Reading the Rain with All Senses: Exposure to, Use of, and Trust in Climate Information in Colombia

Laurel DiSera,* Carolina Hernández Rodríguez,† Flora Lecomte‡

* Postdoctoral Fellow (Department of Earth and Environmental Sciences; International Research Institute for Climate and Society), Columbia University, US; Abdus Salam International Centre for Theoretical Physics, Italy

† PhD Candidate (Department of Geography), National University of Colombia; Centre de Recherche et de Documentation sur les Amériques, Sorbonne Nouvelle University, France

‡ PhD Candidate (Centre de Recherche et de Documentation sur les Amériques), Sorbonne Nouvelle University, France

KEYWORDS

climate information, climate communication, climate change adaptation

ABSTRACT

Climate information is a critical tool for climate change adaptation. However, not all communities use and trust scientific information. This research aims to understand how farmers in Colombia build knowledge of their environment, how they experience and are responding to climate change, and what climate information they are using to make decisions about farming and other practices.

Farmers in two regions are studied here: the mountainous, coffee growing department of Huila, and the low-lying wetlands of La Mojana in northern Colombia. Results suggest that most farmers experience some impacts of climate change, though some are worried less about impacts than others. Farmers use WhatsApp groups, radio communication, published bulletins, and regional agricultural meetings to receive and learn about scientific climate information. In addition to—and often in place of—provided climate information, farmers use natural indicators such as birds, insects, clouds, and the Moon to make decisions about farming and other daily practices.

Generally, there is low trust of climate information provided by the official meteorological institute in Colombia; however, younger generations are beginning to use and trust climate forecasts from Google and the government more than their parents' generation.

I. **Introduction**

The utility of climate services[1] is only as beneficial as the information that is provided to decision makers and end users. This is true, but what defines good information? The first step in assessing this issue is to understand which tools and information and at what timescale the end users desire. Second, it is important to identify if end users trust such information and tools and if they would use them when making decisions about agriculture and other day-to-day practices. Following these user-focused processes, however, is not canonical climate service research method.

Historically, scientific fieldwork has frequently involved extracting knowledge and data from local communities, transporting it back to laboratories in developed nations for analysis, and providing little or no results to the communities studied.[2] More recently, there have been efforts to include communities in research endeavours through requirements of grant proposals, and many more research projects focus on the co-production of climate tools for communities.[3] However, one central issue that confronts co-production research originates from the lack of time scientists are given to learn about the communities and groups with which they are working. Grant proposals require initial research to be completed without financial support to substantiate the credibility of the work, but without funding support and time to adequately understand needs and prior knowledge of communities, the current form of grant proposal writing precludes the ability to truly integrate and work co-productively.[4]

Efforts to effectively work with and co-produce tools with communities have been studied both through theoretical and practical lenses.[5] However, there is still an existing underlying epistemic asymmetry in understanding the needs of communities. Local knowledge of the climate is often undervalued, and is not effectively included in the co-production process. For example, the language (often English) and methodologies used in research are primarily rooted in Western science. Additionally, the local rhythms of day-to-day lives and productive cycles are subsumed in the common timescales of climate forecasts (e.g., seasonal or subseasonal timescales). For instance, Bremmer and Wandekker[6] present the different particularities of time and rhythm practiced by communities around the world and the tacit knowledge built accordingly. Similarly, Venning and Bushaka[7] find that participants in their study view seasonal rhythms differently than the scientifically defined three-month climate season, suggesting that local rhythms for agricultural practices preclude the use of traditional three-month forecasts. Therefore, it is evident that

[1] Dilling, Lisa, and Maria Carmen Lemos. "Creating Usable Science: Opportunities and Constraints for Climate Knowledge Use and Their Implications for Science Policy." *Global Environmental Change*, vol. 21, no. 2, 2011, pp. 680-689; Goddard, Lisa. "From Science to Service." *Science*, vol. 353, no. 6306, 2016, pp. 1366-1367; Brasseur, Guy, and Laura Gallardo. "Climate Services: Lessons Learned and Future Prospects." *Earth's Future*, vol. 4, no. 3, 2016, pp. 79-89.

[2] *see*, for example, Toomey, Anne, et al. "A Question of Dissemination: Assessing the Practices and Implications of Research in Tropical Landscapes." *Ambio*, vol. 48, no. 1, 2019, pp. 35-47; Minasny, Budiman,et al. "Global Soil Science Research Collaboration in the 21st Century: Time to End Helicopter Research." *Geoderma*, vol. 373, 2020, 114299.

[3] "Research Partnerships." *National Science Foundation*, 2025; "Smart and Connected Communities (S&CC)." *National Science Foundation*, 2025; "Community Engagement and Knowledge Coproduction in NSF Arctic Research—Office of Polar Programs (GEO/OPP)." *National Science Foundation*, 2025; "Tackling Helicopter Research." *Nature Geoscience*, vol. 15, no. 8, 2022, pp. 597.

[4] Lamber, W Marcus et al. "Ending 'Domestic Helicopter Research'." *Cell*, vol. 187, no. 8, 2024, pp. 1823-1827.

[5] Vogel, Coleen, et al. "Climate Services in Africa: Re-Imagining an Inclusive, Robust and Sustainable Service." *Climate Services*, vol. 15, 2019, 100107; Vincent, Katharine et al. "What Can Climate Services Learn from Theory and Practice of Co-Production?" *Climate Services*, vol. 12, 2018, pp. 48-58; Grossi, Amanda, and Tufa Dinku. "Enhancing National Climate Services: How Systems Thinking Can Accelerate Locally Led Adaptation." *One Earth*, vol. 5, no. 1, 2022, pp. 74-83.

[6] Bremer, Scott, and Arjan Wardekker. *Changing Seasonality: How Communities Are Revising Their Seasons*. De Gruyter, 2024.

[7] Venning, Mathias, and Bizuneh Bushaka. "Co-Ordinating Agricultural Adaptation: Seasonal Forecasts and Their Influence on Rural Agricultural Rhythms in Ethiopia." *Time & Society*, 2024, 0961463X241260554.

there are gaps in understanding the complex systems and needs of end-users when attempting to co-produce services.

The objective of this research is to understand what participants know about the climate of their region, how and if local farmers trust scientific climate information, and what tools or knowledge they use on a regular basis for agricultural decision-making. Such information will help to provide the foundation for assessing what climate services are needed and what steps need to be taken to co-produce useful climate services for communities.

This research focuses on a particular case study in Colombia, where field work was conducted in two different regions: the Huila department and La Mojana.[8] Prior research on the use of climate information in Colombia has found that those who utilise climate information are able to more successfully reach their greatest potential in agricultural production. However, there are many channels of climate information that are not being fully utilised, such as roundtable discussions, due to lack of opportunity and access.[9] Other studies have suggested new tools or analyses for improving forecasts in Colombia, such as new agroclimatic forecasts for crop modelling;[10] however, direct modelling studies often fall short in directly connecting their tools to communities and participating in evaluation and co-production processes that would facilitate more useful end products.[11] Few studies have successfully co-produced tools and services with communities and find that the best results come from constant incorporation of user requirements and evaluation of tools with communities.[12] Thus, we suggest that there is still work to be done to better connect with communities and facilitate a co-productive process in the design of climate services in Colombia.

The focus of this research targets the initial phase of co-productive research to understand the needs of farmers in two regions of Colombia. Much of this research was funded by small grants and support from associated institutes, as this mission focused on building relationships, forming networks, and understanding individual knowledge and histories, to better contextualise how climate services might be most helpful in the two areas of interest. Effectively, this research is a litmus test to understand the current trust in, perspectives of, and utility of climate information and tools in Colombia to bridge the gap of knowledge between local farmers and scientific researchers, both within and outside of Colombia.

II. **Data and Methods**

This work was conducted in two regions of Colombia, the Huila department and La Mojana (**Figure 1**, below). La Mojana (**1**a), located in northern Colombia, comprises lowlands and the Magdalena River basin, with many *cienagas* (wetland ecosystems) and flooded regions often spilling into towns creating crop losses and difficulties for infrastructure and transportation (**Figure 2**a). The communities in La Mojana rely on fishing and rice growing and depend heavily on rainfall for rainfed agriculture and in river floods for artisanal fishing activities. Huila (**1**b) is a mountainous and the most important department in coffee production in southwestern Colombia (**Figure 2**b), where many farmers grow coffee alongside subsistence farming to support their families,

[8] Colombia is divided into 32 departments. The Huila is one of them. For its part, La Mojana is not a political-administrative division, but rather a biocultural region, formed by 11 municipalities of 4 departments.

[9] Loboguerrero, Ana Maria, et al. "Bridging the Gap between Climate Science and Farmers in Colombia." *Climate Risk Management*, vol. 22, 2018, pp. 67-81; Bouroncle, Claudia, et al. "A Systematic Approach to Assess Climate Information Products Applied to Agriculture and Food Security in Guatemala and Colombia." *Climate Services*, vol. 16, 2019, 100137.

[10] Ordoñez, Leonardo, et al. "Applying Agroclimatic Seasonal Forecasts to Improve Rainfed Maize Agronomic Management in Colombia." *Climate Services*, vol. 28, 2022, 100333.

[11] Esquivel, Alejandra, et al. "Predictability of Seasonal Precipitation across Major Crop Growing Areas in Colombia." *Climate Services*, vol. 12, 2018, pp. 36-47.

[12] Sotelo, Steven, et al. "Pronosticos AClimateColombia: A System for the Provision of Information for Climate Risk Reduction in Colombia." *Computers and Electronics in Agriculture*, vol. 174, 2020, 105486.

but is also home to commercial coffee growers (20% of Colombian coffee is produced in the Huila).[13]

Methods used for this research were based on methodologies presented in Bremmer et al.,[14] which utilized semi-structured interviews to elicit narratives from primarily adult participants. In addition, three workshops were conducted with high-school students to understand the differences in local knowledge, trust, and use of scientific knowledge across generations. For this, we used social mapping and a serious game[15] about the growing cycle of rice. Finally, we participated in guided tours in the wetlands with fishers, that allowed us to better understand situated knowledge on weather, climate, and seasonal flooding in La Mojana.

The interviews took place in Neiva, Gigante, Garzón, Timaná, Pitalito, and La Plata in the Huila department. In La Mojana, interviews were conducted in Montería (department of Córdoba), San Marcos, and Sucre (department of Sucre). This research was conducted in a transdisciplinary team with two human geographers who had in-depth knowledge of the regions of study and one climate scientist. All researchers spoke Spanish, two of the researchers had conducted research in one of these two areas prior to the current fieldwork expedition, and one of the researchers was a Colombian national. These established connections facilitated the trust building process with the inhabitants and enhanced deeper and more intimate conversations.

Sixteen interviews were conducted (**Table 1**, below). Participants were mostly men (with the exception of one of the associations of coffee growers, women led) and ranged in age from early twenties to late seventies. Farmers either cultivated coffee or rice, along with sustenance crops.

Research questions for the interviews focused on two areas. First, how communities experience climate: (i) what climate cycles and climate events are remembered through personal and / or collective memories, and what indicators are used to identify them; and (ii) what does climate change mean to communities? Are wetland (rice growers and fishers) and mountain (coffee growers) farmers experiencing similar or different effects of climate change? The second was focused on understanding how communities are informed about climate and how they react in response to scientific climate information: (iii) where do community members receive their weather / climate information and how do they use it; and (iv) what changes are the communities experiencing and how are they adapting?

In addition to structured interviews, we conducted three workshops with high school aged students in two different towns in the department of Sucre, Sucre and San Marcos. The workshops were aimed at (i) teaching students about the difference between climate variability and climate change; and (ii) acquiring a baseline understanding of student knowledge on climate through their schooling and collective memories of their communities, their exposure to agriculture and environmental changes in their area, and how they understand climate impacts in their communities. Students were asked to participate in several activities where they answered questions about climate: how do you know when it is going to rain? In La Mojana, when is it summer and when is it winter? What is the phenomenon of El Niño? What are the effects of rain in your town? They also identified how much rain they would expect during different stages of the crop growing season and drew maps identifying well-known flooding zones in their town during extreme rainfall events.

[13] *Municipality Agricultural Evaluations*. Office of Agricultural Planning (UPRA).

[14] Bremer, Scott, et al. "Narrative as a Method for Eliciting Tacit Knowledge of Climate Variability in Bangladesh." *Weather, Climate, and Society*, vol. 9, no. 4, 2017, pp. 669-686.

[15] Flood, Stephen, et al. "Adaptive and Interactive Climate Futures: Systematic Review of 'Serious Games' for Engagement and Decision-Making." *Environmental Research Letters*, vol. 13, no. 6, 2018, 063005.

III. **Findings and Discussion**

In the following Section, results are based around the four central research questions. Any direct quotes have been translated from Spanish to English. The goal of these findings was to (i) assess local climate knowledge and the use of scientific climate knowledge and information; and (ii) understand if and how such perceptions of climate knowledge and information have been impacted by interventions from public or university interventions which have influenced the flow of climate information and knowledge in the region.

A. *What Climate Cycles and Climate Events Are Remembered through Personal and / or Collective Memories, and What Indicators Are Used to Identify Them?*

1. Memorable Historical Events

When asked what historical climate events participants remembered, a majority did not speak at length, with surprisingly no climate or weather events described before 2010. The most noteworthy event recalled by several participants in the region of La Mojana was the 2010–2011 La Niña event.[16] In the town of Sucre, Sucre, locals recalled 2010–2011 to be the years of the worst floods in recent history, receiving approximately 30 cm of rainfall, so much so that they needed canoes to move around the town in areas that did not normally flood.

In response to the catastrophic floods of 2010–2011, a national emergency was declared in Colombia, and the Adaptation Fund was created as the entity responsible for the recovery of the most affected areas through four macro-projects, La Mojana being one of them. The Regional Centre for Forecasts and Early Warning (CRPAT) was created in San Marcos as part of the La Mojana macro-project, providing a regional weather and climate centre to help protect the general population in the event of another catastrophic La Niña event. In addition to the created climate and weather centre, participants in La Mojana discussed other mitigation efforts for disaster prevention, such as raising the level of the houses above the 2010 flood level, to reduce their likelihood of reliving the fooding disasters.

In addition to 2010–2011, participants also described the abundance of rainfall and lower temperatures they had experienced more recently, specifically during the three year-long La Niña event between 2020–2023.[17] In La Mojana, this period has been also marked by a non-climatic related event: the rupture of the marginal dike on the Cauca River border, which has created floods in the region even in the absence of above normal rainy seasons. However, participants described temperatures from 2020–2023 to be normal when compared to other rainy seasons in both the Huila and La Mojana regions. In regard to agriculture, one participant from Sucre (M4) described how there were very few fish to be caught in 2022, the opposite of what they experienced in 2010. The reason for this difference is the source of the flooding. While the floods of 2010–2011 were stronger, the flood waters were the result of interseasonal rainfall patterns, which is linked to the reproductive and migration cycles of fish, while the 2022 floods were related to the rupture of the dike, not related to other biological cycles.

Additionally, some of the farmers discussed the current conditions they were experiencing (those of July 2024) to be wetter than normal or even having too much water due to rainfall, with one coffee farmer from Gigante (Huila; H1) noting a recent hurricane with 35 kmh winds that impacted their farm.

Based on the participant responses, it is clear that living and actionable memory in both regions only recalls the most recent extreme rainfall events and less extreme events within

[16] Vargas, Germán, et al. "La Niña Event 2010–2011: Hydroclimatic Effects and Socioeconomic Impacts in Colombia." *Climate Change, Extreme Events and Disaster Risk Reduction*, edited by Suraj Mal et al., Springer, 2018, pp. 217-32; Camargo, Alejandro. "Disastrous Waters, Renascent Lands: Politics and Agrarian Transformations in Post-Disaster Colombia." Ph.D. Thesis, Syracuse University, 2016.

[17] "El Niño / La Niña Update." WMO, 2023.

the last five years, similar to other findings.[18] Even CRPAT did not have a record of major rainfall and flooding events in the area due to their short presence in the region (since 2011). Therefore, very little information appears to be carried over from generation to generation both in an oral and recorded manner. However, the catastrophic floods in La Mojana have created a permanent mark in the collective memory and even in the landscapes[19] (the level of the houses, the water marks in the walls). Such indicators of extreme events have become a reference for what is considered a strong rainy season and how they can be prepared in the event of another.

2. Natural Indicators

Throughout the two regions studied, participants described a strong relationship between climate cycles and their natural environment, or natural indicators, that have been historically marginalised by European / Western paradigms[20] qualifying them as anecdotical. Specifically, many locals discussed their dependence on animals, plants, clouds, and the Moon to make decisions about planting their crops, understanding the upcoming weather events, or identifying annual or interannual fish abundance cycles. The farmers and fishers understand the related rhythms of rain and other biological cycles, like the reproductive cycles of the fish, the migratory patterns of the birds, the physiological rhythms of the plants, etc., and so they adapt their productive practices to those rhythms and cycles.[21]

In regard to animals, participants spoke mostly of birds and the songs that they sing to predict the upcoming weather or season. Coffee farmers in Gigante (Huila; H1) spoke of the Chistosa birds that fly to a green tree if it is going to rain or a dry tree if it is going to be dry. Farmers in La Plata (Huila; H8) described the song of the Noche Larga (also named Chachalaca, *Ortalis columbiana*) bird that signals if it will rain in the morning or the evening (**Figure 3**a). Similarly, in La Mojana, many participants spoke of birds that sing to predict the rain, such as the carrao (*Aramus guarauna*) and chavarri (*Chauna chavaria*) birds (**Figure 3**b; M1, M4). However, such birds of wisdom are not present in every region. In fact, farmers in Garzón (Huila; H2) mention that these birds no longer live in their area and inhabitants in La Mojana say that the carrao populations have decreased because of the degradation of the wetland ecosystems. This ecological alteration has diminished the accuracy of the singing of these birds, with many now stating that the carrao are no longer accurate at describing upcoming seasonal rainfall predictions.

In addition to birds, other animals indicating patterns of rains, flooding or droughts include fish, molluscs, and insects. For example, an abundance of butterflies in Sucre, or the increased activity of the snails, suggests an imminent rainfall event.

Other animals, such as fish, are tied to seasonal rhythms. Fishers in Sucre and San Marcos (La Mojana; M4) discussed the natural cycle of fish in the region. La Mojana is a wetland region that hosts many migratory fish. At the beginning of the *verano* (the dry season) the fish often leave *cienagas* for cooler waters, and return at the beginning of the rainy season. This migratory cycle is related to the cycle of rains and floodings, and marks not only the moments, but the places for the fishing activity.

Locals also rely on snails to anticipate the level of the floodings. A snail laying eggs higher in elevation suggests an above normal rainfall

[18] Harley, Trevor. *The Psychology of Weather*. 1st edn, Routledge, 2018.

[19] Ingold, Tim. *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill*. Routledge, Taylor & Francis, 2002.

[20] Chilisa, Bagele. "Decolonising Transdisciplinary Research Approaches: An African Perspective for Enhancing Knowledge Integration in Sustainability Science." *Sustainability Science*, vol. 12, no. 5, 2017, pp. 813-827.

[21] Bremer & Wardekker (n 6) *supra*; Forigua-Sandoval, Juliana, et al. "The Synchronization of Hydrotemporalities in Fishing Territories: Debating Time and History in the Llanito Swamp, Magdalena River (Colombia)." *Geoforum*, vol. 165, 2025, 104381.

season, thus requiring a safer location for eggs (**Figure 4**, below). A fisherman in Sucre (La Mojana; M4) explained that "snails are the most accurate of all, the snail does not make mistakes". Snails, along with other animal indicators driven by the climate, have been documented by research scientists at the National Federation of Rice Growers (Fedearroz) in Montería, Colombia, who have conducted hundreds of interviews to understand the natural indicators people use to understand weather and climate in Colombia and have published their findings.[22]

Plants and fungi also act as indicators to predicting climate in an upcoming season. One coffee farmer (H8) discussed the importance of fungi as an indicator of rain and humidity in the region and its utility in predicting upcoming rainfall events.

Clouds, though part of the climate system, were also heavily discussed as indicators to predict rainfall. One farmer in Pitalito (Huila; H7) mentioned that he uses clouds over certain parts of the mountains to be an indicator for rainfall. Also, in Gigante (Huila; H1) another participant stated that "when it rains in Bogota, it rains here two days later". Others in La Mojana evaluated clouds based on their colour and position (H4). Dark clouds suggest rain—depending on where they are in the sky—and thunder was described to be the sound of summer, with thunderstorms often being associated with hurricanes. In San Marcos (La Mojana), one farmer (M4) described that depending on if the clouds are on one side of the Moon or the other, it could indicate upcoming rainfall.

When speaking with the younger generation in the school workshops in La Mojana, students shared a similar narrative as their parents and elders about natural indicators. Students referenced songs from the carrao and chavarri birds, along with sounds from crickets and beetles, and low flying formations of dragonfly groups to indicate rainfall. They also explained that worms will burrow deeper into the Earth before it rains. In regard to the sky, many students discuss abundant and dark clouds, distant thunderstorms with thunder and lightning, strong winds, and clouded night skies as indicators of rainfall.

Beyond the Earth, many participants also described their relationship with the Moon's use; not to predict the weather, but for longer rhythms, such as those of planting and harvesting seasons. Farmers in Garzón (Huila; H2) stated that the Moon is the most important indicator for determining when to plant and harvest crops. Many participants, both in Huila and La Mojana (H1, H2, M1, M3, M4), described the best time to plant based on the Moon phase. For example, bananas, beans, and onion are best planted during the waxing phase of the Moon. However, some farmers (H7, H8) dismissed or rebuked the reading of the Moon (and its relationship to crops) and suggested that such methods are only utilised by older generations or that they no longer used such practices that their parents and grandparents had passed down. **Table 2**, below, summarises the indicators used in both regions.

3. Impacts of Seasons and Climate Variability

There are two seasonal states observed by the participants in Colombia that can vary from month to month: *verano* (summer) and *invierno* (winter). *Verano* is described as a period of warmth and little rain, while *invierno* is typically referred to as periods of lower temperature and more abundant rainfall. The fickle fluctuation of these two states is due to Colombia's location in the equatorial region, often impacted by the shifting of the Inter-Tropical Convergence Zone, which leads to less rigid definitions of seasons than what might be experienced at higher latitudes.

When speaking to farmers in the Huila region, many discuss how *verano* is observed between August and the end of the first half of September, and December–March. *Invierno* is often observed in late September, parts of

[22] Saavedra, Enrique, et al. *Bioindicadores Climáticos Usados Por Los Agricultores Arroceros En El Caribe Húmedo Colombiano*. Fedearroz / Universidad de Córdoba, 2022.

October–November, as well April–July. However, in la Mojana, adult participants agree that *verano* is described as December–April, while *invierno* is observed May–November, with a few suggesting that *invierno* can begin as early as April and last through November with the occasional *verano* month in between. Such characterisations of the seasons in La Mojana were validated by students in both Sucre and San Marcos (La Mojana), suggesting that they have a strong understanding of seasonal changes in their area. This consensus is reasonable as the seasonal changes in the levels of the *cienagas* allow for different productive activities: in the rainy season, mounting water levels enables increased fishing, while in the dry months, the lower water levels open space for rice and other sustaining crop production.

Students also had a firm understanding of the impacts of rainfall, or lack thereof, on their communities. They stated that rainfall was beneficial for crops, animals, plants, strengthening of trees, abundance of fish, and waterways, while being detrimental by causing floods in towns (**Figure 5**, below), reducing crop production, damaging natural and electric systems, causing deaths of diverse species, and impacting daily life. The students were also able to accurately draw the most flood-prone regions in their towns.

Adult participants discussed the impacts of rainfall on both coffee and rice crops. In Pitalito, Timaná, and La Plata (Huila), farmers explained that a surplus of sun restricts coffee growth, as excessive heat negatively impacts the flowering of the coffee plants, while an overabundance of rain can also negatively impact flowering by knocking flowers off the coffee plants. Additionally, three weeks of consistent rain and humid conditions can provide a suitable environment for infection, such as coffee rust, to grow on the plant and destroy the harvest, while 15–20 days without rain can dry the coffee plant, impacting coffee production. Drier months, however, are often a relief to most farmers, as diseases, such as coffee rust, and insects are often no longer an issue. Though, generally, one coffee farmer in Timaná (Huila; H3) claimed that "there is a very tempered climate here with no strong winds and it rains most of the time so they [farmers] are able to plant whenever they want to", suggesting that through seasonal variations, there are fewer dynamic shifts of climate in coffee growing regions.

Rice growing in the lowlands, on the other hand, is a "crop of water"[23] and is less impacted by humidity but greatly dependent on rainfall. According to farmers in Sucre (La Mojana; M3), it only takes four hours for rice crops to dry out if there is no standing water present; so, farmers work with the rainfall and forecasts to protect their plants and harvest. Additionally, farmers in San Marcos (La Mojana; M1) discussed how rice seeds will not grow if it does not rain for a month after planting. Such alignment of farmers to the hourly dependence of rice on water and rainfall suggests that farmers in La Mojana have a stronger dependence on weather related forecasts than farmers in the Huila region, thus leading farmers to use rainfall prediction products more seriously in making decisions about agricultural practice.

Predicting rainfall and drought in Colombia becomes less challenging during El Niño and La Niña years. During La Niña events, high quantities of rainfall and flooding are experienced across the country, with firsthand accounts provided in Pitalito (Huila) and San Marcos and Sucre (La Mojana), which have impacts on agriculture. In Huila and La Mojana, El Niño events are characterised by drought. Poor quality coffee is reported during El Niño years due to heat stress on the plant during flowering in Timaná (Huila; H3). Additionally, drier conditions impact rice crop production all La Mojana region, alter the migration cycles of fish, and cause forest fires in the high grounds. However, more descriptive depictions of El Niño events were

[23] Castillo, Laura. "La Vida Social de la Inundación: Experiencias de Pequeños y Medianos Cultivadores de Arroz Frente a la Inundación de Caregato, Ayapel, Colombia." Master's Thesis, Erasmus University Rotterdam, 2023.

provided by students in La Mojana, who often characterised them as long periods of drought, destruction of species and crops, high temperatures and prolonged heat waves, and water shortages.

It is evident that both adult and student participants have a clear understanding of climate cycles and events that impact their communities. They use different indicators, such as plants, animals, clouds, and other environmental features to understand climate cycles, but not all indicators are equally trusted or available in all regions. The impacts of El Niño and La Niña events are well understood and participants could articulate the most recent catastrophes experienced in their regions; however, there was very little discussion of climate variability at longer time scales. Only two participants in La Mojana (M3, M5) recognized long term variability, one citing stronger solar insolation now, compared to insolation in the 1980s, and the second discussing the existence of century cycles, claiming every century experiences different rainfall frequency and intensity. Therefore, short-lived memory of changes in climate is prevalent in both regions, leaving farmers with only the understanding of the current state and less of the greater picture of the region's climate history, which may impact their ability to contextualise changes they are experiencing.

B. *What Does Climate Change Mean to Communities? Are the Wetland (Rice Growers and Fishers) and Mountain (Coffee Growers) Farmers Experiencing Similar or Different Effects of Climate Change?*

1. Impacts on Crops and Farming

Farmers in both Huila and La Mojana described various changes in weather and climate in their regions; however, the majority of coffee farmers discussed changes in rainfall patterns, frequency, and intensity during *invierno*, while rice farmers in La Mojana focused on the changes in sun intensity during months of *verano*. This difference is logical, as farmers are preoccupied with the season where crops are most vulnerable to climate-related changes in each region.

For towns in the Huila region, such as Gigante and Pitalito, farmers cite additional cool and wet days due to climate change, which can be problematic for coffee plants. As one farmer (H8) described this double-edged sword, they need rainfall to feed the coffee plant, but rainfall comes at the cost of more frequent cooler and humid days, which can lead to the loss of the flowering of the coffee plant and the invasion of pests or diseases, leading to lower crop production and lower coffee quality. Diseases (such as coffee rust), pests, and insects pose a great threat to crops.[24] However, these concerns were only recognised in Pitalito (Huila), suggesting that other areas might not be experiencing these issues to the same degree. Pitalito was the highest elevation municipality studied in this research (1,348 meters above sea level); therefore, it is possible that it has unique climate challenges that other regions do not.

Changing rainfall frequency and intensity was also discussed by many coffee farmers. In Pitalito (Huila), one well-known coffee farmer owner noted that rainfall had been particularly high between 2013–2019, while a representative from Las Rosas Coffee Association in La Plata (Huila; H8) stated that she had observed rainfall changes starting around 20 years ago (early 2000s) in addition to more frequent cloud cover in the region.

Farmers also commented that additional and more frequent rainfall is changing the way that the water is absorbed, specifically when considering soil drainage. With increasing soil moisture content, ventilation of the ground is decreasing, impacting plant health by

[24] Bustillo, Álex Enrique. "El Manejo de Cafetales Su Relación Con El Control de La Broca Del Café En Colombia." *Federación Nacional de Cafeteros de Colombia*, 2007; Lu, Li, et al. "Comprehensive Review of Fungi on Coffee." *Pathogens*, vol. 11, no. 4, 2022, p. 411; Góngora, Carmenza, et al. "Sustainable Strategies for the Control of Pests in Coffee Crops." *Agronomy*, vol. 13, no. 12, 2023, p. 2940; Salazar-Navarro, Alexis, et al. "Coffee Leaf Rust (Hemileia Vastatrix) Disease in Coffee Plants and Perspectives by the Disease Control." *Phyton*, vol. 93, no. 5, 2024, pp. 923-949.

waterlogging coffee plants roots.[25] While most conversations in Huila focused on rainfall, one famer in Garzón (H2) did mention that he had noticed more intense and extreme heat in January, which also impacted the flowering and overall health of the coffee plant.

In contrast to coffee farmers, most farmers in La Mojana spoke about the changing intensity of the sun during drier months. In Sucre, one participant noted that during the 1980s the sun had weaker intensity than it does now (M3). Another farmer corroborated this statement by commenting that summer heat has become stronger and more intense since 1992 (M4). Additionally, some farmers discussed seeing changes in rainfall patterns, specifically in Sucre, Sucre (M3, M4).

When speaking with a representative from Fedearroz (M5), it became apparent that traditional indicators of climate that have been used by rice growers for decades are changing, making it more difficult for farmers to use traditional climate knowledge. Therefore, with a lack of climate indicators, farmers have needed to become more familiar with climate information from Fedearroz, IDEAM (the National Institute of Hydrology, Meteorology and Environmental Studies), and other forecasting services.

2. Perspectives from Communities

While most participants knew of climate change, some of them were less concerned about it than others, specifically in coffee growing regions, such as Garzón and Timaná (Huila), where farmers described very little impact of climate change on their farms. On the other hand, rice growers, who are much more dependent on rainfall, appeared to be more openly invested in using climate information provided by organisations such as CRPAT and IDEAM. However, one young rice farmer in San Marcos (La Mojana; M1) admitted that he had never heard of such climate information and services before, but seemed very interested and was later able to get in contact with CRPAT. It is therefore evident that farmers of similar or different crop types have different needs for climate information, which was also echoed by representatives from CRPAT (M6) who mentioned that Indigenous communities also needed different climate information than the rice growers in the area.

Students in Sucre (La Mojana) were all very aware of the dangers associated with climate change. They described climate change both in regard to changing rainfall and temperature, with one student identifying that "climate change is something that affects *our* environment". Some students did not know how to articulate the difference between climate change and changes seen between *verano* and *invierno*, but understood that we as humans are contributing to the issue.

One student wrote:

> *"Climate change can be defined as when it rains one day and not the next, when the sun comes out and it is said to be a rainy sun and this is due to the great damage and impact that we humans cause by throwing garbage."*

Generally, most students understood that climate change produced more wet and hot days in La Mojana when compared to their traditional seasonality.

C. *Where Do Community Members Receive Their Weather / Climate Information and How Do They Use It?*

In addition to the natural indicators mentioned in Section III.A.2, participants mentioned several other sources of climate information that disseminate relevant data through the various channels described below. General trust in climate forecasts and other

[25] León-Burgos, Andrés Felipe, et al. "Soil Waterlogging Conditions Affect Growth, Water Status, and Chlorophyll 'A' Fluorescence in Coffee Plants (Coffea Arabica L.)." *Agronomy*, vol. 12, no. 6, 2022, p. 1270; Toral-Juárez, Marco, et al. "Drought-Tolerant Coffee Plants Display Increased Tolerance to Waterlogging and Post-Waterlogging Reoxygenation." *Environmental and Experimental Botany*, vol. 182, 2021, 104311.

information produced by IDEAM in Colombia is also discussed.

1. Distributors of Climate Information

Several regional and national level organisations were frequently mentioned by participants when asked from where they receive their climate information, including IDEAM and regional climate centres (like CRPAT), the National Federation of Coffee Growers of Colombia (FNC) and local coffee associations, and Fedearroz.

For the coffee farmers interviewed, many were part of a local coffee association and had some level of interaction with the FNC. Participants in Neiva and Gigante (Huila) discussed their use of information disseminated by FNC, which they received from a platform created in collaboration between the FNC and IDEAM. This platform was also described to have the functionality of contacting the farmers to provide additional climate information. Participation in local coffee associations, such as ISEG or Global Cafe, were mentioned by participants in Neiva, Gigante, and Timaná (Huila). These regional associations hold frequent meetings in cooperation with the FNC, with which they have a strong relationship, to provide and translate climate information to local communities. In Pitalito (Huila), one coffee association is made up of 18 families; however, farmers explained that they do not use climate information from IDEAM or other information distributors, but rather use weather information from Google or look to the mountains to determine if it is going to rain (H7). Similarly, a separate large coffee association in Pitalito utilises channels of communication to receive and communicate climate information amongst members, but they also do not use information from IDEAM. This lack of connection between IDEAM and communities in Pitalito (the original municipality in coffee production in the country),[26] likely due to the lack of extension services located in the area, as mentioned by a participant in Pitalito (H7), appears to have contributed to a stronger fortification of local coffee associations and networks, but less knowledge of climate services and tools.

When IDEAM was mentioned during interviews in both Huila and La Mojana, most farmers had strong opinions on the utility of information they have and currently receive from IDEAM. Most know how to access or already receive some sort of climate information from IDEAM through various channels, but many do not use it. One coffee farmer in Garzón (Huila; H2) explained that he does not use climate information from IDEAM because he does not believe that it is local enough to be relevant to his farming practices. The lack of trust of the information provided by IDEAM may be related to the traditional lack of state presence in many territories in Colombia,[27] which has created an extensive lack of trust in the state services and its relevance to local realities.

Other farmers in La Plata (Huila) and Sucre, Sucre (La Mojana) continue to resist the use of scientific forecasts and prefer to use natural indicators to understand weather and climate or use other resources on their phones. One coffee farmer in La Plata (Huila; H8) described that she typically only uses the official ENSO forecast (which describes if conditions are El Niño, neutral, or La Niña) from IDEAM, but knows how to manage her crops for the remainder of the season just knowing the ENSO forecast. In La Mojana, there is greater utilisation of climate information from IDEAM to monitor rainfall, and one rice miller (M3) mentioned that of the small population of farmers who use climate information, many of them use information from IDEAM.

The effective distribution of climate information within La Mojana has a particular advantage with the presence of the Regional Centre for Forecasts and Early Warning (CRPAT). After the devastating 2010–2011 La

[26] UPRA (n 13) *supra*.

[27] Serje, Margarita. "El Mito de la Ausencia Del Estado: La Incorporación Económica de las 'Zonas de Frontera' en Colombia." *Cahiers Des Amériques Latines*, no. 71, 2013, pp. 95-117.

Niña event,[28] local government officials realised that there was a need to bring regional climate information to La Mojana for better prediction of temperature, rainfall, and impacts of climate change. Though it lacks the capacity to carry out climate-related research due to capacity restraints, CRPAT focuses on the creation and dissemination of climate forecasts for the region. Additionally, CRPAT works jointly with IDEAM, the Ministry of Agriculture and Rural Development (MADR), the Food and Agriculture Organization (FAO) and the United Nations Development Programme (UNDP) to provide relevant information and resources to communities in La Mojana.

Fedearroz also has a strong presence in La Mojana, as it is one of the largest rice growing regions in the country.[29] Representatives from Fedearroz (M5) demonstrated the climate tools on their platform (clima.fedearroz.com.co) that can be used by anyone with access to the internet to retrieve climate and weather forecasts, along with historical climate information and bulletins published by the organisation. They explained that the platform has forecasts of lead times up to six months, but that the first three months are most reliable.

Though climate information is communicated from large bodies like IDEAM, CRPAT, FNC, and Fedearroz, farmers and regional climate information distributors frequently mentioned their use of local weather stations. Some farmers have their own or multiple weather stations. One participant in Gigante (Huila; H1) described that he has ten weather stations on his property collecting data that is shared with neighbours that he has used to monitor changes in climate over the last 15-20 years (**Figure 6**, below). Some other towns have local weather stations, such as in Timaná and Pitalito (Huila), but it was unclear how easily local farmers could gain access to such weather information. In La Mojana, Fedearroz explained that they have ten of their own weather stations throughout the region. There is a larger network of >30 weather stations monitored by IDEAM across the country, but only two are located in La Mojana. In San Marcos (La Mojana), CRPAT does not have any weather stations that they own; however, they have accumulated 24 volunteer weather stations—with 19 currently functional—throughout the region where they can gather local data. In the Huila department, there are also stations installed by other actors to monitor important weather and climate indices, such as the electric company Enel Colombia. Enel Colombia constructed a hydroelectric dam El Quimbo, close to Gigante and Garzón (Huila), and installed six weather stations around the hills above the dam to measure the climate impacts produced by the dammed lake.

In addition to station and forecast-based types of climate information and natural indicators, some farmers mentioned other methods that they use to understand upcoming weather or climate events. In Pitalito (Huila; H7) and San Marcos (La Mojana; M1), some farmers discussed the use of Google and other search engines to find weather information, though they did not disclose what sources they were using. Additionally, other forms of information like the local Farmer's Almanac (the Bristol Almanac) and, sometimes, the Mayan calendar were mentioned, though these sources did not seem to be used by most of the participants (M3).

2. <u>Forms of Communication</u>

Four main forms of communication and dissemination of climate information were identified during the interviews and are used most frequently across Colombia: WhatsApp group messages, radio broadcasts, bulletins, and agroclimatic roundtable meeting (MTAs).

[28] Vargas, Héctor, et al. "La Mojana 2030: Un País Posible: Propuestas Para Ordenarla Alrededor Del Agua." *Planeación & Desarrollo*, 2023.

[29] *III Censo Nacional Arrocero Zona Centro No. 3*. Fedearroz, 2008; Castro-Llanos, F, et al. "Climate Change Favors Rice Production at Higher Elevations in Colombia." *Mitigation and Adaptation Strategies for Global Change*, vol. 24, no. 8, 2019, pp. 1401-1430.

The use of WhatsApp groups was pervasive within the two areas of study, with specific groups mentioned by farmers in Neiva, Timaná, and Pitalito in Huila and Montería, San Marcos, and Sucre in La Mojana. Many messaging groups have well-known names, such as CLAP, used by farmers in Timaná (Huila), or Cafe al Dia, used by farmers in Pitalito (Huila). Some of the WhatsApp groups are used to communicate solely amongst the farmers to share information, while others are run by Fedearroz or CRPAT as a primary way to distribute climate information or information about MTA meetings. For smaller coffee associations, some of the groups are private, while others can amass great numbers of members. CRPAT alone mentioned that they have around 30 different WhatsApp groups based on region and other factors that they send information out to daily (M6).

However, even with the abundance of WhatsApp groups available to farmers in both regions, invitations to such groups and, therefore, access to local climate information, do not always find their way into the hands of all farmers. For example, at the time of the interview, one participant in San Marcos (Huila; M1) was not a member of any WhatsApp groups that discussed the climate. He mentioned that he speaks to neighbours about what weather they are experiencing, but had no formal connection to IDEAM or CRPAT. Even with the pervasiveness of CRPAT's operations in the San Marcos region, this demonstrates how difficult it can be to connect small farmers to the network of climate information.

Additionally, in both the Huila and La Mojana regions, organising bodies like the local coffee associations and CRPAT use radio broadcasts to reach farmers to provide more general weather and climate information. Such broadcasts were mentioned with farmers in Pitalito and Timaná (Huila), with one particularly useful channel called Canal Clima which is used to provide information on rainfall. In La Mojana, CRPAT has a radio broadcast sent out to the region daily at 9am with hydraulic, meteorological, and early warning information. In Garzón (Huila), where there is no local coffee association, radio broadcasts from the federal government transmit climate information and changes in coffee prices, along with information about hurricanes on the coast and other country-wide weather impacts.

As regards written and published material, weekly and monthly virtual bulletins are available through some organising bodies. Some local coffee associations, like in Pitalito (Huila), distribute a bulletin that provides information about weather and climate, regional fires, harvesting seasons, and updates on the abundance of crop infections in a region. Bulletins are also distributed by Fedearroz and CRPAT in La Mojana. CRPAT has two forms of bulletins, one that is published daily and a second that is published monthly. The monthly publication provides information at a higher scientific level, proving to be less accessible to some farmers. However, the forecasts published by CRPAT include two-month forecasts and agricultural information which complement the information provided by IDEAM.

Finally, in addition to broadcast or written materials, MTAs are used in La Mojana to communicate and educate farmers and locals on climate information. MTAs in Sucre and other parts of La Mojana were added based on interest from participants in surrounding regions, such as Córdoba[30] and are hosted monthly in Sucre and Córdoba (Huila) by Fedearroz and the FAO. Meetings are attended by 20-22 participants from all of the sectors in the department who receive forecasts from IDEAM—including representatives from CRPAT—and learn about interpreting the forecasts for agricultural purposes. Fedearroz noted that fishers do not typically attend the meetings, but they see stronger attendance from rice farmers in the region; however, as with the WhatsApp groups, the MTAs are not known to all, as one rice farmer only learned of the MTAs during the interview in Sucre (La Mojana; M4).

[30] Loboguerrero et al. (n 9) *supra* at 67-8.

3. Trust in and Use of Climate Information

Throughout the field study, all farmers discussed their use of some sort of climate information, whether it was provided by IDEAM, from natural indicators, or had been passed down generationally from their parents and grandparents before them. Many farmers were still sceptical of forecasts from IDEAM or other regional climate offices, citing a lack of resolution and claiming that climate and weather forecasts were unable to achieve the spatial resolution of their particular land area, making forecasts unusable. One farmer in Timaná (Huila; H3) claimed they only needed weather and climate forecasts with a 1–2-month lead time, so seasonal forecasts were irrelevant to them. On the other hand, one rice farmer in Sucre, Sucre (La Mojana; M3) said that he personally uses information from IDEAM and finds it to be 70% accurate, suggesting there still exists a wide range of opinions on the information provided by IDEAM and other regional climate offices.

Additionally, results suggest that participants of different ages are using climate information differently. For example, many younger farmers (less than 50 years of age: e.g., H7, M1) no longer use historical indicators from their parents' generation and believe that forecasts are important to protect the plants, while older participants spoke more on the use of natural indicators or practices passed down from previous generations. Students, on the other hand, are developing new technologies to help plant and harvest crops with the changing climate and are creating new materials, such as paper, constructed with waste produced by agricultural practices. Therefore, the different mindsets of how to interact with the environment and climate change are shifting between the generations and will likely continue to adapt as climate change increasingly impacts the natural rhythms of rains, animals and agricultural activities in Colombia.

To better understand what information the farmers could benefit from, participants were asked what their ideal weather or climate forecast would look like. Like many participants mentioned with their current use of climate information, most were looking for forecasts in the 1–2-month range, with some interested in shorter, subseasonal, timescales of 2–3 weeks. Farmers were particularly interested in variables such as temperature, precipitation, humidity, and wind to assist in the mitigation of pest invasions in crops and to understand if the upcoming month(s) would be *verano* or *invierno*. Some farmers in San Marcos (La Mojana) also expressed interest in better ENSO state forecasts throughout the year. Farmers therefore see the importance and value of forecasts, but still appear to lack trust in the information that is currently available. Additionally, farmers noted the need to better match the timescales of provided forecast (often three-month forecasts) to the timescales used in local practices.

D. *What Changes Are the Communities Experiencing and How Are They Adapting?*

1. Climate Change in Huila

Many participants discussed the changes they were observing due to climate change (Section III.B). However, there were surprisingly fewer observations than expected in coffee growing regions, and participants rarely elaborated on what they were doing to actively combat climate change in their farming practices. Only one farmer in Pitalito (H4) was able to articulate a change in coffee from climate change by lamenting that coffee quality was good until around 2008, when they started to see more impacts of climate change.

Coffee farmers generally agreed that changing temperatures were impacting their ability to grow coffee. In Garzón, one participant estimated that they have seen a 2–4°C increase in temperature, with warmer night-times, while farmers in Pitalito discussed more frequent cooler days in *invierno*. Additionally, increasing intensity of the rains in July and August is leading to issues with flowering and the proliferation of coffee rust disease on coffee plants in Gigante and other surrounding towns. However, at higher elevations in Pitalito, farmers are experiencing issues with dry conditions, with one farmer (H5) noting that they recently lost a whole harvest of

coffee due to dry conditions and have noticed that rivers are drier than normal.

To combat the accumulation of coffee rust and other pests on their plants, farmers are being forced to move their farms to higher elevations. The increasing altitude of coffee farms reduces temperature and capacity for the air to hold moisture, reducing coffee rust cases. Farmers from most regions agreed that the minimum elevation to successfully grow coffee falls somewhere between 1100–1300 meters above sea level, with most suggesting that 1300–1800 is the best range, and 1900 is the maximum. A farmer in Gigante (H1) suggested a lower elevation of 800 meters, and some farmers in Pitalito explained that the altitude varies based on the variety of coffee one is interested in growing. However, moving coffee farms to higher elevations comes at the cost of deforestation to clear land for the coffee plants, an issue discussed by several farmers in Neiva and Pitalito. To combat the deforestation, there are efforts in Neiva, Gigante, Timaná, and other towns in the Huila department to reforest the lower altitudes the old coffee farms once inhabited.

Additionally, coffee growing seasons are also changing. One farmer in La Plata (H8) observed that the shorter growing season (October–November) is more susceptible to climate change, creating inconsistency in crop yield. This inconsistency of crop production due to climate change is also felt between the different harvests, impacting overall crop production. In Pitalito, farmers (H4, H7) described that they are receiving 70–75% of their harvest during the second harvest, and only 25–30% in the first harvest. Therefore, farmers are increasingly experiencing unpredictability in crop yield leading to greater concerns about year-round economic security.

To add to the complexity of the economic stability of crop yields, participants also noted changes in animals and insect populations. For example, the death of 70–80% of bees was observed in Pitalito in 2024, which impacted the pollination of the coffee and other plants in the region. Additionally, one coffee farmer in La Plata (H8) observed that many plants are not growing and birds are no longer migrating to their area. Animals were also described to be very disoriented and do not appear to know how to interpret the weather. Systemic ecosystem changes will continue to affect the pollination and health of the coffee farms, which are often out of the control of the farmers, but impact the livelihoods of communities.

2. Climate Change in La Mojana

In La Mojana, climate is also impacting the planting season and crop yield. A representative from Fedearroz (M5) mentioned that, due to climate change, some farmers were unable to plant seeds in the early months of 2024. However, with the empowerment of readily available climate information from Fedearroz, CRPAT, and the MTAs, there has been an increase of visible awareness of climate change impacts in La Mojana among rice growers. Representatives from CRPAT (M6) mentioned that before 2011, and the creation of CRPAT, weather and climate information was not coordinated or well understood by the general public. Now, however, after years of MTAs, consistent climate information distribution, and an increased demand for climate information, CRPAT finds that locals use more technical language when discussing weather and climate and the community as a whole is better prepared for climate-related disasters. This is a relative success for the MTAs and other regional projects, that have been active in the region.

IV. **Conclusion**

This article focused on the local climate knowledge of and use of climate services, tools, and forecasts in two regions of Colombia: Huila and La Mojana. Huila, a mountainous department in Colombia, is the largest coffee-producing region and produces coffee year-round. La Mojana is a large expanse of rivers and wetlands in northern Colombia and is home to rice farmers and fishers. Interviews were conducted in both regions to understand how participants

interact with their environment and how they are responding to climate change.

Results suggest that there is very little memory of strong climate events before 2010, but greater memory of conditions over the last five years. Additionally, farmers use their knowledge on biological rhythms of animals such as birds, insects, fish, clouds, the Moon, and other natural indicators to understand rainfall and make decisions on planting and harvesting crops. This varies by region, with some regions no longer trusting the natural indicators that their parents once used.

In regard to climate change, most farmers expressed some level of impact on their farms, but farmers in Huila appeared to be seeing fewer changes than those in La Mojana. However, coffee farmers find that they need to shift the altitude of their farms higher to combat pests brought in by increasing temperatures. Additionally, farmers are seeing changes in the productivity of their two growing seasons, creating greater economic imbalances between harvests. Warming temperatures in La Mojana are impacting rice yield and requiring better utility of forecasts to ensure successful planting and harvesting.

Many farmers received climate information from Institute of Hydrology, Meteorology and Environmental Studies (IDEAM). However, many do not trust or use this information, especially in the coffee growing regions. Climate information is also provided by the National Coffee Federation (FNC), the National Rice Association (Fedearroz), local coffee associations, and regional climate offices (e.g., CRPAT). In most regions, climate information is communicated to farmers through the use of WhatsApp groups, often managed by local coffee associations or by community members themselves. Communication also reaches more rural farmers by radio, often daily, depending on the region. For published material, bulletins are distributed virtually in most regions and contain information ranging from planting practices to climate forecasts. Such material is also communicated at MTA meetings once a month in regions that host MTAs, often facilitated by Fedearroz, FNC, and IDEAM.

Generally, few people trust the information provided by IDEAM, stating that forecasts do not have the spatial resolution or accuracy to be helpful to their farms. But the way farmers are using climate information is changing. Younger generations of farmers are turning more towards forecasts, whether from IDEAM or Google, are gaining confidence in using climate information through training at MTAs, and are rebuking the generational knowledge passed down to them from their parents.

Thus, a few questions remain: do all communities want or need access to additional climate information? And how could this be assessed and what resources can be used to conduct this research and implementation? Most farmers seemed interested in *reliable* forecasts with 1–2-month or 2–3-week lead time for temperature, precipitation, humidity, and wind variables, the important timeframes of their planting and harvesting cycles. However, trust in forecasts is generally low, and with farmers retaining little memory from year to year to validate forecasts, additional efforts need to be made to build trust between scientific and local communities. Such trust-building will allow farmers to gain confidence in the provided tools, resources, and forecasts, help farmers train younger generations on the use of climate information in farming practices, and facilitate scientists' understanding of local climate indicators. However, this will only be possible with the appropriate distribution of resources.

These results have given us a better understanding of how Colombian farmers use climate information. As mentioned in the Introduction, a better understanding of users' needs, in terms of climate information and access to it, can enable future work not only to formulate research projects that are more in line with the needs and expectations of the population, but also to produce information and forms of communication that will be more widely used. Therefore, it is imperative that grants enable researchers to spend time in the

field collecting this information before, during, and after research to inform the co-production of climate services to produce the most useful tools for society. This, however, will require a fundamental shift in the grant proposal and research process, which, we argue, is imperative to improving the ethics of climate research.

Acknowledgements

The fieldwork of this research was partially funded by CATER Schools hosted by NORCE. Additional funding was provided by the Graduate School of Arts and Sciences at Columbia University (Laurel DiSera) and Sorbonne Nouvelle University (Flora Lecomte and Carolina Hernández Rodríguez).

Region	Type of Actor	Places	Number of Interviews	Interviewee Reference
Huila	Coffee Farmer	Gigante, Garzón, Pitalito, Timaná, La Plata	6	H1–H6
	Coffee Associations	Pitalito and La Plata	2	H7–H8
	National Coffee Growers Association	Neiva	1	H9
	Fisherwoman	Neiva	1	H10
La Mojana	Rice Farmers	San Marcos	2	M1–M2
	Rice Farmer and Miller	Sucre	1	M3
	Fisherman	Sucre	1	M4
	National Rice Association	Montería	1	M5
	Regional Centre for Forecasts and Early Warning (CRPAT)	San Marcos	1	M6
Total			**16**	

Table 1: Interviews Conducted in the Huila Department and the La Mojana Region.

Region	Number of Participants	Indicators Used
Huila	18-29: - 30-49: 4 50-69: 7 70+: 2	18-29: - 30-49: Information from Google or other smartphone weather applications, information from IDEAM, mountains, clouds 50-69: Weather stations, the Moon, weather patterns in other parts of the country, birds, clouds, wind patterns, ENSO forecasts, information from IDEAM 70+: The Moon, birds
La Mojana	18-29: 2 30-49: 3 50-69: 3 70+: -	18-29: Information from Google or other smartphone weather applications, information from IDEAM, clouds, birds 30-49: Information from IDEAM, birds, insects, 50-69: Clouds, breezes, insects, fish, slugs, birds, the Moon 70+: -

Table 2: Description of Interview Participants by Age and Types of Indicators Used to Understand the Weather and Climate in Their Region.

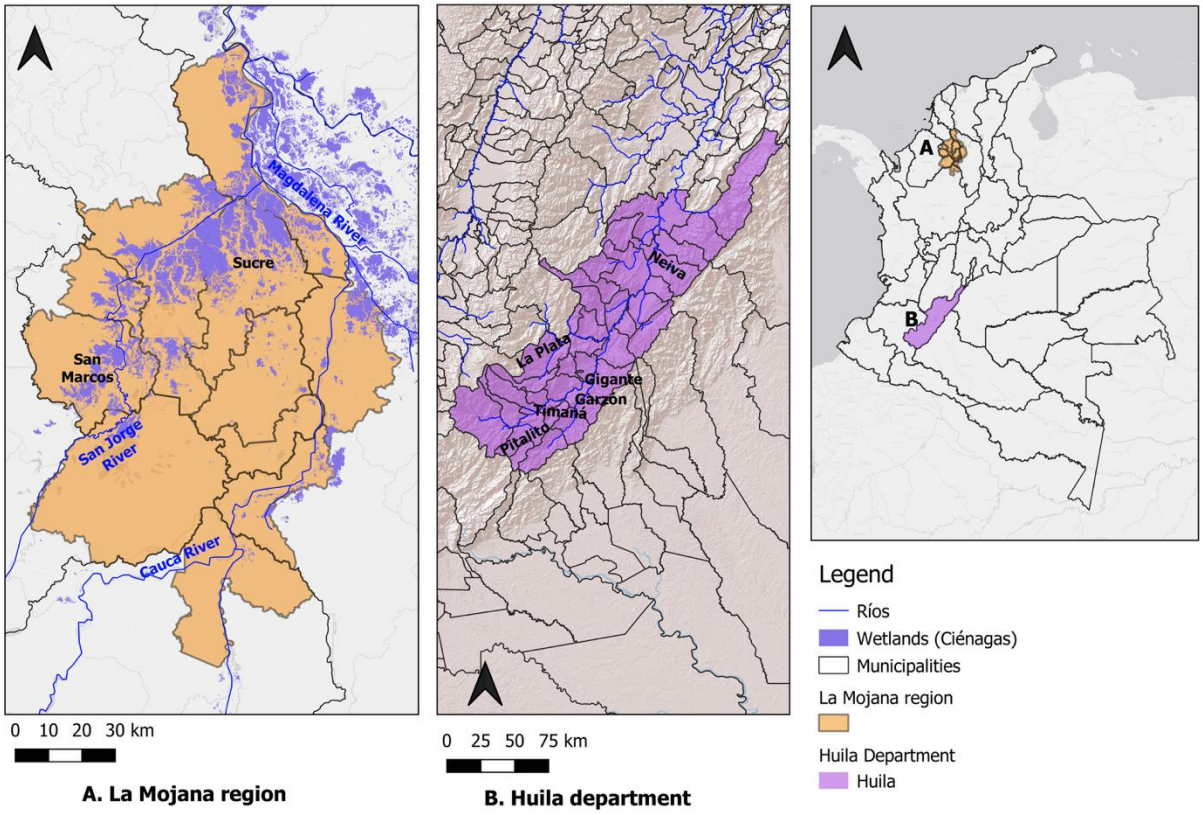

Figure 1: Regions of Study. *Notes: The top region (1a, L) is La Mojana, the low-lying wetland region. The bottom region (1b, M) is Huila, the mountainous and coffee growing department. The two regions are also within Colombia (1c, R).*



Figure 2: La Mojana Lowlands and Wetlands Regions (2a, L) and the Mountainous Coffee Growth Department of Huila (2b, R).



*Figure 3: The Chachalaca (*Ortalis Columbiana*) (3a, L) and the Carrao (*Aramus Guarauna*) (3b, R) (Source: NaturalistaCo / Christof Moning / David Monroy).* *Notes: Birds that announce the rain with their singing in the Huila department and in La Mojana.*



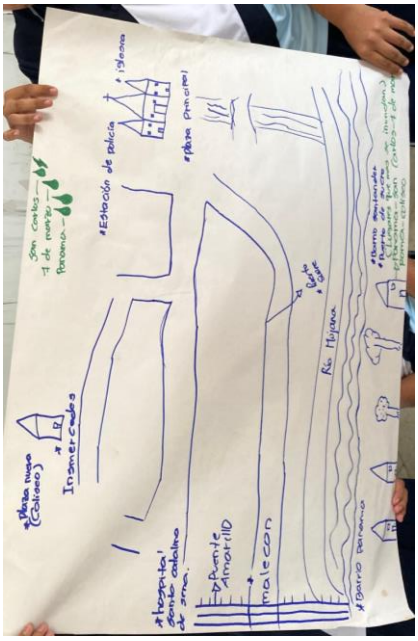

Figure 4 (TL): Snail's Eggs Marking the Maximum Level of Flooding in Sucre, La Mojana (Source: Authors).
Figure 5 (B): Map which Localises the Inundations in the Village of Sucre, Realised by a Group of Students during the Workshop (Source: Authors).
Figure 6 (TR): Enel Weather Station in a Coffee Farm in Gigante (Huila) (Source: Authors).