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Prioritizing Food Products, Environmental Goods and Services from Paramo and Forest Ecosystems in the Chimborazo Province

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Abstract

The study of the prioration of food products, goods and environmental services of the páramo and forest ecosystems of the province of Chimborazo focuses on the identification and valuation of the environmental services provided by the ecosystems of páramo and forest of the province of Chimborazo, in Ecuador.

The study was conducted through an expert survey, literature review, social cartography and weighting methodologies. The results indicate that the most important ecosystem services are the provision of livestock and crop goods, water regulation, water for consumption, while the most valued environmental services are water regulation, carbon sequestration and biodiversity conservation.

Likewise, it was identified that the main problem in the province is the loss of ecosystems, especially moors and natural forests, due to anthropic activities and the misuse of resources such as water and soil. In addition, contamination by human waste to watersheds and rivers is recurrent in all cantons.

Based on these results, there is a need to promote the conservation and restoration of páramo and forest ecosystems in the province, as well as to promote sustainable practices in agricultural and livestock production. It also suggests the implementation of mechanisms for economic valuation of environmental services to encourage their conservation and the development of sustainable economic activities.

Keyboards: environmental goods; environmental services; food products; environmental valuation; ecositemas, páramo, forests, chimborazo.

1. Introduction

The páramo and the forest are fundamental ecosystems for ecological balance and human well-being, these ecosystems provide vital environmental services such as climate regulation, flood control, water supply, biodiversity (1), in addition, they are an important source of food for local communities (2) . However, these ecosystems are threatened by human activity, such as deforestation, mining and unsustainable agriculture. The prioritization and valuation of food products, goods and environmental services offered by these ecosystems are essential to ensure their conservation and sustainable use in the long term. This involves not only identifying, prioritizing and valuing the ecosystem services they provide, but also the active participation of local communities in their conservation and management (3-5).

The páramos are of fundamental importance for millions of people and represent a multiplicity of meanings and values, they are habitats in which endemic species are found, ecosystems capable of providing fundamental environmental services, spaces of cultural importance, among others (6). Thus, the páramos constitute spaces of life and sacred territories for the indigenous peoples who live around them, they also play a fundamental role in the subsistence of various traditional and local populations settled in the high areas of the mountains, being axes of social cohesion that determine the ways of life of the inhabitants of the highlands (7, 8).

The study Millennium Ecosystem Assessment – MEA carried out in 2005 and led by the United Nations for the identification and evaluation of ecosystem services in the well-being of society, (9) encouraged the development of the concept of ecosystem services (SE), defining them as the benefits that society obtains from ecosystems, in addition to proposing a categorization according to the categories of: basic or support services, regulatory, cultural and provisioning services (10, 11). The study shows the degradation or unsustainable use of approximately 60% of ecosystem services, and establishes that, although the total costs of loss and degradation of these services are difficult to measure, the available data show that they are considerable and increasing.

The loss of ecosystem services can have significant impacts on the economy, human health and social well-being. For example, the loss of regulatory services, such as water purification and climate regulation, can have negative effects on human health and well-being, and increase costs to society in terms of water treatment and flood control (12). In addition, the loss of provisioning services, such as food production and

building materials, can have significant economic impacts on local communities and food security (13). It is therefore important to work on the conservation and sustainable management of ecosystems to ensure the continued provision of ecosystem services and maintain human health and well-being, and it is worth noting, however, that the concept of SE is present in previous studies (14). After the MEA, the approach is reinforced by the TEEB study, Economics of Ecosystems and Biodiversity - TEEB initiative of the United Nations Environment Programme - UNEP between 2007 and 2010, which joins global initiatives such as Ecosystem Services Partners and the Intergovernmental Platform on Biodiversity and Ecosystem Services - IPBES that seek to coordinate efforts on the study and policy responses of ES in the world (15).

Ecosystem services (ES), are those benefits that society obtains from ecosystems (10), can be identified for the natural capital of forests and páramos of the province of Chimborazo, according to the following categories: Provision Services that includes products or tangible goods that are obtained from ecosystems and that mostly present a structured market as food, water, fuel, fibers, raw materials, genetic resources, among others; foods that constitute a wide range of products derived from plants, animals and microbes, as well as materials such as wood, jute, skins among many other products; pure water includes water for human consumption and economic activities; firewood (or energy); wood and other biological material that serves as an energy source; the fibers that are the raw materials for use of handicrafts among others; biochemicals such as natural and pharmaceutical medicines, many medicines, biocides and food additives such as alginates and biological materials; genetic resources that include genes and genetic information used for the creation of animals and plants and in biotechnology and ornamental resources such as animal products, skins, peels and flowers that are used as ornaments. (16)

In addition, there are regulatory services which incorporate services related to ecosystem processes and their contribution to the regulation of the natural system such as climate regulation, water purification, pollination, disease regulation, biological control, among others; in addition to maintaining air quality; Climate regulation: Ecosystems influence local and global climate, for example on a local scale, changes in land cover can affect temperature and precipitation. On a global scale, ecosystems play an important role in climate by capturing or emitting greenhouse gases; the regulation of diseases since ecosystems can directly change the abundance of pathogens such as cholera, and can alter the abundance of vectors such as mosquitoes, water regulation as they manifest themselves in the times and magnitude of rainfall, floods and aquifer recharge can be strongly influenced by changes in land cover including in particular alterations that change the potential storage of the system, such as the conversion of wetlands or the replacement of forests; water purification as they can be a source of impurities in fresh

water but also help filter and decompose waste introduced into the water; Pollination that are changes in the ecosystem can affect the distribution abundance and effectiveness of pollination, erosion control since vegetation cover plays an important role in soil retention and in the prevention of landslides; biological control, ecosystem changes can affect the prevalence of crops, pests and diseases; Storm protection, so the presence of coastal ecosystems such as corals and mangroves can reduce the damage caused by hurricanes or high tides. (12, 17, 18)

Finally, we have the cultural services that correspond to non-material services that man obtains from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic enjoyment. Cultural services are closely linked to human values, their identity and their behavior among them we can have spiritual and religious; recreation and ecotourism as people choose where to spend time based in part on the natural features of certain areas; aesthetics; of inspiration already provide a source of inspiration for art, folklore, national symbols, architecture and advertising; educational as they provide the basis for formal and informal education; sense of identity and belonging to a place; cultural heritage; cultural diversity; and social relations (11, 19).

This approach to SEs, however, does not explicitly include the functions that are required to maintain services (20), they propose a broader definition that includes the natural capital functions of ecosystems that allow the flow of SEs, these functions are defined as "those aspects of the structure and functioning of ecosystems with the capacity to generate services that meet human needs, directly or indirectly" approach that resembles the definition coined by Daily in 1997, in which he emphasized the conditions and processes through which natural ecosystems and the species that constitute them sustain and guarantee that human needs are met. (14)

In this sense, this study seeks to highlight these benefits by identifying the main ecosystem services that the forest and moorland ecosystems of the province have, in order to increase awareness of their importance for society, as a political element of positioning in different instances, while allowing to manage resources and policies to guarantee their characterization. Management and sustainability, through the valuation of services that stimulate the capacity of decision-makers.

2. Materials and Methods

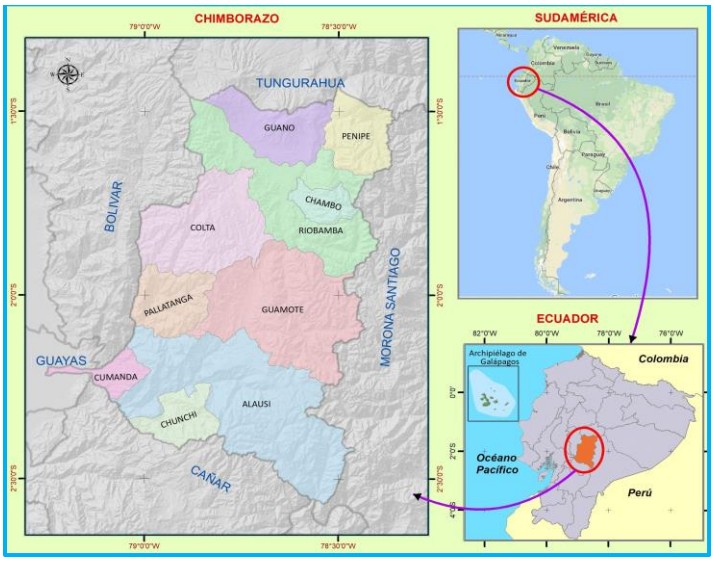
2.1. Case study area

The province of Chimborazo is located in the center south of the country, in the geographical area known as the inter-Andean region or sierra, mainly on the basin of Chambo in the northeast and the basins of

Chimbo and Chanchán in the southwest, shares limits with the province of Tungurahua to the north, Cañar and Azuay to the south, Morona Santiago to the east and Bolívar and Guayas to the west (21).

It is one of the 24 provinces in which Ecuador is divided, with an area of 6,500.66 km2, being the seventeenth province of the country by extension, the altitudinal range of the Province of Chimborazo goes from 135 m.a.s.l. to 6310 m.a.s.l. which means the presence of a wide biodiversity. (7)

Figure 1. Map of the Province of Chimborazo



2.1. Sampling technique and data collection

The valuation is carried out through the identification and quantification of ecosystem services with secondary information on land uses, water uses and use of biodiversity, followed by workshops (focus groups) following the MDP Weight Distribution Method that allows to evidence the cultural values while strengthening traditional knowledge against pressures on ecosystems on the actors in the territory, Interviews will be conducted with identified key actors (22).

Social mapping techniques were applied in the prioritized areas considering the economic valuation methods estimate the willingness to pay for an SE, incorporating direct use values, indirect use values and non-use values. But there are ecosystem services that have cultural value in terms of food security, housing, sense of cultural identity, among others, for local communities that are underestimated. In general, methodologies do not include the perceptions and preferences of local communities that benefit from ecosystems. On the other hand, it is increasingly evident that the good management of natural resources requires the active participation of local communities, direct users of

them. It is therefore essential to identify the value and importance that local communities attach to ecosystems (23).

In those areas identified in the diagnosis, social cartography will be used as a tool, so that the participants of the focus groups identify, validate and spatially locate the environmental units of the landscape, spatially situating problems and conflicts associated with them. Additionally, it seeks to map the different categories of use, or ecosystem services.

The concept of Indigenous Biocultural Heritage encompasses a wide range of other concepts from various disciplines of study and policy forums. Many of these concepts have overlapping meanings (e.g., the concept of "ecosystem services" includes "food" and "spiritual services"). This list is not exhaustive and should include all the essential and interdependent parts that make up the complex socio-ecological reality of indigenous peoples. Ecosystem services Cultural heritage such as biodiversity, traditional knowledge, landscapes Innovations, practices Territory Cultural expressions, Natural resources Spiritual values/services Genetic resources, Intellectual property, Plant varieties Customary law, Water Traditional resources, Seeds Cultural values/services Natural heritage Food (24).

The prioritization of ecosystem services for economic valuation was carried out through a workshop of experts in the area of study. It is based on the consolidated identification and quantification of the SEs and following specific criteria, the SEs that will be valued monetarily will be evaluated and prioritized. Based on the prioritization result, the monetary valuation is then made for three ecosystem services in the Province of Chimborazo: water services, carbon storage services, and scenic beauty service. The sociocultural valuation of the communities is also carried out to include values of non-use of ecosystems. This comprehensive assessment provides a comprehensive overview consistent with international recommendations for the assessment of natural capital and its ecosystem services, as set out in the IPBES report (3).

The prioritization was carried out taking into account the evaluation of three actors: (i) environmental experts from environmental institutions, (ii) communities from the different cantons (mapping and sociocultural assessment workshops) and (iii) consulting team. (i) 8 surveys were conducted with the key institutional actors of the Province

For the monetary valuation of the environmental goods and services of the forests and páramos of the Province of Chimborazo, indirect methods were used based on the expression of preferences revealed in conventional, related or substitute markets, such as: production functions, hedonic prices, the travel cost method and methods based on imputed costs (mitigation costs, prevention, substitution and avoided costs).

For this, social cartography was carried out for the identification of the SE in the different cantons of the province and it was concluded with the evaluation of their importance following the method of Distribution Method by MDP Weights with focus groups, which consisted of identifying with the communities the most important and relevant ecosystem services, these ecosystem services were transcribed in a table and valued by the focus groups; The pebble method was used with a 100% weighting. Based on social cartography, which identified, validated and spatially located ecosystem services, the sociocultural assessment of those ecosystem services identified was carried out.

3. Results and Discussion

The páramos are located in the high parts of the Ecuadorian Andes, dominated by grasslands, rose windows, shrubs, wetlands and small groves. The moors are located between the upper forest boundary and perpetual snows. It is a cold climate ecosystem and is very fragile to changes in land use, so its potential for productive use is, generally speaking, very limited. At the same time, a large downstream population is taking advantage of it indirectly, albeit substantially, especially through its water environmental service.

Table 1. Forest and páramo ecosystem coverage at the provincial level

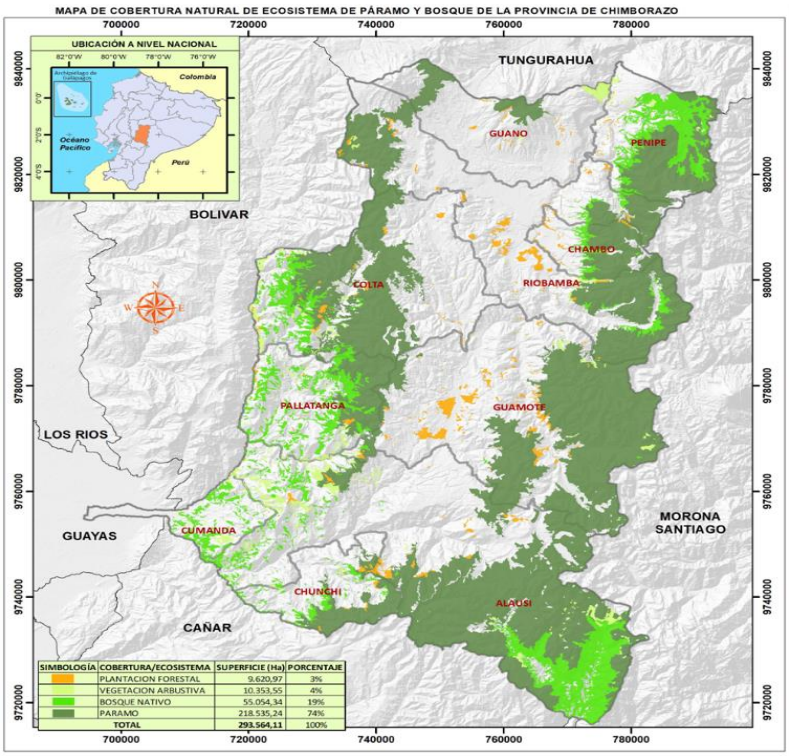
COVERAGE ECOSYSTEM	SURFACE (ha)	PERCENTAGE
FOREST PLANTATION	9.620,97	3%
SHRUB VEGETATION	10.353,55	4%
NATIVE FOREST	55.054,34	19%
PARAMO	218.535,24	74%
TOTAL	293.564,11	100%

According to Table 1, the páramo ecosystem has the largest area, 218,535.24 hectares, which represents 74% of the total ecosystems considered for this study (293,564.11 ha); while the native forest cover has an area of 55,054.34 hectares, which represents 19%; In addition, the shrub vegetation has an area of 10,353.55 ha; which represents 4%; and finally, forest plantations have an area of 9,620.97 ha, which represents 3% of the ecosystems analyzed.

The largest area is found in the cantons: Alausí (20.6%), Guamote (18.3%), Riobamba (11.1%), Colta (10.4%), and in the rest of the cantons in a lower percentage, which varies between (1.8 – 4.7); with the exception of the canton Cumandá. With respect to the native forest ecosystem, in Chimborazo, the cantons with the largest area are: Alausí (7%), Penipe (3.5%), Pallatanga (2.9%), Colta (2.2%), and in the remaining 6 cantons with a total of 3.1%, in relation to the provincial

area. The ecosystems that are found in a lower proportion at the provincial level are: shrub vegetation with approximately 4%, and forest plantation with 3%, and these percentages are distributed in all cantons.

Figure 2. Adjusted natural cover map (páramo and forest) of Chimborazo



The ecosystem services of the province of Chimborazo identified by secondary and primary information are described in Table 2.

Table 2. Ecosystem Services of the Province of Chimborazo

ECOSYSTEM SERVICES CHIMBORAZO PROVINCE		
Ecosystem Services		Description Ecosystem Services in the Province
PROVISION SERVICES	Water for consumption	From sources and mantles of water for different activities of consumption and production. The province has 1,174 inventoried catchments for agricultural use (irrigation), using a flow (Q) of 28.64 m3 / s that supplies 1,016 irrigation units of different sizes and organization. These irrigation units are organized in 760 irrigation management boards (irrigation systems), with a total of 69,649 users. With regard to the water service for consumption in the province of Chimborazo there are about 63,860 homes that have the service, of which 42,742 belong to the urban sector and 21,118 to the rural sector.

	Power generation	In the province of Chimborazo there are three infrastructures: 1) The Nizag Hydroelectric Power Plant that generates an effective power of 0.30 MW, located in the Nizag parish of the Alausí canton. 2) Alao Hydroelectric Power Plant that generates an effective power of 10.00 MW, located in the Pungalá parish of the Riobamba canton. 3) Rio Blanco Hydroelectric Power Plant, which generates an effective power of 3.0 MW, located in the Quimiag parish of the Riobamba canton. Most of the energy generated in our province comes from the Alao hydroelectric plant with 75.96%, about 20% contributes to Rio Blanco and Nizag contributes with a percentage of less than 5%.
	Agricultural crops	Province with high agricultural agricultural production. The Province of Chimborazo has an overall crop area of 151,106.66 hectares, of which 55.65% corresponds to pastures; 22.88% to potatoes, corn and beans; 16.63% to barley, quinoa,, bean, cocoa, alfalfa wheat and the rest of the products register surfaces less than 1%.
	Wildlife supply (hunting, fishing)	Currently with a certain degree of danger due to fragmentation and loss of its habitat. For commercial purposes, river trout fishing is an activity that is still present even in lagoons in the province.
	Genetic resources	The shrubs, the evergreen forest of the Páramo, the low montane evergreen forest of the Western Cordillera of the Andes and the evergreen forest of the western mountain range of the Andes are considered of importance as genetic resources that due to their extension and degree of intervention are the only seed source of species. High biodiversity of genetic resources
	Supply of flora (fibres, wood)	The endemic flora of our province is found in moors, cloud forests and shrubs, both dry and wet, which in extension are highly fragmented and therefore degraded. The ecosystems of the province are defined within a low to medium index, with secondary, regeneration or succession species.
REGULATORY SERVICES	Water purification and contaminant filtration.	The areas for the capture, infiltration and regulation of water resources that give rise to rivers and hydrographic sub-accounts such as: Chambo River, Patate River, Upano River and Yaguachi River; associated with forest and paramo vegetation cover. The elimination and processing of nutrients and organic pollutants, whether these come from anthropic activities that generate a greater impact such as agriculture and livestock since to increase productivity they add fertilizers and pesticides containing sulfates, nitrates, ammonium, etc. to the process. Polluting the soil and infiltrating the water table and generally going to discharge into external water bodies, altering the quality and characteristics of it, however thanks to the biogeochemical cycles the BOD other quality parameters are regularized, however it depends on the load of organic matter, sulfates and nitrates for this ecosystem service to be fulfilled.

	Water quality and quantity	Ecosystems filter, clean and break down chemical compounds and debris through processes in soil and subsoil and act as physical barriers against the movement of pollutants into soil and water. The availability of water in the basins and sub-basins of the province, the Yaguachi Sub-basin (Chimbo and Chanchan) has 541,223 m3/year; the Chambo Sub-basin has 557,091 m3/year; the Sub-basin of the Upano River has 220,100 m3/year. The flow contribution is for irrigation, drinking water and hydroelectric power generation.
	Slow water storage and release that controls flooding Regulation of the water table Groundwater replenishment	These ecosystem services depend on the role of land cover in regulating runoff through drainage basins. Regulation of water flow, maintenance of water table. Recharge and discharge of aquifers. Flood Control. Ecosystems influence the proportion of precipitation that infiltrates, transpires, evaporates and moves in the basins, in their speeds and volumes and therefore the recharge of aquifers, in the percolation, filtering and retention of fresh water. As an example there is the analysis of water retention that is given thanks to the existing vegetation in the moors of the micro-basin of the Chimborazo River, where for an amount of 1,571.2 hectares of pad paramo there is a retention of 2'624,432.38 m3; for 6755.7 hectares of páramo de pajonal there is a volume of 11'283,578.63 m3 of water retained (Vásconez, 2006). In this way, once retained by the vegetation, it infiltrates until it reaches underground channels, increasing the flow, generating springs or water eyes.
	CO2 capture Carbon storage (biomass)	Forest and páramo vegetation cover that captures and retains carbon dioxide. Soils with special soil characteristics that allow carbon accumulation function as carbon sinks in biomass and soils. The province has 35,953 ha in native forest for the year 2014, ranking 22nd in amount of ha (12,753,387 ha in native forest in Ecuador). Chimborazo is the province with the least hectares deforested between 2008 -2014 with 42 hectares, of the total of 47,497 hectares deforested per year throughout Ecuador.
	Physical stabilization of high parts avoiding avalanches and landslides.	This environmental service is linked to the existing geology, soil type and vegetation present in the area. In the cantons Colta and Chambo have a low level of risk for lahars; the cantons of Penipe, Guano and Riobamba have a high level of risk for lahars; however, they represent 2% of the surface of the province. The most affected sectors are on the western slope of the Tungurahua volcano on the Riobamba Baños road, on the eastern slopes of the Chimborazo volcano such as San Juan, Calpi, Riobamba, Guano, San Andrés, as well as the communities on the banks of the Chambo and Blanco rivers.

HABITAT SERVICES	Refuge of species, endemic, migratory and useful Refuge and exchange of species in biomes	The high diversity of high mountain ecosystems that offer habitat to multiple fauna and floristic species, both endemic and cosmopolitan (moors, wetlands, Andean forests, among others) Protection of fauna and floristic species in some degree of threat. 45% of the territory of the province is covered by 17 types of ecosystems, and therefore with a high biodiversity. The páramo grassland is home to 2,769 species of flora and 463 endemic species, in addition to hosting 273 species of flora in the category of threat (IUCN)
CULTURAL SERVICES	Site of tourist interest - natural heritage	The sites of tourist interest in the province are located around the protected natural areas that constitute the Sangay National Park and the Chimborazo Fauna Production Reserve. The main attractions of these areas are the snow-capped mountains and lagoons.
	Conservation of historical and cultural heritage	According to the National Institute of Cultural Heritage, as of 2015, there are 3944 movable cultural assets, 1765 immovable cultural assets and 498 intangible cultural assets in the province. The cantons of the province of Chimborazo still preserve elements of civil and religious architecture of great cultural value, such as The Cathedral of Riobamba is considered an example of the religious architecture of the sector, with a façade built with carved stones of the old city destroyed in the earthquake of 1797; The Chapel of La Moya, in Calpi dating from 200 years ago; the temple of Licto (1900), characterized by the use of living stone in its construction; The church of San Andrés (1916); the Temple of Chambo with its formal design that includes neoclassical and romantic elements; the Church of Punín that has in its vicinity remains of human beings and mastodons. The Virgen de las Nieves church of Sicalpa with its façade cataloged as superior in details to that of Balbanera (1534); the Church of San Lorenzo de Sicalpa (1900), with a neoclassical façade with its side towers designed in 1935, the Mother Church built in 1905 and its Social Rehabilitation Center recovered are some historical references in Alausí, as well as the historical importance with the "railway" considered the "most difficult railway in the world"; engineering masterpiece, whose vertical rock wall called "Devil's Nose", was the biggest obstacle in construction. In the province, there are 209 archaeological sites with vestiges associated with the Qhapaq Ñan Andean Road System and tolas of different sizes. The Puruhá, Panzaleo, Cañari and Inca civilizations were the main cultural occupations of the region. Within the Province of Chimborazo, Alausí is the canton that registers the largest number of archaeological sites (71 sites). In the Guano canton there are extensions of land with pre-Hispanic tombs that are continuously assaulted. The cultural affiliation of these tombs is unknown since since the investigations of Jijón and Caamaño

		(1929) it is reported that the area has not been studied. The site of Alacao is also an important site for its tombs rich in gold and silver. The house of Fernando Daquilema is another of the historical finds, with remains of cangagua walls in which some parts with stone cladding are still preserved. In Punín thanks to excavations a new species of mastodon and the remains of a skull called Punín Man were distinguished. Among the Intangible Heritage as uses, representations, expressions, knowledge and techniques. In addition, there is gastronomy, traditions, customs, crafts, clothing, ethnicities, history and legends. It is important to highlight the "File for the presentation of the Alausí canton before UNESCO, as a candidate for World Heritage" as one of the significant projects of provincial relevance. It highlights the Feast of the Little Devils, the Devotion to the Holy Cross, the Child's Pass, the Mass of the Rooster, the Feast of the Magi, the Jubilee of the 40 hours and the legends "Del Chusalongo", "La Loca Viuda", "El Duende" and the "Legend of the lagoons of Rocón". The practice of traditional medicine, by which "shamans", "healers", "sorcerers use elements of nature such as plants, minerals and animals, such as guinea pig, to initiate healing processes are other references of intangible heritage for the canton of Chambo, for Colta the oral expressions and all the reinterpretations made by its inhabitants are linked to historical events and the prosperous era of the Puruhá nation. The four most important festivals of the Andean culture are also part of the intangible heritage of this canton: the Pawkar Raymi; the Inti Raymi; the Koya, Kolla or Killa Raymi, Feast of the Jora; the Kapak Raymi. These festivities have a direct link with the agrofestive calendar and are celebrated exactly when the solstices and equinoxes occur. The canton Cumandá in its short analysis of intangible heritage, highlights the patron saint festivities of the Virgen de los Dolores, the Virgen de Fátima, the Virgen de la Concepción and the Fiestas del Divino Niño and San Francisco as its main intangible heritage riches. Guamote highlights the Jahuay, ritual of the harvest of wheat and barley, as one of its ancestral intangible goods. The practice of ancestral medicine is also considered a "living intangible cultural heritage"; It is practiced by healers and yachak despite the social and religious influences that threaten it. in Pallatanga highlights the "Visit of Velasco Ibarra" gastronomy as the "preparation of china with coffee past", "the preparation of morocho without sugar", "the preparation of sancocho de chancho", "the hornado with citrrayota salad" and others. In Riobamba the history of the transport of the Chimborazo ice stands out; the legend of the white girl daughter of the taita Chimborazo; the story about Isabel Grandmaison de Godín; the

		stories about Radio el Prado, the Nights of Courier and stories such as the Hunter Condor; the legend of Antun Aya; the history of the construction of the church of Cristo de Alajahuán and its miracles; the legend of the apparition of Our Lady of the Rock; the story about the battle of Tapi; the history of indigenous marriage; importance of the anthropological Guamote Carnival The intangible heritage of Chimborazo is distributed in the fields of performing arts; knowledge and uses related to nature and the universe; artisanal and traditional techniques; oral traditions and expressions; uses, rituals and festive events. (Taken from POT, 2015)

Based on these results, prioritization was carried out taking into account the evaluation of three actors: (i) institutional environmental experts, (ii) communities of the different cantons (mapping and sociocultural valuation workshops) and (iii) environmental experts. The results are detailed in Table 3.

Table 3. Prioritization of ecosystem services in the province of Chimborazo

Ecosystem Service	Importance in the Current State	Importance in the Alternative State	Importance of influence public policies
Water for consumption	3,9	4,8	**5,0**
Water regulation	3,4	4,6	**4,8**
Food – crops	3,5	4,4	**4,4**
Storage of charcoal	1,5	4,3	**3,8**
Water quality	3,0	4,3	**4,8**
Recreation and Tourism	3,0	4,3	**3,5**
Biological regulation - refuge of species habitat	3,1	4,1	**3,3**
Cultural	2,5	3,9	**3,0**
Natural medicines	2,6	3,9	**3,1**
Power source (water)	2,8	3,6	**3,6**
Erosion control	2,3	3,5	**4,6**

Proceeds Aesthetic/Inspiration, Religious	2,1	3,1	**2,8**
Provision Service Livestock	4,3	3,1	**3,1**
Fibers- hunting	**1,5**	**2,0**	**2,4**

* Average rating of the different actors from 1 to 5 (5 for greater importance)

As a result of the weighting of all uses, it is mentioned that in the current state the services of livestock provision 4.3 and water for consumption 3.9 obtained the highest valuation, while in the alternative state water for consumption 4.8 and water regulation 4.6 obtain the highest valuation coinciding with the highest values on the importance for influencing public policies. This denotes that water is an essential element today and future.

Regarding the importance of ecosystem services, according to experts, we can show in Table 4.

Table 4. Importance of ecosystem services

Importance in the current state	Importance in the alternate state	Importance of influencing public policies
PROVISION (livestock and crops)	WATER (consumption, regulation, quality)	WATER (consumption, regulation, quality)
WATER (consumption, regulation, quality)	PROVISION (livestock and crops)	EROSION CONTROL
REFUGE OF SPECIES-HABITAT	TOURISM	PROVISION (livestock and crops)
TOURISM	CARBON	CARBON

As for the importance of services, there are those of livestock provision and cultivation in the current state because they represent the primary economic activity and those of water regulation in an alternative state.

Table 5 Prioritization of ecosystem services and goods based on the WAVES criteria

	Provision (crops - livestock)	Water regulation	Water for consumption	Water quality	Species refuge	Tourism	Carbon storage
Availability of widely accepted methods for analysing the supply of ecosystem services in physical terms at the aggregate level	5	2	5	4	5	4	5
Availability of widely accepted methods for analysing the supply of ecosystem services in monetary terms at the aggregate level	5	2	5	3	3	4	5
Availability of data to measure ecosystem services in physical terms	5	2	5	2	2	3	4
Availability of data to measure ecosystem services in monetary terms	5	2	5	2	2	3	4
Possibility of generating new data on the supply of ecosystem services	1	2	2	2	2	2	2
Economic importance of the ecosystem service	4	3	5	4	4	4	4
Total	25	13	27	17	18	20	24

In this way, ecosystem services are prioritized, being the most weighted water for consumption and provision in terms of crops and livestock activity and the ecosystem service of carbon storage and the scenic beauty service in terms of Tourism.

To identify and quantitatively analyze the preferences and values that the community gives to the different covers and their ecosystem services, the Pebble Distribution Method or weighting of weights (MDP) was used. This method makes it possible to rate the importance that communities attach to coverage and their SEs by establishing relative values (25).

a. Economic valuation of water resources

The páramos have a high capacity for water regulation due to the high degree of infiltration, hydraulic conductivity and soil storage, mainly due to i) the type of soil of the Andes; and (ii) vegetation cover. The role of vegetation is primarily to protect the soil and prevent surface runoff (26)

In the province of Chimborazo the water resource is visualized as a primordial good, according to the Secretariat of Water the main uses given to water are: irrigation, human consumption, trough, fish farming, hydroelectric and scenic. (SENAGUA, 2008)

The execution of the workshops in the different communities of the cantons, were essential to determine the importance of the páramo and forests, which denoted that the water resource is one of the goods of greatest interest, since this is the center of their economic activities, therefore, it is in a constant conflict since they consider that they do not satisfy their basic needs and have poor access for agricultural activities.

The main problem focuses on the loss of ecosystems, especially moors and natural forests, due to anthropic activities; misuse of resources such as water and soil; Pollution by human waste to the springs and rivers is recurrent in all cantons, in addition climate change is reflected in the climatic variations visible in droughts, torrential rains, strong winds, frosts and hailstorms. A specific problem for the cantons of Penipe, Guamote and Alausí is the fragmentation of habitats within the Sangay National Park, while erosion affects the cantons of Guamote, Alausí, Colta and Riobamba. (27)

For the economic valuation of the water resource of the province of Chimborazo is carried out through models or valuation methods according to the users of the resource and the availability of information.

- Benefit Transfer Method (Availability to Pay)

Table 6. Water Service Valuation – DAP (1)

	USD/Ha	Irrigation Users Chimborazo Province (Ha)	Monetary valuation (USD/YEAR)
DAP (1)	12, 00	50.963	611.556

For the second model of economic valuation of the irrigation water service in the province of Chimborazo, the value of 0.75 USD / year is taken, following the average DAP found, adjusting it to prices we obtain a value of 0.75 USD to multiply it by the number of irrigation users of the province as observed

Table 7 Irrigation Water Service Valuation – DAP (2)

	USD/Year	Irrigation users (Number)	Monetary valuation (USD/USER/YEAR)
DAP (2)	0,75	69.649	52.236,75

There are then two values for the approximation to the monetary value of the water service for irrigation of the province:

$ 611,556 (USD/year) according to irrigated hectares and $ 52,236.75 (USD/year) according to irrigation users

For the valuation of the water resource for consumption, the module of human consumption is taken, where an average DAP of 0.25 USD / month was obtained, which means 3 USD per year, as observed

Table 8 Water Service Valuation Consumption – DAP (2)

	USD/year	Users consumption (number of beneficiaries)	Monetary valuation
DAP (2)	3	361.766	1.085.298

The third study - DAP (3) is carried out for the city of Riobamba (28) whose urban drinking water supply sources of the city of Riobamba, in water quality and quantity.

Table 9 Water Service Valuation – DAP (3)

	USD/year	Users consumption (number of households)	Monetary valuation
DAP (3)	45,48	90.442	4.113.302

- Market Price Valuation Method

The valuation of the water resource for consumption is also carried out with a second model according to the real prices that the community pays for the provision of the water service., as explained above, market prices when they exist for environmental goods and services, constitute the most direct way to value since they directly express the real preferences of the participants in these markets.

Table 10 Water Service Valuation – Market Prices

	Water rate (USD / m3)	Household users (beneficiaries)	Monetary valuation
RIOBAMBA (month)	1,40	50.024	840.403
REST PROVINCE (year)	1,00	68.019	68.019
	TOTAL		908.422

To make a monetary assessment of the contribution of the carbon storage service present in the forests and páramos of the province of

Chimborazo, the forest inventories and previous biomass measurements are taken as a starting point. We start from studies that qualify carbon in soil and biomass area in forest and moors, and then through valuation methodologies, approximate the economic value of carbon storage in forests and paramos of the Province of Chimborazo.

b. Determination of carbon stored in forests and moors

To carry out the analysis of the ecosystem service of carbon storage of forests, previous information was available, among the required information are the analysis of multi-temporal deforestation, and the carbon estimate. The estimation of carbon in vegetation in an area may contain: aerial biomass, underground biomass or root system (thick and thin roots), debris or dead wood and organic soil material, for which floristic surveys and forest inventories are required (29, 30). Based on statistical procedures, it is possible to estimate the aerial biomass of individuals from allometric models, scaling to hectares; Thus, from averages of aerial biomass (t/ha) by type of forest are multiplied by the area they occupy in the study area, multiplied by a factor of 0.5. Subsequently, to obtain the value per hectare in the different types of carbon equivalent forest, the factor 3.67 recommended by IPCC (2003, 2006) is used (Alde et al., 2006). For the valuation of the carbon stored in the province of Chimborazo we took four previous studies of carbon quantification:

Table 11 Carbon Stored in Forests and Páramos of the Province.

TYPE OF ECOSYSTEM	HAS	Carbon Biomass (t/ha)	Soil Carbon (t/ha)	Carbon Biomass (t)	Soil Carbon (t)	Total Carbon (t)
Andean montane evergreen forest	55.054	123,1	189,76	6.777.189	10.447.112	17.224.301
Shrub vegetation	10.354	123,1	189,76	1.274.522	1.964.690	3.239.212
Shrubby moors	29.616	159,05	471,59	4.737.143	13.966.798	18.703.941
Herbaceous	188.699	116,18	537,06	21.923.063	101.342.744	123.265.807
		TOTAL		34.711.917	127.721.343	162.433.260

Once we have the quantification of carbon in soil and biomass area in forest and moors, we expose the valuation methodologies to approximate the economic value of carbon storage in forests and stop of the Province of Chimborazo:

Table 12 Estimation of the monetary value of carbon in the Province of Chimborazo

	Total carbon ton	PRICE $/T	MONETARY VALUE USD
Chimborazo Province – Biomass	34.711.917	4,89	169.741.274
Chimborazo Province - Soil	127.721.343	4,89	624.557.369

c. Assessment of the scenic beauty service: tourism in the province of Chimborazo

The province of Chimborazo is surrounded by volcanoes, making it the province with the highest mountainous elevations in the country and in which lies its scenic beauty together with the presence of lagoons and cultural manifestations. According to data collected in the Land Use Plan, it is estimated that in the province of Chimborazo there are 269 tourist attractions, of which 53% are natural sites and 47% cultural manifestations; However, tourism in the province has not been developed and promoted in all its territories and has rather been concentrated only in the areas surrounding protected areas or tourist attractions with easy access.

The monetary valuation of the scenic beauty service, taking as a quantifiable variable the number of tourists to the Province of Chimborazo, was carried out taking as a related market value the average price charged per room in Riobamba, according to the Short-term Accommodation Survey, which is a monthly information survey, carried out on a sample of accommodation establishments registered in the Tourist Cadastre. Its objectives are to provide indicators on the behavior of the accommodation activity that serve as input for strategic decision making. According to these statistics in Riobamba the average rate per room is $ 39 - 2, and the average revenue per available / enabled room of $ 12 with an occupancy rate of 30% in 2016. The province has, according to this tourist cadastre, 163 establishments, 2,668 rooms, and 6,020. In Ecuador, tourism contributed in 2019 7.2% of GDP with $ 1,971 million dollars and according to the number of tourists would contribute $ 4,040,540 dollars to the Province of Chimborazo (31).

Table 13 Monetary Valuation Cultural Service Scenic Beauty – Tourism

Tourist Attraction	Number of tourists	Night value	Valuation (USD)
Chimborazo Fauna Production Reserve	103.0751	39,2	4.040.540
Sangay National Park	19.512	39,2	764.870
Rail – South Routes	70.396	39,2	2.759.523
Community Tourism Ventures	757	39,2	29.674
TOTAL	193.740	39,2	7.594.608

d. Valuation of provision services

Agricultural and livestock activity are the most common provision services in the province of Chimborazo, especially the pressure zones of the páramo and forest ecosystems.

According to data from SINAGAP, INEC – ESPAC, in 2016, the main items of agricultural and livestock production in the province of Chimborazo.

Table 14 Agricultural Production

PRODUCT	HARVESTED AREA HECTARIAS	TONS PRODUCED	PERFORMANCE t/ha	QUINTAL SALE PRICE (USD)	MONETARY VALUATION (USD)
POPE	7,450 ha	113.588 t	15.3 tons/ha	16,50	1.874.202
DRY SOFT CORN	5,939 ha	4.388 t	0.7 t/ha	82,50	362.010
BARLEY	5,804 ha	9.010 t	1.6 t/ha	22	198.220
FREJOL	2,945 ha	5.259 t	1.8 t/ha	41	215.619
TENDER SOFT CORN	2,292 ha	6.146 t	2,7 t/ha	20,50	125.993
HABA	1,746 ha	4.588 t	2.6 t/ha	20	91.760
WHEAT	1,608 ha	2.804 t	1.7 t/ha	19	53.276
COCOA	1,053 ha	450 t	0.4 t/ha	101,96	45.882
PEA	790 ha	994 t	1.3 t/ha	36,50	36.281

[1] Number of tourists who entered the Chimborazo Fauna Production Reserve so far in 2017. In 2016, 95800 tourists entered the year.

BROCCOLI	508 ha	6.373 t	12.5 tons/ha	0.26 kg	1.657
KIDNEY TOMATO	109 ha	4.106 t	37.5 tons/ha	6 box / 35 lb	
TREE TOMATO	28 ha	107 t	3.8 t/ha	26	2.782
		TOTAL			3.007.682

Table 15 Milk Production

PRODUCT	PRODUCTION	SALE PRICE (USD)	MONETARY VALUATION (USD)
MILK	137,454.273 liters/year	0,40 USD	54.981 USD

According to this information cited in the previous table and the one provided collected in the workshops of social cartography of the global surface of crops of the province about 55% corresponds to pastures dedicated to livestock production especially of cattle for milk production, generally the pasture areas are located in the area called foot of páramo between 3,500 and 3,700 meters above sea level and is defined as an area of high altitude crops. This area is characterized by being on the edge of the agricultural frontier, where the grasslands have been devastated.

According to (EcoCiencia and Ecopar 2008:14) the defined zone of páramo is between 3700 and 4200 meters above sea level, however, there is evidence that the agricultural frontier has exceeded that altitude, mainly due to lack of incentives for production in the lower zone, soil infertility and lack of system and technification of water for irrigation.

The second important item corresponds to 25% dedicated to the production of potatoes, corn and beans and finally the remaining 20% to other crops such as beans, barley, wheat and other products. According to information found in the Land Use Plan, the percentage of production according to Canton is as follows:

The canton Alausí after the production of pastures, is the largest producer of barley in the province, with 4,547.95 hectares; Riobamba with vegetables with 1,038.75 hectares. Colta, Guamote, Alausí, Riobamba and Guano are the largest potato producers with 10,776.18 hectares; Alausí in wheat with 1631.74 Has. Colta and Guamote produce the largest area of quinoa with 4784.77 hectares.

Cumandá has 2,920.44 ha of cocoa; Guamote and Alausí have 2,260.45 ha in; Alausí and Guamote with 1,669.86 hectares of beans; Guamote and Riobamba with 1,387.48 hectares of alfalfa. Pallatanga, Alausí, Riobamba, Guamote and Cumandá predominate with 66,670.27 hectares of pasture; Guano in white onion with 1,075.29 hectares, Colta in oats with 528.80 hectares; Pallatanga in arrears with 450.43 hectares;

Colta in melloco with 169.71 hectares; Riobamba in tree tomato and strawberry with 137.84 Has.

4. Conclusions

The province of Chimborazo is one of the provinces with the largest area of páramos in the country: 218535.24 hectares and remnants of native forest with an area of 55,054.34 hectares. This type of ecosystem of Andean black soils are rich in carbon with a high degree of biodiversity, in addition the structure of these soils, allows the infiltration and storage of water that helps the formation of springs and water holes that feed streams and rivers, for this reason the conservation of the páramos is vital for the maintenance of biodiversity and Ecosystem Services (SE) for the present and future of the province and the country, so to highlight the benefits by identifying the main ecosystem services offered by the ecosystems of forests and moors of the Province, in order to increase awareness of their importance for society, as a political element of positioning in different instances, while allowing to manage resources and policies to guarantee their characterization, Management and sustainability.

For this reason, the prioritization of food products, goods and environmental services of the páramo and forest ecosystems of the province of Chimborazo is an important tool for the management and conservation of these valuable ecosystems. The identification of the most important products for local communities and the most relevant environmental services for society in general will allow a more efficient and sustainable planning of agricultural and forestry production in the region. In addition, the negative impacts of human activities on these ecosystems, such as loss of vegetation cover, pollution and misuse of natural resources, should be considered to promote more responsible and sustainable practices in the region. In summary, the prioritization of environmental products and services is an important tool to promote the conservation of páramo and forest ecosystems and ensure their long-term sustainability.

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