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Local-Scale Factors and Dynamics in Climate Adaptability Among Subsistence Farmers

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Abstract

Climate change is the primary environmental threat to subsistence farmers' productivity in Peru. Adaptation is promoted as the best mechanism to cope with climate change in subsistence agricultural livelihoods. However, climatic adaptability depends on the resources the farmer has access to or can use, which are not always adequate to respond effectively to the speed and aggressiveness of climate change. This study explored the local factors and dynamics (assets) influencing the climate adaptability processes of subsistence farmers in Huayhuay, Peru. Twenty subsistence farmers participated in semi-structured interviews within a basic qualitative design. The results brought to light 18 local factors and dynamics that influence the coping mechanisms of climate adaptability. These findings support other investigations that demonstrate the difficulty of climate change adaptation agricultural communities face. The difficulty of climate change adaptation has rooted the interrelationships of assets of different natures within the same adaptive process. Future research and interventions should encourage the active participation of farmers in local climate action and evaluate the efficiency and effectiveness of farmers' adaptability mechanisms, considering the role of each local-scale factor and dynamic.

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Introduction and Problem Statement

Climate change (CC) is the most critical environmental challenge humanity has to solve; however, according to recent studies, CC is so severe it may be irreversible (Arora, 2019; United Nations Environment Programme, 2022). CC severity in Latin America and the Caribbean is documented by increasingly frequent high temperatures, droughts, and extreme weather events (Núñez Collado & Wang, 2020; Reyer et al., 2017). Although CC affects all economic activities, some, such as agriculture, are even more sensitive to climate variability (Dong et al., 2015). Peru, along with other developing countries, relies primarily on agriculture by subsistence farmers (World Bank Group, 2017). Subsistence agriculture is the top Peruvian economic development priority due to its dominance over other forms of agricultural production (World Bank Group, 2017). CC affects the vulnerability of subsistence agricultural livelihoods with implications for food security, food price inflation, and livelihood resilience leading to a need for understanding factors impacting climate adaptability (Baiphethi & Jacobs, 2009).

According to the Food and Agriculture Organization [FAO] (2018), it is no longer feasible for subsistence farmers to mitigate the impacts of CC. The scope and speed of progress of CC impacts exceed the response capacities of most developing agricultural communities (FAO, 2018). While mitigation should still be promoted among subsistence farmers, adaptation seems the best alternative to maintain livelihoods (Shaffril et al., 2018). CC adaptation is a place-based process incorporating local perspectives, beliefs, and contexts (Murtagh & Lane, 2022). Smit and Pilifosova (2001) stated, “adaptation varies according to the system in which it occurs, who performs it, the climatic stimuli that cause it, and its timing, functions, and effects” (p. 881). Therefore, this study aimed to inform local climate action by exploring the local factors and dynamics (assets) farmers considered when implementing CC adaptability strategies.

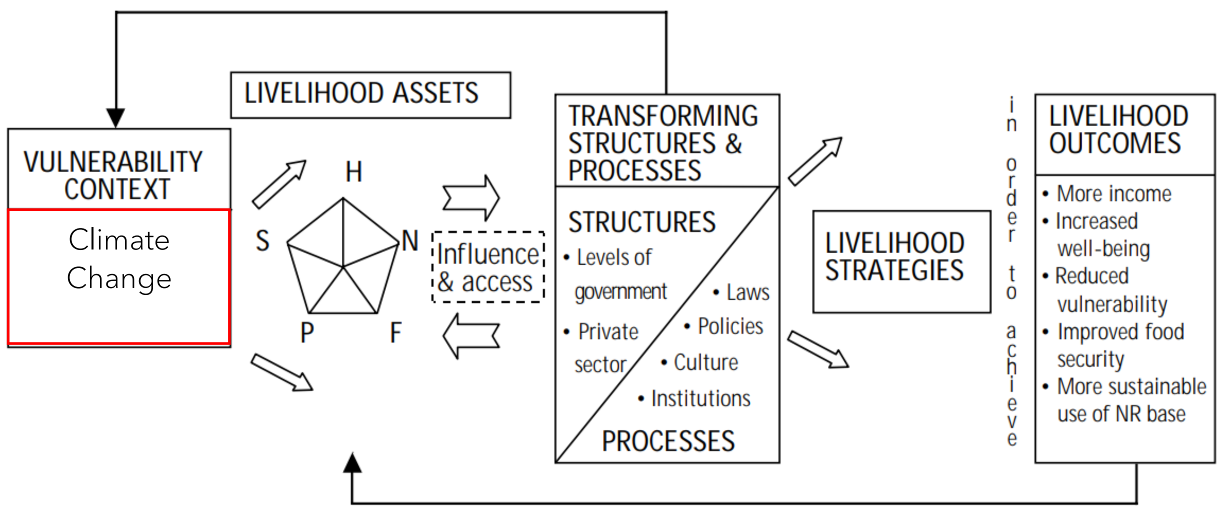
Theoretical and Conceptual Framework

The livelihoods of interest for this study were those of subsistence farmers in Huayhuay, Peru. Therefore, the *Integrated Sustainable Livelihoods Framework* (I-SLF) was adapted from Department for International Development [DFID] (1999) to guide this study. The I-SLF “emphasizes the importance of the livelihood assets [local factors and dynamics] that people have access to, or draw on, and the context within which they devise livelihood strategies so has to attain greater livelihoods outcomes” (Yohannis et al., 2017, p. 6). Due to its flexibility to collect and present livelihood contextual factors and dynamics, particularly from poor populations in developing countries, the I-SLF has been widely implemented to study the stress of climate variability on local agricultural livelihoods (DFID, 1999). For example, Yohannis et al. (2017) used the I-SLF to evaluate the integration of climate-related information into Ghanaian farmers’ livelihoods using information and communication technologies, and Aboye et al. (2022) used the I-SLF to investigate farmers’ experiences derived from major CC impacts in southern Ethiopia. Employing the I-SLF (Figure 1) as the conceptual framework for this study provided a lens to explain how local factors and dynamics (assets) within the five capitals (human, natural, social, physical, and financial) influence livelihood strategies implemented to adapt to climate variability (vulnerability context), and thus, influence livelihood outcomes.

CC and its variability in Peru negatively influence the country's vulnerability context of subsistence farmers (Aboye et al., 2022; Lozano-Poviz et al., 2021). Official reports state that CC impacts the quality and availability of natural resources in Peru (e.g., water, soil, biodiversity) and reduces the productivity of agricultural systems (Lozano-Poviz et al., 2021; U.S. Agency for International Development [USAID], 2017). The impacts of CC on agricultural systems indicate the need for changes in agricultural practices. However, other non-climatic context components, such as human relations and migration patterns, also play a role in determining farmers' adaptability efforts (López et al., 2017).

Figure 1

Integrated Sustainable Livelihoods Framework (I-SLF)



Note: Adapted from the Department for International Development (1999).

Achieving positive livelihood outcomes for farmers requires identifying the local factors and dynamics farmers consider in their climate vulnerability context (DFID, 1999; López et al., 2017). Sometimes, managing the climatic adaptability of subsistence farmers requires transformations of local structures and processes for which normative and regulatory changes are needed that farmers cannot enforce (DFID, 1999). Therefore, improving farmers' adaptability potential is the best option. The United Nations (n.d.) defined adaptation as "adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts and refers to changes in processes, practices, and structures to moderate potential damage or benefit from climate change opportunities" (p. 1). Therefore, local asset availability variation modifies individuals' ability to deal effectively with local climatic variations (DFID, 1999; Scoones, 2015).

Purpose

This study aimed to describe local factors and dynamics (i.e., physical, human, financial, social, natural) subsistence farmers consider when engaging in agricultural climate adaptability strategies to improve their livelihood outcomes. Due to the increase in potential risks and vulnerability in Peru resulting from CC, the national government has fostered adaptability at all socioeconomic and production levels. Therefore, this study was part of a series of research projects designed to engage agricultural stakeholders in local climate action planning in rural Peru. The results will inform CC adaptability initiatives and climate-related public policies implemented by local and central authorities. The research question guiding this study was: What local factors and dynamics (assets) influence Peruvian subsistence farmers' agricultural climate adaptability strategies?

Methods

This basic qualitative research study was grounded in social constructivism (Creswell, 2007; Flick, 2019), which seeks individuals' understanding of the world around them through their own experiences (Creswell, 2007). Twenty semi-structured interviews were conducted with subsistence farmers from Huayhuay, Peru. Participation criteria included: producing on less than two hectares yearly and primary self-consumption of agricultural production. The interview guide was structured using the climate adaptability available literature (Sarkar et al., 2014; Schattman et al., 2016 Rojas-Downing et al., 2017). Five professionals (researchers, practitioners, and policymakers) validated the content and structure of the interview guide (Usry et al., 2018).

Participants were recruited through a personal visit from a Huayhuay Agricultural and Environmental Affairs office member. During the visit, participants received verbal and written information about the study, including future use of the results. Therefore, participants had space to ask questions and then voluntarily share their intention to participate by agreeing with the researcher on a convenient date and time to schedule the semi-structured interview. Most participants self-identified as male (70%, n = 14) and were between the ages of 29 and 72, with an average age of 52. Participants produced various crops, including potatoes, ulluco, barley, and corn, and raised livestock, including goats, sheep, and llamas. Each participant was assigned a pseudonym to protect their privacy.

To participate in the semi-structured interviews, participants traveled to the Huayhuay Agricultural and Environmental Affairs office facilities located at the municipality offices. Upon arrival, they were directed to a private room with audio and video equipment and an internet connection. Following Ortiz's (2015) privacy recommendations for anonymous human research and to establish trust, only the interviewer (first author) and interviewee were present during the interview. The interviewer addressed cultural and power dynamics implicit in the interview process and incentivized rapport with the interviewers by approaching them with a curious attitude, following the recommendations of McGrath et al. (2019). With an interview protocol of 16 guiding questions, interviews lasted an average of 45 minutes and were conducted in Spanish, recorded, and transcribed. The following are examples of two guiding interview questions: Are you receiving any type of support to adapt your agricultural production to climate variability? and Have you noticed changes in the climate? If so, how have these changes affected your farm? A structural coding scheme based on DFID's (1999) five capitals of sustainable livelihoods was implemented to analyze the data using NVivo 12. Coding followed a hybrid approach, incorporating newly emerged themes into pre-established categories. Data were translated during the interpretation of the results by members of the research team who are sociolinguistically competent in Spanish and English (Squires, 2008). Each farmer was given a code name beginning with F and followed by a number 1-20 to anonymously report the findings.

Trustworthiness and rigor were established in several ways. First, credibility was achieved by triangulating the data using detailed observations and the interviewer's reflective memos (Creswell, 2007). Second, transferability was achieved by providing readers with a thick and rich description of the study's information sources and findings (Creswell & Creswell, 2018; Lincoln & Guba, 1985). Third, confirmability was achieved through researchers' self-critical attitude and openness, accounting for their experiences, feelings, and biases in reflective memos (Thomas & Magilvy, 2011). Fourth, reflexivity was achieved through researchers' self-recognition and written self-reflection. Finally, the principal researcher was born and raised in a developing country with similar socioeconomic and environmental conditions to Peru. He has previous experience in research and extension with subsistence farmers in low and middle-income countries. His interest in this community is rooted in a collaborative partnership with local authorities. Four researchers were fluent in Spanish and had previous experience with climate adaptability among agricultural communities in developing countries. Finally, one researcher knew participants before the study was conducted and had professional responsibilities addressing their livelihood needs.

Findings

Eighteen local-scale factors and dynamics influencing climate adaptability were identified and categorized using the five capitals of sustainable livelihoods (Human (*n* = 3), Natural (*n* = 3), Social (*n* = 4), Physical (*n* = 2), and Financial (*n* = 6)).

Human Local Factors and Dynamics

Climate-Related Knowledge

Farmers know that their limited knowledge of climate adaptability prevents them from making sound decisions (F3, F5, F13). This was echoed by F16, who said, "You do what you can. I try to keep the animals [llamas] healthy, but I notice that the heat affects them, but I do not know what else to do." Failure was the most common result of climate adaptability strategies implemented by farmers because they needed to be more adequate and appropriately implemented. F10 commented that he perceived the climate changes and implemented strategies to cope with them but got discouraged when those strategies failed.

Labor Demand

Climate adaptability strategies require higher agricultural labor investment. Farmers are aware of the increment in labor investment they must make to produce under the new climatic scenario (F4, F11, F17). For example, farmers affirmed that practices like irrigation, pest and disease control, and weed demand more time than before, not just because these agricultural treats have become more resistant but because it is harder to perform them with the increase in local temperatures (F4, F9, F14, F19, F20). A common trend among farmers was that they needed help to meet the increasing demand for labor in their agricultural production. F6 commented, “I am old, and the plot demands more work than before. So sometimes, if my son has time, he helps me, and if he doesn’t, I look for someone to work with me for a couple of days.”

Food Consumption Patterns

Local food consumption patterns limited farmers’ climate adaptability. F6 affirmed that customers were looking for more sustainable and environmentally friendly food that is very difficult to produce because of CC. Farmers, especially men in charge of agricultural marketing, commented on how changes in consumer preferences interfered with their climate adaptability processes (F6, F14). F1 mentioned, “When I want to sell quinoa, they [customer] ask me if I applied fertilizers…and of course, I had to. Otherwise, the production will not survive. When I explain that to them, they do not want to buy it anymore.”

Household eating patterns followed a similar trend. Foods preferred by household members usually do not yield adequately in the field due to the climatic variability of the area. For example, F7 said, “We used to eat oats; everyone liked them, and is nutritious and good for children. However, they do not yield, so it is not worth planting them…The heat really affects the oats plants. So, we are now planting grass.”

Natural Factors and Dynamics

Water

Water resource availability for domestic and agricultural uses was essential for climate adaptability among participants. Farmers expressed concern about available water to maintain their agricultural production effectively (F1, F16, F19). F11 shared, “It is risky for me to start planting because I don’t know how much water will be available… The rain doesn’t fall as often anymore, and everyone risks losing everything invested.” While most farmers relied entirely on rainwater, others used water from the community water system, opening up competition between domestic and agricultural water use. F6 mentioned:

> We get water daily [from the community supply system]. But that water is for our house... but, if I want to produce, I have to irrigate the crops, so I try to make good use of the water that I get… I always wonder if I’ll have enough water for the next crop season.

Farmers also highlighted that constantly decreasing water availability prevented them from implementing an irrigation system as an adaptation strategy (F1, F4, F17). F1 affirmed that installing an irrigation system was a big investment that did not bring the expected benefits because " there wasn't enough water to use it."

Local Weather Patterns

The instability of precipitation and temperature made it challenging to implement adaptation strategies such as crop diversification and changes in agricultural production practices (F4, F9, F15). For example, F12 commented, "We changed crops and planting schedules, trying to produce more. However, it doesn't work because it's so hot. I keep thinking it will rain, and it doesn't. So even if I try, it only sometimes works out for me." Local climate variation was described as unpredictable (F3, F17, F20), and farmers acknowledge its influence on climate adaptability strategies' effectiveness.

Soil Fertility

Faced with infertile soil, farmers chose not to implement climatic adaptability strategies for soil conservation and protection due to their self-perception of inefficiency grounded in previous experiences (F4, F13). Other farmers lost interest in other adaptability strategies due to their infertile soil. For example, F20 said, "When I know that I am producing on infertile land, then I don't worry about investing in irrigation or other products that can help me produce more... If the soil is not good, there is not much to do."

Social Factors and Dynamics

Knowledge Generation

Although not all farmers were interested in generating knowledge related to CC, all explained how their limited ability to access productive and educational resources was a hindrance (F3, F17). For example, F11 shared, "every year, they give me a different plot. Everything I implemented and learned last year no longer served me this year. The soil fertility, water availability, and everything were different because I worked in a different plot." Others stated that they decide whether or not to implement an adaptability strategy based on the potential to learn either in practice or from interactions with other farmers (F2, F7, F11). Finally, farmers noted difficulties associated with needing to have records of their implemented efforts to compare and contrast the effectiveness of the strategies (F12, F18) and with their inability to identify strategies that responded to the characteristics of their agricultural production (F8).

Agricultural Exchange

An informal agricultural exchange system operated among farmers in Huayhuay, Peru, who acknowledged its beneficial influence on climate adaptability (F7, F16). Although most of the transactions only involved agricultural products, some farmers participated in exchanges of non-agricultural goods, labor, and knowledge (F4, F8, F11, F19). For example, F16 mentioned, "We exchanged food with relatives to have a greater variety…My husband also helps them install irrigation systems on their plots; sometimes, they pay him with money, and when it is not possible, they pay with something from the harvest." Additionally, farmers claimed to benefit from the exchange of knowledge they maintain with other farmers they perceive as successful in their climate adaptability processes (F2, F7, F11, F16). For example, F13 shared, "I knew very little about mixing crops. But Mr. [Name] had already done it before. So, I asked him, and he helped me do it, and thank God we have improved our production, even when it does not rain."

Farmers Association

Mutual support, access to agricultural products and food, and technical assistance were incentives for farmers' climate adaptability, and they received these through a local farmers' association (F16, F17, F5). F4 commented, "I have been able to have access to an agricultural plot as a member of a community association. We meet at least once a month, and, in that meeting, you can always learn from what others are doing." Farmers prioritize the knowledge and supplies they receive from the association, as they perceive them to be of superior quality (F6, F10, F19).

Migration

Farmers noted how human migration increased and thus interfered with their ability to cope with CC. F3 shared that her husband emigrated, and she could not continue with the family's agricultural production because the changes she had to make due to climate changes were not feasible to do on her own. In addition, migration was more common among men, causing women to assume more responsibilities in family agricultural production. F16 said, "I help my husband with the fieldwork; I do not think I could do it alone. I admire several women in the community whose husbands leave, and they keep working in the plots. For me, it was impossible." Farmers perceived migration as the nonstop flight of knowledge and the best labor force for agricultural production (F2, F9, F13).

Physical Factors and Dynamics

Land Tenure

Land access and ownership were critical to promoting local climate adaptability. In Huayhuay, Peru, most of the agricultural land belongs to the municipality. Therefore, at the discretion of a farmers' association, each farmer received a plot for one year, for which they pay a fee and must abide by the association's regulations. F2 shared, "They assign us a plot each year, and we must do what we can in the space they have assigned us. There is no possibility of making changes or asking for more land. It is what it is." The annual allocation of agricultural land prevents farmers from implementing CC adaptation strategies. This land governance practice adversely affects farmers' implementation capacities because they encounter climate variability and constant change in production settings. F11 mentioned, "Every year, I am assigned a different plot. So, I must wait to find out where it is to start deciding what and how I will produce it." F10 supported that trend and said, "I was very lucky two years ago because they gave me a plot with very good soil. So, I combined crops and produced several foods. This last year, the plot was fertile, but there was no water to irrigate."

Technical Assistance

Farmers have limited access to and a perceived rising need for climate-related technical assistance (F1, F3, F8, F11, F19, F20). Besides what they receive through the farmers' association, they could not identify any other training source. F19 shared, "In other communities, we have seen that they train people on how to improve [agricultural production]; here, we have no support from anyone." Farmers recognized that needing more technical support has obligated them to rely on improvising to adapt to climate variability. Farmers expressed their interest and motivation to participate in climate adaptability training to potentially build capacities (F9).

Financial Factors and Dynamics

Agricultural Income and Investment

Although farmers were implementing climate adaptability strategies that required economic investment, their agricultural production did not generate enough income to meet household needs or allow for investment (F20, F13, F11). Farmers named low productivity, higher prices, and inflation as factors connected to the family income that prevented them from investing in agricultural climate adaptability. F2 commented how in his household, they must prioritize money for essential needs, leaving him with no money to obtain any product or service to improve his agricultural productivity.

Economic Diversification

Faced with economic deficiencies, farmers had to explore other areas of employment. As a result, many farmers earned income through economic sectors other than agriculture (F3, F14). F7, who has worked in agriculture since childhood, recently began working at a local goldmine due to his increasingly negative farm results and perceived inability to meet household needs. This type of economic diversification has led to reduced farmer interest in agricultural climatic adaptation. Participants affirmed that other economic sectors have higher salary or income generation rates and farmers acknowledged reducing the emphasis on productivity when they work outside agriculture (F7, F11). F8 commented:

> Before, my children and I worked together on the plot, but since they wanted to earn more money, they went to try out the mine… They give me money every month, so, no reason for me to keep trying to produce when the weather is not on our side.

Agricultural Credits

Agricultural credits helped support climate adaptability investments. F3 affirmed that agricultural credits were the only financial mechanism to invest in farming inputs and enhance adaptability practices. However, several community members did not qualify for them. F2 commented, "We tried to get a credit to buy an irrigation system, but they did not give it to us; they said we did not qualify for it." Farmers who mentioned having accessed agricultural credits did so through a financial assistance program implemented by an international aid entity, now defunct it due to long-term sustainability issues.

Agricultural Supplies Cost

Farmers reported rising prices for farm inputs, including tools, chemicals, and seeds. The high cost of agricultural inputs reduced farmers' purchasing power and, consequently, their ability to implement adaptation strategies. In addition, farmers stated that the cost of farm supplies discourages them from engaging in climate resiliency practices, as they cannot guarantee future purchasing power. For example, F5 shared, "Every year, I apply more and more fertilizer to have production, and the difficulty is not in the extra work required to do it, but in that the products are more and more expensive."

Agricultural Product Prices

Farmers identified a trend of increasing variability in the marketing prices of their agricultural production, which prevents them from having a reliable and secure income that meets their financial needs and allows them to invest in climate adaptation practices. According to F2, "[Products] change value quickly, I'm producing quinoa, and if I'm not mistaken, it costs 300 soles a quintal, but it goes up or down. So, it's impossible to maintain a price that ensures I will recover everything I invested."

Market Quality Standards

Farmers often found it challenging to sell their products due to non-compliance with visual and organoleptic market standards. They face poor physiological development of crops and vegetables due to climate change. F4 said: "the potatoes are so small that I cannot sell them, so we eat them, so they don't go to waste." F9 shared: "The vegetables were not fully developed; they are super crooked, so no one buys them." Farmers were reluctant to implement adaptability strategies without market acceptance for their products because they did not perceive a reason to improve their production quality (F6, F14).

Conclusions, Discussion, and Recommendations

Peruvian subsistence farmers identified diverse factors and local dynamics influencing their CC adaptation. These findings support literature that has shown how the challenges of adaptability to CC lie in the multitude of interrelationships between factors and dynamics from socio-environmental and economic conditions (Hopkins, 2014; Naylor et al., 2020). Although each local factor or dynamic identified in the current study was classified within a single capital, the literature indicates that livelihoods are not linear and, therefore, many factors and dynamics have concurrent implications (DFID, 1999). For example, migration is a dynamic of social capital due to the experiences of social change it promotes. However, studies have found an improvement in the rural family economy (e.g., financial capital) resulting from migration (Richerson & Boyd, 2008; Rocca, 2020). While one trend may negatively affect one capital, it could improve another (Scoones, 2015).

The local factors and dynamics described in this study highlight many implications of adaptability in the connectivity between vulnerability context and livelihood transformation processes. These transformations are aimed at positive livelihood outcomes, such as increased food diversity and availability, stable income, and human capacities (DFID, 1999). For example, factors and dynamics related to farmers' participation in agricultural markets and their buying and selling power will impact income generation. On the other hand, regarding agricultural productivity, the factors and dynamics could favor the reduction of vulnerability and the assurance of nutritious food in households (DFID, 1999).

The I-SLF suggests a discussion of priority-setting actions to support the adaptation processes of subsistence farmers (DFID, 1999). The current study captured farmers' perspectives regarding what is relevant to them when adapting their livelihoods to CC, and the findings lead to several important implications for practitioners and policymakers. First, farmers' perceptions of and experiences with local factors and dynamics relevant to climate adaptability should be at the center of the climate action discussion. Practitioners, researchers, and funding agencies must view farmers as protagonists in the climate adaptability debate rather than passive information recipients, especially when planning, implementing, and evaluating initiatives focused on improving agricultural livelihoods (Menconi et al., 2017). Second, the spaces and mechanisms for farmers' participation must be created by those in leadership positions that can improve the dynamics associated with climate adaptability (Ariti et al., 2018). Finally, engaging farmers in local climate action reduces participation gaps among stakeholder groups in climate planning. Although the study revealed numerous local-scale factors and dynamics important to subsistence farmers' climate adaptability in Peru, these may not be exhaustive. Climate adaptability research has identified an extensive list of influential factors and dynamics, several of which did not emerge in this study. For example, women's participation, traditional practices, and cultural identities are other local factors and dynamics that influence climate adaptability in communities similar to Huayhuay (Intergovernmental Panel on Climate Change [IPCC], 2022).

Although this study supports the recommendations of Murtagh and Lane (2022) on the importance of promoting people and place-based climate adaptability practices and considering the particularities of the locality and target population, the results revealed local factors and dynamics of high interest among developing countries. Thus, although preliminary, these results offer valuable insights for individuals and organizations to set priorities for research and action to strengthen climate adaptability and improve the livelihoods of subsistence farmers in Peru and similar communities elsewhere. For example, local and regional governments should consider paying farmers for their productive services, ensuring them a source of income and strengthening their livelihoods.

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