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Water access and community vulnerability in Ecuador, principal component and factor analysis to assess the often-overlooked impacts of clean hydroelectric development on small-scale agriculture.

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Abstract

Water is vital for almost any productive activity including food production and energy generation. However, the use of water by different agents arise the problem of access. When conflicting actors compete for their interests, formal mechanisms appear to solve the conflict leaving winners and losers. Influenced by the need for renewable energies, hydroelectricity emerged as an alternative, cleaner option to traditional polluting energies, being prioritized over other spheres of the development, including food security and community welfare. This dissertation assesses the socio-economic characteristics of agrarian communities in the watershed of an Ecuadorian river whose water flow have been allocated to the use of a hydropower plant by the government. This paper estimates the importance of water concessions and irrigation system in people's vulnerability to a potential perturbation to their lifestyle.

Table of contents

Tables

Graphs

Figures

Abreviations

ARCONEL	Agency for the regulation and control of electricity (Agencia de Regulación y Control de Electricidad)
CEPAL	Economic Commission for Latin America and the Caribbean (Comisión Económica para América Latina y el Caribe)
CONELEC	National Council of Electricity (Consejo Nacional de Electricidad)
GDP	Gross Domestic Product
INEC	National Institute of Statistics and Censuses
NBI	Unsatisfied Basic Needs Poverty
OLADE	Latin American Energy Organization (Organización Latinoamericana de Energía)
PCA	Principal Component Analisis
PNBV	National Plan for Good Living (Plan Nacional para el Buen Vivir)
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization (Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura)

Introduction

Water is to life as energy is to development (Costa, 2014). The concept that water is a vital resource and paramount to life is probably one of the most quoted ideas since its importance for the formation and evolution of living beings was scientifically proved. However, the treatment of water as an asset or input for different human activities has been raised only in the past decades because of the withdrawals and use of this resource achieved levels that could endanger the quality of ecosystems and life as we know it today. Water is a highly valuable resource for the production and processing of almost any good or service. In particular, water plays a starting role in the output and generation of both energy and food.

Several authors have advanced the characterization of the relationship between water and life, and energy and development. Moreover, they have recognized that, since there are many forms of energy production, from fossil fuels, to nuclear energy, to renewable forms of generation, development paths also depend greatly on how energy is produced. Hydropower plants have emerged in the literature as a form of clean energy, despite the extensive research that contradicts this proposition, highlighting the noxious effects on the environment and aquatic ecosystems. What is not often analyzed, is the potential for sustainable agriculture that can be lost when water access is appropriated for industrial uses in small farming regions. Water is essential for life since it not only keeps people and ecosystems alive but also moves the machinery in any production process, starting with the most basic one: food production. Therefore, "The consequences of perceiving water and energies' problems as two different challenges can be negative for the environment and can put at risk the advances achieved by economic development" (Naciones Unidas, 2014a, p. n.p.)

The decisions as to water property rights allocations are commonly managed by governments since water is treated as a common good. The trade-offs behind these decisions (e.g. to prioritize water for agriculture, or for industrial processes, or for energy production) are usually managed at a national level, and often they are influenced by the fact that moving from polluting energy technologies to a cleaner way of production is rewarded globally (sometimes with carbon offset credits) and is seen as more sustainable in the long run. However, the tradeoffs cited in government decisions to prioritize hydropower often leave out several factors; climate change and rural agricultural communities' needs. First, hydropower is considered clean energy, which does not take into account the fact that freshwater supplies for hydropower may not, in fact, be completely "renewable." This is because many rivers are drying up due to increasing population withdrawals, and desertification produced by climate change, while freshwater sources for rivers, like glaciers, are quickly melting, and instead of continuing to cycle in terrestrial rivers, their water runs off into the ocean and increases sea levels (Conrad, 2013). Second, in the middle of the dilemma, are rural communities, which often are an example of sustainable, low-impact lifestyles, and whose routines are often directly impacted by "clean" hydro projects. These communities, which are predominantly dependent upon water-use based activities, not only have to struggle with the induced to the vagaries of environmental changes, but also they have to adjust their livelihood to property rights allocations that potentially ban them from using water. To provide a better baseline assessment with which to base any water concessions decision on, an evaluation of local and community-level vulnerability is critical. This paper analyses the socio-economic conditions of a rural agricultural community in Ecuador, whose water use may be in danger because of the property rights allocations made to a private hydropower plant in the Dulcepamba watershed. The analysis is based on the formulation and construction of indicators of vulnerability, understanding three different spheres of the problem; exposure, sensitivity, and adaptive capacity. The methodology includes the use of Principal Component Analysis (PCA), which gives the first impression of the composition of the data, in order to then conduct a factor analysis, which allows for the making of statistical inferences about the information collected, and for conclusions as to how different variables affect the vulnerability of the population. Moreover, the relevance of water concessions as a way to allocate property rights, and the existence of irrigation as a proxy of the importance of water to the population is tested in the context of the indicators generated. This work attempts to bridge the gap between the recognized study of common goods and property rights, and their effects on people's socio-economic structures, and the study of the characterization of the vulnerability.

The next section of the paper deals with a brief conceptualization of water as a common good, and the alternatives proposed by the literature to address the inefficiencies caused by these conditions. Next, the relevance of water in energy generation and agriculture is described, using the case of Ecuador to build the context of the problem. The literature review finishes with the definition of vulnerability as it will be treated and measured in this dissertation. The second section provides the background information of the case study. Research design and methodology is discoursed in the third section, which provides details about the data collection, and the techniques implemented with the information. With the help of PCA, the information from 320 respondents and more than a hundred variables are summarized in three principal components that reflect the main characteristics of the information. Furthermore, factor analysis allows statistical inferences to be made about the relationship of the variables chosen to compose the vulnerability indicators. The analysis of the data and main remarks are laid out driving the discussion and conclussions at the end of the paper.

Literature Review

Energy could be considered both a cause and a consequence of development. The constant need for energy has forced the entire world to develop cheap and accessible sources of energy. Since the discovery of fossil fuels, its extraction has represented a feasible source of energy. Considering this, around the globe both developed and developing countries have sought for alternative and more sustainable sources of energy. In particular, South America is characterized by a high potential for the development of dams and hydroelectric plants. However, South American countries are at the same time highly dependent on the exploitation of natural resources. In this context, and considering that water is a primary input in almost any form of production, and in particular in food (agriculture and farming) and energy production, several conflicts arise among the different agents subject of property rights of, and use of, water resources. Aggravated by having the intrinsic quality of being a common good, water represents a challenge in the design of policy interventions, private entrepreneurship, and community organization.

Water constitutes a resource that crosses several boundaries when definitions arise. For instance, even though some authors defend water as a renewable resource because of its physical properties that in theory make water restorable, others defend that the renewability of water is a matter of access to the resource. “Water is certainly the most abundant and ubiquitous resource on the planet. However, given its physical properties, atmospheric roles, ecological functions, and spatial distributions as well as our current technical and economic capabilities, annual accessible water is minimal” (Lopez & Toman, 2006). Precisely, the spatial distribution of water has made it a resource with nonrivalrous and nonexcludable consumption, having a kind of common good characteristic. This nature of water has made government intervention in its management difficult, as jurisdiction over a common good like water is hard to define.

The central premise underlying this assumption of ineffectiveness and overuse maybe is the assumption that human behavior is driven by self-interest, the same self-interest characterized by Adam Smith when advancing the theory of the invisible hand. As a result, a common good will suffer because "the degree of resource exploitation undertaken by each individual is assumed to be that at which marginal private material gains are brought into equality with the marginal costs of extractive effort" (Sethi & Somanathan, 1996, p. 766).

Water as Common or Public Good

Traditionally, theorists and politicians treated public goods as an externality or a market failure. As a result, logical solutions as central state intervention, market "corrections", and privatization are popular alternatives. However, in last decades scholars and policymakers are more likely to see communal arrangements as favorable compared to state or private ownership; in particular, when equity and sustainability are the main concerns Agrawal (2001). Scholars of commons usually focus directly on rights of access, use, management, exclusion, and transferability of the resources. As could be pointed out, these are the main issues related to property rights; however, delimiting the differences between ownership and other kinds of rights opens possibilities for different schemes of property.

Even though water is sometimes legally defined as a public and common good in numerous countries that have enshrined the right of citizens to water access, policy interventions are still necessary to regulate the use of water. As a result, a kind of property rights issue is a central concern of both governments and users. Schlager & Ostrom (1992, p.249) define property rights scheme from "authorized user, to claimant, to proprietor, and to owner." In the case of water, maybe the critical property rights are related to access and withdrawal rights. Schlager & Ostrom (1992) distinguishes among five basic kinds of property rights. Table 1 shows these definitions adapted to the particular case of water and the actors involved.

Table 1. Types of property rights

Access	The right to enter a defined physical property
Withdrawal	The right of obtain the products of the resource
Management	Right to regulate use patterns and transform the resource
Exclusion	Right to determine who has access and transfers of access
Alienation	Right to sell or lease

Source of information: Schlager & Ostrom (1992)

All these rights could be claimed by one or more actors among the government, the private sector, the community, and individuals in general. Furthermore, these rights have the characteristic that can transpose the borders of the others, and the existence of one of them does not mean the presence of another one. The origins of these rights are various, can be enforced by the government, granting legal and *de jure* rights. On the other hand, property rights may be originated among resource users, by tradition, or by social convention. There are cases where resource users cooperate to define, enforce, regulate, and punish according to self-granted rights. Schlager & Ostrom (1992) call these rights as *de facto* because government authorities do not legally recognize them, so the rights "holders" confront a sort of informality and instability. Formally unchallenged de facto rights are as much relevant as de jure rights.

> "Users of a resource who have developed de facto rights act as if they have de jure rights by enforcing these rights among themselves. In some settings de facto rights may eventually be given recognition in courts of law if challenged, but until so recognized they are less secure than de jure rights" (Schlager & Ostrom, 1992, p. 254)

Commonly, problems surrounding common goods and property rights result from either the privatization of the commons, or from their appropriation and regulation by the state (Sethi & Somanathan, 1996). In the particular case of water, even though it is hard to portray successful models, some authors have demonstrated that some characteristics favor a better use of the resource. Osés-Eraso & Viladrich-Grau (2007) highlight that when population, communities, and families in settings where common goods are crucial have remained stable over long periods of time, there is a better management of the resource. Also, when there is little variation in ownership arrangements when the skills, knowledge, and practices have kept stable when there is an expectation of leaving an inheritance for future generations, and when the community achieved a development of institutions beneficial for the community, the management of water may be more efficient. The conflict with water, in particular, is that the productive uses of the resource involve the interests of many different rights-holders. As input in energy production, a pillar in hydropower generation, and an elemental resource in agriculture and food production, water access is critical and generates disputes between the agents

Importance and Use of Water

Water and Energy

Undoubtedly, energy and water are closely related. In fact, any energy production uses water at some point of the generation process. For example, fossil fuels use it in the extraction of raw materials, refrigeration of thermoelectric plants, and cleaning activities; it is also employed in the farming of products to generate biofuels, and obviously in the hydropower generation (Naciones Unidas, 2014b). In fact, according to United Nations Water, global energy consumption increased almost to fold since the industrial revolution. According to their estimations, the demand will still grow by more than 30% over the next 20 years. Thus electricity demand is expected to increase by 70% by 2013 (UN-Water, n.d.)

Accounting the withdrawals of water for energy production, this use represents 15% of the total water consumption. The United Nations (UN) estimates that 90% of global power generation is water intensive, mainly hydropower and thermal production schemes. Moreover, since the global dependency on fossil fuels have generated social and environmental conflicts worldwide, several initiatives to develop renewable-energy projects have been implemented. Considering that renewable and clean energy could potentially mitigate climate change and avoid irreversible changes in the environment, reductions in the total demand and the diversification of the energy production matrix based on renewable energy are highly recommended (Lior, 2010). Furthermore, hydropower has been suggested to be a renewable source of energy, but not necessarily clean or harmless for the environment.

Hydroelectricity

Hydropower generation has been seen as a renewable source of energy because most of the water used during the generation, in theory, returns to the environment except for the water that evaporates. However, despite its "renewability", some authors claim that it is not entirely clean because the nature of dams can harm the environment and surrounding populations.

According to the UN, hydroelectricity is the largest renewable source of power generation. Some parts of the globe depend even more than others on this kind of energy. For instance, in Latin America and the Caribbean, hydropower represents near the 65% of all electricity generated, while the global average is 16%.

However, although hydroelectricity can be seen as an alternative to traditional energy sources and its environmental effects somewhat less damaging than those caused by fossil fuels, hydroelectricity can significantly affect the local people, especially those located near the plants. As pointed out by De Rus (2010) in cases such as the construction of power stations to provide energy for a certain region, large groups benefit, but there are negative external effects, for example, air and water contamination, which are primarily borne by the population living close to the plant. In the case of the construction of hydropower plants, they can bring about the rupture of the ordinary conditions of communities living in rural areas who depend on activities that also use water such as agriculture and fishing.

Water and Agriculture

Agriculture is an essential human activity because it provides food security, and in some economies is the primary source of national income. Agriculture is the largest water user worldwide. In fact, irrigation accounts for 70% of the total water withdrawals of the world. Although this proportion varies considerably across countries, a great part of the least developed countries dedicates 90% of their water withdrawals to agriculture. Despite improvements intechnology, the UN estimates that agricultural water consumption will increase by 20% in the next 30 years (UN-Water, n.d.). Probably one of the main potential improvements for farmers in this day and age is the implemention of irrigation systems, which allow for the production of better crops, in improved conditions and for longer periods of time that depends less on the climate cycles.

Irrigation

Irrigation is a controlled supply of water designed to enhance the quality and quantity of crops. There is a vast body of literature about irrigations' importance, especially in the field of Plant Sciences, but most of the literature assesses the management of large canal systems, other irrigation structures, and different ways to apply irrigation. However, its importance on a community level, its management both needs and motivates, and institutional arrangements around irrigation have only become part of the literature in recent years (Bardhan, 2000).

According to Schlager & Ostrom (1992), property rights schemes can influence the existence of irrigation since frequently the installation of these systems is costly. In fact, they pointed out that "alienation rights, combined with rights of exclusion, produce incentives for owners to undertake long-term investments in a resource." Consequently, the welfare of a household depends on its access to energy, their access to food and means of production, and their access to water; and these access rights frequently come from property rights. Intuitively, it can be surmised that a kind of *vulnerability* underlies the access to water and its services.

Vulnerability

Although there are many definitions of vulnerability, in general, it is considered to be the susceptibility of a system to harm from exposure to adverse effects. The critical parameter is the stress to which a system is exposed, its sensitivity, and its adaptive capacity (McCarthy & Intergovernmental Panel on Climate Change, 2001), (Adger, 2006), (Kolenikov & Angeles, 2009). Regarding population, Cutter et al. (2009) define vulnerability as the susceptibility to losing the capacity to prepare for, respond, and recover from disasters.

Vulnerability is frequently associated with environmental problems derived from, for example, contamination or climate change. However, in its simplest sense, vulnerability is about the exposure to adverse effects which can be generated by economic agents. There is a plethora of information that addresses the vulnerability of communities, primarily agrarian communities, to resource access distortions and changes. However, there is less in the literature about when access to resources for communities is denied by the legal system, which grants property rights for some agents and prohibits them for other ones. This paper aims to estimate the vulnerability of an agrarian community surrounding the access to water for growing their crops when water access is being restricted by the legal system, which is in turn imposed by the central government, whose primary interest is to promote a private hydropower generation initiative in this same agrarian region.

To establish a vulnerability indicator, many factors about a population must be taken into account. According to Kolenikov & Angeles (2009, pg.129), "usually between 10 and 20 characteristics can be observed, and then the analyst must have a method for aggregating such proxies." However, the interpretation and analysis of the data must come from a summation of these proxies; frequently, the weights come from economic or statistical considerations. The most common statistical methods used are Principal Component Analysis (PCA) and Factor Analysis, which will be explained in the methodology section.

Socioecological Vulnerability

Abson et al. (2012) based on the work of several theorists proposes a concept of socioecological vulnerability as a function of *exposure, sensitivity,* and *adaptive capacity.* At the same time, *exposure* is defined as the degree of experience by internal or external perturbations. *Sensitivity* is the extent to which the system is affected by those perturbations. *Adaptive capacity* is the adjustment of the system behavior to overcome the perturbation. To assess this ecological disruption, and include a holistic insight, it is necessary to understand how multiple indicators vary in relation to each other (Abson, Dougill, & Stringer, 2012, p. 2). With this context, is suggested to have a combination of different variables into aggregate indicators, providing useful, unitless, interpretable indicators in policy information (Abson et al., 2012).

Background information

Ecuador is a small country but blessed with a wealth of natural resources. In fact, some analysts; such as Cori, Monni, & others (2014), Rodríguez, (2015) and Acosta (2009), catalog the Ecuadorian case under the scope of the resource curse hypothesis. Indeed, Ecuador´s economy has historically been based on the exploitation of natural resources, both renewable and non-renewable. As the environmental economist Alberto Acosta (2006) explains in detail, this condition has brought about a profound dependency on natural resources as a foundation for development and a primary source of national income. Oil exports together with agricultural production are two of the main sources of income for the country (Acosta, 2006). More than four decades after the start of the oil boom, Ecuador's economy still relies on agriculture and oil, a characteristic that conditioned many other aspects of the Country's development.

Energy and agriculture in Ecuador

In the past ten years, the makeup of Ecuador's Gross Domestic Product (GDP) clearly shows the relevance of these two activities. Agriculture, hunting and forestry made up an average of 8% of the GDP, while; petroleum and mining related activities made up an average of 12% of Ecuador's GDP.

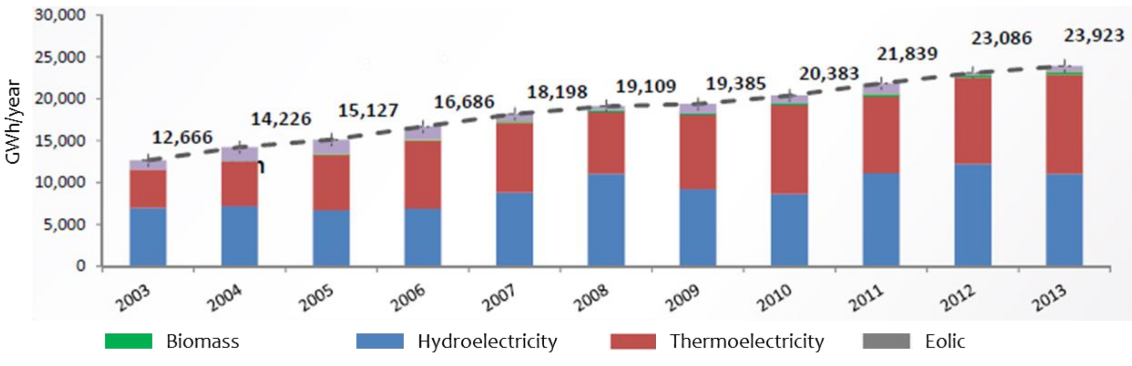
Table 2. Participation of Agriculture and Petroleum exploitation as a percentage of the total GDP. Ecuador period 2005-2015

Year	Agriculture, hunting and forestry		Petroleum and mining related activities		PIB
	Thousands of dollars	% of the GDP	Thousands of dollars	% of the GDP	Thousands of dollars
2011	6 702 431	8%	11 130 891	14%	79 276 664
2012	6 564 353	7%	12 031 501	14%	87 924 544
2013	7 107 444	7%	12 496 079	13%	94 776 170
2014	7 391 854	7%	11 764 815	12%	100 917 372
2015	7 630 865	8%	7 400 686	7%	100 871 770

Source: Central Bank of Ecuador. Monthly statistical report.

Beyond the scope of analysis of the resource curse hypothesis, Ecuador's characteristics may indicate a *petro-state,* because the income from oil exploitation has such importance in the country. As Karl (1997) proposed, petro-states depend on oil revenues, which generates a distinct institutional situation[1] characterized by centralization of political power, poor development practices, and the funding of the state's expenditures with oil income instead of domestic taxation. Ecuador's petroleum-based production structure has favored a particular kind of development, which is reflected in its public policies. Examples of this are the States' significant investments in infrastructure and the country's high dependence on oil derivatives in many aspects of daily life (from massive energy production obtained by burning diesel, to the structure of cooking systems based on liquid petroleum gas). Ecuador's energy matrix is strongly biased towards the use of fossil-fuel technology. Furthermore, data from the Coordinating Ministry of Strategic Sectors of Ecuador (Costa, 2014) indicates that, in 2013, 84% of the energy demand in Ecuador was satisfied by fossil sources, 31% of the energy consumed was in the form of diesel 23% was in the form of gasolines, and 13% in the form of electricity.

Graph 1. Ecuador's electricity generation structure. 2003 – 2013.



Source of information: Costa, (2014)

[1] Considering that many authors such as Keenan (2013) proposes that there is no such resource curse but an institutional curse.

Hydroelectricity in Ecuador

As for hydroelectricity, Ecuador's location and geographic conditions allow the country to have plentiful fresh water availability -20 700 cubic meters per inhabitant per year- more than ten times the global average (SENPLADES, 2013). As a result, the current government has made massive investments in the development of hydropower projects whose main justification is their cleanness and renewability.

The constitution and the National Plan for Good Living (PNBV) support these hydropower initiatives. In fact, Ecuador jumped into the global environmental sphere by making decisions that suggested an environmental purpose driving their development path. First, Ecuador was the first country in the world to recognize the environment as a subject of rights (BBC Mundo, 2008). As a result, the Ecuadorian Constitution in its seventh chapter, based on the Andean indigenous ideology of Good Living or *Sumak Kawsay*, guarantees the Rights of Nature. As the Magna Carta, Ecuadorian Constitution is the principal guideline for the design of policies and interventions, and should be the inalienable rule of law for projects that drive the path of development. The Constitution also enshrines guidelines for energy production, that account of the Rights of Nature, the Human Right to Water, and other Constitutional guarantees. Specifically, Article 313 grant the right of administration, regulation, control, and management of strategic sectors to the state, considering energy in all of its forms (production, distribution, generation) as one of them. Furthermore, Article 413 says that "the State will promote energy efficiency, the development and use of practices and technologies that are environmentally clean and healthy, as well as a diversity of low-impact renewable energies."

Throughout Rafael Correa's Presidency, big hydropower projects have been built, and the government's plans for future development suggest the same trend. In fact, according to the Consejo Nacional de Electricidad (CONELEC) (2009) (now called the Agencia Regulacion y Control de Electricidad ARCONEL), at the end of Correa's term in 2017, it is expected to achieve an additional 2 765MW of generation by hydropower projects, reaching a total of 93% of the total electricity generation by this "clean" technology. The magnitude of the push for hydroelectric development is shown by the number of projects built recently. While in 2005 there were only 19, by 2012 they were 200 (Comisión de Paz y Verificación para el caso San Pablo de Amalí, 2013, p. 5). Not all these projects are purely public, most of them have a mixed schema with participation from the private sector. The idea is to complement the "emblematic" or big projects with small initiatives that are supposed to have the involvement of local governments, communities, and the private sector. This should supposedly incentivize productive local uses, employment, benefits from natural resource use, and the diversification of energy generation. Additionally, the goal was to minimize losses in the connection, transmission, and distribution of energy (SENPLADES, 2013, p. 75).

Within the aforementioned political and legal context, the San Jose del Tambo hydroelectric plant was proposed as a solution to the local necessities in a poor *campesino* farming region in Central Ecuador, and the project was integrated into the Ecuadorian national development plan. However, the project did not consider external effects on the local community who claimed environmental injustice and even illegal and unconstitutional behaviors.

Hidrotambo project

The hydropower plant is located at the base of the Dulcepamba River Basin in Bolivar Province. This project appeared in 2005 when CONELEC subscribed a contract with Hidrotambo S.A. for the production of auto generation and sale of surplus electricity in exchange for a payment of USD 3 681. The plant was designed to have an installed capacity of 8 Megawatts of electricity production. The project was proposed by the company Hidrotambo S.A., which was, at that time, constituted by four private companies, two of them national. In Ecuador, private initiatives like this need to be granted a water concession to operate. Hidrotambo uses the water that drains from the Dulcepamba River watershed. This watershed's drainage is the water source for 72 small farming communities upstream of the dam, and dozens of other small farming communities downstream of the dam. The watershed has an extension of 39 500 hectares, from which a plethora of crops are produced by *campesino* farmers for subsistence, and sale to markets all over Ecuador (Comisión de Paz y Verificación para el caso San Pablo de Amalí, 2013, p. 8).

The problems related to the project have been well documented and have some media cover; however, the documentation has mainly focused on the social conflict between the community, the private hydroelectric company, and the authorities, highlighting the physical and environmental damages generated with the construction of the dam (Saavedra, 2015), (Marquez, 2016), (INREDH, n.d.), (Conrad, 2013), (Comisión de Paz y Verificación para el caso San Pablo de Amalí, 2013), (CEDHU, 2016), (Acción Ecológica, 2015), (EJOLT, n.d.). Moreover, the social and environmental claims of the population deserve a deeper approach that exceeds the scope of the present dissertation. This paper focus only on the vulnerability induced on the population because of the legal concessions and property rights over the water flow of the river and its tributaries given to Hidrotambo rather than to the small agriculture producers.

Methodology

The hypothesis tested in this dissertation suggests that water concessions translated in the access to this resource affect the vulnerability of the population whose principal activities depend on it. To test this hypothesis, measurements of vulnerability are computed through PCA. Then, statistical tests are calculated to determine if there is a significant difference among groups using the current existence of irrigation and water concessions as filters to make these comparisons. The same analysis is later conducted applying factor analysis in order to make statistical inference.

Data collection

Two sources of information were used to determine the components of vulnerability and the effects of irrigation and water concessions on them. First, a survey that collects data on socio-economic characteristics and production structure (inputs, outputs, costs and income of agricultural and breeding practices) among 320 households. This is a representative sample of 10% of the 72 communities upstream of the hydroelectric project, geographically estimated, and weighted based on population density. The questionnaire was conducted between August of 2014 and June of 2015.The sampling method was based on information from the National Institute of Statistics and Censuses (INEC) which provided information desegregated to "census sector[2]" unit level. As a result, a data base with 129 variables was used to estimate a portion of the indicators employed in the PCA.

Second, the 2010 Housing and Population Census, mainly to include in the analysis characteristics of the geographic area under study. Specifically, variables such as economic dependency, access to basic education, access to housing, access to basic services, and overcrowding, which are summarized in the Unsatisfied Basic Needs Poverty (NBI)[3] indicator.

[2] A census sector consists of an extension of territory with identifiable defined boundaries. A census sector usually contains two blocks, and depending on the territorial characteristics and the number of households. Frequently in rural areas, where the dispersion is greater, there are less households per census sector (INEC, n.d.).

[3] NBI indicator is a multidimensional poverty measurement developed by CEPAL. To more detail about the dimensions and the considerations to define if a household is poor or not see (SIISE, n.d.)

This measurement defines a household as "poor" if it is deprived in one or more of the mentioned variables.

It must be said that although the information collected in the watershed is unprecedented, it has some lack of precision, due to several factors. For example, there are missing values, an occasional inability of respondents to provide accurate answers, confusion among traditional or local measurement scales and formal ones, and significant deviation in some variables, among others. For this reason, this exploratory research was determined by a previous analysis of the entire database to depurate, analyze, correct, and identify the variables susceptible to be part of the PCA, which is a typical process in this kind of work (Abson, Dougill, & Stringer, 2012).

Methods

Principal Components Analysis (PCA)

PCA is a multivariate data exploration whose main objective consists in transforming a number of correlated variables into a set of uncorrelated variables that captures most of the variability of the data (Abson et al., 2012; Bartholomew, Steele, Moustaki, & Galbraith, 2008; Devkota, 2014; Peña, 2002; Smola & Vapnik, 1997). There are several applications of PCA, but in general terms, it is used to highlight patterns within multivariate data, as it "provides information about the most meaningful parameters, which are those that describe the whole data set and allow for data reduction with minimal loss of the original information." (Kang, Xuxiang, & Jing, 2015, p. 4296).

The first principal component explains the maximum amount of the original total variance; the second principal component explains the maximum of the total variance not explained by the first component and so on. The full set of principal components will explain the total variance of the original variables. However, if some of the first components account for a large enough part of this variance, the rest can be not considered without losing too much information (Abson et al., 2012; Bartholomew et al., 2008). When choosing the number of components, there are several conditions to follow[4]. Nevertheless, generally the decision is based on the interpretability of the components, the proportion of variation explained, and

[4] Common literature suggests some basic criteria to choose the number of components. 1. Retain the components which explain 70-80% of the total variation. 2. Retain only the components which correlation is greater than 1. 3. Examining the scree plot, which is graphs the eigenvalues versus the component number, retain the components before the "elbow", which is the point where the eigenvalues decrease more slowly. 4. Consider interpretability of the component.

the shape of the scree plot and loading plots (Abson et al., 2012; Devkota, 2014; Kang et al., 2015). Sometimes critics of the method focus their attention on the potential subjectivity of the results. Nonetheless, as explained before, PCA allows the interpretation of a set of variables highlighting the primary information translated in the principal components.

There have been countless case studies conducted using PCA as a methodology to measure different kinds of indicators based on the correlation of a set of variables. In the case of vulnerability due to natural or induced perturbations, there are several examples which focus on different kinds of indicators[5]. However, one of the most prominent works related to socio-economic vulnerability is research conducted by Devkota (2014) about biogas users in Nepal.

In the particular case of the measurement of the vulnerability of the communities affected by the construction of Hidrotambo project, out of 129 variables regarding different social and economic conditions of the respondents were tested. Of them, ten variables were selected because of their relationship with the family's production structure, and the socio-economic characteristics of the household. The PCA allowed the generation of a model with three components, whose results are analyzed in the next section.

Factor Analysis

Factor analysis and PCA are strongly related. In fact, PCA is usually called as a specific type of factor analysis. The difference lies in the potential use of the resulting indicators. PCA is a descriptive method that summarizes the data to express the information in a smaller number of components than the original set of variables. In contrast, factor analysis links the observable variables to unobservables by a probability model, which allows "…inferences about the population using the notions of goodness-of-fit, statistical significance, and precision of estimation." (Bartholomew et al., 2008, p. 177).

Frequently when talking about factor analysis, most authors refer first to latent variables, which differ from other variables because they cannot be directly observed (Abson et al., 2012; Bartholomew et al., 2008; Devkota, 2014; Peña, 2002; Smola & Vapnik, 1997). Latent variables are derived from the information of observable variables. Sometimes a concept (such as vulnerability) can be represented by a single latent variable, but often they

[5] For more information, and to explore the application of PCA in vulnerability in different parts of the world and different spheres such as socio-economic effects, environment interaction, and ecological issues, see (Razzak, Ali, & Ali, 2015), (Piya, Maharjan, Joshi, & others, 2012), (Krishnan, 2010), (Krefis et al., 2010), (Kolenikov & Angeles, 2009), (Kang, Xuxiang, & Jing, 2015), (Devkota, 2014), (Cutter, Emrich, Webb, & Morath, 2009), (Caro & Cortés, 2012), (Abson, Dougill, & Stringer, 2012)

are multidimensional; therefore, involving more than one latent variable or factor (such as *exposure*, *sensitivity*, and *adaptive capacity*). Latent variables allow one to foresee the original variables by discovering the mechanism and relationships within the data set, and thus it is possible to make predictions regarding the factors not observed but generated by the system (Peña, 2002, p. 16). Latent variable models can be used in an explanatory way to identify latent variables, or in a confirmatory way to "test whether a set of items designed to measure particular concepts does indeed reveal the assumed structure." (Bartholomew et al., 2008, p. 177). In the present research, the idea is to select from the observable variables those which are likely to be indicators of the latent variable of vulnerability.

Data analysis

As mentioned before, the dataset includes information on a representative sample of the population affected by the project (320 respondents) in 129 variables. The richness of this information would be subject to an extended statistical descriptive analysis. However, the scope of the present dissertation only assesses those variable part of the model and others that could contribute to delineate the context information for the interpretation of the results.

First, reviewing the continuous variables, the first variable (povertyNBI) was the estimation of the percentage of people of the census sector who lives under poverty conditions with the NBI method criteria. This variable collects implicitly information about the quality of the house, the education levels of family members, overcrowding, and basic services. Next, the number of members of the household (familymembers) is used as a weight of the characteristics of the household. Considering that several variables depend on the stability in the property user and the expectations about the future, it is used the maximum number of years of the respondents in any of the land properties they use wheher they are the owners or not (landyears). Next, considering that is usual that a household uses more than one farm or property, it is considered the total area used by them for any activity (landarea). Considering that the main objective is to estimate the effect on agrarian activities, the area destined to agriculture is considered (croparea). Since it is usual in the watershed a leasing scheme on land properties, the cost of this rental is considered if there is any[6]. Other expenses such as fertilizers, machinery, labor, among other considerations are measured as part of the investment in the production process of crops (cropcosts). Next, using the

[6] It must be said that sometimes the leasing is paid with products, in this case the equivalent in money is used based in the same assumptions made for estimate the crop's income.

production structure, the amount and species of crops collected, the market where they were exchanged, and the average price of them, the income of the household by agriculture was estimated (cropsincome). Finally, considering that animal husbandry is another common activity in the region and requires water management, the number of animals raising was also considered (animals). Table 3 shows the most basic descriptive statistics of these variables, including missing values, number of observations, the mean, the standard deviation, minimum and maximum values, and zero values.

Table 3. Summary of descriptive statistics of quantitative variables used.

Variable	Number of observations	Missing values	Mean	Standard Deviation	Min	Max	Value zero
Poverty NBI (percentage)	320	-	0,93	0,15	0,5	1,0	-
Members of the household (people)	299	21	4,36	2,31	1	15	-
Number of years using the land (years)	297	23	25,81	18,55	1	91	-
Total land area (m2)	305	15	102394,70	215624,80	30	2400000	-
Crops area (m2)	320	-	60175,25	167718,70	-	2520000	21
Cost of land leasing (dollars)	298	22	42,38	227,85	-	2277	281
Investment in crops (dollars)	320	-	581,09	1777,91	-	24050	56
Income by crops (dollars)	320	-	3593,61	12651,42	-	178464	89
Number of animals (units)	320	-	9,09	15,73	-	200	55

Source of information: Survey conducted to Hidrotambo affected community.

The correlation among the variables of the model is shown in figure 1. The specification of the model is better when the correlation among the variables is higher. Several conditions while conducting the survey may have affected the answers of the respondents, which at the same time could have affected the correlation matrix. However, having said that higher correlation would have been better, the current matrix is good enough to conduct a PCA and a factor analysis.

Figure 1. Correlation matrix among variables for PCA

```
. correlate PovertyNBI Familymembers landyears landarea croparea landleasing ///
> cropcosts cropsincome animals landproperty
(obs=295)

             | Povert~I Family~s landye~s landarea croparea landle~g cropco~s cropsi~e  animals landpr~y
-------------+------------------------------------------------------------------------------------------
  PovertyNBI |   1.0000
Familymemb~s |   0.0198   1.0000
   landyears |  -0.0309  -0.1494   1.0000
    landarea |   0.1140   0.0061   0.0584   1.0000
    croparea |   0.1002  -0.0807   0.0024   0.4460   1.0000
 landleasing |   0.0836   0.0945  -0.0772  -0.0069  -0.0041   1.0000
   cropcosts |   0.0601  -0.0682  -0.0615   0.2373   0.6920  -0.0154   1.0000
 cropsincome |   0.0490   0.1050   0.1115   0.1575   0.1517  -0.0385   0.1436   1.0000
     animals |   0.0948  -0.0113   0.0546   0.4619   0.7951   0.0011   0.5899   0.2227   1.0000
landproperty |  -0.0909  -0.1145   0.2219  -0.0539   0.0527  -0.2945   0.0839   0.0928   0.1031   1.0000
```

Source of information: Survey conducted to Hidrotambo affected community.

Also, there are three categorical variables necessary for the analysis. First, one of the variables included in the PCA and factor analysis is the ownership of the household of any of the properties they use (landproperty) as sign of stability. Next, two main variables play the essential role of being filters in the model. Indeed, once the PCA and factor analysis have the variables which will estimate the values for the components and factors, the hypothesis will be tested by contrasting the results for the respondents who have irrigation systems (irrigation), and those who do not in order to know if there is a statistical difference originated by this variable. The same concept will be implemented using the variable (concession). Thus it will be tested the vulnerability indicators in groups with and without water use permits.

Table 4.Tabulation of qualitative variables used.

	Number of observations	Missing values	NO	YES	% NO	% YES
Irrigation	320	0	249	71	78%	22%
Consession	296	24	135	161	46%	54%
Land ownership	320	0	66	254	21%	79%

Source of information: Survey conducted to Hidrotambo affected community.

Principal Component Analysis

After several attempts and model designs, where different combinations of variables were tested, the final model was selected because of its statistical consistency and logical interpretation. Figure 2 shows the results of the model which includes the variables PovertyNBI, Familymembers, landyears, landarea, cropsarea, landleasing, cropcosts, cropsincome, animals, and landproperty.

Figure 2. PCA for Hidrotambo case

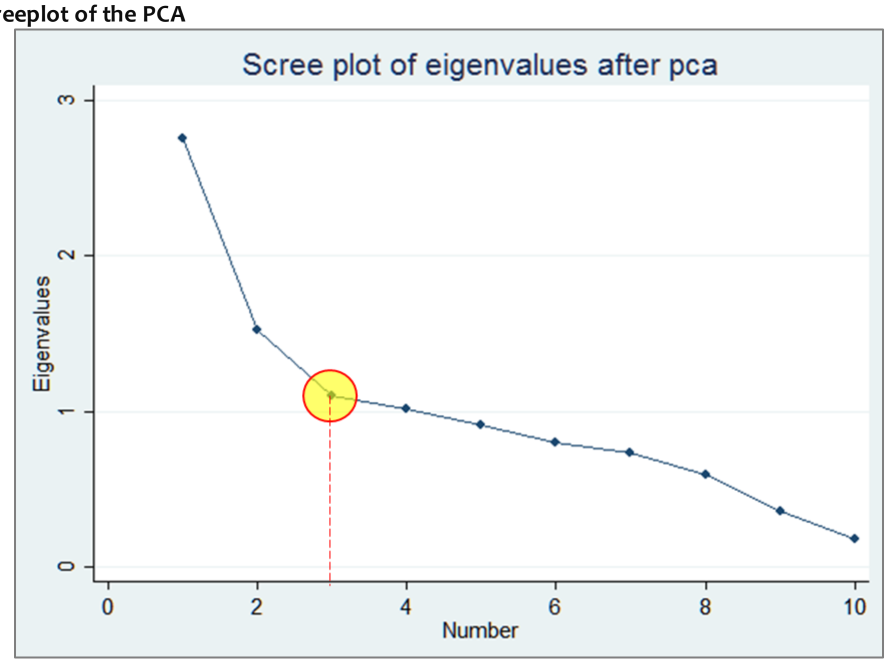
```
. pca  PovertyNBI Familymembers landyears landarea croparea landleasing ///
> cropcosts cropsincome animals landproperty

Principal components/correlation                  Number of obs    =       295
                                                  Number of comp.  =        10
                                                  Trace            =        10
    Rotation: (unrotated = principal)             Rho              =    1.0000
```

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.75691	1.23103	0.2757	0.2757
Comp2	1.52588	.426709	0.1526	0.4283
Comp3	1.09917	.0767693	0.1099	0.5382
Comp4	1.0224	.11099	0.1022	0.6404
Comp5	.911413	.104736	0.0911	0.7316
Comp6	.806677	.0660933	0.0807	0.8122
Comp7	.740584	.143139	0.0741	0.8863
Comp8	.597445	.238416	0.0597	0.9460
Comp9	.359029	.178547	0.0359	0.9820
Comp10	.180482	.	0.0180	1.0000

Source of information: Survey conducted to Hidrotambo affected community.

As expressed before, the literature of PCA recommends certain parameters when choosing the number of components. In this case, components 1,2,3, and 4 have an eigenvalue greater than one, and their cumulative variance is 64%, very close to the recommended 70%. However, it is necessary to see the screeplot before making the decision. Graph 2 shows this information where the elbow in the figure suggest that the number of components to be analyzed can be three since from these point the degree or weight of any other component is marginally smaller.

Graph 2. Screeplot of the PCA

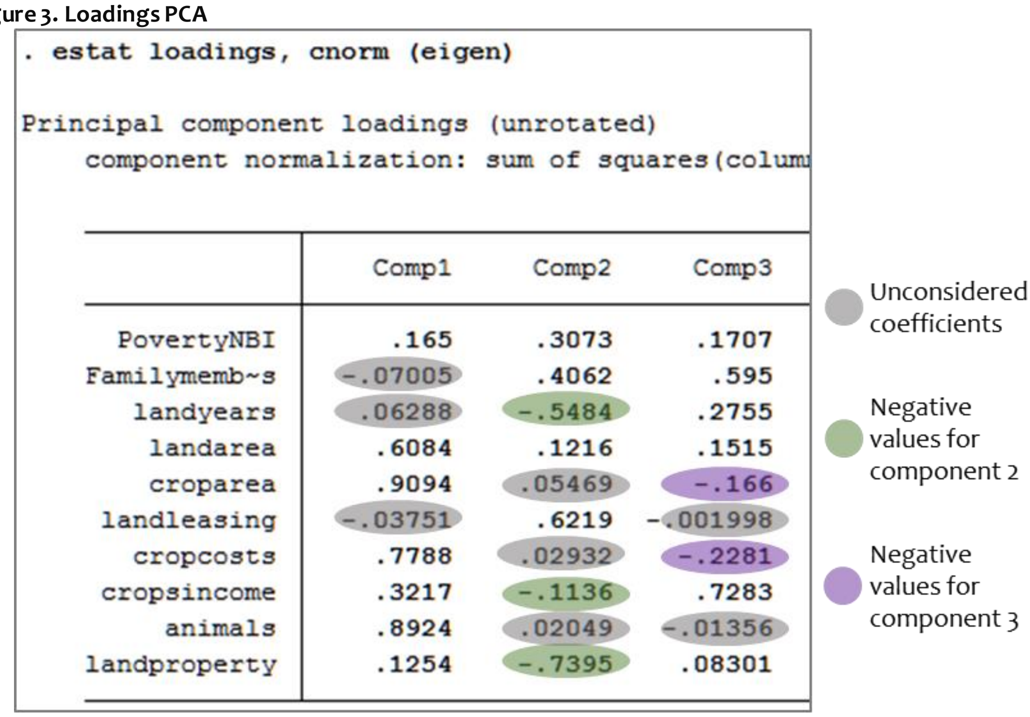


Source of information: Survey conducted to Hidrotambo affected community.

With this information, the loadings of the PCA are generated allowing the interpretation of the results based on the signs and values. Figure 3 shows this information. For interpretability and organization, the components are treated as measurements of *Exposure* (Comp1), *Sensitivity* (Comp2), and *Adaptive Capacity* (Comp3). It must be said that this categorization does not represent exact categories, the three components represent people's vulnerability to a perturbation on their socio-economic conditions.

When analyzing the components, authors suggests that usually the first component should be interpreted as some overall measure of what all variables have in common (Bartholomew et al., 2008). Usually, the first component has large positive values. In the particular case of this model, there are two negative values; however, their magnitude is small and as some authors suggest, the interpretation becomes easier assuming that the small coefficients are zero. "These approximations are reasonable if they do not modify remarkably the structure of the component and improve its interpretation" (Peña, 2002, p. 156).

Figure 3. Loadings PCA



```
. estat loadings, cnorm (eigen)

Principal component loadings (unrotated)
    component normalization: sum of squares(colum
```

	Comp1	Comp2	Comp3
PovertyNBI	.165	.3073	.1707
Familymemb~s	-.07005	.4062	.595
landyears	.06288	-.5484	.2755
landarea	.6084	.1216	.1515
croparea	.9094	.05469	-.166
landleasing	-.03751	.6219	-.001998
cropcosts	.7788	.02932	-.2281
cropsincome	.3217	-.1136	.7283
animals	.8924	.02049	-.01356
landproperty	.1254	-.7395	.08301

Source of information: Survey conducted to Hidrotambo affected community.

As a result, the **Comp1** will exclude the variables Familymembers, landyears, and land leasing. The final component is the overall measurement of *exposure,* which explains the degree of perturbations experience by the households. "The relative size of the weight given to an original variable on a component reflect relative contributions made by each variable to the component." (Bartholomew et al., 2008, p. 124). In this component the greater weight corresponds to the variables directly related to the economic activities. Indeed, the total area destined to crop raising (0.91), the number of animals (0.89), and the investment made in crop raising (0.78) are the coefficients with higher participation.

The rest of components usually are interpreted as shape factors since they usually contrast positive and negative coefficients, which compares groups of variables. The interpretation need to be made based on what the variables in each subset have in common, and what makes the different from the other set of variables. Disregarding the variables croparea, cropcosts, animals, whose magnitude are small, **Comp2** is an indicator of *sensitivity*; namely, the degree to which the system is affected by external perturbations. It contrasts the variables that explain the stability of a household regarding socio-economic conditions. Indeed, the negative values correspond to variables that provide stability to the family, such as, the number of years using a land property (-0.55), the income of crop raising (-0.11), and the ownership of land (-0.74). The positive values correspond to the variables that can increase the sensitivity of a household to a perturbation. The poverty status (0.31), the number of family members (0.41), and the amount of money paid for any land property rented.

Finally, **Comp3** contrast the variables that would allow the household to overcome or adjust the sources of income to overcome a perturbation, so is an indicator of the *adaptive capacity*. Discounting the variables landleasing and animals because of their magnitude, the variables with negative value such as croparea (-0.17) and cropcosts (-0.22) are those that represent the irrecuperable loss of the household in case of a perturbation. On the other hand, the number of family members (0.60), the number of years in the land property (0.28), the total area of land (0.15), the current income by the crops production (0.73), and being owner of land property (0.08) are variables that would allow the household to overcome and adapt the perturbation. One particular case is the poverty which also has positive value (0.17), but considering the variables that are implicitly included in this, higher values represents the situations of households which shortcomings do not allow them to have a established, formal source of income. As a result, they can move for other labor activities[7].

[7] Although it could be debatable, a person who has a formal degree and participates in the formal market in the only activity he or she knows well would find more difficult to overcome a perturbation. On the other hand, a person under poverty conditions may migrate to activity easier.

This results are relevant by themselves; however, to contrast fitted values among groups allows to test if there is any statistical difference. Estimating specific component scores to each respondent of the survey.

First, taking into consideration the existence of legal water concessions, the results indicate that there is no statistical difference in the Comp1 and Comp2 (exposure and adaptive capacity). This is explained because whether the population on the watershed have or not legal permits, they were using water when the survey was made. As a result, the behavior was the same in both groups. As quoted before, property right *de facto* and *de jure* are different only when its legality is tested in the formal system. However, in the case of sensitivity, the difference is statistically significant by almost 50%. This means that if any perturbation affects the system, those who do not have water concession are more sensitive and vulnerable than those who in theory have legal concessions. This results are shown in figure 4.

Figure 4. Principal component's mean comparison by water concession.

```
. ttest pca1, by (concession)

Two-sample t test with equal variances

   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     132    .1308701    .1929304    2.216601   -.2507922    .5125324
       1 |     160   -.1045939    .0799707    1.011559   -.2625358    .0533479
---------+--------------------------------------------------------------------
combined |     292    .0018487     .097656    1.668747   -.1903529    .1940504
---------+--------------------------------------------------------------------
    diff |            .2354641    .1960673               -.1504312    .6213593
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   1.2009
Ho: diff = 0                                     degrees of freedom =      290

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.8846         Pr(|T| > |t|) = 0.2308          Pr(T > t) = 0.1154
```

```
. ttest pca2, by (concession)

Two-sample t test with equal variances

   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     132    .2896222    .1170684    1.345014    .0580329    .5212115
       1 |     160   -.2211217    .0863172    1.091836    -.391598   -.0506455
---------+--------------------------------------------------------------------
combined |     292    .0097625    .0723997    1.237167    -.132731     .152256
---------+--------------------------------------------------------------------
    diff |             .510744    .1426006                .2300806    .7914073
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   3.5816
Ho: diff = 0                                     degrees of freedom =      290

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9998         Pr(|T| > |t|) = 0.0004          Pr(T > t) = 0.0002
```

```
. ttest pca3, by (concession)

Two-sample t test with equal variances

   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     132    .0267086    .0830464     .954131   -.1375771    .1909943
       1 |     160   -.0235653    .0893002    1.129568   -.1999329    .1528023
---------+--------------------------------------------------------------------
combined |     292   -.0008387    .0615887    1.052428   -.1220545     .120377
---------+--------------------------------------------------------------------
    diff |            .0502739    .1239256               -.1936337    .2941815
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   0.4057
Ho: diff = 0                                     degrees of freedom =      290

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.6574         Pr(|T| > |t|) = 0.6853          Pr(T > t) = 0.3426
```

Source of information: Survey conducted to Hidrotambo affected community.

Next, another indicator of the importance of water is the existence of irrigation system. For this reason, the same comparison was made considering households with and without irrigations systems. The results demonstrate that households with irrigation systems have greater exposure, but also have higher adaptive capacity (the sensitivity indicator does not have statistically significant difference). This can be explained because having irrigation systems imply an investment and probably an increased use of water, as a result a perturbation could affect more to those households. However, the adaptive capacity is higher because having irrigation is related to the knowledge, economic capacity, and stability of a household. Consequently, they can be more likely to adjust their behavior to overcome the perturbation. This results are shown in figure 5.

Figure 5. Principal component's mean comparison by water irrigation

```
. ttest pca1, by (irrigation)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     226    -.121663     .114663    1.723763   -.3476137    .1042877
       1 |      69    .3984904    .1649581    1.370245    .0693217    .7276591
---------+--------------------------------------------------------------------
combined |     295   -5.81e-10    .0966719    1.660395   -.1902567    .1902567
---------+--------------------------------------------------------------------
    diff |           -.5201534    .2267346               -.9663882   -.0739186
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -2.2941
Ho: diff = 0                                     degrees of freedom =      293

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0112         Pr(|T| > |t|) = 0.0225          Pr(T > t) = 0.9888
```

```
. ttest pca2, by (irrigation)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     226   -.0386824     .078858    1.185496   -.1940772    .1167123
       1 |      69    .1266989    .1670593    1.387699   -.2066627    .4600606
---------+--------------------------------------------------------------------
combined |     295    1.34e-09      .07192    1.235266   -.1415432    .1415432
---------+--------------------------------------------------------------------
    diff |           -.1653814    .1699149               -.4997898    .1690271
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -0.9733
Ho: diff = 0                                     degrees of freedom =      293

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1656         Pr(|T| > |t|) = 0.3312          Pr(T > t) = 0.8344
```

```
. ttest pca3, by (irrigation)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     226   -.1020844    .0509661    .7661891   -.2025164   -.0016524
       1 |      69    .3343634    .1964097    1.631502   -.0575661    .7262929
---------+--------------------------------------------------------------------
combined |     295    1.77e-09    .0610411    1.048415   -.1201328    .1201328
---------+--------------------------------------------------------------------
    diff |           -.4364477    .1421776               -.7162666   -.1566288
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -3.0697
Ho: diff = 0                                     degrees of freedom =      293

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0012         Pr(|T| > |t|) = 0.0023          Pr(T > t) = 0.9988
```

Source of information: Survey conducted to Hidrotambo affected community.

Factor analysis

Factor analysis tries to explain how observed variables depend on the same latent variable. The existence of a correlation between variables may be proof of a common source of influence. In that sense, and similarly to PCA, factor analysis must be conducted based on the analysis of correlation matrix aiming to estimate a measure that gathers most of the variability of the original information in a multivariate dataset. Though, instead of being only an exploratory method, factor analysis allows statistical inference on the fit of the model depending on the estimation method used. For this case, the method employed is maximum-likelihood factor.

Since factor analysis depends on the number of factors selected, it is useful to use as guidelines the PCA results. For this reason, the model with three factors was fitted and tested. Figure 6 shows these results.

Figure 6. Factor analysis for Hidrotambo case

```
Factor analysis/correlation                        Number of obs    =        295
    Method: maximum likelihood                     Retained factors =          3
    Rotation: (unrotated)                          Number of params =         27
                                                   Schwarz's BIC    =    175.391
    Log likelihood = -10.92134                     (Akaike's) AIC   =    75.8427

    --------------------------------------------------------------------------
         Factor  |   Eigenvalue   Difference        Proportion   Cumulative
    -------------+------------------------------------------------------------
        Factor1  |      2.44080      1.54739            0.6632       0.6632
        Factor2  |      0.89341      0.54711            0.2427       0.9059
        Factor3  |      0.34630            .            0.0941       1.0000
    --------------------------------------------------------------------------
    LR test: independent vs. saturated:  chi2(45) =  670.69 Prob>chi2 = 0.0000
    LR test:    3 factors vs. saturated:  chi2(18) =   21.39 Prob>chi2 = 0.2604
```

Source of information: Survey conducted to Hidrotambo affected community.

The goodness-of-fit test used for this case is the likelihood-ratio test which states as a null hypothesis that the factor model generated the observed data (i.e. no expected difference between the observed correlation matrix and the specified by the factor model). Failure to reject the null hypothesis leads to infer that the model is a good fit. Therefore, with a chi.sq of 21.39 and a p-value of 0.26, we fail to reject the equivalence between models implying that our model is a good fit, at all conventional levels.

Figure 7 shows the observed, fitted, and residual correlations between items and standardized versions of the residuals. When analyzing the results, it is shown that most of these residuals are small enough to conclude that the model is a good fit. In fact, the absolute standardized values are not greater than 2 or 3 (which is the conventional criterion to conclude goodness-of-fit), so there is not a clear sign of poor fit.

Figure 7. Observed, fitted, and residual correlations between ítems and standardized versions of the residuals

```
. estat residuals, obs fitted
```

Observed correlations

Variable	Pover~I	Famil~s	landy~s	landa~a	cropa~a	landl~g	cropc~s	crops~e	animals	landp~y
PovertyNBI	1.0000									
Familymemb~s	0.0198	1.0000								
landyears	-0.0309	-0.1494	1.0000							
landarea	0.1140	0.0061	0.0584	1.0000						
croparea	0.1002	-0.0807	0.0024	0.4460	1.0000					
landleasing	0.0836	0.0945	-0.0772	-0.0069	-0.0041	1.0000				
cropcosts	0.0601	-0.0682	-0.0615	0.2373	0.6920	-0.0154	1.0000			
cropsincome	0.0490	0.1050	0.1115	0.1575	0.1517	-0.0385	0.1436	1.0000		
animals	0.0948	-0.0113	0.0546	0.4619	0.7951	0.0011	0.5899	0.2227	1.0000	
landproperty	-0.0909	-0.1145	0.2219	-0.0539	0.0527	-0.2945	0.0839	0.0928	0.1031	1.0000

Fitted ("reconstructed") values for correlations

Variable	Pover~I	Famil~s	landy~s	landa~a	cropa~a	landl~g	cropc~s	crops~e	animals	landp~y
PovertyNBI	1.0000									
Familymemb~s	0.0264	1.0000								
landyears	-0.0184	-0.0206	1.0000							
landarea	0.1010	0.0302	0.0580	1.0000						
croparea	0.1007	-0.0631	-0.0043	0.4381	1.0001					
landleasing	0.0517	0.0614	-0.1059	0.0397	0.0015	1.0000				
cropcosts	0.0523	-0.0818	-0.0342	0.2593	0.6932	-0.0197	1.0000			
cropsincome	0.0285	-0.0006	0.0846	0.1690	0.1687	-0.0366	0.0882	1.0000		
animals	0.1022	-0.0427	0.0595	0.4685	0.7955	-0.0192	0.5859	0.2080	1.0000	
landproperty	-0.0995	-0.1300	0.2269	-0.0455	0.0549	-0.2884	0.0821	0.0934	0.0973	1.0000

Raw residuals of correlations (observed-fitted)

Variable	Pover~I	Famil~s	landy~s	landa~a	cropa~a	landl~g	cropc~s	crops~e	animals	landp~y
PovertyNBI	-0.0000									
Familymemb~s	-0.0066	-0.0000								
landyears	-0.0125	-0.1288	0.0000							
landarea	0.0131	-0.0241	0.0004	0.0000						
croparea	-0.0005	-0.0176	0.0067	0.0078	-0.0001					
landleasing	0.0318	0.0331	0.0287	-0.0467	-0.0056	0.0000				
cropcosts	0.0079	0.0136	-0.0273	-0.0220	-0.0011	0.0043	0.0000			
cropsincome	0.0205	0.1055	0.0269	-0.0114	-0.0171	-0.0019	0.0554	-0.0000		
animals	-0.0074	0.0314	-0.0049	-0.0066	-0.0004	0.0204	0.0040	0.0147	-0.0000	
landproperty	0.0087	0.0155	-0.0049	-0.0084	-0.0021	-0.0061	0.0018	-0.0007	0.0058	-0.0000

```
. estat residuals, sresid
```

Standardized residuals of correlations

Variable	Pover~I	Famil~s	landy~s	landa~a	cropa~a	landl~g	cropc~s	crops~e	animals	landp~y
PovertyNBI	-0.0000									
Familymemb~s	-0.1138	-0.0000								
landyears	-0.2142	-2.2109	0.0000							
landarea	0.2233	-0.4145	0.0068	0.0003						
croparea	-0.0080	-0.3008	0.1146	0.1235	-0.0010					
landleasing	0.5460	0.5676	0.4904	-0.8008	-0.0957	0.0000				
cropcosts	0.1351	0.2329	-0.4693	-0.3657	-0.0159	0.0746	0.0006			
cropsincome	0.3528	1.8127	0.4598	-0.1934	-0.2892	-0.0333	0.9479	-0.0001		
animals	-0.1260	0.5397	-0.0841	-0.1025	-0.0055	0.3499	0.0590	0.2469	-0.0000	
landproperty	0.1486	0.2647	-0.0828	-0.1446	-0.0368	-0.1010	0.0311	-0.0115	0.0990	-0.0001

Source of information: Survey conducted to Hidrotambo affected community.

The factors loadings have similar interpretation to the components in a PCA. Thus, again it will be interpreted the first factor as an indicator of *exposure*, the second factor as indicator of *sensitivity*, and the third factor as indicator of *adaptive capacity*.

Figure 8. Factor loadings for Hidrotambo case

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Uniqueness
PovertyNBI	0.1079	-0.1391	0.0925	0.9604
Familymemb~s	-0.0656	-0.1588	0.1238	0.9552
landyears	0.0192	0.2937	0.2202	0.8649
landarea	0.4852	-0.1072	0.3641	0.6205
croparea	0.9376	-0.0337	-0.0561	0.1168
landleasing	-0.0109	-0.3707	0.0145	0.8623
cropcosts	0.7253	0.0221	-0.2480	0.4120
cropsincome	0.1975	0.1020	0.2310	0.8973
animals	0.8588	0.0326	0.1519	0.2384
landproperty	0.0858	0.7750	-0.0109	0.3919

Unconsidered coefficients

Negative values for factor 2

Negative values for factor 3

Source of information: Survey conducted to Hidrotambo affected community.

The only difference, when comparing to the PCA results, is the sign in front of those variable loadings that were taken into account to interpret the second factor. For this reason, its interpretation is the opposite, but the conclusions are exactly the same. Moreover, calculating individual scores on the latent variable, and testing statistical differences among irrigation and concession groups, the results point towards similar conclusions with the same levels of statistical significance as for the PCA. These estimates are shown in figure 9 for concessions and figure 10 for irrigation.

Figure 9. Factor's mean comparison by water concession

```
. ttest fa1, by (concession)

Two-sample t test with equal variances

   Group       Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

       0       132    .0908218    .1178305     1.35377   -.1422751    .3239187
       1       160   -.0723741     .034289     .433725   -.1400947   -.0046535

combined       292    .0013994    .0565695    .9666602   -.1099379    .1127366

    diff              .1631958    .1134546               -.0601029    .3864946

    diff = mean(0) - mean(1)                                      t =   1.4384
Ho: diff = 0                                     degrees of freedom =      290

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9243         Pr(|T| > |t|) = 0.1514          Pr(T > t) = 0.0757
```

```
. ttest fa2, by (concession)

Two-sample t test with equal variances

   Group       Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

       0       132   -.1805345    .0795409    .9138559   -.3378855   -.0231835
       1       160    .1396005    .0541019    .6843411    .0327495    .2464516

combined       292    -.005118    .0474455    .8107491   -.0984979    .0882618

    diff              -.320135    .0936259               -.5044074   -.1358627

    diff = mean(0) - mean(1)                                      t =  -3.4193
Ho: diff = 0                                     degrees of freedom =      290

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0004         Pr(|T| > |t|) = 0.0007          Pr(T > t) = 0.9996
```

```
. ttest fa3, by (concession)

Two-sample t test with equal variances

   Group       Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

       0       132    .0512603    .0575337    .6610124   -.0625552    .1650758
       1       160    -.045381    .0466438    .5900022   -.1375023    .0467403

combined       292   -.0016938    .0365095    .6238739   -.0735499    .0701623

    diff              .0966413    .0732639                -.047555    .2408376

    diff = mean(0) - mean(1)                                      t =   1.3191
Ho: diff = 0                                     degrees of freedom =      290

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9059         Pr(|T| > |t|) = 0.1882          Pr(T > t) = 0.0941
```

Source of information: Survey conducted to Hidrotambo affected community.

Figure 10. Factor's mean comparisson by irrigation

```
. ttest fa1, by (irrigation)

Two-sample t test with equal variances

   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     226   -.0559183    .0678279    1.019678   -.1895775     .077741
       1 |      69    .1831526     .086419    .7178503    .0107062    .3555991
---------+--------------------------------------------------------------------
combined |     295   -1.02e-09     .056002    .9618652   -.1102155    .1102155
---------+--------------------------------------------------------------------
    diff |           -.2390709    .1317835               -.4984331    .0202912
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -1.8141
Ho: diff = 0                                     degrees of freedom =      293

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0353         Pr(|T| > |t|) = 0.0707          Pr(T > t) = 0.9647
```

```
. ttest fa2, by (irrigation)

Two-sample t test with equal variances

   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     226    .0160128    .0524716    .7888217   -.0873859    .1194115
       1 |      69   -.0524478    .1050642    .8727288   -.2621001    .1572046
---------+--------------------------------------------------------------------
combined |     295   -1.86e-09    .0470561    .8082151   -.0926095    .0926095
---------+--------------------------------------------------------------------
    diff |            .0684606    .1112804               -.1505497    .2874709
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   0.6152
Ho: diff = 0                                     degrees of freedom =      293

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7306         Pr(|T| > |t|) = 0.5389          Pr(T > t) = 0.2694
```

```
. ttest fa3, by (irrigation)

Two-sample t test with equal variances

   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     226   -.0469077    .0388878    .5846113   -.1235385    .0297231
       1 |      69    .1536398    .0855624    .7107347   -.0170973    .3243769
---------+--------------------------------------------------------------------
combined |     295    1.83e-10    .0361553    .6209882   -.0711561    .0711561
---------+--------------------------------------------------------------------
    diff |           -.2005475     .084751               -.3673454   -.0337497
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -2.3663
Ho: diff = 0                                     degrees of freedom =      293

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0093         Pr(|T| > |t|) = 0.0186          Pr(T > t) = 0.9907
```

Source of information: Survey conducted to Hidrotambo affected community.

Discussion and Conclusions

The relevance of any analysis is useless without a connection to the real world. All around the globe, tons of water is used in agricultural production to satisfy basic needs, but also sumptuary desires. At the same time, the planet is suffering the noxious effects of a fossil-fuel energy system. In this context, hydropower plants have been raised as a clean alternative energy production option which can potentially mitigate or reduce environmental damages. However, as a result, there is a conflict of interests among agricultural producers and hydropower proponents, since both depend on water use. In this debate, decisions are often made to favor hydropower, with the justification that it will serve "the greater good" on a national and global scale. However, the community and local levels have relied on activities that need water for generations. This population's vulnerability to water use is in great need of both attention and assessment.

As shown in the literature review, there are numerous studies and works about property rights and the conflict of interest that arises when they are designed to correct market failures and externalities. Nevertheless, the characteristics of water and its role in almost every production process make any policy intervention a determinant for people's welfare. The current dissertation is based on the few investigations undertaken to assess the vulnerability of agrarian communities by the perturbation that could affect a lack of water access. However, these approaches usually take into consideration the natural externalities. Instead, this dissertation proves that policy interventions on the property rights scheme over water access can also be understood to be a perturbation of a system with devastating consequences for the population.

There is a limited body of work about property rights and its effects on resource use through equity approaches. Traditionally, these works seek to identify where and how a policy intervention is justified. The present work contributes to understanding the effects of those policies beyond the spheres of efficiency, asking for a deeper understanding of the socio-economic effects on the affected population. As has been demonstrated, the vulnerability indicators clearly reflect how concessions make a difference especially in the degree to which a household can be affected by any perturbation. Moreover, irrigation is also important since households with these systems have less exposure to any perturbation but even more importantly, they have more opportunities to adjust their behavior to overcome the disruption of normal conditions.

Besides, the currency of the conflict among the community, the state, and Hidrotambo S.A., invites us to think about the probable denouement that may happen in few years. This study helps to understand the importance of *de jure* property rights over *de facto* ones. Likewise, it is useful to comprehend a trichotomy over the vulnerability concept and comprehend that some variables could affect exposure in a negative way, while affecting sensitivity or adaptive capacity in a positive way.

Even though the population that resides in the Dulcepamba watershed has demanded government action to provide reparation for damage caused, trying to demonstrate how the construction of Hidrotambo affects their lives not only by an increased physical risk but also because their production structure could be transformed and even banned, they have not found an effective way to communicate their concerns. Made with strict unbiased criteria, this dissertation shows measurements of the perceived effect on the population.

Regarding the findings, there are predictable results that were corroborated, but there were others that can be taken as unexpected results. In terms of vulnerability, the *exposure* indicator shows the degree to which a househols experiences any perturbation. The variables that influence this indicator the most are the amount of area the family has designated to crops and the number of animals they have. This can be explained by understanding that those are the main sources of income in the community, and when perturbed in any way, they begin to sell their assets. Next, when assessing the *sensitivity*, or the degree to which the system is affected, being the owner of the land gives a kind of stability, while the amount of money spent in land leasing, the number of household members, and the poverty indicator increases the indicator, or level of vulnerability. The *adaptive capacity* is particularly high in households with bigger landholdings and more years using the land, demonstrating that remaining stable over extended periods of time allows communities to have better management of their resources.

Water is essential to the people in the Dulcepamba watershed, not only for their own consumption, but also for their production. The results are not only relevant because they demonstrate that the allocation of property rights and concessions by the state to the industrial actors have an adverse impact in the welfare of civil society, in particular on those households where farming and agriculture represent a considerable portion of income. The results also demonstrate that the techniques used in the agricultural production process are entirely relevant, and can be used as tools to confront possible difficulties derived from the interaction with other actors. In this particular case, the existence of irrigation has a significant influence on the vulnerability indicator. Despite the limitations of this approach, the recommendations that have been made by (Brouwer, Hoevenaars, Van Bosch, Hatcho, & Heibloem, 1992; FAO, 2013) on countless occasions about the importance of irrigation for conserving the environment and taking advantage of agriculture in a better and sustainable way, were corroborated. Moreover, the importance of irrigation is also seen in the vulnerability indicator for agrarian households, which can achieve better adaptive capacity by installing these systems. "households with access to irrigation (physical assets) will face fewer risks of crop damage during droughts compared to those households depending entirely on rained agriculture."(Piya, Maharjan, Joshi, & others, 2012, p. 7). One of the causals of irrigation system installations is the stability of a family. Thus, those households with more years using the land, or with ownership over it, are more likely to make this kind of long-term investment.

Contrary to what would be expected, the existence of concessions does not yet influence irrigation. As with many other variables, here is demonstrated that *de jure* and *de facto* rights act in the same way until they are tested in a formal judgment under a legal framework.

Not only access to water is essential but property rights and ownership has also demonstrated to be relevant to mitigate vulnerability. Following the work of Amartya Sen's entitlements approach, this model expresses what other authors also have found: that "the lack of or limited access to livelihood assets increases the defenselessness or incapacity to avoid risks as well as increases the shocks and stresses to which an individual or household is exposed to" (Piya et al., 2012, p. 6).

To conclude, such a transversal resource as water is essential in different spheres of human activity, but as stated in Ecuador's constitution, in keeping with what logic suggests, the welfare and security of people must be prioritized over any other interest. Only having satisfied the most basic needs, can other goals be pursued. Although private entrepeneurships and collaboration with the government's objectives are desirable, social, economic, and environmental issues must be assessed with a holistic approach. Instead of vetting for the privatization of the resources, or the justification of government interventions, it is important to understand the logic behind the social and community systems that have managed their resources effectively for decades. As scholars, it is also indispensable to conduct unbiased research, help to understand the situation, the consequences of a certainly difficult decision, and the degree of impact for the most vulnerable populations. The results presented here do suggest that the interaction with people and communities, the survey collection, and the statistical and econometric approach are useful to understand the logic behind the conflict, and hopefully will lead to collaboration among the actors in order to negotiate the individuals goals and achieve the optimal situation for everyone, without minimizing the need to reducenegative impacts on the most vulnerable populations.

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Appendix

Survey questionnaire for data collection

_____/____/______Fecha   ________________ Hora de Inicio   __________________________Ubicación
________________ Hora de Terminar   _____________________ # de Sector Censal y # de Encuesta

Si una persona aparte del encuestado está anotando las respuestas, escriba el nombre de esta(s) persona(s):_____________________

Por favor, responda a las preguntas en la mejor manera que pueda. Por favor, escoja la persona de este hogar con el mayor conocimiento sobre la agricultura para responder a las preguntas abajo.

NO PONGA LOS NOMBRES DE LOS HABITANTES DEL HOGAR. Sus respuestas se mantendrán anónimos, y estarán guardados en una manera estrictamente confidencial.

REFERENCIAS PARA LA REALIZACIÓN DE LA ENCUESTA

OJO: Cuando se hace referencia a los últimos 12 meses, significa entre el 31 de Agosto del 2013, hasta el 31 de Agosto del 2014.

PAGINA 2: *= En caso de que algunas familias posean más de un terreno en una comunidad, por favor, asigne un numero diferente a cada uno de sus terrenos.

Ej:
Terr 1 = Bilobán 1
Terr 2 = Bilobán 2
Terr 3 = Bilobán 3

≠ = Es posible contestar estas preguntas sin preguntar el encuestado. Por eso, no es necesario contestar la pregunta durante la encuesta. ¡Hazlo después!

TERRENO- Cuéntame sobre cada terreno de que Ud. es dueño ahora, y de los terrenos que Ud. ha cultivado pero de que no es dueño, durante los últimos 12 meses. Por favor, reporte TODOS sus terrenos, aunque sea que estén ubicados aquí en su comunidad, o en otra parte de la región

____________________ # de Sector Censal y # de Encues

Terrenos	A. En cuales comunidades su familia tiene terrenos?* Ej: Terr 1 = Bilobán1 Terr 2 = Bilobán 2 Terr 3 = Bilobán 3	B. Para cada Terreno que anota, está ubicado dentro de la comunidad, o en los alrededores? Por favor, ponga un visto en la línea apropiada.	C. Para cada terreno que anota, ¿cuál es el área? Por favor, escriban el número al lado de la unidad de medida apropiada. Si responde Otro, por favor incluya unidades de medida.	D. ¿Cuál es la conexión de este terreno con su hogar? Para cada terreno que anotó, por favor, ponga un visto abajo en la respuesta apropiada para el terreno.	E. Para cada terren ¿en cual año adquirió este terreno? Ej: 1999 Ej: 0 (si no sabe)
Ejemplo Terr 1	**San Vicente** (Comunidad)	Dentro de la comunidad __✓__ Alrededores _____	_______ Hectáreas _______Solares __4__ Cuadras _______Metros^2 _______ Otro_________	✓ Propio ___ Usamos gratis ___ Alquilamos de alguien ___A medias (de otro dueño) ___ Otro __________	**1999** (Año)
Terr 1	___________ (Comunidad)	Dentro de la comunidad _____ Alrededores _____	_______ Hectáreas ________Metros^2 _______ Cuadras _______ Otro_________	___ Propio ___ Usamos gratis ___ Alquilamos/arrendamos de alguien ___A medias/partidario (de otro dueño) ___ Otro __________	__________ (Año)
Terr 2	___________ (Comunidad)	Dentro de la comunidad _____ Alrededores _____	_______ Hectáreas ________Metros^2 _______ Cuadras _______ Otro_________	___ Propio ___ Usamos gratis ___ Alquilamos/arrendamos de alguien ___A medias/partidario (de otro dueño) ___ Otro __________	__________ (Año)
Terr 3	___________ (Comunidad)	Dentro de la comunidad _____ Alrededores _____	_______ Hectáreas ________Metros^2 _______ Cuadras _______ Otro_________	___ Propio ___ Usamos gratis ___ Alquilamos/arrendamos de alguien ___A medias/partidario (de otro dueño) ___ Otro __________	__________ (Año)
Terr 4	___________ (Comunidad)	Dentro de la comunidad _____ Alrededores _____	_______ Hectáreas ________Metros^2 _______ Cuadras _______ Otro_________	___ Propio ___ Usamos gratis ___ Alquilamos/arrendamos de alguien ___A medias/partidario (de otro dueño) ___ Otro __________	__________ (Año)
Terr 5	___________ (Comunidad)	Dentro de la comunidad _____ Alrededores _____	_______ Hectáreas ________Metros^2 _______ Cuadras _______ Otro_________	___ Propio ___ Usamos gratis ___ Alquilamos/arrendamos de alguien ___A medias/partidario (de otro dueño) ___ Otro __________	__________ (Año)
Terr 6	___________ (Comunidad)	Dentro de la comunidad _____ Alrededores _____	_______ Hectáreas ________Metros^2 _______ Cuadras _______ Otro_________	___ Propio ___ Usamos gratis ___ Alquilamos/arrendamos de alguien ___A medias/partidario (de otro dueño) ___ Otro __________	__________ (Año)

USO DEL SUELO- Estas preguntas refieren a los terrenos sobre los cuales Ud. contestó en la sección titulada "TERRENO". Use "Terreno 1" par describir el primer terreno que describió en la primera sección, "Terreno 2" para describir el segundo terreno que describió en la primera sección, etc. Por favor, ponga un visto al lado de la opción adecuada.

__________________ # de Sector Censal y # de Encues

F. En lo últimos 12 meses, ¿para qué han utilizado estos terrenos? Por favor, pongan un visto al lado de todas las opciones correspondientes. 1. Cultivos 2. Silvicultura 3. Bosque 4.Pasto natural/pasto mejorado 5. Laguna/pozo/ojo de agua/rio/vertiente 6. En descanso **(por mínimo 12 meses)** 7. Lo alquilamos a alguien 8. Dimos a otros a medias 9. Otro (especifique)_______	G. Si dejó en descanso su terreno, ¿porque lo dejaron en descanso? 1. No hay suficiente acceso al agua 2. Queremos dejar que se recupere el suelo 3. El suelo es de mala calidad 4. El terreno es demasiado pequeño para justificar uso 5. Insumos y repuestos fueron demasiado caros 6. No hay un mercado accesible/disponible 7. Los precios de venta de los cultivos están demasiado bajos 8. No sembramos porque estamos rotando cultivos. 9. Falta de peones/familiares para labrar la tierra 10. Otro (especifique)_____________	H. Si escogió "dejé en descanso," ¿por cuantos meses ha dejado en descanso este terreno? Ej: 14 Ej: 0 (si no sabe) ***Ojo:** Tiene que ser un mínimo de 12 meses	I. <u>Si en caso de que han escogido números 7 o 8 en La F, anotar esta fila.</u> Si alquilaron este terreno a otro(s), o lo dieron a medias, en los últimos 12 meses, cuánto dinero u otro tipo de compensación recibió Ud. en el ultimo año? (Escriba la cantidad de dinero que recibió, o si recibió una parte de la cosecha, escriba el numero y encierre las unidades de medida.)
TERRENO 1: Ej. ____1 ____2 ____3 _✓_4 ____5 _✓_6 ____7 _✓_8 ____9	_✓_1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9 ____10 (otro) ________	__12__ (Meses)	__**500**__ $ por año ______ Lb/Racimo/Caja/Saco/#
TERRENO 1: ____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9	____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9 ____10 (otro) ________	________ (Meses)	______$ por año ______ Lb/Racimo/Caja/Saco/#
TERRENO 2: ____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9	____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9 ____10 (otro) ________	________ (Meses)	______$ por año ______ Lb/Racimo/Caja/Saco/#
TERRENO 3: ____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9	____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9 ____10 (otro) ________	________ (Meses)	______$ por año ______ Lb/Racimo/Caja/Saco/#
TERRENO 4: ____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9	____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9 ____10 (otro) ________	________ (Meses)	______$ por año ______ Lb/Racimo/Caja/Saco/#
TERRENO 5: ____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9	____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9 ____10 (otro) ________	________ (Meses)	______$ por año ______ Lb/Racimo/Caja/Saco/#
TERRENO 6: ____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9	____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9 ____10 (otro) ________	________ (Meses)	______$ por año ______ Lb/Racimo/Caja/Saco/#
TERRENO 7: ____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9	____1 ____2 ____3 ____4 ____5 ____6 ____7 ____8 ____9 ____10 (otro) ________	________ (Meses)	______$ por año ______ Lb/Racimo/Caja/Saco/#

CULTIVOS

___________________ # de Sector Censal y # de Encues

J. ¿Cuáles cultivos han cosechado en los últimos 12 meses? (Si tiene más que 8 tipos de cultivos, por favor ponga abajo los 8 cultivos con el área más extensiva)	K. Por favor, identifique las ubicaciones donde Ud. cultivó este cultivo, usando los números que usó para identificar terrenos en la sección titulada "TERRENO" (Ej: 1, 2, 8)	L. Por favor, especifique cuantas cuadras, etc. de este cultivo ha cultivado en cada de los terrenos mencionados en la respuesta anterior. (Ej: 5c, 1)	M. ¿En cuales de los terrenos mencionados anteriormente **utilizó riego en los últimos 12 meses?** Use los números que usó para identificar terrenos en la sección titulada "TERRENO" (Ej: 1, 2, 8)	≠N. ¿Cuál es el área **TOTAL** cultivado de cada cultivo? Ponga el área de cada cultivo al lado de las unidades de medida apropiada (metros cuadrados/hectáreas/cuadras/Otro)	O. Cuanto…[cultivo]… en kg/sacos/cajas/libras/ etc. ha COSECHADO en los últimos 12 meses? Por favor, escriba el número y **encierre** la unidad de medida. (Ej: 1, 2, 8)	P. Cuanto…[cultivo]… en kg/sacos/cajas/libras/ etc. ha VENDIDO en los últimos 12 meses? Por favor, escriba el número y **encierre** la unidad de medida. (Ej: 1, 2, 8)	Q. Si vendió cultivos, donde e que **Ud. o los intermediarios** los vendió? 1. SP Atenas 2. Chillanes 3. S.J.D. Tambo 4. Guayaquil 5. Ambato 6. Quito 7. Babahoyo 8. No sabe 9. Otro________
Ejemplo 1 Mora	1 Número(s) de terreno	**5c, 1** _____ _____ _____	1 Número(s) de terreno	_____ Hectáreas 5 Cuadras _____ Otro	**120** Kg, Sacos, Latas, (Cajas), Lb, Racimos, Quintales, Unidades, Jureñas	**120** Kg, Sacos, Latas, (Cajas), Lb, Racimos, Quintales, Unidades, Jureñas	**1,2** #(s) de ciudad(es) Otro__________
1	___________ Número(s) de terreno	_____ _____ _____ _____	___________ Número(s) de terreno	_____ Hectáreas _____ Cuadras _____ Otro	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	_________ #(s) de ciudad(es) Otro__________
2	___________ Número(s) de terreno	_____ _____ _____ _____	___________ Número(s) de terreno	_____ Hectáreas _____ Cuadras _____ Otro	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	_________ #(s) de ciudad(es) Otro__________
3	___________ Número(s) de terreno	_____ _____ _____ _____	___________ Número(s) de terreno	_____ Hectáreas _____ Cuadras _____ Otro	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	_________ #(s) de ciudad(es) Otro__________
4	___________ Número(s) de terreno	_____ _____ _____ _____	___________ Número(s) de terreno	_____ Hectáreas _____ Cuadras _____ Otro	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	_________ #(s) de ciudad(es) Otro__________
5 Mezclado ______/______/ ______/______/	___________ Número(s) de terreno	____ ____ ____	___________ Número(s) de terreno	_____ Hectáreas _____ Cuadras _____ Otro	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	_________ #(s) de ciudad(es) Otro__________
6 Mezclado ______/______/ ______/______/	___________ Número(s) de terreno	____ ____ ____	___________ Número(s) de terreno	_____ Hectáreas _____ Cuadras _____ Otro	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	________Kg, Sacos, Latas, Cajas, Lb, Racimos, Quintales, Unidades, Jureñas	_________ #(s) de ciudad(es) Otro__________

RIEGO/INTERMEDIARIOS ____________________ # de Sector Censal y # de Encuesta

Si su hogar vende sus cultivos por medio de intermediario(s) (comerciantes), por favor, responda a las siguientes preguntas.

P1.

1. En los últimos 10 años, su hogar ha **comenzado** de usar riego en alguno(s) de sus cultivos?	**SI**	**NO**

2. En el futuro, su hogar planea o comenzar de usar riego para alguno(s) de sus cultivo(s) existentes (A), o incrementar el uso de riego en alguno(s) cultivo(s) existentes (B), o cultivar nuevos cultivo(s) bajo riego (C)? Encierre todo lo que aplica para su situación y describa cuando.	**A** **Cuando:_______** _______________	**B** **Cuando:____** ____________	**C** **Cuando:______** _______________
3. En su opinión, cómo ha cambiado la situación de riego en los pueblos cercanos en los últimos 10 años?	**A.** **Aumentado**	**B.** **Disminuido**	**C.** **No subió ni bajó**

R. Cuáles de sus cultivos vendió por medio de un intermediario en los últimos 12 meses? Por favor, escriba el nombre de cada cultivo.	S. ¿Ud. vendió el TOTAL de este cultivo por medio de un intermediario? **Si = 100%**	T. ¿Si NO vendió el TOTAL por medio de un intermediario, cual porcentaje aproximadamente vendió por medio de un intermediario? Por favor, ponga un visto al lado de la respuesta adecuada.
Ejemplo 1 Mora	✓ Si ___ No	240 (fracción) 300
1	___ Si ___ No	___
2	___ Si ___ No	___
3	___ Si ___ No	___
4	___ Si ___ No	___
5	___ Si ___ No	___
6	___ Si ___ No	___

ANIMALES DE LA FINCA- Si su hogar ha criado animales en los últimos 12 meses, por favor, responda a las siguientes preguntas.

____________________ # de Sector Censal y # de Encuesta

U. Por favor, enumere la cantidad de cada tipo de animal que ha tenido en los últimos 12 meses.	V. ¿Cuántos de estos animales (vivos) vendieron durante los últimos 12 meses?	W. ¿Cuánto en TOTAL recibieron para la venta de estos animales… en los últimos 12 meses?
Ganado ____	_______________ (# vendido)	$ _______________
Chanchos ____	_______________ (# vendido)	$ _______________
Borregos ____	_______________ (# vendido)	$ _______________
Cabras ____	_______________ (# vendido)	$ _______________
Caballos ____	_______________ (# vendido)	$ _______________
Burros o Mulares ____	_______________ (# vendido)	$ _______________
Gallos/Gallinas ____	_______________ (# vendido)	$ _______________
Cuyes ____	_______________ (# vendido)	$ _______________
Trucha/tilapia/otros peces _____	_______________ (# vendido)	$ _______________
Otro (especifique) ______________	_______________ (# vendido)	$ _______________

INSUMOS Y OTROS GASTOS EN LA FINCA ___________________ # de Sector Censal y # de Encuesta

Por favor, escriba el costo de sus insumos y otros gastos en los últimos 12 meses en la tabla abajo.

Tipo de insumo	X. ¿Cuál era el TOTAL que gastaron en los insumos en los últimos 12 meses? Si no usó un cierto insumo, ponga 0.
Semillas, plantas de semilleros	$ ___________
Estiércol/Otros abonos orgánicos	$ __________
Fertilizantes químicos	$ __________
Otros químicos	$ __________
Comida para animales de la finca	$ __________
Servicios veterinarios	$ __________
Medicinas, vitaminas, despulgantes, otros complementos para la dieta de animales	$ __________
Transporte de animales	$ __________
Combustible	$ __________
Aceite y lubricantes	$ __________
Piezas extra/repuestos	$ __________
Mantenimiento	$ __________
Otros gastos en maquinaria	$ __________
Gasto: Alquiler de terrenos agrícolas (de otros)	$ __________
Otros gastos: (especifique) __________	$ __________

JORNALEROS, ALQUILER DE MAQUINARIA, Y ALQUILER DE ANIMALES _________________ # de Sector Censal y # de Encuesta

Y. TRABAJO DE JORNALEROS (PEONES) Si su hogar utilizó la mano de obra de peones **en los últimos 12 meses**, por favor, conteste las siguientes preguntas.	Z. MAQUINARIA Si su hogar alquiló maquinaria para uso agrícola **en los últimos 12 meses**, por favor conteste las siguientes preguntas.	A1. ANIMALES Si su hogar alquiló animales para uso agrícola **en los últimos 12 meses**, por favor conteste las siguientes preguntas.
Cuantos **jornales** pagaron a peones en los últimos 12 meses? _______________# Jornales pagados en los últimos 12 meses *OJO: si no entienden lo que significa "cuantas jornales pagaron," pregúnteles por cuantas días/semanas/meses en los últimos 12 meses ocuparon peones, y cuantas personas (aprox.) vinieron cada día durante este tiempo, y haz los cálculos… GRACIAS!! Ej: 2 peones por día, 2 veces a la semana, por 4 meses en todo el último año = **64 jornales pagados** Pago promedio/jornal-$_____	_________# de maquinas usadas/día _________# de días en que usaron la(s) maquinas _________$ Costo de alquiler por día	_________# de animales usados/día ________# de días en que usaron el/los animales _________$ Costo de alquiler por día

CONCESION AL AGUA

B1. ¿Usted **o su comunidad** tiene adjudicado el agua que utiliza? ___SI ____NO. Si es así, **encierre** los tipos de concesiones que tiene:

ABREVADERO DOMESTICA RIEGO FUERZA MECANICA INDUSTRIA PISCICULTURA

Si la adjudicación es para la comunidad, ponga un visto aquí _____ y si es individual, ponga un visto aquí _____.

PESCA

C1. ¿En promedio, cuántas veces en los últimos 12 meses han comido pescado en su hogar **que proviene de los ríos de la cuenca del rio Dulcepamba**, y de donde viene el pescado? Por favor, escriba el número, encierre la unidad de medida adecuada.

___________________________ # (a la semana / al mes / al año) _______________ Nombre del rio/sector de donde proviene el pescado

PRODUCTOS ELABORADOS ___________________ # de Sector Censal y # de Encuesta

D1. ¿Cuales productos han elaborado durante **los últimos 12 meses**? Ponga un visto al lado de la opción adecuada.		E1. ¿Cuánto ELABORARON **en los últimos 12 meses**? Escriba un valor, y **encierre** la unidad de medida apropiada. Ej: 14 Ej: 0 (si no sabe)	F1. ¿Cuánto VENDIERON en los **últimos 12 meses**? Escriba un valor, y **encierre** la unidad de medida apropiada. Ej: 14 Ej: 0 (si no sabe)	G1. ¿Cuánto dinero recibieron de la venta de este producto en **los últimos 12 meses**?
Carne de res	___ Si ___ No	________ Kg, Lb	________ Kg, Lb	$______________
Leche	___ Si ___ No	________ Litros, Galones	________ Litros, Galones	$______________
Huevos	___ Si ___ No	X	________ Docenas	$______________
Queso	___ Si ___ No	________ Kg, Lb, Unidades de ___?lbs	________ Kg, Lb, Unidades de ___?lbs	$______________
Chocolate	___ Si ___ No	________ Barras, Kg, Lb	________ Barras, Kg, Lb	$______________
Panela	___ Si ___ No	________ Unidades de ___?lbs, Kg, Lb	________ Unidades de ___?lbs, Kg, Lb	$______________
Pájaro azul/ Pata de vaca	___ Si ___ No	________ Litros, Galones	________ Litros, Galones	$______________
Café	___ Si ___ No	________ Kg, Lb	________ Kg, Lb	$______________
Otro ________	___ Si ___ No	________ Kg, Sacos, Cajas, Lb, Litros, Galones, Docenas	________ Kg, Sacos, Cajas, Lb, Litros, Galones, Docenas	$______________

TRABAJO DE JORNALERO

____________________ # de Sector Censal y # de Encuesta

H1. Si Ud. y/o miembros de su hogar proveen mano de obra para **otras** fincas, por favor proporcione el TOTAL de **jornales** que han trabajado como peón en los últimos 12 meses. Ej: 14 Ej: 0 (si no sabe)	I1. ¿Cuál es pago promedio que recibieron por jornal? Ej: $7 Ej: 0 (si no sabe)
_______ # jornales	$_______________/jornal ≠$_______________Total ganado en los últimos 12 meses

OTRAS OCUPACIONES

J1. Alguien de su hogar tiene otra ocupación aparte de la agricultura? ______SI _______NO

K1. Si es así, cuantas personas de su hogar tienen estos otros trabajos? ________ (#)

L1. Cual es el TOTAL de los otros ingresos aparte de agricultura? $__________

Otros usos del agua (encierre SI o NO)

pisicultura	trapiche	molino
SI NO	SI NO	SI NO

M1. Remesas: Cuanto aproximadamente recibió su familia en los últimos 12 meses en remesas ($$ mandado de otro lado para apoyar a su hogar)? $___________

DATOS PERSONALES

N1. ¿Cuantas personas, incluyendo Usted, forman parte de su hogar? ________________________________

O1. Cuales son las edades de los miembros de su hogar, y cual nivel de educación han **terminado**?
Por favor, escriba la edad, y encierre el nivel de educación terminado para cada miembro del hogar.

______ Edad de familiar 1. Primaria, Colegio, Universidad, Otro_____

______ Edad de familiar 2. Primaria, Colegio, Universidad, Otro_____

______ Edad de familiar 3. Primaria, Colegio, Universidad, Otro_____

______ Edad de familiar 4. Primaria, Colegio, Universidad, Otro_____

______ Edad de familiar 5. Primaria, Colegio, Universidad, Otro_____

______ Edad de familiar 6. Primaria, Colegio, Universidad, Otro_____

______ Edad de familiar 7. Primaria, Colegio, Universidad, Otro_____

______ Edad de familiar 8. Primaria, Colegio, Universidad, Otro_____

P1. ¿Cuántos hombres y cuantas mujeres forman parte de su hogar?
Por favor, ponga un número al lado del género.

_____ Masculino _____ Femenino _____ Otro

¡Mil gracias por su tiempo y colaboración! De verdad, esta unidad nos da las fuerza para seguir en la lucha para el agua y la vida! ¡Que viva el agua!