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# Public Perceptions of Climate Change in the Peruvian Andes

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**Abstract:** How people subjectively perceive climate change strongly influences how they respond to its challenges. To date, relatively little is known about such perceptions in the Global South. This research examines public perceptions of climate change in the Peruvian Andes, a semi-arid high-mountain region that is highly exposed and vulnerable to adverse effects of climate change. Based on questionnaire data collected through face-to-face interviews (N = 1316), we found that respondents identify various climate-related issues as the most important challenges for their country. Many of these issues are related to water. Respondents also noticed more subtle changes and expected them to continue (e.g., extreme temperatures, food shortages). Climate impacts were clearly seen as negative, which was also reflected in the presence of emotions. When compared to previous research, more respondents had personally experienced extreme weather events (80%) and they were more certain that the climate is already changing, is caused by human activity, and is affecting distant and close places similarly. A comparison of the perceptions along different socioeconomic characteristics suggests that more vulnerable groups (e.g., rural, low income and education levels) tended to perceive climate change as more consequential, closer, and as a more natural (vs. anthropogenic) phenomenon than those from less vulnerable groups. The salience of water-related problems and personal experiences of climate-related events, as well as differences between various subgroups, could be used to improve measures to adapt to the consequences of climate change by correcting misconceptions of the population and of decisionmakers.

**Keywords:** climate change perceptions; personal experiences; psychological distance



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## 1. Introduction

The emission of greenhouse gas and the corresponding changes in the climate system increase many risks The emission of greenhouse gas and the corresponding changes in the climate system increase many risks for human systems and natural environments—-that is, the likelihood of negative consequences in the future as a function of hazard (the probability of an extreme weather or climate event), exposure (people, livelihoods, environmental services, and assets in an area in which the event may occur), and vulnerability (the propensity of exposed elements to suffer negative consequences when affected by an event) [1,2]. To the extent that emissions continue to be high, they are likely to cause "severe, widespread, and in some cases irreversible impacts globally within this century" [3] (p. 34). To reduce such risks, it is important that individuals and societies around the world not only try to reduce the magnitude of climate change (through mitigation), but also take adaptive measures that help people and ecosystems to prepare for the negative consequences of climate change and to take advantage of its positive consequences (through adaptation) [2].

An important factor that influences the level of mitigation and adaptation is how people subjectively perceive climate change and its consequences (for reviews, see [4–7]). The perception of climate change can be understood as a mental construct that encompasses experiential (such as past personal experiences of extreme weather), affective (such

as worry), cognitive (spontaneous associations, self-assessed knowledge), and evaluative dimensions (perceived risk; [8,9]). Such perceptions influence the extent to which individuals seek information (climate services; [10,11]) or adapt to changing environmental conditions [12–17]. Perceptions also matter because they influence opinions about and the acceptance of private and governmental measures (e.g., building a new water reservoir) and policies [18,19]. Moreover, understanding how the public thinks and feels about climate change is also an important starting point to develop targeted and thereby more effective communication strategies, education measures, and behavior-change campaigns [20,21].

Gaining an in-depth understanding of public perceptions of climate change is especially important in regions where ecosystems and human populations are highly exposed and vulnerable to adverse effects of climate change. Here, the pressure for timely and substantial adaptation measures is high, and a good understanding of public perceptions can play a crucial role in assisting relevant change. Unfortunately, available research on public perceptions of climate change is heavily biased toward findings from Western, educated, industrialized, rich, and democratic (WEIRD) countries in the Global North [22,23], and we know comparatively little about public views on climate change in countries where people are most vulnerable and least resilient to its adverse effects [24–27]. To examine climate change perceptions in a vulnerable region in the Global South, this paper focuses on the Cusco region in Peru as a case study.

## 2. Dimensions of Climate Change Risk Perceptions

The way people respond to climate change is influenced by how they subjectively think and feel about the issue [8,9,28]. Previous work has operationalized such perceptions in different ways. Among other things, perceptions have been equated with spontaneous associations, beliefs about the reality of climate change, knowledge, attitudes, the likelihood or severity of certain impacts, and the presence of negative emotions [9,29–31]. The present research adopts a broad understanding of perceptions that encompasses experiential, cognitive, evaluative, and affective dimensions [8,9].

The *experiential* dimension refers to personal, firsthand experiences with events or changes that can plausibly be linked to climate change. Personal experiences may render the otherwise abstract phenomenon climate change more concrete and familiar, which could, in turn, make it easier to visualize future impacts and link them to one's own life [32,33]. There is some support for the idea that personal experiences influence climate-related beliefs and behaviors [8,13,34], but other research questions the strength and stability of such effects [28,35–37].

The *cognitive* dimension concerns people's subjective beliefs as well as more formal forms of knowledge (i.e., what is correct or incorrect from a scientific perspective). The underlying assumption here is that people generally act on what they believe. To effectively deal with a threat, they need to be aware of it, know its causes and consequences, and understand how they can effectively respond to it. This view is supported by research on mental models, which shows that the type of beliefs people hold (e.g., if climate change is caused by environmental pollution or carbon emissions) is related to policy support [30]. Similarly, greater amounts of formal knowledge are associated with higher likelihood ratings of serious negative consequences, increased levels of worry, and increased willingness to change behaviors and support policies [8,38–40].

Moreover, it matters how people *evaluate* the consequences of climate change, that is, what meaning and relevance they attach to them. This includes, for example, evaluations of the severity of climate change for different groups of people and nonhuman beings, the likelihood of events and changes, and judgments of when and where changes will occur. Generally speaking, the more people evaluate climate change as likely, severe, and negative, the more they tend to support behaviors and policies aimed at mitigating climate change and at adapting to its consequences [8,18,31,41–44].

Strongly related to evaluations are people's *affective* responses to climate change. Affective responses include broad affect (e.g., positive vs. negative, unpleasant vs. pleas-

ant; [8,31]) as well as discrete emotions about climate change (worry, hope; [40,45–48]). Higher levels of general negative affect and the more specific emotion of worry are typically associated with increased risk perceptions and a higher willingness to act on climate change [43,45]. A plausible mechanism for this is that people want to avoid undesired outcomes through their actions [47,49]. However, whether negative affect translates into threat-reducing behavior also depends on other factors such as beliefs about one's vulnerability and ability to act [50].

## 3. Climate Change and Its Perception in the Peruvian Andes

This semi-arid high-mountain region in the Southern Andes of Peru is highly vulnerable to the impacts of climate change. More specifically, the ecosystem, economy, society, and culture in this region are strongly influenced by glaciers and dependent on their freshwater runoff. At first, climate change leads to an increase in runoff. Later, however, the runoff and the availability of fresh water decreases as the glaciers' surface area and volume shrink [51]. Various glaciers in this region have already crossed this peak [52]. Since 1985, glaciers in this region have lost 30% of their surface and 45% of their volume [53], and many low-lying glaciers are expected to completely disappear within a few decades [54,55]. This glacier recession aggravates the already-existing scarcity of freshwater during the dry season in the high mountains as well as downstream, which poses problems for food production, livelihoods, hydropower production, tourism, biodiversity, and ecosystem integrity, and intensifies conflicts over water resources [26,52,56,57]. Although precipitation trends are difficult to identify because of the scarcity of high-quality observational records and the strong influence of the varying topography [57], at least some climate change models for the 21st century predict decreases in precipitation, which would lead to additional water stress and aggravate these problems [26,58]. Climate change also increases the likelihood of other hazards in the Peruvian Andes, such as flooding and landslides during the wet season due to heavy precipitation and peak glacier runoff [26,59].

Some ethnographic and anthropological studies have examined how rural communities in the Peruvian Andes perceive climate change. These studies have shown that people in rural areas have both noticed changes in the natural environment and heard about climate change. For instance, interviewees reported that they noticed the retreat of glaciers, more frequent and intense extreme weather events, more irregular rainfall, shortened rainy seasons, decreased snowfall, decreasing availability of water, and more extreme temperatures (i.e., warmer days and colder nights; [60–64]). In some studies, people have blamed climate change for deteriorations in human and animal health as well as for their economic situation (e.g., because new pests make their farms less productive; [62,63]). When thinking about the future, people are strongly concerned about the availability of water and conflicts that may arise as a result [60,62].

Through local schools, workshops led by nongovernmental organizations (NGOs), modern media (television, radio), and interactions with Western tourists, many people are familiar with the term "climate change" and use it to explain environmental problems [60–62,65]. However, in contrast to climate scientists' understanding of climate change as a global process, the interviewees often attribute environmental changes to local human behavior (e.g., glacier research, pollution, tourism, modern lifestyles; [60–62]). In addition, some people believe that nonhuman powers (spiritual beings, ancestors, mountains, winds) are also responsible for the changes and that they punish people for abandoning traditional practices (e.g., ritual offerings) and other incorrect actions [60,61,66,67].

## 4. The Present Research

This article aimed to examine how people from the general public in a sensitive region in the Global South perceive climate change, particularly what they associate with climate change, what type of climate-related events they have personally experienced, what they think are its causes and consequences, and how they relate to it emotionally. Another goal

was to explore if and how these perceptions vary for different sociodemographic groups (e.g., women vs. men).

This article contributes to the literature by increasing our understanding of climate change perceptions in non-WEIRD populations (i.e., not Western, educated, industrialized, rich, and democratic; see [22,23]). Moreover, the survey research presented here is based on a broader database than existing qualitative work from the same region to allow estimations of how prevalent different perceptions are in the population. A comprehensive understanding of these perceptions is an important basis for planning and implementing climate action more effectively.

Based on face-to-face interviews with a large and heterogeneous sample (N = 1316), we explored climate change perceptions in five areas in the Cusco region in Peru. Using open and closed questions, we found that participants strongly linked climate change to water-related problems (including glacier retreat) that many have already experienced and expect to worsen in the future. Other salient aspects of climate change were more extreme temperatures and general deterioration of society and the environment. When compared to climate change perceptions in Europe and North America, people from the Cusco region perceived climate change as closer, more certain, more negatively, and more worrying.

## 5. Methods

### *5.1. Study Area*

The interviews were conducted in and around Cusco. This semi-arid high-mountain region is located in the southern Peruvian Andes. Its highest peaks are around 6000 m above sea level and have been covered by glaciers for centuries. The climate is characterized by 2 seasons: The rainy season between November and March, and the dry season between April and October. The temperatures are relatively consistent throughout the year, with an average high of 19–21 °C and an average low of 0–6.5 °C. To reflect the region's heterogeneity in terms of degree of urbanization (e.g., population), socioeconomic conditions (e.g., most relevant economic sectors, access to electricity, presence of paved roads), and environmental conditions (e.g., proximity to flood-prone rivers, elevation above sea level), we interviewed respondents in 5 locations (Figure 1).

**Cusco**. The region's center, Cusco, stretches over 4 districts and is home to almost 400,000 people [68]. The city's elevation is around 3400 m above sea level. A considerable part of the population works in agriculture, especially corn and native tubers, as well as in tourism and industry. Within our study, the sample of Cusco represents a highly urbanized population with relatively low exposure and vulnerability to effects of climate change.

**Izcuchaca and Huacarpay**. Izcuchaca is a rural town, located in the district of Anta (estimated population: 1000 inhabitants), situated at 3345 m above sea level. Its main economic sustenance is based on bio-gardens, the vegetable trade, and the raising of small animals, with tourism remaining a rare activity. According to the technical reports of the National Institute of Civil Defense [69], it is located in a geological high-danger zone as it is prone to landslides.

Huacarpay is located in the Lucre district in the Quispicanchi province, south of Cusco (515 inhabitants; [68]), at an approximate altitude of 3020 m above sea level. Its main economic activity is tourism related to the Huacarpay Wetland. The town is located in a geological danger zone prone to landslides and, additionally, to flooding of the Lucre River [70]. The town experienced a severe flooding event in 2010, which forced the population to be relocated. However, the inhabitants have since returned to the flood-risk areas.

In our study, both towns represent rural locations with similar climatic conditions as Cusco, although they are economically less well-off and probably both more exposed and vulnerable to the consequences of climate change. Whereas Izcuchaca is particularly challenged economically, Huacarpay is more exposed to flooding and has already experienced such catastrophic events. Note that the samples were drawn only from the villages Izcuchaca and Huacarpay, not the entire districts.


**Figure 1.** Study area in the Peruvian Andes.

**Urubamba**. With 13,942 inhabitants [68], Urubamba is the largest town in the Sacred Valley (Valle Sagrado). The town is located relatively low at 2870 m. The Vilcanota (or Urubamba) River as well as 2 smaller rivers, which carry the runoff of the surrounding snow-capped mountains including Chicón, run through the town. These rivers have repeatedly caused damage due to flooding. During the dry season, the town often suffers from water scarcity and droughts. Whereas a large part of the town's population works in agriculture, it has also a thriving tourist industry. This location represents a relatively urbanized population, which, in contrast to Cusco, is more vulnerable and particularly exposed to effects of climate change. In fact, it is considered a high-risk area prone to flooding [71].

**San Isidro de Chicón**. San Isidro is the population center of the Chicón Basin, which is a side valley of the Sacred Valley (Valle Sagrado) directly connecting the center of Urubamba with the snow-capped Chicón (5530 m). In spite of the closeness to the economic center Urubamba, the valley is poorly developed and holds only about 584 inhabitants [68]. Climatically, Urubamba and Chicón are directly connected, and when flooding hits the Chicón Basin, parts of Urubamba are also affected. The last catastrophic event happened in 2010, when a part of the Chicón glacier broke and caused a flood wave that reached deep into Urubamba, causing heavy damage. People in Chicón mainly live from arable farming and livestock production. Because there is hardly any tourism in Chicón, it is economically less well-off than Urubamba. This is visible, for example, in the lack of asphalt roads and only limited access to electricity. The level of education is lower and the influence of indigenous culture stronger, with many people having Quechua as their first language.

Therefore, this sample—though of limited size—represents the counterpoint to Cusco: A rural population highly vulnerable and exposed to consequences of climate change.

### *5.2. Sample and Procedures*

After thorough piloting with members of the public, trained local interviewers conducted tablet-assisted, structured face-to-face interviews in Spanish between May 2016 and January 2017. Three considerations guided the target sample size. First, the sample needed to be large enough to perform the planned analyses with sufficient statistical power. Of all analyses planned within this project, the analysis that required the largest sample was a structural equation model (not reported here). This analysis required a sample size of approximately 900 respondents (see [8,28]). Second, the sample should be broadly representative of the general population of the research area in terms of age, gender, education, income, and income. Representativeness ensures that the samples are not biased toward specific sociodemographic characteristics, some of which have been found to be related to perceptions of climate change [8,72]. Moreover, representativeness is important to make descriptive claims (e.g., 'X% think that . . . '). To achieve a broadly representative sample, 1067 respondents are necessary (margin of error: ±3%, confidence interval: 95%). Third, we had to consider the limited resources of this project. In sum, although the ideal sample size would have been at least 1000 participants for each question asked, we could only interview 1804 people in total and secure a final overall sample size of 1316.

Members of the general public in the Cusco region were selected by a random route procedure [73]. In each of the 5 study locations, interviewers started from roads that were previously selected on maps. From there, they went in all available directions and asked in every second house if someone 16 years or older was willing to participate, irrespective of whether the house was a private home, a business, or a farm (which most houses in rural areas were). They followed this sampling strategy until they had interviewed 4 people in each direction. People younger than 18 years were included to account for the fact that many future impacts of climate change will be experienced by young people and because it provided more cases to compare the very young people (<20 years) with those older than 20 years. According to ethics regulations in Peru, people between 16 and 18 years are allowed to complete surveys with the consent of their parents, which was obtained before the interviews. According to Hoffmeyer-Zlotnik [73], random route samples are representative for the specific geographic area sampled, even though people refusing an interview bias the sample. Although no data were available to check the representativeness of the sample at the level of the 5 locations, some comparisons with the population of the Department of Cusco were possible [68]. This showed that people in the age category 20–29 were overrepresented (difference in relative proportion: 11%), and the distributions of the remaining age categories were very similar (difference <5%). Moreover, people with a university degree were overrepresented (difference: 26%), and those with no formal or primary education level were underrepresented (difference: 8%, 12%). Those who learned Quechua as their first language were underrepresented in our sample (difference: 23%), while native Spanish speakers were overrepresented (difference: 25%). With respect to gender and religion, the composition of the sample was very similar to the official statistics (difference <3%; [68]). So, while not perfectly representative, particularly due to the bias toward higher educated native Spanish speakers, we deem the sample a valid basis for drawing conclusions regarding perceptions of climate change in the region. The differences between under- and overrepresented groups will be investigated in the analyses.

The survey included a broad range of topics, and most questions were presented in a closed-ended format. Because completing all questions would have lasted 4 hours, we created different versions with overlapping sets of topics. This enabled us to cover all topics without putting too much strain on respondents. The interviews typically took between 50 min and 90 min to complete.

To avoid influencing answers to the open questions at the beginning of the interview, interviewers said that they were interested in the interviewees' "opinions", and no infor-

mation about the content of the survey was provided until the open questions were given and entered into a tablet. Interviewers were instructed to adhere to the item wordings and to explain unclear words to the participants without influencing the answers. For example, "climate" and "weather" were difficult to distinguish for many participants, as the same word (el clima) is commonly used for both. Key concepts, such as climate change, the data-gathering procedure (e.g., the answering scales), and, of course, the interview itself (to obtain the informed consent of the participants), were carefully explained by the interviewers.

Of the 3609 people approached, 1804 (50.0%) agreed to start the interview. To ensure good data quality, we excluded 163 respondents who found it difficult to understand the questions (e.g., because their first language was not Spanish or because the interview setting was too loud), who rushed through the questions responding "Don't know" most of the time, who were overly distracted (e.g., because they were serving clients at the same time), or who did not want to complete the interview. Further, 325 cases were removed based on a check of the entire database (i.e., also items that were not used in the presented analyses) regarding item discrimination. Cases that regularly provided almost the same answers to very different constructs were excluded. The final sample included 1316 respondents (see Table 1 for its sociodemographic characteristics).

**Table 1.** Demographic profile of survey respondents.

| Variable | Statistics |
|---|---|
| Age | |
| N; Refused | 1275; 0 (0.0%) |
| 16–19 | 143 (11.2%) |
| 20–29 | 439 (34.4%) |
| 30–39 | 282 (22.1%) |
| 40–49 | 171 (13.4%) |
| 50–59 | 146 (11.5%) |
| 60–69 | 62 (4.9%) |
| 70 or older | 32 (2.5%) |
| Gender | |
| N; Refused | 1300; 0 (0.0%) |
| Female | 695 (53.5%) |
| Male | 605 (46.5%) |
| Education | |
| N; Refused | 1293; 0 (0.0%) |
| No formal | 22 (1.7%) |
| Primary | 110 (8.5%) |
| Secondary | 421 (32.6%) |
| Technician | 164 (12.7%) |
| Higher | 576 (44.5%) |
| Income | |
| N; Refused | 1264; 206 (15.7%) |
| 100–500 Sol | 168 (15.9%) |
| 600–1000 Sol | 226 (21.4%) |
| 1100–1500 Sol | 259 (24.5%) |
| 1600–2500 Sol | 223 (21.1%) |
| 2600–5000 Sol | 151 (14.3%) |
| >5000 Sol | 31 (2.9%) |
| First language learned | |
| N; Refused | 1297; 0 (0.0%) |
| Spanish | 866 (66.8%) |
| Quechua | 422 (32.5%) |
| Other | 9 (0.7%) |
| Religion | |
| N; Refused | 1287; 0 (0.0%) |
| Catholic | 1026 (79.7%) |
| Evangelist/other Christian | 151 (11.7%) |
| Other | 110 (8.5%) |

**Table 1.** *Cont.*

| Variable | Statistics |
|---|---|
| Political orientation | |
| N; Refused | 1269; 309 (23.5%) |
| Left | 340 (35.4%) |
| Middle | 394 (41.0%) |
| Right | 226 (23.5%) |
| Household size | |
| N; Refused | 1292; 0 (0.0%) |
| 1–2 | 197 (15.3%) |
| 3–6 | 947 (73.6%) |
| more than 6 | 142 (11.0%) |
| Children | |
| N; Refused | 1281; 0 (0.0%) |
| 0 | 551 (43.0%) |
| 1–2 | 433 (33.8%) |
| more than 2 | 297 (23.2%) |
| Place | |
| N; Refused | 1266; 0 (0.0%) |
| Cusco | 802 (63.3%) |
| Urubamba | 209 (16.5%) |
| Huacarpay | 70 (5.5%) |
| Izcuchaca | 72 (5.7%) |
| San Isidro | 113 (8.9%) |
| Residency | |
| N; Refused | 1288; 0 (0.0%) |
| 0–2 | 96 (7.5%) |
| 3–10 | 337 (26.2%) |
| more than 10 | 854 (66.4%) |

Note: 'Refused' means that respondents did not want to or could not answer the question. Missing answers (e.g., because participants did not complete the whole survey) were not included in this category.

### *5.3. Measures*

The survey contained a broad range of questions on people's perceptions of climate change and possible ways to respond (including willingness to help others and accept help from others, behavioral intentions, and policy support with respect to both mitigation and adaptation). This paper focuses exclusively on aspects of climate change perceptions. We used open- and closed-answer formats. For the latter type, categorical counts and Likert scales were used. The Likert scales had 5 answer options if the answers were unipolar (i.e., running from a neutral value to an extreme) and 9 options in the case of bipolar items (i.e., running from an extreme to the opposite extreme). This way, the resolution for answers on Likert scales was constant throughout the questionnaire. The interviewer provided a printed scale and explained the meaning of the extreme and neutral values, and the participants could indicate their answer by pointing to a specific value (Figure 2). The graphics had different forms of symbolizing the more/less concept of the scales and, before asking the first question using scales, the interviewers explained the concept and the graphics.

**Most important issue**. To contextualize respondents' perceptions of climate change in the broader context of their everyday experiences and preoccupations, the first question in the survey asked them to describe, in their own words, what they thought would "be the most important problem Peru will face in the next 20 years" [46].

**Associations with climate change**. To explore existing perceptions of climate change that were not biased by the survey questions, we then asked approximately half of the respondents (n = 711, 54.0%) to name the "first ideas, pictures or feelings" that came to mind when they thought about climate change [46,74]. Note that this question was asked before the interviewers explained the concept of climate change. If respondents did not understand what the question was about, the interviewers related the concept to everyday

experiences, such as having heard about it on TV. If the participant still felt unable to reply, the interviewer continued with the next question. A formal introduction of the concept was provided only later in the questionnaire.

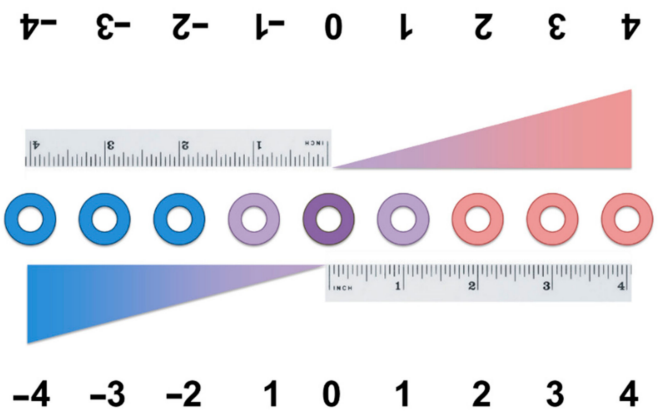


**Figure 2.** Graphic of the 9-point scale used for answering items with Likert scales by pointing to a value between extremes instead of providing verbal descriptions of the values.

**Personal experiences of climate-related events**. Next, respondents were asked how frequently they had personally experienced 5 types of single climate-related events with potentially catastrophic effects in the last 5 years in their area: (1) Droughts and water shortages, (2) storms or heavy rainfall that led to destruction, (3) severe and unusual flooding, (4) mudslides or avalanches, and (5) diseases or pests that had previously been uncommon in their region. Five answer options were provided: "Never", "Once", "Twice", "Three times", and "More than three times." Respondents could also answer with "Don't know", "Don't want to say", and "Don't remember", which we collapsed into the single category, "Refused." The specific contents of this and other questions relating to environmental changes were selected based on the impacts described by the IPCC [2]. The goal was to select events that are of high relevance in the investigated area, but also in other parts of the world to allow comparisons with future studies.

**Perceptions of environmental and societal changes**. Participants then indicated how much they thought 18 types of environmental and societal phenomena had changed in the last 10 years. The 5 phenomena investigated in the previous questions about personal experiences were also assessed here. However, the focus was on perceptions (which can be based on own experiences or not) of changes (and not the phenomena themselves). For example, a person might have experienced the last flooding event as not too severe but perceive that flooding events are becoming more and more severe. In addition to the phenomena for which personal experiences were assessed, 12 other changes were investigated, including agricultural yields and the melting of glaciers. The 9 answer options matched the content of the questions (e.g., −4 = "Much less frequent" vs. 4 = "Much more frequent" for frequency of rain).

**Self-assessed knowledge about climate change**. A single question was used to gauge respondents' subjective level of knowledge about climate change: "Have you ever heard about climate change, global warming, or the greenhouse effect? How much do you think you know about this phenomenon?" (0 = "Never heard about it", 4 = "I'm an expert on this topic"). After participants answered this question, the interviewer explained the concept of climate change as used in the survey.

**Beliefs about the reality and the causes of climate change**. Participants indicated to what extent they believed that climate was changing (1) locally and (2) globally. Answer options ranged from "Certainly not changing" (−4), to "I am totally unsure" (0), to "Certainly changing" (4). Participants who at least considered that the climate might be changing (i.e., with scores higher than −4 on both previous questions) then indicated on a 9-point scale

whether they believed it was caused "Only by natural processes" (−4), "Equally by natural processes and human activities" (0), or "Only by human activities" (4).

**Psychological distance**. To keep the questionnaire length manageable, we included only the spatial dimension of psychological distance, which is the most widely researched dimension and therefore the most suitable for comparisons with other research [75–78]. Respondents were asked how they thought different places, ranging from their immediate environment to the whole world, would be "affected by consequences of climate change due to global warming, such as droughts, flooding, diseases, or mudslides and avalanches." Answer options ranged from "Not affected at all" (0) to "Strongly affected" (4).

**Expectations about future changes**. To investigate respondents' expectations about how things might change in the future, respondents were asked to indicate how much and in what direction climate change would affect 18 dimensions of the natural and human environment. These questions were presented with 9-point Likert scales that matched the content of the questions (e.g., "Will strongly decrease" vs. "Will strongly increase" for questions about the extent of changes, and "Will strongly deteriorate" vs. "Will strongly improve" for questions about qualitative changes).

**Worry about climate change**. Finally, respondents indicated how worried they were about climate change [8,46]. The response options ranged from "Not worried at all" (0) to "Very worried" (4).

### *5.4. Analyses*

**Analyses of closed-ended questions.** To gain a better understanding of how people in the Cusco region generally perceive climate change, we first examined the perceptions of the entire sample (percentages and means). In a second step, we investigated whether perceptions varied for different sociodemographic groups (e.g., women vs. men). Because the conditions for ANOVA were not met (normal distribution, homogeneity of variance) for many of the dependent variables, we used Kruskal–Wallis analyses of variance by ranks, with the perception variables (personal experiences, perceived past and expected future changes, knowledge, beliefs, psychological distance, and worry) as dependent measures and the sociodemographic variables as independent variables. Because some categories only included very few people and to facilitate interpretation, we combined some of the subcategories of the sociodemographic variables before conducting the analyses. The conditions for using this nonparametric method were met: The dependent variable was at least ordinal, the observations between groups were independent, and the independent variable had 2 or more levels. In total, we ran 572 Kruskal–Wallis tests, of which 108 resulted in statistically significant ($p < 0.05$) results. To identify the rank means that differ significantly, we used Dunn's test for pairwise multiple comparisons with Holm's correction for multiple group comparisons. The Kruskal–Wallis tests and the pairwise comparisons were conducted using the R package rstatix [79]. To reduce the results to a manageable number, we tried to identify patterns of results that had at least 3 statistically significant differences. To avoid overinterpreting randomly occurring effects, single results that did not align into a pattern were reported as exceptions. Detailed results can be found in the Supplementary Materials.

**Analyses of open-ended questions.** The analysis of open-ended questions involved 4 steps. First, we prepared the data by converting all words to lowercase, correcting spelling errors, removing function words (words with relatively little semantic meaning such as "the" or "at"), and standardized some terms (e.g., using the infinitive for frequent verbs). Second, we analyzed the frequency of single words. Third, to gain a deeper understanding of the meaning of these frequencies, we explored how much they co-occurred with other words [80]. Fourth, we translated the results from Spanish to English.

To conduct the analyses and prepare this article, we used the statistical software R and R Studio [81,82] and several R packages [83–91].

## 6. Results

To give a general overview about the broader socioeconomic context in the Cusco region, this section first presents the issues that respondents are most concerned about in general. We then focus on more specific climate change questions, starting with typical climate change associations and ending with levels of worry.

### *6.1. Climate Change in the Context of Other National Issues*

The most frequent words that respondents mentioned as most important problem in Peru in the next 20 years were "water", "shortage", "pollution", "change", "lack", and "climatic" (translated from Spanish; Table 2).

To gain a deeper understanding of the meaning of these frequencies, we explored how much they co-occurred with other words (Figure 3). "Water", which was mentioned by 37.2% of the sample, often co-occurred with "shortage", "lack", "pollution", and "food." Among other things, "water" was also linked to "droughts", "problems", "corruption", and even "war." These water-related concerns were also obvious in that "water" was the most frequent association with the words "shortage" (mentioned by 11.9%) and "lack" (mentioned by 6.2%; Figure 3). "Food" was the second most frequent word that co-occurred with these scarcity terms. Thus, increasing water scarcity and the consequences of this process in terms of food and social security were very salient issues.

Another frequently mentioned issue was "pollution", mentioned by 9.0%. Participants also linked this to "water" and also to other aspects of the natural environment (e.g., "environmental", "environment"), but also to concerns about health, safety, and social issues ("diseases", "insecurity", "corruption").

The term "change" (mentioned by 7.3%) was most often mentioned with "climatic" and "climate" and also linked to weather-related terms such as "water", "temperature", "rain", and "droughts" (Figure 3). The salience of climate change as a relevant problem was also evident in the relatively large proportion of respondents who explicitly mentioned "climate change" or "global warming" (9.4%).

**Table 2.** The 20 most frequently mentioned words when talking about important issues Peru will face in the next 20 years (translated from Spanish).

| Word | N |
|---|---|
| water | 489 |
| shortage | 157 |
| pollution | 118 |
| change | 96 |
| lack | 82 |
| climatic | 71 |
| droughts | 54 |
| climate | 53 |
| delinquency | 52 |
| food | 46 |
| environmental | 46 |
| problems | 46 |
| warming | 44 |
| global | 44 |
| economy | 42 |
| poverty | 32 |
| heat | 31 |
| corruption | 30 |
| economic | 30 |
| diseases | 27 |

Note: In total, 1308 respondents answered this question.

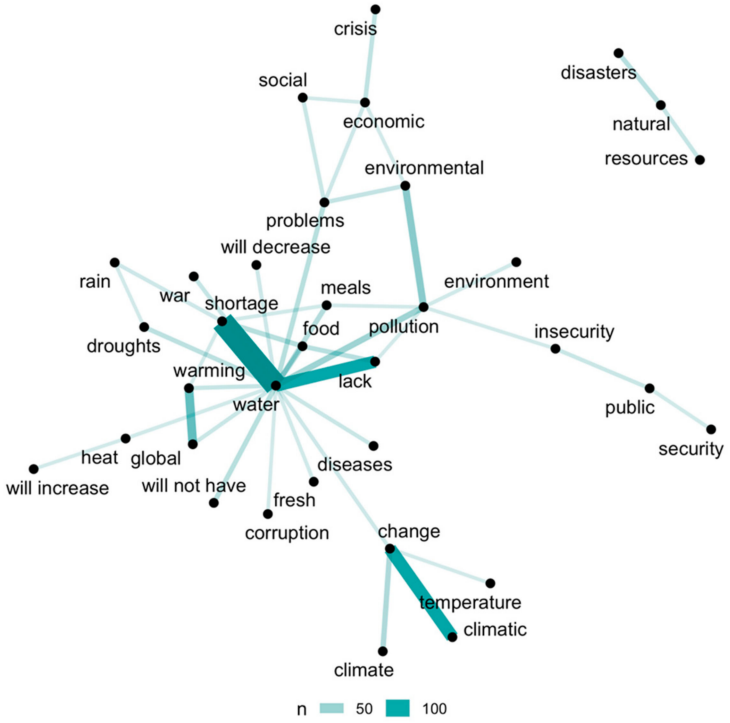


**Figure 3.** Visual depiction of connections between the words mentioned as the most important problem (n = frequency of co-occurrence that occurred at least five times; some translations resulted in multiple English words).

### *6.2. Associations with Climate Change*

When prompted directly about their thoughts on climate change, the most frequently mentioned word was again "water" (Table 3). A closer look at participants' associations with climate change corroborates the findings from the most important issue question: "Water" often co-occurred with terms denoting scarcity (including droughts) and concerns about food and societal problems (e.g., "war"; Figure 4). This further emphasizes the salience of water-related issues in the Cusco region and shows that respondents linked them to climate change.

"Heat" was the second most frequently mentioned association with climate change and most strongly linked to "cold", "extreme", and "droughts" (which was the fifth most frequently mentioned association). The noun "concern", which was the third most frequent association with climate change, was most often mentioned together with "sadness", "water", and "change" (Figure 4). Other frequent associations with climate change were "pollution" and "droughts." Respondents also mentioned issues that were unrelated to climate change, for example, the ozone layer (Figure 4).

**Table 3.** The 20 most frequently mentioned associations with climate change (translated from Spanish).

| Word | N |
|---|---|
| water | 117 |
| heat | 71 |
| concern | 60 |
| pollution | 59 |
| droughts | 51 |
| cold | 49 |
| change | 44 |
| rain | 41 |
| sadness | 40 |
| shortage | 39 |
| lack | 38 |
| disasters | 36 |
| diseases | 33 |
| natural | 29 |
| climate | 24 |
| sun | 24 |
| temperature | 24 |
| sorrow | 22 |
| destruction | 20 |
| warming | 17 |
| will not have | 17 |

Note: In total, 711 respondents answered this question. Some translations resulted in multiple English words.


**Figure 4.** Visual depiction of connections between words that respondents associated with climate change (n = frequency of co-occurrence that occurred at least five times; some translations resulted in multiple English words).

### 6.3. Personal Experiences of Climate-Related Events

About 8 in 10 (79.8%; n = 277) of those asked about personal experiences with single climate-related events with potentially catastrophic effects (n = 347) had experienced at least 1 such event in the last 5 years. The most prevalent experiences concerned storms and heavy rainfall that caused damage (experienced by 59.2%) and droughts and water shortages (experienced by 56.5%; Table 4). Severe flooding (50.0%) and mudslides or avalanches (44.9%) had been encountered less frequently but still by about half of the sample. Even the least frequently encountered personal experience—unusual diseases or pests—were reported by a considerable percentage of participants (38.4%).

Several consistent patterns of differences of means (more precisely, mean ranks between groups defined by sociodemographic characteristics) could be identified for the personal experiences of climate-related events (Supplementary Materials). All events were experienced more by people with Quechua (vs. Spanish) as their first language (effect sizes: $eta^2 \leq 0.03$), and most (except storms and flooding) more by people with more than two children ($eta^2 \leq 0.03$). In contrast, people with higher education levels and living in Cusco experienced most events (except mudslides and, in the case of education, flooding) less than the other groups ($eta^2 \leq 0.03$).

**Table 4.** Summary statistics and frequency of personal experiences of climate-related events (percentages).

| Event | N | Refused | Mean | SD | 0 | 1 | 2 | 3 | 4(+) |
|---|---|---|---|---|---|---|---|---|---|
| Destructive storms or heavy rainfall | 347 | 6 | 1.4 | 1.5 | 40.8 | 21.4 | 13.8 | 9.1 | 15.0 |
| Droughts and water shortages | 345 | 7 | 1.4 | 1.5 | 43.5 | 16.9 | 11.8 | 10.4 | 17.5 |
| Severe and unusual flooding | 344 | 4 | 1.0 | 1.3 | 50.0 | 25.9 | 10.6 | 5.0 | 8.5 |
| Mudslides or avalanches | 346 | 5 | 0.9 | 1.3 | 55.1 | 21.7 | 8.8 | 5.6 | 8.8 |
| Unusual diseases or pests | 344 | 3 | 0.8 | 1.3 | 61.6 | 17.3 | 7.0 | 4.7 | 9.4 |

### 6.4. Perceptions of Environmental and Societal Changes

With respect to environmental and societal changes, respondents most strongly noticed the shrinkage of glaciers, a general deterioration of the environment, and a cooling of winter nights (Table 5). Between 66.0% and 79.4% of the respondents who answered these questions felt that glaciers and the temperature of winter nights have much or considerably decreased and that the state of the environment much or considerably deteriorated (i.e., the two lowest answer options). Another phenomenon that, according to many respondents (54.5%), had decreased much or considerably was agricultural yields.

**Table 5.** Perceived environmental and societal changes (percentages).

| Event | N | Refused | Mean | SD | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Duration of dry periods | 337 | 6 | 2.2 | 2.0 | 3.0 | 0.6 | 5.7 | 1.8 | 4.5 | 6.6 | 21.8 | 30.5 | 25.4 |
| Temperature summer days | 342 | 7 | 1.5 | 2.5 | 5.7 | 6.9 | 6.0 | 2.4 | 3.9 | 5.7 | 23.0 | 25.7 | 20.9 |
| Severity of flooding | 234 | 15 | 1.4 | 2.3 | 3.2 | 5.9 | 6.4 | 6.4 | 8.2 | 9.6 | 24.2 | 15.1 | 21.0 |
| Intensity of storms | 334 | 18 | 0.8 | 2.3 | 4.7 | 5.4 | 11.4 | 5.7 | 16.1 | 6.6 | 22.5 | 16.8 | 10.8 |
| Intensity of hail | 337 | 23 | 0.5 | 2.0 | 2.5 | 5.7 | 10.8 | 8.9 | 19.4 | 15.9 | 22.0 | 9.9 | 4.8 |
| Intensity of rain | 338 | 12 | 0.4 | 2.3 | 5.2 | 6.4 | 15.3 | 11.7 | 11.3 | 9.8 | 18.1 | 12.9 | 9.2 |
| Frequency of hail | 339 | 20 | −0.7 | 2.1 | 8.2 | 13.8 | 22.6 | 11.9 | 16.3 | 6.3 | 12.9 | 5.0 | 3.1 |
| Frequency of rain | 338 | 7 | −1.5 | 2.2 | 16.3 | 22.4 | 27.5 | 8.8 | 6.3 | 4.2 | 6.0 | 4.8 | 3.6 |
| Agricultural yields | 344 | 3 | −2.2 | 1.9 | 26.1 | 28.4 | 18.8 | 10.6 | 6.2 | 3.2 | 2.6 | 3.5 | 0.6 |
| Temperature winter nights | 339 | 9 | −2.5 | 1.7 | 32.1 | 33.9 | 17.3 | 4.8 | 3.9 | 1.5 | 4.2 | 1.2 | 0.9 |
| State of the environment | 334 | 2 | −2.7 | 1.6 | 41.6 | 27.7 | 16.6 | 5.4 | 1.8 | 1.5 | 3.9 | 1.2 | 0.3 |
| Size of glaciers | 333 | 8 | −3.0 | 1.5 | 44.9 | 34.5 | 11.4 | 2.5 | 0.9 | 1.8 | 2.2 | 1.2 | 0.6 |

Note: −4 means much diminished/deteriorated/shorter/less frequent/severe, +4 means much increased/improved/longer/more frequent/severe.

The duration of dry periods, the temperature of summer days, and the severity of flooding were the changes that respondents felt had increased the most: 55.9%, 46.6%, and

36.1% felt that these respective phenomena had increased considerably or strongly (i.e., the two highest answer options).

The phenomena that participants perceived as having changed the least were the intensity of hail, storms, and rain and the frequency of hail. Between 11.3% and 19.4% indicated that these phenomena had not changed.

Regarding differences between groups defined by sociodemographic variables, no patterns could be identified. A tendency might be observed that more vulnerable parts of the population (e.g., low education levels for agricultural yields and frequency of rain; Quechua as a first language for agricultural yields and intensity of storms; low income for severity of flooding) perceived the changes more negatively (e.g., lower agricultural yields and frequency of rain, more intense storms and severe flooding; $eta^2 \leq 0.03$).

### *6.5. Self-Assessed Knowledge*

The vast majority of respondents (96.8%, Figure 5) indicated that they had heard about climate change or global warming. However, the level of self-assessed knowledge was rather low: 47.3% said that they knew "a little", and 33.7% said that they knew "something" about climate change. The proportion of those who felt that they knew a lot about it (14.2%) or were experts (1.6%) was relatively small.

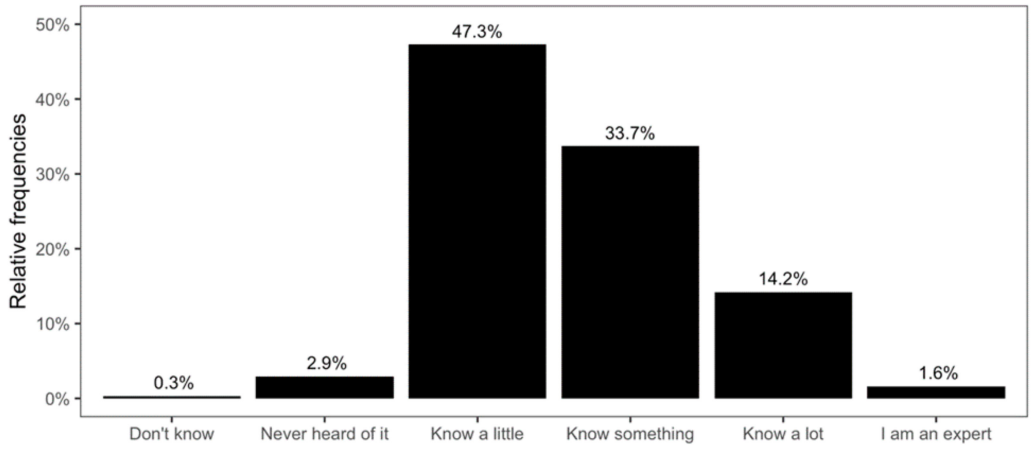


**Figure 5.** Subjective knowledge about climate change (N = 1303).

As could be expected, a linear tendency could be identified that the higher education level ($eta^2 = 0.05$) and the higher the income ($eta^2 = 0.02$), the higher people assess their knowledge about climate change. Further, men ($eta^2 = 0.01$) and people with Spanish as their first language ($eta^2 = 0.02$), left political orientation ($eta^2 < 0.01$), no children ($eta^2 = 0.03$), and from Cusco ($eta^2 = 0.04$) assessed their knowledge as higher, while the oldest age group ($eta^2 = 0.01$) and people who had lived in the region for less than 2 years ($eta^2 = 0.01$) assessed it lower than the other groups.

### *6.6. Beliefs about the Reality and Causes of Climate Change*

When asked how certain they were that the climate was changing, almost all respondents felt that the climate was changing both globally (96.2%) and locally (96.4%; i.e., values > 0 in Figure 6). The perception that the climate is changing globally was lower for men ($eta^2 < 0.01$) and for people with the lowest education levels ($eta^2 = 0.01$), Quechua as their first language ($eta^2 = 0.01$), and non-Catholic Christian religion ($eta^2 < 0.01$). The perception was higher for the highest income group ($eta^2 < 0.01$) and people having one or two children ($eta^2 = 0.01$). Further, this conviction was higher in Urubamba than in Cusco ($eta^2 = 0.01$).

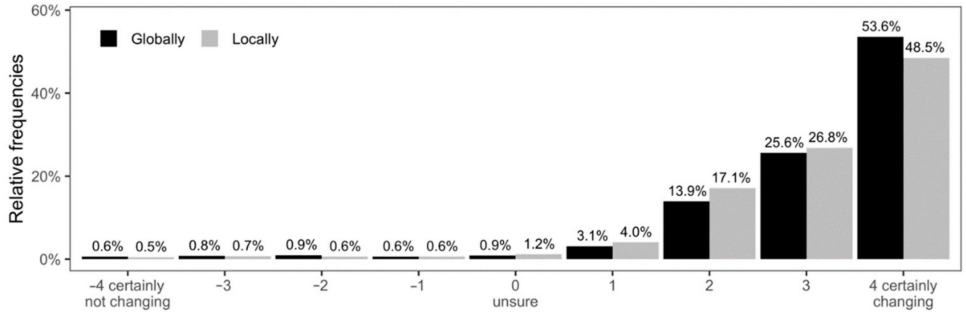


**Figure 6.** Beliefs about global and local climate change (N = 1286/1287).

However, the perception that the climate is changing locally was quite different. Whereas, again, women ($eta^2 < 0.01$), the highest income group ($eta^2 = 0.01$), and people with one or two children ($eta^2 = 0.01$) reported this conviction with more certainty, and people from Cusco reported it with less certainty ($eta^2 = 0.03$), the lowest income group now reported higher certainty ($eta^2 = 0.01$), and people with more than two children no longer differed from the others ($eta^2 = 0.01$; indeed, the largest households are less convinced than the other groups, $eta^2 < 0.01$). Further, respondents from San Isidro de Chicón were convinced of a locally changing climate ($eta^2 = 0.03$). Also, people of ages 40–59 were more convinced of a local change than other groups ($eta^2 = 0.01$).

The majority of respondents (69.4%) attributed climate change more to human activity than to natural processes, and about one-quarter (22.7%) thought that it was caused equally by natural processes and human activities (Figure 7; the 13 (1.0%) participants who refused to answer were not included in this category). Less than 1 in 10 respondents (8.0%) leaned toward a mostly naturally caused explanation of climate change. People with lowest education ($eta^2 = 0.01$) and income ($eta^2 = 0.01$) levels and Quechua as their first language ($eta^2 < 0.01$) tended to explain climate change more by naturally occurring processes than their counterparts.

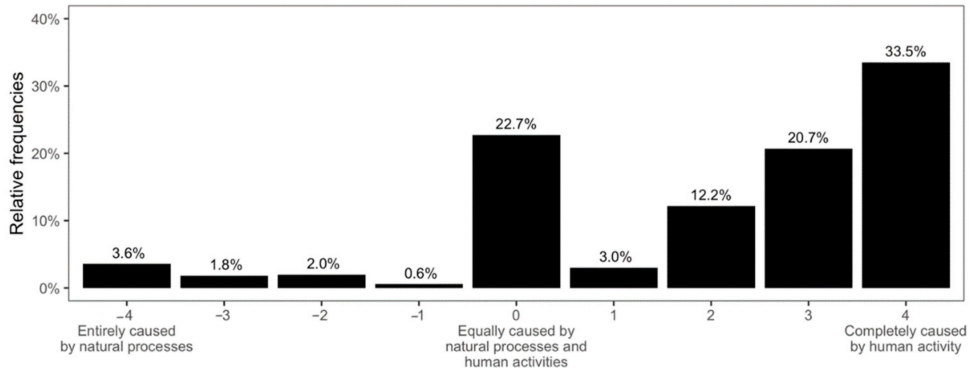


**Figure 7.** Beliefs about the causes of climate change (N = 1266).

### *6.7. Psychological Distance of Climate Change*

When respondents indicated how strongly they thought that climate change would affect specific places ranging from one's neighborhood to the world as a whole, the perceived impacts were similar at different spatial scales (see means in Table 6). Thus, this finer-grained analysis of spatial impacts mirrored the finding that respondents did not strongly distinguish between global and local climate impacts (Figure 6). Two places that were perceived as (relatively) less threatened than others were respondents' "neighborhood" and "rich countries." These were the only two places that 5% or more of the sample believed to be unaffected by climate change.

Whereas these perceptions were indistinguishable for close ranges (i.e., one's province, area, or neighborhood), people in the lowest income group consistently expected lower im-

pacts for more distant places compared to the other income groups (though only marginally significant for rich countries; $eta^2 \leq 0.02$). Similarly, people with Quechua as their first language expected lower impacts for regions further away (the whole country and further, though no significant differences were found for rich countries) but, additionally, more impact for their own neighborhood ($eta^2 \leq 0.01$). Such turn of perception can also be found for education levels, though less clearly. Those with the highest level of education perceived lower impacts nearby (neighborhood and area 50 km around) but more impact for most developing countries (marginally significant). Another systematic pattern found for psychological distance is that women expected generally lower impacts than men, even though this difference was statistically significant only for the Peruvian Andes, the whole country (Peru), and the whole world ($eta^2 \leq 0.01$).

**Table 6.** Expected extent of climate change impacts across different spatial scales (percentages).

| Place | N | Refused | Mean | SD | Not at All | Slightly | Somewhat | Quite | Strongly |
|---|---|---|---|---|---|---|---|---|---|
| Your neighborhood | 340 | 0 | 2.6 | 1.1 | 5.3 | 10.9 | 23.2 | 37.1 | 23.5 |
| Your area (50 km) | 340 | 0 | 2.8 | 1.0 | 2.9 | 5.9 | 23.5 | 41.8 | 25.9 |
| Your province | 338 | 1 | 3.1 | 0.9 | 0.9 | 3.6 | 16.3 | 43.9 | 35.3 |
| The Peruvian Andes | 231 | 4 | 3.1 | 0.8 | 1.3 | 3.1 | 10.6 | 50.7 | 34.4 |
| The Peruvian coast | 231 | 9 | 2.9 | 1.0 | 1.8 | 6.8 | 17.6 | 43.7 | 30.2 |
| Rural areas in Peru | 231 | 4 | 3.2 | 0.8 | 0.4 | 4.0 | 11.9 | 45.8 | 37.9 |
| Urban areas in Peru | 230 | 4 | 2.9 | 0.9 | 1.8 | 7.5 | 16.8 | 48.2 | 25.7 |
| Our whole country | 230 | 5 | 3.1 | 0.8 | 1.3 | 2.7 | 12.9 | 50.2 | 32.9 |
| Latin America | 231 | 8 | 3.0 | 0.9 | 1.3 | 5.8 | 17.0 | 43.9 | 31.8 |
| Most developing countries | 231 | 9 | 2.9 | 1.0 | 2.7 | 6.3 | 17.1 | 41.4 | 32.4 |
| Rich countries (e.g., U.S.) | 229 | 10 | 2.6 | 1.1 | 5.0 | 11.9 | 21.0 | 38.8 | 23.3 |
| The whole world | 230 | 7 | 3.1 | 0.9 | 0.4 | 4.5 | 15.2 | 42.6 | 37.2 |

### *6.8. Expectations about Future Changes*

Expectations about future changes mirrored respondents' perceptions of past changes and were pessimistic. The largest expected change concerned glacial retreat, with about half of the respondents (52.9%) strongly expecting glacial retreat to continue unabated (i.e., the lowest answer option; Table 7).

**Table 7.** Expectations about future changes (percentages).

| Impact | N | Refused | Mean | SD | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Duration of dry periods | 285 | 10 | 2.3 | 1.9 | 2.2 | 2.2 | 2.5 | 2.9 | 2.9 | 5.8 | 21.1 | 33.1 | 27.3 |
| Temperature of summer days | 277 | 8 | 2.3 | 2.0 | 2.6 | 3.7 | 2.6 | 3.3 | 0.7 | 3.7 | 22.7 | 30.1 | 30.5 |
| Frequency of severe droughts | 285 | 10 | 2.1 | 2.2 | 5.1 | 2.5 | 4.7 | 1.5 | 2.2 | 4.7 | 17.5 | 33.5 | 28.4 |
| Unusual diseases or pests | 278 | 12 | 2.0 | 2.2 | 1.5 | 4.9 | 6.8 | 3.8 | 3.8 | 3.0 | 24.8 | 24.4 | 27.1 |
| Frequency of mudslides/avalanches | 304 | 48 | 1.0 | 2.4 | 5.5 | 5.1 | 9.4 | 8.2 | 6.6 | 11.3 | 23.4 | 13.7 | 16.8 |
| Frequency of severe floods | 277 | 21 | 0.8 | 2.4 | 2.0 | 10.2 | 14.1 | 7.4 | 6.6 | 8.2 | 19.9 | 16.4 | 15.2 |
| Intensity of severe storms | 314 | 33 | 0.8 | 2.4 | 3.6 | 7.1 | 13.5 | 7.5 | 7.5 | 11.4 | 20.3 | 14.6 | 14.6 |
| Magnitude of floods | 277 | 31 | 0.8 | 2.5 | 4.9 | 6.9 | 14.2 | 8.5 | 6.5 | 9.3 | 19.9 | 13.8 | 15.9 |
| Frequency of severe storms | 315 | 29 | 0.7 | 2.5 | 3.5 | 8.7 | 18.2 | 6.3 | 7.0 | 6.3 | 20.3 | 15.0 | 14.7 |
| Frequency of hail | 310 | 38 | −0.2 | 2.6 | 8.8 | 13.6 | 23.5 | 6.6 | 8.5 | 5.1 | 13.2 | 7.4 | 13.2 |
| Intensity of rain | 295 | 26 | −0.3 | 2.8 | 15.2 | 14.1 | 14.5 | 6.3 | 6.7 | 5.6 | 17.8 | 8.9 | 10.8 |
| Frequency of rain | 293 | 21 | −1.3 | 2.6 | 21.0 | 21.0 | 22.8 | 5.1 | 2.9 | 4.4 | 8.1 | 7.7 | 7.0 |
| Temperature of winter nights | 278 | 10 | −1.3 | 2.8 | 17.9 | 33.2 | 17.9 | 4.5 | 2.2 | 0.7 | 4.9 | 4.5 | 14.2 |
| Economic situation and living standard | 302 | 18 | −1.6 | 2.3 | 21.5 | 26.4 | 20.1 | 6.0 | 4.2 | 4.9 | 8.5 | 5.3 | 3.2 |
| State of society | 272 | 15 | −2.0 | 2.0 | 24.5 | 25.7 | 27.2 | 6.2 | 1.6 | 3.9 | 6.6 | 2.7 | 1.6 |
| Availability of food | 300 | 6 | −2.3 | 1.8 | 29.3 | 26.5 | 25.9 | 5.8 | 2.4 | 2.4 | 6.1 | 0.7 | 1.0 |
| State of the environment | 273 | 5 | −2.4 | 2.0 | 35.4 | 29.1 | 19.0 | 3.0 | 0.7 | 2.2 | 6.3 | 2.2 | 1.9 |
| Size of glaciers | 278 | 2 | −2.9 | 1.8 | 52.9 | 18.8 | 18.8 | 1.1 | 0.4 | 1.1 | 2.9 | 2.2 | 1.8 |

Note: −4 means will strongly decrease/deteriorate, +4 means will strongly increase/improve.

More than one-quarter of respondents expected droughts and water-related problems to intensify. Respondents believed that the temperature of summer days (30.5%), the duration of dry periods (27.3%), and the frequency of severe droughts would strongly increase (28.4%). In line with this perception of water becoming increasingly scarce,

respondents expected rain to become less frequent, although this expectation was less strong (21.0% expected a strong decrease).

Overall, respondents expected socioeconomic conditions to deteriorate. Between 21.5% and 35.4% of the sample expected that the state of the economy, society, and environment, as well as the availability of food, would decrease or deteriorate strongly (i.e., the lowest answer option). Another problem that about one-quarter (27.1%) of the respondents believed would strongly increase were diseases and pests that had previously been uncommon in their region.

Respondents' expectations were most divided when estimating how the frequency of hail and the intensity of rain would change, which was obvious in that the average of the expected change was very close to zero (*Ms* = −0.2, −0.3). Respondents' expectations were also quite balanced with respect to whether flooding and storms would become more frequent and intense (*Ms* = 0.7, 0.8).

Only a few differences between sociodemographic groups could be identified. Most prominently, people from Urubamba expected a stronger increase of diseases and temperatures and, marginally, a stronger increase of the intensity and magnitude of storms and floods, while people from Cusco expected less increase of diseases and colder winter nights, as well as hotter summer days ($eta^2 \leq 0.02$). People who had lived at the current place for a shorter period expected a stronger increase in the frequency of floods, mudslides, and (marginally) hail ($eta^2 \leq 0.01$). Surprisingly, people with Quechua as their first language expected the frequency of droughts and the duration of dry periods to increase less than people with Spanish as their first language ($eta^2 \leq 0.01$).

### *6.9. Worry about Climate Change*

The view that future changes would be negative was paralleled by a high level of worry. Of those who indicated their level of worry, very few respondents worried "not at all" (0.8%) or "slightly" (7.7%) about climate change (Figure 8). The large majority (91.6%) were at least "fairly" worried about climate change, while most (39.7%) indicated that they were "very" worried.

People from San Isidro de Chicón reported higher levels of worry than people from other locations (except for Izcuchaca; $eta^2 = 0.04$). Women were more worried than men ($eta^2 < 0.01$), people in the age group 40–49 more than 20–39-year-olds ($eta^2 = 0.01$), and people with one or two children and a household size of three to six more than people with fewer children ($eta^2 = 0.01$) or living in larger households ($eta^2 < 0.01$).

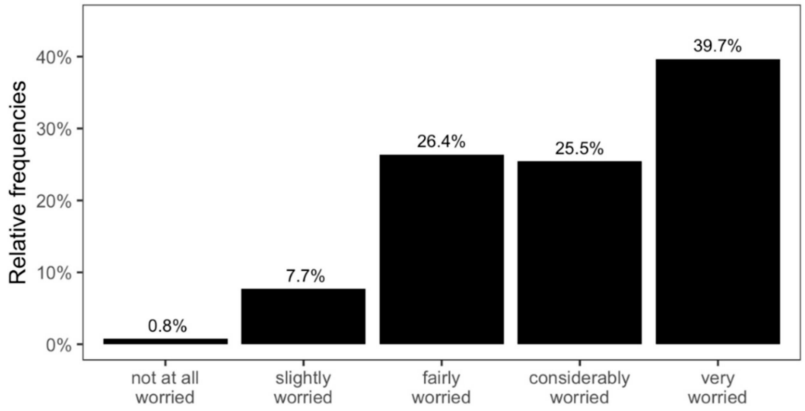


**Figure 8.** Worry about climate change (N = 1288).

## 7. Discussion

This research used a large and heterogeneous sample from the Peruvian highlands to assess how people feel about past and possible future effects of climate change. We used both open-ended and a broad range of closed questions (i.e., qualitative and quanti-

tative data) to holistically assess climate change perceptions in a vulnerable region in the Global South.

### *7.1. Salience of Water-Related Problems and Its Experiential Basis*

Water-related problems were at the forefront of respondents' minds. Not only did more than one-third (37.2%) of the sample spontaneously mention water scarcity as one of the most important future threats to their country, but many respondents had already personally experienced negative consequences arising from either water scarcity, droughts, or flooding. Respondents also directly linked water-related problems to climate change and expected them to intensify in the future.

The salience and consistency with which water scarcity emerged as a topic across different types of questions is both expectable and surprising. It was expectable because water stress has been an issue in the Cusco region and other areas in Peru for a long time [60–63]. As such, the salience of water-related problems corresponds to what people have personally experienced or heard from others. However, it is surprising that water scarcity is so much more salient than other issues. For instance, of those asked about personal experiences with extreme weather events in the past 5 years, at least half had personally experienced other extreme events as well (e.g., destructive storms, severe flooding, mudslides). Also, climate change campaigns and the coverage of this topic in the media typically highlight such extreme events [92]. However, associations such as "floods" or "natural disasters" were not mentioned very frequently and were less clearly linked to climate change than issues related to water scarcity (Figures 3 and 4).

Another surprising finding was that respondents reported that temperatures had become more extreme irrespective of the season (hotter summer days, colder winter nights) and expected that this trend would continue. The belief that winter nights are becoming colder may seem surprising at first because it conflicts with the idea that climate change will lead to a general warming effect. A first explanation for this perception is that people see climate change as a phenomenon that makes the weather more extreme (for a similar finding in the U.K., see [93]). Second, it is possible that recent winters were actually cooler. Such effects are in line with the subjective perception that nights have become colder (although not specifically those during the winter; [62,63]) and converge with instrumental temperature records in some highland areas [94]. Although we do not have access to instrumental weather records for the region and period (2010–2015) that the respondents evaluated, earlier records for Peru show that, although both maximum and minimum temperatures increased between 1950 and 2010, the trend was less strong for minimum temperatures [53,95]. Thus, it is also possible that the recollection of the last five winters as being colder than usual is consistent with instrumental records or that people feel the winter nights colder in contrast to the warmer days.

In general, people with Quechua as their first language and larger families experienced more events that might be related to climate change, whereas people with higher education and living in Cusco experienced fewer such events. Further, people with Quechua as their first language, low education levels, and low income perceived past changes as more problematic (e.g., reduced agricultural yields, less rain, more intense storms and flooding). Although this is not too surprising, this pattern would confirm differences in the experiential basis between people who will suffer the consequences of climate change the most and those who are more likely to assume positions in society in which they will make decisions about climate change and its consequences (for a similar finding, see [96]).

### *7.2. Climate Change Is Seen as a Real and Psychologically Close Issue*

Similar to previous studies in the Peruvian Andes (e.g., [61,62]), participants were aware of climate change and believed that it was occurring both globally and locally. The proportion of respondents who doubted that climate change was occurring was low and similar to the levels found in a European survey [46], but lower than in the U.S. [97]. Women and people in the highest income group were more convinced and people from

Cusco were less convinced that the climate is changing globally and locally. Although people with Quechua as their first language and with lowest education levels were less convinced that the climate is changing globally, people in the lowest income group were more convinced that it is changing locally. With respect to global climate change, the highest convictions were found for Urubamba, and the strongest belief that the climate was changing locally was found in the neighboring San Isidro de Chicón. Thus, the groups that experience the consequences of climate change most strongly tend to perceive the changes as occurring locally more than globally, while understanding the complex and abstract concept of a global climate change is associated with higher levels of education.

When compared to other studies, respondents in the present research attributed climate change more strongly to human activity than to natural causes [46,97]. One way to interpret this is that—despite the low levels of self-assessed knowledge, particularly by people with Quechua as their first language and lower levels of education and income—participants' beliefs about the occurrence and the main cause of climate change were consistent with the current state of climate science [98]. This might be due to relatively strong though superficial media coverage on climate change that attributes it to human behavior. An alternative interpretation is that some people in this region have a mental model in which local actions cause environmental changes. Ethnographic work shows that many people attribute environmental changes to interference with nature (e.g., extracting ice from glaciers) and to abandoning traditional rituals (e.g., offerings to mountain deities), for which people are punished by nonhuman powers [60–62,66,67]. However, this latter interpretation is not entirely consistent with the finding that people with Quechua as their first language attributed climate change significantly less strongly to human actions and relatively more strongly to naturally occurring processes, because such traditional beliefs should be more common among them.

Another finding that differs from previous work is that people in and around Cusco believed that climate change would affect close and distant places to a similar extent. This stands in contrast to the prevalent finding that people see climate change mainly as something that affects distant times, places, and people more strongly than in the here and now [31,46,99–101]. A possible explanation for this difference is that previous research has typically been undertaken in affluent nations in the Global North (for notable exceptions from the Global South, see [99,101]), where the vulnerability to environmental hazards may indeed be relatively low. People living in the Peruvian Andes might be different in this respect because they are highly exposed to environmental changes and vulnerable to their direct and indirect consequences [58]. This higher exposure is not just an academic evaluation. It became obvious, for example, when respondents connected concerns about the future to basic needs for food and water. Such concerns are usually absent in research from Europe and North America [46,102,103]. Higher exposure to environmental hazards is also evident in that 80% of our respondents had personally experienced extreme weather events (compared to 16–34% in Europe and North America; [13,104]). Also noteworthy is that people with lowest income and Quechua as their first language—who are probably the most vulnerable group—expected less impact for regions further away (or even more impact for their own neighborhood). This, too, suggests differences in the sample investigated here with the commonly investigated samples from the Global North. The perception that close places are similarly (instead of less) affected by climate change compared to distant places may thus reflect the region's relatively higher exposure and vulnerability and people's realization of this fact ([27]; for a similar finding, see [96]). A possible theoretical explanation—-which is consistent with the high prevalence of personal experiences in our sample—-is that firsthand, personal experiences of climate change may render it more concrete and real, thereby reducing its perceived psychological distance [32,33,105].

### *7.3. A Change for the Worse*

Respondents consistently perceived climate change and its effects as negative. This was evident in their association of climate change with detrimental consequences (e.g.,

problems, war) and in their references to negative emotions such as concern, sadness, and sorrow (Table 3). Further evidence of negativity was that participants expected most environmental and societal aspects to deteriorate rather than improve. Surprisingly, however, people with Quechua as their first language, who might depend more on agriculture and, thus, the availability of water, perceived the most critical developments—the ones related to the lack of water—to be deteriorating less than people with Spanish as their first language. A possible explanation is that subsistence farmers feel more control over the situation, for example, because they have already knowledge of certain adaptation strategies.

About 90% of participants were worried a lot about climate change—especially in the less developed area of San Isidro de Chicón—which is higher than the 60–79% found in surveys from the U.S. and Europe [46,97].

### *7.4. Implications for Adaptation*

The results can inform strategic decisions related to adaptation to the local consequences of climate change. Here, we adopt a similar position to Paerregaard [62], who argues for an informed participatory approach. That is, we suggest that adaptation initiatives should consider both local voices and academic experts. More specifically, we take the answers of the participants as opinions from local experts knowing best their specific situation and everyday life. Adaptation initiatives should be based on and tailored to their views and beliefs, as they might indicate important aspects to consider in the design of future measures [106]. At the same time, it is crucial to consider opinions from academic experts and to acknowledge that they can differ from those of "everyday" experts. If such differences exist, they can provide important starting points for developing adaptation measures.

A first important finding is the ostensible discrepancy between what local people see as relevant problems caused by climate change and the measures that have been implemented and planned by governmental and nongovernmental actors. Our study suggests that most people in the region are mainly concerned about water scarcity and the distribution of available water, while catastrophic weather-related events appear to be less relevant. This is at odds with the considerable amounts of money that have been invested in recent years nationally and locally in infrastructure projects aiming at protecting people from negative effects of such weather events [107,108]. This discrepancy about which problems are (not) important may undermine public support for measures, as the population does not recognize their relevance or find them necessary. This is evident, for example, when residents in San Isidro de Chicón started to oppose infrastructure measures. At the same time, the population might become more frustrated because what really concerns them—problems related to water scarcity—does not receive enough attention.

To reduce these discrepancies and possible conflicts, it seems that two types of effort are needed. First, people in the investigated region seemed to underestimate the threats from extreme weather events as a consequence of climate change. Based on the observed perceptions, education campaigns could be developed that aim at increasing awareness of these hazards. This would contribute to greater public support for relevant measures and higher resilience against catastrophic events [109,110]. On the other hand, and maybe even more importantly, authorities and experts should also listen to the voices of the population as they might miss important problems for which communities need to prepare.

One specific problem area that participatory adaptation efforts should address is water scarcity and resultant conflicts over the distribution of water. A number of measures could be taken to reduce such problems, such as fine-grained local weather forecasts (e.g., [111]), changing or varying the crops [112], and strengthening the institutions and fostering local knowledge [63]. Measures could also be taken to reduce existing and prevent future conflicts [113]. To our knowledge, close to no efforts in such directions have been taken in the investigated area until now.

Another important result is the negative expectations regarding future changes and the perceived closeness of the (negative) effects of climate change. On one hand, this shows

that the population is aware of possible future problems and that there is only little need to convince the investigated population about them. However, expectations differ, and some groups might not be sufficiently aware of some problems. For example, the subgroup of our sample that represents people of influence or who might become decisionmakers (i.e., people with high levels of education and income, who live in Cusco) appeared to underestimate problems related to new diseases and pests. Since at least some members of this group are likely to assume important positions in society in the future, it is important to make them aware of problems related to climate change that do not currently receive much attention. On the other hand, these consistently negative results could mean that the investigated population has a quite fatalist attitude. That is, participants might believe that things are already bad and will deteriorate further without there being much they can do about it (for a similar finding, see [64]). However, within a functioning democratic system, some of the expected changes are under a certain control of the population. Measures aimed at increasing the knowledge about options for societal development and at inspiring optimism in the population's ability to implement them could therefore be key to promote adaptive capacity in this region [114,115].

### *7.5. Limitations and Future Research*

There are several limitations to this study that should be noted. First, only participants who spoke Spanish could participate. This means that for the 55% of those who learned Quechua as their first language in the Cusco area [68], participation was possible only if they had acquired sufficient skills in Spanish as a second language—which, however, might have been the case for most of them. Moreover, our sample was somewhat biased toward younger and, particularly, well-educated people. Since many differences were found between education levels, some caution is warranted when generalizing our findings to the broader population of the Cusco area. Similarly, regions in Peru differ strongly in geographic, climatic, and socioeconomic characteristics. The findings presented here can therefore not be scaled up to the whole country. However, the situation might be similar in other Andean areas.

Second, this research did not systematically examine the correspondence between participants' perceptions of past environmental changes and instrumental weather/climate records in specific locations [54,55,96,116,117], nor did we examine the extent to which participants' expectations about specific changes matched those of experts [26,55,58]. To the extent that such instrumental data and predictions are available at the level of towns, future research could close these gaps and thereby help to better understand the extent to which people are capable of accurately perceiving different climate-related events and changes and to identify possible gaps between lay perceptions and expert models. Such insights, especially if obtained for specific locations, could be the foundation for effective risk communication and help to implement appropriate adaptation measures [109,110].

## 8. Conclusions

The availability and quality of water is clearly the most salient problem in the Cusco region. Because people in this area already connect water-related problems to climate change, the water-climate nexus could offer a starting point for discussions and campaigns around climate change, its consequences, and possible adaptation measures. Similarly, practitioners could build on the prevalent personal experiences of extreme weather events, and develop campaigns aimed at a deeper understanding of how such events are linked to climate change and of the changes and events that can be expected in the future. Finally, our findings indicate that the everyday problems with water scarcity and water-related conflicts might be more urgent issues to address than catastrophic events, such as flooding or landslides, which appear to be higher on the agenda for many decisionmakers in the region.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/2071-1050/13/5/2677/s1. Table S1: Strength of association between socio-demographic variables, Table S2: Kruskal-Wallis tests sorted according to effect size, Table S3: Dunn pairwise comparisons, Table S4: Means and standard deviations.

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