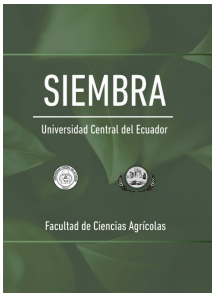
Original Article

Peasant survival strategies in high Andean agroecosystems

Estrategias campesinas de sobrevivencia en agroecosistemas alto-andinos



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Abstract

A study was conducted to identify peasant survival strategies with a systemic approach in the Chugchilán parish, Cotopaxi province, in areas at 3,000 meters above sea level. The results addressed five different zones according to their particular topography, soil types and climate; those zones are: cold peaks, low slopes of the Quilotoa volcano, high and low slopes of the western mountain range and the Toachi river basin. The strategies implemented by the farmers to cope with their vulnerability were: itinerant migration to the city to sell their labor force, agricultural production for sale (60 %) and self-consumption (40 %), and the use of traditional crops such as chocho (*Lupinus mutabilis*) for sale in the market. Other non-agricultural sources of income were also reported, such as construction, handicrafts and services related to rural tourism. Farmers' socioeconomic conditions may improve or worsen depending on the agroecosystem conditions where they are located.

Keywords: Mountain territories, *Lupinus mutabilis*, production systems, peasant economy, ecotourism.

Resumen

Se realizó un estudio para identificar las estrategias de sobrevivencia campesina con enfoque sistémico en la parroquia Chugchilán, provincia de Cotopaxi, en áreas a 3.000 m.s.n.m. Los resultados abordaron cinco zonas diferentes de acuerdo a su particular topografía, tipos de suelo y clima; las zonas son: cumbres frías, faldas bajas del volcán Quilotoa, laderas altas y bajas de la cordillera occidental y la cuenca del río Toachi. Las estrategias implementadas por los campesinos para hacer frente a su vulnerabilidad fueron: migración itinerante a la ciudad para vender su fuerza de trabajo, producción agrícola para la venta (60 %) y el autoconsumo (40 %), y el uso de cultivos tradicionales como el chocho (*Lupinus mutabilis*) para la venta en el mercado. Se reportaron también otras fuentes de ingresos no agrícolas como la construcción, la artesanía y los servicios relacionados con el turismo rural. Las condiciones socioeconómicas de los agricultores pueden mejorar o empeorar dependiendo de las condiciones del agroecosistema donde se encuentren.

Palabras clave: Territorios de montaña, *Lupinus mutabilis*, sistemas de producción, economía campesina, ecoturismo.

1. Introduction

The Andes constitute a vast territory that encompasses countries such as Venezuela, Colombia, Ecuador, Bolivia, Peru, Argentina and Chile. Its conformation has originated a diversity of ecosystems, life zones, characterized by an important biological diversity and environmental history specific to each area (Deza Rivasplata & Delgado de la Flor Badaracco, 2018).

Among the Andean territories, high altitude zones or high mountain ecosystems stand out. Located in areas with a great diversity of climates, plant and animal species, these high altitude zones are strategic for several ecosystem services such as food generation, ecotourism, carbon storage, provision of water resources to low-lying areas, among others (Mena Vásconez & Hofstede, 2006); nonetheless, they also present conditions of complexity and fragility (Amat & León Chávez, 2012). Indeed, these fragile areas have many limitations on their use (Hofstede, 2004) due to adverse environmental conditions such as strong winds, very low temperatures, intense solar irradiation in the mornings, and susceptibility to erosion due to their topography, which limit the development of agricultural activities (Loza Paz, 2008). However, the constant pressure for access to farmland has led to the advance of the agricultural frontier, and the transformation of these areas into crop fields, pastures and human settlements (Ruiz et al., 2015).

Several studies conducted in the Andean region show the transformation processes suffered by these spaces (Ruiz et al., 2015), the unfavorable economic conditions of their inhabitants (Avellaneda-Torres et al., 2014), and the fragile conditions in which peasant production develops due to climatic factors (Loza Paz, 2008; Pérez et al., 2010).

In Ecuador, also, several investigations have reflected processes of deterioration of these areas (Torres Celi, 2014), conditions of vulnerability and poverty of the peasant population, especially indigenous population (Chiriboga & Wallis, 2010), and, in the specific case of *Páramo* (the Andean moorlands) of the Cotopaxi province, a drastic reduction of natural vegetation (Terán, 2007), and an incompatibility of use emerging between the natural aptitude of the soil and the agricultural activities carried out (Nieto et al., 2017), which aggravate the vulnerability of the peasantry inhabiting these areas.

The emphasis of the studies conducted in these high Andean areas has been highlight the unfavorable circumstances for the living conditions of the peasant population and the development of agriculture. However, it is important to specify the factors that aggravate or favor resilience in the face of these conditions and, above all, the strategies adopted by families in order to continue carrying out their productive activities in these fragile areas, taking into consideration the great diversity of situations to be found in these territories.

Within this framework, this study took the Chugchilán parish as the scenario for analysis: a high Andean territory located in the province of Cotopaxi, specifically in the western mountain range of the Ecuadorian Andes. This space presents an area of 24,875 ha (GAD Municipal Sigchos, 2015), where it is possible to identify a diversity of particularities (various types of climate, irregular topography, limited presence of water sources for irrigation, valorization of traditional crops, development of ecotourism, among others), that influence the conditions faced by peasant agriculture in the high Andean zones.

The objective of the research was to identify the diversity of geographical conditions faced by families in the high Andean zone of Chugchilán and, based on this, to characterize their production systems, highlighting operating logics and survival strategies. Specifically, we identified the diversity of territorial agroecosystems, or homogeneous agroecological zones, the main characteristics and agrarian landscapes resulting from the interaction of ecosystems with humans, the activities developed by producers to cope with the particularities of these areas, and the socioeconomic conditions of the families according to the productive systems implemented, and the geographic location within the territory. These elements constitute guidelines for understanding the diversity of situations faced by the social conglomerate in the high Andean zones, and for advancing proposals to improve the conditions of peasant agriculture in these territories.

2. Materials and Methods

The study was conducted in the Chugchilán parish, in the western highlands of the Cotopaxi province (Figure 1). This area is characterized by being located at an altitude above 3,000 m a.s.l., with a cold climate and an irregular relief due to the presence of the Andes. The area of analysis was divided into two zones in order to cover most of the territory, and to contrast the conditions in which the farmers find themselves. Thus, two scenarios were analyzed: (i) northeastern communities, located in *páramo* areas with higher humidity, areas with

steep slopes, and small areas with gentle relief: and, (ii) southeastern communities, located in *páramo* areas with lower humidity or dry character, strong relief and flat areas with a strong influence of its soils, sandy and with low water retention, caused by the eruption of the Quilotoa volcano over 700 years ago. In both cases, the methodology, study variables and instruments were similar, in addition to being conducted at the same time.

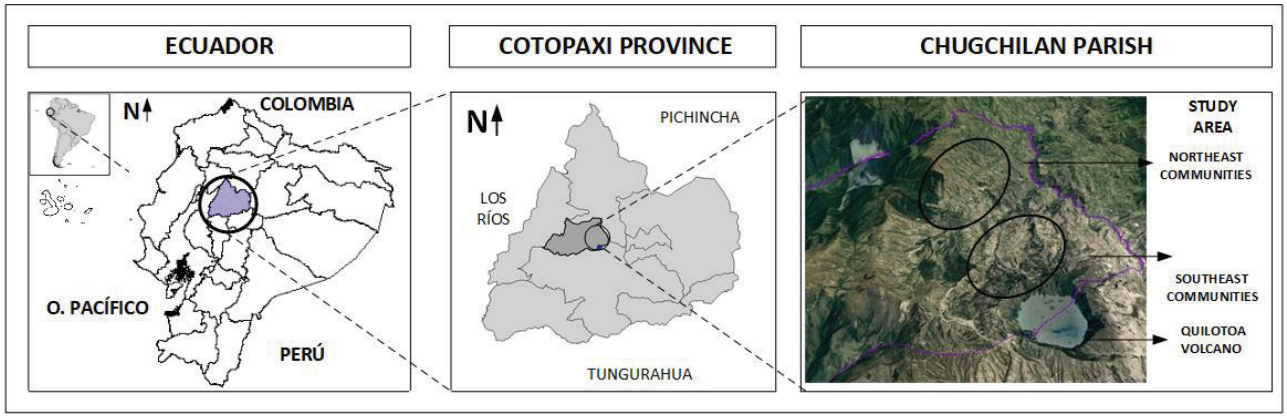

Figure 1. Location of the study area, Chugchilán parish.

The research was conducted considering the methodological principles for the study of agrarian systems, and production systems proposed by Apollín and Eberhart (1999) and Cochet et al. (2002). This approach allowed to analyze the parish from an integral perspective, and to know in-depth the reality that emerging within both territories.

Sequentially, the following stages were considered:

2.1. Agroecological zoning

This stage was aimed at identifying the diversity of scenarios and realities of agriculture in the high Andean zone of Chugchilán, and to establishing agrarian landscape units as a result of the valorization of the environment. For this purpose, it was essential to carry out an analysis and superimposition of thematic cartography of the area, analysis of aerial photography, tours throughout the area, and interviews with people familiar with the reality of each sector. Subsequently, the diversity of spaces was translated in a typology of territorial agro-ecosystems and agrarian landscapes through the use of GIS software.

2.2. Identification of peasant production systems, construction of a pretypology of producers and elaboration of case studies

Taking into consideration the construction of a preliminary typology of producers based on the analysis of the agrarian landscape and interviews with key actors such as community leaders and technicians from institutions present in the territory. Interviews were conducted with farmers on the farms through case studies. For this purpose, it was essential to use a structured format, that considered aspects such as availability and destination of family labor, access to and tenure of land, crops, livestock, availability of equipment and tools, origin of other family income, among other aspects. A total of about 100 case studies were carried out with producers in the two territories of the parish (Table 1), and the survey of each study lasted approximately one hour.

2.3. Characterization of production systems and construction of a definitive typology

In order to demonstrate the diversity of production systems and the different particularities that can be identified in the territory under analysis, based on the results emerging from the case studies, a definitive typology of producers was proposed. For this purpose, we used three differentiation criteria: 1. size of the farm, 2. productive orientation, and 3. geographic location according to the division of the communities (Table 2).

Table 1. Cases studies carried out in the high Andean zone of Chugchilán.

Study Area	Communities	Reference population	Number of case studies conducted
Northeastern communities	Chinalo alto	116 families	15
	Rodeo, Guantug, Tonducto		11
	Chinalo bajo, Chasualó		10
	Itualó, Sigue		7
Subtotal			**43**
Southeastern communities	Pilapuchín	262 families	9
	Chaupi, Guayama San Pedro, Guayama Grande, La Moya		22
	La Moya, Cuisana, Shiñacunga, Moreta		16
	Moreta, Cóndor Ucto		7
Subtotal			**54**
Total			**97**

Table 2. Differentiation criteria for the construction of producer typologies.

1. Property size	2. Productive orientation	3. Location
< 2 ha	Increased focus on livestock	Northeastern communities
2,1 a 5,1 ha	Increased crop orientation	Southeastern communities
5,1 a 10,1 ha	Diversified (crops and livestock)	
> 10,1 ha	Tourism-related services	

2.4. Determination of the agro-socioeconomic reality and identification of farmer strategies

The case studies provided the information necessary to estimate the generation of Gross Product [GP] on a family farm and its destination (sale and/or self-consumption), land productivity or Net Value Added [NVA], family farm income [FFI], and the strategies linked to obtaining other sources of remuneration.

For the socioeconomic characterization, the generation of economic indicators was contemplated through a calculation methodology (Figure 2).

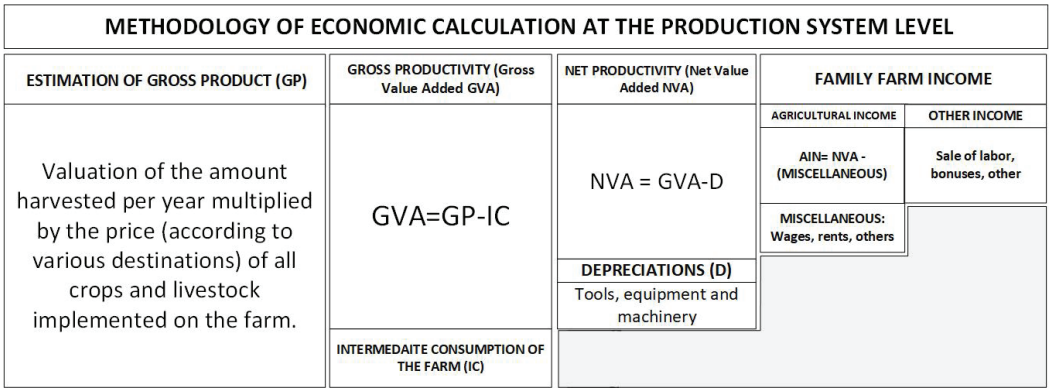

Figure 2. Reference framework for socioeconomic characterization at the farm level

2.5. Determination of the influence of agroecological conditions on peasant production systems

Based on the incorporation of an additional criterion for the differentiation of producers, "geographic location", we proposed an expanded typology, by contrasting with the conditions faced by farmers according to the agro-ecological zone area of productive activities implementation.

3. Results

3.1. The high Andean territory, an area with diverse agro-ecosystems

In the high Andean zone of Chugchilán it is possible to identify different areas with particular characteristics in relation to climate, greater or lesser susceptibility to erosion, soil type, predominance of a certain type of crop or breeding, among other aspects. Each of these spaces is associated with the valorization forms of a given local ecosystem by a population group over time; therefore, they can be categorized as agroecological zones, or agroecosystems from a territorial perspective. Globally, five scenarios were identified in which farmers implement their activities: (A) cold peaks of the mountain range; (B) lower flanks of volcanic structures (volcanic strata of the Quilotoa); (C) upper slopes of the Toachi river basin; (D) lower slopes and reliefs of the Toachi river basin; and (E) bottoms of the Toachi river basin

i) **Cold peaks of the mountain range (Zone A):** These areas are located on the mountain peaks, at an altitude above 3,400 meters above sea level, and their main characteristic is the cold climate. These areas can be identified in the northeastern and southeastern communities with contrasting conditions. While in the northern zone, the humid *páramo* has been largely replaced by pastures for cattle raising and short-cycle crops, in the southern part, the dry character of the ecosystem and its fragility is more evident, accompanied by the existence of natural vegetation such as *páramo* thatch (Stipa ichu), and valorization through sheep raising and the implementation of short-cycle crops (Figure 3).

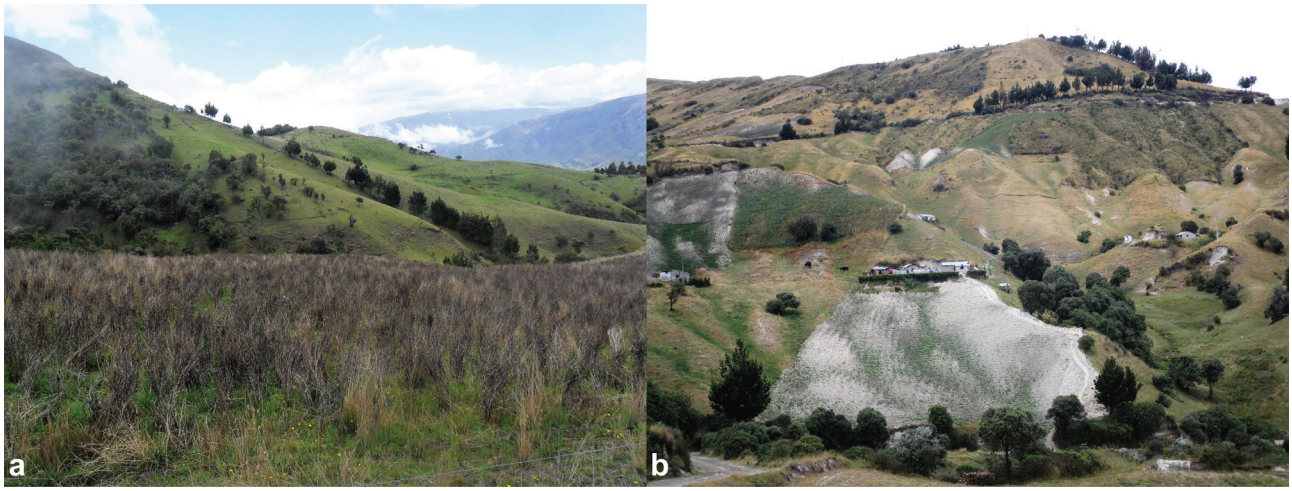

Figure 3. Colds peaks of the mountain range, Chugchilán parish: a. Chinalo Alto, northeastern area, b. Condoructo south-eastern area.

ii) **Lower flanks of volcanic structures (volcanic strata of the Quilotoa-Zone B):** These areas are located on the slopes of the Quilotoa volcano at an altitude between 3,000 and 3,400 m a.s.l. The topography is irregular at higher elevations and smooth at the base, where the predominance of soils with low moisture retention, and the presence of stones (gravel) is notable (Figure 4). Production is characterized by the development of short-cycle crops and the raising of small livestock, mainly sheep and guinea pigs.

Figure 4. Volcanic strata of Quilotoa, Chugchilán parish: a. Quilotoa volcano, b. Guayama, c. Chaupi.

iii) **Upper watershed of the Toachi river basin (Zone C):** Characterized by steep gradient (Figure 5), as they are located on the inner slopes of the western cordillera, at an altitude between 3,000 and 3,400 meters above sea level. This area is characterized by a dynamic linked to the development of short-cycle crops and the raising of large and small animals.

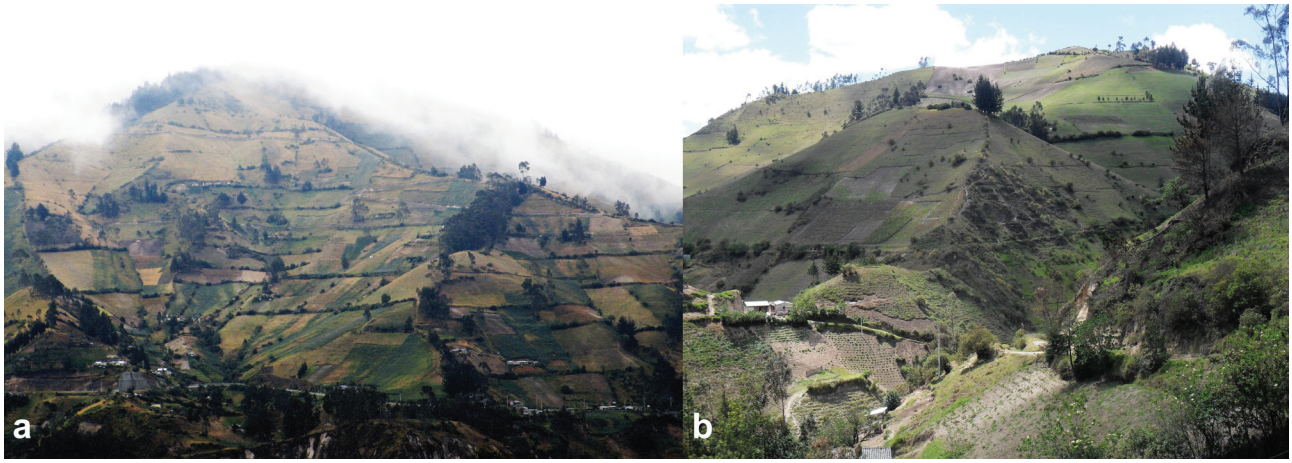

Figure 5. Upper watersheds of the Toachi river basin, Chugchilán parish: a. Tonducto, b. Guantug.

iv) **Watersheds and lower reliefs of the Toachi river basin (Zone D):** This is a strip of land located in the central-northern part of the parish, in the lowlands, at an altitude of approximately 3,000 m a.s.l. It is characterized by areas with moderate relief and a less cold climate (Figure 6). Short-cycle crops, and large and small animals livestock are the main activities of the sector.

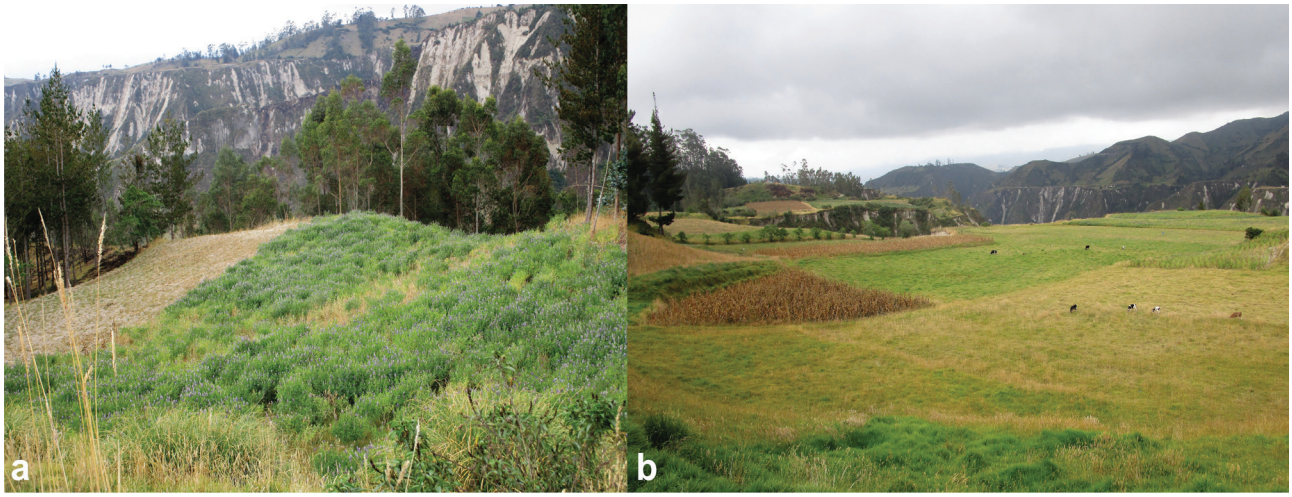

Figure 6. Watersheds and lower reliefs of the Toachi river basin, Chugchilán parish: a. Sigue, b. Chasualó.

v) **Toachi river basin bottoms (Zone E):** This is a strip of land located in the lower parts of the parish, mainly along the course of the Toachi River and its tributaries (Figure 7). This is an area with production limitations in some communities. It is possible to identify areas with agricultural activity and access to irrigation in small natural terraces at the bottom of the watershed (north of the parish), and areas with limited or no agricultural activity due to steep inclines (northern and southern sections of the parish).

Finally, it should be noted that within each of these areas, different agrarian landscapes were observed, reflecting the diversity of situations that can be found in this high Andean territory. Figure 8 shows the territorial diversity identified within the agroecological zones and agrarian landscapes

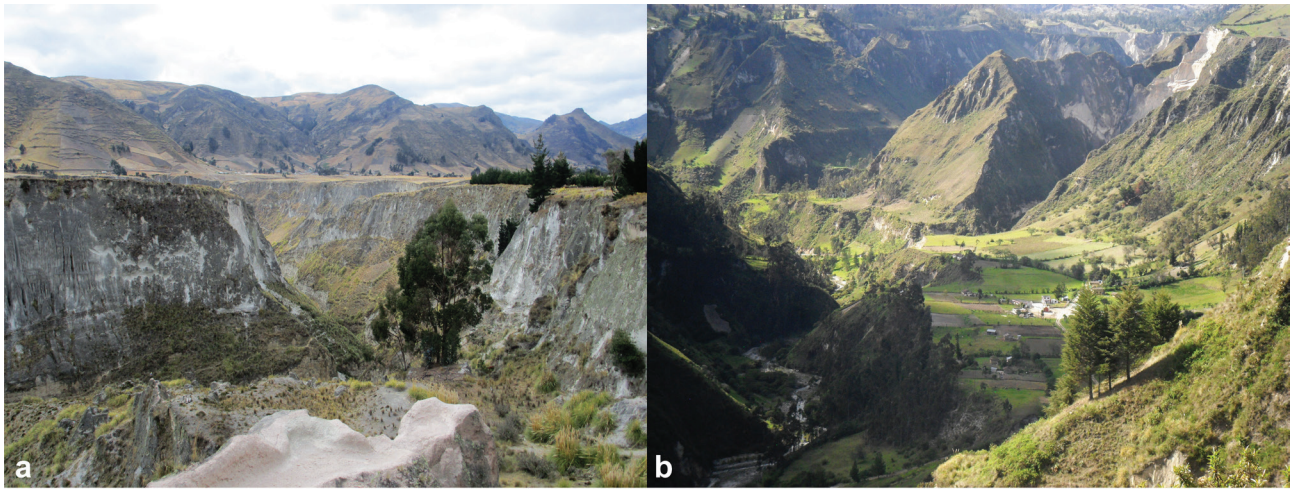

Figure 7. Toachi river basin bottoms: a. Toachi river canyon, Zumbahua parish, b. Itualó, Chugchilán parish.

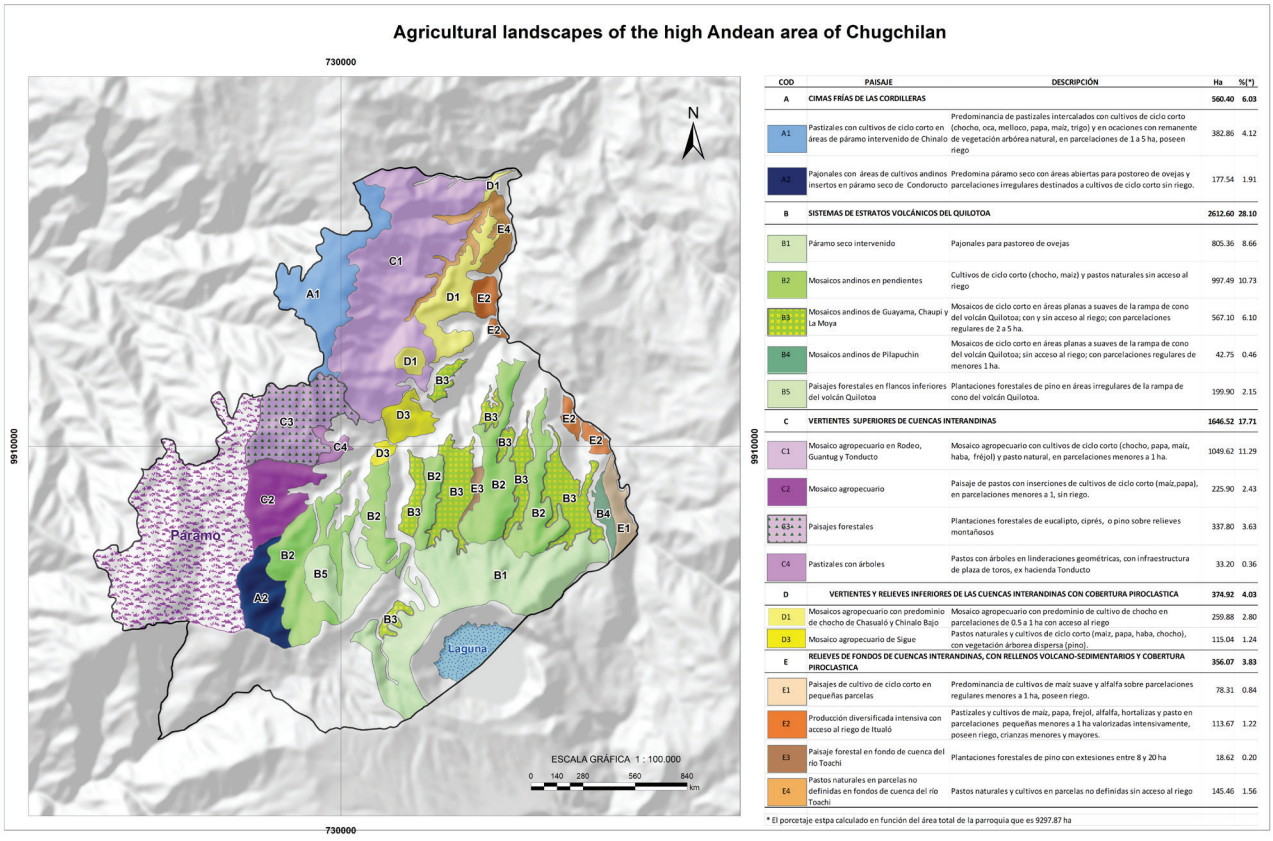

Figure 8. Agroecosystems and agrarian landscapes of the high Andean zone of Chugchilán.

3.2. Characterization of production systems by type of producer

In general, four types of producers were identified: (i) livestock farmers in the northeastern communities (N-or.); (ii) diversified farmers in the northeastern communities (N-or.); (iii) diversified farmers in the southeastern communities (S-or.); and (iv) family microenterprises related to tourism services (Table 3). While livestock systems are exclusive to the northeastern communities, the implementation of diversified systems is present in both areas of analysis. Additionally, one aspect that differentiates the zones is the implementation of livestock raising. While in the humid *páramo* (northeast) the vegetation was replaced by pastures for livestock and short-cycle crops, in the southeastern communities there are areas of grasslands valued mainly for extensive sheep raising.

Table 3. Types of producers identified, high Andean zone of Chugchilán.

Types of producers	Productive orientation (productive system)
Livestock farmers in northeastern communities (N-or.)	Cattle ranching in pastures that supplanted *páramo* vegetation. In addition, implementation of short-cycle crops (including chocho).
Diversified farmers from northeastern communities (N-or.)	Production of short-cycle crops (including chocho), and major livestock such as cattle and minor livestock such as guinea pigs, chickens and, to a lesser extent, sheep.
Diversified farmers from southeastern communities (S-or.)	Production of short-cycle crops (including chocho), and small livestock such as guinea pigs and cattle. In addition, sheep are raised in *páramo* areas.
Tourism micro-entrepreneurs with crops and breeding (N-or.)	Their main activity is tourism and lodging; however, in order to take a dvantage of their access to the land, they value it with large-scale farming and short-cycle crops such as chochocho.

Access to land presents similarities and contrasts in the two zones. In both areas there are families with less/more access to land, as in the case of cattle raising systems in the northeastern communities, and intensive diversified systems in the southeastern communities (Table 4).

Table 4. Typologies of identified producers, high Andean zone of Chugchilán.

Productive orientation	Total (x)		Own		Leasehold		Shared Leasehold	
	ha	%	ha	%	ha	%	ha	%
Livestock (N-or.)	6,4	100,0	4,3	68,1	2,0	31,1	0,1	0,8
Diversified (N-or.)	3,6	100,0	2,4	66,5	1,0	28,7	0,2	4,8
Diversified (S-or.)	6,2	100,0	6,0	97,6	0,2	2,4	0,0	0,0
Tourism micro-entrepreneur with crops and livestock (N-or.)	23,0	100,0	23,0	100,0	0,0	0,0	0,0	0,0

Most tenure is of an ownership nature in the two areas of analysis; however, the logic of leasing plots of land -mainly pasture for livestock-, is more common among producers located in the north and, to a lesser extent, in the south. Other forms of tenure, such as "*al partir*" (Shared Leasehol), can be identified in the northern territories of Chugchilán. The greatest access begins to be found among recent settlers in the central part of the parish, where -in addition to providing services related to rural tourism (lodging)-, they own land in the highlands for agricultural activities.

Throughout the high Andean zone of Chugchilán, it is possible to identify several types of land use that denote a tendency towards diversification of production; however, there are some differences between the two study zones. In the northeastern communities there is a greater orientation towards the production of larger species through the valorization of pastures, as in the case of livestock systems and diversified systems that implement them in about 50 to 90 % of the total area of the farm; while for the diversified farmers in the south, the greater percentage of the land is oriented towards short cycle crops, alfalfa (*Medicago sativa*) for raising small animals such as guinea pigs and *páramo* areas for raising sheep (Table 5). A common aspect among diversified producers in both localities is the planting of chocho (*Lupinus mutabilis*), which represents 15 to 30 % of the total area of the Agricultural Production Units [UPAs].

The trend described above is related to the greater or lesser number of animals that the production systems have according to their location in the parish. In the case of producers in the northeast, major species such as cattle and minor species such as guinea pigs represent about 60 % of the animals on the farm, while for diversified production systems in the south, sheep and guinea pigs have a greater weight within the UPAs, about 80 % (Table 6).

Table 5. Land use, high-Andean zone of Chugchilán.

Productive orientation	Total (x)	Chocho		Other short cycle*		Cattle pasture		*Páramo*		Grass sp. minor	
	ha	ha	%	ha	%	ha	%	ha	%	ha	%
Livestock (N-or.)	6,4	0,2	3,6	0,5	7,2	5,7	89,2	0,0	0,0	0,0	0,0
Diversified (N-or.)	3,6	0,5	15,3	1,0	28,8	2,0	55,8	0,0	0,0	0,0	0,0
Diversified (S-or.)	6.2	1,7	23,1	1,7	22,4	0,2	3,2	1,2	24,3	1,6	27,2
Tourism micro-entrepreneur (N-or.)	23,0	7,6	33,1	1,0	4,4	14,4	62,5	0,0	0,0	0,0	0,0

* corn (*Zea mays*), potatoes (*Solanum tuberosum*), beans (*Vicia faba*), others.

Tabla 6. Tipos de crianzas implementadas por campesinos, zona alto-andina de Chugchilán.
Table 6. *Types of farming implemented by peasants, high-Andean zone of Chugchilán..*

Productive orientation	Total	Cattle		Sheep		Chickens		Guinea pigs		Others	
		n	%	n	%	n	%	n	%	n	%
Livestock (N-or.)	18	7	36,0	3	17,0	3	14,0	6	25,0	2	8,0
Diversified (N-or.)	27	4	13,0	3	11,0	9	32,0	12	43,0	0	0,0
Diversified (S-or.)	59	4	7,0	13	21,0	7	11,0	33	56,0	3	5,0
Tourism micro-entrepreneur	20	20	100,0	0	0,0	0	0,0	0	0,0	0	0,0

3.3. Peasant survival strategies implemented in the high Andean zone of Chugchilán

3.3.1. Agriculture, itinerant migration and the search for non-agricultural employment beyond the limits of the territory

Most peasant systems use family labor to work on their farms (Table 7). However, at least one member of each category (generally the father) is active in the labor market. Despite this trend, there were differences related to the type of activity carried out by the farmers. While livestock and diversified farmers in both zones mainly develop activities related to construction outside their communities in an itinerant manner (they migrate to the cities for short and constant periods during the year, between 70 and 100 days per year^{-1}); diversified farmers in the southeastern communities may also be linked to the production of handicrafts and artisanal handicrafts. This particularity is mainly influenced by their proximity to the Quilotoa volcano, the main tourist attraction of this high Andean zone.

Table 7. Availability and destination of family labor, high-Andean zone of Chugchilán

Productive orientation	UTF* Total	Days (d)	On farm			Off farm			
			UTF*	d year^{-1}	%	UTF*	d year^{-1}	%	Activity
Livestock (N-or.)	3,6	792,0	3,3	715,0	90,3	0,4	77,0	9,7	Construction workers
Diversified (N-or.)	4,1	897,6	3,4	748,0	82,9	0,7	149,6	17,1	Construction workers
Diversified (S-or.)	3,6	794	3,2	705	88,7	0,4	89	11,3	Construction/craft workers
Tourism micro-entrepreneur	2,2	484,0	0,4	88,0	18,2	1,8	396,0	81,8	Tourist activity

* UTF: Family labor units.(*Unidades de trabajo familiar*)

A particular case is the category of family tourism micro-entrepreneur, which allocates the highest percentage of labor to non-agricultural activities, such as services related to lodging and tourism, because its center of activity is in Chugchilán, and it is influenced by the attraction offered by the Quilotoa volcano.

The number of family members in suitable conditions for agricultural work (active age) varies between five and seven people; and the age of the heads of household in the peasant systems is between 40 and 50 years old (Table 8). In addition, the kinship nucleus is characterized by having between two and five children of working age (Table 8).

Table 8. Working-age family members, high Andean zone of Chugchilán.

Productive orientation	Members per family	Parents		Children	
		N	Age (x)	N	Aged (x)
Livestock (N-or.)	6	2	44	4	10
Diversified (N-or.)	7	2	44	5	14
Diversified (S-or.)	5	2	48	3	17
Tourism micro-entrepreneur	5	2	80	3	35

3.3.2. The relative balance between sales logic and self-consumption

The generation of value, measured through the Gross Product (GP) of the farm in the year and the orientation of production, show fluctuations among the families of the high Andean communities of Chugchilán. While there was a tendency for farmers in the northeastern communities to focus on the market a bigger part of the farm generated items, between 75 and 92 %; diversified producers in the southeastern communities use it with a certain balance for sale and self-consumption on the farm, either as food for the family, animal consumption and seed supply for new plantings (Table 9). The differences are largely due to the proximity to markets, access roads and implementation of more market-oriented crops such as milk, vegetables and fruits in some production systems in the north. Despite the differences found, we can highlight that, in diversified farming systems, on average, there is a relative balance between the logic of production for the market, with about 60 %, and on-farm self-consumption with 40 %.

Table 9. Generation and destination of the farmers' gross product, high-Andean zone of Chugchilán.

Productive orientation	Surface (ha)	GP Total		GP Sale		GP self-consumption *	
		USD year^{-1}	%	USD year^{-1}	%	USD year^{-1}	%
Livestock (N-or.)	6,4	4.288,7	100	3.804,2	88,7	484,5	11,3
Diversified (N-or.)	3,5	4.046,4	100	3.003,9	74,2	1.042,5	25,8
Diversified (S-or.)	6,2	4.144,8	100	1.744,9	42,1	2.399,9	57,9
Tourism micro-entrepreneur	23,0	5.196,7	100	4.768,2	91,8	428,5	8,2

***** Household consumption, animal and seed for new cycle.

3.3.3. Valorization of traditional species: chocho cultivation

The promotion and valorization of traditional crops from high Andean areas, such as chocho, also known as tarwi (*Lupinus mutabilis*), is becoming progressively more important due to its high protein and fatty acid content (Basantes Morales, 2015; Canahua and Román, 2016; Chirinos-Arias, 2015); in addition to the increase in consumption within the country in recent years (Mercado, 2018), and the increase in exports to international markets (Llangari Yaguachi, 2017; Yumbla Mantilla, 2006).

In Chugchilán, this species has become more relevant since the promotion of its planting and commercialization by external actors since the 2010s, in order to improve peasant conditions in high altitude areas. Indeed,

this species currently makes an important contribution to family incomes with some nuances. In livestock systems, chocho and other short-cycle crops contribute 26 % of the agricultural income [AIn] of the families; while livestock represents about 73 % (Table 10). This tendency differs in diversified systems; in all cases, both in the northeastern and southeastern communities, this species contributes around 40 % of the AIn, which shows the importance of this item for the farmers. However, the contribution of other crops (potato, maize, beans, among others) and livestock (cattle, sheep and guinea pigs) to family livelihoods is also evident. A particular case is the tourist micro-entrepreneur type, where chocho represents about 90 % of agricultural income due to the larger area planted with this species in the production system.

Table 10. Contribution of chocho (*Lupinus mutabilis*) cultivation to the household economy, high-Andean zone of Chugchilán.

Productive orientation	TOTAL AIn	AIn Chochos		AIn other crops		AIn breedings?	
	USD year^{-1}	USD year^{-1}	%	USD year^{-1}	%	USD year^{-1}	%
Livestock (N-or.)	3.435,8	554,5	16,1	358,4	10,4	2.522,9	73,4
Diversified (N-or.)	3.304,9	1.353,0	40,9	902,5	27,3	1.049,5	31,8
Diversified (S-or.)	2.331,0	1.016,0	43,6	840,0	36,0	476,0	20,4
Tourism micro-entrepreneur	3.767,7	3.411,5	90,5	16,4	0,4	339,8	9,0

3.3.4. Dependence on other non-agricultural sources of income

Despite the farmers' orientation towards livestock production, the implementation of diversified systems and the valorization of traditional species such as chocho, these strategies are not sufficient for the farmers in the high Andean zone of Chugchilán to subsist solely from agricultural activities. Consequently, they have to find other sources of income to support their families. In fact, all farmers depend on other sources of income for about 40 to 87 % of their income, which shows the importance of income alternatives in these areas (Table 11). However, there are substantial differences in relation to their origin (Table 12). While the peasant systems depend on salaries obtained even when working outside their territory and the province, representing between 40 and 50 % of other income [OI], and the social bonus granted by the State, which can even reach 60 % of non-agricultural sources, only the case of the family microenterprise obtains income related to rural tourism (mainly lodging services in areas near the Quilotoa volcano).

Table 11. Importance of other remunerations in farmer´s family income, high-Andean zone of Chugchilán.

Productive orientation	Total Income [TI]		AIn		OI	
	USD	%	USD	%	USD	%
Livestock (N-or.)	5.386,8	100	3.235,8	60,1	2.151,0	39,9
Diversified (N-or.)	6.728,7	100	3.304,9	49,1	3.423,3	50,9
Diversified (S-or.)	4.366,6	100	2.331,0	53,4	2.035,6	46,6
Tourism micro-entrepreneur	30.912,0	100	3.767,7	12,2	27.144,0	87,8

Table 12. Composition of producers' Other Income (OI), high-Andean zone of Chugchilán.

Productive orientation	OI	Social Bonus		Wage Activity		Tourism Activities		Remittances	
	USD	USD	%	USD	%	USD	%	USD	%
Livestock (N-or.)	2.151	1.304	60,63	847	39,38	0	0,00	0	0,00
Diversified (N-or.)	3.423	1.487	43,43	1.907	55,70	0	0,00	31	0,89
Diversified (S-or.)	2.036	600	29,48	1.436	70,52	0	0,00	0	0,00
Tourism micro-entrepreneur	27.144	0	0,00	0	0,00	27.144	100,00	0	0,00

3.4. Influence of the agroecological environment on peasant conditions.

The high Andean production systems of Chugchilán are influenced by a diverse agroecological environment such as: (i) cold climate in the highest areas or also called cold peaks that influences the development of certain plant species; (ii) steep slopes in areas of declivity of the mountain range and consequent susceptibility to soil erosion; (iii) soil with abundant stones (gravel) with limited water storage and high infiltration rates, as is the case of the lower flanks of the Quilotoa volcano; (iv) strong winds that cause erosion and soil moisture loss; and (v) limited availability of water sources for irrigation, particularly in the case of a dry *páramo* ecosystem (with emphasis on the southeastern communities).

The existing agroecological environment influences both the productivity generated by production systems and household income. Wealth, land use efficiency, land productivity or Net Value Added [NVA], varies according to the location of the production systems. In the cold peaks, in general, the lowest productivity per hectare was identified, both in livestock systems in the northeastern communities and in diversified systems in the south under extreme conditions. In the case of the slopes or foothills of the mountain range (areas with steep slopes), the lower relief of the Toachi river basin (moderate to flat relief), and the volcanic stratum of the Quilotoa (soils with abundant stones and low water retention), the figures show greater homogeneity, and the values generated by diversified systems are between 1,000 and 1,500 USD ha^{-1} $year^{-1}$. A particular case is the micro-enterprise system, where extensive livestock activity yields the lowest land use efficiency, below 500 USD ha^{-1} $year^{-1}$.

In relation to agricultural income, the effect of agroecological conditions also has a significant influence (Table 13). In the case of diversified farmers, despite implementing production systems with a similar logic, economic results vary according to their location. In the cold peaks, agricultural incomes below five dollars can be identified; even less than one dollar in cases where there are more family members and they are located in extreme natural conditions. Farmers located in the lower elevations of the Toachi river basin (flat to undulating areas and, in some cases, with access to irrigation), are those who obtain the highest agricultural income per day of work, around six dollars per day^{-1}. In contrast, in the volcanic strata of Quilotoa, there is evidence of the vulnerability of the population, with incomes below three dollars; however, there are cases of producers also categorized as high Andean shepherds (due to their sheep-raising activity in the *páramo*), who manage to obtain higher remuneration for the contribution of this activity. In general, the farming systems identified in both zones obtain an agricultural remuneration of less than six dollars, while the total daily income fluctuates between two and eight dollars.

Table 13. Farmers' productivity and income based on the agroecosystems identified, high-Andean zone of Chugchilán.

S. de P. Campesinos	Average Surface (ha)	NVA ha^{-1} (USD ha^{-1} $year^{-1}$)	AIn $día^{-1}$ (USD $year^{-1}$)	TI $día^{-1}$ (USD $year^{-1}$)
1. Cold-top cattle ranchers (N-or.)	6,4	582,2	4,8	5,8
2. Diversified cold-top diversified (S-or.)	5,1	131,1	0,5	1,7
3. Diversified of upper slopes (N-or.)	4.3	1.024,4	3,4	5,2
4. Diversified on volcanic strata of the Quilotoa (S-or.)	3,0	1.120,0	2,3	4,8
5. Diversified on lower reliefs (N-or.)	4,4	976,1	5,6	7,5
6. High Andean pastoralists (diversified) on volcanic strata of the Quilotoa (S-or.)	3,2	1.502,5	5,4	4,5
7. Tourist businessman with major crops and livestock (N-or.)	23	201,5	42,8	63,9

4. Discussion

In the high Andean zone of Chugchilán it is possible to identify different areas characterized by a particular type of climate and topography, susceptibility to soil erosion, greater or lesser development of agricultural activity, among other relevant aspects. Associated with the identified territories, there are several agrarian landscapes and productive dynamics, such as cattle ranching activities on the cold peaks in the northern zone,

the valorization of natural vegetation by raising sheep in the dry *páramo* of the southern communities, and areas for the development of short-cycle crops and large and small animals livestock raising on the lower flanks of the volcanic structures, slopes, lower reliefs, and bottoms of the Toachi river basin. In this perspective, several studies conducted in high altitude territories also highlight their complexity as a characteristic feature of these areas, evidencing the existence of several landscapes and natural ecosystems (Suárez et al., 2022; Suárez-Robalino et al., 2023), as well as a significant diversity of flora and fauna (Alvear et al., 2010; Barros et al., 2023; Biganzoli, 2022; Romoleroux et al., 2023; Zapata-Ríos., et al 2023), cultivated species (Franco et al., 2016), sociocultural characteristics (Manosalvas et al., 2023), and productive dynamics (Avellaneda-Torres et al., 2014; Lacour and Vaillant, 2007; Sherwood et al., 2023). However, this research also shows the existence of a diversity of agrarian scenarios in which the peasant population inhabit. These are defined geographically, in order to serve as a frame of reference for the analysis of the productive systems of each area, to know their limitations or influence on agricultural development and, on this basis, to open the possibility of promoting and implementing in the future differentiated proposals according to the reality of each identified territory.

Production systems in the high Andean zone of Chugchilán are characterized by having more than three working age family labor units [UTF] of, and most of the family labor is oriented to agricultural activities on the farm; however, at least one member is involved in activities outside the communities (generally men), leaving the management of the farm in the hands of the women. This dynamic is consistent with the results found by García Zambrano (2014) in the community of Sarachupa in the province of Chimborazo. This suggests the existence of a greater availability of family labor force in high Andean areas with a predominantly indigenous population; unlike other peasant areas mainly made up of mestizo people, where the productive systems are predominantly characterized by elderly farmers, over 60 years old, whose children are no longer linked to agricultural activity (Tamayo et al., 2017).

The cultivation of chocho in Chugchilán is variable (between 0.2 and 3 ha), and less than 30 % of the total area of peasant farms due to the logic of diversification of their production systems. These data are close to those recorded by Moncayo et al. (2000) in the province of Cotopaxi, and even in other high Andean areas of the country with a predominance of indigenous communities (García Zambrano, 2014). However, according to the potential zoning for its implementation by Caicedo and Peralta (2000), planting would be developed to a greater extent in territories with limitations. Although its valorization contributes substantially to the families' income; however it does not solve by itself all the adversities faced by farmers. Despite the reality identified, the contribution of this species is crucial to achieve economic, social and environmental sustainability of family-type production systems in other Andean areas, such as the case of the Mantaro valley, at an average altitude of 3,300 m asl in Peru (Aquino Zacarías, 2018). This evidence suggests the importance of valuing native species in high altitude areas, and the need to investigate their contribution to family livelihoods.

The presence of the Quilotoa volcano as a natural attraction, and the type of producer identified reflect the importance of tourism as an alternative to improve the living conditions of farmers in Chugchilán. In this regard, Narváez (2011) and Mena Vásconez and Hofstede (2006) emphasize that ecotourism can be a viable activity in high Andean *páramo* areas with natural landscapes and attractions. Despite this potential, there are still few benefits for the majority of farmers in the study area, which is limited to the population with greater purchasing power to invest in lodging centers and other tourism services. This particularity is consistent with the results of several studies on tourism dynamics in high Andean areas, which show that this activity would be benefiting only a restricted segment of the population with investment capital in lodging and transportation services, and would generate socioeconomic differentiation at the community level (Barrientos Paredes, 2014; Gascón, 2011; Figueroa Pinedo, 2018; Sánchez, 2017). Although we identified this reality, the effect of local tourism at the community level was not one of the specific objectives of the study; for this reason, it would be important to conduct research that analyzes in more detail the tourism dynamics and its impact on the socioeconomic level.

The influence of the different agroecological zones in the high Andean territory of Chugchilán is tangible when reflecting the socioeconomic situation of peasant families, especially in areas of the cold peaks of the mountain range, and territories settled on the lower flanks of the Quilotoa volcano (southeastern communities), where the lowest family incomes were recorded. Therefore, the more complicated the agroecological environment where an agricultural system is implemented, the more vulnerable the situation of the families. The evidence is consistent with that identified by Nieto et al. (2017), who propose the existence of a land use conflict in high Andean zones of Cotopaxi, and that this particularity would be one of the causes of poverty in these areas. However, the research conducted allows to visualize that living conditions worsen or improve depending on the type of agro-ecosystem, or agroecological zone in which the population is located, proximity and access to markets, availability of irrigation, productive logic, and insertion in tourism activity. Hence, the

importance of identifying different homogeneous areas at the territorial level, in order to promote proposals according to the particularities of each area. The results obtained are also partially consistent with those expressed by Chiriboga and Wallis (2010) highlighting that Indigenous campesino owing less that 2 hectares of land have low productivity and depend on waged activities; nontheless, the information generated shows that in this Andean region all types of producers, including farmers with greater access to land, depend on off-farm activities, and are in conditions of vulnerability.

Finally, as a result of the observations conducted within the area of analysis, we can highlight that the existence of farmers oriented towards agroecological production was identified. Although this is an aspect that was not part of the sample envisioned for the present study for personal reasons, a brief testimony collected, throughout the observation of the improvements made on the farm in relation to infrastructure for production and tourism, appears to suggest that this characteristic could lead toward a better socioeconomic situation. For this reason, future research should address the importance that the implementation of agroecological production systems could have as an alternative in the high Andean territory.

5. Conclusions

The high Andean zone of Chugchilán presents a diversity of territorial agroecosystems or agroecological zones, and agrarian landscapes that highlight the valorization form of the environment, as well as the diverse situations faced by the local peasant population: from areas located above 3,400 m a.s.l. (cold peaks), areas with steep slopes and susceptible to erosion processes, to areas with gentle relief and the presence of soils with little moisture retention (lower flanks of volcanic structures). In order to cope with these conditions, farmers implement various strategies such as diversification of production and its destination for sale and/or self-consumption, sale of labor force in an itinerant manner in areas beyond the political and administrative limits of the communities, valorization of chocho cultivation, search for other sources of income and, in specific cases, ecological tourism thanks to the landscape and natural environment of the territory. Despite the development of these activities, in general, the rural population finds itself in a situation of economic fragility, and their situation improves or worsens depending on their location and geographic reality.

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Contributor Roles

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- Darío Alexander Cepeda Bastidas: conceptualization, formal analysis, funding acquisition, methodology, supervision.
- Gustavo Fernando Sevillano Vásquez: data curation, formal analysis.
- Kerlly Bethsabe Cisneros Quilligana: investigation.
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Ethical Issues

Authorization from the Universidad Central del Ecuador (former Ethics Committee) through Oficio No.405-CE-UCE-2016.

Conflict of interest

The authors declare that they have no affiliation with any organization with a direct or indirect financial interest that could have appeared to influence the work reported.

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