Use Policy*, *46*, 142–154. https://doi.org/10.1016/j.landusepol.2015.02.009

Ward, P. S., Bell, A. R., Parkhurst, G. M., Droppelmann, K., & Mapemba, L. (2016). Heterogeneous preferences and the effects of incentives in promoting conservation agriculture in Malawi. *Agriculture, Ecosystems and Environment*, *222*, 67–79. https://doi.org/10.1016/j.agee.2016.02.005

Yeboah, F. K., Lupi, F., & Kaplowitz, M. D. (2015). Agricultural landowners' willingness to participate in a filter strip program for watershed protection. *Land Use Policy, 49*, 75–85. https://doi.org/10.1016/j.landusepol.2015.07.016

Yehouenou, L. S., & Grogan, K. (n.d.). *Improving BMP Cost-Share Enrollment Rates: Insights from a Survey of Florida Farmers*.

Yépez, A. R. (2014). *Diseño Arquitectónico, Estructural, Hidrosanitario y Medioambiental del Nuevo Establo de La Hacienda Colache ubicada en el Cantón Mejía*. Universidad San Francisco de Quito.

APPENDICES

Appendix A – Number of Bovine Heads and Breeds

Region and Province	Total	BOVINE LIVESTOCK						
		Brown Swiss	Brahman o cebú	Holstein Friesian	Jersey	Mestizos	Criollos	Other Breeds
NATIONAL TOTAL	**4,056,796**	**276,947**	**601,837**	**365,246**	**94,536**	**1,528,142**	**963,677**	**226,410**
REGIÓN SIERRA	1,963,731	94,922	93,442	285,817	49,648	728,452	657,536	53,913
REGIÓN COSTA	1,720,719	145,474	445,934	53,133	35,314	686,252	266,738	87,874
REGIÓN AMAZÓNICA	371,123	36,307	62,194	26,097	9,376	113,124	39,402	84,623
ZONAS NO DELIMITADAS	1,223	244	267	199	198	314	0	0

Province	Total bovine heads	Province	Total bovine heads	Province	Total bovine heads
REGIÓN SIERRA		***REGIÓN COSTA***		***REGIÓN AMAZÓNICA***	
AZUAY	323,461	EL ORO	144,397	MORONA SANTIAGO	125,468
BOLÍVAR	179,617	ESMERALDAS	254,148	NAPO	27,520
CAÑAR	119,594	GUAYAS	296,417	ORELLANA	43,894
CARCHI	88,397	LOS RÍOS	101,510	PASTAZA	13,999
COTOPAXI	250,787	MANABÍ	921,823	SUCUMBÍOS	89,537
CHIMBORAZO	221,857	SANTA ELENA	2,424	ZAMORA CHINCHIPE	70,705
IMBABURA	84,671				
LOJA	161,123				
PICHINCHA	272,700				
TUNGURAHUA	125,708				
SANTO DOMINGO DE LOS TSÁCHILAS	135,815	**ZONAS NO DELIMITADAS**	1,223		

Source: INEC

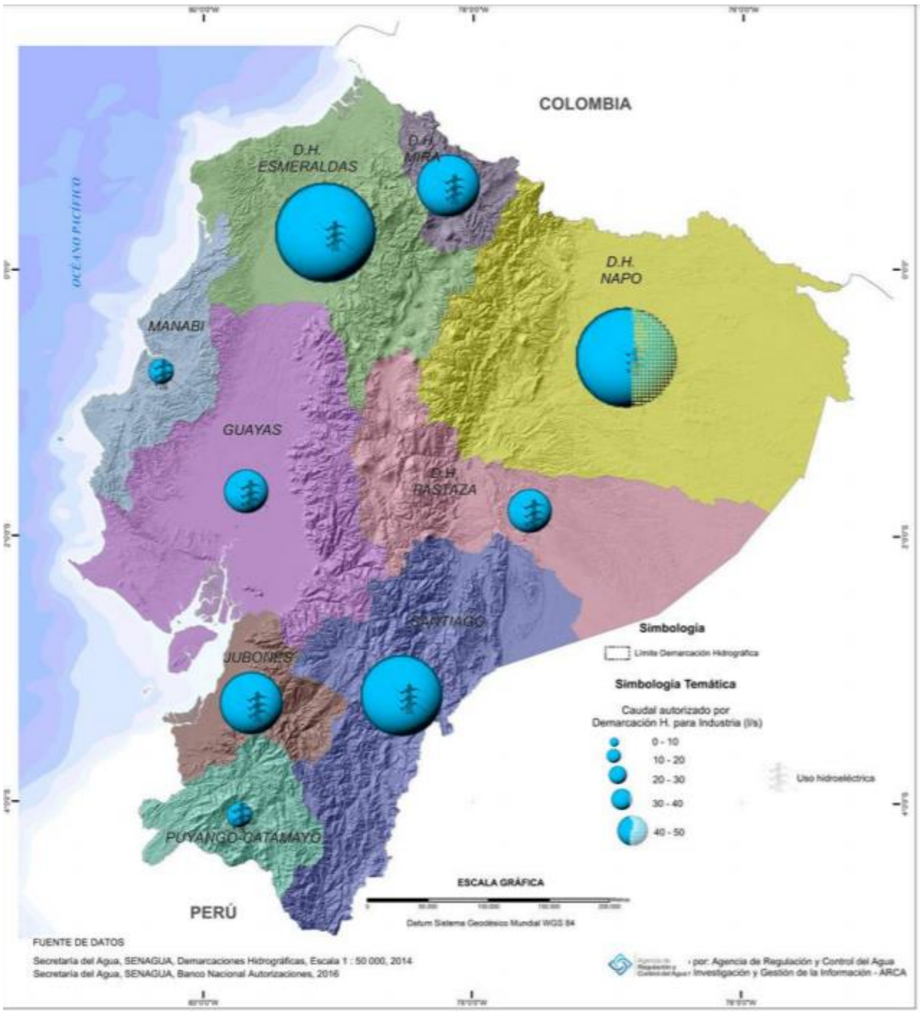
Appendix B – Water Risk/Stress per Country LAC

COUNTRY	WATER RISK
Chile	High (40-80%)
Mexico	High (40-80%)
Guatemala	Medium - High (20-40%)
Peru	Medium - High (20-40%)
Venezuela	Medium - High (20-40%)
Cuba	Medium - High (20-40%)
Dominican Republic	Low - Medium (10-20%)
Haiti	Low - Medium (10-20%)
El Salvador	Low - Medium (10-20%)
Ecuador	Low - Medium (10-20%)
Argentina	Low - Medium (10-20%)
Bolivia	Low - Medium (10-20%)
Costa Rica	Low (<10%)
Brazil	Low (<10%)
Colombia	Low (<10%)
Belize	Low (<10%)
Honduras	Low (<10%)
Panama	Low (<10%)
Nicaragua	Low (<10%)
Paraguay	Low (<10%)
Uruguay	Low (<10%)
Guyana	Low (<10%)
Jamaica	Low (<10%)
Suriname	Low (<10%)
Antigua and Barbuda	NoData
Bahamas	NoData
Barbados	NoData
Dominica	NoData
Grenada	NoData
Saint Kitts and Nevis	NoData
Saint Lucia	NoData
Trinidad and Tobago	NoData
Saint Vincent and the Grenadines	NoData

Source: WRI

Appendix C – River Basin Districts

River Basin Districts



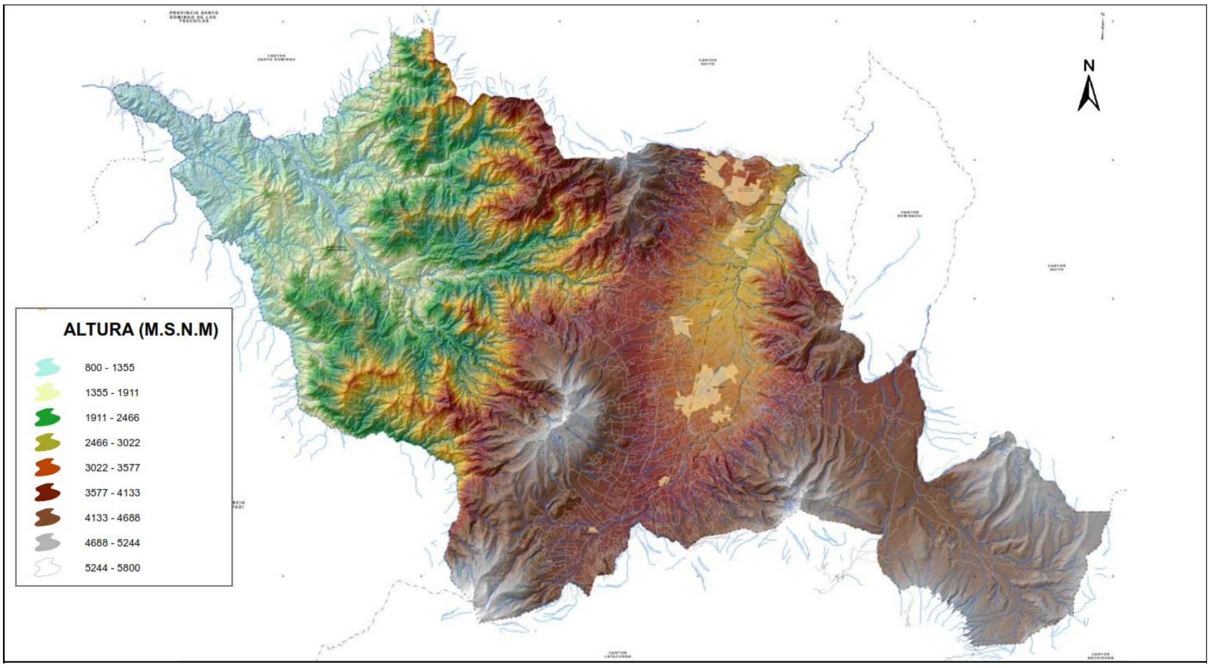
Source: SENAGUA

Appendix D – Water Risk in Ecuador per Province

COUNTRY	WATER RISK
Galápagos	Extremely High (>80%)
Loja	Medium - High (20-40%)
Manabi	Low - Medium (10-20%)
El Oro	Low - Medium (10-20%)
Guayas	Low - Medium (10-20%)
Cañar	Low - Medium (10-20%)
Santa Elena	Low - Medium (10-20%)
Los Rios	Low - Medium (10-20%)
Bolivar	Low - Medium (10-20%)
Santo Domingo de los Tsachilas	Low - Medium (10-20%)
Azuay	Low (<10%)
Pichincha	Low (<10%)
Chimborazo	Low (<10%)
Esmeraldas	Low (<10%)
Cotopaxi	Low (<10%)
Zamora Chinchipe	Low (<10%)
Imbabura	Low (<10%)
Napo	Low (<10%)
Sucumbios	Low (<10%)
Tungurahua	Low (<10%)
Morona Santiago	Low (<10%)
Carchi	Low (<10%)
Orellana	Low (<10%)
Pastaza	Low (<10%)

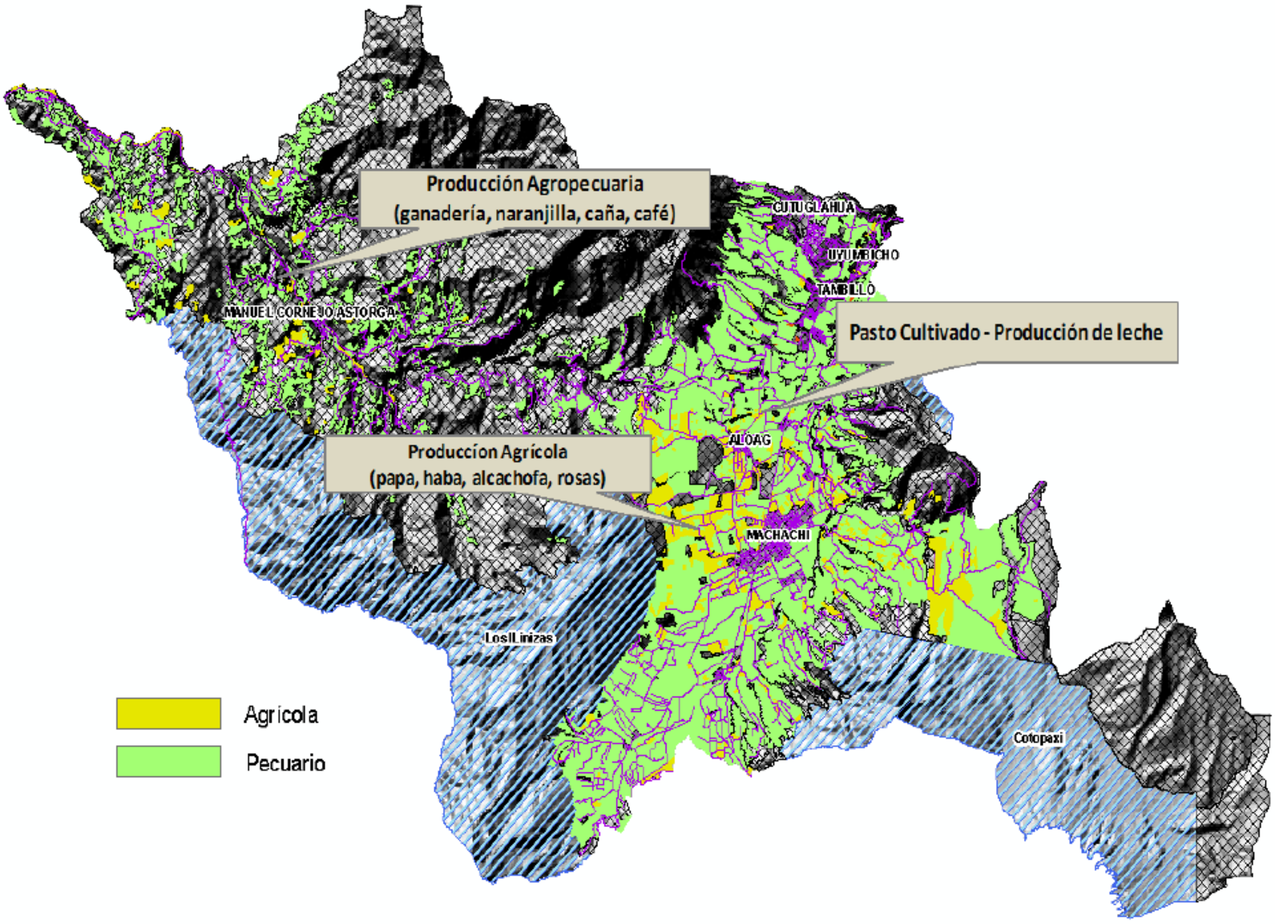
Source: WRI

Appendix E – Areas in Mejía According to Altitude



Source. (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

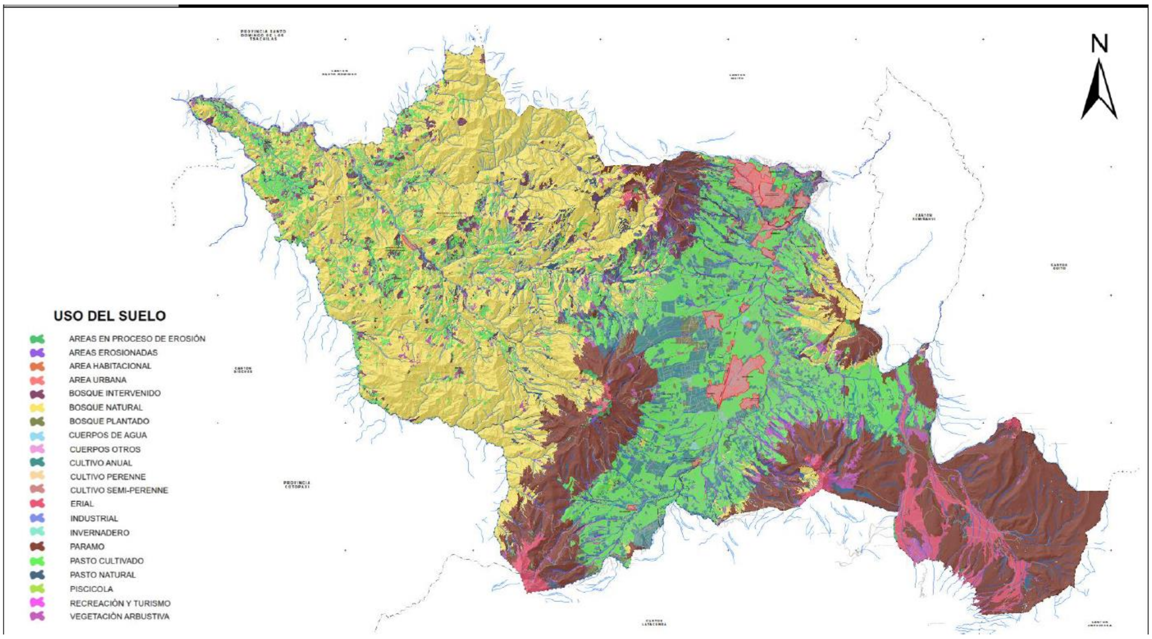
Appendix F – Homogenous Zones Map



Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

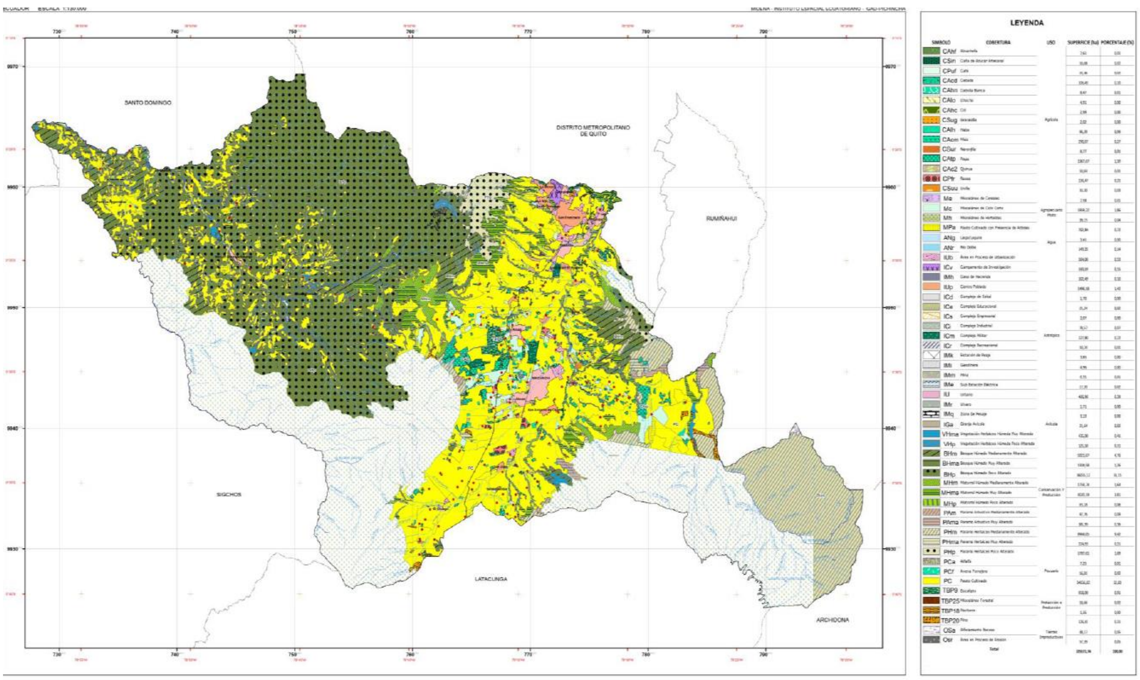
Appendix G – Land Use in Mejía

G.1 - Land use in Mejía



Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

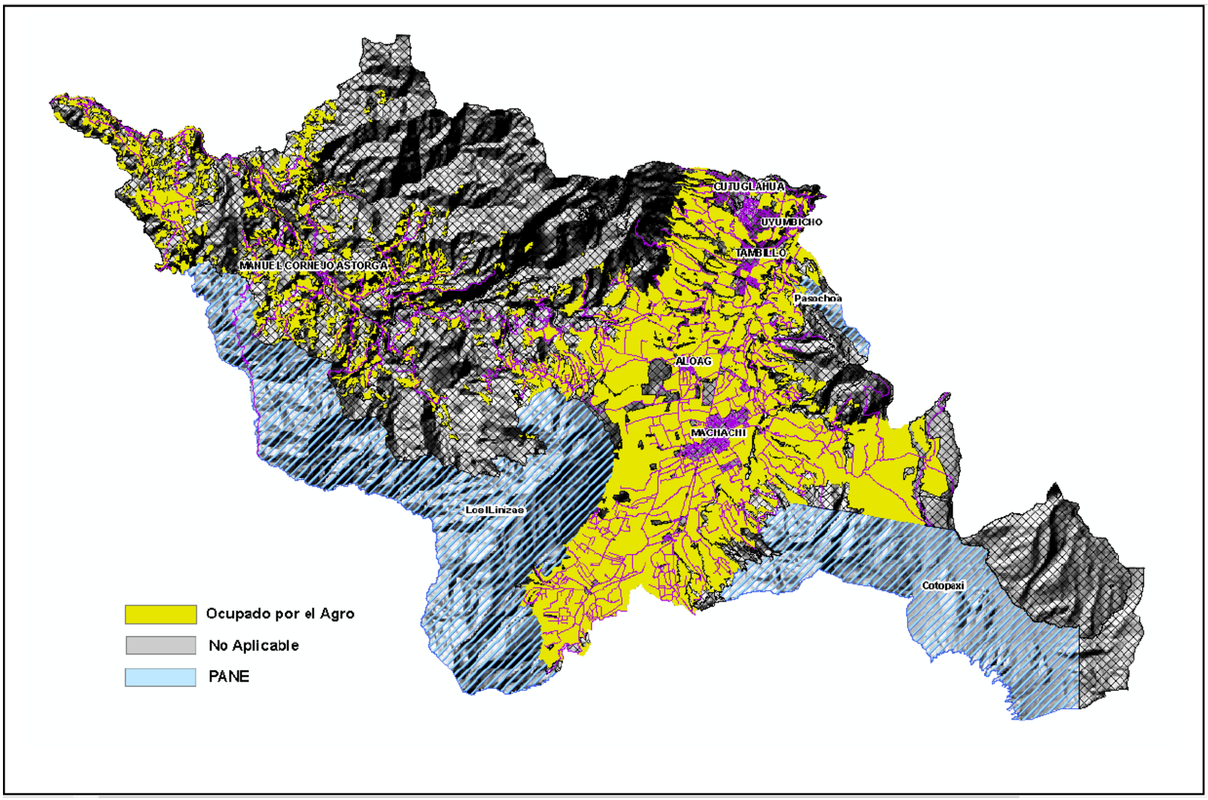
G.2 - Map of Soil use



Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015

Appendix H – Surface Occupied by agricultural activities

Surface Occupied by Agricultural activities



Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

Appendix I – Mejía's Hydrology

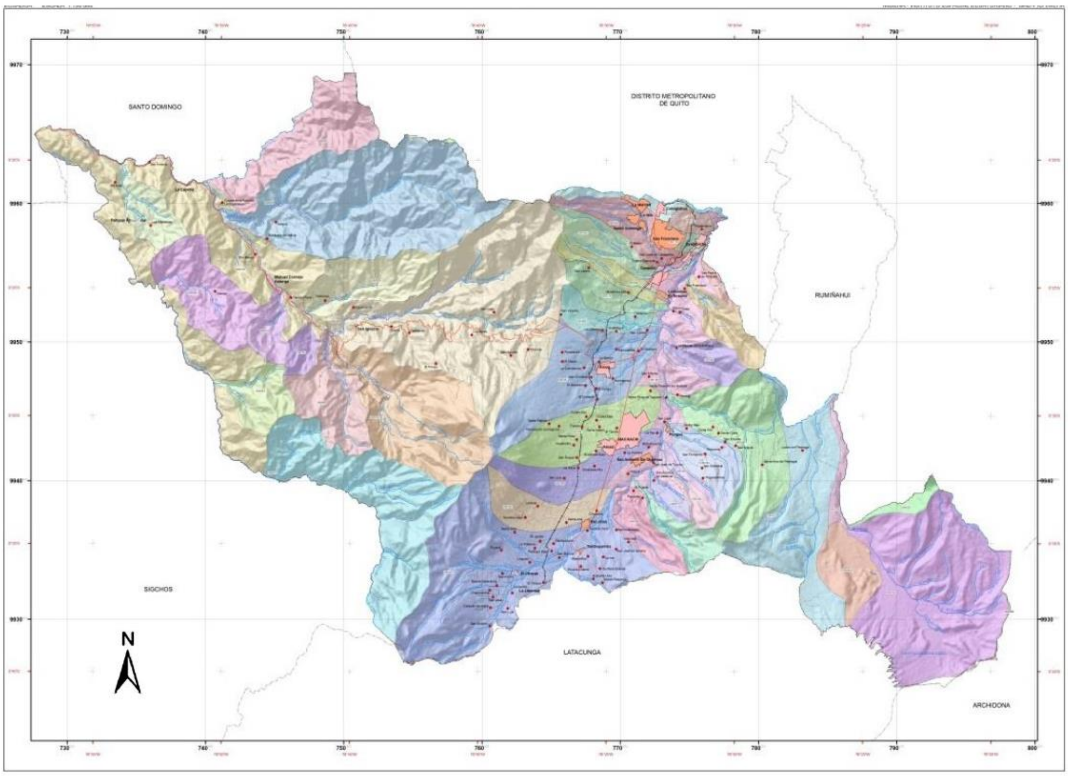
Sub River Basin	Name of Body of Water	Location
Río Blanco	Río Pilatón, Chictoa, La Esperanaza, Santa Ana, Yamboa, Naranjal, Minas Guilca Grande, Quitasol, Negro, Tandapi, Verde, Zarapu, Atenas, Zarapullo, Napa, Toachi	North West Manuel Cornejo Astora, Alóag, Chaupi
Río Guayallabamba	Río San Pedro, Pedregal, Jambelí, Pita, Hualpaloma, Tamboyacu	South East Alóag, Chaupi, Cutuglagua Tanadapo, Uyumbicho, Aloasí, Machachi

Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

Appendix J - Hydrografic Division y Micro River Basins

		RÍO PITA	1201030
		QUEBRADA MERCED	1201031
		QUEBRADA VICTOR PUÑAN	1201032
		RÍO SALTO	1201033
		QUEBRADA CARIACU	1201035
		RÍO JAMBELI	1201037
		QUEBRADA SAN FRANCISCO	1201038
		QUEBRADA PUCHALITOLA	1201039
		QUEBRADA SAN AGUSTIN	1201040
		MICROCUENCA S/N	1201041
		QUEBRADA SIGSICHUPA	1201042
		QUEBRADA GUITIG	1201043
		QUEBRADA EL TIMBO	1201044
		RÍO PEDREGAL	1201045
		QUEBRADA SANTIAGO	1201046
	RÍO GUAYLLABAMBA	QUEBRADA LLUGSHI	1201047
		QUEBRADA SUNIHUAICU	1201048
		QUEBRADA GIRON	1201049
		QUEBRADA SANTA ANA	1201050
		QUEBRADA TAMBILLOYACU	1201051
		MICROCUENCA S/N	1201052
		QUEBRADA PUGRON	1201053
		QUEBRADA CANARI	1201054
		RÍO SAN NICOLÁS	1201056
RÍO ESMERALDAS		DRENAJES MENORES	1201120
		QUEBRADA JAJARIN	1201169
		MICROCUENCA S/N	1201170

		MICROCUENCA S/N	1201170
		QUEBRADA CHAUPIURCU	1201171
		QUEBRADA SANTO DOMINGO	1201172
		QUEBRADA SIGSIHUAYCU	1201175
		QUEBRADA DE PUCHE	1201226
		RÍO JATUNCAMA	1202007
		RÍO ZARAPULLO	1202019
		QUEBRADA EL SEMINARIO	1202021
		RÍO ATENAS	1202022
		MICROCUENCA S/N	1202023
		RÍO CORAZON	1202025
		RÍO NARANJAL	1202026
RÍO ESMERALDAS		RÍO CHISINCHE	1202027
		RÍO YAMBOYA	1202028
	RÍO BLANCO	RÍO SANTA ANA	1202029
		RÍO CHICTOA	1202030
		RÍO SALOYA	1202037
		RÍO LAS PALMERAS	1202039
		DRENAJES MENORES	1202103
		RÍO RANDAPI	1202152
		QUEBRADA CHORRERA NEGRA	1202157
		RÍO NAPA	1202177
		RÍO SALOVA	1202187
RÍO NAPO	RÍO JATUNYACU	RÍO TAMBOYACU	7402002
RÍO PASTAZA	RÍO PATATE	RÍO CUTUCHI	7601001
		RÍO BLANCO	7601003

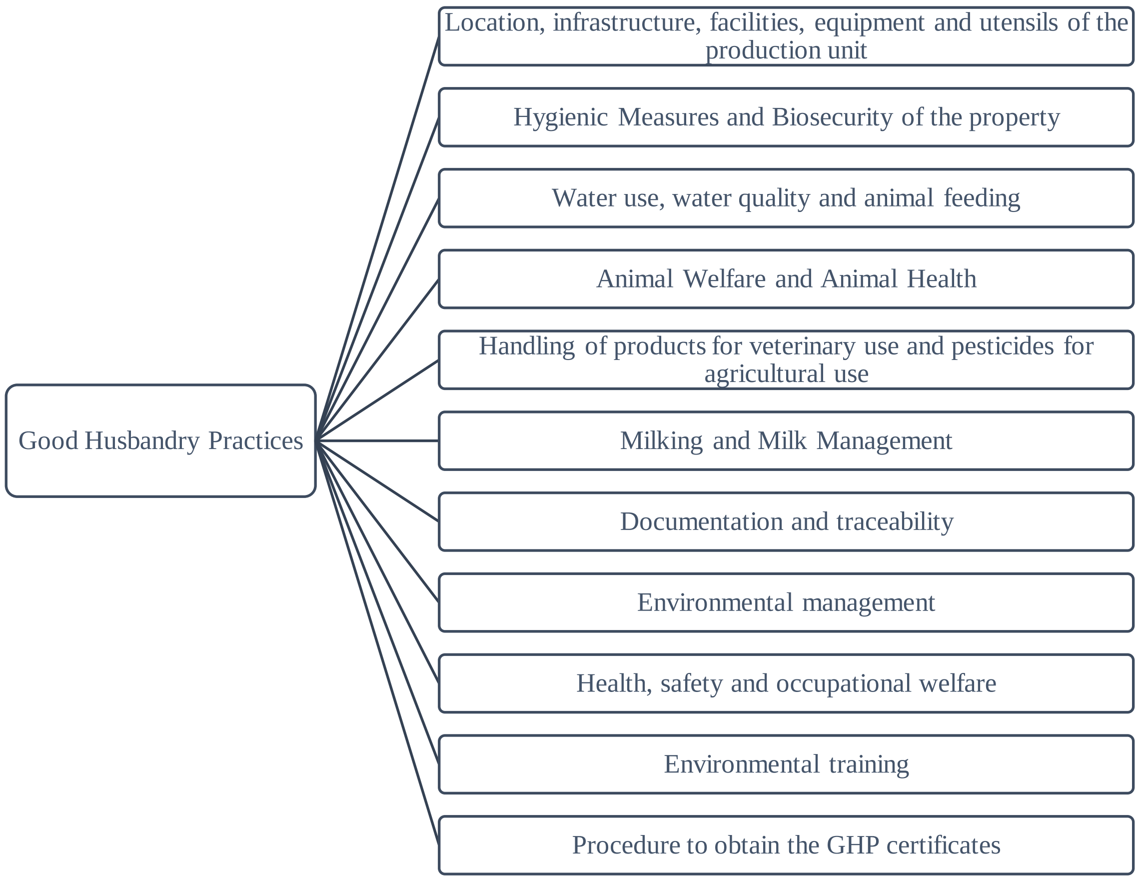


Source: (Gobierno Autónomo Descentralizado Municipal del Cantón Mejía, 2015)

Appendix K – D-Efficiency Design

Improved Grazing Systems	Buffer Zones	Animal Waste Treatment	Micro-Sprinkler Irrigation	Proper Waste Mgmt	Implem. Cost	Choice Set	alt	block
2	1	2	1	1	1	1	1	3
1	2	1	2	2	2	1	2	3
1	2	1	1	2	1	2	1	2
2	1	2	2	1	3	2	2	2
1	1	1	1	1	1	3	1	3
2	2	2	2	2	3	3	2	3
1	1	2	2	1	1	4	1	3
2	2	1	1	2	3	4	2	3
1	1	2	2	2	3	5	1	2
2	2	1	1	1	2	5	2	2
2	2	1	2	2	1	6	1	2
1	1	2	1	1	3	6	2	2
1	2	1	1	1	2	7	1	2
2	1	2	2	2	1	7	2	2
1	1	1	2	2	2	8	1	3
2	2	2	1	1	3	8	2	3
2	1	1	1	2	3	9	1	3
1	2	2	2	1	2	9	2	3
1	1	2	1	2	2	10	1	1
2	2	1	2	1	3	10	2	1
1	2	2	1	2	3	11	1	1
2	1	1	2	1	1	11	2	1
1	2	2	2	2	2	12	1	3
2	1	1	1	1	1	12	2	3
1	2	2	1	1	1	13	1	1
2	1	1	2	2	2	13	2	1
1	2	1	2	1	3	14	1	2
2	1	2	1	2	2	14	2	2
1	1	1	1	1	3	15	1	1
2	2	2	2	2	1	15	2	1
2	1	2	1	1	2	16	1	2
1	2	1	2	2	1	16	2	2
1	1	1	2	2	3	17	1	1
2	2	2	1	1	2	17	2	1
1	1	2	1	2	1	18	1	1
2	2	1	2	1	2	18	2	1

Appendix L – Good Husbandry Practices in Ecuador



Source: ("Guía de Buenas Prácticas Pecuarias en la producción", 2016; "Guía de carácter voluntario", 2010)

Appendix M – Cost Calculation

PRACTICE NUMBER	ATTRIBUTES	LEVELS	IMPLEMENTATION COST	Maintenance Cost (Monthly)	SAVINGS (Monthly)	NET COST (Monthly)
P1	Grazing systems	1. Rational Viosin Grazing Systems (Intensive rotational system)	$ 113.17	$ 394.00	$ 50.00	$ 344.00
		2. Mix of organic fertilization + chemical fertilization (30-70) (Intensive rotational system)	$ 65.52	$ 454.00	$ 15.00	$ 439.00
P2	Agricultural frontiers: Buffer zones	1. Buffer zone with wood fences	$ 247.00	$ -	$ -	$ -
		2. Buffer zones with native vegetation and temporal fences	$ 54.40	$ -	$ -	$ -
P3	Treatment of animal waste	1. Biodigesters (2 of 10m3 for 20 cows)	$ 1,760.00	$ 15.00	$ 15.00	$ -
		2. Stabilization Pond (1 of 500m3 for 20 cows)	$ 2,564.00	$ 15.00	$ 15.00	$ -
P4	Efficient Irrigation Systems	1. Micro-sprinkler 2. No Micro-sprinkler				
			$ 1,200.00	$ -	$ -	$ -
P5	Proper Manure Management and Recycling systems	1.Individual recycling system	$ 240.00	$ 25.00	$ -	$ 25.00
		2. Shared recycling system	$ 240.00	$ 5.00	$ -	$ 5.00
P6	Implementation Cost	1. 40% 2. 60% 3, 75%				

M.2 - Cost Calculation Grazing Systems

Rational Viosin Grazing System

IMPLEMENTATION COSTS							
Material Costs					**Labor Costs**		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Posts	65	$ 0.50	$ 32.50	Terán, 2015	3	$ 15.00	$ 45.00
Wires	19.6	$ 1.82	$ 35.67	Terán, 2015			
Subtotal			$ 68.17		Subtotal		$ 45.00
						TOTAL	**$ 113.17**

MAINTENANCE COST							
Material Costs					**Labor Costs**		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
			$ -		1	$ 394.00	$ 394.00
Subtotal			$ -		Subtotal		394
						TOTAL	$ 394.00

SAVINGS							
Material Costs					**Labor Costs**		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Chemical Fertilizer	2	$ 25	$ 50.00	MAGAP			$ -
			$ -				
Subtotal			$ 50.00		Subtotal		$ -
						TOTAL	$ 50.00

NET MAINTENANCE COST	
TOTAL	$ 344.00

Mixture organic and chemical fertilizer

IMPLEMENTATION COSTS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Posts	35	$ 0.50	$ 17.50	Terán, 2015	2	$ 15.00	$ 30.00
Wires	9.9	$ 1.82	$ 18.02	Terán, 2015			
Subtotal			$ 35.52		Subtotal		$ 30.00
						TOTAL	$ 65.52

MAINTENANCE COST

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Chemical Fertilizer	2	$ 25.00	$ 50.00	MAGAP	1	$ 394.00	$ 394.00
Organic Fertilizer	1	$ 10.00	$ 10.00	Interviewed farmer			
Subtotal			$ 60.00		Subtotal		$ 394.00
						TOTAL	$ 454.00

SAVINGS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Chemical Fertilizer	2	$ 25.00	$ 15.00	MAGAP			$ -
			$ -				
Subtotal			$ 15.00		Subtotal		$ -
						TOTAL	$ 15.00

NET MAINTENANCE COST

	TOTAL	$ 439.00

M.3 - Cost Calculation Buffer Zones

Buffer Zones with Wood Fences

IMPLEMENTATION COSTS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Wood Posts	0.5	$ 2.80	$ 1.40	Asked in a wood fence firm	2	$ 100.00	$ 200.00
Wood Fences	1	$ 5.60	$ 5.60	Asked in a wood fence firm			
Other Materials	8	$ 5.00	$ 40.00	Asked in a wood fence firm			
Subtotal			$ 47.00		Subtotal		$ 200.00
						TOTAL	**$ 247.00**

MAINTENANCE COST

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
							$ -
Subtotal			$ -		Subtotal		$ -
						TOTAL	$ -

SAVINGS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
			$ -				$ -
			$ -				
Subtotal			$ -				$ -
						TOTAL	$ -

NET MAINTENANCE COST

TOTAL	$ -

Buffer Zones with Native Vegetation and Temporal Fences

IMPLEMENTATION COSTS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Plants	20	$ 0.40	$ 8.00	Asked in a plant store in Mejía	3	$ 15.00	$ 45.00
Posts	0.5	$ 2.80	$ 1.40	Asked in a wood fence firm			
Wires	1	$ 0.40	$ 0.40	Online search in MercadoLibre			
Subtotal			$ 9.40		Subtotal		$ 45.00
						TOTAL	$ 54.40

MAINTENANCE COST

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Subtotal			$ -				
						TOTAL	$ -

SAVINGS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Subtotal			$ -				
						TOTAL	$ -

NET MAINTENANCE COST

	TOTAL	$ -

M.5 - Cost Calculation Manure Management

Biodigesters

IMPLEMENTATION COSTS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Masonry	1	$ 73.00	$ 73.00	Chungandro, 2010	1	$ 380.00	$ 380.00
Biodigester	1	$ 122.00	$ 122.00	Chungandro, 2010			
Other Materials	1	$ 55.00	$ 55.00	Chungandro, 2010			
Subtotal			$ 500.00		Subtotal		$ 380.00
						TOTAL	**$ 1,760.00**

MAINTENANCE COST

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
					1	$ 15.00	$ 15.00
Subtotal			$ -		Subtotal		$ 15.00
						TOTAL	$ 15.00

SAVINGS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Chemical Fertilizer	2	$ 25.00	$ 15.00	MAGAP			
			$ -				
Subtotal			$ 15.00				$ -
						TOTAL	$ 15.00

NET MAINTENANCE COST

TOTAL	$ -

Stabilization Pond

IMPLEMENTATION COSTS							
Material Costs					Labor Costs		
Materials	Units	Unit Cost	Total	Source	Number of Workers	Daily Cost	Total
Machinery per hour	27	$ 25.00	$ 675.00	Asked a contractor	2	$ 15.00	$ 30.00
Transportation	1	$ 180.00	$ 180.00	Asked a contractor			
Geomembrane	1	$ 1,240.00	$ 1,240.00	Asked a contractor			
Seives	3	$ 20.00	$ 60.00	Asked a contractor			
Posts	21	$ 6.00	$ 126.00	Online search: MercadoLibre			
Wires	1	$ 68.00	$ 68.00	Online search: MercadoLibre			
Water pipe	1	$ 185.00	$ 185.00	Online search: MercadoLibre			
Subtotal			$ 2,534.00		Subtotal		$ 30.00
						TOTAL	**$ 2,564.00**

MAINTENANCE COST							
Material Costs					Labor Costs		
Materials	Units	Unit Cost	Total	Source	Number of Workers	Daily Cost	Total
					1	15	15
Subtotal			$ -		Subtotal		15
						TOTAL	$ 15.00

SAVINGS							
Material Costs					Labor Costs		
Materials	Units	Unit Cost	Total	Source	Number of Workers	Daily Cost	Total
Chemical Fertilizer	2	$ 25.00	$ 15.00	MAGAP			
			$ -				
Subtotal			$ 15.00		Subtotal		$ -
						TOTAL	$ 15.00

NET MAINTENANCE COST		
	TOTAL	$ -

M.6 - Cost Calculation Irrigation systems

Micro-Sprinkler Irrigation

IMPLEMENTATION COSTS							
Material Costs					Labor Costs		
Materials	Units	Unit Cost	Total	Source	Number of Workers	Daily Cost	Total
				Asked a contractor			
Subtotal			$ -		Subtotal		$ -
						TOTAL	$ 1,200.00

MAINTENANCE COST							
Material Costs					Labor Costs		
Materials	Units	Unit Cost	Total	Source	Number of Workers	Daily Cost	Total
Subtotal			$ -		Subtotal		$ -
						TOTAL	$ -

SAVINGS							
Material Costs					Labor Costs		
Materials	Units	Unit Cost	Total	Source	Number of Workers	Daily Cost	Total
Subtotal			$ -		Subtotal		$ -
						TOTAL	$ -

NET MAINTENANCE COST	
TOTAL	$ -

M.7 - Cost Calculation Waste Management System

Individual Waste Management System

IMPLEMENTATION COSTS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Containers	4	$ 60.00	$ 240.00	Online Search: MercadoLibre			
Subtotal			$ 240.00		Subtotal		$ -
						TOTAL	**$ 240.00**

MAINTENANCE COST

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
					1	$ 25.00	$ 25.00
Subtotal			$ -		Subtotal		$ 25.00
						TOTAL	$ 25.00

SAVINGS

Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Subtotal			$ -		Subtotal		$ -
						TOTAL	$ -

NET MAINTENANCE COST

	TOTAL	$ 25.00

Shared Waste Management

IMPLEMENTATION COSTS							
Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Containers	4	$ 60.00	$ 240.00	Online Search: MercadoLibre			0
			$ -				
Subtotal			$ 240.00				0
						TOTAL	**$ 240.00**

MAINTENANCE COST							
Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
					1	$ 25.00	$ 5.00
Subtotal			$ -		Subtotal		$ 5.00
						TOTAL	$ 5.00

SAVINGS							
Material Costs					Labor Costs		
Materials	**Units**	**Unit Cost**	**Total**	**Source**	**Number of Workers**	**Daily Cost**	**Total**
Subtotal			$ -		Subtotal		$ -
						TOTAL	$ -

NET MAINTENANCE COST		
	TOTAL	$ 5.00