Article

Not peer-reviewed version

Livelihoods and Perceptions of Climate Change among Dairy Farmers in the Andes: Implications for Climate Education

Julio C Vargas-Burgos , Marco Heredia-R * , Yenny Torres , Laura Elena Puhl , Biviana N Heredia , Jhenny Cayambe , Julio Hernán-González , Alexandra Torres , Marcelo Luna , Theofilos Toulkeridis , Bolier Torres

Posted Date: 12 May 2023

doi: 10.20944/preprints202305.0881.v1

Keywords: Climate change; livestock farmers; rural livelihoods; climate education.

Article

Livelihoods and Perceptions of Climate Change among Dairy Farmers in the Andes: Implications for Climate Education

Julio C. Vargas-Burgos [1], Marco Heredia-R [1,*], Yenny Torres [1], Laura Puhl [2], Biviana N. Heredia [3], Jenny Cayambe [4], Julio Hernán-González [5], Alexandra Torres [6], Marcelo Luna [7], Theofilos Toulkeridis [8] and Bolier Torres [9,10]

1 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
2 Departamento de Métodos Cuantitativos y Sistemas de Información, Facultad de Agronomía, Universidad de Buenos Aires, Buenos Aires, Argentina
3 Facultad de Ciencias Exactas. Universidad de las Fuerzas Armadas ESPE Sede Latacunga, 050102. Ecuador
4 School of Agricultural and Environmental Sciences, Pontificia Universidad Católica del Ecuador - Ibarra (PUCESI), Imbabura 100112, Ecuador
5 Cátedra de Producción Lechera, Departamento de Producción Animal. Facultad de Agronomía. Universidad de Buenos Aires, Buenos Aires, Argentina
6 Facultad de Ciencias Jurídicas, Sociales y de la Educación. Universidad Técnica de Babahoyo. Extensión Quevedo (UTB). Km 3 1/2 Vía a Valencia. Los Ríos 120550, Ecuador
7 Faculty of Earth Sciences, Amazon State University (UEA), Pastaza 160101, Ecuador
8 Department of Earth Sciences and Construction, University of the Armed Forces ESPE, Av. General Rumiñahui S/N, Sangolquí 171103, Ecuador
9 Facultad de Ciencias de la Vida, Universidad Estatal Amazónica (UEA), Puyo 160101, Ecuador
10 Departamento de Producción Animal, Facultad de Ciencias Veterinarias, Universidad de Córdoba, 14071 Córdoba, Spain
* Correspondence: mherediar@uteq.edu.ec

Abstract: Climate change mainly affects production and consumption systems, such as: food, livelihoods, production (e.g., reduced milk production), water, and land use. The role of local knowledge has been recognized as important for decision-making under changing circumstances. This study was conducted in the northern part of the Ecuadorian Andes using a sample of 170 dairy-cattle-producing households. The objectives were: i) to characterize the rural livelihoods of dairy cattle farmers, ii) to evaluate access to climate information and perceptions of climate change, and iii) to determine the relationship between livelihoods and perceptions of climate change. Significant differences were identified between the groups evaluated in relation to the dairy farmers' livelihoods. In addition, 85.29% of the respondents mentioned that climate information is important, but 67.83% do not trust the sources of information. It was found that there is a significant relationship between the level of education and age with the variables of climate change perceptions. This combined knowledge allows people to promote agri-environmental and educational policies to achieve climate literacy at a rural level.

Keywords: climate change; livestock farmers; rural livelihoods; climate education

1. Introduction

Livestock production systems in developing countries are heterogeneous and dynamic and are undergoing dramatic changes due to various factors [1]. So far, neither the interactions of these drivers nor the magnitude of the impact on livestock production is well understood [1,2]. Several authors emphasized that there are still knowledge gaps regarding perceptions of climate change (CC) and its relationship with livelihoods in different production systems and what adaptation strategies should be implemented [2–5].

Livelihoods are defined as "the capabilities, assets (stores, resources, claims, and access) and activities necessary for a livelihood" [6]. Figure 1 includes the main factors affecting livelihoods and the relationships between these factors [7]. This framework contains multiple complex interactions, many non-linear, but there are four relationships that illustrate the sustainable livelihood pathway. The first is between vulnerability (the external environment in which people live) and livelihoods, which comprise human, natural, financial, social, and physical capital [7]. The second connects livelihood assets and transformative structures and processes. For example, government policies and institutions create assets through investments in infrastructure and education but may suppress the growth of social capital and limit access to natural and financial resources [7]. The third relationship represents the impact that such policies and institutions have on people's livelihood strategies [7]. The final relationship is between livelihood strategies and livelihood outcomes. The combination of activities carried out and choices made determines people's livelihood outcomes, including their degree of livelihood security [7].

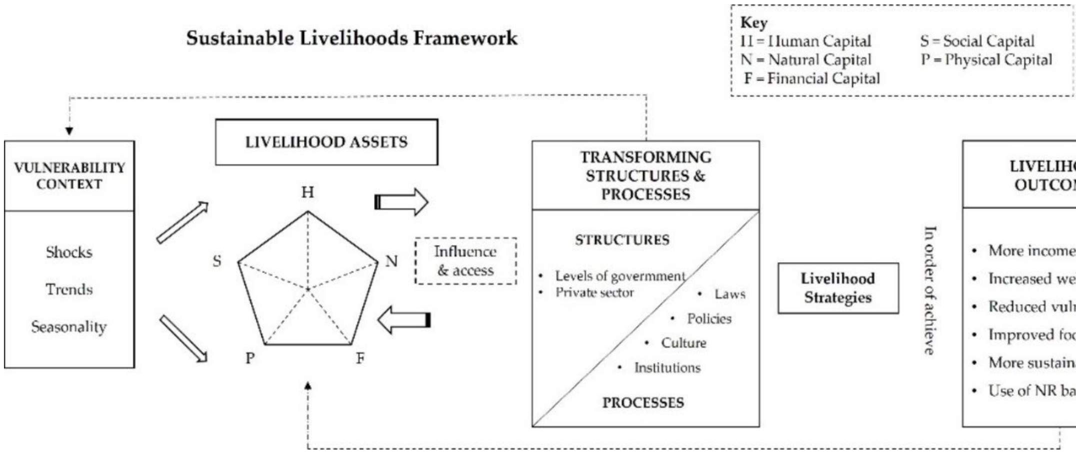

Figure 1. Sustainable Livelihoods Framework (DfiD, 1999).

Having a secure livelihood means that an individual or group has the ability to cope, recover from stress and shocks, and maintain or enhance current and future capabilities and assets, without extinguishing the natural resource base [6]. One outcome of livelihood security is a reduced vulnerability to stress and shocks and improved food security [7].

This paper focuses on vulnerability, specifically perceptions of CC and its relationship to livelihoods. The three components that make up vulnerability (shocks, trends, and seasonality) play a critical role in one's ability to acquire and maintain livelihood assets. Poor smallholders tend to be the most vulnerable to CC due to their dependence on agriculture, small landholdings, and a lack of assets and savings to enable them to change livelihood practices [8]. Livestock is an important source of income and an asset for rural households, particularly for the poor [9]. Livestock farming has been shown to be more resilient to climatic changes compared to crop production in several rural areas [10]. Thus, households living in variable and unpredictable climatic conditions are more likely to engage in livestock production as a precautionary way of maintaining savings and insurance against shocks, highlighting its potential role as a safety net [11].

Studies suggest that the increased frequency and intensity of climate shocks and the associated variability of rainfall patterns negatively impact rural production, decreasing the resources available to invest in livelihood activities [12,13].

Smallholders in the Andean region of South America are expected to be increasingly affected by CC [14]. Multiple climate models indicate that by 2050 the Andes will experience significant loss in rural productivity and ecosystem degradation [14]. The Intergovernmental Panel on Climate Change (IPCC) models suggest that CC could significantly affect water management systems and food and energy security in South America [13,14]. IPCC reports also show that CC on this continent has already led to alterations in the frequency, intensity, and duration of extreme weather events [12,13].

From 1901 to 2012, temperatures have increased by between 0.5 and 3 °C, with an average warming of almost 0.1 °C per decade [13,15].

These changes have been identified in both tropical regions and the Andes, where only two of the last 20 years have experienced an average increase of below 0.1 °C/decade [13,15,16]. An increase of 0.1 °C/decade is likely to result in a global temperature increase of at least 1.5 °C above pre-industrial levels between 2030 and 2052 [17]. This relatively small amount of change is projected to potentially irreversibly increase climate-related risks to natural and human systems [17]. The immediate impacts of rising temperatures include an increase in the amount of evaporation, resulting in drier soils, which in turn leads to less productive crops and reduced pasturelands [18]. Warmer temperatures can also mean increased proliferation and frequency of diseases in production systems [19,20].

In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) declared: "Education is an essential element in mounting an adequate global response to climate change" [21]. Few would argue against the importance of education in providing an informed response to environmental problems. Solutions to climate change tend to focus on mitigation and adaptation measures, and the successful implementation of either strategy requires the general public to be well-informed and educated. Interest in education and climate change has increased in recent years [22], in part due to the leadership efforts of organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) that continue to advocate for educational efforts in order to respond to climate change [23]. Incorporating climate change education into all formal or informal education systems may be one of the most important and effective means of building capacity to address the climate crisis. This is due to its multiplying effects, where families and communities benefit when people share what they have learned [24].

Within this context, the objectives were to a) characterize the rural livelihoods of dairy farmers using capital theory, b) assess the acquisition of climate information and CC perceptions, and c) determine the relationship between livelihoods and CC perceptions. Finally, the paper concludes with potential agri-environmental and educational policy implications to support the Nationally Determined Contributions (NDCs) and the Paris Agreement's central goal of limiting global warming to less than 2 °C.

2. Materials and Methods

2.1. Geographic Location

The study area is found in the northern Andes of Ecuador, in a landscape that combines productive systems and conservation ecosystems. It is located between: (1) the Area of Conservation and Sustainable Use (ACUS for its Spanish acronym), created in 2016 to protect water sources, paramos, and forests, which has an area of 175.6 km^2 and belongs to the Mira River watershed [25] and (2) the El Angel Ecological Reserve, which has an area of 164.51 km^2 and was created in 1992, forming part of the Ecuadorian System of Protected Areas, whose objective is to conserve mainly the Hesperian paramos (Figure 2).

The existing ecosystems in the landscape are paramo grassland (Hesperian) (RsSn01), the high montane evergreen forest of the Western Andes Cordillera (BsAn03), the high montane evergreen forest of the northern part of the Western Andes Cordillera (BsAn01), and paramo grassland (HsSn02) [26]. The productive and conservation landscape is located in the province of Carchi, an area of great importance for dairy milk production in the Andean region [27].

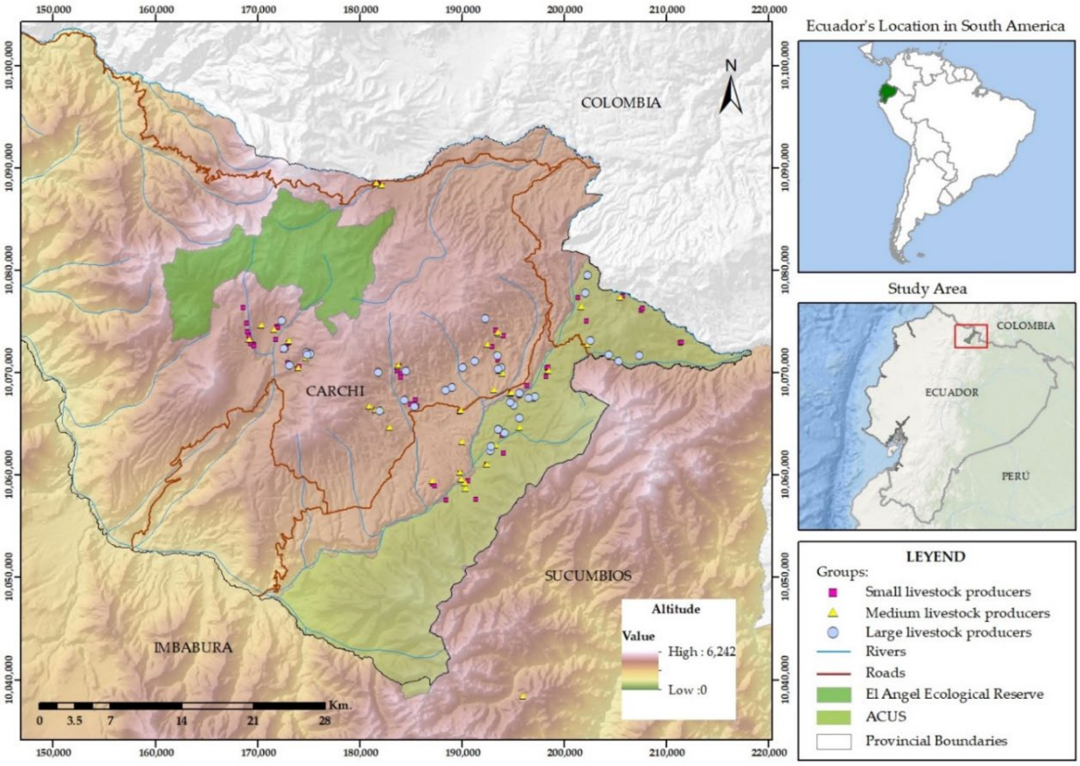

Figure 2. Location of dairy farms in the productive-conservationist landscape of the Ecuadorian Andes.

2.2. Sampling and Data Collection

The research project involved 170 dairy farmer households, divided into three groups of producers: 78 small (less than 6 ha), 55 medium (between 6 and 10 ha), and 37 large (greater than 11 ha). Data were collected through site visits and 65-minute interviews with rural Mestizo farmer heads of households that were held between January and February 2020.

The questionnaire had 38 questions adapted from the Poverty and Environment Network (PEN) template [28] and the questions were split into three sections: 1) Living conditions according to capital theory (human, social, natural, financial, and physical; 20 questions) (Table 1) [29–31], 2) means of acquiring climate information (11 questions), and 3) perceptions of CC (7 questions) (Annex 1) with binomial response options (yes/no). Due to the difficulties in moving around in the productive and conservation landscape, the sampling technique used was by non-probabilistic convenience following the criteria: (i) dairy cattle producers with a farm extension of 1 to 40 ha, and (ii) milk production must be carried out by Mestizos. Obtaining free and informed consent was achieved with the support of the Mestizo community leaders, through whom all households were approached. The surveys were conducted in accordance with the principles of ethical research [32], where the objectives, methodology, and schedule of the study were explained *a priori* to the heads of households of the cattle-rearing groups.

Table 1. Themes and variables studied in capital theory.

Theme	Variables
Human and Social	Age, gender, and educational level of the head of the household; Experience in milk production, work outside the farm, and whether the farmer receives advice from community leaders.
Natural Financial and Physical	Total farm area, pasture area, cultivated land area. Owns motorized strimmer, portable milking equipment, owns manual fumigation pumps, number of cows in production, number of bulls, total herd, number of months cows are in production, total milk production in liters per day, milk price– average in dollars per liter, receipt of government welfare money, and receipt of livestock/agricultural insurance.

2.3. Statistical Analysis Systems

The differences between the three groups of dairy farmers, in terms of the variables obtained from the survey, were analyzed with different tools according to the distributional characteristics of the response variables. In the case of the two-level categorical response variables (Yes or No), these were coded as 0 or 1 respectively and a generalized linear model with binary distribution was fitted with producer groups as a fixed effect [33]. For the discrete quantitative response variables, the Kruskal Wallis nonparametric test was used since they did not fit the Normal distribution. In the case of the Educational Level variable, the observed percentages were analyzed with the Chi-squared test to determine if there is homogeneity between groups of producers. When significant differences were detected between groups, Fisher's LSD test was used to determine those groups that differed significantly from each other. To measure the association between the different capital variables and the CC perception variables, Spearman's correlation coefficients were calculated within each group of producers (small, medium, and large). Then, to visualize the associations graphically, a Correspondence Analysis [34] of the correlation matrix between the capital and perception variables was performed for each group. The resulting graph allows one to detect positive and negative associations between the variables according to their closeness or remoteness in the ordering, respectively. An alpha significance level of 0.1 was used for all tests. The analyses were performed with the statistical program Infostat [35], and R software [36].

3. Results

3.1. Characterization of dairy farmers' livelihoods using capital theory

3.1.1. Human and Social Capital.

The average age of the head of the household was 48.22 years. In terms of gender, there are significant differences ($p \leq 0.0847$) between producer groups and, on average, there are more men (60.66%) than women listed as heads of households (Table 2). In relation to the years of education of the heads of households, there are significant differences ($p \leq 0.0016$) between groups of milk producers. It is evident the category of small producers contains the highest number of heads of households who: 1) only received primary education, 2) attended a literacy program, and 3) have not received any level of education. Meanwhile, in the category of medium and large producers, there are heads of households with university education (9.09% and 2.70%, respectively). As for years of experience in milk production across the categories of producers, there are no significant differences; but in the variable of off-farm or non-farm work, there are highly significant differences ($p \leq 0.0001$). The relationship demonstrates that when the production area is larger, off-farm work is lower, which is contrary to the dynamics in small producers where the greatest work activity is off-farm among the categories studied. Regarding advice from community leaders, in the three categories of milk producers, 96.18% on average have not received any, while small milk producers were the group who received the most advice: 1.49% and 2.43% more than medium and large producers, respectively.

Table 2. Averages of the main variables that represent the human and social capital of milk producers in the productive-conservationist landscape of the Ecuadorian Andes.

Variable		Dairy cattle farmers				
		Small	Medium	Large	Average	*p-value*
Age (years)		46.73 (12.61)	49.16 (12.23)	48.76 (15.22)	48.22	0.6998 [1]
Gender (%)	Men	72[a]	80[ab]	89[b]	80.33	**0.0847** [2]
	Women	28[a]	20[ab]	11[b]	19.67	
Educational level (%)	None	6.41	5.45	2.70	4.86	**0.0016** [3]
	Literate	1.28	0.00	0.00	0.43	
	Primary	76.92	72.73	64.86	71.51	
	Secondary	14.10	12.73	29.73	18.85	
	Technological training	1.28	0.00	0.00	1.28	
	University	---	9.09	2.70	5.90	
Experience in dairy production (years)		20.29 (11.58)	23.38 (13.38)	20.30 (12.90)	21.32	0.4657 [1]
Where they work (%)	On the farm	52.56[a]	74.55[b]	89.19[c]	72.10	**0.0001** [2]
	Outside the farm	47.44[a]	25.45[b]	10.81[c]	27.90	
Receives advice from community leaders (%)	Yes	5.13	3.64	2.70	3.82	0.8050 [2]
	No	94.87	96.36	97.30	96.18	

p-value corresponds to: [1] the Kruskal-Wallis test for quantitative variables; [2] the effect of groups in the generalized linear model for the case of binary variables (Yes/No); and [3] the Chi-squared test for homogeneity. *p-values* in bold are less than the level of significance. Different letters in the rows indicate significant differences at 10% between producer groups for Fisher's LSD test.

3.1.2. Natural Capital

In terms of natural capital, among the evaluated variables and producer categories (Table 3), there are significant differences ($p \leq 0.0001$). The total farm area of small dairy farmers is 2.28 and 5.64 times smaller than medium and large ones. In relation to pastures, the average area was 7.11, while the large-scale farmers have 6.45 and 2.71 times larger pasture areas than the small- and medium-scale farmers. With respect to crop area, the relationships are closer across the three categories of producers.

Table 3. Averages of the main variables that represent the natural capital of dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

Variable	Dairy cattle farmers				
	Small	Medium	Large	Average	*p-value*
Area of the farm (ha)	3.36[a] (1.32)	7.67[b] (1.38)	18.95[c] (6.27)	9.99	**<0.0001**
Area of pastureland (ha)	2.17[a] (1.10)	5.17[b] (1.45)	14.00[c] (6.82)	7.11	**<0.0001**
Area of cultivated land (ha)	1.19[a] (0.82)	2.50[b] (1.41)	4.95[c] (3.23)	2.88	**<0.0001**

p-value corresponds to the Kruskal-Wallis test. *p-values* in bold are less than the significance level. Different letters in the rows indicate significant differences at 10% between groups for Fisher's LSD test.

3.1.3. Physical Capital

It was evident that most of the farmers in the three groups do not have motorized strimmers, with an average of 96.91% (Table 4). Concerning the ownership of portable milking equipment, the largeholders have 1.10 and 2. 11 times more than the medium and smallholders. With regard to the ownership of manual spray pumps, on average 73.31% of the farmers have them; among the small-scale farmers, 23.08% do not have manual spray pumps, at a ratio of 1.20 and 1.30 with respect to the medium- and large-scale farmers. In relation to the variables: number of cows in production ($p < 0.0001$), number of bulls (p 0.0005), total herd ($p < 0.0001$), total milk production (liters per day) (p

0.0001), gross income from milk production (p < 0.0001), and average milk price (dollars per liter) (p < 0.0001), there are significant differences between the categories of farmers. Large-scale farmers have 2.33 and 4.50 times more cows in production than medium- and small-scale farmers, respectively. There are no significant differences between small- and medium-scale farmers in terms of the number of bulls and large-scale farmers have an average of 1.11; the average herd total is 10.05. With respect to total milk production (liters per day), small-scale farmers produce 6.55 and 3.00 times less than large- and medium-scale farmers, respectively. There are no significant differences between the average milk prices among small- and medium-scale farmers, while in the large-scale milk producers the cost is 0.40 dollars. Regarding the number of months that the cows are in production, there are no significant differences between the categories of farmers and the average value is 7.13 months.

3.1.4. Financial Capital

In terms of financial capital (Table 4), there were no significant differences in the variables of those who receive government welfare money and livestock insurance among the categories of farmers. The average number of dairy farmers who receive welfare money was 6.90% and, in the three categories of farmers, it is evident that more than 90% did not receive livestock insurance.

Table 4. Averages of the main variables that represent the physical and financial capital of dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

Variables		**Dairy cattle farmers**				
		Small	**Medium**	**Large**	**Average**	***p-value***
Owns a motorized strimmer (%)	Yes	3.85	-	5.41	4.63	0.1273 [2]
	No	96.15	100	94.59	96.91	
Owns portable milking equipment (%)	Yes	5.13	9.09	10.81	8.34	0.4944 [2]
	No	94.87	90.91	89.19	91.66	
Owns manual fumigation pumps (%)	Yes	76.92	72.73	70.27	73.31	0.7190 [2]
	No	23.08	27.27	29.73	26.69	
Number of cows in production		4.06[a] (2.54)	7.84[b] (4.37)	18.24[c] (15.65)	*10.05*	**<0.0001** [1]
Number of bulls		0.46[a] (0.68)	0.60[a] (1.05)	1.11[b] (0.99)	0.72	**0.0005** [1]
Total herd		4.53[a] (2.74)	8.44[b] (4.47)	19.35[c] (15.70)	10.77	**<0.0001** [1]
Number of months that the cows are in production		7.11 (0.77)	7.22 (1.33)	7.06 (0.98)	7.13	0.8109 [1]
Total milk production (liters per day)		33.94[a] (21.10)	75.22[b] (58.11)	222.30[c] (203.57)	110.48	**0.0001** [1]
Gross income from milk production		2663.62 [a] (1737.19)	6048.46 [b] (4821.63)	19351.65 [c] 1(((18816.23)	7390.82	**<0.0001** [1]
Average milk price (dollars per liter)		0.36[a] (0.04)	0.37[a] (0.03)	0.40[b] (0.04)	0.38	**0.0002** [1]
Receipt of government welfare money (%)	Yes	8.97	7.50	2.70	6.39	0.3824 [2]
	No	91.03	92.50	97.30	93.61	
Receipt of livestock insurance (%)	Yes	1.28	0.00	0.00	0.43	0.4572 [2]
	No	98.72	100.00	100.00	99.57	

p-value corresponds to: [1] the Kruskal-Wallis test for quantitative variables; [2] the effect of groups in the generalized linear model for the case of binary variables (Yes/No); and [3] the Chi-squared test for homogeneity. *p-values* in bold are less than the level of significance. Different letters in the rows indicate significant differences at 10% between producer groups for Fisher's LSD test.

3.2. Access to Climate Information

Of the 11 variables evaluated (Table 5), the variable "information on lunar phases is important" presented significant differences (p 0.0222) between the categories of producers– there is a similarity between small and medium producers as opposed to large producers. With respect to receiving climate information, small producers did not receive any, while 4.52% of medium and large producers did receive it. 85% of the producers consider climate information important and there is an average difference of 1% and 53.04% with respect to the cattle ranchers who consider temperature and precipitation important and not important, respectively. As for obtaining information on the climate, 91% of the farmers do not employ ancestral knowledge, 56% of the farmers use almanacs or agricultural calendars, 29% use newspapers, radio, and television, and 98.45% do not consult government or non-governmental organizations' media, and, in global terms, 68% of the dairy farmers consider the sources of climate information to be reliable.

Table 5. Averages of the main variables that represent the acquisition of climate information by dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

Variable		Dairy cattle farmers				
		Small (%)	Medium (%)	Large (%)	Average (%)	*p-value*
Does the farmer have access to climate information?	Yes	0.00	1.82	2.70	1.51	0.2786
	No	100.00	98.18	97.30	98.49	
Does the farmer consider obtaining climate information to be important?	Yes	88.46	83.64	83.78	85.29	0.6701
	No	11.54	16.36	16.22	14.71	
Does the farmer consider information about temperature to be important?	Yes	51.00	54.55	45.95	50.50	0.7204
	No	49.00	45.45	54.05	49.50	
Does the farmer consider information about precipitation to be important?	Yes	82.00	80.00	67.57	76.52	0.2183
	No	18.00	20.00	32.43	23.48	
Does the farmer consider information about lunar phases to be important?	Yes	35.00[a]	29.09[a]	56.76[b]	40.28	**0.0222**
	No	65.00	70.91	43.24	59.72	
Does the farmer obtain climate information using ancestral knowledge?	Yes	15.00	7.27	5.41	9.23	0.1610
	No	85.00	92.73	94.59	90.77	
Does the farmer obtain climate information using an almanac or agricultural calendar?	Yes	60.00	50.91	56.76	55.89	0.5637
	No	40.00	49.09	43.24	44.11	
Does the farmer obtain climate information through the media, e.g., newspapers, radio, and television?	Yes	21.00	32.73	32.43	28.72	0.2044
	No	79.00	67.27	67.57	71.28	
Does the farmer obtain climate information through the Internet?	Yes	10.00	14.55	10.81	11.79	0.7424
	No	90.00	85.45	89.19	88.21	
Does the farmer obtain climate information through a government body or NGO?	Yes	1.00	3.64	0.00	1.55	0.3188
	No	99.00	96.36	100.00	98.45	
Does the farmer believe the sources of information regarding the climate are reliable?	Yes	65.00	70.91	67.57	67.83	0.7974
	No	35.00	29.09	32.43	32.17	

p-value corresponds to the hypothesis test of the effect of groups in the generalized linear model. *p-value* in bold are less than the level of significance. Different letters in the rows indicate significant differences at 10% between groups for Fisher's LSD test.

3.3. Perceptions of Climate Change

Regarding perceptions of CC (Table 6), of the 7 variables evaluated, the variable "Does the farmer know that climate change means sudden weather changes?" presented significant differences (p 0.0283) between the categories of milk producers. It was identified that among medium and large producers, the results are similar to each other but different to small milk producers. In general terms, only 73. 69% of milk producers have heard about CC. In relation to the variables that they understand by CC, 31.66% indicated an increase in temperature, while 60.17% and 73.74% consider that they are not related to extreme temperatures and a reduction in rainfall, respectively. 93.95% of the producers

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 May 2023 doi:10.20944/preprints202305.0881.v1

confirm that CC is a serious problem for livestock and 87.09% that production activities are responsible for CC.

Table 6. Averages of the main variables that represent perceptions of climate change held by dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

Variables		Dairy cattle farmers				
		Small (%)	Medium (%)	Large (%)	Average (%)	*p-value* (%)
Has the farmer heard about global climate change?	Yes	65.38	80.00	75.68	73.69	0.1544
	No	34.62	20.00	24.32	26.31	
Does the farmer know that climate change means an increase in temperature?	Yes	24.36	38.18	32.43	31.66	0.2252
	No	75.64	61.82	67.57	68.34	
Does the farmer know that climate change means extreme temperatures?	Yes	37.18	36.36	45.95	39.83	0.6046
	No	62.82	63.64	54.05	60.17	
Does the farmer know that climate change means sudden weather changes?	Yes	67.95[a]	52.73[b]	43.24[b]	54.64	**0.0283**
	No	32.05	47.27	56.76	45.36	
Does the farmer know that climate change means reduced rainfall?	Yes	21.79	27.27	29.73	26.26	0.6047
	No	78.21	72.73	70.27	73.74	
Does the farmer believe that climate change is a serious problem for cattle farmers?	Yes	93.59	96.36	91.89	93.95	0.6338
	No	6.410	3.64	8.11	6.05	
Does the farmer believe that agriculture and livestock farming are responsible, on some level, for climate change?	Yes	82.05	92.73	86.49	87.09	0.1865
	No	17.95	7.27	13.51	12.91	

p-value corresponds to the hypothesis test of the effect of groups in the generalized linear model. *p-value* in bold are less than the level of significance. Different letters in the rows indicate significant differences at 10% between groups for Fisher's LSD test.

3.4. Relationship between dairy farmers' livelihoods and perceptions of climate change

Positive (80%) and negative (20%) correlations were identified in perceptions between the variables of capital and CC (Table 4). The strongest positive associations were found between the variables: pasture area (4), number of cows in production (7), number of bulls (8), and total milk production in liters per day (9) and the variable " Has the farmer heard about global climate change?" (A). The variables: level of education (2), receipt of government welfare money (10), and receipt of agricultural/livestock insurance (11) were also positively associated with respect to "reduced rainfall" (D). Negative associations were identified between the variables of educational level (2) and receipt of agricultural/livestock insurance (11) with respect to the belief that livestock farming is responsible, on some level, for climate change (E) (Figure 3).

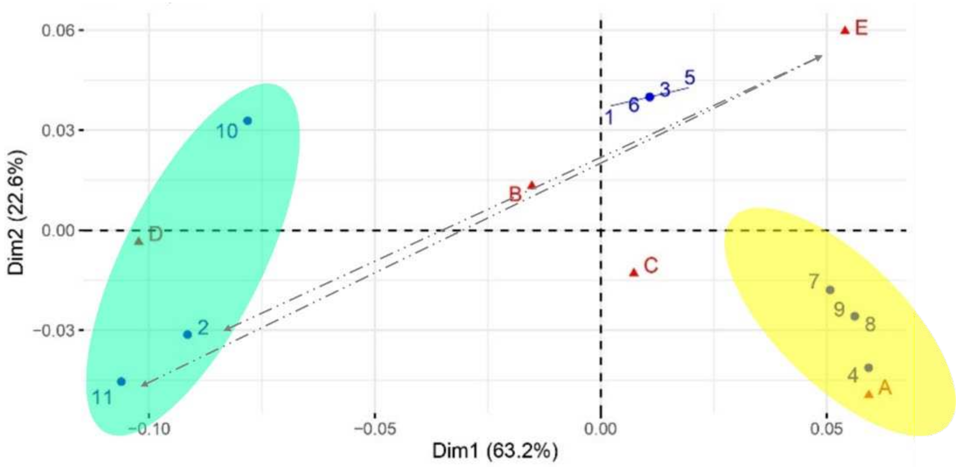

Figure 3. Ordering of Spearman's correlation values between the capital theory variables and perceptions of climate change in small dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 May 2023 doi:10.20944/preprints202305.0881.v1

In the perceptions of medium-sized dairy farmers, positive (60%) and negative (40%) correlations were identified between the variables of capitals and CC (Table 4). Positive associations were found between the variables: pasture area (4), ownership of portable milking equipment (6), number of cows in production (7), and total milk production in liters per day (9) with respect to the variables of sudden changes in climate (C), reduction of rainfall (D), and the belief that livestock farming is responsible, on some level, for climate change (E). Negative associations were identified between the variables of age (1) and experience in milk production (years) (3) with respect to the variable "Has the farmer heard about global climate change?" (A). This was also the case for "owns portable milking equipment" (6) and total milk production in liters per day (9) with respect to the variable of extreme temperatures (B) (Figure 4).

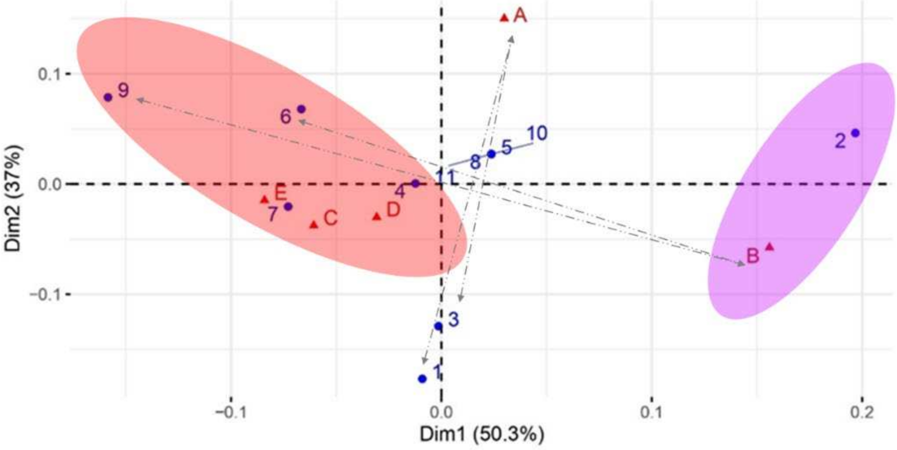

Figure 4. Ordering of Spearman correlation values between capital theory variables and climate change perceptions variables in medium-sized dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

In the perceptions of large dairy farmers, positive (37.5%) and negative (62.5%) correlations were identified between the variables of capitals and CC (Table 4). Positive associations are evidenced between the variables crop area (ha) (5) and "Has the farmer heard about global climate change?" (A), educational level (2), and "climate change means reduced rainfall" (D). Negative associations were identified between the variables of pasture area (4) and total milk production in liters per day (9) as regards "Has the farmer heard about global climate change?" (A), age (years) (1), experience in milk production (years) (3), "climate change means extreme temperatures" (B). This was also true for "receipt of government welfare money" (10) and the belief that livestock farming is responsible, on some level, for climate change (E) (Figure 5).

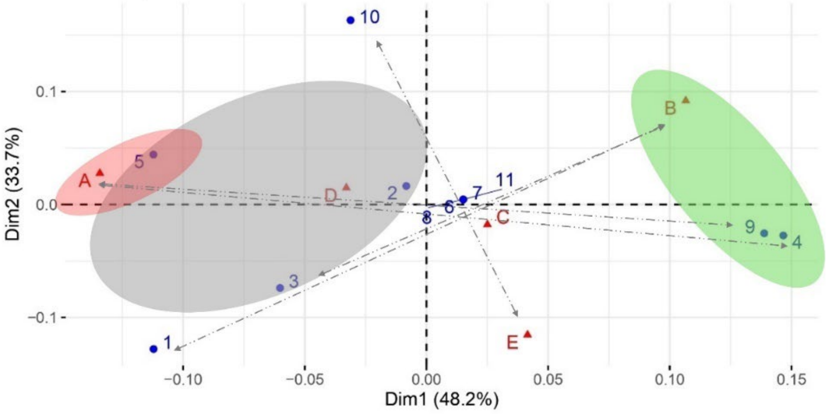

Figure 5. Ordering of Spearman's correlation values between capital theory variables and climate change perception variables in large-scale dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 May 2023 doi:10.20944/preprints202305.0881.v1

Based on the correlation coefficients, different dynamics were identified (Table 7) in global terms in human and social capital (32.14%), natural capital (21.53%), and financial and physical capital (46.42%) with respect to the relationships or approximations with the variables of CC perceptions.

Table 7. Values of Spearman's correlation coefficients between the variables of the capital theory and climate change perceptions in small- (S), medium- (M), and large-scale (L) dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

Capital	Variable	Has the farmer heard about global climate change? (A)			Climate change mean: Extreme temperatures (B)			Climate change mean: Sudden weather changes (C)			Climate change mean: Reduced rainfall (D)			Does the farmer believe that livestock farming is responsible, on some level, for climate change? (E)		
		S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Human and Social	1. Age (years)	-	-0.46****	-	-	-	-0.44***	-	-	-	-	-	-	-	-	-
	2. Educational level	-	0.26*	-	-	0.51****	-	-	-	-	0.19*	-	0.29*	-0.20*	-	-
	3. Experience in milk production (years)	-	-0.36***	-	-	-	-0.27*	-	-	-	-	-	-	-	-	-
Natural	4. Pastureland area (ha)	0.24**	-	-0.36***	-	-	-	0.25**	0.26*	-	-	-	-	-	-	-
	5. Area of cultivated land (ha)	-	-	0.32*	-	-	-	-	-	-	-	-	0.45***	-	-	-
Financial and Physical	6. Owns portable milking equipment	-	-	-	-	-0.24*	-	-	-	-	-	-	-	-	-	-
	7. Number of cows in production	0.21*	-	-	-	-	-	-	0.39***	-	-	-	-	-	0.26*	-
	8. Number of bulls	0.24**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9. Total milk production in liters per day	0.24**	-	-0.34**	-	-0.37***	-	-	-	-	-	-	-	-	0.22*	-
	10. Receipt of government welfare money	-	-	-	-	-	-	-	-	-	0.27**	-	-	-	-	-0.42***
	11. Receipt of agricultural/livestock insurance	-	-	-	-	-	-	-	-	-	0.21*	-	-	-0.24**	-	-

Asterisks (*) indicate significant correlations at *10%, **5%, ***1%, and <0.1%****. A dash (-) indicates no significance in the correlation between the variables.4. Discussion.

4.1. Characterization of dairy farmers' livelihoods using capital theory

The average age of the dairy farmers was 48.22 years (Table 2), while the small-scale dairy farmers adjacent to Chimborazo Fauna Reserve (RPFC) in Ecuador are 5.32 years younger [37]. In the Sumaco Biosphere Reserve of the Ecuadorian Amazon, the farmers are 8.18 years older [38] and in the central Andes of Peru (Province of Pasco), they are 1.68 years older [39]. Regarding gender, there are 60.66% more men than women as heads of households in livestock systems, which could generate a nutritional imbalance of household members, since it has been shown that when women are heads of households, there is a significantly greater positive effect on child nutrition and household food security [40].

In relation to the years of education of household heads, 71.51% completed primary school. Creating rural educational programs is essential, particularly for households with female heads, as children's health and schooling are more closely related to the mother's education than the father's [41]. The average in years of experience in milk production was 21.32, which could have a direct relationship with a higher economic income [42] but could not be related to sustainable cattle farms from social, environmental, and governance perspectives [43]. Regarding advice from community leaders, 96.18% of livestock farmers indicated that they do not receive this benefit, which prevents the formation of networks needed to improve adaptive governance and social cohesion [44]. Therefore, advice as a social process among people at a local level is necessary, as it helps to improve a community's capacity to adapt to CC [45].

The average farm area was 9.99 ha (Table 3), which is 7.12 ha more than cattle-producer farms in Chimborazo and Tungurahua (Ecuador) [46]. Nonetheless, the farms we studied are smaller than the existing Mestizo cattle farms (27.9 ha) in the Sumaco Biosphere Reserve [47]. Of the total of the

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 May 2023 doi:10.20944/preprints202305.0881.v1

dairy farms studied, 71.17% of the surface area represents pastureland; therefore, it is important to reduce the environmental impact of milk production and optimize production on the available land without over-applying fertilizers, thus improving sustainable soil management and grazing rotation [48].

In the dairy farms evaluated, there are hardly any assets, such as motorized strimmers and mechanical milking equipment, with an average of 94.3% responding "No" to ownership. Meanwhile, only 26.69% do not have fertilizer spray pumps (Table 4), which puts at risk the theory that owning physical assets (farm size, bicycle, etc.) produces significant impacts. The characteristics of the farm help producers to improve the quality of their land and increase asset building, and microfinance programs can improve their food security [49].

The significant difference between the evaluated groups in the variables of number of cows in production, total herd, milk production (liters per day), price per liter of milk (dollars/liter), and gross income from milk production (Table 4) implies a commercial disadvantage for small- and medium-scale producers. This is because it has been proven that different forms of technical and financial support on forage and herd management significantly impact the overall profitability of the investment [50].

Almost all (93.61%) of the cattle farmers are not in receipt of welfare money, which could be detrimental to the home environment. In Mexico, Nicaragua, and Costa Rica, it has been shown that welfare in social terms increases school enrollment and attendance alongside improving nutrition and decreasing child labor [51–53]. In other settings in Ecuador, welfare money increased school enrollment by 5% [54], had a statistically significant positive effect on the nutritional status of children [55], and reduced child labor by around 17% [56–58].

Regarding livestock insurance on the farms, 99.57% are not in receipt of it. This could generate some uncertainty surrounding how they would address CC impacts, given that insurance is recognized as 1) a risk reduction strategy, and 2) an efficient way of building and improving resilience [59,60]. Livestock insurance offers compensation payments after a disaster and can be an effective way of decreasing vulnerability to CC [61]. Generally, failure to insure livestock may be due to an inaccurate perception of the performance of insurance companies and insurance services [62].

4.2. Relationship between livelihoods and perceptions of climate change

Studies focusing on livestock farmers' perceptions of CC in Latin America are limited, but some descriptive work has been done [46,63,64]. CC is generally perceived as a greater risk in developing countries than in most of the Western world [65]. Of course, CC risk judgments not only vary between different countries but also between individuals in the same country [66,67].The dynamics found in the Maule region of Chile were similar to the producers studied here (Figure 1; Table 4), revealing that younger, more educated farmers and those who own their land tend to have clearer perceptions of CC than older, less educated, or tenant farmers [68].

It was evidenced that cattle farmers with larger farms – in terms of area, pasturelands, and larger numbers of animals – were more likely to have heard about CC, which could be related to concerns about production efficiency and reproduction of cattle. Increasing temperatures cause heat stress in cattle, which negatively affects milk production, reproduction, and animal health [69,70]. Climate change and seasonal fluctuation in forage quality and quantity affect cattle welfare and lead to a decrease in the cattle's production and reproductive efficiency [71].

4.3. Agri-environmental and educational policy implications for dairy farmers in a changing climate

The institutional framework in terms of CC for compliance with the NDCs for Ecuador was promoted under Executive Decree No. 1,815 (2009) and, in 2010, Modified Decree No. 1,815 was issued under Decree No. 495. This declares climate change adaptation and mitigation to be state policy, making it essential to promote these agri-environmental policies in the productive-conservationist landscape (Figure 2). The sectoral policies committed to in the NDCs should be intensified in the rural productive sector and include incentives for low-carbon production in small-, medium- and large-scale dairy producers (Tables 2 and 3). Other strategies to be implemented are those that help mitigate greenhouse gas emissions with improvements in soil quality and agricultural system efficiency, sustainable land management, restoration of degraded pastures, and good livestock practices [72]. There should also be a strengthening of agri-environmental policies that promote the use of pastures resistant to extreme climate events, the use of efficient technologies for irrigation, the adoption of strategies to support small agricultural and livestock producers, and the dissemination of soil conservation systems.

Considering that the surveyed heads of households have mostly a primary-school educational level (Table 2), the means for acquiring climate information (Table 5), and that in the variables of CC perception (Table 6) there are divergences among dairy farmer groups, it is indispensable to develop local programs for climate education. Such education is a fundamental component when addressing CC problems [73]. Consideration should be given to UNESCO's Education for Sustainable Development program that aims to help people understand the impact of global warming today and increase a climate culture [74]. The key objectives of this program, which would help dairy farmers, are to 1) strengthen pedagogical programs to provide high-quality CC education for sustainable development at primary and secondary school levels, and 2) foster and enhance innovative teaching approaches to integrate high-quality CC education in formal and non-formal settings.

Educational strategies to enhance a climate culture among dairy farmers could include: improving local education policies; boosting education analysis, research, and planning; improving rural teacher education and training for education strategy-makers; promoting better climate science education; and promoting school-wide approaches to climate change education [75].

5. Conclusions

According to the rural livelihoods characterized, of the 20 variables evaluated, there are significant differences between small, medium and large scale dairy farmers in eight variables: gender, educational level, on-farm work, number of cows in production, number of bulls, total herd, production, and average milk price. Regarding the acquisition of climate information, 98.49% of producers did not receive information and only 1.55% obtained information from the government or non-governmental organizations, even though 85.29% of dairy farmers stated that it is important to obtain climate information. Furthermore, of the producers participating in the study, 26.31% have not heard about climate change but 93.95% think that it is a serious problem for farmers and 87.09% consider that agricultural/livestock farming is responsible, on some level, for climate change.

In the relationship between the livelihoods of dairy farmers and perceptions of climate change, it was identified that younger dairy farmers have heard about global climate change more frequently than their older counterparts. Moreover, the higher the dairy farmers' educational level, the greater the relationship with the variables of climate change perceptions. In broad terms, natural and physical capital has an impact on whether dairy farmers have heard about climate change.

Author Contributions: Conceptualization, J.C.V.-B. and M.H.-R. and B.T.; methodology, M.H.-R.; L.P.; J.H.-G.; formal analysis, J.H.-G.; L.P.; M.H.-R.; investigation and data curation, J.C.V.-B.; B.N.H.; J.C.; A.T. and M.L.; writing—original draft preparation, J.C.V.-B.; M.H.-R.; Y.T.; L.P.; writing—review and editing, J.C.V.-B.; M.H.-R.; T.T.; B.T.; project administration, J.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study, which is part of the Project: Analysis of livelihoods, agrarian sustainability, and perception of climate change in mestizos and indigenous people in the Ecuadorian Andes.

Data Availability Statement: Data supporting the reported results can be found by emailing the first or corresponding author.

Acknowledgments: The authors thank the dairy farmers who participated in this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Thornton, P. K., van de Steeg, J., Notenbaert, A., & Herrero, M. The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. *Agricultural systems*, **2009**. 101(3), 113-127.
2. Escarcha, J. F., Lassa, J. A., & Zander, K. K. Livestock under climate change: a systematic review of impacts and adaptation. *Climate*, **2018** 6(3), 54.
3. Herrero, M., Wirsenius, S., Henderson, B., Rigolot, C., Thornton, P., Havlík, P., De Boer, I., and Gerber, P. J. Livestock and the environment: what have we learned in the past decade?. *Annual Review of Environment and Resources*, **2015**. 40.
4. Weindl, I., Lotze-Campen, H., Popp, A., Müller, C., Havlík, P., Herrero, M., Schmitz, C., and & Rolinski, S. Livestock in a changing climate: production system transitions as an adaptation strategy for agriculture. *Environmental Research Letters*, **2015**. 10(9), 094021.
5. Toulkeridis, T., Tamayo, E., Simón, D., Merizalde, M.J., Reyes, D.F., Viera, M. and Heredia, M. Cambio Climático según los académicos ecuatorianos - Percepciones versus hechos. *La Granja: Revista de Ciencias de la Vida*. **2020**. 31(1):21-46. http://doi.org/10.17163/lgr.n31.2020.02.
6. Chambers, R., & Conway, G. Sustainable rural livelihoods: practical concepts for the 21st century. Institute of Development Studies (UK) **1992**.
7. DfiD. Sustainable Livelihoods Guidance Sheets: Framework Introduction Vulnerability Transforming. London, UK. **1999**. https://doi.org/10.1002/smj.
8. Harvey, C. A., Martínez-Rodríguez, M. R., Cárdenas, J. M., Avelino, J., Rapidel, B., Vignola, R. Donatti, C., and Vilchez-Mendoza, S. The use of Ecosystem-based Adaptation practices by smallholder farmers in Central America. *Agriculture, Ecosystems & Environment*, **2017**. 246, 279-290.
9. Pica-Ciamarra, U., Tasciotti, L., Otte, J., & Zezza, A. Livestock assets, livestock income and rural households: Cross-country evidence from household surveys **2011**. https://openknowledge.worldbank.org/handle/10986/17890
10. Thomson, G. R., Penrith, M. L., Atkinson, M. W., Atkinson, S. J., Cassidy, D., & Osofsky, S. A. Balancing livestock production and wildlife conservation in and around southern Africa's transfrontier conservation areas. Transboundary and emerging diseases, **2013**. 60(6), 492-506.
11. Abay, K. A., & Jensen, N. D. Access to markets, weather risk, and livestock production decisions: Evidence from Ethiopia. Agricultural Economics, **2020**. 51(4), 577-593.
12. A Magrin, G. O., Marengo, J. A., Boulanger, J.-P., Buckeridge, M. S., Castellanos, E., Poveda, G., Vicu˜na, S. Central and South America. In V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, L. L. White (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change **2014**. (pp. 1499–1566). Cambridge, UK: Cambridge University Press.
13. Marengo, J. A., Chou, S., Torres, R. R., Giarolla, A., Alves, L. M., & Lyra, A. Climate change in central and South America: recent trends, future projections, and impacts on regional agriculture. CCAFS Working Paper **2014**.
14. Hannah, L., Ikegami, M., Hole, D. G., Seo, C., Butchart, S. H., Peterson, A. T., and Roehrdanz, P. R. Global climate change adaptation priorities for biodiversity and food security. *PLoS One*, **2013**. 8(8), e72590.
15. Vuille, M., Francou, B., Wagnon, P., Juen, I., Kaser, G., Mark, B. G., and Bradley, R. S. Climate change and tropical Andean glaciers: Past, present and future. Earth-science reviews, **2008**. 89(3-4), 79-96.
16. Chevallier, P., Pouyaud, B., Suarez, W., & Condom, T. Climate change threats to environment in the tropical Andes: glaciers and water resources. Regional Environmental Change, **2011**. 11(1), 179-187.
17. IPCC. Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, **2021**. pp. 3–32, doi:10.1017/9781009157896.001.
18. Seager, R., Lis, N., Feldman, J., Ting, M., Williams, A. P., Nakamura, J., Lui, H., and Henderson, N. Whither the 100th meridian? The once and future physical and human geography of America's arid–humid divide. Part I: The story so far. Earth Interactions, **2018**. 22(5), 1-22.
19. Chakraborty, S., & Newton, A. C. Climate change, plant diseases and food security: an overview. Plant pathology, **2011**. 60(1), 2-14.
20. Elad, Y., & Pertot, I. Climate change impacts on plant pathogens and plant diseases. Journal of Crop Improvement, **2014**. 28(1), 99-139.
21. United Nations United Nations Framework Convention on Climate Change. New York: United Nations, General Assembly. **1992**.
22. Læssøe, J., & Mochizuki, Y. Recent trends in national policy on education for sustainable development and climate change education. Journal of Education for Sustainable Development, **2015**. 9(1), 27-43.

23. UNESCO. United Nations Educational, Scientific and Cultural Organization (UNESCO). UNESCO strategy for the second half of the United Nations Decade of Education for Sustainable Development. Paris. **2010.**
24. Mochizuki, Y., & Bryan, A. Climate change education in the context of education for sustainable development: Rationale and principles. Journal of Education for Sustainable Development, **2015**. 9(1), 4–26.
25. GADPC. Creación del Área de Conservación y Uso Sustentable de la Cordillera Oriental del Carchi. Gobierno Autónomo Descentralizado de la Provincia del Carchi/CONDESAN Proyecto EcoAndes. Tulcán. Ecuador **2016.** (Accessed Apr 24 2022).
26. MAE. Sistema de Clasificación de los Ecosistemas del Ecuador Continental. Subsecretaría de Patrimonio Natural. Ministeriodel Ambiente del Ecuador. Quito, Ecuador **2013**. (accessed Apr 24 2022).
27. Cayambe, J.; Iglesias, A. The cost of mitigating greenhouse gas emissions in farms in Central Andes of Ecuador. Span. J. Agric.Res. **2020**, 18, 1–17.
28. Cavendish, W. How Do Forests Support, Insure and Improve the Livelihoods of the Rural Poor? A Research Note; Center for Interna-tional Forestry Research: Bogor, Indonesia, **2003**.
29. Ellis, F. The Determinant of Rural Livelihood Diversification in Developing Countries. Journal of Agricultural Economics, **2000**. 51, 289-302.
30. Scoones, I. Sustainable Rural Livelihoods a Framework for Analysis. Analysis. **1998** 72: 1-22.
31. Torres, B.; Cayambe, J.; Paz, S.; Ayerve, K.; Heredia-R, M.; Torres, E.; Luna, M.; Toulkeridis, T.; García, A. Livelihood Capitals, Income Inequality, and the Perception of Climate Change: A Case Study of Small-Scale Cattle Farmers in the Ecuadorian Andes. Sustainability **2022**, 14, 5028. https://doi.org/10.3390/su14095028
32. Vanclay, F., Baines, J. T., & Taylor, C. N. Principles for ethical research involving humans: ethical professional practice in impact assessment Part I. Impact assessment and project appraisal, **2013**. 31(4), 243-253.
33. Zuur, A.F.; Ieno, E.N.; Walker, N.J.; Saveliev, A.A.; y Smith, G.M. Zero-truncated and zero-inflated models for count data. Mixed effects models and extensions in ecology with R. Ed. Springer New York, **2009**. pp 261-293.
34. Greenacre, M. J. Correspondence analysis in practice. 2nd edition. Chapman & Hall/C RC Press, Boca Raton, Florida. **2010**. xiii + 280 pp. (464)
35. Di Rienzo J.A., Casanoves F., Balzarini M.G., Gonzalez L., Tablada M., Robledo C.W. InfoStat versión **2015**. Grupo InfoStat, FCA, Universidad Nacional de Córdoba, Argentina. URL http://www.infostat.com.ar
36. R Development Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria **2019**.
37. Torres, B.; Cayambe, J.; Paz, S.; Ayerve, K.; Heredia-R, M.; Torres, E.; Luna, M.; Toulkeridis, T.; García, A. Livelihood Capitals, Income Inequality, and the Perception of Climate Change: A Case Study of Small-Scale Cattle Farmers in the Ecuadorian Andes. Sustainability **2022**, 14, 5028. https://doi.org/10.3390/su14095028
38. Torres, B.; Andrade, V.; Heredia-R, M.; Toulkeridis, T.; Estupiñán, K.; Luna, M.; Bravo, C.; García, A. Productive Livestock Characterization and Recommendations for Good Practices Focused on the Achievement of the SDGs in the Ecuadorian Amazon. Sustainability **2022**, 14, 10738. https://doi.org/10.3390/su141710738
39. Radolf, M., Wurzinger, M., & Gutiérrez, G. Livelihood and production strategies of livestock keepers and their perceptions on climate change in the Central Peruvian Andes. Small Ruminant Research, **2022**. 215, 106763.
40. Babu S, Gajanan SN, Sanyal P. Food security, poverty and nutrition policy analysis: statistical methods and applications. New York, NY: Academic Press **2014**.
41. Schultz, T. P. Why governments should invest more to educate girls. World development, **2002**. 30(2), 207-225.
42. Holmann, F. J., Rivas Ríos, L., Carulla, J., Giraldo, L. A., Guzman, S., Martinez, M., Rivera, B.; Medina, A. and Farrow, A. Evolution of milk production systems in the tropics of Latin America and its interrelationship with markets: An analysis of the Colombian case. Paper presented at the ninth world congress on animal production. Porto Alegre, Brazil, **2002**. 26-31 October 2003. Nairobi (Kenya): ILRI
43. Heredia-R, M., Torres, B., Vasseur, L., Puhl, L., Barreto, D., & H Díaz-Ambrona, C. G. Sustainability dimensions assessment in four traditional agricultural systems in the Amazon. Frontiers in Sustainable Food Systems, **2022**. 5, 545.
44. Vasseur, L.; Thornbush, M.J.; Plante, S. Engaging Communities in Adaptation to Climate Change by Understanding the Dimensions of Social Capital in Atlantic Canada. Sustainability **2022**. 14, 5250. https://doi.org/10.3390/su14095250
45. Jones, N.; Clark, J.R.A. Social capital and the public acceptability of climate change adaptation policies: A case study in Romney Marsh, UK. Clim. Chang. **2014.** 123, 133–145.

46. León-Alvear, V., Torres, B., Luna, M., Torres, A., Ramírez, P., Andrade-Yucailla, V., Muñoz-Rengifo, J. C. y Heredia-R, M. Percepción sobre cambio climático en cuatro comunidades orientadas a la ganadería bovina en la zona central de los Andes Ecuatorianos. Livestock Research for Rural Development. **2020**. 32, 165. http://www.lrrd.org/lrrd32/10/mageh32165.html
47. Zambrano, E., Torres, B., Ochoa-Moreno, S., Reyes, H., Torres, A., Velasco, C., Heredia-R, M. Determinantes socioeconómicas del uso forestal maderable en la zona de amortiguamiento del Parque Nacional Sumaco Napo Galeras, Amazonía Ecuatoriana. Ecosistemas **2021**. 30(3): 2216. https://doi.org/10.7818/ECOS.2216
48. Galloway, C., Conradie, B., Prozesky, H., & Esler, K. Opportunities to improve sustainability on commercial pasture-based dairy farms by assessing environmental impact. *Agricultural Systems*, **2018**. 166, 1-9.
49. Kassie, M., Stage, J., Teklewold, H and Olaf, E. Gendered food security in rural Malawi: why is women's food security status lower?. Food **2015**. Sec. 7, 1299–1320 https://doi.org/10.1007/s12571-015-0517-y
50. Bernet, T., Hervé, D., Lehmann, B., & Walker, T. Improving land use by slope farmers in the Andes: an economic assessment of small-scale sprinkler irrigation for milk production. Mountain Research and Development, **2002**. 22(4), 375-382.
51. Behrman, J. R., Sengupta, P., & Todd, P. Progressing through PROGRESA: An impact assessment of a school subsidy experiment in rural Mexico. Economic development and cultural change, **2005**. 54(1), 237-275.
52. Maluccio, J., & Flores, R. Impact evaluation of a conditional cash transfer program: The Nicaraguan Red de Protección Social. Intl Food Policy Res Inst. **2005**.
53. Duryea, S., & Morrison, A. The effect of conditional transfers on school performance and child labor: Evidence from an ex-post impact evaluation in Costa Rica **2004**.
54. Vos, R., León, M., & Brborich, W. Are cash transfer programs effective to reduce poverty? Mimeo. **2001**.
55. León, M., & Younger, S. D. Transfer payments, mothers' income and child health in Ecuador. The Journal of Development Studies, **2007**. 43(6), 1126-1143.
56. Martínez, D., Borja, T., Medellín, N., & Cueva, P.¿Cómo funciona el Bono de Desarrollo Humano?: mejores prácticas en la implementación de Programas de Transferencias Monetarias Condicionadas en América Latina y el Caribe. BID. **2017**.
57. Ponce, J., & Bedi, A. S. The impact of a cash transfer program on cognitive achievement: The Bono de Desarrollo Humano of Ecuador. Economics of Education Review, **2010**. 29(1), 116-125.
58. Schady, N. R., & Araujo, M. Cash transfers, conditions, school enrollment, and child work: Evidence from a randomized experiment in Ecuador **2006**. (Vol. 3). World Bank Publications.
59. Ghahramani, A., & Bowran, D. Transformative and systemic climate change adaptations in mixed crop-livestock farming systems. Agricultural systems, **2018**. 164, 236-251.
60. Amamou, H., Sassi, M. B., Aouadi, H., Khemiri, H., Mahouachi, M., Beckers, Y., & Hammami, H. Climate change-related risks and adaptation strategies as perceived in dairy cattle farming systems in Tunisia. Climate Risk Management, **2018**. 20, 38-49.
61. Karimi, V., Karami, E., & Keshavarz, M. Vulnerability and adaptation of livestock producers to climate variability and change. Rangeland Ecology & Management, **2018**. 71(2), 175-184.
62. Biglari, T., Maleksaeidi, H., Eskandari, F., & Jalali, M. Livestock insurance as a mechanism for household resilience of livestock herders to climate change: Evidence from Iran. Land Use Policy, **2019**. 87, 104043.
63. Torres, B.; Cayambe, J.; Paz, S.; Ayerve, K.; Heredia-R, M.; Torres, E.; Luna, M.; Toulkeridis, T.; García, A. Livelihood Capitals, Income Inequality, and the Perception of Climate Change: A Case Study of Small-Scale Cattle Farmers in the Ecuadorian Andes. Sustainability **2022**, 14, 5028. https://doi.org/10.3390/su14095028
64. Browning-Aiken, A., Morehouse, B., Davis, A., Wilder, M., Varady, R., Goodrich, D., Carter, R., Moreno, D. and McGovern, E. D. Climate, water management, and policy in the San Pedro Basin: results of a survey of Mexican stakeholders near the US–Mexico border. Climatic Change, **2007**. 85(3), 323-341.
65. Kim, S. Y., & Wolinsky-Nahmias, Y. Cross-national public opinion on climate change: The effects of affluence and vulnerability. Global Environmental Politics, **2014**. 14(1), 79-106.
66. Smith, N., & Leiserowitz, A. The rise of global warming skepticism: Exploring affective image associations in the United States over time. Risk Analysis: An International Journal, **2012**. 32(6), 1021-1032.
67. Whitmarsh, L. Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. Global environmental change, **2011**. 21(2), 690-700.
68. Roco, L., Engler, A., Bravo-Ureta, B.E. Jara-Rojas, R. Farmers' perception of climate change in mediterranean Chile. Reg Environ Change 15, 867–879 **2015**. https://doi.org/10.1007/s10113-014-0669-x
69. Hammami, H., Bormann, J., M'hamdi, N., Montaldo, H. H., & Gengler, N. Evaluation of heat stress effects on production traits and somatic cell score of Holsteins in a temperate environment. Journal of dairy science, **2013**. 96(3), 1844-1855.
70. Sanker, C., Lambertz, C., & Gauly, M. Climatic effects in Central Europe on the frequency of medical treatments of dairy cows. Animal, **2013**. 7(2), 316-321.

71. Sejian, V., Kumar, D., Gaughan, J. B., & Naqvi, S. M. Effect of multiple environmental stressors on the adaptive capability of Malpura rams based on physiological responses in a semi-arid tropical environment. Journal of Veterinary Behavior, **2017**. 17, 6-13.
72. Samaniego, J., Alatorre, J., Ferrer, J., Muñoz, L., Arpaia L, Panorama de las contribuciones determinadas a nivel nacional en América Latina y el Caribe, 2019: avances para el cumplimiento del Acuerdo de París (LC/TS.2019/89-P), Santiago, Comisión Económica para América Latina y el Caribe (CEPAL), **2019**
73. González-Gaudiano, E. J., & Meira, P. Á. Educación para el cambio climático: ¿Educar sobre el clima o para el cambio? Perfiles educativos, **2020**. 42(168), 157-174.
74. Læssøe, J., & Mochizuki, Y. Recent Trends in National Policy on Education for Sustainable Development and Climate Change Education. Journal of Education for Sustainable Development, **2015**. 9(1), 27–43. https://doi.org/10.1177/0973408215569112
75. UNESCO. Climate change education for sustainable development. UNESCO Climate Change Initiative. **2010**. Retrieved from: http://unesdoc.unesco.org/images/0019/001901/190101E.pdf.