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Productive Livestock Characterization and Recommendations for Good Practices Focused on the Achievement of the SDGs in the Ecuadorian Amazon

Bolier Torres [1,2], Verónica Andrade [3], Marco Heredia-R [4,*], Theofilos Toulkeridis [5,*], Kleber Estupiñán [4], Marcelo Luna [6], Carlos Bravo [6] and Antón García [2]

1 Facultad de Ciencia de la Vida, Universidad Estatal Amazónica (UEA), Pastaza 160101, Ecuador
2 Animal Science Department, University of Cordoba, Rabanales University Campus, 14071 Cordoba, Spain
3 Carrera Agropecuaria, Facultad de Ciencias Agrarias, Universidad Estatal Península de Santa Elena 1 1/2 km Vía a Santa Elena, La Libertad 240204, Ecuador
4 Facultad de Ciencias Pecuarias y Biológicas, Universidad Técnica Estatal de Quevedo (UTEQ), Quevedo Av. Quito km, 1 1/2 Vía a Santo Domingo de los Tsáchilas, Quevedo 120550, Ecuador
5 Departamento de Ciencias de la Tierra y Construcción, Universidad de las Fuerzas Armadas ESPE, Sangolquí 171103, Ecuador
6 Facultad de Ciencias de la Tierra, Universidad Estatal Amazónica (UEA), Puyo 160101, Ecuador
* Correspondence: mherediar@uteq.edu.ec (M.H.-R.); ttoulkeridis@espe.edu.ec (T.T.)

Abstract: The increase in livestock production in the Ecuadorian Amazon Region has caused an increase in deforestation and the advance of the agricultural frontier. The aim of the current study was to conduct a socioeconomic and productive characterization in Andean-Amazonian livestock systems in Ecuador. The study area was part of the Sumaco Biosphere Reserve (SBR) and three other zones: low (400 to 700 masl), middle (701 to 1600 masl), and high (701 to 1600 masl). Data were collected from 167 ranching households. There are significant differences ($p \leq 0.001$) in the results. It was identified that 56.1% of the producers in the middle zone are indigenous (Kichwa). The largest ($p \leq 0.01$) average household size (6.7 household members) and the highest level of household heads without schooling (16%) were found in the same area. Heads of households over 54 years of age were reported throughout the gradient. The largest farms were also found in the middle zone, with an average of 62.3 ha, of which an average of 32.9 ha is native forest, 2.1 ha is agricultural land, and 27.2 ha is cattle pasture. The household economy is driven by a greater investment in livestock in the upper area, and therefore their annual gross income has a high impact on their economy. With these results, this study presents recommendations to achieve the Sustainable Development Goals.

Keywords: Amazon; livestock income; land use; livestock management; sustainable development goals; Ecuador

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1. Introduction

The Sustainable Development Goals (SDGs) were adopted by all member states of the United Nations in 2015 and are valid until 2030 [1–4]. They provide a shared agenda of peace and prosperity for people and the planet for the present and the future [5]. The 17 SDGs are an urgent call to action by all countries in a global alliance, recognizing that ending poverty and other deprivation must go hand in hand with strategies to improve health and education [6,7], minimize inequalities, stimulate economic growth while considering climate change [8,9], and work to preserve the oceans and forests [10,11]. In short, the SDGs exist within a common framework to overcome important interconnected challenges such as the food supply, water scarcity, weak health systems, human nutrition, environmental pollution, and biodiversity loss [12,13]. However, several authors state that achieving the SDGs is an ambitious and complex task [14–16].

In 2020, the world population increased to 7.8 billion, and it is projected to be 9.8 billion by 2050 and 11.2 billion by 2100 [5]. Of those 7.8 billion people, about 2 billion are undernourished due to protein, micronutrient, and vitamin deficiencies [17,18]. It is estimated that about 60 percent of rural households in developing countries depend wholly or partially on livestock for their livelihoods [19], which provide essential protein and micronutrients for poor populations [19,20]. On a global scale, livestock farming is a key mechanism for reducing stunting and wasting in children [21–23]. Therefore, the livestock sector can play an important role in eliminating hunger, malnutrition, and child development, which in turn can be an engine for the fulfillment of various SDGs. Subsequently, good livestock practices must be incorporated based on the derived emissions reduction approach of deforestation and forest degradation (REDD+) in the Ecuadorian Amazon Region (EAR) [24,25].

Due to the demands of a growing population, especially in developing countries, livestock management is shifting towards careful stewardship and sustainable intensification [26,27]. This management seeks the integration of agriculture and livestock and may be part of the great challenge to advance towards the SDGs [28,29]. Sustainable livestock management can promote several of the SDGs, for example SDG 1 (No Poverty) because it generates income for smallholders [30,31]. It also provides a balanced diet that includes beef to alleviate malnutrition, which affects 2 billion people worldwide. Therefore, livestock farming is also critical to promoting SDG 2 (Zero Hunger) [32] and SDG 3 (Good Health and Well-being) [33]. Likewise, livestock activities strengthen SDG 4 (Quality Education), since field schools can generate capacity development [34,35], and SDG 5 (Gender Equality), as they are considered a key source of employment and self-employment for a large proportion of the world's rural populations [36]. In this regard, for small ranchers in the Ecuadorian Andes, it was demonstrated that between 23% and 47% of cattle farms were managed by women [27]. However, the livestock industry consumes approximately 8% of the world's water supply [37], with a strong impact on SDG 6 (Clean Water and Sanitation), so beef has a water footprint higher [38] than poultry, pigs [39], and many agricultural products [40]. Therefore, sustainable intensification and proper management of pastures are necessary to contribute to SDG 6 [41–43]. Sustainable livestock production with a REDD+ approach can contribute to SDG 13 (Climate Action) and SDG 15 (Life on Terrestrial Ecosystems), due to the relationship between climate change and the livestock sector [25,44,45].

One of the areas where the livestock frontier is expanding at the highest rate in Ecuador is in the EAR [46,47], which is becoming one of the main drivers of land use change and deforestation [48]. In this region, there were an estimated 1.2 million hectares of grasslands in 2014 [49] dedicated to extensive cattle ranching [49,50], providing meat and milk to satisfy the local demand and national markets [51].

In a priority research framework for the SDGs [8], the current study pursues four major objectives. The first is to analyze the main socioeconomic, demographic, and land use characteristics, while the second is to describe the differences between the productive characteristics of livestock management in the Andean-Amazonian altitudinal gradient. The third objective is to compare the levels of income, investments, and benefits of the ranchers along the studied altitudinal gradient. Finally, the work concludes with recommendations for decision making aimed at improving livestock systems in Andean-Amazonian ecosystems, as a contribution to the SDGs.

2. Materials and Methods

2.1. Geographic Setting

The study area is located in an Andean-Amazonian altitudinal gradient in the province of Napo, Ecuador. We worked with livestock households located from 400 m above sea level in the lower zone to 2000 m above sea level in the upper zone (Figure 1). In addition, the study area is located in one of the world's biodiversity hotspots (Western Amazon Highlands), which are unfortunately being threatened by a variety of circumstances [9,52–59]. The predominant ecosystems are Piedemonte Evergreen Forest (BsPn03) in the lower zone and Lower Montane Evergreen Forest (BsBn01) and Montane Evergreen Forest (BsMn01) located in low, middle, and high zones in the northern part of the Andean Cordillera Real [60,61].

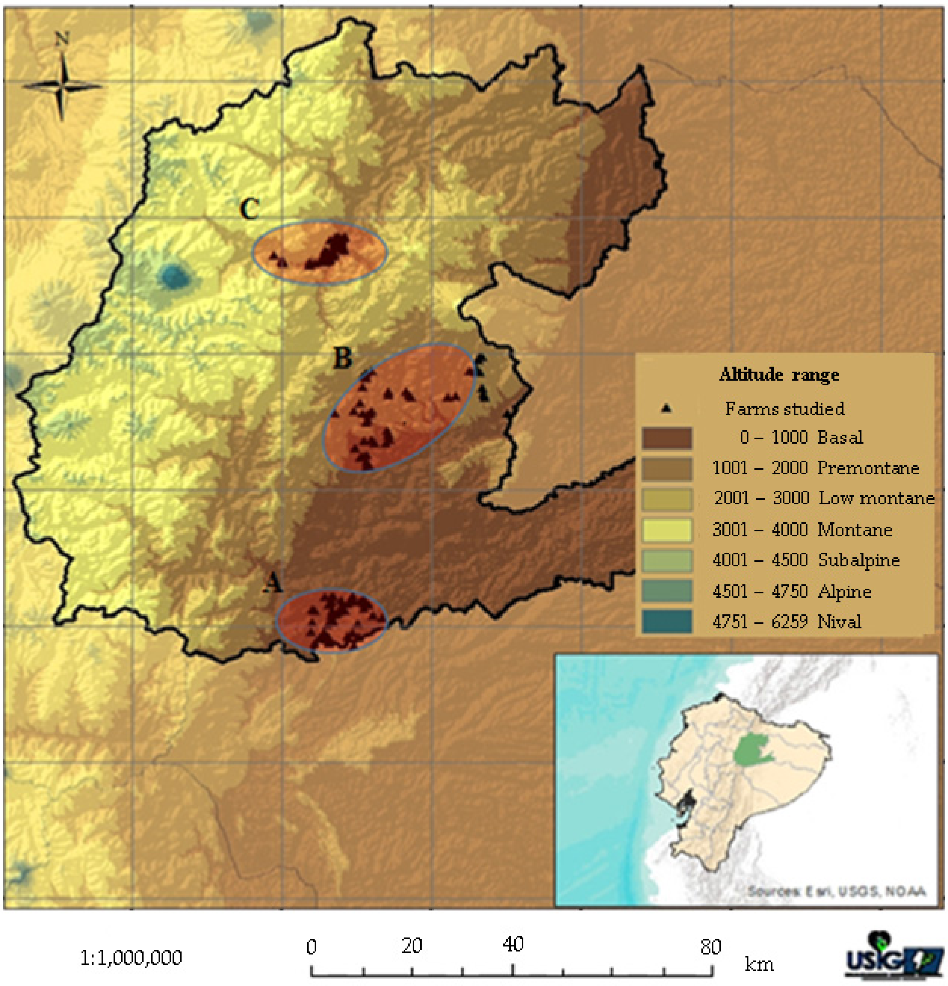

Figure 1. Households with livelihood strategies based on livestock, distributed along an altitudinal gradient: (**A**) low zone, (**B**) middle zone, and (**C**) high zone, in the province of Napo, Ecuadorian Amazon.

2.2. Sampling System and Data Collection

The study population consisted of 464 farms that represented three edaphoclimatic conditions of the territory and all the land uses of the altitudinal gradient, where cattle raising in the Napo province (Ecuador) is representatively located. From these 464 cattle farms, 167 household were surveyed, by stratified randomized sampling with proportional assignation in the three elevational gradients: 57 farms in the low zone (Quijos canton), 57 in the middle zone (Archidona canton), and 53 in the high zone (Carlos J. Arosemena Tola canton) (Figure 1). The non-probabilistic quota sampling technique was used [62,63] with the conditions of, firstly, a herd of at least ten head of cattle, and secondly, more than three years of consecutive activity. The questionnaire was applied to the heads of households and had an average duration of 90 min. This allowed the collection of information, which was later subjected to analysis and validation. Socio-economic, demographic, livestock system management, land use, income, investment, and net benefits variables were evaluated.

For the calculation of livestock costs and income, all fixed costs (land rental, maintenance of facilities), financial expenses (payment of interest on loans), and variable costs (purchase of livestock, various inputs, and maintenance of pastures) were considered, thus determining the total cost per household. Net income per household was obtained from net income minus total costs. All data were processed using the statistical system IBM-SPSS version 22 [62].

2.3. Calculation of Revenues, Investments and Net Income

Fixed investments include: (a) live fixed assets (working animals, production animals, breeding animals, and animals of mixed aptitude), or "livestock" in the legal terminology, and (b) inanimate fixed assets (machines, tools, work utensils, vehicles, harnesses, and electrical appliances and utensils) [63]. Therefore, the precise identification of all the concepts that represent income and expenses in agricultural activity is essential. Outgoing payments can be classified as costs (expenses that will generate benefits in the future) and expenses (cash outflows that currently represent benefits), for example administrative, sales, marketing, and financial expenses [64]. Cost-benefit analysis is a formal, personalized, clear, systematic technique for rational decisions. It is applied in the face of complex alternatives or uncertain times (Appendix A) [65].

3. Results and Discussion

3.1. Sociodemographic Characteristics

The results showed that livestock activity along the altitudinal gradient in Napo province began in different periods of settlement. The population first settled in the high zone (1601–2000 masl) approximately 70 years ago, then in the lower zone (400–700 masl) 45 years ago, and finally in the middle zone (701–1600 masl) some 35 years ago (Table 1).

Table 1. Characteristics of cattle producers along the altitudinal gradient, Napo, Sumaco Biosphere Reserve, Ecuadorian Amazon.

Variable	Altitudinal Gradient (Zone)			*p*-Value †
	Low	Middle	High	
Elevation range (masl)	400–700	701–1600	1601–2000	-
Average elevation (masl)	543.1 ^{a}	1114.1 ^{b}	1778.0 ^{c}	0.01
Year of settlement	1975	1984	1952	n.s

† ANOVA; $p < 0.01$; n.s.: not significant. Superscript letters denote significant differences between elevational gradients.

Regarding the socioeconomic and demographic characteristics, seven variables were studied, and it was identified that in the middle altitude region, there are Kichwa households that manage livestock systems (56.1%) (Table 2). This provides evidence for the adoption of productive dynamics similar to those of migrant settlers [66,67], which could be due to the proximity to highways and access to markets [68]. However, it has been demonstrated in this area that Kichwa households involved in livelihood strategies based on livestock obtain significantly lower income from this activity than migrant settlers, due to scarce technical assistance, to having little or no formal or informal training in livestock production, and to sociocultural contexts [25]. As for the size of the households, over the entire altitudinal gradient studied, there is a range of 5.1 to 6.7 household members, and a similar average (5.3) to those reported in the small Kichwa livestock producers of the Ecuadorian Amazon Region southern zone [69] and in the Yasuní Biosphere Reserve [43,70]. The average size of the households of small Kichwa cattle producers that inhabit the central Andes of Ecuador is smaller (3.8) [45]. The average age of the head of household in the study areas is over 50 years old, which is similar to that of the producers who own small livestock species in the low areas of the province of Napo [71].

A high level of illiteracy (15.8%) was observed among the heads of households of the middle altitude gradient, where 56.1% are Kichwas who have adopted a subsistence strategy based on livestock. In the lower zone, there is a higher percentage (61.4%) of ranchers with primary education, which could be due to the fact that they live a shorter distance from educational centers and have easy access to them. However, in the high zone, the households are far from the schools, and 50% of household heads have secondary education; this dynamic could be explained by these household heads being settlers who migrated from the coastal lowland and Andean regions [65]. In these territories, integration into society and the national economy in general has received little academic attention [72]. This factor is reflected in the fact that many people migrated outside their places of origin to complete some level of study.

These characteristics make it possible to propose capacity development programs and sustainable training activities at the individual, family, and community level [35], as well as the development of academic and productive support programs aimed at young people in the area. The objective would be to minimize the effect of their leaving to study outside their towns or communities, which limits the generational change in agricultural tasks once the young people have obtained their degrees [73]. This information is important, as both agriculture and the young rural population are in decline [74], and the immersion of young farmers brings an increase in social, economic, and human capital to a country [45].

Table 2. Average of the main sociodemographic characteristics of livestock producers along the altitudinal gradient, Napo, Sumaco Biosphere Reserve, Ecuadorian Amazon.

Variable	Altitudinal Gradient (Zone)			*p*-Value †
	Low	Middle	High	
Ethnicity (% Kichwa)	0.0 [a]	56.1 [b]	0.0 [a]	0.001
Household size (number of people)	5.56 [a,b]	6.70 [a]	5.04 [b]	0.01
Household members who work on the farm	2.63	3.00	2.32	n.s
Head of household age (years)	54.79	56.77	57.60	n.s
Head of household without education (%)	8.8	15.8	3.8	n.s
Head of household with primary education (%)	61.4	47.4	28.3	n.s
Head of household with secondary education (%)	22.8	24.6	49.1	n.s

† ANOVA for continuous variables; and X^2 for discrete variables. $p < 0.001$; n.s.: no significance. Superscript letters denote significant differences between elevational gradients.

3.2. Land Use in Livestock Producers of the Altitudinal Gradient

Regarding the main uses of the land, the average surface of the farms is 47 ha, of which 62% is pastures for cattle, in the lower zone; 62 ha, with around 55% dedicated to pasture, in the middle zone; and 35 ha, with 81% grassland, in the upper zone. In absolute terms, there were no statistical differences in the average size of the pastures in the three zones, but there was a slightly significant difference ($p < 0.05$) in the total size of the farm area (Table 3). Producers in the middle zone have, by far, the largest total farm area and the largest amount of pasture, which is in line with the theory that producers with more land dedicate more hectares to pasture [75].

The fact that the use of pastures does not present significant differences suggests that ranchers satisfy the demand for green forage of the animals. This is due to the fact that in the different altitude zones, there is a different productive behavior in grasslands with vegetal biomass, coinciding with the findings of Martín et al. [76], who mentions that with a larger grassland area, the herd, availability, quality, and diversity can be increased. Persistence of forage biomass, especially when there is a combination of herbaceous and woody plants, is able to increase photosynthesis, nutrient recycling, biota recovery, soil fertility, and biodiversity [77]. On the other hand, Requelme et al. [75] reported that the expansion of forage species destined for animal feed significantly reduces the presence of secondary forests on farms with production systems, considering other aspects such as land use and deforestation on land. This is especially true on land belonging to settler populations, which are associated with the opening of new roads, access to markets, or changes in household life cycles [78,79]. These dynamics produce a loss of forest cover in favor of other more intensive uses, especially pastures that constitute an essential production factor for farmers involved in livelihood strategies based on livestock [72].

In households oriented to livestock as their main activity, the remaining forest is less than 40% of the total farm, differing significantly ($p < 0.05$) in the three study areas.

Middle-area households have the largest area of forest and cropland, which may be due to having larger farms [78]. The distribution of land use is based on the physical space of the farm, where the forestry component tends to be incorporated in productive systems, in this case pasture [76]. Land tenure in Ecuador is a conditioning factor for the presence of livestock systems with a greater or lesser degree of intensification [80,81].

Table 3. Average of the main characteristics of land use of livestock producers along the altitudinal gradient, Napo, Sumaco Biosphere Reserve, Ecuadorian Amazon.

Variable	Gradiente Altitudinal (Zona)						p Value †
	Low		Middle		High		
	Avg (ha)	%	Avg (ha)	%	Avg (ha)	%	
Pasture land	26.8 (19.2)	62	27.2 (28.6)	55	22.5 (17.2)	81	n.s.
Crop land	1.6 [a] (1.9)	4	2.2 [a] (3.3)	5	0.4 [b] (1.1)	2	0.001
Remnant Forest Land	20.1 [a,b] (29.8)	34	32.9 [a] (56.2)	40	12.2 [b] (28.1)	17	0.05
Total land	47.3 [a,b] (42.1)	100	62.4 [a] (70.6)	100	35.2 [b] (40.2)	100	0.05

† ANOVA; $p < 0.05$; $p < 0.001$; n.s.: not significant. Superscript letters denote significant differences between the altitude gradient. Values in parentheses are standard deviations from the mean.

3.3. Management of Livestock Systems in the Altitudinal Gradient

Livestock activity (Figure 2) in the high zone began in the 1950s due to the abundant presence of plant biomass for animal feed; in this area, livestock production is mainly dairy. Subsequently, livestock production began in the lower area in the mid-1970s, with meat and milk production. The same two products are produced in the middle zone, where ranching was established at a later date (the 1980s). This is due to various occurrences that arose during those periods, such as bovine diseases due to the entry of animals from different parts of the country [82], precisely at a time when human settlement in the EAR was massive.

In tropical regions, sustainable livestock development is being promoted from an economic, social, and environmental point of view [83]. Ranching, in particular, offers an alternative source of capital that the rural poor can accumulate as a "savings account" to hedge against fluctuations in income [84,85]. Therefore, raising livestock in rural households is considered an alternative form of insurance, allowing them to earn income from the sale of animals in times of crisis [86,87]. Several authors have recently provided evidence that the welfare of ethnic minority households with livestock production was higher than that of those without livestock production [88]. The profitability of livestock systems depends on the grazing systems implemented [88], management for environmental protection [89], and availability of resources for transformation to agroforestry systems [90].

Regarding grassland systems, Table 4 lists in order of importance the main forages, between grasses and legumes, along the altitude gradient. It is evident that throughout the studied gradient, grasses predominate. In the lower zone, marandú grass (*Brachiaria brizantha*), dallis grass (*Brachiaria decumbes*), and guinea grass (*Panicum maximum*) predominate. In the middle zone, the most important species are honey grass (*Setaria splendida*) and dallis grass, and the least predominant is German grass (*Echynochloa polystachya*). In the low and middle zones, the use of imperial grass (Axonopus scoparius) is scarce. Meanwhile, in the highlands, the most important species are kikuyu grass (*Pennisetum clandestinum*) and honey grass (*Setaria splendida*), and the least used is ryegrass (*Lolium multiflorum*). In addition, along the gradient, forage legume species are the least used and have a lower number of species distributed by gradient. Specifically, in the low and middle zone, the forage peanut (*Arachis pintoi)* is the most common, while in the high zone, it is the lotus (*Lotus pedunculatus*) [76,91] (Table 4).

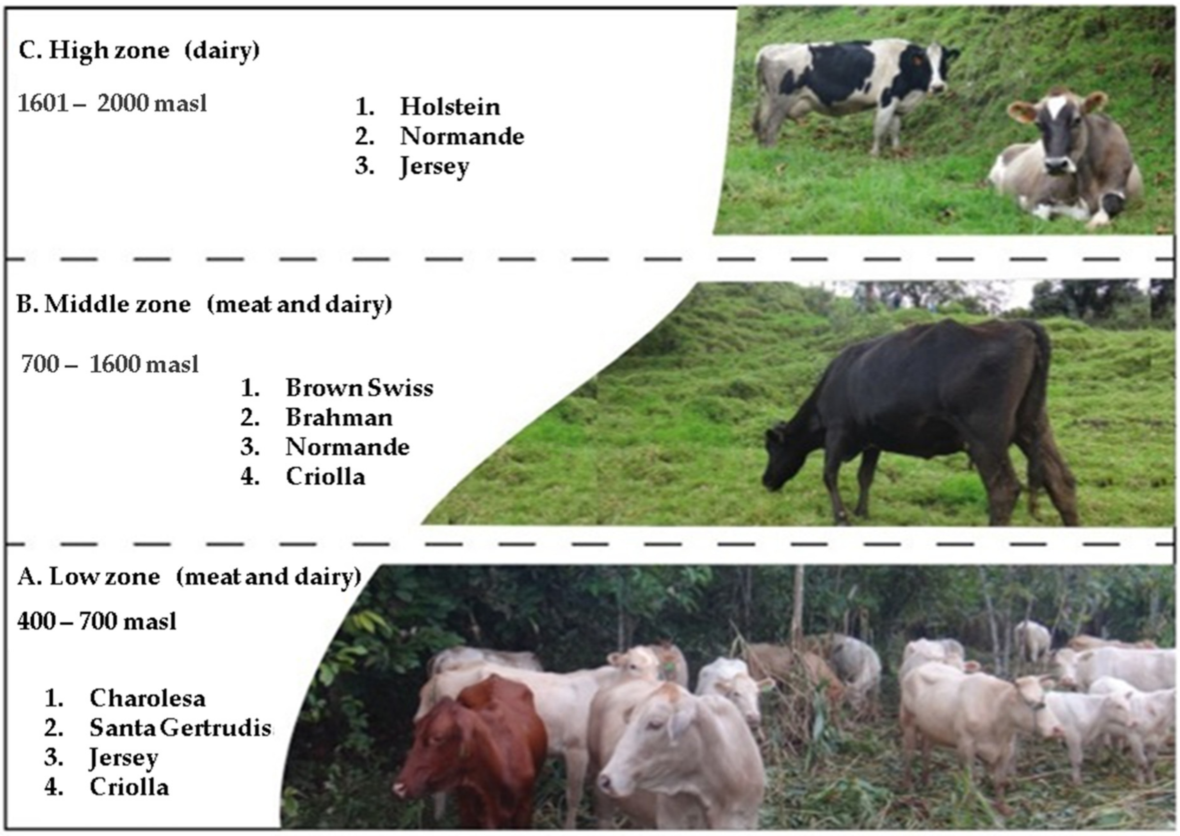

Figure 2. Livestock systems distributed along the altitudinal gradient: (**A**) low zone (meat and dairy), (**B**) middle zone (meat and dairy), and (**C**) high zone (dairy).

Table 4. Distribution of forage species of livestock producers along the altitudinal gradient, Napo, Sumaco Biosphere Reserve, Ecuadorian Amazon.

Low Zone **400 to 700 masl**	**Middle Zone** **701 to 1600 masl**	**High Zone** **1601 to 2000 masl**
	Grasses	
Marandu grass (*Brachiaria brizantha*) Dallis grass (*Brachiaria decumbes*) Imperial grass (*Axonopus scoparius*) Savoy grass (*Panicum maximum*)	Honey grass (*Setaria splendida*) Dallis grass (*Brachiaria decumbes*) Imperial grass (*Axonopus scoparius*) Guinea grass (*Panicum maximum*) German grass (*Echynochloa polystachya*)	Kikuyu grass (*Pennisetum clandestinum*) Honey grass (*Setaria splendida*) Orchard grass / dactyl grass (*Dactylis glomerata*) Ryegrass (*Lolium multiflorum*)
	Legumes	
Forage peanut *(Arachis pintoi)* Bellflower (*Centrosema pubescens*)	Forage peanut *(Arachis pintoi)* Bellflower (*Centrosema pubescens*)	Lotus (*Lotus pedunculatus*) White clover (*Trifolium repens*) Buttercup (*Tithonia diversifolia*)

Pastures provide the largest volume of forage for animals throughout the gradient and, although they are rich in energy, they are poor in protein [45]. On the other hand, the forage types with legumes are the least predominant: only 40% in the low zone, 13% in the middle zone, and 8% in the high zone reported the use of legumes in their paddocks (Figure 3). This is an aspect to be improved throughout the entire EAR [76,91], considering that legumes are usually used to increase the protein and mineral portion of calcium (Ca) and phosphorus (P), enhance the diet of animals, and fix nitrogen in the soil, from symbiosis with bacteria of the genus *Rhizobium* [92]. For the entire EAR, including the study area [76], agroecological management alternatives are recommended, such as agrosilvopastoral systems, protein banks, a combination of grasses and legumes, and the incorporation of native breeds, together with good agricultural and livestock practices.

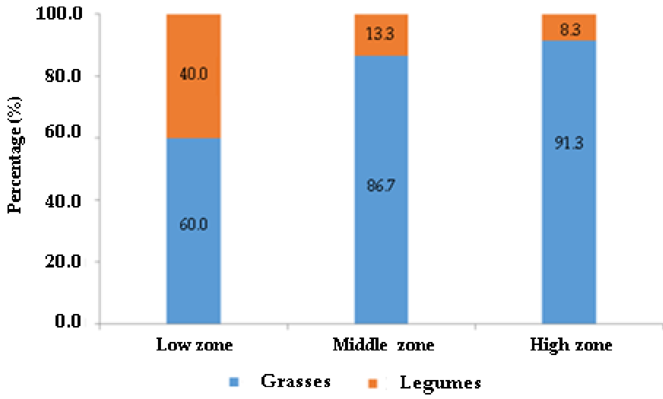

Figure 3. Types of pastures used by small ranchers in the Andean-Amazonian altitudinal gradient, Napo province, Ecuador.

3.4. Variation in Income, Investments, and Net Benefits in the Altitudinal Gradient

Regarding the economic analysis, considering the gross values of investment and income (Table 5), the three altitudinal zones differ in terms of animal stock and average of daily milk yield, with the high zone being the one with the highest average number of animals per producer (30.4 heads) and highest average daily milk yield by cows (7.2 L/cow). In terms of annual investment, there is a significant difference ($p < 0.001$) in the three areas studied. The high zone had the highest annual investment ($4307.3), and likewise, this zone reported the highest income, which is probably due to both the number of animals and the higher level of investment (Table 5). Therefore, in the high zone, farmers are more successful and prefer to continue with this activity, since the income they obtain from raising livestock is greater than the cost of investing in livestock [93]. These results are similar to those obtained by [76], who realized that in the lower areas of the EAR there are fewer animals and low yields, which could be partly related to low investments and the low nutritional value of the pastures used, as well as the presence of parasites and diseases, such as mastitis and deficiencies in the reproductive process [93].

Table 5. Average of total animals, daily milk yield, investments, gross income and annual net income in USD of livestock producers along the altitudinal gradient, Napo, Sumaco Biosphere Reserve, Ecuadorian Amazon.

Variable	Altitudinal Gradient (Zone)			*p* Value †
	Low	Middle	High	
Total animals (heads)	24.2 ^{a} (13.8)	18.8 ^{a,b} (17.1)	30.4 ^{b} (21.8)	0.01
Average daily milk yield (litre/cow)	1.4 ^{a} (0.7)	2.6 ^{a} (1.2)	7.2 ^{b} (4.3)	0.001
Total investment (USD)	1709.9 ^{b} (1547.1)	1555.8 ^{b} (1403.7)	4307.3 ^{a} (2814.7)	0.001
Total gross income (USD)	2762.7 ^{b} (3038.1)	3415.1 ^{b} (4939.6)	19,042.6 ^{a} (26,204.6)	0.001
Net profit (USD)	1052.7 ^{b} (3259.3)	1859.3 ^{b} (4682.1)	14,735.3 ^{a} (25,120.3)	0.001

† ANOVA; $p < 0.01$; $p < 0.001$; n.s.: no significance. Superscript letters denote significant differences along the elevational gradient. Values in parentheses are standard deviations from the mean.

3.5. Good Livestock Practices Recommended for the Achievement of the SDGs

The resulting characterization of the livestock systems in the studied Andean-Amazonian gradient presents different dynamics for each area evaluated. Therefore, the following recommendations are considered to be of high priority along the studied altitudinal gradient, with a view towards sustainable intensification of livestock systems for decision makers (Table 6) and towards the achievement of the SDGs.

Table 6. Recommendations for strengthening the SDG indicators for livestock producers in the altitudinal gradient, Napo, Sumaco Biosphere Reserve, Ecuadorian Amazon.

Sustainable Development Goal (SDG)	Recommendation	Examples
SDG 1: End of Poverty	Implement accounting records and productive and reproductive planning systems, among other aspects of good livestock management practices, and improve grazing systems and management of leguminous forage species to increase productivity.	[25,76]
SDG 2: Zero Hunger	Diversify livestock systems with crops, fruit trees, and timber (sustainable livestock intensification). Generate sustainable food-oriented production, implementing an animal-based diet, which could also alleviate malnutrition (hidden hunger).	[94]
SDG 3: Good Health and Well-being	Promote a healthy human diet through precision farming and the incorporation of good farming practices that prevent diseases and promote product quality.	[94]
SDG 4: Quality Education	Propose field schools to promote good livestock practices aimed at making land use more efficient, freeing up pasture areas to promote reforestation and landscape restoration processes, as well as associativity and business development.	[25,34]
SDG 5: Gender Equality	Promote greater participation and training of women in activities of good livestock practices to promote equal opportunities in sustainable societies.	[25,36]
SDG 6: Clean Water and Sanitation	Reduce the water footprint of livestock, considering sustainable intensification through good livestock practices that incorporate waste management, in order to obtain economic, environmental, and social co-benefits from livestock activity.	[25,41,94]
SDG 8: Decent Work and Economic Growth	Identify resilience factors that promote the adaptation and buffering capacity of farms and that favor adaptation capacity at the supply chain level. Conduct economic analysis through poverty quintiles and capital theory to make extension and training programs more efficient.	[27]
SDG 10: Reduced Inequalities	Promote research on inequities in livestock systems and policies to reduce inequity through animal breeding programs with solid agroecological principles and pasture technification, serving these vulnerable populations.	[27]
SDG 11: Sustainable cities and Communities	Promote policies that encourage good livestock practices towards sustainable livestock landscapes at the community level, and that also add value to livestock products.	[23]
SDG 12: Responsible Consumption and Production	Promote responsible consumption policies so that society insists on the consumption of products that do not cause negative environmental externalities throughout the production chain.	[35,95]
SDG 13: Climate Action	Promote public and private action policies with key actors to implement projects that promote good livestock practices with an REDD+ approach. Promote experimental research with the support of academia to facilitate technical assistance towards climate-smart livestock systems. Implement waste management systems such as artisanal vermiculture, composting, and semi-artisanal biodigester.	[25,94]
SDG 15: Life on Land	Promote policies to implement deforestation-free livestock systems and improve the ecosystem services of grasslands by implementing good livestock practices, such as passive and active restoration in degraded areas due to overgrazing, and rehabilitation of grasslands with the inclusion of tree, fruit, and forage species. Promote policies to implement deforestation-free livestock systems and improve the ecosystem services of grasslands by implementing good livestock practices, such as passive and active restoration in degraded areas due to overgrazing, and rehabilitation of grasslands with the inclusion of tree, fruit, and forage species.	[25]
SDG 17: Partnerships for the Goals	Promote policies for the organizational development of associations of livestock producers that promote cooperation, complementarity, solidarity, conflict resolution, the construction of local capacities, and the necessary planning to achieve the SDGs.	[35]

4. Conclusions

Livestock activities throughout the Andean-Amazonian altitudinal gradient studied began approximately seventy years ago in the high zone, with the presence of migrant settlers. However, in the middle zone, there are reports of Kichwa households involved in life strategies based on livestock, who maintain large family nuclei with household heads over fifty years of age and low educational levels. On average, cattle farms along the altitudinal gradient are more than 35 ha, with more than 50% of the farm area dedicated to pasture. The high zone stands out with little presence of forest on the farms, but with the highest economic income.

It is necessary to complement the efforts between public and private entities and academia to develop applied research that facilitates the identification of appropriate combinations of good livestock practices towards sustainable intensification to simultaneously increase productivity without affecting the environment. This also allows the development of new products through bioenterprises derived from small- and middle-scale livestock systems. Furthermore, it generates research and development of local governance models in order to optimize the supply of products provided by sustainable livestock. Finally, it leads to an evaluation of the dynamics and environmental and climate change impacts of the livestock sector.

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Appendix A. Variables Used to Determine Total Income, Cost/Investments, and Net Porfit

Financial Concept	Analyzed Items
Income from milk production	Calculation of annual milk production
Income from meat production	Total annual sales of cows, calves, heifers, cows, bulls, and juvenile bulls.
Total Revenues	Income from livestock economic activities
Fixed costs (investments)	Financial costs Land rental costs Facilities maintenance
Variable costs in production	Artificial insemination Acquisition of cows for production Vaccines for the cattle herd Grass fertilizers Grass seed Pesticides and herbicides Balanced feeding for milking cows Balanced feed for dry cows Balanced feeding for pregnant cows Balanced feeding for calves or calf Balanced feeding for stallion bulls
Total costs	Sum of fixed and variable costs
Net Profit	Income from livestock activity minus total costs

Appendix B. Household Survey Used to Carry Out the Productive Characterization and Recommendations of Good Practices Oriented to the Achievement of the SDGs

1. Control information and general farm data
Interviewer name:
Identification of the farm:
Date
Canton
Parish
Farm number
Farm name
Owner's name
Owner's mobile number
2. Location
Height, masl
Average slope, %
Coordinates
Farm slope (%): 1 =< 25; 2 = 26 < and <=35; 3 = 36 < and <50; 4 = more than 50
3. Social structure
Year of foundation of the farm
Owner's age
Do you have relief on your farm? Yes = 1, no = 2. Who?
Level of schooling (basic = 1, middle = 2, and university = 3, none = 4).
Do you belong to any agricultural association? Yes = 1, no = 2. Which one?
4. Uses on the farm
Total farm area, ha
Pasture area in ha
Average slope of the area in livestock %
5. Herd ownership and structure
Total number of animals kept by the farm
Cows
Average useful life of cows, years
Cattle calves
Weaned cows
Toretes destetados
Bovine stallions
Mean useful life of stallions, years
Fattening bulls

6. Household Composition									
Name	**Relationship (Relationship with the Head of the Household)**	**Gender (F = Feminine; M = Masculine)**	**Age (Years)**	**Occupation (Tasks/Jobs you Do on and off the Farm)**		**Hours of Work per Day**	**Working Days per Week**	**Cost (per Month)**	**Education Level (ns = no studies; *p* = primary; y = secondary; u = university)**
				On the Farm	**Outside the Farm**				

7. Agricultural (Crops) and Forestry Component: Indicate the total area of the farm (ha):					
Farm uses	**How much area (ha) does each use have?**	**How many trees are there for each use or crop?**	**If it is associated, indicate here with which crop or use**	**Annual contribution of each use to farm income?**	**Observations**

8. Livestock component:								
Uses of the farm	**How much area (ha) does each use have?**	**Number of cattle (min 10 per use)**	**Kg of balanced per cattle supplied per month and price per kg of balanced (usd)**	**Number of cattle sold**	**Annual contribution of each use to farm income?(per sale, in usd)**	**Average selling price**	**Who do you sell to?**	**Observa-tions**

9. Structure of the grazing system
Area dedicated to grazing, ha
Pasture status: 1 = slightly degraded, 2 = moderately degraded, 3 = severely degraded, 4 = improved grass
Total area of compensation, ha
- Like cane, ha
- As forages, ha
- As shrubs, ha
- Other forages (short cycle cultivation)
Area of fallow grass, ha
Number of paddocks
Mean size of the paddock, ha
Grazing method: 1 = rope, 2 = rotational, 3 = rational, 4 = continuous
Number of groups in the herd
Predominant grass: 1 = gramalote, 2 = creepers, 3 = legumes, 4 = erect
It has a reproductive record: yes= 1, no = 2
Age of incorporation to reproduction, months
Cow/bull relationships
Organize calving strategy in the year: yes = 1, no = 2
Stallion age, months
The stallion has some testicular deformation: yes = 1, no = 2
Breeds of bovine breeders
Why do you prefer this breed?
Stallion breed
10. Production data
Milking cows
Number of cows with affected quarters
First calving cows
Second calving cows
Cows with three calvings or more
Milk production in the last year, thousands of liters
Production of milk intended for sale in the last year, thousands of liters
Milk production for calves (artificial breeding)
Milk yields, liter per cow per day
Initial inventory of cows and year of start of the cattle activity
11. Final productions sold
Milk price, USD
Price per foot kg sold, USD
Price of other productions sold
In which months of the year is the largest production of marketed milk concentrated? 1–12
In which months of the year is the highest production of commercialized livestock concentrated? 1–12
Sale milk, sale meat, or cattle

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