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

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Abstract: Climate change mainly affects the production and consumption systems associated with food, livelihoods, production (e.g., reduced milk production), water, and land use. The role of local knowledge is 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-farming households. The objectives were to: (i) characterize the rural livelihoods of dairy cattle farmers; (ii) evaluate access to climate information and perceptions of climate change; and (iii) 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 indicated that climate information is important, but 67.83% did 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 will allow 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 in developing countries are heterogeneous and dynamic and are undergoing dramatic changes [1]. So far, the interactions of these drivers and the magnitude of the impact on livestock production are not well understood [1,2]. Several authors demonstrated a knowledge gap regarding perceptions of climate change (CC) and its relationship with livelihoods in different production systems [2–5]. Livelihoods are defined as "the capabilities, assets (stores, resources, claims and access) and activities necessary to earn a living" [6].

Livelihoods have multiple complex, non-linear interactions, but four relationships illustrate the path of sustainable livelihoods [7]: the vulnerability between livelihoods (human, natural, financial, social and physical capital); assets; structures; and the transformative processes, policies and institutions that have an impact on livelihood strategies and the relationship ends with livelihood outcomes [7].

This article focuses on vulnerability, specifically on perceptions of CC and its potential relationship with the livelihoods of livestock producers. Poor smallholders tend to be the most vulnerable to CC due to their reliance on agriculture, their small holdings, and their lack of assets and savings [8]. Livestock are an important source of income and an asset [9]. Livestock have been shown to be more resilient to the effects of CC compared to agriculture [10]. Therefore, households are likely to engage in livestock production to maintain savings and insure against shocks, trends, and seasonality [11]. Extreme climate variability was proven to negatively impact rural production, decreasing costs and the resources available for investment in subsistence activities [12,13].

Smallholder farmers in the Andean region of South America are expected to be the most affected by CC [14], due to the significant loss in productivity and ecosystem degradation expected by 2050 [14]. Models from the Intergovernmental Panel on Climate Change (IPCC) indicate a significant impact on water management systems, food, and energy security [13,14] and show changes in the frequency, intensity, and duration of extreme weather [12,13]. From 1901 to 2012, temperatures increased by between 0.5 and 3 °C, with an average warming of almost 0.1 °C per decade [13,15]. Alterations are evident in tropical regions such as the Andes [13,15,16] and are potentially irreversible for natural and human systems [17]. These include increased evaporation, drier soils, less productive crops and pastures [18], and an increased proliferation and frequency of diseases in production systems [19,20].

In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) declared that: "Education is an essential element in mounting an adequate global response to CC" [21]. Solutions to CC tend to focus on mitigation and adaptation measures, but successful implementation requires a well-informed and educated society. The interest in education and CC has increased in recent years [22], due to the efforts of the United Nations Educational, Scientific and Cultural Organization (UNESCO) that continue to advocate for educational programs to respond to CC [23]. Mainstreaming CC education into all formal or informal education systems can be one of the most important and effective means of building capacity to address the climate crisis. This is due to its multiplier 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 1).

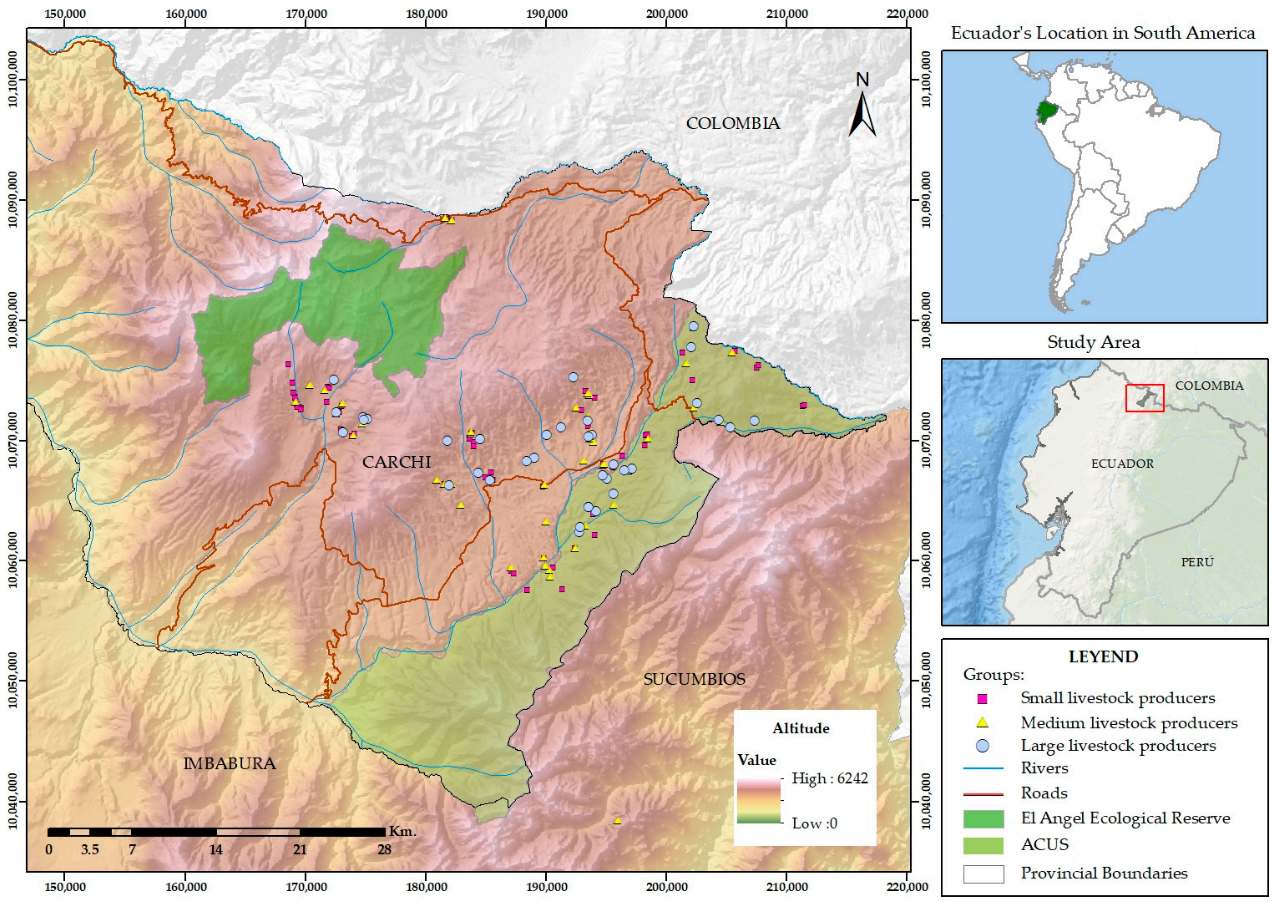

Figure 1. Location of dairy farms in the productive-conservationist landscape of the Ecuadorian Andes.

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-conservationist landscape is located in the province of Carchi, an area of great importance for dairy milk production in the Andean region [27].

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-min interviews with rural Mestizo farming 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-conservationist landscape, the sampling technique used was by non-probabilistic convenience with the following criteria: (i) dairy cattle producers with a farm extension of 1 to 40 ha; and that (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 dairy cattle 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 was homogeneity between the 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 allowed us 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 was a trend ($p \leq 0.0847$) between producer groups; on average, there were 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 were significant differences ($p \leq 0.0016$) between groups of milk producers. The category of small-scale producers contained the highest number of heads of households who: (1) only received primary education; (2) attended a literacy program; and (3) had not received any level of education. Meanwhile, in the category of medium- and large-scale producers, there were heads of households with university educations (9.09% and 2.70%, respectively). As for years of experience in milk production across the categories of producers, there were no significant differences; but in the variable of off-farm or non-farm work, there were highly significant differences ($p \leq 0.0001$). The relationship demonstrated that when the production area was larger, off-farm work was lower, which was contrary to the dynamics in small-scale producers, where the greatest work activity was off-farm among the categories studied. Regarding advice from community leaders, in the three categories of milk producers, 96.18% on average had not received any, while small-scale milk producers had received the most advice: 1.49% and 2.43% more than medium- and large-scale 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. The SD (σ) of the variables is indicated in brackets.

3.1.2. Natural Capital

There were significant differences ($p \leq 0.0001$) in terms of natural capital among the evaluated variables and producer categories (Table 3). The total farm area of small-scale dairy farmers was 2.28 and 5.64 times smaller than medium- and large-scale farmers. In relation to pastures, the average area was 7.11, while the large-scale farmers had 6.45- and 2.71-times larger pasture areas than the small- and medium-scale farmers. With respect to crop area, the relationships were 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. The SD (σ) of the variables is indicated in brackets.

3.1.3. Physical Capital

It was evident that most of the farmers (an average of 96.91% (Table 4) in the three groups did not have motorized strimmers. Concerning the ownership of portable milking equipment, the large-scale farmers had 1.10 and 2.11 times more than the medium- and small-scale farmers. An average of 73.31% of the farmers owned manual spray pumps them; 23.08% of the small-scale farmers did not have manual spray pumps, at a ratio of 1.20 and 1.30 with respect to medium- and large-scale farmers. There were significant differences between the categories of farmers in relation to the following variables: the 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) ($p < 0.0001$). Large-scale farmers had between 2.33 and

4.50 times more cows in production than medium- and small-scale farmers, respectively. There were no significant differences between small- and medium-scale farmers in terms of the number of bulls and large-scale farmers had an average of 1.11; the average herd total was 10.05. With respect to total milk production (liters per day), small-scale farmers produced 6.55 and 3.00 times less than large- and medium-scale farmers, respectively. There were no significant differences between the average milk prices among small- and medium-scale farmers, while in the large-scale milk producers the cost was 0.40 dollars. Regarding the number of months that the cows were in production, there were no significant differences between the categories of farmers, and the average value was 7.13 months.

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)	19,351.65 [c] (18,816.23)	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). *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. The SD (σ) of the variables is indicated in brackets.

3.1.4. Financial Capital

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

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 was a similarity between small- and medium-scale producers as opposed to large-scale producers. With respect to receiving climate information, small-scale producers did not receive any, while 4.52% of medium- and large-scale producers did receive it. Eighty-five percent of the producers considered climate information to be important and there was an average difference of between 1% and 53.04% with respect to the producers who considered temperature and precipitation to be important or not important, respectively. As for obtaining information on the climate, 91% of the farmers did not employ ancestral knowledge, 56% of the farmers used almanacs or agricultural calendars, 29% used newspapers, radio, and television, and 98.45% did not consult media from government or non-governmental organizations. In global terms, 68% of the dairy farmers considered 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 seven 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-scale producers, the results were similar to each other but different to small-scale milk producers. In general terms, only 73.69% of milk producers had heard about CC. In relation to the variables understood as being related to CC, 31.66% indicated an increase in temperature, while 60.17% and 73.74% considered that they were not related to extreme temperatures and a reduction in rainfall, respectively; 93.95% of the producers confirmed that CC is a serious problem for livestock, while 87.09% of the producers indicated 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 2).

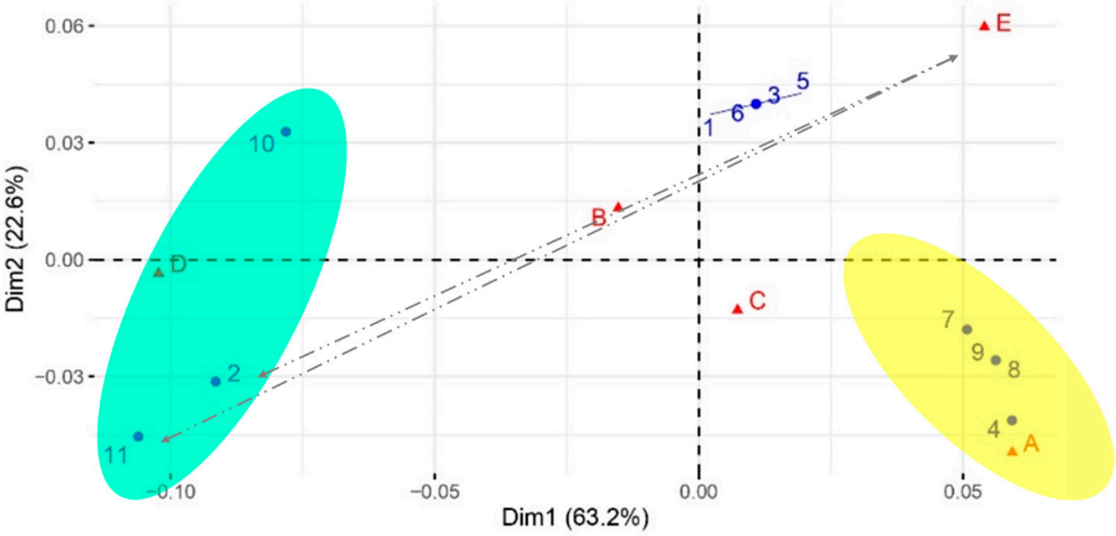

Figure 2. Ordering of Spearman's correlation values between the capital theory variables (numbers) and perceptions of climate change variables (letters) in small-scale dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

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 3).

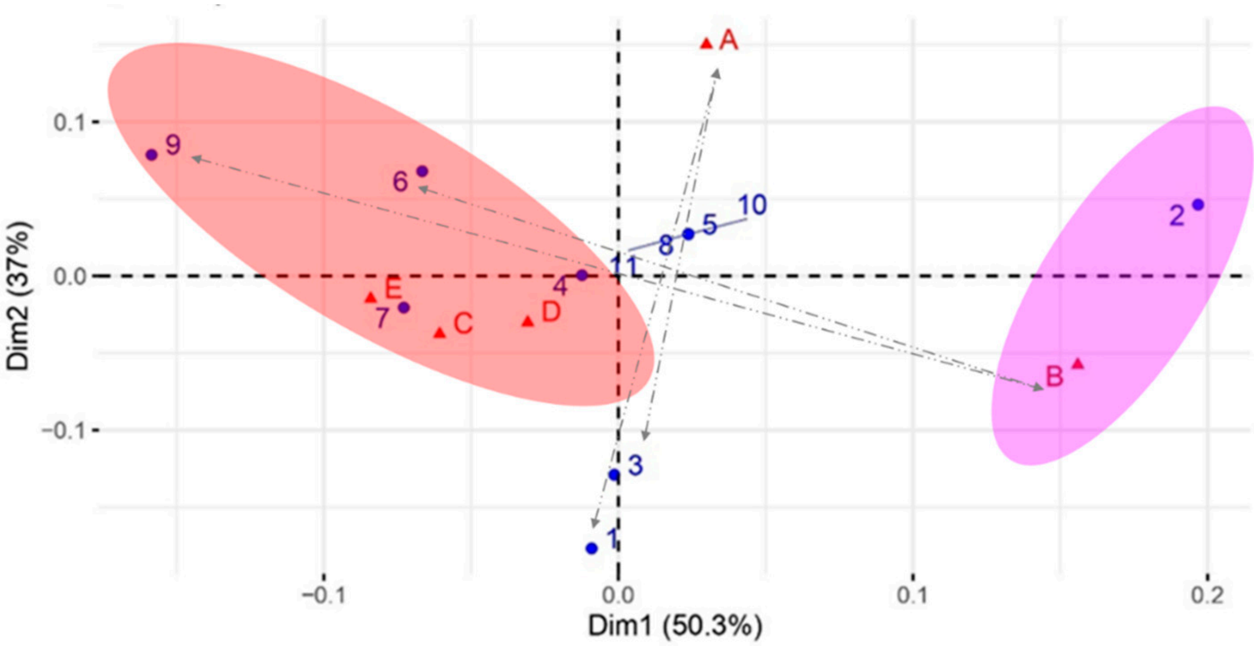

Figure 3. Ordering of Spearman correlation values between capital theory variables (numbers) and climate change perceptions variables (letters) in medium-sized dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

In the perceptions of large dairy farmers, positive (37.5%) and negative (62.5%) correlations were identified between the variables of capital and CC (Table 4). Positive associations were shown 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 4).

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									Does the Farmer Believe That Livestock Farming Is Responsible, on Some Level, for Climate Change? (E)		
					Extreme Temperatures (B)			Sudden Weather Changes (C)			Reduced Rainfall (D)					
		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.

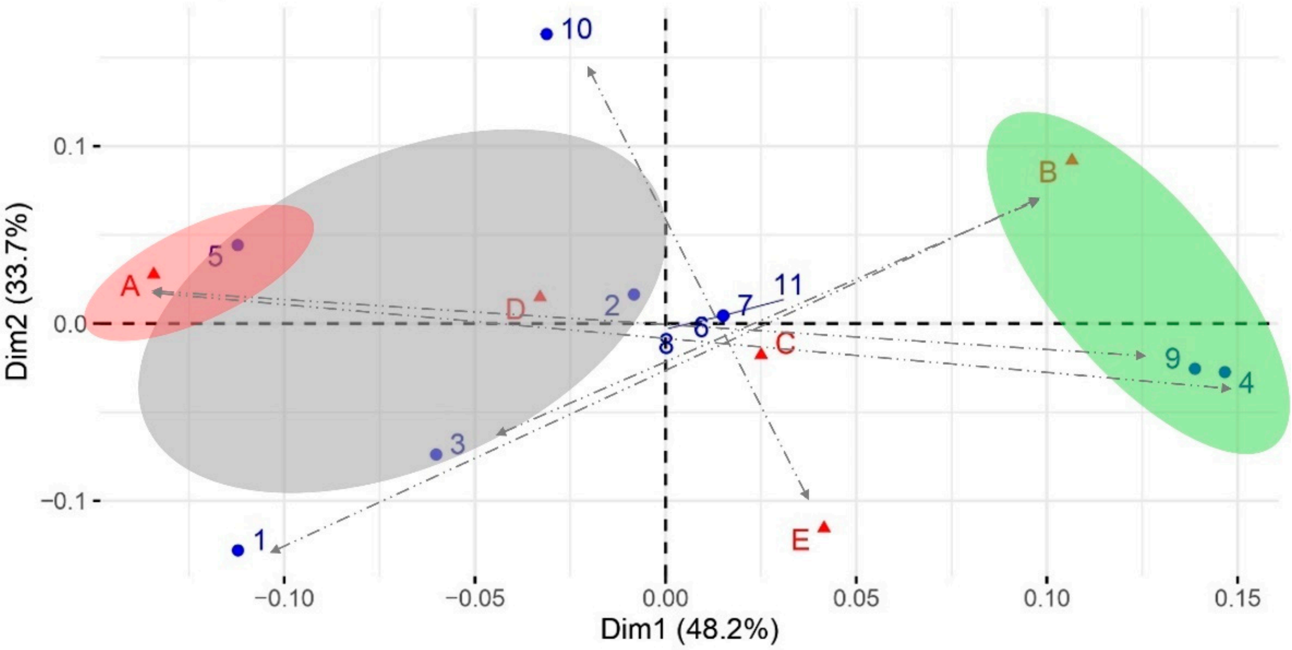

Figure 4. Ordering of Spearman's correlation values between capital theory variables (numbers) and climate change perception variables (letters) in large-scale dairy farmers in the productive-conservationist landscape of the Ecuadorian Andes.

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 were 5.32 years younger [37]. In the Sumaco Biosphere Reserve of the Ecuadorian Amazon, the farmers were 8.18 years older [38] and in the central Andes of Peru (Province of Pasco), they were 1.68 years older [39]. Regarding gender, there were 60.66% more men than women as heads of households in livestock systems, which could generate a nutritional imbalance among 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% had 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 were smaller than the existing Mestizo cattle farms (27.9 ha) in the Sumaco Biosphere Reserve [47]. Of the total of the dairy farms studied, 71.17% of the surface area represented 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].

There were hardly any assets, such as motorized strimmers and mechanical milking equipment, among the dairy farms evaluated, with an average of 94.3% responding "No" to ownership. Meanwhile, only 26.69% did 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 the 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 for forage and herd management significantly impact the overall profitability of an investment [50].

Almost all (93.61%) the cattle farmers were 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% were not in receipt of it. This could generate some uncertainty surrounding how CC impacts would be addressed, 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, a 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 was conducted [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 vary not only 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 those of 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].

Studies have shown 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 in cattle. Increasing temperatures cause heat stress in cattle, which negatively affects milk production, reproduction, and animal health [69,70]. Climate change and seasonal fluctuations in forage quality and quantity affect cattle welfare and lead to a decrease in cattle 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. 1815 (2009) and, in 2010, the Modified Decree No. 1815 was issued under Decree No. 495. This declared climate change adaptation and mitigation to be a state policy, making it essential to promote 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 mostly had a primary-school educational level (Table 2), the means for acquiring climate information (Table 5), and that, according to the variables in 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 impacts of global warming today and develop 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% had 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 had 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 had an impact on whether or not dairy farmers had heard about climate change. Future research should focus on strengthening the capacities of older livestock producers and on formulating non-formal educational programs to promote a climate culture among producers.

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