

Climate Change Adaptation Dynamics: Exploring Rural Communities' Perceptions and Strategies in Cauca, Colombia

Dissertation

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Submitted by

Juan Fernando Mendoza Ledezma

from Santander de Quilichao, Colombia

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Department of Earth System Sciences

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Reviewers: Prof. Dr. Martina Neuburger
Dr. Tobias Schmit

Members of the examination commission: Prof. Dr. Martina Neuburger
Dr. Tobias Schmit
Prof. Dr. Hermann Held
Prof. Dr. Bernd Leitl
Dr. Martin Döring

Chair of the Subject Doctoral Committee Prof. Dr. Hermann Held

Earth System Sciences:

Dean of MIN Faculty: Prof. Dr.-Ing. Norbert Ritter

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Juan Fernando Mendoza Ledezma

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Journal articles and manuscripts published / in preparation

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Mendoza Ledezma, J. F., Strengthening Resilience in a Colombian Post-Conflict Region: A Community Capital Approach to Climate Challenges.

Summary

Recent reports on climate change have heightened awareness of the vulnerability of rural areas, especially concerning small-scale farmers in Global South countries. This research emphasizes the importance of local perspectives in promoting resilient and sustainable rural communities through a participatory qualitative approach. Utilizing the community capitals framework, a basic needs approach, and the concept of vulnerability, it examines whether different climate change adaptation practices can protect the livelihoods of small-scale farmers and to what extent, while highlighting the complex dynamics of rural areas.

The work demonstrates that assessing community capital helps formulate robust and sustainable adaptation strategies based on the local population's basic needs. The research methods used were predominantly qualitative, based on active community participation to explore behaviors and decision-making processes. Thus, data analysis, historical contextualization, stakeholder surveys on vulnerability and adaptation needs, and various interviews were combined.

The study underscores the need for external interventions, improved access to meteorological information, and the development of joint strategies to increase climate resilience in vulnerable communities. Additionally, the research identifies limitations of climate change adaptation measures and emphasizes the importance of education and external support. Community assets, including social, natural, and human resources, are crucial in developing adaptation strategies and increasing resilience. Furthermore, community empowerment and balanced gender leadership reduce inequalities and reinforce cohesion.

Therefore, the research provides important insights for rural development policies and climate change adaptation strategies, emphasizing the importance of local perspectives and community capitals. In summary, the results highlight the significance of local action in increasing resilience to climate change and forging a more sustainable future. The study not only underscores the importance of gender inclusion in climate change adaptation but also demonstrates that the studied communities are on the right path to creating long-term resilience. Thus, the climate adaptation measures analyzed in the study can be considered the foundation for a more sustainable and climate-resilient future in which local communities play a crucial role in shaping a better world.

Zusammenfassung

Aktuelle Berichte zum Klimawandel haben das Bewusstsein hinsichtlich der Vulnerabilität ländlicher Gebiete – insbesondere in Bezug auf Kleinbäuer*innen in Ländern des Globalen Südens – erhöht.

Die vorliegende Forschungsarbeit betont die Bedeutung lokaler Perspektiven bei der Förderung widerstandsfähiger und nachhaltiger ländlicher Gemeinschaften unter Verwendung eines qualitativ-partizipativen Ansatzes. Mit Hilfe des Community Capitals Frameworks, des Grundbedürfnisansatzes und dem Konzept der Verwundbarkeit wird untersucht, ob und inwiefern verschiedene Praktiken der Klimawandelanpassung die Lebensgrundlage von Kleinbäuer*innen schützen können, und gleichzeitig werden die komplexen Dynamiken ländlicher Räume aufgezeigt.

Die Arbeit zeigt, dass eine Bewertung der Gemeinschaftskapitalien dazu beiträgt, robuste und nachhaltige Anpassungsstrategien zu formulieren, die auf den Grundbedürfnissen der lokalen Bevölkerung basieren. Dabei wurden überwiegend qualitative Forschungsmethoden angewandt, die auf einer aktiven Beteiligung der Gemeinschaften zur Erforschung von Verhaltensweisen und Entscheidungsprozessen beruhen. So wurden Datenanalysen, historische Kontextualisierungen, Stakeholder-Befragungen zu Verwundbarkeit und Anpassungsbedarf und verschiedene Interviews miteinander kombiniert.

Die Studie unterstreicht die Notwendigkeit externer Interventionen, verbesserten Zugangs zu Wetterinformationen und die Entwicklung gemeinsamer Strategien zur Steigerung der Klimaresilienz vulnerabler Gemeinschaften. Zusätzlich identifiziert die Forschung Limitationen der Anpassungsmaßnahmen an den Klimawandel und betont die Bedeutung von Bildungsmaßnahmen und externer Unterstützung. Die Vermögenswerte der Gemeinschaft, einschließlich sozialer, natürlicher und menschlicher Ressourcen, spielen eine entscheidende Rolle bei der Entwicklung von Anpassungsstrategien und dem Aufbau von Resilienz. Darüber hinaus trägt das Empowerment der Gemeinden und eine gendergerechte Besetzung von Führungspositionen zu einer Reduzierung von Ungleichheiten und einer Stärkung des gemeinschaftlichen Zusammenhaltes bei.

Die Forschung liefert somit bedeutende Erkenntnisse für Politiken der ländlichen Entwicklung und für Strategien der Klimawandelanpassung, wobei die Bedeutung lokaler Perspektiven und Gemeinschaftskapitalien hervorgehoben wird. Zusammenfassend unterstreichen die

Ergebnisse die Relevanz lokaler Maßnahmen beim Aufbau von Klimaresilienz und der Gestaltung einer nachhaltigeren Zukunft. Die Studie hebt nicht nur die Bedeutung der Geschlechterinklusion bei der Anpassung an den Klimawandel hervor, sondern zeigt auch, dass die untersuchten Gemeinschaften auf dem richtigen Weg sind, um langfristige Resilienz aufzubauen. Somit können die in der Arbeit untersuchten Klimaanpassungsmaßnahmen als Basis für eine nachhaltigere und klimaresiliente Zukunft, in der lokale Gemeinschaften eine entscheidende Rolle bei der Gestaltung einer besseren Welt spielen, angesehen werden.

1 Introduction

Climate change has had a series of effects on the planet, producing rapid and widespread changes in the atmosphere, ocean, cryosphere, and biosphere, with evidence of increased precipitation and temperature in the atmosphere, oceans, and land. These increases relate to human influence in developing its activities, with constant greenhouse gas emissions since about 1750. In addition, since 1850, each decade has been successively warmer than the previous one (IPCC, 2022). Thus, human influence on the climate system is evident, and recent anthropogenic greenhouse gas emissions are the highest in history (FAO, 2019).

According to FAO, agriculture emits around one-quarter of greenhouse gases. Still, it holds almost half of the solutions to global climate goals, and climate change contributes to the loss of ecosystems and reduction of biodiversity, compromising food production as the basis of human existence. Therefore, it is crucial to work with adaptation actions in forests, soils, water, and food systems to reduce emissions and remove carbon from the atmosphere, helping rural communities, the primary food producers, in their resilience to climate change (FAO, 2019).

Numerous adaptation and mitigation strategies can contribute to tackling climate change, yet relying on a singular approach is unlikely to suffice. Instead, successful implementation hinges on multi-level policies and cooperation and can be bolstered by comprehensive approaches that connect adaptation and mitigation with broader societal goals (IPCC, 2014).

The consequences of climate change need action by countries, communities, and individuals through adaptation processes (Howden et al., 2007). Climate change adaptation has a wide range of potential implications for reducing the risks of climate change. Simultaneously, ecosystems managed sustainably, such as ecosystem restoration, prevention of degradation and deforestation, biodiversity management, sustainable aquaculture, and utilization of local/indigenous knowledge, can play a role in climate change adaptation efforts (IPCC, 2018).

In this context, Colombia is a country where there are differences in welfare levels between population groups and regions. For example, according to (IDEAM et al., 2018), 25% of the Colombian population lives in rural areas, 47% do not have access to essential sanitation services (drinking water), and almost all of the rural population (94%) do not have access to

sewage and sanitation, and 12% is illiterate. Likewise, the poverty rate was 38.6% in 2016 (C.R.I.C et al., 2020; DANE, 2018).

Furthermore, over 50 years of armed conflict have affected all country regions. As a result, a peace agreement was signed in 2016 with the FARC (Revolutionary Armed Forces of Colombia), one of the illegal groups. Especially the Cauca department (located in the southwest of Colombia) is considered a strategic area for implementing the peace process because it is one of the processes most affected by current conflicts, poverty, and inequality. It also has strong socio-economic, environmental, and multicultural potential. For these reasons, it is necessary to establish transition processes from armed conflict to scenarios to construct commitments, pacts, and society with consolidated peace.

However, the agreement has yet to be consolidated since its signature (2016). Thus, new illegal groups have emerged up to the present date, reactivating violence and the presence of illegal crops, which cause the replacement of traditional crops and generate environmental impact on natural resources (C.R.I.C Consejo Regional Indígena del Cauca, 2020).

Thus, in the Colombian context, the economic growth of 4.3% of gross domestic product-GDP is based on its main economic activities in the mining and oil sectors, contributing to reducing poverty and inequality. However, these sectors depend on many natural resources, leading to environmental degradation following an unsustainable path, presenting the highest rate of disasters caused by natural phenomena (more than 600 events per year) on average (Banco Mundial, 2014). Therefore, in the context of climate change, environmental impacts are generated by hydro-meteorological phenomena with a possible increase in their intensity and recurrence, also leading to economic losses of 0.49% of the current GDP, according to the study on the Economic Impacts of Climate Change (DNP & BID, 2014).

Therefore, to develop relevant and coordinated actions at the national level to create sustainable territories and be resilient to climate change, people must act locally with mitigation and adaptative measures. Thus, the process to reduce Greenhouse Gases-GHG by 20% by 2030 involved departmental territories with an important role, and the Cauca department is included, where impacts such as water reduction and forest resources are perceived, with impacts not only on biodiversity reduction but also on GHG levels (Ministerio de Ambiente y Desarrollo Sostenible, 2016). Moreover, the rural conditions of the

department, with a marked deficit in basic sanitation and high levels of poverty, increase the possibility of the territory being affected by climate change.

Additionally, in zones like the Cauca department, where the economy is based on agriculture, farmers and rural people must adjust agricultural systems to make them more resilient in the face of increasingly variable weather (adaptation) (Arbuckle et al., 2015). According to (Coumou & Rahmstorf, 2012), there is strong evidence linking specific extreme events or an increase in their numbers to the human influence on climate, being more evident when there are no adaptation measures in place.

The research is mainly conducted in the Santander de Quilichao municipality ("Santander"), located north of the Cauca department. The landscape variety and thermal floors characterize Santander mainly for its multicultural composition, including Indigenous, Afro-descendants, and Mestizos. Furthermore, in Santander is located the Municipal Natural Reserve "Munchique Los Tigres," an area of strategic importance for conservation that also supplies water to Santander, with the active participation of social and institutional actors. Productive systems in Santander are mainly agriculture, commerce, and industrial-free zones (Alcaldía Santander de Quilichao, 2011). Thus, in Cauca, there are evident climate change conditions with substantial action concentrations, mainly focused on water resources, biodiversity, and the component of human habitat and health (Ministerio de Ambiente y Desarrollo Sostenible, 2016).

Accordingly, in the rural area of Santander de Quilichao, two villages (Guayabal and Pavitas) were chosen according to their community characteristics, mainly their organizational dynamics, proximity to the nature reserve, presence of indigenous and peasant population, types of agricultural and livestock production systems, road and security access conditions, interest in participating in the project and community permission to intervene due to restrictions resulting from the COVID-19 pandemic.

Thus, the study is developed mainly using a qualitative approach, promoting active local stakeholders' participation through participatory workshops as a starting point to collect community diagnostic information on positive and negative aspects. Subsequently, the checklist implementation is related to agricultural and livestock production factors and evaluates technical, economic, organizational, educational, environmental, and public order components within the two villages. Finally, the diagnosis is concluded with an assessment of

essential human needs to identify how people can have a dignified life with development opportunities to move towards the practical adoption of development visions and climate change adaptation measures in the rural sector.

Therefore, with background information from communities, there is a need to understand the factors and circumstances that strengthen relationships and livelihoods with the semi-structured interview application according to the community capital framework. Also, surveys of climate change perception in both internal actors (inhabitants) and external (organizations) allow for identifying the understanding, the level of vulnerability, and information on climate change critically key actors, which gives way to the possibility of implementing adaptation strategies to climate change. Besides, to collect the knowledge and daily experiences of the inhabitants of the two villages, collective mapping was implemented as a creative dialogue tool, which promoted participation and visual identification of community characteristics to end with local reflections related to climate change.

Finally, a vulnerability analysis was developed for each of the two communities to enhance the understanding of the climate-territory relationship from the exposure and sensitivity to provide guidelines to the actors in creating adaptation measures.

2 Objectives

This dissertation aims to contribute to a better understanding of the rural dynamics in a climate change adaptation context, including the impacts and possible adaptation strategies oriented to help farmers and decision-makers assess and manage communities to reduce risk deriving from climate change in the study area. This study also focuses on understanding local stakeholders' perspectives on climate change, how they have responded to climate risks, their adaptation strategies, and the strengthening or creation of new strategies. To achieve the aims of this thesis, the following four objectives were pursued:

- a. Generation and application of a participatory community diagnosis of the territorial components in the historical reconstruction process in the two communities
- b. Identify and describe the effects of climate change in rural communities according to the Community Capitals Framework (CCF).
- c. Analysis of the communities' adaptive capacity to climate change.

d. Designing participatory alternatives to climate change adaptation according to fundamental human needs, strategies, and livelihoods.

Thus, implementing a process that should guide the application of the Community Capitals Framework (CCF) leads to a complete description of the territory and the dynamics of the community, which is completed. The CCF allows social analysts to wage an inventory of various types of capital, including human, social, cultural, physical, financial, political, and natural, that collectively build the resilience and adaptive capacity of the community (Flora & Flora, 1993). Therefore, community assessment contributes to evaluating and interacting with capitals and their status, leading to knowledge about communities' strengths, weaknesses, and vulnerabilities in climate change.

Additionally, it is essential to understand the evolution of community capitals, their character as a territory, their dynamics, and their influence on vulnerability to climate change as historical information collected by the communities themselves. Analyzing historical trends and trajectories is indispensable to identifying patterns of change in community capitals over time, considering past environmental, economic, and social dynamics (Berkes et al., 2000). Furthermore, the goal is to scope the intricate relationship between governmental hubs and the selection of methods for implementing measures to adapt to climate change. This encompasses not only short-term solutions but also encompasses the broader spectrum of enduring trends and persistent challenges. The insights gathered from this analysis are instrumental in formulating efficacious adaptation strategies and coordinating monitoring efforts and interventions that target the root structural issues underlying the problem.

Several methods are needed to gain a deeper understanding of the communities. For instance, collective mapping involves locals visually depicting resource distribution and land usage. This provides a tangible overview of community dynamics (Klooster, 2007). In addition, semi-structured interviews allow us to delve into community members' perspectives, values, and decision-making processes (Fontana & Frey, 2005). This grants insight into the intricacies of community life.

Furthermore, participatory workshops offer a platform for collaborative problem-solving and decision-making. They facilitate the exchange of knowledge and the development of shared visions for community resilience (Pretty et al., 1995). By engaging stakeholders in these approaches, we ensure diverse viewpoints are considered, enhancing the credibility and

relevance of our findings. This inclusive process fosters community ownership and empowerment, laying a solid foundation for collaborative climate change adaptation efforts.

Additionally, it is crucial to assess how rural communities handle change, including their capacity to confront challenges, bounce back from setbacks, and adjust to unfamiliar situations. This concept, "adaptive capacity," essentially measures a community's flexibility and resilience. By grasping the level of adaptability within these communities, it becomes feasible to pinpoint their areas of strength and areas where support may be required. This insight guides them in crafting targeted interventions to support their resilience and enhance their capacity to tackle whatever obstacles arise (W. Adger et al., 2007).

Therefore, enhancing the efficiency and longevity of adaptation endeavors becomes feasible by obtaining community strengths and basic human necessities and utilizing the diverse resources and data gathered. This guarantees that the distinct requirements and concerns of rural communities receive attention. Moreover, anchoring adaptation plans in fundamental human necessities ensures they are attuned to rural settings' socio-economic and cultural fabric. Adapting to climate alterations entails addressing ecological consequences and the deeper social, economic, and political determinants of vulnerability and resilience.

Emphasizing human necessities like food security, health, housing, and livelihoods facilitates crafting adaptation strategies that foster comprehensive well-being and sustainable progress.

Moreover, incorporating local perspectives is essential to this research endeavor, not only for comprehending the terrain but also for molding adaptation tactics. Their varied perspectives and first-hand knowledge offer priceless insights into the objectives and reality of the community. By utilizing local networks, resources, and expertise, involving local stakeholders guarantees that adaptation plans are viable, long-lasting, and contextually relevant.

Therefore, the goal is to unite people through an empowerment-driven strategy that promotes agency, resilience, and a sense of ownership, thus guaranteeing the long-term sustainability of adaptation activities. These cooperative decision-making processes involving several stakeholders make possible the collaborative development of inclusive, equitable, and culturally appropriate adaptation solutions (Smith et al., 2000). Participatory methods also increase community resilience by promoting social cohesion, trust, and group efforts.

Ultimately, the goals, which encompass participatory community appraisal, historical reconstruction, and adaptive capacity assessment within the conceptual framework, emphasize the significance of community-based methodologies in tackling the research question: How do climate change adaptation strategies from a community capital approach reduce the vulnerability of rural areas? Communities may create tailored adaptation plans that increase resilience and reduce susceptibility to the effects of climate change by comprehending the dynamics of community capitals, evaluating adaptation capacities, and including local stakeholders in the planning process.

3 Structure of work

Through the following structure, the challenges posed by climate change to rural communities in the Cauca department, especially in the municipality of Santander de Quilichao, are proposed to be analyzed. These communities are exposed to rising temperatures and changes in precipitation patterns that adversely affect agricultural production systems and food security. This highlights the interdependence between climate, natural resources, and people's lives in the study area. It is crucial, therefore, to develop sustainable adaptation strategies that not only mitigate the impacts of climate change but also strengthen the resilience of these communities in the long term (Smith et al., 2000), contextualizing the urgency and relevance of the climate change issue in rural communities.

The Introductory part describes the general characteristics of climate change and the importance of generating sustainable adaptation alternatives in rural communities. It also describes the study area's geographical, social, economic, and climatic conditions.

The literature review will explore previous studies and existing theories related to adaptation to climate change, with a particular focus on those conducted in rural communities. As (Agrawal, 2008) points out, rural communities are especially exposed to the impacts of climate change due to their dependence on natural resources and limited adaptive capacity. Adaptation approaches based on natural resource management and community participation will be highlighted (Agrawal, 2008), and gaps in existing literature, such as the need for studies specifically focused on the Cauca department, particularly the municipality of Santander de Quilichao, will be identified.

Therefore, the second part explains the relevant secondary information research for this study based on the conditions of the study area and its relation to climate change adaptation.

The third part details the methodology used in the research, based mainly on qualitative methods with active community participation, complemented with a quantitative analysis focused on analyzing the adaptive capacity of communities to climate change.

Thus, the methodology will detail the methods used in the research based on a participatory approach that actively involves the community. As (Chambers & Conway, 1992) suggests, community participation is essential to ensure the relevance and effectiveness of adaptation strategies. It will explain how these methods were selected and applied in the context of the Cauca department and how challenges and ethical considerations associated with research in rural communities were addressed (Banks et al., 2011). Additionally, it is argued that using multiple qualitative methods allows for verifying the consistency of findings, such as triangulation. Furthermore, each method presents its strengths and limitations; therefore, the aim is to fill the gaps of each method and obtain more comprehensive information that allows for a better understanding of the dynamics of rural communities in the Municipality of Santander de Quilichao. Finally, combining several methods demonstrates the flexibility of research during data collection and analysis and the ability to adapt to the conditions and interests of communities, leading to a deeper and more valid understanding of the study area.

The fourth part focuses on describing the research results. Presenting: The historical community evolution from a participatory diagnosis perspective and the territory's historical reconstruction, with critical actors' presence and decision-makers. This chapter also includes an overview of the effects of climate change on communities in the post-conflict zone, according to the Community Capitals/Resources Framework (CCF), and their fundamental human needs, emphasizing life strategies and perceptions about climate change. Finally, according to the livelihoods and life strategies, an overview of the climate change adaptation alternatives.

Moreover, the results will be presented structured, highlighting the most important findings regarding the historical evolution of communities, followed by the effects of climate change in the municipality of Santander de Quilichao and the life strategies developed in response to these impacts. Qualitative and quantitative data will be used to support the findings, and concrete examples of how these communities face climate change challenges will be provided. Additionally, adaptation measures will be developed in conjunction with the

inhabitants. This section will highlight rural communities' resilience and adaptation capacity in the Cauca department (W. Adger et al., 2007).

In the fifth part, the results are analyzed and discussed according to the proposed research question and the relevant literature review of the study area. Thus, an analysis and discussion of results will be conducted, delving into the analysis of findings and evaluating how they relate to existing theories and previous studies reviewed in the literature. Emerging patterns will be identified, and the practical and theoretical implications of the results for developing effective adaptation strategies in the Cauca department will be explored (Berrang-Ford et al., 2011).

The sixth and final part includes the study discussion, conclusions and recommendations for stakeholders and decision-makers, and possible alternatives to consider in future research. Then, a reflection on key findings and lessons learned will be provided, as well as proposals for future studies or policy generation in the Municipality of Santander de Quilichao. Additionally, adaptation strategies will be proposed with an emphasis on the need to strengthen the capacity of rural communities to address the challenges of climate change and broaden the understanding of this phenomenon and adaptation processes (Kelly & Adger, 2000).

4 Study area and context

4.1 Study area description

This chapter presents an overview of the geographical conditions, climate settings, and socio-economic context, mainly from the rural communities in the Cauca department in Colombia.

4.1.1 General geographical and climate change description

The Cauca department is located in south-western Colombia, with a lowland coastal region, two cordilleras of the Andes, and a central inter-Andean valley where much of the natural resources are concentrated and has one of the largest concentrations of indigenous people (Instituto CISALVA, 2003). This department is divided into 42 municipalities, with 60.15% in rural areas (Gobernación del Cauca, 2020). Agriculture is the main economic driver, and

other productive activities include livestock, mining, commerce, timber extraction, and tourism (Figure 1).

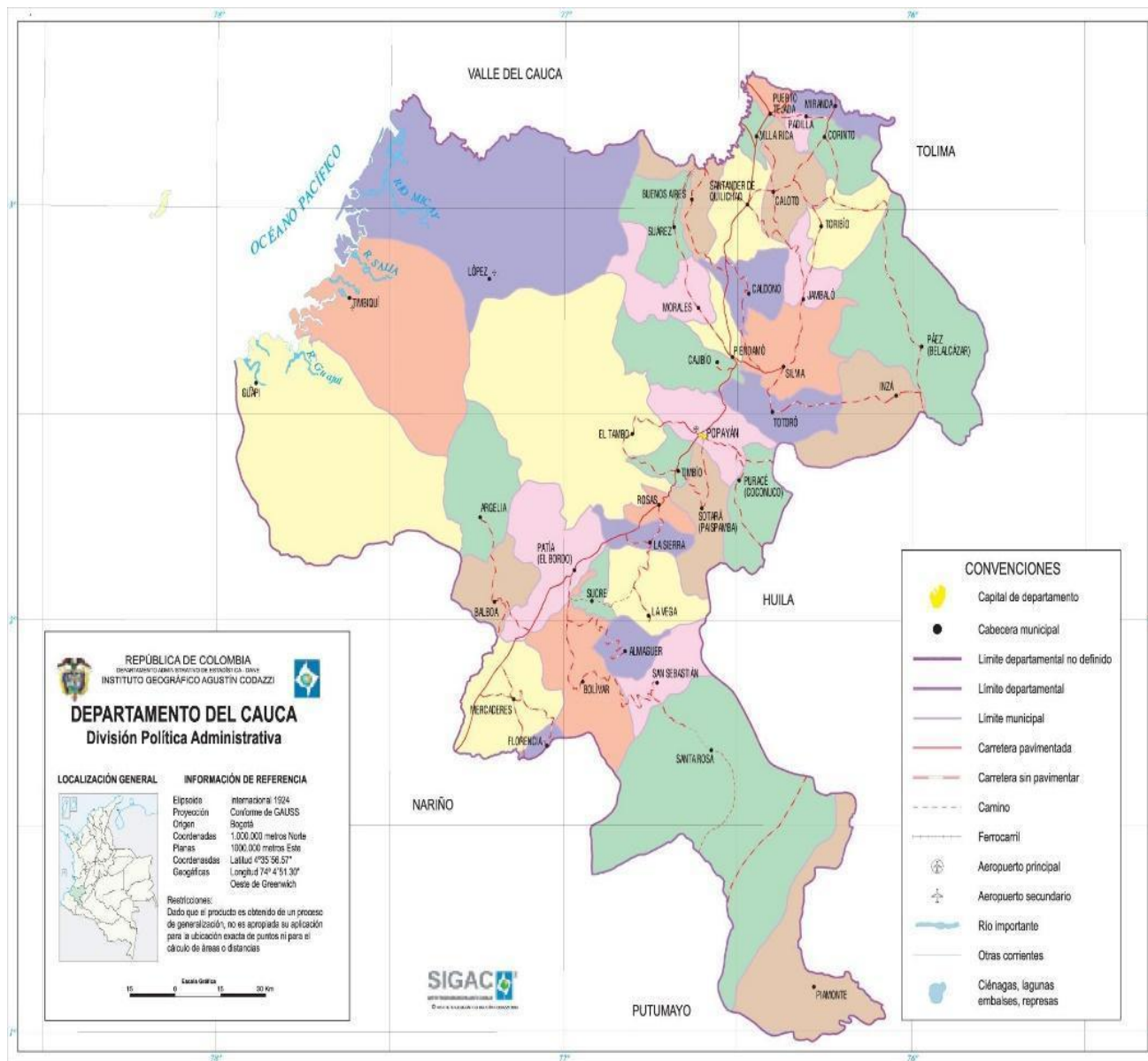


Figure 1: Cauca department

Source: Instituto Geográfico Agustín Codazzi

The Cauca department represents 3% of Colombia's national population (DANE, 2016). According to the latest DANE census in 2018, Colombia's total population of the Cauca department is approximately 1.46 million people, 49.5% of whom are men and 50.5% of whom are women. The population distribution is 77.1% in the municipal capitals and 22.9% in rural areas (DANE, 2018). According to The Third National Agricultural Census 2016, in the department of Cauca, there is a mainly agricultural vocation, where the area with agricultural

use is 42.7% and 53.2% corresponds to the area in natural forests, 2.12% to other land uses and land cover and the remaining 1.89% to non-agricultural use (DANE, 2016). This rural territorial distribution, therefore, demands a decentralization of the departmental government.

Historically, the Department of Cauca has had a struggle for land and territory, represented in various forms of violence, mainly by the presence of armed groups such as the Revolutionary Armed Forces of Colombia-FARC, the Self-Defense Forces of Colombia (Autodefensas de Colombia) and the National Liberation Army (Ejército de Liberación Nacional-ELN). This has demanded the need to recover lands; therefore, during the second half of the 20th century, and more specifically from 1970 onwards, indigenous communities took an active role by undertaking actions to recover their ancestral lands and demanding the creation of protected areas and autonomous local governments (PNUD, 2014). This struggle for territory, coupled with the lack of opportunities and institutions, led communities to plant marijuana and coca crops, resulting in social conflicts and environmental impacts in the region.

These conflicts have been addressed by social and political organizations representing power relations, with the presence of the Regional Indigenous Council of Cauca (CRIC) and the Indigenous Minga, as an expression of resistance and democratic mobilization, as well as agricultural and livestock peasant organizations, popular movements, community councils, and peasant associations. Some of these organizations are represented by 115 indigenous reservations located in 30 municipalities in Cauca, of which 6 (Las Delicias, La Concepción, Guadualito, Tigres and Munchique, Canoas, Nasa kiwe Tekh Ksxaw) are in the municipality of Santander de Quilichao.

The CRIC is the traditional authority of the indigenous peoples of Cauca, a public entity of unique character. It makes crucial decisions for the life of these communities, defining policies and actions in areas such as economy, society, culture, territory, environment, and law. It aims to rebuild and strengthen indigenous life plans, clear constitutional rights, and promote territorial, political, economic, educational, health, and legal autonomy. CRIC's mission is to defend indigenous peoples' fundamental and specific rights through training, legal support, and projects. Its guiding principles are unity, land, and culture. The cabildos are its basic organizational structure and are recognized as a Traditional Authority, managing the indigenous territories as a Special Entity of the State (C.R.I.C Consejo Regional Indígena del Cauca, 2020).

Therefore, the Department of Cauca, due to its conflict conditions, social struggle, and agricultural vocation, is considered a strategic territory for the strengthening of the peace process through dialogues with the actors of the conflict to overcome the humanitarian crisis, reduce poverty levels, as well as the protection of natural resources, taking into account that it is the department where the Colombian massif is located, one of the central regions of fresh water production, where 5 of the most important rivers of Colombia are born (Cauca, Magdalena, Patía, Putumayo and Caquetá).

The department extension is 29,308 km²; it has a Geography extremely varied, ranging from mountains to flat plains, with all the climatic variants, from the coldest in the Nevado del Huila (5.750 m) and the volcanoes of Puracé and Sotará to the lands off the coast (Instituto CICALVA, 2003). According to the Climatic Atlas of Colombia, Cauca has an annual pluviosity average of 2.132 mm (it rains about 200 days/year), relative humidity of 77%, and a temperature of 18.9 °C (IDEAM, 2005).

The department of Cauca has a diversified economy, with the agricultural sector being an important player. Products grown include coffee, sugarcane, corn, plantains, yucca, tropical fruits, and vegetables. Livestock and poultry farming are also important activities. However, Cauca faces challenges in terms of unequal access to essential services, such as education, health, and infrastructure, due to a lack of investment and resources. In terms of the environment, the region has a great diversity of ecosystems but faces problems such as deforestation, contamination of water sources, and loss of biodiversity. In northern Cauca, sugarcane, coffee, and banana production are the main crops that generate employment and income for the local population and contribute to the regional economy (Gobernación del Cauca, 2020).

Regarding the department's conditions in the face of climate change, the high inequality in the territory indicates that it faces more significant impacts due to its low adaptation to climatic phenomena such as prolonged droughts or extreme rains. This focuses mitigation efforts on water resources due to the pressure generated by population growth, pollution, and the lack of treatment systems. In addition, biodiversity is affected by the expansion of the agricultural frontier, livestock, illegal mining, and illicit crops, which fragment ecosystems and reduce the environmental supply. It is also necessary to consider the impact on human habitat and health, as insufficient infrastructure makes it difficult to control diseases related to heat waves

and extreme rainfall. Therefore, it is crucial to establish a synergy between local actors and decision-makers to improve adaptive capacity to climate change (Ministerio de Ambiente y Desarrollo Sostenible, 2016).

4.1.2 Climate change

Climate state change refers to the variability of its properties that persist for some time, typically decades or more. For example, natural processes or anthropogenic changes in the atmosphere structure or land use alter the composition of the global atmosphere. Therefore, climate change is considered in addition to natural climate variability over comparable periods (IPCC, 2018).

Consequently, economic and demographic growth has contributed to increased greenhouse gases with higher concentrations, such as carbon dioxide, methane, and nitrous oxide. Their effects have been detected throughout the climate change system and are highly likely to have been the observed dominant warming cause since the mid-20th century. Therefore, the situation is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and is in addition to natural climate variability observed over comparable periods (IPCC, 2022b).

According to the IPCC's (2019) report "Climate Change and Land," farmland degradation, decreased crop yields, and increased wildfires will occur, increasing the global mean temperature and generating food instability, low water availability, and vegetation loss.

4.1.3 Climate change in the Colombian context

Colombia is located in the northern tropical zone of South America. Consequently, there are differences in welfare levels among population groups and regions with diverse and complex climatic conditions due to the significant presence of orographic factors (**Figure 2**).

Nevertheless, most of its territory (79%) is considered warm areas with humidity between 36% and 40% (IDEAM et al., 2018).

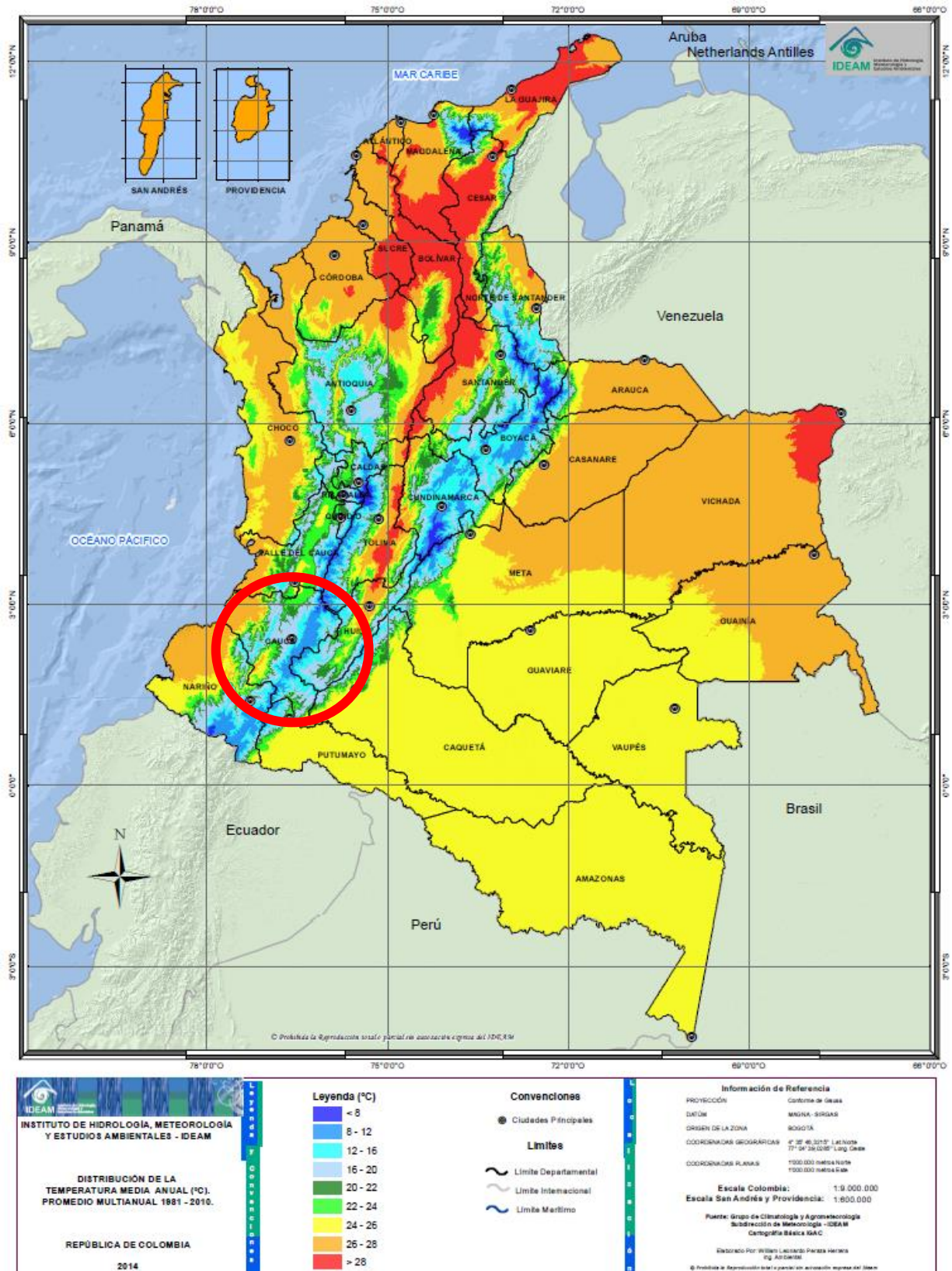


Figure 2: Study area – Cauca, Colombia

Source: <http://www.siac.gov.co/catalogo-de-mapas>

Colombia contributes 0.4% of the global emissions of greenhouse gases, mainly due to deforestation and the lack of adaptability strategies focused on water resources, biodiversity, and the human habitat and health component. Therefore, education must be promoted in the context of climate change, and science and technology must be promoted. The climate variable must be included in the instruments of Planning and Land Management (Ministerio de Ambiente y Desarrollo Sostenible., 2015).

Moreover, the impact on communities less responsible for climate change, such as colonized or extractivist territories that supply the needs of global capitalism, is evident (González-Hidalgo et al., 2022), i.e., because floods, fires, and droughts generate infinitely different ways of experiencing loss, distress, and trauma (Tschakert et al., 2019) (Kaijser & Kronsell, 2014). Indigenous territories and rural communities, in general, present a challenge in the struggle to meet their basic needs, but at the same time, face conditions of climate injustice, both present and intergenerational.

Consequently, climate change studies have been carried out in Colombia, analyzing mainly the historical trends and forecasts of climatological variables —such as temperature and precipitation—(MAVDT et al., 2010; Pabón J.D. & Hurtado G., 2002; Perez et al., 2016; Poveda, 2009) and the frequency and intensity of climatic events extremes (Benavides H et al., 2007; Mayorga R et al., 2011), in addition to the initiatives of the National Government through the first national communication on climate change in Colombia (the year 2001), the second national communication (2010) and the third national communication (2015) as the primary reporting mechanism of the member countries of the United Nations Framework Convention on Climate Change (UNFCCC) and the primary source of information and technical knowledge to support decision making, as well as to show progress in mitigation, adaptation and education actions, among others.

As a result, climate change is causing various alterations to the ecosystems and increasing threats like drought, soil and water degradation, flooding, and fires. With this as a precedent, it is considered that “climate change constitutes an imminent social challenge, especially for the most vulnerable populations like the rural communities, considering that the level of vulnerability will depend mainly on the geographical location, the time, and the social, economic and environmental conditions of each region” (Selvaraj et al., 2022). Thus, climate

change fundamentally challenges the social structure of rural communities and their interaction with livelihoods.

However, despite all the efforts of public and private entities, according to (IDEAM & PNUD, 2016) in the "First National Survey of Public Perception of Climate Change in Colombia: What do Colombians think about Climate Change?" it is evident that access to information is limited and it is not enough to conduct studies without the active participation of vulnerable populations, which can take ownership of the threat situation of this concept and take a step towards adaptation to climate change.

Regarding the role of institutions, it is considered that there is not enough investment and research on climate change in the country, which coincides with the fact that programs or projects are not carried out due to insufficient resources at the municipal level, which is reflected in the low citizen participation, limiting the recognition of spaces by civil society to carry out actions to raise awareness on the problem of climate change, reflected in a low level of visibility of the institutions in charge of climate change, so it is necessary greater coordination between entities of national and territorial order (IDEAM & PNUD, 2016).

Thus, Colombia incorporates climate change into its national policy from an institutional perspective in response to the need for structured and articulated guidelines. This policy provides continuity to adaptation, resilience, and low-carbon development policies, including implementing the Paris Agreement commitments (Ministerio de Ambiente y Desarrollo Sostenible, 2016).

In addition, Colombia's National Development Plan includes climate change as a priority issue, establishing the need to create the National Climate Change System (Sisclima) to consolidate the National Climate Change Policy. Hence, there is a tendency to develop adaptation and mitigation plans for the effects of climate change in all regions of the Colombian territory to reduce greenhouse gas emissions (IDEAM & PNUD, 2016).

The National Planning Department-DNP and the Inter-American Development Bank-IDB refer to a study about the projected economic impacts (2011-2100) of climate change in Colombia regarding transport, forestry, fishing, livestock sectors, agriculture, water resources, and native species, showing results with losses in production, reflecting annual losses of the

Gross Domestic Product-GDP of 0.49%, under an assumption of no adaptation to climate change (DNP & BID, 2014).

In this context, Colombia and Latin America have low GHG emissions; however, they are highly vulnerable to the effects of climate change due to their geographic, ecological, and socioeconomic characteristics. This condition forces them to adapt as a response to the effects of climate change on their territories (IDEAM & PNUD, 2016). For these reasons, a National Climate Change Adaptation Plan (PNACC) supports the country's preparation to face extreme climate events and the gradual climate transformation to reduce the long-term negative socioeconomic consequences. Thus, in the process of fulfilling the objective of the PNACC, the national government is developing a series of methodological inputs aimed at the territories to (a) generate more significant knowledge about potential risks and current impacts, including their economic valuation, (b) take advantage of opportunities associated with climate change and variability, (c) incorporate climate risk management into sectoral and territorial development planning, and (d) identify, prioritize, implement, evaluate and monitor adaptation measures to reduce the vulnerability and exposure of socioeconomic systems to climate events (Ministerio de Ambiente y Desarrollo Sostenible, 2016).

Additionally, according to the vulnerability analysis carried out by IDEAM & PNUD (2016) in the Cauca department, based on components such as food security, water resources, biodiversity, health, human habitat, and infrastructure, the ability to adapt to climate change regarding the indicators evaluated was between Medium, Low, and very low.

In this way, each department contributes to developing an Integrated Territorial Climate Change Management Plan (PIGCCT) to improve its capacity to adapt to climate variables. Therefore, in the Cauca department, the PIGCCT becomes a guiding instrument allowing knowledge generation and tools to incorporate climate change into development management. Also, it allows the creation of an articulated and effective action for sustainable territories, adapted and resilient to climate change, acting from the local level with research projects (such as this dissertation), which contribute to the construction of mitigation, adaptation, and resilience measures to the effects of climate change.

Mainly, in the department of Cauca, indigenous communities refer to the importance of generating actions that promote the adaptation of the agricultural sector through measures aimed at improving knowledge and information on climate change since the lands of the

Andean Region of Cauca have been intensively exploited for centuries without adequate productive practices, all of which has an impact on their food security and sovereignty (Ministerio de Ambiente y Desarrollo Sostenible, 2016). Currently, in the context of climate change in the tropical Andes, the number of transformations in ecosystems, such as migration and extinction of species, is undeniable (Vergara, 2009).

Wilches-Chaux, 2015 proposes adaptation and co-evolution practices, that is, taking advantage of existing potentialities (natural, social, cultural and regulatory) with an active intervention in the process of environmental transformation and the use of comparative advantages as a means to reduce climate vulnerability, taking into account the optimal colombian geographical conditions, highlighting, "water storage capacity at different scales, biodiversity, ethnic and cultural diversity, demographic characteristics of the population, solidarity and recursion, rural-urban reciprocity, the existence of the rule of law and environmental institutions, the potential for food security, sovereignty and autonomy, academic and ancestral knowledge, and the potential for technological reconversion by sector" (Osorio-Guzmán et al., 2019), reducing the risks associated with this phenomenon.

Finally, in terms of adaptation, Colombia prioritized, among others, some actions for 2030: 1) 100% of the national territory covered with climate change plans formulated and being implemented, 2) a national system of adaptation indicators to monitor and evaluate the implementation of adaptation measures, 3) water resource management instruments with climate variability and change considerations in the country's priority basins, 4) inclusion of climate change considerations in planning instruments and innovative adaptation actions in six priority sectors of the economy.

5 Theoretical frame and conceptual thoughts

This chapter provides an extensive literature overview, discussing conceptual concepts and theoretical frameworks pertinent to the study, emphasizing vulnerability and adaptation to climate change from a community capital framework. The purpose is to be able to use concepts and theories from the understanding of the target population to simplify the complexity to make it understandable and helpful in the search for contributions to community development, filling local conceptual and theoretical gaps through the application of participatory methods.

However, given the complexity of climate change, it is necessary to use several approaches for its scientific analysis. It is not easy to define the use of a single specific approach, and even more so when working with personal and community interests, where there are dynamics of interaction between human beings and the environment, in which not only concepts of vulnerability, resilience, adaptation, climate change, sustainability, and livelihoods must be taken into account, but also the analysis of the decision-making process, the factors that motivate human behavior, as well as the socio-ecological interaction.

Thus, the following is a critical review of the theoretical concepts necessary to address the research question: **How do climate change adaptation strategies from a community capital approach reduce the vulnerability of rural areas?**

5.1 Sensitizing concepts: theoretical argument and conceptual thoughts

In this chapter, existing literature in the fields related to the perception of the impacts of climate change on rural communities, the development of productive systems, and their impact on livelihoods and community assets were examined. This analysis had three fundamental objectives. Firstly, to address the theoretical aspects surrounding the local perception of climate change impacts in rural contexts, the importance of adapting productive systems to these changes, and their influence on livelihoods and community assets. Secondly, limitations of existing theories were identified, and thirdly, a conceptual framework for the current research was developed. This conceptual framework, elaborated in this chapter, must establish specific theoretical concepts for validating the identified social phenomena. Instead, it provides theoretical sensitivity for designing and operationalizing the current research and interpreting its findings.

Considering the limitations of existing theoretical approaches, it is crucial to address both farmers' perceptions regarding the impacts of climate change and adaptation and theoretical conceptions through the main theoretical approaches. However, focusing solely on one of these dimensions would reveal only a part of reality.

Throughout the process, it is essential to recognize that local perception plays a significant role in establishing links between theoretical factors and applied methods. For this reason, this research adopts a holistic and integrative approach to address research questions. This implies sensitizing theoretical concepts within a framework that includes local perception and

incorporating various qualitative methods at the data collection stage. This diversity of qualitative methods ensures a more comprehensive and enriching understanding of the underlying complexities in the perception of climate change impacts by rural communities and the development of adaptation strategies to this phenomenon (**Figure 3**).

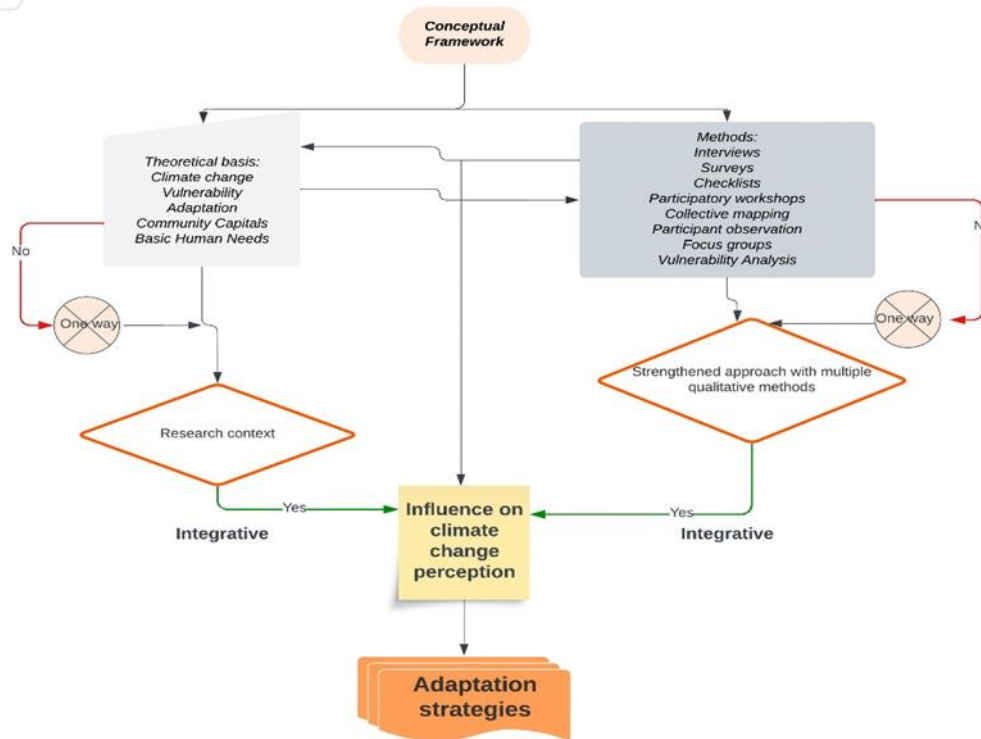


Figure 3. Conceptual framework

Therefore, this chapter has comprehensively reviewed the literature on climate change, vulnerability, community-based adaptation strategies, and fundamental human needs. The importance of rural contexts and social dynamics in perceiving the impacts of climate change and intentions to adapt to them has been emphasized. However, it is essential to underscore that the relationship between community resources (community capitals) and the perception of climate change is intricate and multifaceted. It is not a one-way relationship but involves individuals' cognitive and emotional factors.

Hence, a need arises for a comprehensive conceptual framework encompassing both theoretical and cognitive aspects of local perception. This conceptual framework will enable a more comprehensive understanding of how these elements influence farmers' perceptions of climate change.

In explaining the theoretical foundation upon which the research is based, it was decided to divide it into two pillars. One pillar focuses on the perception of climate change impacts and contributions from theoretical arguments about the phenomenon. The second pillar for identifying perception criteria involves a combination of qualitative methods to define measures for climate change adaptation in rural communities. This approach is chosen mainly because it can no longer be assumed that adaptation is not taking place in the rural area of Cauca. Determining the specific roles of agents in the outcomes of rural adaptation and resource-based conflict resolution, as well as the limited coordination among grassroots agents, is attributed to the limited information reaching the communities. Nevertheless, these factors are crucial for climate change adaptation processes.

I propose integrating a new subdiscipline – the complement of qualitative methods analyzing social relationships – in the governance of resources to assess and address the challenges of rural climate governance for holistic natural resource management. Access to quality information, clarifying the actors responsible for its dissemination in a rural community, and facilitating the transfer of knowledge about adaptation through an understanding of community capital is essential.

This suggestion to integrate a new subdiscipline that complements qualitative methods and focuses on the analysis of social relationships to address the challenges of rural climate governance can significantly contribute to research in this field, including, for example:

Social Network Analysis: Incorporating a social network analysis approach to map and understand the relationships among various actors involved in rural climate governance. This can help identify critical connections, information flows, and the influence of actors in decision-making related to natural resource management.

Participatory Approach: Promoting active community participation in the research process. This involves engaging community members in problem identification, data collection, and co-constructing solutions, strengthening the understanding of community capital and climate adaptation.

Local Narratives and Stories: Collect and analyze local narratives and stories describing the community's relationship with natural resources and how it has evolved. These stories can

provide a rich perspective on climate governance and the challenges faced by the community.

Social Impact Assessment: Conducting social impact assessments to understand how climate governance policies and practices affect different groups within the rural community. This can help identify inequalities and develop more equitable approaches.

Integration of Information Technologies: Using information and communication technologies to improve the dissemination of information about climate adaptation in the rural community. This includes using mobile applications, online platforms, and social media to facilitate communication and knowledge transfer.

Education and Training: Designing education and training programs for the rural community to enhance their understanding of climate challenges and strengthen their adaptive capacities. This may include workshops, training sessions, and promoting sustainable practices.

Multiple Case Studies: Conducting case studies in rural communities to compare and contrast climate governance dynamics, identifying best practices and common challenges in different contexts.

Policy Evaluation: Evaluating the impact of climate governance policies on natural resource management in rural communities. This can help identify the most effective policies and areas that require improvement.

By integrating these suggestions into a research subdiscipline, rural climate governance challenges can be addressed holistically and contribute to more effective natural resource management in the context of climate change. In addition to maintaining and balancing the seven community capitals, this approach will ensure an effective response to hazardous environmental events and increase resilience. However, these capitals are strongly recommended to be maintained and improved to achieve balance and better functioning. In this regard, it is essential to understand the vulnerability level of a specific population and the factors determining that level of vulnerability if sustainable adaptation policy analysis is to be considered (W. N. Adger et al., 2011). Additionally, governments can play a critical role in creating resilient mechanisms, supporting pro-poor risk management, and reducing vulnerability.

In the research related to adaptation and its capacity, there is an urgent need to establish an institutional framework that ensures equitable access to essential resources (Jones et al., 2010). While it is true that most nations, sectors, regions, and communities are generally capable of autonomously adapting to gradual climate changes, it becomes evident that when facing unprecedented climate transformations in recent history, external support at both the national and community levels is indispensable. This support becomes fundamental in making conscious and practical adjustments to climate challenges. Then, the institutional context is a dominant determinant of vulnerability.

5.2 Vulnerability

Before going into detail on the concept of vulnerability, it should be mentioned that vulnerability can be the starting point for analyzing adverse effects. However, it has also been extensively used to evaluate the impacts produced at the end and the capacity to react and recover by reducing the adverse effects (Kelly & Adger, 2000). Therefore, in this research, the concept of vulnerability is considered from the execution of the participatory diagnosis to the creation of strategies for adaptation to climate change, which integrates the concept from beginning to end, using the social vulnerability and IPCC approach.

Thus, different authors and organizations have defined the concept of vulnerability, which encloses a remarkable complexity despite being understandable and well-known. Its meanings range from the individual to the evaluation of environmental conditions, giving rise to the inclusion of sociocultural analyses to understand the dynamics (Feito et al., 2007). There are vulnerability approaches with a social perspective aimed at exposure to contingencies, stress factors, and the difficulty people face (Chambers, 1983), analysis of how cultural changes, wars, and economic crises affect an individual or groups (W. N. Adger, 1996). The vulnerability concept is related to various fields, such as natural hazards, food security, and climate change (Brooks, 2003). Notably, the vulnerability concept is considered a threat that is always present and that different places face because of natural phenomena such as climate change. It also includes the probability of impact of natural hazards, focusing on frequency, extent, and magnitude, which refers to biophysical vulnerability (Belliveau et al., 2006).

This is how this research seeks to apply the concept of vulnerability through the dynamic interaction of human spheres and natural factors in the context of adaptation to climate

change (O'Brien et al., 2004). Thus, in a climate change context, vulnerability is the level of susceptibility of a system and its ability to withstand the adverse effects of climate change and its extreme phenomena, depending on the adaptive capacity to change. Therefore, the consequences of climate change include natural disasters and extreme events (Kocur-Bera, 2019a) (the understanding of how one of the most important capitals/resources, such as land, particularly in rural communities, can provide goods and services that meet needs is sought (Barungi & Maonga, 2011; Sullivan, 2002). However, a vulnerability analysis is necessary to analyze this natural asset affected by climate change and exposure (Barungi & Maonga, 2011).

In the Colombian context, measures are needed to help mitigate these effects. Therefore, Colombia needs a detailed analysis of vulnerability to climate change and the association between forced displacement and subsequent exposure to risks due to armed conflict (Pollock et al., 2018). This exposure to vulnerability is most evident in communities with low economic incomes and little access to livelihoods, which can impact high levels of cultural, gender, and economic exclusion (Peters, 2019). In this way, livelihoods are more susceptible to risks (Few et al., 2021).

When physical aspects (economic and environmental) are examined, vulnerability is considered (Cardona et al., 2012). A system's ability to adapt to a climatic change depends on socioeconomic changes, the physical environment, and exposure level. Resistance to climate change is assessed to reduce vulnerability, determining the probability of alterations (Bryan et al., 2013).

Therefore, the multiple interactions that develop within a community, both internal and external, are the response that the population may or may not offer in the presence of a specific event that generates impacts, including risk factors and potential threats. Vulnerability also includes factors such as exposure (character and degree to which a system is exposed to significant climatic variations, determined by the impact level) and sensitivity (defined as the level at which a system is affected positively or negatively due to climatic variability) (IPCC, 2001b).

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), vulnerability demonstrates an interconnected relationship between these components (exposure, sensitivity, and adaptation). Consequently, the presence of individuals in the impacted areas -

termed Exposure -, the extent of harm, and the susceptibility to incoming disturbances - referred to as Sensitivity -, as well as the capacity to determine how effectively the affected system can respond, endure, and adjust to the adverse impacts of incoming disturbances, allows identifying the –Adaptive capacity- (Smit & Wandel, 2006).

It has been verified that vulnerability is contextually defined, and the application, measurement, and evaluation areas are widely varied. Now, in the literature review, common themes are found that focus on analyzing vulnerability according to 1) the level of community participation, 2) development and measurement, and 3) approaches to integrating collected data (Cains & Henshel, 2019).

If there is an inability to survive and recover from climate impacts or other disturbances due to poor adaptive capacity, vulnerability is present in the territory (McLeman & Hunter, 2010); therefore, in the processes of sustainable development of the agricultural sector, it is essential to conduct a detailed assessment of vulnerability to cope with climate change (Tran et al., 2022). In addition, to create adaptation strategies, communication, training, and description of the study area should be included as determining factors that significantly influence the capacity of farmers to reduce their vulnerability to climate change at the regional level (K. Kuntiyawichai et al., 2017).

Furthermore, with the concept's scope, finding a theory that addresses study areas involved in armed conflict or post-conflict processes takes work. Generally, approaches are found from a perspective of natural disasters and their adverse effects (Zakour & Gillespie, 2013a); also, vulnerability analyses based on socioeconomic and environmental aspects are identified (Kelman et al., 2016; Zakour & Gillespie, 2013).

According to the current literature, the application of the concept of vulnerability and the analysis of the community capital framework allows, in addition to improving the conditions for adaptation to climate change, the basis for the creation of policies according to the various socioeconomic, cultural, environmental and climatic conditions, including other relevant factors that affect vulnerability at different levels (household, community, municipal or regional) and various subcomponents that can be modified to adapt to the context of the study area (Huong et al., 2019). Thus, the sustainable livelihoods framework is valuable for assessing household vulnerability to climate change (DFID, 2000; Hahn et al., 2009).

Therefore, when discussing rural communities' economic income, it is essential to clarify that these depend mainly on the agricultural and livestock sectors. This increases vulnerability due to temperature changes and rainfall variations, limiting exposure to economic risks. Eventually, small producers seek to diversify their income sources, which implies more significant uncertainty in satisfying basic needs (Jalal et al., 2021). Thus, it is visible how agricultural and climate vulnerability influence the integrated vulnerability of households in the study area.

Hence, since agricultural and livestock income is the primary source of income for the rural population, it is understood that these significant factors from a community capital approach analysis allow reducing the overall vulnerability status of households and, in turn, poverty reduction (El-Osta et al., 2008; Sloan et al., 2018). On the other hand, given the research results that showed that most rural households perceived a significantly high impact of climate change on their livelihoods and a medium to high climate vulnerability, it is clear the need to establish climate change adaptation measures with the subsequent creation of participatory policies that direct the processes of development and improvement of the quality of life.

In addition, alterations in livelihoods due to climate variability cause an increase in vulnerability, which reduces the possibilities of securing livelihoods and reducing poverty (D'Amato et al., 2017). In general, for studies in rural areas affected by climate change, it is vital to assess the behavior of this phenomenon, as well as hazards, climate impacts, climate vulnerability, and climate resilience from a common capital framework approach that allows a complete characterization of community livelihoods, also identifying their basic needs. However, conditions in each study area are different; therefore, applying qualitative methods cannot be a general rule in the search for adaptation.

On the other hand, talking to rural communities about vulnerability is not easy; small producers generally need help understanding the concept. However, there is an influence on the perception of risks, suffer the consequences through the adverse effects of climate change on efforts to reduce poverty, unemployment, and food insecurity in rural communities (D'Amato et al., 2017), in turn affecting the two dimensions of vulnerability (exposure, sensitivity, and adaptive capacity).

Therefore, vulnerability in the context of climate change and armed conflict has received significant attention in recent academic literature. In this sense, research includes a field of study marked by a wide range of theoretical and empirical approaches that seek to understand and address vulnerability from local community perspectives.

Thus, vulnerability is considered for analyzing adverse effects and as a process that spans from identifying risks to implementing adaptation strategies (Kelly & Adger, 2000). This integrated approach allows for a more detailed understanding of the dynamics and complexities of rural communities by assessing the interrelationship between vulnerability, climate change, adaptation, and community capital, which contributes to understanding how communities face these challenges (Chambers, 1983). Thus, the contributions of various academics and organizations to define vulnerability and its scope are analyzed.

Regarding the specific contribution of the research, its integrative approach in the practical application of the concept of vulnerability in the Colombian rural context stands out, in which local perception plays a determining role in the analysis of exposure to risks derived from climate change. This applied approach demonstrates an effort to transcend theoretical discussions and address the concrete challenges affected communities face.

However, certain limitations in the proposed approach are recognized. For example, the complexity of measuring vulnerability in post-conflict rural contexts and the need to integrate local government for policy support and development. These limitations point to critical areas for future research.

Finally, as a result, the gaps that the research seeks to fill are the possibility of implementing the vulnerability analysis through data collection methods and promoting active local participation and a clear explanation of its operation, but, above all, defining the purpose of its implementation, which seeks to promote a vulnerability reduction and improve local living conditions by identifying their level of exposure, sensitivity and adaptive capacity in a post-conflict context.

5.3 Exposure, Sensitivity, and adaptive capacity

In addition, it is necessary to evaluate exposure, sensitivity, and adaptive capacity to understand the interaction between these concepts in the productive systems of rural communities, especially in small producers, and thus analyze vulnerability from a holistic

perspective. According to (Dunn & Holtz-Eakin, 2000) and (Iglesias et al., 2011), the relationship between the sensitivity of production systems and the capacity to adapt to climate change, added to the previous exposure assessment, highlights the importance of socioeconomic and cultural factors in this process; however, this research aims to further deepen the understanding of the dynamics of the territory through the application of multiple qualitative methods and thus not only focus on the capacity of social and ecological systems to adjust to new environmental and social conditions but also to have an integration of local knowledge and scientific research for the future implementation of adaptation strategies.

Production systems are exposed to variable conditions, not only climatic; additionally, it is the people, in this case, small producers, who develop their activities in post-conflict rural areas with low levels of quality of life, which is transformed into an environment with multiple components and characteristics that provide impacts from various disturbances, often related to a particular hazard; thus in this context, the diversity in the way communities face and adapt to climate change highlights the need for adaptive and contextualized approaches that take into account local specificities.

Understanding the concepts before applying them in the field is essential. The resemblances among the elements and overarching concepts highlight the challenges in distinguishing between them. Delimiting the influences on vulnerability within the conceptual subcomponents is not straightforward and needs to be clarified when interpreting the gathered data.

Thus, resilience is the ability of interconnected social, economic, and ecological systems to cope with a hazardous event, trend, or disturbance by responding or reorganizing in ways that maintain their essential function, identity, and structure. Resilience is a positive attribute when it maintains the capacity to adapt, learn, and transform (IPCC, 2014).

The adaptive capacity to climate change focuses on modifying or changing local characteristics (IPCC, 2001b) according to the pressures of climate variability, reducing risk, threats, and vulnerability through decision-making based on environmental, socioeconomic, and cultural conditions.

Adaptation strategies involve the physical environment and dynamic social and institutional circumstances, which means the adaptation process needs knowledge and local experience

and supports external actors (Dunn & Holtz-Eakin, 2000). Moreover, adaptation is a crucial factor for food production and defining the future shape severity of climate change (Iglesias et al., 2011).

It is therefore suggested that, at the moment of having conceptual clarity, as well as the use of one or several scientific approaches, when talking about climate change, the perception of each community should be highlighted, being different from others, as well as the diversity and state of livelihoods, since it is the communities who define how to face and adapt to climate change and in effect, the determination of their level of vulnerability.

5.4 Sustainable Livelihoods Approach and Community Capitals Framework

Livelihoods should be noted as an approach to development and livelihoods based on the local capacity that aims to facilitate social equity and economic and environmental sustainability, developed initially in the 1990s (Chambers & Conway, 1992; DFID, 2000), widely recognized for providing the framework for understanding how people live, what resources/capitals they have to subsist, by assessing five capitals (human, social, environmental, physical and financial), also known as resources (Chambers & Conway, 1992; DFID, 2000).

Initially, the livelihood approach focused very much on how people organized their lives, more on opportunities and agency, rather than concentrating on their impoverishment, which has led to the need to evolve the approach. This evolution led the concept to be rapidly incorporated into academic debates on development, promoting its application and criticizing it (De Haan, 2012). Assets should not be understood only as "things" that enable survival, adaptation, and poverty; they provide the power base and the capacity to be and act in using and transforming natural resources (Bebbington, 1999).

The livelihoods approach has also been criticized because local projects will keep the macroeconomic framework the same. On the other hand, capitals emphasize material aspects. They should not be considered "things" but assets that allow being and acting because of the difficulty in defining the concepts and the not-very-well-defined differences between capitals. Furthermore, there is the need for political will, where community desires for improvement are quick and visible, reflecting the challenge of encouraging the public and private sectors to undertake pro-poor actions (Wong, 2015).

The approach has been widely used and adapted according to the needs of each organization and trying to fill the conceptual gaps, i.e., the Food and Agriculture Organization of the United Nations (FAO), in its efforts to improve access to food and reduce poverty, has included in one of its objectives "Sustainable rural livelihoods and more equitable access to resources" to improve capacity for achieving sustainable livelihoods, the United Nations Development Programme (UNDP) had adopted a sustainable livelihoods agenda more prominent in the poverty and environment initiative and less apparent at the policy levels, and World Food Programme of the United Nations (WFP), in its food vulnerability and insecurity analyses, has implemented not particularly the livelihoods approach, but an adaptation of it, investing in assets and human capital, taking advantage of development opportunities and thus generating more sustainable livelihoods (Hussein, 2002).

Therefore, because of these constant processes of adapting the approach and analyzing one of its main criticisms about the importance of linking the macro level to local realities and how to map the power relations between the local processes in which livelihoods are embedded and macro level policies and strategies, other approaches such as the Community Capitals Framework have emerged.

Thus, based on the livelihoods approach, the Community Capitals Framework (CCF) was created by Flora et al. 2003 to identify mainly the strategies, roles, and impact of the capital on a community's well-being to development contribution. Furthermore, this approach evaluates communities and their development efforts from a systems perspective, including a complete resources analysis (Mattos, 2015). This approach allows a detailed vision of the community and how the actors carry out their activities through available resources and interactions between different parts of a community (Jacobs, 2011).

Consequently, for the interests of the research, the CCF was chosen which, compared to the livelihoods approach, does not include in detail four additional factors: 1) vulnerability and its context, 2) policies, institutions, and processes, 3) livelihood strategies, and 4) livelihood outcomes (DFID 1999), being this the approach called Community Capitals Framework that recognizes the importance of balance and synergies between assets or capitals in sustainable rural development processes (Emery & Flora, 2006; Gutierrez et al., 2016), and that in addition to the five capitals of the livelihoods approach, adds two capitals (cultural and political), making it a complete approach in the evaluation of sustainability processes and the

creation of livelihood strategies that promote the satisfaction of basic human needs and well-being.

(C. Flora et al., 2004) Argues the need to evaluate seven capitals/resources and the respective interactions to know the functioning of a community that allows it to develop its productive and reproductive livelihoods (activities). Therefore, a balanced analysis of Natural, Social, Human, Cultural, Financial, Political, and Built/Physical resources is used in the endogenous development community processes (**Figure 4**).

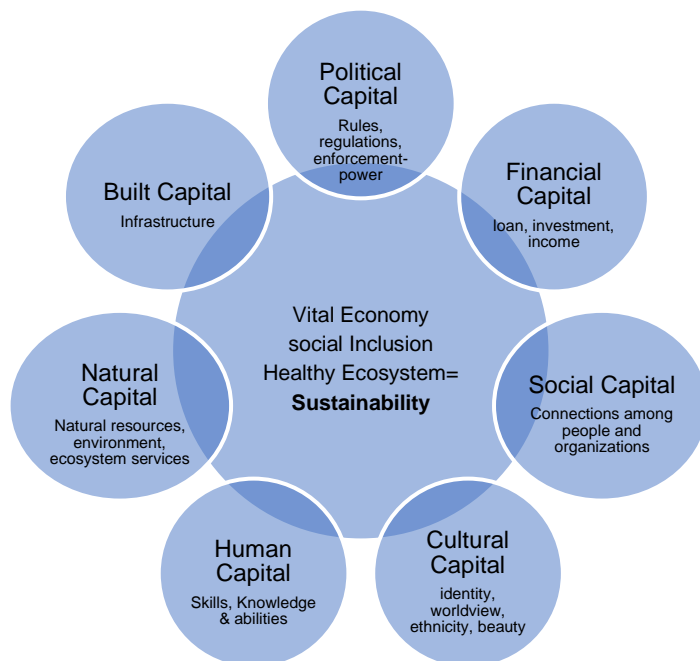


Figure 4: Community Capitals Framework (CCF)

Modified from Flora et al., 2004

The Community Capitals framework is increasingly used and needed to answer the question of how investment in one capital can be linked to others and better used to achieve change in the community. Not only is the characterization and importance within the communities of the separate capitals achieved, but this approach allows us to analyze the interaction between the seven capitals and define their subsequent use according to their value and need in such a way that they create a vital local/regional economy, with social well-being and a healthy ecosystem (Mattos, 2015).

It is worth highlighting then, from a broad perspective, climate-associated changes in livelihoods affect the social and economic systems of rural communities (Chen et al., 2018;

Singh et al., 2019), both by climatic and non-climatic factors, i.e., all the dynamics of the seven community capitals (social, human, cultural, financial, environmental, physical, political) should be effectively employed to give continuity to the processes of sustainability and active participation of both internal and external organizations, recognizing the institutional heterogeneity that promotes the formulation of adaptation policies according to local and regional needs.

Thus, in climate change, vulnerability, and adaptation assessment processes, one must work with a holistic approach based on 1) participatory research methods, 2) integrating data in addition to local and regional that involve various disciplines, and 3) promoting solutions from community interests (Cains & Henshel, 2019).

Therefore, it is proposed that a planning tool be developed to monitor the vulnerability of the rural communities of Guayabal and Pavitas in the municipality of Santander de Quilichao to climate change and the adaptation strategies adopted in each case. Thus, the planning strategy is based mainly on community capital, adopting an innovative approach involving several qualitative methods that complement each other to recognize communities as holders of various capitals, including natural, social, human, cultural, and economic resources. These capitals represent not only tangible assets but also social networks, traditional knowledge, and mutual support systems that can be mobilized to face the challenges of climate change (Pretty, 2003). This implies using the potential of communities and promoting the sustainable management of local ecosystems (Bumpus & Liverman, 2008).

In addition, and in contrast to traditional studies in which follow-up indicators are used, it is proposed to monitor the state of community capitals to measure the effectiveness of adaptation strategies. This involves developing participatory methods to assess the evolution of natural resources, social cohesion, access to essential services, and other aspects relevant to community resilience. This approach provides a complete understanding of how adaptation strategies affect critical community assets and allows adjustments to be made as needed (Adger et al., 2005).

Finally, this community capital-based approach provides a sound and holistic conceptual framework for climate change adaptation planning and monitoring in the hamlets of Guayabal and Pavitas. Focusing on local assets and resources promotes greater resilience and sustainability in rural communities.

5.5 Resilience

Resilience is the ability of interconnected social, economic, and ecological systems to cope with a hazardous event, trend, or disturbance by responding or reorganizing in ways that maintain their essential function, identity, and structure. Resilience is a positive attribute when it maintains the capacity to adapt, learn, and transform (IPCC, 2014).

Various social, economic, and ecological systems with diverse objectives are interconnected to cope with a hazardous event, trend, or disturbance that may arise from the potential impacts of climate change or human actions. Therefore, resilience seeks ways to respond or reorganize positively to maintain or enhance adaptive, learning, and transformative capacity in local livelihood development.

In this context, it is necessary to identify community recovery-action processes in these climatic events to strengthen social connections between rural producers and local governments in the face of climate-induced hazards, significant changes in temperature, droughts, and prolonged rains.

As mentioned above, recovery actions are clearly determined by local interests and conditions and the political and economic support needed to be resilient in the long term (Beitnes et al., 2022). However, the literature review suggests alternatives such as subsidies to producers, continuous training, irrigation systems, and promoting bank loans with low interest rates, strategies aimed at promoting adaptation to climate change from a resilient community (Tran et al., 2022).

According to (Adzawla et al., 2020), "Climate resilience has become a major aspect for climate discussions since it largely determines how climate efforts such as adaptation are yielding results, especially into the future." That is why, in the face of climate crises, a complete assessment of the household and its livelihoods contributes to the identification of local conditions, giving way to changes in the direction of sustainable development with adaptation principles, ensuring that recovery periods are not extensive since this would determine a low level of resilience.

It should be noted that the concept of resilience applied in this research promotes the identification of productive systems affected by climate change but evaluated from the concept of how these systems can continue to provide the same or better productive

functions despite negative impacts on community capital due to climate change (Blazquez-Soriano & Ramos-Sandoval, 2022).

Finally, studies show that there is no consensus on resilience measurement, mainly due to the lack of a straightforward methodological approach to measurement, which also lacks integration of process-based perspectives and representative outcomes more holistically, and that decision-making strategies should allow for the analysis of interactions between multiple factors at different scales and between systemic risks (Laurien et al., 2022). Therefore, during the information-gathering process, local perspectives in conjunction with the vulnerability analysis and the community capital framework will be vital in understanding the resilience processes within the study area without going into detail on resilience measurement processes.

5.6 Adaptation

The adaptive capacity to climate change focuses on modifying or changing local characteristics (IPCC, 2001a) according to the pressures of climate variability, reducing risk, threats, and vulnerability through decision-making based on environmental, socio-economic, and cultural conditions.

Adaptation strategies involve the physical environment and dynamic social and institutional circumstances, which means the adaptation process needs knowledge and local experience and supports external actors (Dunn & Holtz-Eakin, 2000). Thus, adaptation is necessary to incorporate future climate risk into policy-making to protect – and enhance – human well-being. Therefore, to face this condition (e.g., reassessment of current plans, improvement of societal awareness, increased understanding of the factors that enhance or threaten the adaptability and a new focus on assessing the flexibility and resilience of social and managed natural systems) (Lim et al., 2004).

On the basis that there is a wide range of strategies to address climate change adaptation in the context of agriculture, e.g., policies, improved access to climate information, new cropping patterns and technology adoption, local knowledge that has been based on test and error over the years should be recognized in the first instance, indirectly allowing to approach climate change adaptation processes, consistent with (McNamara & Buggy, 2017) that with

studies have successfully demonstrated that adaptation strategies are based on local knowledge of locals.

Therefore, income, social connections, formal education, and perception of climate change are recognized as determinants for adaptation to diversity in livelihoods and producers. Thus, social support, belonging to a local organization, level of education, size of the productive unit, diversity of products, and access to credit and subsidies significantly influence the adaptive capacity to cope with climate impacts (Pickson & He, 2021).

On the other hand, in developing countries and particularly in rural areas, there is a need for more budget to explore climate change assessment processes that give way to formulating adaptation policies (Ahsan & Warner, 2014; Sam et al., 2017). Faced with this situation, communities have opted for diversification of productive systems and sources of income that would guarantee financial stability. This is reflected in the implementation of crops tolerant to high temperatures, changes in planting times, and activities outside the productive unit related to the sale of labor and migration to populated centers, resulting in adaptation processes based on local needs.

Therefore, the implementation of adaptation strategies to support the impacts generated by climate change on agricultural production and population dynamics is critical to rural development processes. Thus, the role of the actors is essential, both for the actions taken by governments, communities, and individuals in their capacity to reduce the effects of climate change and make the necessary adjustments when required (Akinngbe & Irohibe, 2014).

Additionally, a factor to consider, and even though there are multiple studies (as mentioned above), is the validation of local knowledge as an alternative for adaptation to climate change; there are also studies that surprisingly reflect that the experience of the producer can negatively and significantly affect the adaptation decision, for example, in the resistance to adopt new technologies due to lack of confidence, knowledge or fear of changing their traditional practices that have worked over the years (Ahmed et al., 2021).

Finally, it should be considered that not all adaptation processes reduce vulnerability (O'Brien et al., 2004; Pelling, 2010); these processes mainly should not be designed as projects that only think about development and the search for change in the practices of the least favored rural populations, on the contrary, it is necessary to implement learning processes within local

organizations with active participation of external institutions, being these the center of the objectives of adaptation, in such a way that the approach is expanded from an inclusive point of view of social change, as well as structures and systems (O'Brien et al., 2004; Pelling, 2010). Thus, "providing education and training to increase adaptive capacity is one of the appropriate adaptation strategies for vulnerable households" (Arifah et al., 2022).

In the same sense, if there is greater access to the seven resources/capitals, including access to climate information, the levels of vulnerability to climate risks will be lower. However, measures should not be limited only to the availability and use of resources/capital but also to the local perception of the impacts of the climate phenomenon and how it influences decision-making, which requires producers with more excellent local knowledge and better access to climate information so that decision-making is more accurate and benefits rural production processes (Etongo et al., 2022).

In conclusion, if there is greater access to the seven resources/capitals, including access to climate information, the levels of vulnerability to climate risks will be lower. However, measures should not be limited only to the availability and use of resources/capital but also to the local perception of the impacts of the climate phenomenon and how it influences decision-making, which requires producers with more excellent local knowledge and better access to climate information so that decision-making is more accurate and benefits rural production processes (Etongo et al., 2022).

5.7 Basic Human Needs

In scientific approaches, the creation and understanding of concepts are not enough since the operationalization of these determines their effectiveness; it is the dialogue between concept and action that generates learning; otherwise, "conceptualization without action runs the risk of losing contact with reality and becoming irrelevant, while action without conceptualization or theorization runs the risk of becoming activism and also becoming irrelevant" (Imbach, 2016).

Therefore, Max-Neef (1997) proposed distinguishing between needs and how to meet them in different places, cultures, and times so that people can have a dignified life and development opportunities; however, Imbach modified the approach to basic needs to move

forward towards the practical adoption of development visions, leaving behind the economist vision in the rural sector.

Likewise, the emergence of the concept of human needs promotes the development of human beings and not in the sense of developing countries or producing material goods (de la Bellacasa, 2012), raising the change of approach where the concept of welfare was linked only to economic growth.

Thus, if development is mentioned, one should strive for people to have a dignified life that allows them to carry out all their abilities, desires, and projects. In other words, to decide on their own life in dignified conditions since all people have needs, but they are satisfied in different ways (Imbach, 2016), contrary to the thoughts of different theoretical currents that argue that all people have fundamentally exact needs (de la Bellacasa, 2012).

Finally, it is again observed that there is no conceptual unanimity. Therefore, this causes conflicts in measuring basic human needs, even more so in a post-conflict context in rural areas with evident climatic impacts. For these reasons, the analysis of basic human needs, according to the literature review, is recommended to start with an analysis of the resources available in the community, i.e., an evaluation of the common framework of capital that allows identifying the livelihoods that generate satisfiers and that together configure the life strategies that aim to satisfy human needs at different levels (Imbach, 2016).

5.8 Climate Justice

The concept of climate justice is grounded in several fundamental principles. Firstly, it draws upon the experiences of developing countries and vulnerable populations, such as children and future generations, women, workers, Black, Indigenous, People of Color, and other marginalized groups, who are disproportionately affected by climate change in both developed and developing nations. Secondly, it emphasizes developed countries' involvement and their role in decision-making processes concerning less developed nations. Lastly, beyond addressing vulnerabilities, climate justice encompasses responsibilities for climate actions, which can lead to improved measures for vulnerable stakeholders. These responsibilities include mitigation, adaptation, addressing losses and damages, financial support, and capacity building (Onifade, 2021).

Thus, climate justice implies the need for a fair and practical agreement that focuses on people, especially the most vulnerable, and that guarantees an equitable distribution of responsibilities and benefits in response to climate change to protect vulnerable populations and ecosystems from the impacts of this phenomenon, promoting development and economic prosperity. Climate justice thus argues that it is possible to address climate change in a way compatible with sustainable development that protects and treats people equitably (Cameron et al., 2013).

Therefore, seeking climate justice for rural communities in Colombia is limited by the extractivist advances of non-renewable resources of fossil fuels and renewable resources, added to the climatic events now present in a context of violence caused by internal armed conflict (Howden et al., 2007b). Additionally, to achieve the autonomy of rural territories, one of its interests is to promote the provision of alternatives for the sustainable use of natural resources, building an environment that generates local well-being (Tajima et al., 2022). However, this climate injustice, in addition to industrial extractivism, poses a broad challenge to overcoming the conditions of the Colombian context: impoverished economies, internal armed conflicts, and displacement (González-Hidalgo et al., 2022b).

Consequently, addressing climate justice in the Colombian context, especially in the rural sector, is grounded in several fundamental principles to address the inequalities and vulnerabilities associated with climate change. These groups often bear the impacts of climate change despite having contributed minimally to greenhouse gas emissions. Thus, beyond addressing vulnerabilities, climate justice entails responsibilities for climate action, including mitigation, adaptation, loss and damage, financial support, and capacity-building in the most vulnerable countries (Schlosberg, 2007).

These responsibilities are intended to ensure that individuals have access to a safe and healthy environment and opportunities for sustainable development. In this way, rural communities in Santander de Quilichao can reduce their vulnerability and increase resilience to climate change. However, the Colombian context in which armed conflict is a factor to consider, and its interaction with climate change hinder the pursuit of climate justice in rural communities, compounded by extreme weather events such as floods and droughts, which can exacerbate existing conflicts by competing for scarce resources like water and land. This, then, poses challenges for development, and it is here where adaptation processes with a

comprehensive approach recognizing the specific experiences and needs of these communities play a crucial role in reducing these inequality gaps.

5.9 Identified knowledge gaps

This study is grounded in a comprehensive understanding of the livelihoods of rural communities, serving as a tool to identify vulnerability, its components, and relevant interactions in the climate change adaptation process. It acknowledges various factors, such as limited economic resources, impacts on natural resources, infrastructure weaknesses, low levels of knowledge, and the amplified effects of climate variability on productive systems and overall living conditions at the local level. As a result, this research presents new perspectives and pertinent approaches for rural communities in climate change adaptation processes through an extensive review of literature on climate change, adaptation, vulnerability, and the applicability of the common framework of community capitals. The objective is to comprehend and evaluate the systems and their vulnerability and enhance the existing approach.

The proposed methodological framework primarily emphasizes combining qualitative methods to facilitate a profound, contextualized, and enriching understanding of the phenomena under study. It incorporates flexibility, exploration of multiple perspectives, and theory generation, thereby fostering a comprehensive and meaningful investigation. This research contributes to adaptation processes, focusing on the unique needs and characteristics of the community. It employs interdisciplinary, participatory, and technological approaches to address the challenges of climate change effectively and sustainably in rural areas.

Furthermore, the framework will be utilized to analyze how vulnerability analysis, basic human needs, and the shared capital framework can be strengthened to address the identified knowledge gaps in this thesis. The anticipated outcomes of this research encompass potential governance alternatives for resource management within the context of climate change adaptation. These alternatives aim to generate new proposals and policies that enhance the adaptive capacity to climate-related conflicts in rural areas of Colombia, employing a participatory approach with communities as key actors.

Additionally, my contribution focuses on refining the Community Capitals framework approach (CCF) by incorporating additional elements. This includes integrating equity and social justice

measures, as rural communities often face economic and social inequalities that are not fully considered within the CCF. Furthermore, the potential of the CCF to foster innovation and entrepreneurship in rural communities and enhance their human capital is emphasized. This can stimulate the emergence of new businesses and innovative projects. The analysis not only evaluates each community capital individually but also assesses the impact of climate change on each capital (natural, human, social, physical, financial, political, and cultural). This enables the identification of key areas of vulnerability and prioritization of actions required to strengthen community resilience.

Moreover, the joint capital framework approach is suggested to reinforce information and monitoring systems in rural communities affected by climate change. By leveraging this approach, more precise data can be collected on the status of different community capitals and the impacts of climate change. An effective monitoring system would facilitate the evaluation of the effectiveness of adaptation strategies and rural development programs implemented within the community. For instance, implementing an early warning monitoring system could aid in mitigating risks associated with the rise of the Quilichao River.

Furthermore, the objective is to extend the use of this approach beyond characterizing community capitals. It can serve as a method for ongoing evaluation of productive and economic systems within the community. This enables the identification of opportunities for sustainable economic development that align with natural resource conservation and strengthening human, social, and financial capital.

Regarding vulnerability analysis, a comprehensive assessment will be conducted that goes beyond examining the vulnerability of rural communities solely with their agricultural and livestock production systems. It will encompass a broader evaluation of the satisfaction or lack thereof of basic needs, the community capitals, their interactions, and challenges to promote improved adaptation to climate change. This inclusive analysis will provide insights into the resilience capacities of productive systems and ecosystems to withstand, adapt, and recover from climate change impacts. It will also consider their interconnectedness with the community's adaptive capacity. Furthermore, the assessment will incorporate a collective mapping of the primary components identified by community residents, thereby ensuring their active participation in the process.

Finally, the vulnerability analysis proposed in this research incorporates features of climate justice assessment. It entails examining how climate change impacts disproportionately affect different groups within rural communities, particularly those already vulnerable due to poverty, discrimination, and social marginalization. The assessment aims to identify barriers to adaptation and the need for policies and strategies that address existing inequalities.

6 Methodology

6.1 Procedure

This chapter discusses the methodology used in this study to address the research objectives mentioned above. The methodology here refers to the analytical methods and tools used for the analysis (data collection and assessment) and the procedures applied for the whole research to answer the research question and achieve this dissertation's aims. The study methodology consists mainly of a qualitative method. This study was developed from October 2019 to February 2023, allowing for a rough classification of the methodological procedure.

This research uses mainly a qualitative approach with the active participation of the community to understand behaviors, accessing "embedded" processes by focusing on the context of people's everyday lives in which decisions are made and enacted rather than simply looking at the characteristics or content of the situations. The main component of the empirical work included interviews and the application of a semi-structured protocol that was applied to stakeholders and private and public institutions, according to the Community Capital Framework proposed by (C. B. Flora & Flora, 1993). Verbal approval was obtained from the interviewees for using the information and personal reference in the data analysis if necessary. The protocols were conducted in Spanish.

Hence, according to the local situation, it is essential to focus on everyday interactions: it can make a unique contribution through aspects of social processes that other methods cannot access because qualitative research answers very different questions to those addressed by quantitative research and some criticisms directed against qualitative research have, at times, failed to take this into account (Barbour, 2014).

Therefore, in this study, it is essential to validate the results and increase credibility and rigor by using multiple methods, data sources, and perspectives to study adaptation to climate change. By triangulating different sources of information, it is possible to understand better

the community's response and the factors that influenced it in a particular situation. Typically, its accepted use includes quantitative as a form of validation or verification and qualitative through inquiry and description (Hanson-DeFusco, 2023). Thus, triangulation is particularly important to explore the complex interactions between methods and socio-environmental factors and generate insights from different sources that inform policy and practice (Carter et al., 2014).

Triangulation can be viewed as a combination of methods and different theoretical perspectives. In this research, data triangulation was utilized to incorporate various information sources. The objective was to distinguish between time, space, and persons as subtypes of data triangulation. This entailed examining phenomena at different time points, geographical locations, and with diverse individuals (Flick, 2009).

Another form of triangulation was employed, utilizing different observers or interviewers to identify or mitigate biases arising from the researcher's influence. Therefore, triangulation aimed to validate the results obtained through multiple methods, enriching the knowledge by linking the perspectives of various participating authors through diverse methods such as interviews, surveys, and workshops, among others, about the realities within the study area (Flick, 2009).

Therefore, the step-by-step triangulation employed in this study was developed as follows:

- **Defining the Purpose of Triangulation:** The purpose of triangulation was to comprehend how the communities of Guayabal and Pavitas were adapting to climate change and its impact on their productive systems.
- **Identifying Triangulation Sources:** Triangulation sources included interviews with local farmers and external stakeholders, long-term climate data analysis, and other applied methods.
- **Designing the Triangulation Strategy:** The strategy involved conducting in-depth interviews with farmers, analyzing decades of climate data, and organizing participatory diagnostic workshops.
- **Data Collection:** Data collection encompassed implementing the methods within the rural areas, gathering data, and collecting information.

- **Data Analysis:** Data were analyzed separately, considering the experiences and perspectives of farmers and external agents, as well as the researcher's viewpoint, to identify patterns of climate change adaptation.
- **Comparing Results:** Results were compared to identify similarities and differences in adaptation strategies mentioned by farmers and other involved authors.
- **Integrating Findings:** Findings were integrated to understand how rural communities adapted to climate change and how agricultural practices had evolved.
- **Reflecting on Triangulation:** Reflection involved considering how combining qualitative data from interviews and quantitative data from climate records enriched the community's understanding of climate change adaptation.
- **Reporting Results:** The research document detailed how triangulation was applied to address climate change adaptation in rural communities.
- **Continuing Triangulation:** If additional research is conducted or new questions arise regarding climate change adaptation, the ongoing application of triangulation is considered to enhance understanding and the effectiveness of adaptation strategies in the rural community.

Consequently, for this research, it is crucial to complement the study with quantitative analysis, focused on identifying statistically significant relationships between variables in the analysis of the adaptive capacity of communities to climate change in 2 (two) rural communities (Guayabal, Pavitas) in the municipality of Santander de Quilichao, Cauca, Colombia.

Multivariate analysis examined the relationships and interactions between multiple variables related to community capital. Subsequently, from the data collected, both qualitative and quantitative data and the multiple variables of interest were used to apply the multivariate principal component analysis technique and their interrelationships. Infostat statistical software was used to analyze and examine the data, the direction of the relationships, and the impact of variables on other variables. The variables were defined according to the community capital's findings. They were subsequently assigned a code to facilitate their use of the software. Finally, this analysis made it possible to identify which community capitals have the most significant relationship with each of the communities evaluated, leading to a careful interpretation of the results, which are fundamental for obtaining significant information in creating strategies for adaptation to climate change.

The main methodological instrument focused on analyzing the Community Capital Framework (CCF) as a complete method of empirical information collection. The CCF provides a method for evaluating community and economic development efforts through a systems approach. It achieves this by identifying the assets or resources present in each capital (known as stock), the various types of capital being invested (known as flow), the interaction among the different types of capital, and the resulting impacts across all capitals (Emery & Flora, 2006). The CCF and place attachment are connected despite being based on different assessment levels. The CCF focuses on the community, while place attachment is more individualized. However, both concepts are related because the CCF identifies various attributes, such as social, political, and financial capital, that exist within a community. However, whether individual community residents perceive these depends on their presence or absence (Paul et al., 2020). Consequently, a complementary analysis of qualitative and quantitative approaches will allow a better understanding of the implications of using multiple methods and gaining insight into the phenomenon of interest (Carter et al., 2014).

Therefore, the qualitative sampling plan in this research describes how many methodological instruments, protocols, or information were needed to find data. The key features of qualitative sampling include different situations that capture the perception of various participants to define the information to be collected. As a consequence, the amount of information collected in the communities according to the criteria of validity when trying to reconstruct reality and identify local interactions and, ultimately, to understand it in its entirety is determined in part by the close relationship between research and intervention, between thought and decision within the framework of the importance of transformation as an indicator of the level of incidence and impact of the process (Paz Sandín Esteban, 2000). In essence, the role of local actors and their analysis of the environment is relevant, providing the necessary information to identify and understand the dynamics, achieve the objectives, and understand the phenomenon under study (Moser & Korstjens, 2018).

In this context, the Community Capitals Framework (CCF) was created by Flora et al. 2003 to identify the strategies, roles, and impacts of the capitals (social, human, political, physical, financial, natural, and cultural) on a community's well-being to development contribution. According to (C. Flora et al., 2004), capitals are the resources of different types that people and their communities possess in their endogenous processes, regardless of their socioeconomic level, whether marginalized or not. These resources are of several types: 1)

those that can be consumed (used and exhausted), 2) those that can be stored and conserved (no one can use them), and 3) those that can be invested to create more resources.

Furthermore, this approach evaluates communities and community development efforts from a system's perspective, including a complete resources analysis (Mattos, 2015). This approach allows a detailed vision of the community and how the actors carry out their activities using available resources and interactions between different parts of a community (Jacobs, 2011).

C. Flora et al., 2004 argue the need to evaluate seven capitals/resources and their respective interactions to get to know the functioning of a community that allows it to develop its productive and reproductive livelihoods (activities). Therefore, the endogenous development community processes use a balanced analysis of the resources (Natural, Social, Human, Cultural, Financial, Political, and Built).

6.2 Research Phases

The methodological process was carried out in three phases:

The **first phase** involved a literature review and internet-based research (reports from public institutions and local community organizations, project documents carried out by external agents, thesis, scientific papers, and historical community documents, as specific documents about climate change studies in Colombia and the Cauca Department) in obtaining background information about the research topic and the study area. The literature review was done in three stages: 1. Exploration, 2. Focus and methods analysis, and 3. It compares and analyzes academic articles that highlight or analyze qualitative methods with a focus on the climatic adaptability of rural areas.

The search was conducted within the 2017-2019 time frame to obtain recent publications while ensuring it was broad enough. Based on preliminary reviews, it was noted that the methods used in studies before 2017 did not vary significantly. Therefore, research areas related to qualitative methods within that period were prioritized. The search includes variables such as "adaptation to climate change," "qualitative methods," "rural development," "rural communities," "post-conflict," and "participatory rural methodologies." Likewise, a combined search of these descriptors was carried out to expand the research criteria.

The selection of scientific articles was done through the Scopus tool, prioritizing two general themes: 1. Social Sciences (1.1 Geography, Planning and Development, 1.2 General Social Sciences, 1.3 Gender Studies, 1.4 Development) and 2. Environmental Sciences (2.1 General Environmental Sciences, 2.2 Global and Planetary Change, 2.3 Management, Monitoring, Policy, and Law). The idea was to select the search with subtopics to focus more on the literature review, emphasizing and selecting scientific articles in journals that include climate change. Finally, a list was obtained to complement the database of the other research tools.

Subsequently, a search was conducted for scientific articles in journals indexed by Science Direct and Google Scholars according to the variables chosen, reviewing only the methodological section concerning adaptation to climate change. Thus, 55 relevant publications were reviewed, all applying qualitative methods in rural areas.

Besides, an analysis of the information and methodologies implemented in each study was conducted, evaluating common and divergent aspects among the selected documents through a comparison exercise about the qualitative methods used. The documents included a mix of environmental, social, cultural, economic, and interdisciplinary studies, all within the rural context.

Following the literature review, the methods used during the data collection phase were defined, thus initiating phase 2 of the research.

The **second phase** involved an extended field trip to Colombia, which included:

- a) Initially, 19 communities were visited, facing difficulties of public order, internal indigenous norms, and the COVID-19 pandemic, which led to developing the research with three communities (Guayabal, Pavitas, and a third community subsequently decided not to publish the results) that had the desired characteristics of the project and allowed the execution of the research, with active participation.
- b) Socialize with the stakeholders to explain the research and capture local perspectives with active community participation.
- c) Collect general information from stakeholders and farmers through participatory workshops, interviews, surveys, collective mapping, observation routes, meteorological data, and vulnerability analysis.

However, the efforts for initial data collection could have been improved by the effects of the COVID-19 pandemic, including restrictions imposed by the Colombian government and the refusal of rural communities to meet with individuals external to the community. This led to the modification of the research timeline. This had numerous effects on the empirical work: Indigenous communities could not be visited, other communities decided not to participate in the project, access conditions to the sites were increasingly restricted, program meetings were repeatedly postponed without prior notice, and when data collection finally began, there was considerable skepticism on the part of the inhabitants of the study area.

Consequently, during the first months (**March to June 2020**), only the communities could be contacted remotely by phone or the Internet. During this time, however, data could be collected using virtual meetings, and some face-to-face meetings were held with key stakeholders in the study area to socialize the research project. This allowed us to move forward with the planning and collection of initial information needed and ensured progress in research. Nevertheless, this slowed down the research progress decisively.

Due to the problematic situation, a suspension of the DAAD-Colfuturo scholarship for six months (**June to December 2020**) was necessary. During this time, 19 rural communities were visited, starting in July 2020, to socialize the project to more people, obtaining a positive community response from 3 of these communities. Also, contacts and connections were strengthened with the three participating communities, making participant and non-participant observation routes to identify the study site's physical characteristics and social dynamics. In addition, contacts were made with local institutions participating in the villages to learn about their functions and modes of participation in supporting the villages in the research area.

To ensure that the field stay was successful, two requests for an extension of the field research were submitted and approved (from January to February and March to April 2021).

Furthermore, the first field trip was meant to capture local perspectives with active community participation. Through workshop implementation, data from key actors and stakeholders about the socio-ecological context and its linkages to climate change were mainly collected.

Since January 2021, I have continued to collect data in Colombia, taking advantage of the fact that there are fewer restrictions on access to the communities. Instead of returning to Hamburg, as planned in the original work plan, in intensive exchange with my supervisors, it was considered appropriate to continue with the fieldwork until the end of March to take advantage

of the links created to the communities and their receptivity. In that context, by the end of March 2021, I had planned to return to Hamburg, making use of the reactivation of the partial DAAD scholarship and the loan from the Colombian organization Colfuturo.

Nevertheless, because of the restrictions due to COVID-19, the data collection and fieldwork schedule was altered again to such an extent that to meet the data collection objectives, it was necessary to postpone the return trip to Germany because it was essential to continue the research process without an additional field trip, as there was no funding available to cover these expenses. However, this schedule modification due to the pandemic caused my residency permit to expire due to my extended stay in Colombia.

Subsequently, the research process continued, and at this point, the project had already made progress, capturing local perspectives with the active participation of rural communities. As a result, a complete participatory diagnosis in each community in four workshops with indigenous and rural leaders was concluded as a method of inclusion. It is essential to know their perspectives as a critical component of understanding.

- the dynamics within the communities,
- the needs of the communities, and
- how communities influence the system as well as
- what are alternative solutions to the identified problems?

Consequently, everything has been a learning process. Thus, with the results obtained from the project, local organizations showed interest in the research and the possibility of establishing cooperation agreements (despite the conditions of violence in the study area). However, with the increase of COVID-19 cases in Colombia, there were again restrictions to access the communities, adding to the rainy periods that generated landslides and road blockages. This situation led me to bring forward my trip to Germany, this time with my two children, and although my new visa was approved, my children's visa was denied. Therefore, the DAAD demanded that I travel as soon as possible, or I would have to renounce the scholarship. However, in my situation, I did not contemplate leaving my children without knowing how their immigration status would be resolved, in addition to the firm intention to complete the fieldwork that had already been reformulated on several occasions. Consequently, I decided to renounce the DAAD scholarship.

In the **third phase**, all results were compiled, reviewed, and discussed along with the research questions and goals.

The field stays in Colombia were planned to collect empirical data. The aim was to establish contact with various indigenous and peasant communities, clarify their willingness to participate, and start the research process with the selected communities. Their perspectives made it possible to generate a participatory community diagnosis of the territorial components with the development of participatory workshops in the process of historical reconstruction and to understand the realities of the different groups (indigenous and peasant).

Furthermore, the study employed participant and non-participant observation methods to comprehend better the two communities' physical attributes and social interactions, leading to more robust connections and relationships. Additionally, the research process allowed me to connect with local institutions that actively support these villages to gain insight into their functions and involvement methods in the research area.

In addition, at the project socialization in each of the two villages, the attendees agreed to participate; however, since not all the inhabitants attended these meetings, the community leaders decided that I would walk and visit the homes and ask if they wanted to answer the protocols. Therefore, the inhabitants interviewed (20 per community) were selected according to their interests and availability. Most peasants were people over 40 years old, including men with an agricultural vocation and homemakers.

Additionally, variables of greater and lesser interest were identified based on the results collected in each village through semi-structured interviews and collective mapping. Furthermore, it identifies the life experience of the participants and the impacts on their lives from the analysis of the sociocultural components, contamination, places of interest, threats, and environment since it allows them to project themselves as autonomous and empowered subjects for decision-making. Therefore, a graphical representation (word clouds) was developed to provide the basis for the subsequent detailed analysis.

Finally, I returned to Hamburg in January 2022 to continue with the data analysis process, which, despite the schedule modifications, has managed to adjust to the changing conditions and with significant progress. However, it was necessary to have financial resources to address the following phases with the respective activities that fulfill the objectives and, therefore, the

research question. Also, a last field trip to Colombia was conducted from December 2022 to January 2023 to socialize the empirical results with the communities. Exchange results with local communities helped to identify and prioritize adaptation measures adequate for each local context.

There was an unexpected turn of events during the final process of the research, after the exhaustive collection and analysis of data in Guayabal, Pavitas, and a third community. With an eye on an upcoming change of local leaders of the communal action board and the indigenous cabildo authorities, the community in question decided not to allow the publication of the data obtained. Although surprising, the decision of this community was thoroughly respected, and efforts were concentrated on including the results and analysis of the other two communities, Guayabal and Pavitas. To strengthen the research analysis, some general comparisons were made anonymously, and some determining points of the third community were highlighted, always under anonymity, but without mentioning specific data or details, thus providing a solid and enriching perspective to the results obtained. This decision was made on the principles of ethics and respect for the communities involved, ensuring the integrity and value of the research as a whole.

6.2.1 Methodological tools

For the research, it was necessary to evaluate different qualitative methods and approaches, which were most relevant to answering the research question and allowing for the collection of detailed information on communities' experiences and perceptions of climate change and its effects on livelihoods.

Therefore, different interviewing approaches can affect the quality and depth of the data collected. One of the most common interview approaches is the structured interview, which involves asking preset questions to all participants in a specific order. This approach is practical when collecting accurate and comparable information across participants (Babbie & Mouton, 2015). However, this approach was not used in the research because it limited the ability of participants to provide detailed and in-depth information, as in this approach, they are asked to answer specific questions.

Another evaluated approach was the in-depth interview, which focused on a specific topic and allowed participants to speak freely about that topic (Patton, 2015). However, not as much depth of information was needed, and time was a constraint; in addition, other methods

were used with a different approach that complemented the data collection and diversified the methodology in its application in the field.

Thus, the approach chosen was the unstructured or semi-structured interview, as it is more flexible, allowing the inhabitants of the communities to participate freely in their experiences and perceptions (Seidman, 2013). This approach helped understand the complexity of participants' experiences and uncover new themes that had not previously been considered. However, analyzing and comparing the data was also challenging, as participants' qualitative responses varied among themselves.

Applying semi-structured interviews, surveys, checklists, focus groups, workshops, and collective mappings (**Table 1**) allowed qualitative data analysis, which involved a detailed interpretation of the material collected in the two communities.

The qualitative information was structured as follows: 1) to carry out a historical participatory community diagnosis, 2) to frame the existing environmental impacts concerning climate change, and 3) to make participatory proposals for climate change adaptation measures.

Table 1: Methods applied

Method	Aim	Quantity
Workshops	Initial participatory diagnosis	2
Focus Group	Identifying community characteristics by component	2
Timeline	Historical reconstruction - positive/negative	2
Semi Structured Interviews	Identifying community capitals	40
Checklists	Identifying basic human needs	20
Surveys	Villages' Climate Change Perception	26
Surveys	Institutions' climate change perception	4
Collective Mapping	Visual description by components	2
Vulnerability analysis	Identify the climate vulnerability of livelihoods in each community	2

The first contact was the application of a general participatory diagnosis of the current conditions and a historical reconstruction (last ten years, 2020 backward) through the

participatory workshop method, which led to the identification of positive and negative aspects of the two communities in Cauca, Colombia. Utilizing a participatory research methodology makes it possible to incorporate the stakeholder's perspectives and explore questions that communities prioritize but are frequently overlooked by researchers (Duea et al., 2022). Participatory Workshops are based on an overarching knowledge structure, i.e., a coherent system of activities designed to facilitate the socio-cognitive learning process (Bertella et al., 2021). Research has demonstrated that employing participatory methods in scenario development can lead to enhanced results. Additionally, the participatory process promotes a sense of ownership among stakeholders and contributes to the research findings' transparency, clarity, and credibility (Kurniawan et al., 2022). The process consisted of initially inviting the inhabitants of each community to begin collecting empirical data on the project. This was done in weekly local meetings in the community assembly house, where I was given time to explain the objective of the first participatory workshop. However, some limitations were encountered during its implementation, such as the participants' lack of punctuality due to lack of time, which resulted in rushed activities, incomplete discussions, and inadequate participation. In addition, in the first workshops, the diversity of participants reflected attitudes of low interest in the activity. Power dynamics also showed that some participants wanted to dominate the activity, resulting in the passivity of other inhabitants.

Focus groups typically involve a single gathering of individuals who share a similar experience. The aim is for stakeholders to feel heard and for their concerns to be understood. This approach is particularly useful in involving participants, especially those from communities who are often marginalized and may not have a voice in issues that impact them (Carey & Asbury, 2016). Usually, focus groups are conducted in a relaxed and friendly atmosphere, with a semi-structured session, to collect the intended audience's ideas, viewpoints, and attitudes toward specific products. The discussion uses general guideline questions and visual prompts such as photographs to encourage participation (Esmerino et al., 2017). The implementation of **focus groups** allowed for identifying community characteristics by component (technical, economic, organizational, education, environmental, and public order). In addition, social/cultural norms were identified in group dynamics, exploring various experiences or points of view among the inhabitants participating in the activity from each village. Although focus groups were an effective research method, they also presented limitations that are important to be aware of. These are some of the evidenced

limitations of the focus group method: 1. There was concern at the beginning that the decisions or results of the activity would be the "voice" of the community, when in reality, the participants did not numerically represent the entire population, which led to a limitation in the opinions regarding the topic of adaptation to climate change, 2. Due to the free opinion method approach, some had socially acceptable opinions for fear of being judged and later shared additional information with me in private, 3. Limited generalizability: Focus group results are not generalizable to the broader population, as the sample size is usually small and the participants are self-selected.

The focus group was conducted through the **timeline** methodological tool to preliminarily diagnose the characteristics of the communities over the last ten years (2010-2020). A timeline is constructed by chronologically arranging a person's life experiences and marking essential or meaningful events with visual signals. According to the literature on visual techniques, timelines can enhance data collection and accuracy, particularly when studying sensitive subjects or groups often marginalized (Berends, 2011; Sheridan et al., 2011). Therefore, first, the instructions for the activity were given. Then, the attendees were given pieces of paper and pencils and asked to identify the positive and negative aspects of the last ten years, followed by the placement of the papers on the bulletin boards of each workshop participant. In addition, each person explained their comment; the other participants gave their opinion, and, with the guidance of the researcher, the timeline was constructed.

All components (technical, economic, organizational, educational, environmental, and public order) were explained during the participatory workshop. The importance of their identification as a means for future decision-making was mentioned. Subsequently, once the activity had been explained, the participants were given red papers for the negative aspects and green for the positive ones. They had to write down the information and place it on the billboard in the respective item. The activity ended with analyzing the current situation, how the positive aspects could be exploited, and how the identified shortcomings could be solved. The exact process was carried out in each village with an average participation of 17 people per community in each of the two participatory diagnostic workshops. The timelines enabled identifying a chronological series of significant events in the communities. However, they needed to have the scope to understand the community context in which these events had occurred, limiting the analysis and the fact that the participants needed to remember all the details of their opinions.

Subsequently, and according to the availability and interest of the inhabitants, the application of particular methods was carried out, starting with **semi-structured interviews** focused on the capital framework of the community. This method aimed to understand individual experiences better and gain a broader knowledge of the context, diving into sensitive topics, examining life histories, and identifying perspectives. Semi-structured interviews consist of a collection of critical questions covering the study area, with flexibility, while open-ended follow-up questions stimulate participants' answers (Gill et al., 2008). The semi-structured interview is a qualitative research technique frequently employed in the social sciences as an exploratory interview or for data collection. While it typically adheres to a pre-established guide or protocol centered on a central theme, providing an overall structure, the semi-structured interview also permits exploration, with the flexibility to pursue thematic trajectories that emerge during the conversation (Magaldi & Berler, 2020).

The semi-structured interviews were conducted with people who agreed to be included in the data collection during the project socialization and initial participatory diagnosis meetings. These were subsequently developed through visits to each household. The interviews lasted between 30 and 60 minutes each. The interview protocol included questions for each of the seven community capitals and a final section to clarify doubts or additional comments (Appendix A). On the other hand, regarding the method limitations, a few participants needed to be more comfortable providing personal information and were somewhat dissatisfied with the lengthy interview duration. This time factor was not only a constraint for the interviewees, but also for the researcher since progress in data collection for the two communities could have been faster and more efficient due to the multiple protocols to be used.

In addition, the same perception **surveys** on climate change (Appendix B) were carried out with closed and open questions for private and public organizations that have had or have participated in the communities. **Surveys** use a structured questionnaire to generate data and offer a simple method of gathering information. A survey helps identify a particular phenomenon's causes by examining and comparing several cases. Through survey research, the aim is to learn the causes of a particular phenomenon by examining variations in different cases and identifying other characteristics that are systematically associated with it (De Vaus & de Vaus, 2013). The organizations were selected based on the literature review, where they have historically participated in development projects in the study area, and on the results of the participatory community diagnosis, where the stakeholders considered it

essential to involve them in the project to continue or improve the support received. Four organizations were selected. The information was obtained through virtual interviews due to the COVID-19 pandemic. As a result, during the pandemic, online interviews became a valuable method for conducting research in its initial phase while maintaining social distancing. The procedure consisted of scheduling a date and time for the interview and using a videoconferencing platform, such as Zoom or Google Meet, to conduct the interview remotely. One of the advantages of online interviews was convenience and accessibility. Both for the researcher and the participants, since it was possible to make the connection without having to travel, which meant saving time and resources, especially when there was a national restriction of lockdown. However, there were limitations. Technical problems, such as a bad Internet connection or visual or audio failures on the part of the interviewees, since they were located in rural areas. Therefore, it interrupted the development of the interview. Overall, online interviews provided a solution to early research during the pandemic. However, it is essential to be aware of their limitations and the potential biases that can arise from the online environment. Respondents for each organization were chosen based on the criteria of participating in projects in the study area.

During this second phase, the individual **checklists** were applied based on fundamental human needs and gender equity (Appendix C). This method – as a quick application tool of a qualitative and quantitative nature – made it possible to address the general perception of human needs and the level of satisfaction for each person who agreed to answer the checklist. It also contributed to distinguishing between the needs and how to satisfy them in each village, considering their perception and culture so that later strategies can be created where farmers can have a dignified life with development opportunities. On the other hand, a limitation was that the depth of the analysis was focused on basic human needs by having a closed list. However, the participants provided greater detail in their responses that could not be directly recorded in the survey format. At some point during the application of the checklists, being a short tool, the number of participants was so high that it was not possible to apply it to all interested parties.

Max-Neef 1997 proposed distinguishing between needs and how to meet them in different places, cultures, and times. So that people can have dignified lives and development opportunities, Imbach (2012) modified the basic needs approach to move towards the practical adoption of development visions, leaving behind the economic vision in the rural

sector. Therefore, a checklist (Annex D) was applied in the communities to identify their basic needs.

In this particular context, an analysis was conducted to identify and understand basic human needs, which were categorized into four primary groups:

Basic needs: These encompass the essential requirements for survival, including Food, Health (personal care, disease incidence), Shelter (housing and clothing), Basic services, and Security (physical, social, legal).

Personal needs: These include Affection (family, friends), Knowledge (experience, training, education), Identity (belonging, spirituality, self-awareness), Self-esteem, and Responsibility.

Environmental needs: These encompass a Healthy environment (clean air, water, nature) and Freedom (rights and responsibilities, the ability to make decisions).

Action needs: These involve Creative and productive work, Recreation (rest and enjoyment), Participation (organization, solidarity, equity), and Communication (with others, information, transportation).

Therefore, this approach facilitated the understanding and differentiation regarding the satisfaction of human needs with households' livelihood strategies.

Afterward, **collective mapping**, based on aerial photographs taken by a drone, was implemented as a dialogue tool to have a historical description of each village. Thus, **collective mapping** is a method in which a social analysis of the geographies of the territory is promoted through a map, using graphic and playful aids that promote discussion and creation as a starting point to generate knowledge from the deep analysis of critical elements, power relations, and organizational processes, (Risler & Ares, 2018) lender's participation (Risler & Ares, 2018). However, maps are essential to collect knowledge and daily inhabitants' experiences. Therefore, collective mapping was implemented as a creative dialogue tool, which promoted participation and visual identification of community characteristics, to end with local reflections related to providing guidelines to the actors in creating adaptation measures to climate change. Moreover, it was important to work with a qualitative perspective analysis to enhance understanding of the climate-territory relationship, which involved a detailed interpretation of the material collected in the two communities.

Consequently, to apply collective mapping as a qualitative tool, base maps must be needed for the dynamic's development. In case that fails, use aerial photographs that require specialized equipment or a detailed search for their use, some of which are freely available while others require payment. The application of collective mapping made it possible to compare the results with instruments such as **participant and non-participant observation** in each village. Firstly, participant observation attempts to systematically identify the components of the observed scene and possible subcategories (Griffiths, 2008).

Furthermore, it involves the researcher immersing themselves in a culture as a member or visitor to gain an insider understanding of the culture as an active participant. Secondly, non-participant observation, on the other hand, involves observing from an outsider's perspective without interacting with the subjects of observation, allowing the researcher to gain a new understanding of the world without prevalent categorizations and evaluations. However, in some cases, direct involvement may be necessary to fully understand certain subcultures (Ciesielska et al., 2018). For both types of observation, the researcher can approach the field from an outsider's or guest's perspective while getting closer to it (Cassell et al., 2018).

However, collective mapping was based on aerial photographs a drone took due to the need for cartography. The method was implemented as a dialogue tool to have a historical description of each village. The participating social groups in each village were represented mainly by the adult population, with a minority of young people in attendance. Still, the total number of men and women was almost equal. With the help of this method, a process could be initiated to reflect jointly on one's own experiences, knowledge, existing socio-environmental problems, and possible alternatives. The method allows for improving the understanding of the local context and the relational union that sustains the historical functioning of the territory in a participatory and creative way.

The process illustrated in **Figure 5** consisted first of the conformation of the groups. A brief presentation of the members was requested; later, the objective and times of the dynamics were explained. Afterward, the aerial photographs were socialized and handed out to the participants, initially asking them to locate their homes; the next step was to explain and learn the icons' meaning and the colors' meaning. At that time, each group located icons in aerial photographs to socialize. Later, the work was carried out; this led to identifying differences between mappings, note-taking, response to concerns, and closure of the activity with the finished map.

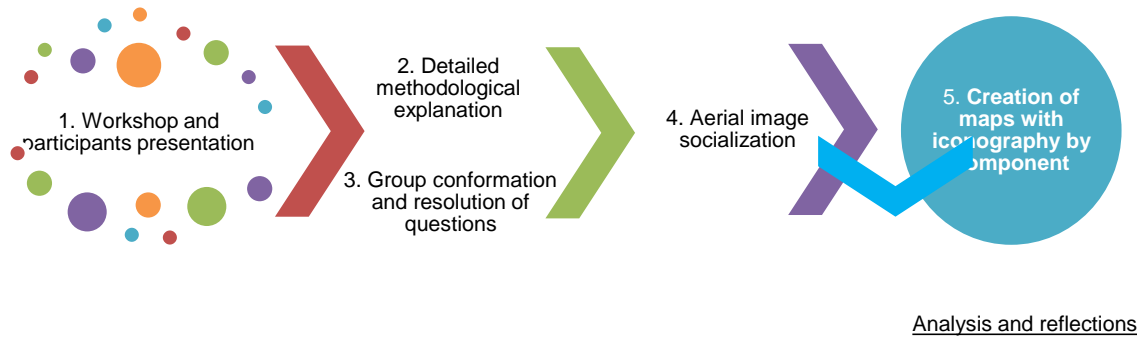


Figure 5: Collective mapping process

As a visual tool, **Figure 6** illustrates that the use of colored icons in each component favored the understanding of the activity, and the aerial photographs were striking for the inhabitants when they wanted to identify the places of interest or impact in their community.

In this context, it was crucial to develop participatory community workshops using collective maps as a dialogue tool to capture local information through participation. It became a playful instrument that motivated the population's participation. During collective mapping development, 17 people participated in the first village, 11 in the second one, people between the ages of 16 and 70, all inhabitants of the place, including farmers, homemakers, merchants, and leaders, with reasonable satisfaction in the development of the method.

Thus, collective mapping as a method to integrate local perspectives and identify community voices and diverse knowledge has focused on taking advantage of local stakeholders' knowledge of the territory and building alternatives to the potential problems identified (Laituri et al., 2023). In its application in community development, collective mapping seeks to enhance the voices of the excluded and improve the inclusion and participation of the historically marginalized (Radil & Anderson, 2019). Furthermore, Within the analysis of territorial processes, the construction of new territorial narratives of collaborative creation requires tools that promote participation and encourage reflection based on participatory dialogue (Risler & Ares, 2013).

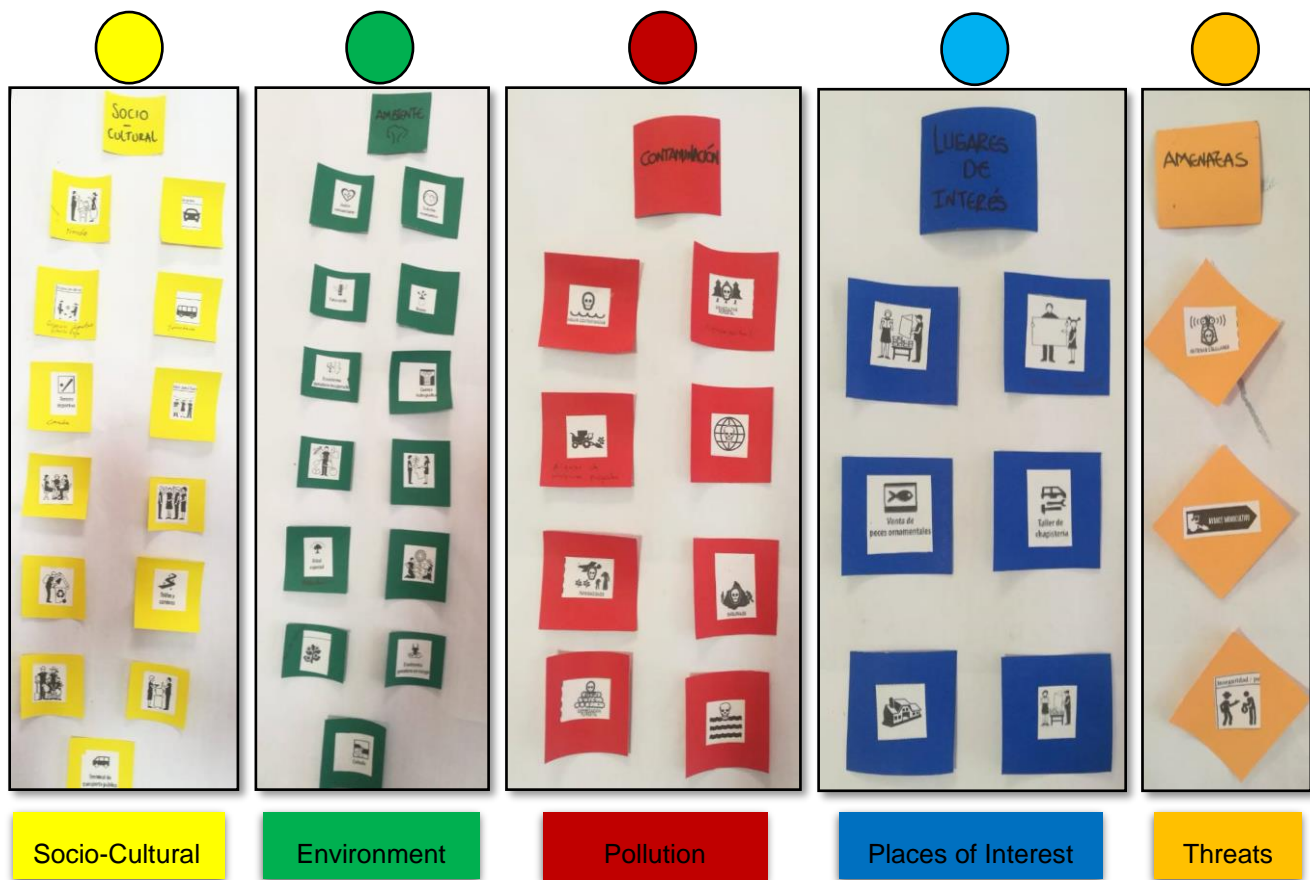


Figure 6: Components by colors in collective mapping

Consequently, there has been some research on the relationship between vulnerability and the CCF. According to Whittaker et al. (2021), vulnerability was critical in shaping the community's social, cultural, and economic capital. The study also highlighted the importance of addressing vulnerability issues to promote sustainable community development. On the other hand, another study examined the application of the CCF in the context of climate change adaptation in rural communities in Australia. The study found that vulnerability was a significant factor in determining a community's capacity to adapt to the impacts of climate change. It highlighted the need for community-based approaches that address the specific needs of vulnerable populations (Marshall et al., 2014).

While CCF is a helpful framework for understanding the resources and capacities of communities, its effectiveness in promoting sustainable development may be limited by vulnerability issues. There is a need to strengthen the analysis with the application of various qualitative methods to provide valuable insights into the experiences and perspectives of vulnerable populations, helping to inform policies and interventions that address their specific

needs and challenges and to gather information to understand community realities and thus identify climate change adaptation strategies that address the specific needs of a vulnerable population.

6.3 Vulnerability Analysis

Vulnerability analysis as a key tool for climate change adaptation in rural communities presents several approaches, i.e., the Systems Analysis approach, which considers the interactions between the different components of the system and how these interactions can influence a community's vulnerability (O'Brien et al., 2004). In addition, there is the Climate Justice approach, which identifies the social and environmental inequalities that influence a community's vulnerability (Schlosberg & Collins, 2014). The Resilience-Based approach, which considers the capacity of a community to resist, absorb, and adapt to the impacts of climate change, was also analyzed (W. N. Adger et al., 2011). In this regard, selecting the most appropriate approach according to the research objectives and the community context was necessary. Therefore, the approach based on Exposure, Sensitivity, and Adaptive Capacity was chosen for its emphasis on identifying key factors that influence the vulnerability of a community and developing appropriate livelihood-based adaptation strategies (Turner et al., 2003).

Besides that, measuring vulnerability related to climate change is a complex task requiring considering multiple factors that can contribute to vulnerability. Some approaches focus on Composite indicators (Birkmann, 2006), Climate risk assessments (IPCC, 2014), and Participatory assessments (Smit & Wandel, 2006). This last approach involves engaging with communities to understand their experiences and perceptions of vulnerability to climate change. These assessments can help to identify local priorities and strategies for adaptation.

Therefore, measuring vulnerability related to climate change requires a comprehensive and integrated approach that considers the complex and interrelated factors that contribute to vulnerability. Consequently, based on the information collected through the application of the qualitative methods described in the methodology (semi-structured interviews, climate change perception surveys, etc.), the identification of climate vulnerability in each community was carried out, prioritizing the participatory approach, assessing exposure according to the impact on livelihoods, including sensitivity to damage and lack of capacity to cope with and adapt to climate change. Therefore, the following three factors and their respective conditions

were considered to determine the level of vulnerability of livelihoods to climate change (Figure 7).

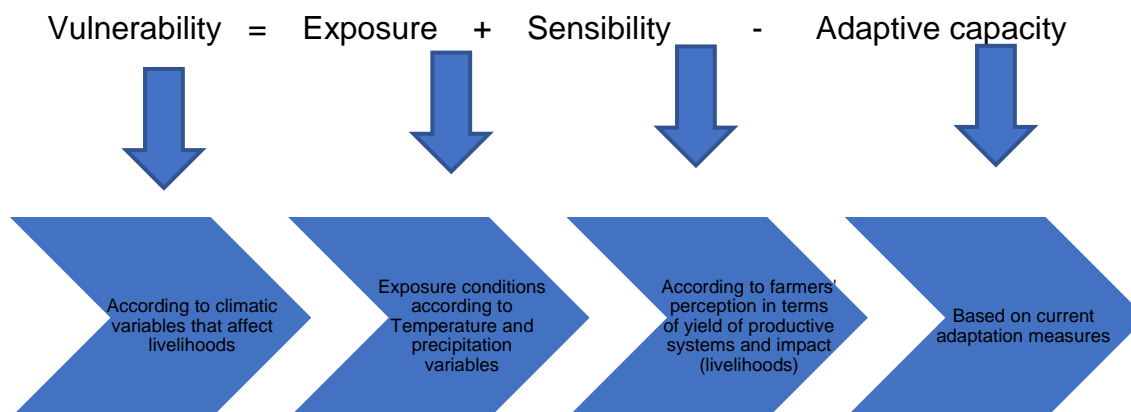


Figure 7: Determining factors for vulnerability analysis in the communities of Guayabal and Pavitas

Source: IPCC 2001, Modified

Thus, with the community capital information, through semi-structured interviews application, participatory workshops, and focus groups, the people from the communities who participated in the activities with the researcher's guidance were able to identify the main livelihoods and their relationship with climate change perception to determine exposure, moreover, which was corroborated and complemented by the application of checklists of productive systems to identify livelihood strategies and adaptation measures carried out by the inhabitants.

6.3.1 Exposure

The concept analysis of climate exposure was based on the main climatic variables that people identify with temperature and precipitation. Additionally, the factor of local perception and its influence on social events was evaluated. To illustrate this exposure criterion, colors were used: green indicated no perception of climate change, yellow represented moderate climate change, and red represented extreme climate change.

The level of exposure was evaluated through a combination of qualitative and quantitative methods, which allowed for its classification into three levels: low (1), medium (2), and high (3). The criteria utilized for this categorization are explained in detail (Table 2).

Table 2: Exposure categorization criteria

Levels	Changes according to Precipitation and Temperature	Inhabitants' perception	Risk of disruption to livelihoods
Low(1)	No change perceived	No change perceived	No change perceived
Medium(2)	Some changes	Inhabitants perceive some moderate changes in the weather.	They perceive a risk of disruption to some of their livelihoods.
High(3)	Extreme changes	Inhabitants perceive extreme weather changes	They perceive a risk of disruption to all their livelihoods.

Source: Modified from (Rios, 2010)

6.3.2 Sensitivity

To assess sensitivity in a rural context, and with the preliminary data already collected through the development of the focus groups and the perception of climate change through the perception surveys, it was possible to identify local climate trends, socioeconomic conditions, land use patterns, availability of natural resources, community perceptions of climate change, and the potential impacts of climate change on local ecosystems, agriculture, and water resources, the main objective was to involve engaging with local communities to gather information about their perceptions of climate change and their adaptive capacity. This helped to ensure that adaptation strategies are customized to the particular requirements and preferences of the community, thus increasing their likelihood of long-term effectiveness.

Therefore, based on the data's observation and to identify how the system has responded to past climate variability and how it may respond to future changes, three levels were defined based on the affectation of livelihood productivity according to climate changes: low sensitivity (1), medium sensitivity (3), and high sensitivity (5).

6.3.3 Adaptation Capacity

Concerning the adaptation criterion, as with the previous ones, it was approached qualitatively and quantitatively with a category of low adaptation (1), medium adaptation (2), and high adaptation (3). This rank scale was defined to facilitate the classification of the variables in a specific order, i.e., their relative importance, by assigning them numerical values (1, 3, and 5) that indicate their position about the others. To achieve the numerical rating, during the participatory workshops, the inhabitants were asked to identify their main productive systems and then mention what actions they carry out to face changes in the

climate (adaptation measures). Once this identification was completed, they were asked to give a numerical rating of each action's effectiveness, and the inhabitants' perception of each livelihood identified as main was considered. One of the qualification criteria was the effectiveness of adaptation measures for each livelihood according to the inhabitants.

Briefly, the result of a vulnerability evaluation in a climate change rural context, including livelihoods analysis, is a comprehensive understanding of the potential impacts of climate change on the rural community's ability to sustain their livelihoods. The community can develop strategies to adapt to climate change and build resilience.

6.4 Climatic variables analysis

Apart from the qualitative methods, a complementary analysis of climatic variables was carried out by requesting **data** from the Santander de Quilichao **weather station** for the last 24 years (1997-2020). Therefore, a database was generated with monthly information on temperature (Minimum, Average, Maximum), precipitation, solar radiation, relative humidity, year, month, altitude, and location, and subsequently to carry out a comparison of these variables versus the local climatic perception by the inhabitants and with the national data collected by IDEAM.

6.5 Participatory data interpretation methodology

This data analysis was carried out through participatory workshops, using the decision-making analysis method to determine who decides in the community, on what parameters, and what the responsibilities are. The decision-making process was developed in 6 steps: 1. Identification of the problem resulting from participatory diagnostics, 2. Definition of decision criteria, including the analysis results of community capitals, such as economic conditions, social impact, environmental sustainability, technical conditions, and potential solutions; 3. Identify options, evaluate current strategies, and assess future ones; 4. Evaluation of options according to community interests and characteristics, e.g., an irrigation system is technically possible but not economically feasible, 5. Synthesizing the results according to the options that benefit the community most, 6. Implement the chosen options, evaluate, and make adjustments to ensure their effectiveness.

Furthermore, using the brainstorming method allowed the collection of opinions from the stakeholders and decision-makers of the region according to the results socialized for the

construction of the strategies. It contributed to the integration of the communities' perspectives in regional planning. This method aims to produce numerous ideas within a brief duration, and it requires a collective effort involving a group of people who are given a problem or topic to solve and are encouraged to generate as many ideas as possible without criticism or evaluation of the ideas. The participants are free to express any ideas that come to mind, no matter how unconventional or impractical they may seem. The goal is to generate many ideas, believing that some will lead to more innovative solutions (Rizi et al., 2013). During method application with the communities, four steps were followed: Definition of the problem or topic, in this case, the perception of climate change; 2. Defining the rules reiterating that all opinions are valid and active participation is sought, mentioning that criticism or evaluation is not allowed, 3. To generate and record ideas, participants write their opinions on poster boards to be placed given everyone on the wall, and the facilitator records all contributions. 4. Evaluation of the ideas and the most promising ones are chosen for further development.

Therefore, digitized maps as an intervention method were a great help due to inhabitants' interest in this tool for decision-making and participation in calls for projects that previously had these requirements.

As outcomes of the final field trip, the results of the first empirical phases are consistently strengthened by communication with and verification by the communities involved. Furthermore, results are transferred to policymakers.

In addition, the aim was to achieve agreements and possible commitments with the institutions involved in the study area and the institutions interested in participating in the research. Furthermore, the historical data, research results, and local opinions about climate change adaptation were comparatively evaluated.

6.6 Ethical Consideration

Several ethical considerations were considered when conducting the research in rural communities. One of the main concerns was ensuring that the research was conducted respectfully, reflected the community's culture and values, considered their indigenous traditions, and would not exploit or harm the community in any way. Additionally, the participants' informed consent, confidentiality, and privacy were considered; however, through their Communal Action Board, the participants reported no problem with public information.

To address these circumstances, it was essential to carry out the research through a cooperative and participatory approach, involving community members in the research planning and implementation process based on their interests and availability. This approach helped to make the research suitable to the community's culture and pertinent to their needs. Additionally, obtaining informed consent from participants, safeguarding their privacy, and ensuring the confidentiality of their data in specific situations were crucial measures.

Another important ethical consideration was maintaining the power balance between the researcher and community members. Interventions were developed without imposing arbitrary values or decisions; the aim was to promote active participation in the research process, generating empowerment by assigning tasks such as data collection and follow-up of implemented adaptation measures.

During the project's socialization and before the protocols were applied, each interviewee was asked if they agreed to the audio recording. Additionally, the participants agreed to be acknowledged with their names if any opinion was mentioned in the doctoral thesis document. Furthermore, as a commitment, at the end of the research, a summary document in digital format will be sent to each community action board of the two communities.

In brief, having taken into account ethical considerations as a fundamental aspect of the research, prioritizing collaborative and participatory processes, as well as taking measures to protect the rights and dignity of community members, it was possible to carry out the intervention activities without losing the scientific approach and ensuring that it was ethically sound.

On the other hand, As mentioned earlier, the research was conducted in collaboration with three rural communities; however, towards the project's conclusion, one of these communities made an unexpected and collective decision concerning the impending changes in leadership within the community action board and the indigenous council. They chose to discontinue their participation. As a researcher, I consider this decision a significant ethical consideration, fully respecting the autonomy and wishes of the community.

To address this unexpected situation, the following approaches were undertaken:

- **Inclusion of General Results:** Despite the community's decision to withdraw, general results obtained during their initial involvement in the study are mentioned without

delving into specific details. These results serve as points of reference and context within the research.

- **Maintenance of Community Anonymity:** In the final document, the community that opted not to continue in the project is called the "anonymous community" to safeguard its identity.
- **Focus on Remaining Communities:** The research concentrated on the communities that remained actively engaged in the project, facilitating a more detailed analysis of their experiences and contributions.
- **Emphasis on Community Autonomy:** The document underscores the importance of respecting communities' autonomy and their ability to make informed decisions about their participation in the research.
- **Offering Future Collaboration Opportunities:** The possibility of future collaborations with the community that chose to withdraw was left open should they decide to rejoin or express interest in future projects.

This ethical and respectful approach allowed the research project to maintain its integrity while honoring the decisions and desires of the involved communities.

6.7 Positionality

This chapter explores the researcher's positionality within the study, considering the social, cultural, and personal factors that shape the researcher's perspectives, biases, and interpretations. The primary objective is to critically examine the researcher's position, recognizing and reflecting on its potential influence on the research process and the resulting outcomes.

Positionality encompasses an individual's worldview and stance towards a research task and its social and political environment. It encompasses an individual's beliefs about the nature of social reality, knowledge, what can be known about the world, and how we interact with and relate to our environment (Bahari, 2010; Holmes & Gary, 2020).

Today, several researchers have established a consensus on the importance of critically reflecting on the position of both the researcher and the researched, making this a widely accepted practice (Hopkins, 2015). Furthermore, the importance of linking reflexivity with a

broader vision of how the world should be and what changes are needed is emphasized. In this sense, researchers must reflect on their actions and the motives and ways they carry them out while considering their identity. A central aspect of participatory ethics is the degree of involvement, consultation, and participation of the various groups involved in the research (Holmes & Gary, 2020).

Therefore, considering my positionality as a researcher, originally from Santander de Quilichao and possessing a general understanding of the social context of the study, it was essential to exercise caution to avoid influencing decisions regarding what to investigate and how interpretations might be affected. However, more than merely comprehending the territory and the general issues faced by the communities was required. It was necessary to go deeper into the communities' social, cultural, and political dynamics to gain a more profound understanding of the realities farmers face and the challenges they encounter in their productive systems.

As a researcher, I also acknowledged my personal, cultural, and socioeconomic position, which could influence data collection and analysis. Being Colombian, born in Santander de Quilichao, white-skinned (not common in the communities), a middle-class adult, a researcher at the University of Hamburg in Germany, and a recipient of the DAAD and Colfuturo scholarships, I possessed relatively favorable economic conditions compared to the rural communities being studied. Furthermore, I could reflect, discuss, and write about the emotional consequences of social and environmental injustice without experiencing the same devastating emotional effects in my daily life. Therefore, it was crucial to be aware of the potential biases inherent in my position and take steps to mitigate my influence on the study.

I adopted a reflective and critical stance during data collection, consistently questioning my interpretations and preconceptions. I sought multiple sources of information and conducted interviews and observations in diverse contexts with different actors to obtain a comprehensive and objective view of the phenomena under study.

Additionally, I recognized the challenges posed by differences in cultural norms and power dynamics between the researcher and the participants. Given that indigenous communities have political structures and make decisions through consensus under their norms, particular emphasis was placed on establishing effective communication mechanisms to understand the participants' perspectives and experiences.

This reflective and positionality-aware approach facilitated engagement with research participants, establishing trust over four years (2019-2023), creating a close relationship, and fostering a safe space for open and honest dialogue. Active listening to participants' perspectives and experiences validated their voices, ensuring their knowledge and viewpoints were central to the research process. This approach enabled the collection of meaningful data and enriched the understanding of the issues addressed in the study.

Furthermore, special attention was paid to ethical considerations concerning power differentials between the investigator and the participants. The importance of informed consent was emphasized, and participants' autonomy was promoted to ensure they could make free and voluntary decisions about their involvement in the study. It is worth noting that 14 communities chose not to participate in the study, indicating a commitment to respecting and safeguarding the rights and dignity of the participants from the outset.

In summary, this qualitative study employed participatory methods, with local actors playing a fundamental role in understanding the dynamics of the territory. However, they faced skepticism and rejection that often accompany the presence of researchers pursuing different objectives. To address this, realistic, sincere, and critical communication was established, clarifying that the goal was to identify climate change-related issues and work together with the community to explore adaptation alternatives that could improve the living conditions of farmers. Local knowledge and the individual and collective experiences of these populations were highly valued, while the researcher's guidance aimed to avoid promising direct economic support to the communities.

It is important to emphasize that this study only solved some problems or answered all questions, as some communities may have initially expected. Instead, the aim was to recognize new questions and foster spaces for debate around the issues faced by the involved communities, highlighting the significance of adaptive and participatory approaches to climate change adaptation rather than providing definitive solutions.

Finally, it is essential to acknowledge the limitations of the study. Despite implementing measures to address the researcher's position, eliminating the researcher's influence on the research was not feasible. Therefore, a reflective and self-critical stance was maintained, openly discussing the limitations, including resource and time constraints, limited access to information, the challenges of conducting research during the COVID-19 pandemic, and the

initial skepticism encountered by 14 communities during the initial socialization phase. Additional measures such as expert consultation, mixed methodologies, and peer review were employed to enhance the integrity and quality of the results and ensure that the researcher's perspective and knowledge did not bias the interpretation of the data.

7 Results and discussions

This chapter comprehensively analyzes rural communities' perception, vulnerability, and adaptation strategies in the Colombian municipality of Santander de Quilichao. The chapter begins with an overview of the methods and results obtained, followed by a detailed analysis of the climatic variables of the study area. The findings of the capitals of each community are also highlighted here, along with an analysis of the vulnerability. This section also focuses on the specific challenges that communities face due to the impacts of climate change, as well as the need to apply adaptation strategies in productive systems to make them more resistant to climate variability. The study is a unique research that combines perception, vulnerability, and adaptation in a rural area of Colombia, and its conclusions will help us better understand climate change in the area.

Understanding the structure of the results is fundamental to analyzing vulnerability in rural communities in the context of climate change adaptation. Therefore, **Table 3** provides valuable insights into the interconnections, patterns, and dependencies that shape the vulnerability landscape concerning the research methods. By examining structural aspects of the results, such as relationships between variables, distribution of impacts, and spatio-temporal dynamics, a deeper understanding of the underlying factors contributing to vulnerability can be obtained.

These results were relevant for vulnerability analysis as they provided a comprehensive understanding of how climate factors, local perceptions, historical context, and livelihoods combined to influence communities' vulnerability. This understanding was crucial for developing effective strategies for climate change adaptation, prioritizing resources, and mitigating the risk of negative impacts on people's livelihoods.

Table 3: Importance of Results for Vulnerability Analysis

Result	Importance in Vulnerability Analysis
Analysis of Climate Variables	This analysis was fundamental in understanding the region's past and future climate patterns. It allowed the identification of significant changes in climate variables, such as higher temperatures, irregular precipitation, or increased frequency of extreme events. These findings helped evaluate how climate could impact community vulnerability.
Database Elaboration of Climate Variables	Creating a database linking climate data with local perceptions enabled a more accurate vulnerability assessment. By comparing objective data with the community's subjective perceptions, the gap between climate reality and community risk perception could be identified, which was essential for designing effective adaptation strategies.
Analysis of Climate Behavior	This analysis involved a comparative examination of historical climate data, IDEAM data, and scenario projections. A comprehensive understanding of climate behavior and its alignment or divergence with local perceptions was achieved by juxtaposing objective climate information with community perceptions. This was crucial to determining community perceptions' accuracy and relevance in assessing vulnerability.
Participatory Historical Community Diagnosis	Understanding the social, economic, environmental, and historical factors that had influenced the community's current vulnerability was critical. This diagnosis enabled the identification of strengths and weaknesses regarding climate-related challenges and shed light on how historical changes had impacted the community's adaptive capacity. It provided a contextual framework for analyzing vulnerability and identifying key areas for action.
Livelihood Diagnosis and Strategies	Diagnosing community livelihoods and their strategies for coping with climate risks was essential. It helped identify the resources, skills, and assets available to the community and the strategies that had proven effective in the past. This assessment helped evaluate adaptive capacity and identify opportunities to enhance existing livelihoods or develop new approaches to improve resilience to climate-related challenges.
Vulnerability Analysis	The vulnerability analysis enabled the identification of impacts, climate risks, and the overall level of vulnerability within community livelihoods. A comprehensive assessment of vulnerability could be conducted by considering exposure to climate risks, the sensitivity of livelihoods, and adaptive capacity. This analysis helped prioritize adaptation measures and mitigate risks associated with climate change, safeguarding livelihoods and community well-being.

7.1 Rural communities Guayabal and Pavitas

The two rural communities are located in the eastern part of Santander de Quilichao, north of the department of Cauca, in the upper part of the Munchique hill, which has historically been the municipality's water supply source.

Community organization in the region is based on the structures of the Canoas indigenous cabildos, which represent the communities of Pavitas, and the Munchique Los Tigres cabildo, which covers the Guayabal village. These local government structures play a fundamental role in decision-making and management of community affairs. The population in these areas is mostly composed of indigenous communities, who preserve and practice their cultural

traditions and ancestral ways of life. However, mestizo settlers have also established ties with the indigenous communities.

The predominant economic activities in these communities are agriculture and livestock. Agriculture is carried out on small family plots, where various agricultural products are grown as subsistence crops (corn, beans, yucca) and market products (coffee, bananas, fruits). These traditional agricultural practices are rooted in the ancestral knowledge of the indigenous communities and are characterized by respect for the land and biodiversity.

In particular, coffee has been an economic and cultural engine in Cauca and Colombia, especially in rural areas. The country stands out for the quality of its coffee and its role as a world producer and exporter. Small coffee growers, known as "cafeteros," cultivate coffee on family farms using traditional methods. This activity has generated employment, income, and roots in rural communities. However, it faces challenges such as price fluctuations, diseases, pests, and the impact of climate change.

Livestock also plays an important role in the local economy. Families own small farms where they raise cattle and pigs, which provides them with an additional source of food and income generation.

Furthermore, a comprehensive analysis was conducted that encompassed not only local perceptions but also the viewpoints of external organizations that influence the communities of Guayabal and Pavitas. The main objective was to assess the state of intervention and understand both the local perspective and the perspectives of external actors on climate change in these communities.

7.2 Guayabal characterization

The village Guayabal is located in the eastern rural zone of Santander de Quilichao (**Figure 8**), belongs to the indigenous territory of Munchique Los Tigres, and is in the area of influence of the Munchique natural reserve. The population is mostly peasant and, to a lesser extent, indigenous, with 100 families representing approximately 400 people, altitude between 1.500 and 1.700 above sea level in the influence of the micro-basin of the Quilichao River, with agricultural and livestock vocation.

The Guayabal region, located within the Quilichao River micro-watershed in the Cauca department, is part of an Andean forest ecosystem, as defined in the IDEAM ecosystem classification (2001). According to the 2010 Watershed Management Plan (POMCH), two bioclimatic floors are identified in this area according to the Calda-Lang classification: Temperate-Humid and Cold-Humid. These floors are characterized by average temperatures between 17 and 24°C and an average annual precipitation of around 1900 mm.



Figure 8: Political map of Guayabal village

Source: Modified from OpenStreetMap

The Guayabal community has worked hard to strengthen its territory and authority, facing various challenges such as colonization movements linked to armed conflicts, forced displacements, territorial invasions, and the intervention of armed groups, among other events that have shaped its evolution. An example of these changes is the deforestation and contamination of the Quilichao River micro-watershed. These actions have significantly impacted ways of life and community spaces, altering cultural values within the Munchique

los Tigres reservation and affecting perceptions regarding the use and conservation of water, land, and other natural resources among the area's inhabitants.

Guayabal is diverse and multicultural due to the coexistence and interaction of ethnically differentiated communities and people. There are indigenous, peasant, and mestizo populations and, to a lesser extent, Afro-descendants. Its organizational structure is based on the Juntas de Acción Comunal (JAC), a common organizational structure in Colombia. The JACs are citizen participation entities representing the community and promoting local development. In Guayabal, the JACs are central to decision-making and community affairs management. These boards are composed of members democratically elected by the community. They are responsible for promoting projects and programs that benefit the community in different areas, such as education, health, infrastructure, and the environment. The JACs also facilitate communication between the community and local authorities, promoting citizen participation and considering the community's general interests. Through their organizational structure, Guayabal's Community Action Boards encourage the active participation of community members and strengthen the sense of belonging and collaboration among the inhabitants.

In Guayabal, the community is also integrated into higher-level political structures, such as the indigenous cabildo, the municipality of Santander de Quilichao through the municipal mayor's office and the department of Cauca through the Governor's office. These bodies represent broader levels of government and play an important role in making decisions that affect the Guayabal community. The indigenous cabildo, in particular, is an autonomous institution representing the interests and rights of the local indigenous population. The cabildo promotes community participation and governance through its organizational structure, safeguarding the community's traditions and cultural values. The municipal mayor's office is the local entity that administers governmental affairs at the municipal level, providing services and programs to the community. The Cauca governor's office is the highest political entity responsible for coordinating and executing the department's regional policies and development programs. Political integration in these higher-level structures allows the voice and needs of the community of Guayabal to be represented in decisions and policies at the municipal and departmental levels, thus contributing to its socioeconomic development and the well-being of its inhabitants.

The community of Guayabal is characterized as a rural community located in a natural and agricultural environment. Its inhabitants mainly engage in agricultural activities, with coffee and bananas being the most representative and economically important crops. The community is closely linked to the land and its natural resources, depending on them for subsistence and income generation. In addition, community members identify with their traditions and cultural values rooted in history and the rural environment. There are ties of solidarity and cooperation among the inhabitants, reflected in the community organization and the joint search for solutions to their challenges.

7.3 Pavitas characterization

Pavitas is located in the eastern rural zone of Santander de Quilichao (**Figure 9**). It belongs to the Canoas indigenous territory, with a peasant and indigenous population, at an altitude between 1.400 and 1.600 meters above sea level, under the influence of the Quilichao River micro-basin, with agricultural and livestock vocation. In the Pavitas village, there are pastures for livestock and intervened forest and natural forest ecosystems that correspond to the natural reserve of the Canoas reservation and the municipality of Santander de Quilichao (Cauca), whose vegetation is located at an altitude that ranges between 1400 and 1600 meters above sea level, bordering the Guayabal village.

Mapa Político Vereda Pavitas

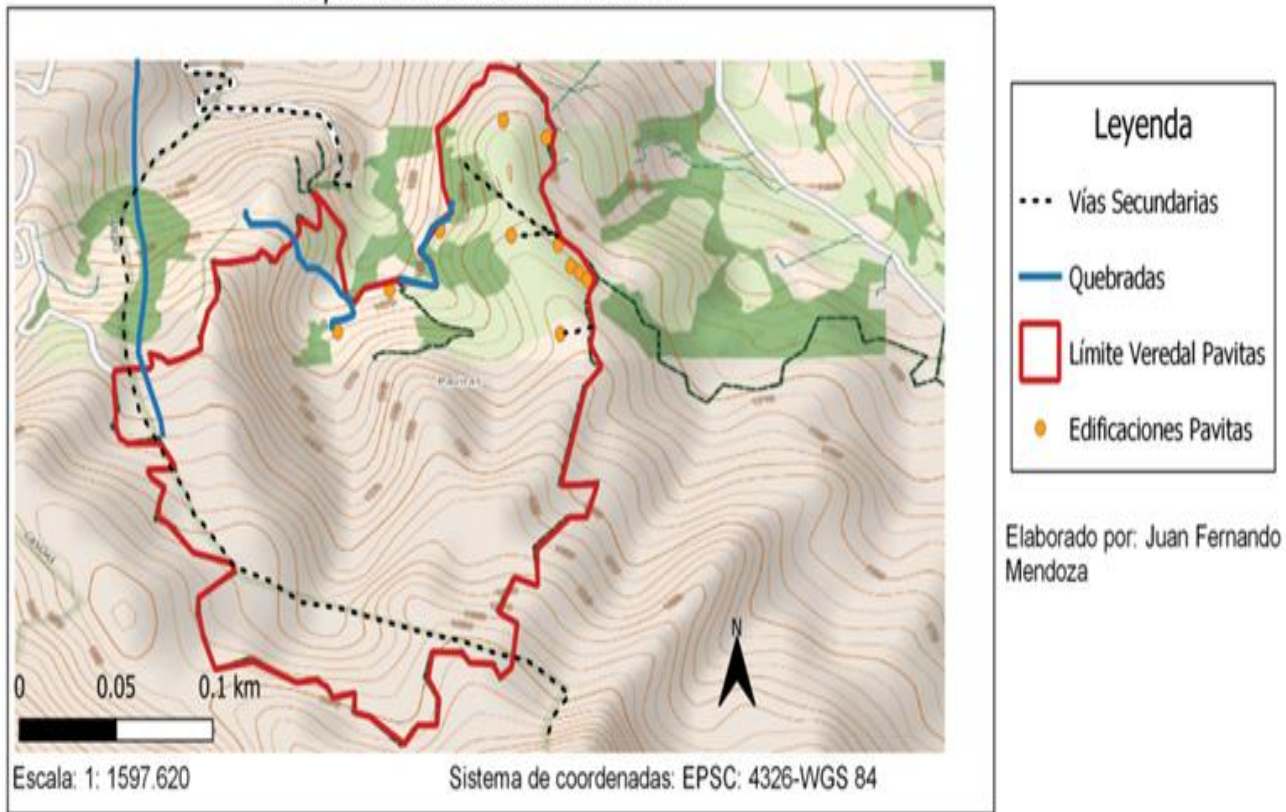


Figure 9. Political map of Pavitas village

Source: Modified from OpenStreetMap

Pavitas is in a mountainous area close to the Munchique reserve, giving it significant natural wealth and biodiversity. Unlike Guayabal, Pavitas has a greater presence of productive livestock systems, implying greater community activity. These livestock systems are in addition to the traditional crops of coffee, plantain, yucca, corn, and fruit trees, which are the community's economic base. Vegetables are also grown for both commercialization and home consumption, although to a lesser extent.

The Pavitas community is experiencing changes in its territory. Examples of these changes are the presence of religious groups in the village, the intensive use of agrochemicals, and the migration of the young population. These actions have significantly impacted the ways of life and community spaces, altering the cultural values within the Canoas reservation and modifying the traditional agricultural land use with annual and transitory crops.

The population of Pavitas is mostly indigenous, although there are also mestizos in the community. This cultural diversity enriches the social fabric and encourages interaction

between ethnic groups. Pavitas preserves its cultural heritage and deep-rooted traditions through its customs, festivities, and sporting events, which are shared and celebrated in various community events.

Pavitas belongs to the Canoas indigenous cabildo, which highlights its indigenous cultural identity and the importance of its participation in the political and administrative sphere. The political and governmental structure of the village is based on the community action board and the cabildo, which implies a participatory and autonomous community organization in decision-making. This political structure also includes the presence of the mayor's office of Santander de Quilichao and the Cauca governor's office, which allows for community representation and participation at different levels of government. The participation of both men and women in decision-making and community life is valued and promoted.

Collaboration and solidarity are fundamental values at Pavitas. Activities characterize the community through working together on community projects, sharing knowledge and resources, and strengthening social cohesion. Despite the community's efforts, Pavitas faces challenges regarding access to basic services, such as needing potable water, unstable electricity, and unstable communications, such as cellular signals.

7.4 Perception of climate change by external organizations

This holistic approach allowed for a comprehensive understanding of the dynamics and challenges related to climate change, considering multiple perspectives and seeking synergies for more effective and sustainable interventions.

Therefore, four surveys were conducted with organizations (Unicomfacauca, Corporación Autónoma Regional del Cauca-CRC, Fundación prociencia Quilichao, Secretaria desarrollo social, económico y Medio Ambiente) with active participation in the area, obtaining the following results: 90% have observed changes in the climate, including changes in temperature, floods, droughts and rains at different times of the year.

Climate has changed because of greenhouse gases and deforestation in the Munchique natural reserve zone, which used to be cold and is now warm. All of this has influenced the reduced availability of water in the Quilichao River micro-watershed, which affects not only the rural sector but also the availability of water for the aqueduct in the municipality of Santander de Quilichao, in addition to the evident changes in the rainy and summer seasons.

Unicomfacauca

Unicomfacauca, as a private institution of higher education aiming to contribute to economic and social development and prepare professionals suitable for various organizational and entrepreneurial contexts, holds a position in the northern region of the Cauca department. This is achieved through involvement in research and social outreach projects to foster the region's economic and social development.

Unicomfacauca participates in decision-making processes but more as a proactive actor rather than from a position of power about the communities. As a result, there is a strong relationship between the community and the university. Additionally, many students come from rural areas, allowing them to better understand real-life contexts from an academic perspective in collaboration with the productive sector.

The director of the Agroenvironmental Engineering program, Ever Martínez, answered the interview, and through academic projects, the Unicomfacauca University is present in the area, especially in the Guayabal village. During the time they have been involved (approximately 15 years), they believe there have been changes in the climate, evidenced by a more significant presence of floods, droughts, and rains due to greenhouse gases and notably higher temperatures compared to previous years.

As an external organization, it does feel threatened, not only by being unable to carry out academic projects due to extreme weather conditions. The conditions also show how food sovereignty is threatened, food cannot be grown as planned, and no fixed employment source meets the farmers' basic needs. For example, concerning health, the proliferation of diseases during winter is more significant, with farmers suffering from respiratory and gastrointestinal illnesses.

In terms of natural resources, the quality and quantity of water due to the El Niño phenomenon reduces the flow of water sources, as in the case of the Quilichao River micro-basin. On the other hand, during the rainy season (La Niña phenomenon), much water causes flooding, in addition to the production of contamination because there is a greater presence of dissolved solids and waste. Therefore, both extremes currently generate problems in the communities. In terms of soil resources, during periods of drought, the soil is

severely affected; there is no effective production, and there is erosion and burns that directly affect soil quality with the loss of nutrients and microorganisms.

Related to physical capital, for Unicomfauca, it is clear the emphasis is on two periods (dry-rainy), especially in higher rainfall, the roads and access roads to the villages that had been repaired by the community with its resources but not by the state are affected. As for the water distribution systems, since there are no aqueducts, there is no water treatment and high turbidity levels due to the high presence of sediments and palisades, which sometimes means there is no access to water for household consumption.

In economic aspects, credits and production depend on climatic phenomena, but this does not mean that banks will or will not grant credits due to climatic variations. In these cases, the farmer must ensure production to pay the credits because he will not have 100% of the expected production; however, due to climatic variability and the uncertainty of production results, many farmers decide to refrain from requesting loans from banks. On the other hand, social relations have been strengthened to some extent because communities have become aware of the need to work together to adapt to climate change.

Regarding public organizations' presence, Unicomfauca believes the project's execution is not always carried out on time, either because of the difficulty of access to communities due to roads state during the rainy season or because of flooding in the houses, which prevents them from participating in the meetings convened.

At the cultural level, climate changes, with the “El Niño” and “La Niña” phenomena, affect the popular organizations' beliefs; they still have their beliefs. However, the peasants focus more on current phenomena because the rainy seasons are no longer well-defined. Moreover, the young population is more uncertain than adults due to the same changes in the rainy seasons. Therefore, they choose current technologies such as weather forecasts.

Finally, for Unicomfauca, it is crucial to implement strategies to adapt to climate change to help reduce the territories' vulnerability concerning this phenomenon affecting development processes.

Corporación Autónoma Regional del Cauca-CRC (Environmental Authority)

The Regional Autonomous Corporation of Cauca-CRC is an autonomous public entity operating in the Cauca region, Colombia. Its position in the region lies in its role as an entity

responsible for environmental management and protecting natural resources in the Cauca department. The CRC is integrated into the department's and the country's institutional structure as an autonomous public entity responsible for decision-making and the execution of programs related to environmental management and the protection of natural resources.

The CRC holds significant authority regarding managing and regulating the environment and natural resources within its area of influence. It can make decisions related to the implementation of environmental policies and regulations, as well as the execution of programs and projects aimed at the conservation and protection of the natural environment, responded Francy Gómez, the director of the CRC Northern Zone.

The CRC engages with communities through participation and citizen consultation processes on environmental issues. Additionally, it works closely with other local stakeholders, such as communities, municipal and departmental authorities, non-governmental organizations, and other interested sectors, to address environmental issues and promote sustainability in the Cauca region. The CRC seeks to involve communities in decision-making related to environmental management and foster environmental awareness in the region.

The departmental environmental authority is responsible for controlling and enforcing environmental laws and regulations in the territory and, in turn, promotes the care and protection of the environment. In this sense, in its intervention processes, it believes that it has witnessed changes in climate in recent years, mainly in the increase in temperature, being climate change a global issue, what happens on the planet with this phenomenon is also evident in local changes as in the area of Munchique. Therefore, they are trying to implement the reforestation process, seeking habitat restoration; however, these temperature changes affect the growth of trees. Before the climate was temperate, it was warm.

These conditions also affect nearby municipalities, as is the case of Santander de Quilichao; a few years ago, there was a drought that affected the entire municipality, and there was the need to carry out water reasoning, which implied not having access to the resource daily since the summer season affected the micro-basin of the Quilichao River.

Consequently, the micro-basin condition means that in drought times, the river flows decrease considerably, there is a threat, generating problems with the water availability from the municipal aqueduct for the necessary supply flow, and in winter, there are torrential

downpours, also affecting the urban area because there is no technology to continue functioning when there is excess sediment and palisades.

Regarding the effectiveness of the environmental authority and its presence in the communities, he states that it is challenging to be effective because they must cover the entire department and can only sometimes meet the established schedules. However, it is clear that there is a greater awareness of climate change and how farmers are affected; therefore, it is necessary to continue with control and follow-up processes that involve climate change adaptation strategies.

Procuencia Rio Quilichao Watershed Foundation

The foundation operates as part of the Santander de Quilichao Water and Sewage Utility Company, Emquilichao ESP, and was established to safeguard the water supply source in the municipality and implement conservation initiatives. This organization possesses the authority to influence decisions and exercise control over the protection of the watershed. It is empowered to make determinations concerning implementing environmental programs and projects to preserve and safeguard the natural environment.

The Forestry Engineer, Marden Jaramillo, the person in charge of the Foundation at the time of the survey, provided the following information. The foundation actively engages with the local communities through various participation and citizen consultation processes on environmental matters. Furthermore, it collaborates closely with other key local stakeholders, including the communities, municipal and departmental authorities, non-governmental organizations, and other interested sectors. The foundation addresses various environmental issues through these partnerships and advances regional sustainability. The foundation's approach prioritizes communities' involvement in environmental management decision-making while promoting environmental awareness.

In addition, soil quality has declined despite being a highly productive area with various crops. Currently, the pressure on the resources is more significant. It is partly due to the increased application of agrochemicals and the increased discharge of gray water directly into the soil.

In terms of physical capital, municipal government interventions have increased the adequacy of the roads. However, due to the constant and heavy rains, intervention is required in

different rural sectors of the municipality, and machinery is only sometimes available, which delays the interventions for the adequacy of the roads.

Currently, it is a challenge for producers. Productive projects are affected by climate variation in planting planning; climatic uncertainty generally causes projects not to give the expected results, and the schedules are altered to fail to meet the objectives set. Hence, it is important to contribute to creating strategies for adaptation to climate change to promote development and reduce farmers' vulnerability to this phenomenon.

Secretariat of social, economic, and environmental development

The Secretariat of Social, Economic, and Environmental Development functions as a department within the municipal government of Santander. This secretariat is crucial in working with rural communities, primarily focusing on capacity building and executing various productive projects that significantly impact these areas.

The following information was obtained from the survey with Engineer Jairo Vernaza. The secretariat may be involved in capacity strengthening, productive projects, socioeconomic development, and environmental initiatives to support local communities. The Secretariat of Social, Economic, and Environmental Development is instrumental in driving progress and development in the rural areas under its jurisdiction. It serves as a key link between local communities and the municipal government, working to address these regions' unique needs and challenges.

This secretariat is an agency of the Santander municipal mayor's office, impacting rural communities by strengthening local capacities and implementing productive projects. Therefore, throughout the years of intervention, they ensured that there had been changes in the climate, which were evident by the increase in rainfall, the presence of floods, droughts, and increases in temperature. They consider that the local causes are multiple; they have to do with land use, which has become intensive, expansion of the agricultural frontier, and deforestation. Moreover, at a general or global level, what is known as fossil fuels and CO₂ use.

Currently, there are changes in the frequency of rainfall. Years ago, there was a bimodal period, i.e., two rainy seasons; the first occurred between April and May, and the second from October to November; meanwhile, the dry periods included one between January and

February and the other between July and August. However, it has changed; there have been more than six months of droughts or the opposite phenomenon with prolonged rainfall or drought times.

Whether or not it feels threatened as a public institution, they consider it pretty threatened. Therefore, it is necessary to adapt and mitigate the impacts, promote spaces for training, generate research, and search for allies to generate strategies to disseminate information in the communities for sustainable project development. The projects also support the improvement of health conditions in the population suffering from respiratory diseases and the proliferation of viruses that affect the respiratory system.

According to the secretary, communities' natural capital has been affected in the sense that although there is good forest cover. In the reserve zone, the quality of the water in the middle and lower parts has decreased due to soil washing and agricultural activities (direct liquid pollutants into the river), and in turn, the quality of the water sources that used to have more flow in the past. Furthermore, this pressure generated by intensive agriculture and soil washing, in the context of global warming, means that the soil is more exposed to solar radiation, which influences the development of microorganisms in the soil and transforms it into less productive land with a decrease in nutrients.

Like the other organizations interviewed, another point to mention is the impact on roads. They agree that landslides impact and damage the road in heavy rains due to landslides and earth slopes. Additionally, floods have caused damage to agricultural production due to excess moisture; in the livestock sector, the overflowing of rivers affects fish farming systems, reeds, and bread crops. In summer, fires affect crops, forest areas, and homes; intense drought causes problems for crops because there are no irrigation districts.

Regarding the economic factor, the secretary recognizes the difficulty of accessing bank loans because most are small-scale producers. Therefore, they support the technical concept of accessing credit or refinance. In addition, they recognize that there is slight aid for the area and that access to resources from the national and departmental government needs to be improved.

Finally, the secretary identifies that, due to climate change, communities have had to change some of their traditional practices. In rural extension, the secretariat has had to work hard to

implement new cultural practices to complement the agricultural theme, be friendly to the environment, promote a change in environmental education and culture, respecting, for example, the current beliefs in the cycles of the moon. However, they maintain that the lunar calendar could be more effective today, leading to rethinking these new climate change phenomena.

7.5 Climate change variables in the research area

To evaluate the information collected in the communities, historical meteorological data from IDEAM, based on the historical temperature series analysis (

Figure 10), indicates a trend of increasing temperatures in the national territory (red dots), which means that days will be warmer (IDEAM, 2011). On the other hand, according to IDEAM et al., 2015 in the new climate scenarios for Colombia study, it is projected that for the period 2071 - 2100, there will be an increase in precipitation levels between 10 to 30% in about 14% of the national territory, including the department of Cauca. These increases in rainfall could increase the possibility of landslides, damage to rural aqueducts, and damage to road infrastructure in mountain areas.

Data from the Santander de Quilichao meteorological station for the period 1997-2020 (23 years) show changes in precipitation and temperature (**Figure 11**), which coincides with the perception of the inhabitants of the two communities.

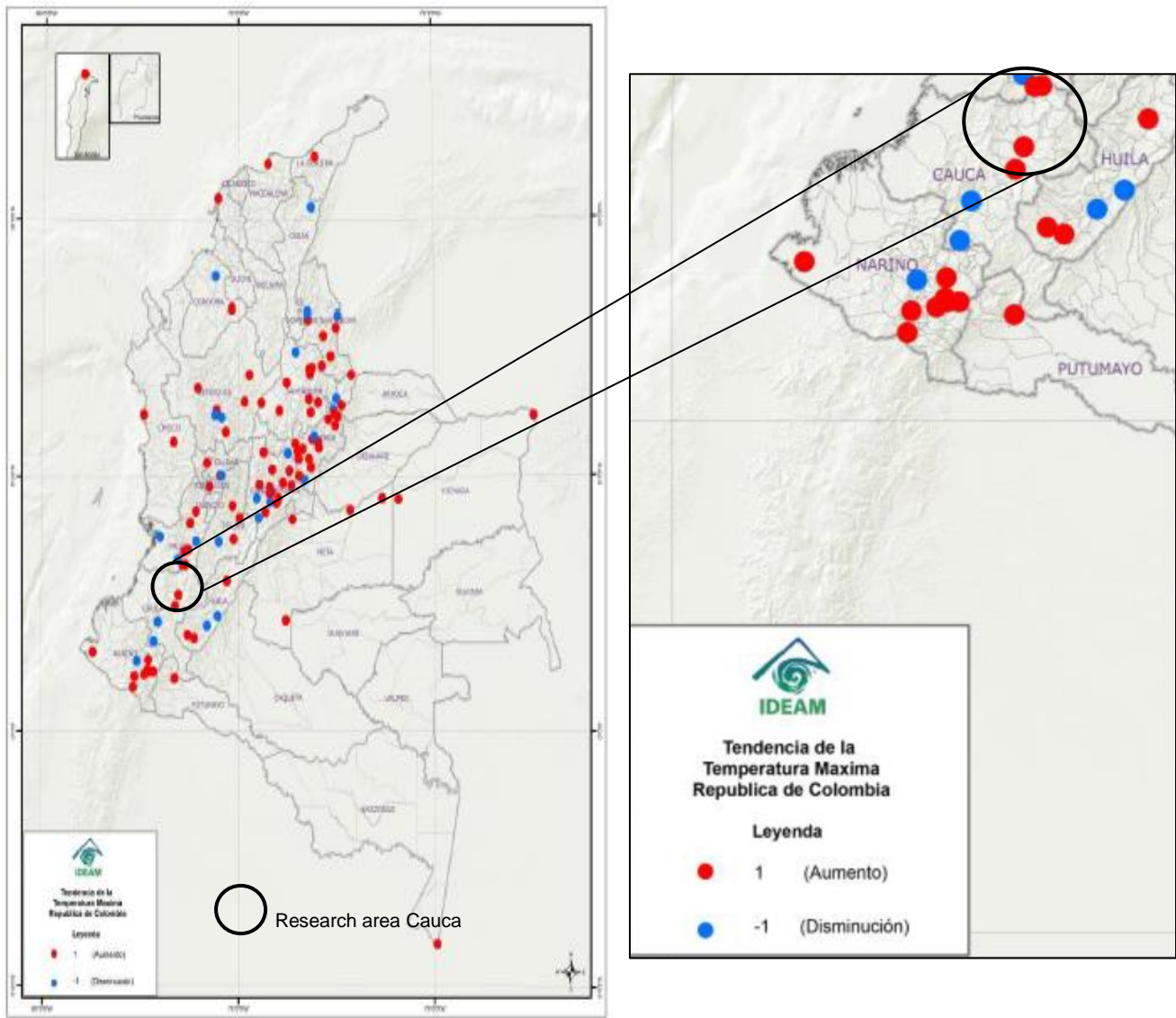


Figure 10: Maximum temperature tendency indicator

Source: IDEAM, 2014

According to data from the meteorological station of Santander de Quilichao, the average temperature between 1997 and 2020 (23 years) exhibits an upward trend, with the highest average values in the years 2015 and 2016 with 23.9°C and concerning the value of the year 2011 where the lowest average value 21.9°C was recorded (Figure 11).

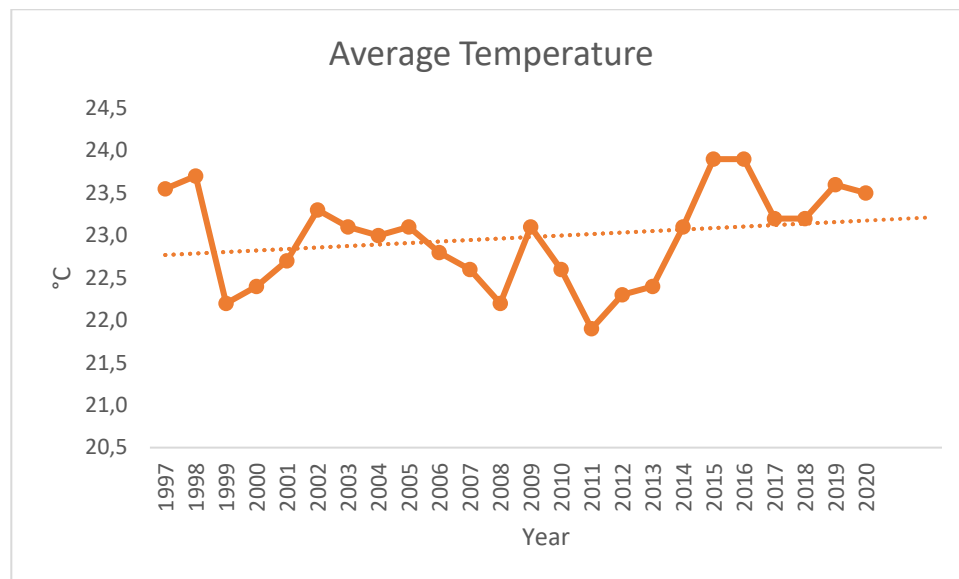


Figure 11: Historical average temperature meteorological station SQ

Source: Cenicafía, 2021.

The comparison of mean temperature levels over two decades, as presented in **(Table 4)**, reveals a difference of up to $+0.2^{\circ}\text{C}$ when comparing the 1997-2008 decade to the 2009-2019 decade. While this 0.2 degree Celsius difference may appear relatively small at first glance, its significance and implications warrant careful consideration.

Firstly, it is important to note that a 0.2°C change can substantially impact climate and natural systems. Although seemingly modest, alterations in the global mean temperature can trigger a cascade of secondary effects, including rising sea levels, shifts in precipitation patterns, and the intensification of extreme weather events such as heatwaves, droughts, and floods (Altieri & Nicholls, 2008). Consequently, even a 0.2°C increase can contribute to disturbances within climate systems, yielding adverse consequences.

Furthermore, for contextualization, it is crucial to recognize that international agreements, such as the Paris Agreement, aim to limit the global temperature increase to well below two $^{\circ}\text{C}$ relative to pre-industrial levels, with a preference to keep it below 1.5°C (UNFCCC, 2015). Within this framework, a 0.2°C rise over a mere two decades signifies a concerning trend toward higher levels of global warming.

Hence, while 0.2°C may seem relatively minor in absolute terms, its impact on the climate and environment is substantial. This underscores the urgency of implementing measures to

curtail greenhouse gas emissions and address climate change before its effects become more pronounced.

Table 4: Difference in temperature per decade

Period	The average temperature in the decade (°C)	Difference between decades
1997-2008	22,8	
2009-2019	23,0	+0,2

Regarding the precipitation values obtained from the meteorological station of Santander de Quilichao between 1997 and 2020 (23 years), the maximum precipitation averages show an upward trend but with constant changes.

Between 2000 and 2004, a downward trend was observed, followed by an increase above average until 2008. Finally, after a period without remarkable increases in precipitation between 2007 and 2010, there was an increase in pluviosity between 2011 and 2020. This situation coincides with locals' perception of the two communities' unpredictability and increased pluviosity throughout the year (**Figure 12**) (see the chapter about Climate Change Effects from local actors' perspective).

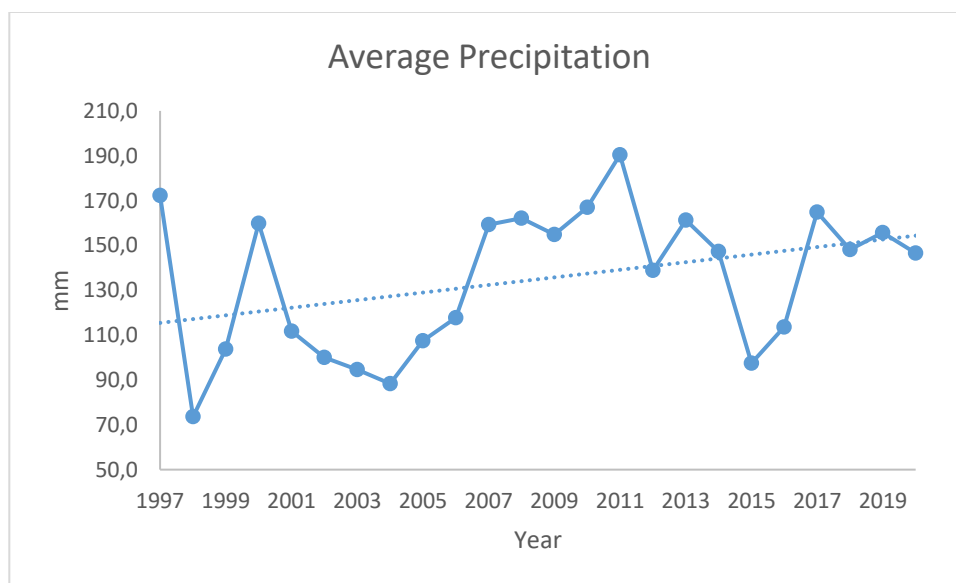


Figure 12: Historical average precipitation meteorological station SQ

Source: Cenicafña, 2021

An analysis of total precipitation shows the behavior of this parameter during the 23 years (1997-2020), which is about the year of highest to the lowest precipitation (**Table 6**). Also, a

comparative precipitation analysis between 1997-2020 (**Table 5**). In the initial years, it is observed that the amount of precipitation varies, with some years having lower levels, as seen in 1997 and 1998. However, 2000 stands out as an exception, with significantly high precipitation. A notable aspect of the decade spanning from 2008 to 2018 was that a significant increase in precipitation occurred, with an accumulated difference of +446.15 mm compared to the first decade (1997-2007). This indicates a pattern of rising precipitation during those years.

Thus, **Table 5** demonstrates that, while there were annual fluctuations in the amount of precipitation in Santander de Quilichao, a substantial increase was observed in the decade from 2008 to 2018, implying a noteworthy shift in precipitation patterns in the region. This data analysis is crucial for understanding local climate trends and can be valuable for decision-making in managing water resources and agriculture in the area. This information also refers to the perception of producers when they mention that it is currently raining more, but there is no certainty as to when this will happen.

Therefore, such an increase in precipitation is significant for a region like Santander de Quilichao, characterized by its specific climate and geographical features, typically experiencing a tropical rainforest climate. The amount of additional precipitation (446.15 mm) over a decade can have profound implications, given the region's reliance on agriculture and potential susceptibility to extreme weather events. This change can impact local agriculture, water resources, and ecosystem dynamics.

The perception of local producers that it is raining more aligns with the observed increase in precipitation. This perception often reflects the day-to-day experiences of those closely connected to the land and agricultural activities. However, it is crucial to acknowledge that while there has been an observed increase, climate variability can lead to fluctuations in precipitation patterns. Therefore, long-term planning and adaptation strategies are essential to effectively manage and make the most of this increased rainfall.

Table 5: Total precipitation vs. order precipitation by year

	Year	Total Precipitation	Highest to lowest	Year order
1	1997	688,9	2284,6	2011
2	1998	736,1	2004	2010
3	1999	1245,9	1978,4	2017
4	2000	1918,3	1968,2	2019
5	2001	1341,3	1935,2	2013
6	2002	1201,4	1918,3	2000
7	2003	1135,3	1911,1	2007
8	2004	1060,6	1859,3	2009
9	2005	1290,2	1778,6	2018
10	2006	1414,1	1767,5	2014
11	2007	1911,1	1759,5	2020
12	2008	1044,6	1666,2	2012
13	2009	1859,3	1414,1	2006
14	2010	2004	1363	2016
15	2011	2284,6	1341,3	2001
16	2012	1666,2	1290,2	2005
17	2013	1935,2	1245,9	1999
18	2014	1767,5	1201,4	2002
19	2015	1169,4	1169,4	2015
20	2016	1363	1135,3	2003
21	2017	1978,4	1060,6	2004
22	2018	1778,6	1044,6	2008
23	2019	1968,2	736,1	1998
24	2020	1759,5	688,9	1997

Table 6: Difference in precipitation per decade

Period	Average precipitation in the decade (mm)	Difference between decades
1997-2007	1267,563636	
2008-2018	1713,709091	+446,15

In this context, the data collected from the Santander de Quilichao weather station and the farmers' perceptions of the two communities through various participatory methodologies coincide with new IDEAM scenario projections. Then, specifically for the Cauca department (**Figure 13** and **Figure 14**), significant increases can be appreciated according to the modeled scenarios by 2.1°C (

Table 6) on average (IDEAM et al. 2016).

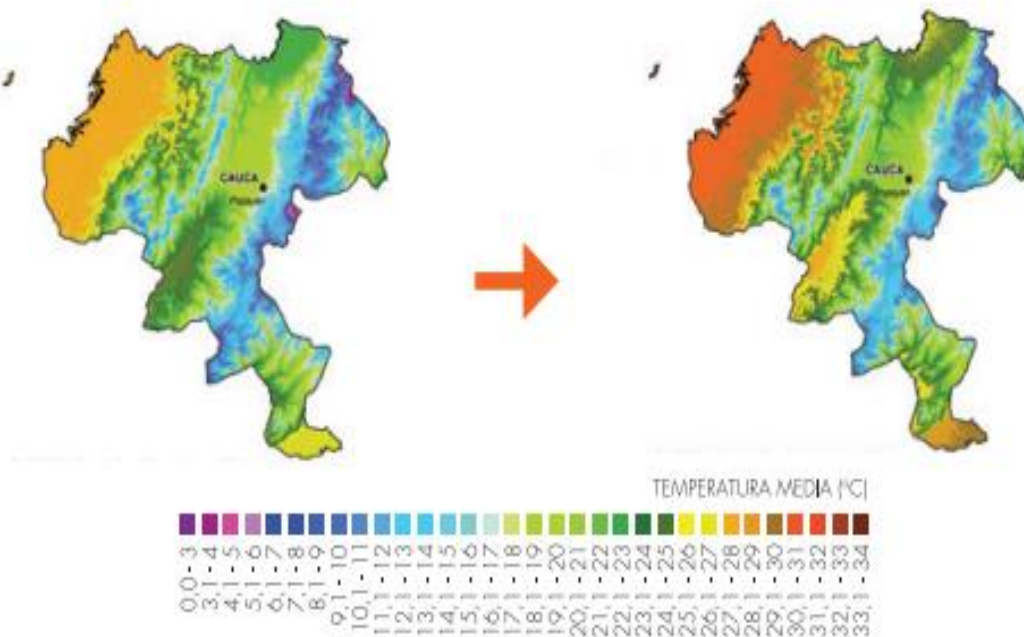


Figure 13: Average reference temperature 1976-2005 °C- Average assembly scenario 2071-2100 °C

Source. IDEAM et al., 2016

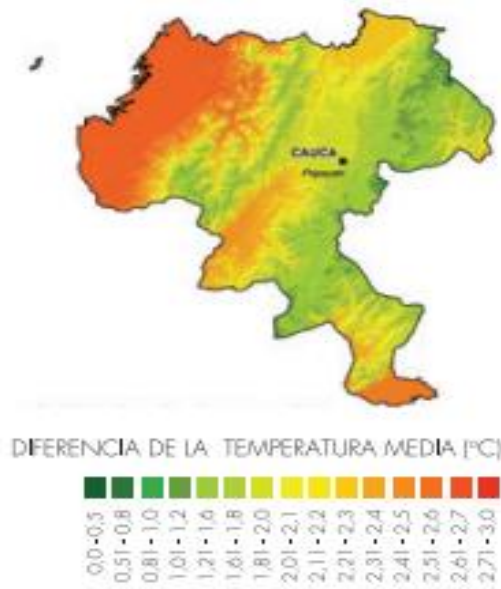


Figure 14: Temperature difference in °C between the 2071 - 2100 scenario concerning the average reference temperature. 1976-2005

Source. IDEAM et al., 2016

Regarding precipitation behavior, according to IDEAM projections in the scenarios 'construction (Figure 15 and Figure 17), precipitation in Cauca could increase by 18.4% by the end of the century (**Table 7**). In particular, the northeast of the department, including the municipality of Santander de Quilichao, may increase precipitation by up to 30% (IDEAM et al., 2016).

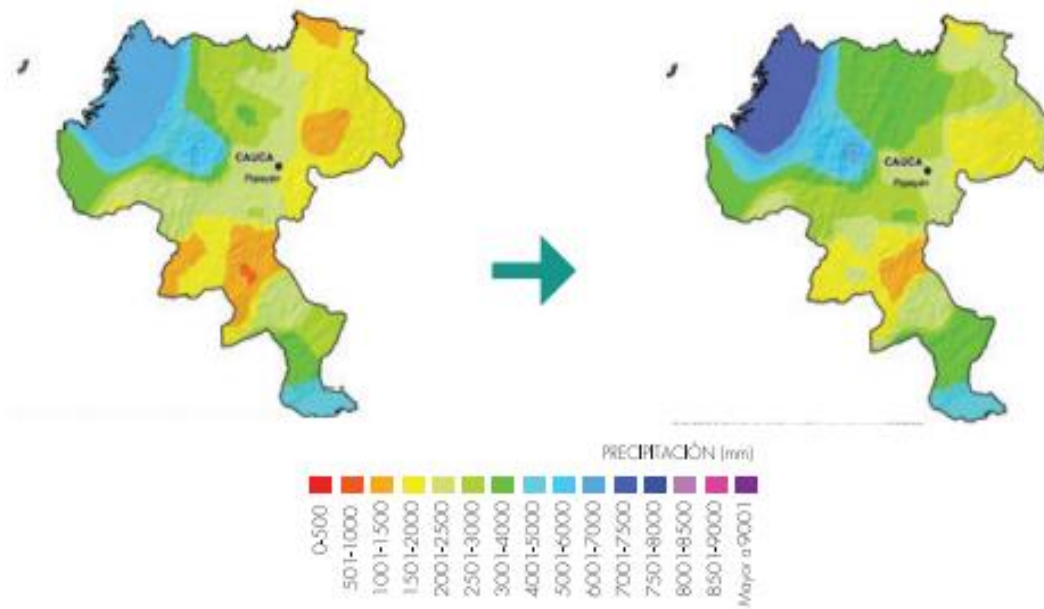


Figure 15: Average reference precipitation 1976-2005 (%) - Average assembly scenario 2071-2100 (%)

Source. IDEAM et al., 2016

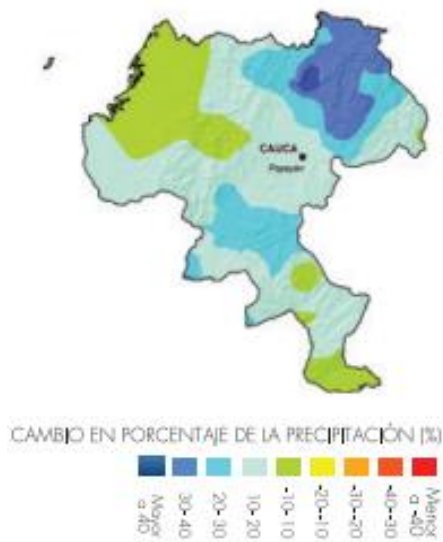


Figure 16: Difference in precipitation in % between the 2071-2100 scenario with respect to the average reference precipitation 1976-2005

Source. IDEAM et al., 2016

Table 7: Periods and scenarios of climate change in the Cauca department

Table Temperature convention		TABLE BY PERIODS / CLIMATE CHANGE SCENARIOS 2011-2100								Table convention Precipitation	
Change	Value Range Temperature	2011 - 2040		2041 - 2070		2041 - 2070		change	%		
		Average temperature change °C	Precipitation Change (%)	Average temperature change °C	Precipitation Change (%)	Average temperature change °C	Precipitation change (%)				
Low	0 - 0,5							Severe Deficit	<-40%		
Low Medium	0,51 – 1	0,7	16,18	1,4	17,5	2,1	18,4	Deficit	-39% y 11%		
Medium	1,1 - 1,5							Normal	-10% y 10%		
Medium -High	1,5 – 2							Excess	11%y 39%		
High	2,1 - 3,9							Severe Excess	>40%		

Source: IDEAM et al., 2015

7.6 Climate Change Adaptation according to Community Capitals Framework (CCF): Exploring Local Vulnerabilities and Community Perspectives.

Based on the community's characterization, a solid foundation was established for conducting a more specific analysis of community capital. This analysis systematically evaluated the community's vulnerability, considering various aspects influencing their capacity to adapt to climate change. The approach used for this analysis was based on the common framework method of community capital.

The sequence in which the different capitals were addressed in the analysis was justified by several considerations. It began with human capital, as individuals and their skills were essential in addressing the challenges associated with climate change. Social capital was then addressed, as the community's networks and social relationships played a crucial role in the collective response to extreme weather events.

Next, the analysis focused on physical capital, which included infrastructure, housing, and basic services. The condition and ability of these infrastructures to withstand climate impacts were determining factors in the community's vulnerability. Natural capital was then examined, considering the available natural resources and their capacity to provide ecosystem services that assisted the community in adapting to climate change. Ecosystem services refer to ecosystems' various benefits to humans and other organisms. These services are essential for supporting life and human well-being. Ecosystem services can be categorized into four main types: provisioning services (such as food, water, and raw materials), regulating services (such as climate regulation and water purification), supporting services (such as nutrient cycling and soil formation), and cultural services (such as recreation and aesthetic enjoyment). These services are crucial for maintaining ecological balance, sustaining livelihoods, and enhancing overall quality of life. Recognizing and valuing ecosystem services is important for sustainable resource management and conservation efforts.

The analysis also included cultural capital, as the community's beliefs, values, and traditional knowledge played an important role in adaptive capacity. Political capital

was assessed to evaluate community participation in decision-making processes and their ability to influence climate change adaptation policies and measures. Finally, financial capital was considered, referring to the economic resources available to address climate impacts and implement adaptation measures.

Their interconnection and mutual influence justified this sequence in analyzing the different community capitals. Each capital played a crucial role in the community's adaptive capacity, and the systematic evaluation of these capitals allowed for identifying specific strengths and weaknesses that could be addressed to reduce vulnerability to climate change.

Therefore, the order in which community capitals are assessed is based on their relative importance and how they interact with each other to influence the community's capacity to adapt to climate change. In this case, evaluating human capital initially allowed for understanding the individual capacities, knowledge, and resources available to address climate change challenges. Subsequently, social capital was assessed due to its significance in fostering networks and social relationships within the community. These networks and relationships can be crucial for collaboration, mutual support, and collective response to climate impacts. They assess social capital after human capital and provide insights into how individuals interact and organize themselves to address climate challenges.

Following that, physical capital was evaluated after social capital, as infrastructure and physical resources are essential for providing secure and sustainable conditions for the community. Assessing physical capital at this stage allowed for an understanding of how existing infrastructure and physical resources can impact the community's adaptive capacity. Natural capital was then evaluated due to its importance in providing ecosystem services and natural resources that sustain community life. Assessing natural capital after physical capital helped us understand how natural resources and local ecosystems may be affected by climate change and how this can influence community vulnerability.

Finally, cultural, political, and financial capitals were assessed to comprehend how cultural, political, and financial aspects influence the community's adaptive capacity. Cultural capital includes beliefs, values, and traditional knowledge, while political capital refers to participation and the ability to influence decisions related to climate change. Lastly, financial capital was evaluated to understand the economic resources available to address climate impacts and finance adaptation measures.

Given that communities, regardless of their poverty level, have resources, it is important to evaluate their capital, identify strengths and weaknesses, and analyze how they can contribute to managing adaptation strategies to climate change.

7.7 Guayabal

7.7.1 Human capital

The percentages of those interviewed were 66.6% men and the remaining 33.3% women. The strong familial bond among the community members is evident, with a sense of solidarity characterized by joy. However, despite the presence of younger individuals with fresh ideas, their level of participation could be improved. Notably, adults above 40 are the most active in community participatory activities and are responsible for transmitting their knowledge and experiences to younger generations. Their active involvement ensures the continuity of cultural practices and the preservation of valuable community wisdom. By recognizing the active role of older adults and encouraging the participation of younger individuals, a more inclusive and intergenerational approach to community development can be fostered, harnessing the collective strengths of different age groups.

The community is composed of different family sizes, mainly with the presence of both parents, who have different levels of schooling. It is observed that high school education prevails (33.3%), followed by completed primary education (22.2%). However, a significant portion of the population has incomplete primary education (22.2%), and a proportion (11.1%) have not attended any educational level. On the other hand, it is worth noting that some individuals (11.2%) have advanced to a higher educational level, such as technical or professional education. This connection

between educational attainment and age is evident, as younger individuals aspire to pursue university-level studies, while older adults have typically completed only basic or high school education. However, there is a noticeable trend among the youth to migrate to nearby towns or cities such as Santander de Quilichao, Popayán, or Cali in search of educational alternatives. This migration further impacts the community's human and social capital, emphasizing the need for sustainable development strategies that address the challenges posed by the outflow of the younger population.

The community comprises families, predominantly adults and older adults, with the younger population being a minority. However, it is important to note that the youth in the community often face challenging circumstances, with a significant portion living in conditions of poverty. A few large coffee production farms are also in the area, but individuals outside the village own them. Despite these dynamics, the community has attracted people from various regions of the country who have chosen to settle in the village. They are drawn to Guayabal due to its perceived safety, tranquil environment, and availability of land for agricultural activities, offering a peaceful life and improved living conditions.

Community leaders are key in promoting participation in training activities to enhance the community's capacities. Through these trainings, the community has established a plant nursery for reforesting the village, contributing to environmental conservation efforts. The acquired skills and knowledge have also enabled the community to engage in commercial activities, generating communal income. The development of tourism activities has also improved conditions for visitors to the village. The community has received training in various areas, including the management of nurseries and reforestation by the environmental authority "Corporación Autónoma Regional del Cauca-CRC," home gardens by indigenous councils, and tour guiding, food handling, animal livestock, and sports, such as soccer, by the municipal mayor's office of Santander de Quilichao. The organizations mentioned for these training sessions are the National Federation of Coffee Growers, Emquilichao, and the National Learning Service-SENA, focusing on coffee cultivation and agricultural practices. These initiatives have strengthened the community's economic prospects, resilience, and

capacity for sustainable development. The National Federation of Coffee Growers provides concrete support to coffee growers in Guayabal. This support includes technical assistance throughout the coffee production process. Farmers receive guidance on best practices for planting, cultivating, and harvesting coffee, as well as pest control and quality management recommendations. This technical support helps farmers optimize their coffee production and improve the overall quality of their beans.

Despite the leaders' efforts to encourage community participation in training sessions, attendance is only sometimes extensive. While there is a clear call for community members to participate in these capacity-building activities, various factors may contribute to limited attendance. Some community members may need help balancing their daily responsibilities, such as work or household obligations, which may hinder their ability to engage in training sessions fully. Additionally, accessibility issues, limited resources, and competing priorities can impact attendance. Recognizing these challenges, ongoing efforts are being made to address barriers and ensure that training opportunities are accessible and relevant to the diverse needs and circumstances of the community. By continuously improving outreach strategies and adapting the training programs to meet the community's requirements better, it is hoped that greater participation and engagement can be fostered in future training initiatives.

The interviewees expressed a strong interest in receiving training on various topics related to climate change adaptation, environmental conservation, sustainable tourism practices, and solid waste management. While these trainings would provide them with valuable knowledge and skills, it is important to note that the communities already possess practical skills developed through generations of experience and knowledge transfer. For example, they have improved their abilities in producing endemic trees for reforestation, undertaking road improvements to enhance accessibility, implementing innovative water capture techniques to overcome the lack of a formal water supply system, adapting their agricultural practices, and transitioning crops according to climate conditions. These practical skills, combined with the potential benefits of formal training, contribute to the community's resilience and capacity to effectively navigate the challenges posed by climate variability.

The skills and knowledge possessed by the community members serve various purposes. Primarily, their agricultural expertise allows them to engage in productive farming activities, which form a significant source of livelihood for the community. This includes cultivating crops, tending to livestock, and managing minor species. Additionally, community members are skilled at performing various household functions such as cooking, engaging in handicrafts, and participating in construction activities, contributing to their self-sufficiency and well-being.

Furthermore, a generational shift occurs within the community, with children acquiring different skills from their parents. The younger generation demonstrates proficiency in using information technologies, social networks, and the Internet, enabling them to readily access and acquire new knowledge. These technological skills offer opportunities for learning, communication, and accessing information beyond traditional methods, potentially opening doors to new educational and economic prospects for the community's younger members.

Health in general terms in the community is good; however, at the time of the interviews, there were several cases of people with colds and common diseases such as fevers, diarrhea, and colds. The community does not have a health center and must go to the municipality of Santander de Quilichao for care if required. However, the first option is to treat health problems with traditional medicine in the village or visit the health brigades that visit the communities occasionally.

The relevance of these results on human capital is crucial in understanding the degree of vulnerability of the community to various situations such as climate change, economic crises, political conflicts, and others. The detailed analysis of human capital allowed for the assessment of individual capacities, knowledge, and resources available within the community, which was fundamental in determining adaptive capacity and resilience towards different challenges. These results provided a comprehensive insight into the skills and strengths of individuals, as well as potential gaps or limitations in terms of education, technical skills, and resource access. Accurately identifying human capital enabled the design of appropriate strategies to

enhance existing capacities and address areas of weakness, aiming to reduce community vulnerability and promote sustainable development in the context of the specific challenges faced.

7.7.2 Social Capital

There is a strong connection between human capital and social capital due to the active role of leaders working towards community development through the Community Action Board (CAB), which promotes community engagement in implementing activities and projects. The CAB is a social, civic, and community organization in the village composed of residents over the age of 14 who come together to address the community's most pressing issues. These CABs are democratically elected every four years, allowing community members to choose their leaders and participate in decision-making.

One of the main characteristics of Guayabal is its level of peacefulness. The predominant result of the interviews was that it was very peaceful to live in (88.8%), followed by more or less peaceful (11.1%). This condition is related to the absence of illegal groups, the absence of illicit crops, and the low level of crime compared to other regions of the country. Conflicts arise within the community, primarily related to property demarcation and illegal deforestation. These conflicts originate in land ownership, borders, and resource exploitation disputes. The issue of property demarcation often leads to disagreements and tensions among community members as conflicting claims and competing interests emerge. Additionally, illegal deforestation exacerbates the conflict, as it contributes to environmental degradation, loss of biodiversity, and the loss of valuable natural resources. These conflicts strain social cohesion and pose significant challenges to the community's sustainable development and environmental conservation efforts. Addressing these conflicts requires careful negotiation, effective governance mechanisms, and the implementation of sustainable land management practices to promote harmonious coexistence and mitigate the negative impacts on the community and its natural surroundings.

Access to various media channels, including television, radio, and cell phones, is an emerging phenomenon in the community, with a gradual increase in internet connectivity, particularly in educational centers and communal spaces. However, it is important to note that not all community members have equal access to these communication tools, and internet infrastructure installation is still in its early stages. This limited access to media and internet connectivity has implications for the community's vulnerability, particularly concerning climate change. These media channels provide information about climate change and serve as a means of communication with government offices. Therefore, restricted access to these mediums may hinder effective communication and engagement with government agencies responsible for climate change adaptation and disaster response. Bridging the digital divide and ensuring equitable access to media and internet services are essential for fostering community resilience and effective communication with relevant government entities.

Historically, people have demonstrated an ability to work together for the benefit of the community. Over time, various situations have arisen where community members have come together to address common challenges, such as natural disasters, conflict, or economic hardship. These experiences have demonstrated the ability of people to collaborate, support each other, and find joint solutions. The main reasons for participating in these community organizations, such as the CAB, are collaboration, personal satisfaction, selfless service, learning, and the desire to help the development of the community. 100% of the members state that the CAB management is effective, further emphasizing the trust and confidence placed in these organizations.

The JAC is a clear example of how trust and mutual support are fostered in the community. It represents and promotes the interests of the area's inhabitants, providing a space for community members to meet, share ideas, and work together to address their needs and problems. Additionally, thematic committees are formed at the community level to meet specific needs in sports, religion, education, economics, and children. The formation of these committees creates an environment conducive to

collaboration and trust, as members share common interests and work together to improve these particular aspects of community life.

Community togetherness in developing projects and meeting needs further strengthens trust within the community. The active participation of community members in activities such as building infrastructure, cleaning up public areas, or implementing social programs promotes solidarity, a sense of belonging, and trust among the members. The willingness of individuals to selflessly demonstrates their trust in the collective power of the community to bring about positive change.

The migration of the young population in search of employment opportunities outside the community has a significant impact on the social capital of the rural community. When young people migrate in search of employment, the participation of this generation in the community is reduced, and social ties are weakened. Youth migration has led to decreased participation in community organizations such as the CAB and thematic committees.

On the other hand, some families work as day laborers on other people's farms within the community, which may be related to existing social differences. These families may need access to their land or sufficient economic resources for productive activities. As a result, they are forced to work as day laborers on the farms of other community members who have greater economic power or more resources.

The life of the Guayabal community stands out for the relevance of its solidarity networks and the social cohesion strengthened over time, allowing them to face crisis phases and overcome them with fewer losses. This community strength is of great importance in the context of climate change and its relationship with vulnerability. These networks allow for greater response capacity and resilience in extreme weather events like floods, droughts, or storms. Solidarity and cooperation among community members provide them with mutual support and shared resources, which helps them cope with crises.

In addition, the strengthened social cohesion in Guayabal also translates into a greater capacity to adapt to climate change. The community is better prepared to implement

adaptation strategies, such as implementing weather stations, diversifying their economic activities, and implementing sustainable management of natural resources. Trust and collaboration among community members facilitate the implementation of these measures and promote greater resilience to climate change impacts.

There is the presence of external public and private authorities such as the CRC in conservation programs, the National Federation of Coffee Growers with technical assistance and product commercialization, the public utility company Emquilichao through the Procuencia Quilichao Foundation as a control entity, support in conservation and project execution, the Santander de Quilichao Mayor's Office with health brigades in charge of the health promotion company Quilisalud, and the Secretary of Economic and Environmental Promotion and Development for support in agricultural and livestock systems.

The abovementioned programs are intended to support and promote development in different communities. However, it is important to remember that if they are not implemented properly, they could have certain effects in terms of vulnerability; for example, a conservation program can benefit environmental preservation through compliance with environmental regulations or reforestation days. However, the local community has yet to be fully involved. Participation must consider their needs and traditional knowledge, thus avoiding increased vulnerability by excluding local people from decision-making and natural resource management.

In the case of the National Federation of Coffee Growers, providing technical assistance and product marketing to coffee producers has improved farmers' productivity and income, decreasing the vulnerability of cultivation practices to climate variability. However, there are cases in the community with clear conditions of inequalities in access to resources and markets, thus increasing the vulnerability of small producers, especially if they depend heavily on the coffee industry and face fluctuations in prices and demand.

The Procuencia Quilichao Foundation has developed control and support programs for conservation and project execution. Although its presence has positively impacted

environmental management and sustainable development, it is essential to ensure that its actions do not generate conflict with the inhabitants not involved in conservation activities, which could lead to conditions of social exclusion. On the other hand, the Municipal Mayor's Office, through health programs, has had a positive impact in terms of access to health services and health awareness, considering that the community does not have a health center and that some adults find it difficult to visit health centers outside the community. Therefore, they have partially addressed the specific health needs of the community. Finally, the Secretary of Economic and Environmental Promotion and Development has provided in agricultural and livestock systems to improve the production and livelihoods of farmers, promoting sustainable agriculture, avoiding harmful practices, and, in turn, reducing vulnerability levels.

7.7.3 Physical Capital

One of the community's most significant challenges lies in its infrastructure, particularly the condition of access roads and the availability of public services. The secondary roads connecting Santander de Quilichao consist of partially paved sections alongside dirt roads. This limited road infrastructure hinders transportation and connectivity, making it difficult for residents to access essential services and seize opportunities beyond their immediate vicinity. Moreover, climate variability significantly affects these roads, especially during excessive rainfall. Intense rainfall can lead to flooding and landslides, further deteriorating road conditions.

In addition, the community needs access to basic public services, including potable water and sewage systems. The absence of these services exacerbates the vulnerability of community members. People connect hoses to nearby water sources to obtain an alternative water supply instead of having reliable access to safe drinking water or adequate wastewater treatment. Sewage is often discharged into septic tanks at the same time. Unfortunately, greywater is often discharged directly into the ground or rivers, causing environmental and public health risks.

Poor roads and inadequate access to public services create significant challenges for the community, restricting their ability to improve living conditions and heightening their

vulnerability. Addressing these infrastructural and service deficiencies is crucial for enhancing the community's well-being and resilience.

The unstable electricity service and its suspension during rain or wind events contribute to the community's vulnerability. The availability of reliable electricity is essential for various aspects of daily life, including lighting, refrigeration, communication, and access to modern technologies. The intermittent electricity supply makes it difficult for community members to carry out their daily activities and impacts their quality of life.

Furthermore, the lack of access to alternative energy sources, such as solar energy, further exacerbates the vulnerability. The community members have shown interest in adopting solar energy due to successful experiences in other areas. Solar energy could provide a more sustainable and reliable source of electricity, reducing their dependence on the unstable grid. However, the high cost of solar equipment limits its installation in the community, hindering their ability to access this cleaner and more resilient energy source.

The combination of unreliable electricity service and limited access to alternative energy options increases the community's vulnerability. It affects their ability to cope with power outages, adapt to changing weather conditions, and access essential services and opportunities that rely on a stable energy supply. Addressing these energy-related challenges is crucial to enhancing the community's resilience, improving their quality of life, and reducing their vulnerability to external disruptions.

The access roads are gravel roads that require constant maintenance due to inclement weather and become difficult to access during the rainy season, either because of poor drainage or rising river levels. In addition, not all houses have access to roads; small roads reach some in mountainous areas with scattered houses.

The primary mode of transportation in the area is a type of bus known as "Chiva," but its weekly regularity is limited to 1 to 2 times. As a result, many residents choose to use motorcycles, either owned or through paid transportation services. The opinions about the transportation service vary, with approximately 44.4% considering it regular, 11.1%

perceiving it as bad, and another 44.4% believing it to be good. However, it is important to note that transportation may depend on socioeconomic factors. Individuals who own motorcycles may opt to rely on something other than the bus service due to its limited frequency. The socioeconomic status of community members plays a role in their transportation preferences.

Although it is a disadvantage for communication between the community and main population centers, this physical capital weakness represents the other capital's strength. This situation is part of the dynamics and interrelation of the different capitals in the community. Inadequate solid waste and wastewater management directly affect natural capital by putting wildlife and natural resources at risk. At the same time, the low availability of public transportation and the promotion of organizational group activities to improve roads and strengthen local management are related to the physical and social capital of the community. These interactions between the different capitals demonstrate the importance of comprehensively addressing environmental and social challenges to promote sustainable and resilient development in the community.

The infrastructure of the school and communal house is in acceptable condition. Most houses have brick and cement walls, clay tiles, and wooden or metal doors. However, there are also houses built entirely of wood.

7.7.4 Natural Capital

Guayabal has abundant natural resources sources; 100% of the interviewees recognize there are reserve zones in the village, 66.6% consider their level of importance " Excessive," and 33.4% the natural resources are " Fairly" necessary, predominantly water resources, rivers such as the Quilichao river flow through them. Nevertheless, recently, there has been evidence of contaminants in the water sources due to agricultural activities, their expansion into forest areas, and the intensive use of agrochemicals. Additionally, the observed decrease in water availability during the summer compared to previous years indicates the potential impacts of climate change on the village's water supply. These factors collectively demonstrate how Guayabal is

vulnerable to the effects of climate change, specifically in terms of its water resources and the associated risks to the community's well-being and sustainability.

Therefore, water availability in Guayabal is a critical aspect of the community's well-being, and this situation exhibits a marked characteristic of extremes throughout the year. During the rainy seasons, the community experiences excess water, which can sometimes lead to flooding and other challenges associated with excessive precipitation.

However, the real concern is when water availability significantly decreases in the summer. During this period, a water shortage is observed, impacting the community and its activities, such as agriculture and the water supply. The reduced quantity of water available during the summer may result from reduced aquifer recharge due to a lack of rainfall and increased evaporation due to high temperatures.

This contrast between water abundance during rainy periods and scarcity in the summer accentuates Guayabal's vulnerability to the effects of climate change. Climate extremes, characterized by periods of severe drought followed by heavy rainfall, can significantly impact water availability and community sustainability. Therefore, proper water resource management and adaptation to climate change become essential to ensure a consistent and safe water supply for the Guayabal community throughout all seasons of the year.

Guayabal's vulnerability to climate change is evident in several aspects, such as seed quality due to the excessive use of agrochemicals. Interviewees mentioned that the seeds are less resistant to pests, diseases, and environmental changes. In addition, soil erosion, because it is a mountainous area with steep slopes, makes soils more prone to erosion, as water tends to flow quickly and wash away soil particles. In addition, heavy rains, especially in short periods, have generated surface runoff, meaning water flows quickly over the soil's surface instead of infiltrating it. In addition, the lack of vegetation to retain the soil has increased the effects of erosion.

In general, according to the farmers, the community is environmentally clean and free of noise and polluted air, but concerning solid waste management, there is no

sustainable management plan; waste is burned and disposed of in the open air, even though there have been attempts to implement recycling programs, but without continuity from external institutions.

The presence of the forest in the community represents one of the most significant natural resources, as it provides a wide range of ecosystem services crucial to the community's livelihood. The forest provides a habitat for diverse flora and fauna and plays a vital role in regulating the local climate, providing clean air, and regulating water resources. In addition, the forest provides valuable provisioning services, such as timber and non-timber forest products, which contribute to the community's economic activities.

Most of the community has developed a culture of conservation, recognizing the importance of sustainable resource use. They adopt practices promoting the long-term conservation of the forest and its resources. For example, when felling trees in the forest, community members must follow guidelines and obtain permits from the Procuencia Foundation, part of the Municipal Mayor's Office, as a control and support institution in developing projects; this guarantees responsible and regulated extraction.

7.7.5 Cultural Capital

The village's cultural capital is strengthened. It is characterized by a mostly mestizo and indigenous population with a low presence of the Afro community. A wide range of traditions, customs, and ancestral knowledge evidence the ethnic and cultural diversity present in Guayabal. These cultural elements strengthen the community's cultural capital, representing a form of identity and cultural heritage transmitted from generation to generation. The main language is Spanish, and some people preserve the Nasa Yuwe language, which is promoted through its inclusion in school education.

Cultural capital is the one that brings the most happiness to the farmers, as reflected in the celebration of traditional festivities that promote the active participation of the inhabitants in the process of organization and enjoyment. As a result, 77.7% said they felt happy in their communities, 11.1% were "Very happy," and 11.1% referred to being

"unhappy" or "not very happy" due to the lack of employment, opportunities, and poverty conditions in the area.

The main celebrations are the "corridas de jaula," between July and August. During this annual festival, the inhabitants try to capture a cage of candy or a hen on horseback. This activity is also accompanied by typical food, drinks, music, and dance to promote healthy recreation, as well as the collection of funds through the sale of food, drinks, or games of chance for the project's execution or the future local festivities celebrations.

Also, sports activities promote unity within the community and with external communities that are invited to participate in the events and serve as an alternative to get out of the routine. These activities are expressions of cultural capital in themselves and strengthen social capital, another form of capital related to relationships, promoting unity, and creating social networks in the community. Nevertheless, these sporting events had to be canceled in 2020 due to the pandemic. At the same time, the interviewees identified characteristics that make them different from other communities in the area and mainly focused on the fact that they live in a peaceful community and that people are friendly.

The community is part of the indigenous cabildo Munchique Los Tigres, recognized as the traditional authority of the indigenous peoples of Cauca. This public entity promotes the defense of the indigenous people's fundamental and specific rights through its laws and has been maintained over time despite external governmental pressures.

In some interviewees' opinion, 22.2% completely preserve traditional ancestral practices, and some cultural practices of sowing, such as those based on the moon cycle, are maintained. However, 77.8% consider this has been changing due to the need to adapt to changes in climate, and some customs have been lost because there is no more extended clarity about when it will rain or when it will be summer. This change, in turn, becomes a strength as a measure of adaptation to changes.

This change in cultural practices and the loss of some customs due to adaptation to climate change has implications for vulnerability to climate change. On the one hand, retaining traditional ancestral practices may provide some resilience to climate change,

as these practices have evolved to adapt to local climatic conditions. By maintaining these practices, the community may have proven strategies and traditional knowledge that enable them to cope effectively with climate change.

However, recognizing that some cultural practices have changed reflects a necessary adaptation to climate change's uncertainty and new challenges. Lack of clarity about weather patterns, such as when it will rain or when it will be summer, can make it difficult to apply traditional practices that rely on specific climate predictions. Therefore, the community is forced to look for new strategies and ways to adapt to unpredictable changes in climate.

In this sense, changing cultural practices can become a strength in terms of adaptation to climate change. The community's willingness to abandon some customs and adopt more flexible approaches allows them to explore new ways of coping with climate challenges. They can incorporate scientific knowledge, modern technologies, or sustainable management techniques to maintain their livelihoods and ensure their well-being in a changing context.

7.7.6 Political Capital

In Guayabal, the local authority is identified as a community action board (CAB) led by a president and supported by a vice president, treasurer, and members of thematic committees. This board is democratically elected every four years. They are responsible for overseeing the organization and development of the community, as well as acting as a bridge of contact with external governmental authorities.

Some people mentioned that the leading authority is the indigenous council, which dictates the strictly enforced laws. Moreover, in Guayabal, the community action board has the autonomy to make decisions about its territory regarding development and local projects without this representing a conflict of competencies with the indigenous council. Therefore, there is knowledge that they need government support, and it is clear that the municipal mayor's office of Santander de Quilichao is the one that fulfills this support role. However, in the opinion of the farmers, they have felt the lack of accompaniment, which is more visible during election seasons in search of votes.

Regarding vulnerability to climate change, the community of Guayabal depends largely on government support to face the challenges of climate change, and the mayor's office's lack of support increases its vulnerability. The community needs help accessing the resources, financing, and knowledge needed to implement adaptation measures and reduce its vulnerability to adverse climate impacts.

In addition, the lack of accompaniment by the mayor's office indicates a lack of continuity in policies and programs related to climate change. This hinders decision-making processes and the implementation of effective measures to address vulnerability to climate change. The dependence on the mayor's office as the main support provider generates uncertainty and difficulty in long-term planning to address climate challenges.

In Guayabal, the decision-making processes are made through public calls, always promoting democratic actions. However, despite this, there is only sometimes participation of all the inhabitants, and those who make the decisions regularly attend the meetings called by the community action board. In the case of conflict resolution, they do it through the conciliation committee, calling the parties involved to discuss the issue and seek solutions. Still, they resort to the cabildo authority with more demanding measures if an agreement is not reached. If no solution is found in this instance, ordinary justice will finally decide.

This dynamic has had implications for community stability and consensus. On the one hand, limited participation in decision-making processes has generated discontent and tensions within the community. However, those who do not regularly attend the meetings must assume the decisions due to non-participation. Limited participation in decision-making processes and reliance on formal conflict resolution mechanisms can affect the ability to react quickly and adequately to climate change threats. Promoting inclusive participation and seeking agile decision-making is important to strengthen community responsiveness to climate challenges, identification, and timely implementation of adaptation measures.

In evaluating the results, the importance of the leading factor in the optimal management of the community action board is evident. Hence, the farmers interviewed said that when the community action board does not have a group of leaders willing to watch over the community's development, there is little progress in the territory regarding development. In contrast, members with leadership vocations have seen how they relate with external institutions and promote the execution of projects that benefit the inhabitants.

The continuity of most of the same members in the community action board during the last decade has proven to be positive due to the accumulated experience and community recognition. This stability and cohesion in leadership has been crucial to achieving optimal board management and fostering community development. On the other hand, having members in Guayabal with leadership vocations shows how they establish relationships with external institutions and promote implementing projects that benefit the inhabitants. These leaders can mobilize resources and generate strategic alliances, promoting community development and reducing territory vulnerability.

Additionally, the levels of participation according to gender and age of the population were investigated, resulting in 66,6% of men and 33,3% of women participating in the activities. However, the low participation of young people represents the difference.

Historically, gender inequality in community participation in Guayabal is due to sociocultural norms that assign women domestic and caregiving roles, limiting their participation. In addition, low youth participation generates a generation gap in community development. To address this inequality, equal opportunities must be promoted, stereotypes challenged, access to resources and education provided, and inclusive spaces created to encourage the participation of women and youth in community decision-making and activities.

Although challenges persist in women's participation in community activities, women's involvement has increased in the last decade. This increased participation not only contributes to gender equality but also has a positive impact on the community by

ensuring a more equitable representation of women's voices and needs and promoting inclusive and sustainable development.

7.7.7 Financial Capital

In Guayabal, the source of income is diversified, with the main productive activities being agriculture and the sale of labor. 100% of agricultural and livestock products are sold in Santander de Quilichao on market days through intermediaries or direct sales, whose income is used for subsistence and self-consumption of products.

In Guayabal, an income inequality situation is observed in which precarious land tenure plays a relevant role. Community members with limited access to productive resources due to lack of land face difficulties in generating sufficient income to meet their basic needs, access health and education services, and improve their quality of life. In addition, these economic disparities may generate social tensions and lead to the exclusion of certain groups within the community. To address this inequality, policies that promote a more equitable distribution of land and encourage economic empowerment of those with precarious tenure, as well as measures that promote gender equality, are needed. This would strengthen community resilience and move towards more inclusive and sustainable development.

The sale of labor occurs inside and outside the community, and this service generates additional income for people who do not have land to grow crops or raise animals. On some occasions, another source of income, which the interviewees said is temporary, is related to tourism and visits from educational institutions for tours of the nature reserve, who pay a voluntary fee, in addition to buying lunch for the local inhabitants, which generates an additional but temporary source of income. However, it is important to note that these labor sales are only one of the sources of income for most of the inhabitants and tend to be sporadic. This information highlights that income in Guayabal is flexible and constant, depending on the availability of labor opportunities in the community. This variability in income may contribute to the economic vulnerability of the community, as there is no stable source of income for many people.

It is worth mentioning that 44,4% of interviewees consider it relatively easy to access bank loans, the other 44.4% consider it moderately easy, and 11.1% believe it is difficult to access a bank loan. Besides, it is not very common to apply for them because they do not have a fixed monthly income; since this depends on the marketing of agricultural products, which in recent years have been affected by climatic factors in terms of yields, this represents a relevant factor on the changes in income, where interviewees argue that they have decreased due to low productivity due to excessive humidity or lack of water at different times of the year for both crops and livestock systems, seeing the need to make changes in production systems that lead to trial and error according to climatic conditions and adaptability of the system.

Banco Agrario de Colombia is a public-sector commercial bank dedicated to rural development in the country. Its objective is to provide financial solutions for investments in agricultural production, with requirements considered "attainable" for small producers. However, it is also recognized that a percentage considers access to loans difficult, suggesting that there are still challenges to overcome regarding financial inclusion and equitable access to banking services. It is important to highlight that land tenure is one of the determining factors for accessing credit in the agrarian context. In many cases, Banco Agrario de Colombia requires applicants to own land or property as collateral to grant loans. This can create difficulties for small producers who need secure land tenure. This creates a gap in access to financial resources between those who have land and those who do not, which can contribute to economic inequality, limit sustainable rural development, and increase vulnerability in recent years.

Therefore, the reliance on natural resources as the main source of income in Guayabal highlights the community's vulnerability to climate events. Given that their income is derived from activities directly linked to natural resources, such as agriculture and livestock, they are highly susceptible to the impacts of climate change. Climate events like droughts, floods, or extreme weather patterns can significantly affect their productivity and livelihoods.

Plantain cultivation is one of the driving forces of the local economy, along with coffee cultivation, the latter of which is supported by “The National Federation of Coffee Growers,” both in terms of technical assistance throughout the production process, as well as in the sales phase by allowing farmers to sell coffee at the Federation.

Plantain and coffee cultivation are significant contributors to the local economy in Guayabal. The coffee sector specifically receives support from the "National Federation of Coffee Growers" (Federación Nacional de Cafeteros) in various aspects of the production and sales processes.

The National Federation of Coffee Growers is also crucial in the sales phase. Farmers are allowed to sell their coffee directly to the Federation. This direct sales channel gives farmers access to a broader market and helps ensure fair prices for their coffee beans.

It should be noted that the performance of the coffee economy in terms of productivity and prices can be influenced by various factors such as global supply and demand, weather conditions, and international trade policies. Market fluctuations and price volatility are common challenges faced by coffee growers worldwide. However, with the support and backing of the National Federation of Coffee Growers, the coffee growers of Guayabal have the support to overcome these challenges and strive to obtain better economic results in the coffee sector.

The support and resources provided by the National Federation of Coffee Growers have contributed to the development and productivity of the coffee sector in Guayabal. With technical assistance and market access, coffee growers can enhance their production methods, improve the quality of their coffee, and potentially increase their income.

In addition, crops such as beans, corn, and cassava, as well as home gardens and poultry farming, contribute to income, but mainly for family consumption, as do fruit trees such as oranges, lemons, tangerines, guavas, avocados, mangoes, bananas, among others. Finally, the opinions indicated that they do not receive transfers from

relatives outside the village, but some families (55,5%) are beneficiaries of subsidies from the National Government.

7.7.8 Capital Analysis and its Interconnections in the Guayabal Community

Analyzing the different capitals in the Guayabal community reveals strengths and weaknesses regarding their interconnectedness and dynamics. Among the capitals, social, natural, and cultural capital is the strongest, while human and political capital also present some strength. On the other hand, financial and built capital are identified as the weakest in the community.

Social capital stands out for the presence of strong community ties and support networks among the inhabitants of Guayabal. This solidarity and social cohesion allow collaboration in problem-solving and implementing community initiatives. Natural capital is another significant asset, as the community relies heavily on natural resources for its economic activities, such as agriculture and livestock, in addition to being in the area of influence of a natural reserve zone. In addition, cultural capital is evident through the traditions, customs, and cultural practices rooted in the community, strengthening local identity and generating a sense of belonging.

Human and political capital also play an important role, although with certain limitations. Although there is a base of knowledge and experience in diverse areas, opportunities can be identified to strengthen the education and training of the inhabitants, especially in specific areas related to economic development and sustainable practices, by the institutions that are present in the zone, such as SENA and the National Federation of Coffee Growers (Federación Nacional de Cafeteros). On the other hand, with the political capital, a certain level of participation is recognized; it is necessary to promote greater inclusion and active participation of all community sectors.

It is important to evaluate how the dynamics of the capital have evolved in recent years or decades and whether there have been significant changes. For example, strengthening social capital has been related to the continuity of community leadership, active participation in local organizations, and collaboration in joint projects. On the

other hand, financial and built capital has experienced limitations due to a lack of access to financial resources, poor infrastructure, and a lack of investment in physical development and land distribution.

The interdependence of the capitals of the Guayabal community is evident in various aspects, such as the relationship between financial and natural capital. The availability of income and access to credit (financial capital) is fundamental for the economic development and welfare of the village to cover basic needs and to have funds for investment in productive activities, education, and health. Thus, there is a close relationship between access to land ownership (natural capital) as a fundamental resource for housing and the development of agricultural and livestock activities as a source of self-consumption and income from sales. Thus, the availability of income, access to credit, and land ownership are interconnected to the extent that they influence the inhabitants to acquire or maintain land ownership. For example, higher-income people may have more resources to buy land or access loans to invest in property acquisition or to technify their productive systems.

These interconnections between the different capitals have implications for community vulnerabilities. For example, dependence on natural resources and agricultural activities makes the community particularly vulnerable to the impacts of climate change, such as droughts or extreme weather events. Also, financial and built capital limitations may hinder the community's coping with economic or infrastructural challenges.

Table 8 concludes that the analysis of capital in the Guayabal community reveals a panorama in which social, natural, and cultural capital is the most solid, followed by human and political capital—however, financial and built capital present areas for improvement. The interconnection between these capitals and their relative dynamics and strengths has implications for community vulnerabilities, especially regarding climate change adaptation, economic development, and resilience to external challenges.

The general results from the interviews are presented in the following **Table 8**:

Table 8: Characteristics of the communities for each capital - Community Capitals Framework (CCF) - Guayabal

CAPITAL	STRENGTHS/ WEAKNESSES	GUAYABAL
HUMAN	Strengths	Basic Primary Education Technical assistance: SENA, Coffee Growers' Federation Producers with wide experience Good health
	Weaknesses	The presence of diseases such as influenza and diabetes Low participation of young people Low educational level
SOCIAL	Strengths	Peaceful community No illicit crops Effective community organization High participation in community work
	Weaknesses	There is little presence of external organizations Low access to external information Lack of credibility of the inhabitants with the institutions.
NATURAL	Strengths	Ample availability of natural resources, mainly water and forest Conservation activities Reserve zone inside the village
	Weaknesses	Deforestation Inadequate solid waste disposal (burning - burying) No wastewater treatment system
CULTURAL	Strengths	Traditional festivals Maintain popular beliefs High participation in local cultural events Cultural diversity
	Weaknesses	Young population with poor participation Interests outside the community
PHYSICAL/BUILT	Strengths	Public transport

		Electric power grid Low internet coverage and cellular signal Elementary school
	Weaknesses	Access roads in need of constant repair Low frequency of public transportation Unstable energy service No health center No potable water
FINANCIAL	Strengths	Production systems for self-consumption and sale Diversification of production: agricultural and livestock production Raising hens
	Weaknesses	Low-tech production systems Low access to bank loans High production costs
POLITICAL	Strengths	Presence of responsible organization in the reserve area: Emquilichao Connection of local leaders with the municipal government
	Weaknesses	Low effectiveness of local government

Therefore, as an extension to the CCF, an analysis of basic human needs was carried out, deepening its interconnection with community capitals, vulnerabilities, and collective mapping in the villages of Pavitas and Guayabal. This analysis is essential in formulating adaptation strategies, which will be explored in detail in the next subchapter.

7.8 The general perception of Basic Human Needs

The analysis of community capitals evaluated their interconnections, strengths, and weaknesses and how they directly influence the capacity of the communities of Pavitas and Guayabal to satisfy their basic human needs. For example, it was identified that access to strong social networks such as the Community Action Board and adequate

educational and natural resources facilitates satisfying food security, health, and education needs.

Therefore, the basic needs analysis identified key aspects of how social networks can facilitate the exchange of knowledge and skills, promoting community resilience to climate change adaptation challenges (social capital). It also identified the need to strengthen access to education to help them make informed decisions about their well-being and understanding of climate risks and capacity to adapt (human capital).

The level of satisfaction with basic human needs demonstrated by people in the villages of Guayabal and Pavitas was constructed based on the criteria emic (perspectives identified by the inhabitants of the communities as significant for them) and etic (a critical analysis of scientific theories on the causes of different social and cultural behaviors of groups in societies).

The analysis follows the classification of Imbach (2012) of four major groups: Basic Needs, Person or Personal Needs, Environment Needs, and Action Needs. Thus, the numeric scale for each group was set as follows: 1=Unsatisfied, 2=Partially unsatisfied, 3=Acceptable, 4=Good satisfaction, 5=Completely satisfied. Finally, for each group included in the needs classification, the mean was used to measure central tendency in the analysis of results. This was because the differences between the participants' responses were not significant. An average value was obtained using the mean, providing an overview of the responses and results related to each needs group.

Thirty checklists were applied in the two communities. Thereby, the needs and strategies to meet them in every village were collected to identify how people can have a dignified life with development opportunities to move towards the practical adoption of development visions and climate change adaptation measures in the rural sector.

The charts show examples of how the information obtained from the checklists is being analyzed for each community:

According to the human needs group (Action Environment Person Basics) the satisfaction level is shown on a numerical scale (1-5). For example, concerning Personal Needs, the average rating between Affection, Knowledge, Identity, Self-esteem, and Responsibility indicates a "Good satisfaction = 4."

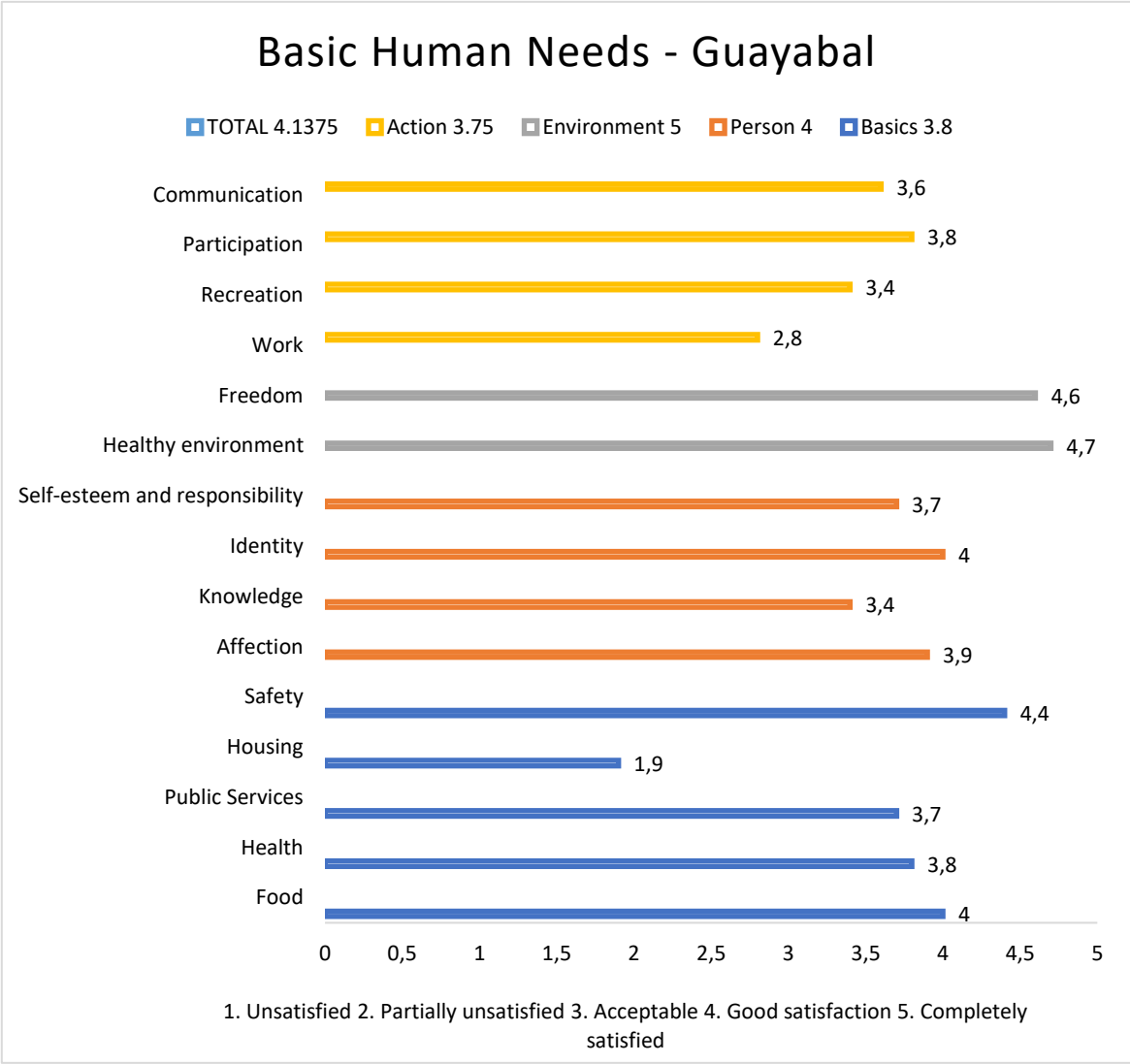


Figure 17: Basic Human Needs Analysis – Guayabal

Therefore, with the sum of all the averages of the basic needs groups, the result was "Total = 4.1375." this means that the participants (10) who completed the checklist considered that they have "Good satisfaction" in their basic human needs. Mainly because they consider that they have what is necessary to live: enough food,

knowledge to carry out their tasks, good health, being surrounded by nature, and good communication between the Inhabitants. Despite the overall satisfaction with basic needs, it is important to remember that there are differences between the different needs groups. Not all aspects reach the same level of satisfaction, which indicates that changes and improvements are still required in certain areas to ensure an optimal quality of life in all aspects evaluated.

The analysis of the **Action** group, **Figure 17**, reveals that participation and communication are the highest-ranking values in terms of satisfaction. While these aspects demonstrate a satisfactory level, they fail to reach a "Good satisfaction." This indicates that although there is some participation and communication within the community, there is still room for improvement to achieve optimal satisfaction in these areas. For example, residents engage in community activities such as community board meetings, workshops, or local events. However, they may desire greater involvement in decision-making processes or implementing projects directly impacting the community.

On the other hand, recreation falls below the level of "Good satisfaction." This suggests that although recreational activities occur in the community, they may need to be more sufficient or fully meet the participants' expectations. This could be due to limited options, inadequate facility conditions, or infrequency of activities.

In contrast, the aspect that receives the lowest rating within the "Partially satisfied" range is Work. This indicates that participants are only partially satisfied with the available job opportunities in the community. Many residents must seek employment outside the community, and even when jobs are available, the wages are low, and work is often inconsistent.

The analysis of the **Environment** group reveals that freedom and a healthy environment are the highest values in terms of satisfaction in the rural community of Guayabal. These aspects have obtained a rating of Good satisfaction and are very close to Completely satisfied. This shows that the residents of Guayabal experience a high level of freedom in exercising their rights and enjoy a healthy, natural environment.

Freedom in the community is reflected in the ability of residents to exercise their rights and fulfill their responsibilities without significant restrictions. For example, they can express their opinions, participate in community decision-making, and exercise their civil rights. Guayabal residents can organize themselves into community groups, such as the CAB, to make collective decisions and promote the general welfare.

The community of Guayabal benefits from the natural reserve's healthy environment, which includes abundant natural resources, clean air, water, and nature. Residents can enjoy the beauty of their surroundings and natural resources, contributing to their physical and mental well-being.

The analysis of the **People** group reveals that the rural community of Guayabal is highly satisfied with identity, knowledge, affection, self-esteem, and responsibility. These elements are fundamental to community well-being and resilience, especially in the context of vulnerability to climate change.

Guayabal residents have a strong sense of identity and belonging to their community. They value their cultural heritage and traditions, such as festivals and local cuisine. These aspects strengthen social cohesion and community resilience, providing a cultural and emotional bond that unites them in difficult times, such as extreme weather events.

Knowledge is another prominent aspect of the Guayabal community. Residents value the experience accumulated over generations and pass it on through orality and participation in educational activities. For example, knowledge of traditional agricultural techniques and sustainable management of natural resources is essential for adapting to the impacts of climate change, such as droughts or floods. Sharing knowledge between generations strengthens the community's capacity to face environmental challenges and promotes resilience.

Affection and solidarity are also prominent in Guayabal. Family and community ties are strong, and residents support each other in difficult times. This network of emotional and social support is critical in coping with the impacts of climate change, as it provides a space for containment, mutual aid, and collaboration in the search for solutions. For

example, the community comes together in road damage due to excessive rainfall to assist those affected and rebuild.

Self-esteem and responsibility strengthen the community's capacity to face the challenges of climate change. Guayabal residents take pride in their culture and their contribution to the sustainable development of their community. They also take responsibility for caring for their environment and taking measures to mitigate and adapt to climate change. For example, they may implement sustainable agricultural practices, such as crop rotation or soil conservation, to reduce environmental impact and ensure food security.

The analysis of the group of **Basic** needs in the rural community of Guayabal reveals different levels of satisfaction in different aspects. Safety and food are prominent, with a rating of Good satisfaction and close to Complete satisfaction. This indicates that residents feel relatively safe in their community and have adequate access to food that meets their basic needs. For example, the indigenous cabildo's surveillance systems, cooperation among neighbors, and the non-presence of illegal groups contribute to improved security in the community. At the same time, the diversity of crops and the availability of local products guarantee good food for residents.

Public services and health range from acceptable to good satisfaction. This implies that residents can access basic services such as water and electricity, but the service could be more regular. Although they do not have a health center, they consider their health good; therefore, there may be improvements in the city and coverage of these services.

However, the infrastructure of the houses is the aspect with the lowest rating, rated as unsatisfactory. This means that many homes in the community need to improve in terms of construction quality, access to basic services, and habitable conditions, which increases residents' vulnerability to climate change and hinders the community's ability to adapt and recover.

In the Guayabal community, it is important to highlight the gender disparities revealed in the analysis of fundamental human needs. As shown in **Figure 18**, men generally

show higher satisfaction levels in the action group, including aspects such as recreation, participation, and communication. On the other hand, both men and women experience similar satisfaction levels in other groups. However, there is a notable gender gap in the fundamental group, especially in housing, where both men and women express lower levels of satisfaction. Women also show lower levels of satisfaction in the action group.

These gender differences have significant implications for vulnerability to climate change. Lower levels of housing satisfaction for both genders suggest inadequate infrastructure or living conditions that could exacerbate community vulnerability to climate-related events. In addition, disparities in the action group indicate potential barriers to women's access to and benefit from recreational activities, participation in decision-making, and effective communication channels. This may limit their ability to respond effectively and adapt to climate change impacts.

A marked gender difference in satisfaction with the need for work is observed. While men report higher satisfaction levels, women express dissatisfaction in this area. This disparity can have significant implications for vulnerability to climate change, as the lack of satisfactory employment opportunities limits women's economic capacity and ability to cope with climate impacts. Addressing this gender gap in access to and quality of employment is crucial for promoting equity and strengthening community resilience in climate change.

Addressing these gender disparities is crucial to improving community resilience and reducing vulnerability to climate change. It requires targeted interventions that address the specific needs and challenges women face regarding housing, access to resources, and opportunities for active participation. By promoting gender equality and empowering women in decision-making, the Guayabal community can leverage their diverse perspectives, knowledge, and skills to develop more inclusive and effective climate change adaptation and mitigation strategies.

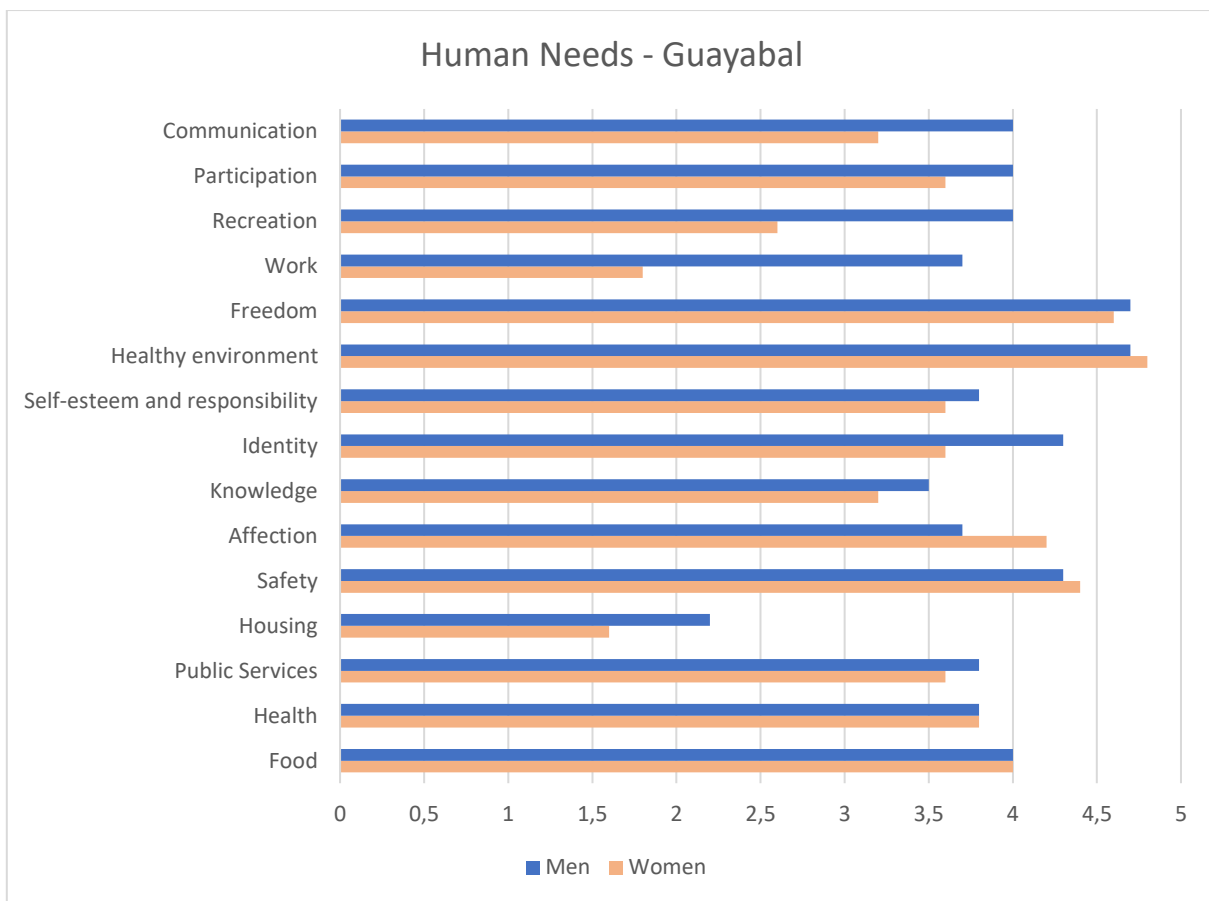


Figure 18: Gender comparison of basic needs Guayabal

7.9 Collective mapping data analysis-Guayabal

The results chapter covers the use of collective mapping as a meaningful method for gathering information and analyzing the geographies of the territory. Through the use of graphic and playful aids, discussions were stimulated, and stakeholders actively participated in the creation of a visual representation of community characteristics (**Figure 19**). The qualitative perspective analysis allowed a detailed interpretation of the collected material, leading to a deeper understanding of the relationship between climate and territory. These results provided insight into the vulnerabilities to climate change in the two communities examined, providing valuable knowledge to guide the development of effective adaptation measures. By exploring these results, a comprehensive understanding of the local context is achieved, which helps to formulate strategies to address the challenges of climate change.



Figure 19. Participatory mapping process

The socio-economic structure of the participants, which included individuals from various professional backgrounds, occupations, and social statuses, was an important factor in analyzing the mapping results. The diverse range of participants, such as farmers, homemakers, merchants, and community leaders, brought a wealth of knowledge and perspectives to the mapping process. Each participant's unique experiences and expertise contributed to a more comprehensive understanding of the community's characteristics and vulnerabilities to climate change. This varied socio-economic composition impacted the results by providing a holistic view of the community's dynamics and informing effective strategies to address climate-related challenges.

In addition, it is important to mention that at the time of the project's socialization in each of the two villages, the attendees agreed to participate; however, since not all the inhabitants attended these meetings, the community leaders decided that I would walk and visit the homes and ask if they wanted to participate in the workshops. Therefore, the inhabitants interviewed were selected according to availability, and most of them were people over 40 years old, including men with agricultural vocations and homemakers.

In the case of the first village-Guayabal, by the components proposed for the research and described in the methodological chapter, the socio-cultural (places of interest where social and cultural activities take place) and environmental components were the most identified in the aerial photographs, representing the importance of social and natural capital for the inhabitants as a basis for the development of group activities and

the use of ecosystem services. For example, recreation and tourism: Natural landscapes and places of cultural interest, such as waterfalls and trails, attract visitors and tourists, generating economic opportunities through sustainable tourism. Also, it is the case of the sense of belonging and rootedness: The preservation of natural spaces and the promotion of local traditions generate a sense of rootedness in the community, strengthening the emotional bond with the place and encouraging participation in its care and conservation.

The identified components, referring to the socio-cultural and environmental aspects, served different purposes in the research context. The aerial photographs revealed that these components existed and were highly relevant for understanding the dynamics of the first village, Guayabal. The socio-cultural component provided insights into the community's traditions, cultural heritage, and social interactions, contributing to the formation of their collective identity. On the other hand, the environmental component sheds light on the natural resources, landscapes, and ecological features that play a crucial role in the villagers' livelihoods and vulnerability to climate change. By identifying and analyzing these components in the aerial photographs, a comprehensive understanding of the village's socio-cultural and environmental contexts was obtained, facilitating informed decision-making and the development of targeted interventions for sustainable development.

In the second village, many participants also identified socio-cultural conditions, environmental factors, and places of interest. However, within the exercise of identifying daily experiences, threats needed to be more widely identified.

According to the five components, the sociocultural through organizational structures and celebration of traditions were the factors most quickly and easily identified by the participants. Even though the water in Guayabal is not potable, the pollution levels remain relatively low due to its source being located in the upper part of the Quilichao River micro-basin. This water is used for human consumption, irrigation of crops and livestock, and cleaning purposes. The environmental component is the most representative as it provides ecosystem services for productive, recreational, and

regulatory activities. However, there are significant environmental challenges in the community. After consumption, water is discharged directly into the soil and water sources without proper treatment. Additionally, there is no designated site for solid waste disposal, resulting in waste burning on the farms. Moreover, traditional practices related to farming and harvesting, such as those based on lunar cycles, have been lost due to uncertainties caused by climate variability. These examples illustrate the community's vulnerabilities and environmental issues, highlighting the need for sustainable practices and improved environmental management.

Additionally, collective mapping identified greater and lesser interest variables based on the results collected in each village. The results of the graphic representation using word clouds in **Figure 20** lead to identifying the importance of the natural resources and ecosystem services offered by the nature reserve, with the high availability of water resources, which promotes agricultural and livestock practices. The participants expressed their positive life experiences through their attitudes and perspectives during the research process. They showed a sense of agency and empowerment, demonstrating their ability to make decisions and control their lives. Their narratives and discussions reflected a strong sense of autonomy and self-determination, indicating that they see themselves as active agents in shaping their destinies.

This positive outlook and self-perception have significant implications for vulnerability and the development of adaptation strategies. When individuals feel empowered and have a sense of control over their lives, they are more likely to engage in proactive measures to address vulnerabilities and adapt to changing circumstances, such as the impacts of climate change. Their positive life experiences are a foundation for resilience and the motivation to seek solutions and implement adaptive actions.

Furthermore, the participants' sense of autonomy and empowerment can contribute to community development and collective resilience. When individuals feel empowered, they are more likely to collaborate, share knowledge, and work together towards common goals. This collective strength and cohesion are vital for developing and implementing effective adaptation strategies. By harnessing the participants' positive

life experiences and empowering attitudes, the community can foster a culture of resilience, build adaptive capacities, and effectively respond to the challenges posed by climate change.

Moreover, the results of the graphic representation using word clouds in **Figure 20** indicate that the participants consider the nature reserve and the water resource availability very important, promoting agricultural and livestock practices, as it allows them to project themselves as autonomous and empowered subjects. Thus, part of the community of Guayabal is located within a protected reserve, which adds to its unique environmental characteristics. Several water sources, including natural springs, the Quilichao River, and micro-watersheds, further enhance the area's ecological significance. These water resources play a crucial role in supporting various ecosystem services and provide essential benefits for the community's livelihoods, such as freshwater for drinking, irrigation of crops, livestock watering, and cleaning purposes. The proximity to these valuable water sources within the reserve underscores the community's reliance on the surrounding natural environment. It emphasizes the need for sustainable management and conservation practices to ensure these vital resources' long-term availability and quality.

However, deforestation practices, changing climatic conditions with heavy rains, and long summer periods lead to road damage, which, in addition to the poor local transportation system, results in low productivity of productive systems. Excessive rainfall can lead to road deterioration, making transportation challenging and sometimes even impossible. The damaged roads impede the smooth flow of goods and increase transportation costs and time, impacting the ability of farmers to bring their products to market. As a result, the commercialization of agricultural products, such as coffee, plantains, tomatoes, and vegetables, to the weekly markets in Santander de Quilichao becomes more challenging, limiting the income opportunities for the community and hindering their economic development.

Furthermore, the low levels of education and limited access to economic resources exacerbate the challenges faced by the community in Guayabal. The lack of

educational opportunities hinders individuals' capacity to acquire the necessary skills and knowledge to enhance their livelihoods and adapt to changing circumstances. This lack of education also affects their ability to access better employment opportunities and higher incomes. The limited economic resources in the community restrict investment in productive activities, infrastructure development, and essential services, further perpetuating the cycle of poverty and vulnerability.

The results of participatory mapping further highlight the impact of these limitations. During the mapping process, community members expressed concerns about the limited access to credit and financial services, which hampers their ability to invest in agricultural inputs, equipment, and technology. Despite the availability of bank loans, the community needs help accessing them due to the lingering effects of climate variability and previous losses in agricultural production. These factors have eroded their confidence in borrowing and investing in agricultural activities. Additionally, the need for adequate healthcare facilities and services was identified as a significant challenge, with limited access to quality healthcare impacting the well-being and resilience of the community.

These findings underscore the interplay between socio-economic factors and vulnerabilities in Guayabal. The combination of environmental challenges, such as deforestation and changing climatic conditions, along with the lack of education and economic resources, creates a complex web of vulnerabilities that hinders the community's capacity to meet their basic needs and adapt to the impacts of climate change. Addressing these underlying issues is crucial for developing effective adaptation strategies and fostering long-term resilience in the face of environmental and socio-economic challenges.



Figure 20: Word cloud main interests – Guayabal

First, in community No.1, **Figure 21** and **Figure 22** show a distribution of the five components throughout the territory. This situation surprised the inhabitants, who thought most activities were around the school. In this analysis, the socio-cultural component is the most mentioned, giving significant importance to the relationships among the inhabitants. They strengthen social cohesion and preserve their traditional cultural practices.

The map reveals significant interrelationships and spatial relationships within the community, unequal resource distribution, and problems and threats in several components. The environmental component highlights the existence of a natural reserve and the availability of natural resources, which is crucial for social life and community activities. However, it is important to mention that the water available in the area is not potable and is consumed without treatment. Despite this limitation, there is abundant access to water for human and animal consumption and crop production, which is still fundamental for the community. In addition, the nature reserve is home to diverse fauna and flora species, contributing to the area's richness and ecological

value. These natural resources have important significance for social life, identity, and community work despite the need to address challenges related to water quality and its impact on community health and well-being. However, water contamination is also observed, which is increasing downstream of the Quilichao River micro-watershed, and deforestation is more evident within the reserve, posing challenges to environmental sustainability and quality of life. However, they needed to learn about some forest damage points observed in the aerial photographs and the collective mapping.

The socio-cultural component includes family gathering places, soccer fields, traditional celebrations, and local markets. These places are distributed in various sectors of the village. However, given the village's size, they are close to each other and play a fundamental role in social life, cultural identity, and community work, strengthening ties and fostering social cohesion.

This unequal distribution of vulnerabilities and threats in the community has profound implications for social life and sustainable development. Disparities in access to natural resources, infrastructure, and basic services generate socioeconomic gaps and social exclusion. Those in areas with a higher concentration of resources, such as the natural reserve zone, have greater opportunities and capacity to cope with the challenges of climate change and other hazards.

Conversely, those in areas with an uneven distribution of resources and greater exposure to hazards may experience greater vulnerability. For example, water pollution and deforestation can affect the availability of drinking water and forest resources, compromising food security and community health.

The places of interest include stores, workshops, community houses, and schools. These spaces are fundamental for the economic and educational development of the community and for promoting productive and learning activities.

In addition, threats such as cell phone antennas and robberies are identified, which, although they represent specific locations, represent challenges to the security and well-being of the community. These threats generate insecurity and stress in the community, affecting their well-being and quality of life. These problems can also

impact trust and social cohesion, hindering the community's ability to face challenges together.

Therefore, these interrelationships and unequal distribution of resources and hazards have significant implications for community vulnerability. The spatial overlap of these elements can generate mutually increasing vulnerabilities, exacerbating the inequalities and risks certain people or sectors face. For example, those who rely heavily on natural resources may be more vulnerable to environmental impacts. At the same time, those with limited access to services and opportunities may face greater challenges in their socioeconomic development. Understanding these interactions is crucial to identifying and addressing inequalities and improving community resilience to the threats and changes they face.

Spatial relations of the principal components - Guayabal

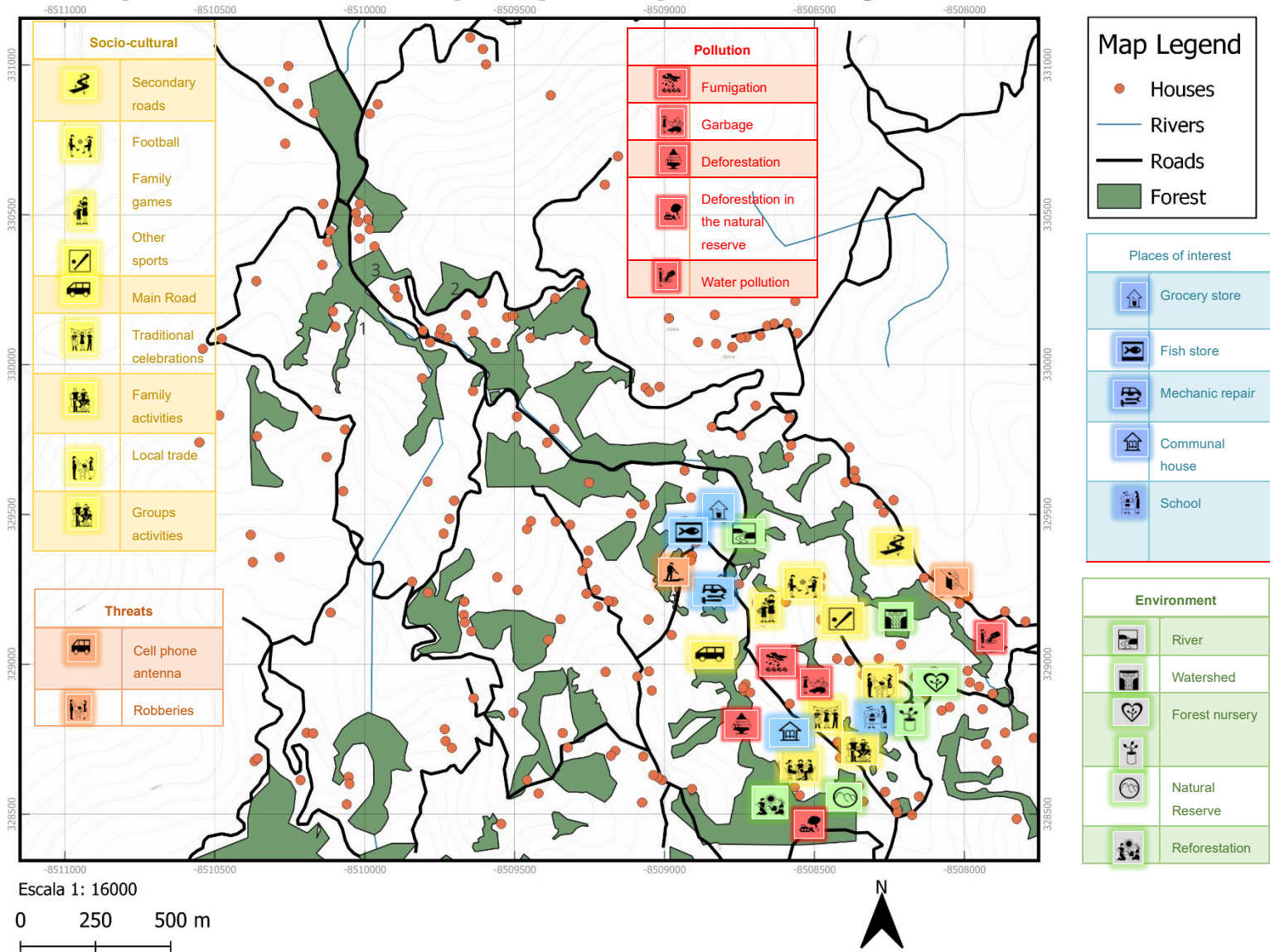


Figure 21: Mapping components-community Guayabal

To visually represent the interrelationships between water resources, forest resources, and productive activities, a graphic design was proposed in collaboration with the community **Figure 22**. It was adjusted according to their interests and the interpretations that emerged from the collective mapping and climate vulnerability analysis. This design symbolizes the water resource as the fundamental basis of the territory for the development of community activities, highlighting its importance for human consumption, agricultural production, and animal husbandry. Forest resources also provide essential ecosystem services for the community, such as water regulation and biodiversity conservation.

The graphic design includes the participation of inhabitants of different ethnic groups that coexist in the territory, reflecting the cultural and ethnic diversity present in the community. These inhabitants play a fundamental role in producing coffee, plantain, and corn, and these agricultural activities are the community's main sources of economic sustenance. However, due to climate variability, the territory has experienced significant changes and challenges in agricultural production, which has affected the community's food security and economic stability.

Based on the community's collective interpretation and representation, this graphic design highlights the interdependence between water resources, forest resources, and productive activities. This visual representation seeks to raise awareness about protecting and sustaining these natural resources and promoting adaptation to climate change and community resilience. This graphic design also serves as a communication tool to sensitize other external stakeholders about the situation and challenges faced by the community regarding climate variability and associated vulnerability.

TERRITORY – LOCAL PERCEPTION

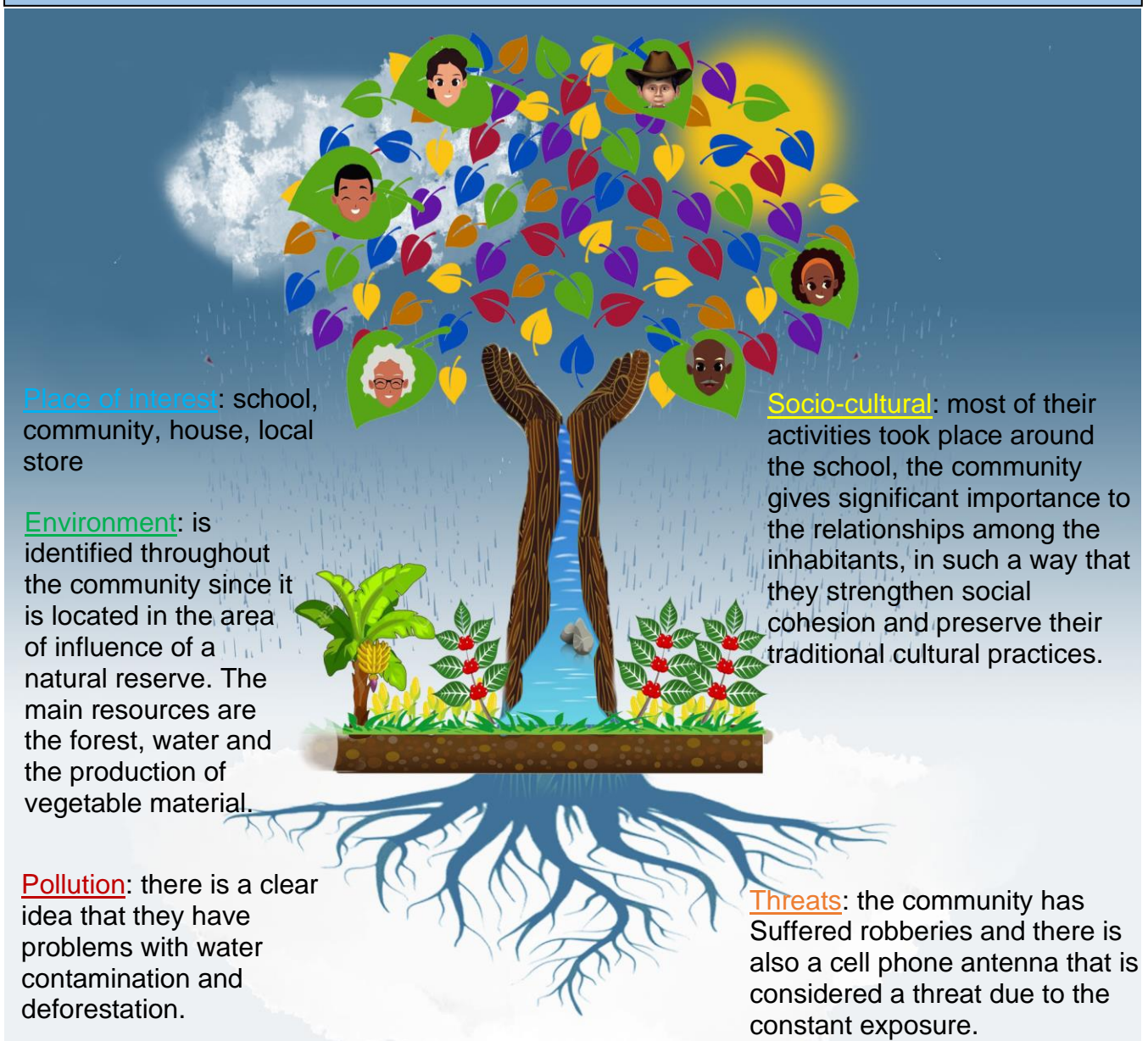


Figure 22: Collective mapping result-community Guayabal

7.10 Participatory community diagnosis-Guayabal

A mixture of challenges and limited progress in various dimensions has characterized the dynamics within the community of Guayabal within the last ten years. While the community has shown resilience and determination in addressing vulnerabilities related to climate change, economic progress has not been as significant as anticipated. However, community

members have actively participated in the identification and utilization of their social and natural capital, recognizing the value of their cultural heritage and environmental resources.

Regarding social aspects, the community has successfully maintained the conservation of traditional celebration practices, fostering a sense of cultural identity and cohesion. This has been instrumental in preserving their rich heritage and promoting social interactions among community members. Despite the challenges posed by climate change, the community has made necessary adjustments to their production practices, allowing them to adapt and continue their agricultural activities, although with modifications.

However, the community has faced limitations in achieving substantial progress on the economic front. The unequal distribution of resources, limited access to financial opportunities, and market constraints have hindered their economic development. These factors, combined with the impacts of climate change, have created additional hurdles for the community's livelihoods and economic stability.

The dynamics of the last ten years in the Guayabal community have been the subject of analysis, evaluating the positive and negative aspects that have shaped its trajectory. This analysis is presented in the table below.

Table 9 presents the positive aspects of the last ten years in the Guayabal community through a timeline to give an initial perspective of the overall achievements and progress in this period. This overview provided a holistic understanding of the progress and important milestones in the community. However, for a more structured and detailed analysis, **Table 10** was used based on specific components such as technical, economic, organizational, educational, environmental, law and order, and others. This table analyzes each component to understand better the interactions and dynamics that influence the community. This approach achieved a deeper and more detailed understanding of the challenges and opportunities that emerged over the years. This componential analysis was instrumental in developing more precise and effective strategies and actions that would drive sustainable development and resilience in the Guayabal community.

According to the diagnosis using the timeline tool, in the last ten years, the positive (Green) and negative (red) aspects (**Table 9**) are related to

Table 9: Timeline - Positives and negatives aspects of Guayabal

		2010	2011	2012	2014	2015	2016	2017	2018	2019	2020
POSITIVE					Installation of a reclaimable well for communal sewage water		2016-2020: No flooding of La Antolina Creek		Aquarisk intervention project proposal, with indirect benefits such as the sale of lunches.		
					First, "corrida de jaula" (traditional feast) community meal	Tree planting (Eucalyptus, Pines, Urapanes)	New JAC	Installation of the playground near the school	Change of teacher at school, different thinking with greater inclusion	Reforested areas	
									Munchique cabildo soccer championship, Guayabal champion	Ecological school visits	Improvement of the main road
	2010 to 2020 improvement in the management of the municipality's properties		Tourist guide training offered by SENA						Adequacy of the soccer field	40 years of JAC	Good health on the sidewalk despite the pandemic
NEGATIVE		Termination of JAC contracts	Death of community leader Rogelio Ípia	from 2012 to 2016, the contracts for the care of the municipality's land within the village were signed by individuals and not by the mayor's office or the community.							Loss of community leader from the JAC
		1996 and 2006: Landslides and flooding of the Quilichao River, road damage, etc.									The pandemic and the death of several inhabitants from different causes

Analyzing the positive and negative aspects of the timeline of the Guayabal community has significant implications for vulnerability to climate change. The improvements in municipal property management and the training of tourist guides demonstrated an increased capacity to address environmental challenges and adapt to changes. The community organization, through JAC (Community Action Board), also had the potential to strengthen community resilience by enabling a collective response to the impacts of climate change.

Furthermore, negative events such as landslides, floods, and the impacts of the COVID-19 pandemic highlighted the community's vulnerability to climate risks. These events could adversely affect infrastructure, livelihoods, and residents' health, adding further difficulties in the context of climate change.

On the other hand, in the diagnosis by components (**Table 10**), the environmental component represents an easy identification of its characteristics both at a positive and negative level, emphasizing the lack of drinking water, institutions for the control of the pollution processes present due to the lack of protection of the environment by some inhabitants. Although there are water sources, they have diminished their flow, mainly in summer. In contrast to the rainy season, abundant water generates floods and loss of crops due to excess humidity.

It is clear to observe the identification of coffee cultivation as the primary agricultural production system. This characteristic was also found in the application of checklists, together with the optimal organizational capacity for the development of community work. In addition, comparing results in basic needs identification with the participatory appraisal, it is evident that the inhabitants live in a peaceful community since there are no public order problems such as illegal armed groups, illicit crops, robberies, or violence.

Regarding the effects of climate change perceived by the community, the main impacts are the effects on crop yields, reflected in the low market prices for their products, which directly affect the local producers' income.

Additionally, the analysis of the community characteristics in Guayabal reveals both positive and negative aspects across various components. In economics, the community benefits from easily marketable products from their production systems, particularly the successful coffee harvest. However, financial challenges include migration to the city for employment and a need for work opportunities on the farms.

During the last decade, agricultural production in the community of Guayabal has exhibited acceptable levels, particularly in crops such as coffee and sugarcane. However, an analysis of production systems reveals a significant inequality between coffee producers with relatively advanced technological standards and those with limited capital. This disparity also extends to vegetable producers, as only a few plots are protected by greenhouse structures, exposing them to the adverse effects of climate change, such as extreme heat.

This situation has implications for the vulnerability and resilience of the community. On one hand, the agricultural production levels indicate a certain level of economic stability and food security within the community. The success of coffee and sugar cane cultivation can contribute to the community's resilience by providing income and livelihood opportunities.

The organizational aspect showcases positive features such as the effective functioning of the Community Action Board and regular community meetings. However, residents must improve communication and cooperation regarding environmental guides and visitor control. Additionally, incentives for learning about the reserve and active participation in reforestation campaigns still need to be included.

The community has a primary school that provides a good education, but the village needs a high school. Access to drinking water remains an issue, and environmental authorities have a limited presence to address environmental concerns. Technical assistance for crop development is needed, and there is room for enhancing community collaboration in training initiatives.

From an environmental perspective, the community benefits from the presence of a reserve area cared for by residents and several water sources. However, there is a need to increase the number of crops under cover, such as greenhouses, to improve agricultural productivity. The diversity of flora and fauna highlights the potential for conservation efforts, but the impact of climate change on crops is already being felt.

However, the inequality between producers with varying technological resources, ownership of land, and capital creates a vulnerable situation. Coffee producers with limited resources may need help adapting to changing climatic conditions or investing in sustainable practices, making them more susceptible to the impacts of climate change. Similarly, the lack of protective measures like greenhouse structures for vegetable producers puts their crops at higher risk, leading to potential yield losses and economic instability.

Addressing the inequalities in agricultural production is crucial to enhancing the community's resilience and reducing vulnerability. This can be achieved through targeted interventions and support, such as providing all farmers access to resources, knowledge, and technology. Implementing climate-smart practices, including using house structures and promoting sustainable farming techniques, can help mitigate climate change risks and ensure agricultural activities' long-term viability.

In addition, promoting collaboration and knowledge sharing among farmers, especially between those with higher technological levels and those with limited resources, can promote a more equitable distribution of agricultural benefits and improve the community's overall resilience. By building adaptive capacity and promoting inclusive and sustainable agricultural practices, the Guayabal community can better withstand the challenges posed by climate change and strengthen its overall resilience.

Public order is not a significant issue, as the community enjoys a peaceful environment and has no major problems. However, there is a low frequency of public transportation, which can hinder mobility within and beyond the community.

In other aspects, the community demonstrates solidarity and support during family tragedies, emergencies, and other challenging situations. Some inhabitants, however, do not share the idea of preserving the reserve and may not actively participate in reforestation campaigns. Additionally, there needs to be more interest in participating in workshops and more investment by the responsible company in the nature reserve.

Table 10: Participatory Diagnosis Guayabal

COMPONENT DIAGNOSIS – GUAYABAL / Community characteristics (positive and negative)							
	<u>Economics</u>	<u>Organizational</u>	<u>Education</u>	<u>Environmental</u>	<u>Technical</u>	<u>Public Order</u>	<u>Others</u>
POSITIVE	What is produced in the production systems is easily marketed	Good functioning of the Junta de Acción Comunal - JAC	School with good primary education	Reserve area in the village cared for by residents	Approach with external institutions (SENA, Secretary of Development Promotion of the Municipality of Stder) to promote technical assistance	No public order problems	Community support in family tragedies, fires, emergencies, illnesses, deaths, etc.
	Good coffee harvest in April and May 2020	Planned community meetings	High school on the neighboring sidewalk	Soils suitable for crops	Training with SENA	Free displacement	
	Agriculture is the main economic activity, followed by coffee, bananas, plantain, orchards, and livestock activity, including livestock, fish, poultry, timber extraction, and home transportation (motorcycle).	Frequent community work	IT room at the school	Diversity of flora and fauna	Training but low community collaboration	Peaceful community	
				Recognition from municipal authorities Several water sources (springs)			
NEGATIVE	They need to do better financially.	Improve communication between residents on the subject of environmental guides and visitor control.		Lack of drinking water	Few crops under cover-greenhouse		Low frequency of public transportation
	Migration to the city in search of employment in the construction sector, public transportation, domestic workers, etc	More incentives are needed for institutions, companies, and individuals to learn about the reserve.		Lack of presence of environmental authorities	Lack of technical assistance for crop development		The community is interested in something other than participating in workshops.
	More employment or work on the farms is needed. Women migrate to the city and do not farm in the village.			Emquilichao is the company in charge of the nature reserve, which has a low investment in the area.			
				Some inhabitants do not share the idea of preserving the reserve and do not participate in the reforestation campaigns. The environmental impact of climate change on crops is being felt.			

The results of the community's participatory diagnosis, combined with the representation of the timeline in which the positive and negative events are related, made it possible to relate the respective dynamics and elaborate on the corresponding interactions.

An analysis of the relationship between tour guide training and the COVID-19 pandemic reveals some interesting insights. While the community devoted significant time and resources to training tour guides, enhancing local tourism infrastructure, and promoting economic growth, the pandemic severely affected the industry, reducing visitor numbers and financial struggles for local businesses and guides. However, the valuable skills acquired by tour guides can be repurposed for other community services or adapted for future tourism experiences, relieving the economic losses incurred.

On the other hand, managing the internal community can lead to better upkeep of access roads, which decreases susceptibility to weather-related events. Unfortunately, the community has experienced landslides and floods that have put infrastructure and public safety at risk. By implementing effective property management measures, such as drainage enhancements and early warning systems, the impact of natural disasters can be lessened, thereby reducing damage to community assets. Consequently, the CAB provides a platform for collective decision-making, resource mobilization, and community resilience-building initiatives. This is achieved through streamlined interaction with the structured CAB, which enables prompt responses to climate change effects and coordinated efforts in emergency response, resource allocation, and long-term adaptation planning.

Within this context, the CCF plays a crucial part in interactions. The community's social capital situation, including support systems and networks, has fostered solidarity and mutual aid during the pandemic, enabling sharing of resources and information. Unfortunately, negative events like the COVID-19 pandemic have strained human capital, disrupting education, healthcare, and employment opportunities and exacerbating socioeconomic inequalities within the community. Nevertheless, despite the challenges posed by the pandemic, the community's robust social capital has enabled resilience by mobilizing collective action, providing emotional support, and disseminating critical health guidelines, successfully mitigating some of the adverse impacts on human capital.

Furthermore, sustainable farming methods, like crop diversification and water conservation techniques, can improve agricultural productivity and fortify resilience against climate

variations. Nonetheless, unforeseeable weather changes, such as droughts or erratic rainfall, lead to reduced crop yields and negative effects on agricultural livelihoods. By combining natural capital (such as soil fertility) with social capital (like knowledge exchange among farmers), communities can enhance their adaptive abilities to reduce the impact of climate variations on farming output. For instance, farmers may share resilient crop varieties or water management strategies (like rainwater harvesting systems) to cope with fluctuating climatic conditions.

7.11 Climate Change Effects from local actors' perspective-Guayabal

The perceptions of local farmers regarding climate change reveal distinct narratives, including concerns about pollution, the belief in divine will, and the impact of youth emigration. Farmers acknowledge that the climate has changed over the past decade, with hotter temperatures, unpredictable rainfall, and intensified seasons. Some attribute these changes to God's wishes, viewing the weather events as signs of the end times or the end of the world. Others recognize the shift in climate patterns but attribute it to pollution, including water source contamination, waste burning, and deforestation.

These perceptions of climate change, which locals attribute to the divine will as a message or punishment from God, are interpreted as signs of the end of time or even the end of the world, depending on their religious beliefs. This perspective reflects a worldview in which faith plays a central role in interpreting natural phenomena. From this perspective, it is important to note that some religions and spiritual beliefs may incorporate the idea of human responsibility for environmental protection. This could be a starting point for discussing how religious communities can contribute to awareness and action in the fight against climate change.

Some individuals' spiritual beliefs are closely tied to their connection with the environment. As a result, they hold a deep respect for the Earth as a divine creation. Therefore, environmental degradation is not solely a physical issue but a spiritual crisis requiring urgent action. The people of Guayabal, for instance, strongly emphasize the religious idea that humans are responsible for caring for the Earth and ensuring its continued vitality. With this in mind, addressing climate change is an environmental necessity and a moral and ethical obligation.

Thus, by recognizing the potential of religious vocation to play a significant role in the fight against climate change, opportunities for dialogue were provided in workshops and focus groups to mobilize people towards collective action, leveraging shared values of compassion,

justice, and respect for creation. This approach aligns with the holistic approach of the research, integrating scientific knowledge with spiritual wisdom and fostering a sense of interconnectedness and collective responsibility.

Through collective decision-making, it was determined that adaptation strategies would be developed in response to the issues identified regarding climate change, taking into account the diverse beliefs and reasons underlying this phenomenon. This approach signifies a shared acknowledgment of the pressing need for proactive and collaborative action against climate change. Despite varying perspectives and motivations, the community recognizes the significance of working together to address the environmental challenges that impact them all. As such, the development of adaptation strategies serves as a unifying point, where differences are set aside in pursuit of a shared objective: safeguarding the environment and securing sustainability for future generations.

Thus, respondents believe that the main causes of climate change are increased pollution, mainly in the water sources, burning of solid waste, and deforestation for timber. In addition, the inhabitants say they feel threatened by the climate because there is uncertainty, water availability is decreasing, crops are not produced as well now, frost damages the harvest, and the constant and unpredictable changes in the climate have caused illnesses among the inhabitants.

First, in the communities' diagnostics workshops, the farmers agree that the climate has changed, saying: "Ten years ago it was not so hot; we knew when it would rain. Moreover, and the exact time of planting and harvesting, now the weather is crazy. It rains in summer, and winters are stronger"¹ (O. Ayala, personal communication, June 2020).

Concerning the general climate conditions in the region, the farmers recognized a bimodal climate, with a summer period between May and September and a rainy period from October to April. Still, this situation has changed, and there is no certainty of when it will rain or when it will be dry.

¹ Personal translation

The analysis of the responses of the leaders interviewed (ten) in the Guayabal village showed that 100% consider that in the last ten years, they have observed changes in the climate, the main changes being the increase in temperature droughts and heavier rains.

On the other hand, some farmers may associate climate change with environmental pollution, such as deforestation and greenhouse gas emissions. They see human activity, especially the exploitation of natural resources, as a key factor contributing to climate change and its negative impacts on the farming community, which implies the loss of efforts with the productive systems regarding land preparation, loss of seeds, reduction in yields, and, therefore, a decrease in family income. For example, they expressed, "In 2019, we planted beans; however, due to excessive rains, the crop was damaged, it had much humidity, and it was supposed to be a summer period" (focus group participants, personal communication, January 2021). Additionally, the heavy rains that have been occurring for approximately six years affect water availability due to the damage caused to the hoses of the electric distribution grid."

In the last ten years, all interviewees have noticed significant climate changes, such as increasing temperatures, more frequent rainfall, and periods of drought (40% of respondents). They primarily attribute these changes to pollution, garbage burning, tree felling, and the degradation of water sources. Surprisingly, 70% do not associate these changes with climate change, even though they acknowledge the shift towards warmer and wetter weather.

A social aspect related to climatic behaviors and generational dynamics emerges from our semi-structured interviews and workshops. Only a small number of young people are engaged in research activities and local organizations, while the general perception among farmers is that the younger generation is less interested in traditional agricultural and livestock pursuits, often opting to migrate to densely populated urban areas in search of employment opportunities in the industrial or commercial sectors.

These local perceptions directly connect with the findings from previous chapters, underscoring how climate change has impacted the Guayabal community. It has affected agricultural production, water resources, and public health while fostering uncertainty and anxiety regarding the village's future.

Regarding the perceived threat to the population, 80% of interviewees express moderate to high levels of concern, generating uncertainty about the village's future and its ability to

maintain its agricultural systems. Additionally, the community widely believes that water resources are diminishing, leading to reduced crop yields, intensified by recent intense summers and winter frosts that disrupt crop growth and hinder farmers' activities due to climate-related illnesses, mainly respiratory issues.

Climate change perceptions are also reflected in water resource alterations, with 60% of interviewees believing that the quality and quantity of water used for agricultural production have been affected. Causes include reduced water flow, longer and more intense summers, spring contamination, increased pests, and intensive mineral extraction.

The common opinion (100%) is that in the past, it was clear when it would rain and when the summer season would be. Nowadays, rains in the summer and droughts in winter frequently generate instability in production and a constant search for strategies to overcome the losses of production systems, such as applying more agrochemicals and changing crops.

According to the interviews conducted regarding climate change perception, the inhabitants know this phenomenon has generated a series of changes in Guayabal. The principal changes include low crop yields, constant temperature changes with a tendency toward high temperatures, and alterations in crop choices to adapt to the new conditions (**Table 11**).

Table 11: Community climate perceptions-Guayabal

Past	At present
June, July, and August were always summer months	Heavy rainfall during these months
Cooler climate	High temperatures
Higher crop yields	Lower crop yields
Low use of agrochemicals	Intensive use of agrochemicals
Moderate rainfall	Heavy rains
Established planting and harvesting dates	Uncertainty in planting and harvesting dates
Planting based on beliefs (phases of the moon)	Planting based on beliefs (moon phases) and climatic data

These results highlight the vulnerability of the Guayabal community to climate change impacts. Eighty percent of interviewees feel threatened by climate change and recognize its negative effects on their daily lives and livelihoods, revealing low resilience and adaptive capacity.

However, not all community members are affected in the same way. Although 100% of the interviewees recognize climate change, their vulnerability and response capacity perceptions vary. For example, 20% of the inhabitants indicate feeling slightly or little threatened by changes in climate, which may suggest that they have more resources or capacities to adapt. On the other hand, the remaining 80% feel threatened to a great extent, indicating greater vulnerability.

Implementing the above adaptation strategies may be limited by factors, including high costs, associated risks, and barriers to accessing resources or expertise. While some individuals may have the resources and capacity to implement adaptations, other community members will likely need help. This can lead to inequalities in the community's ability to respond and adapt to climate change.

In summary, these results highlight the vulnerability of the Guayabal community to climate change and the need for adaptation activities to protect their production systems and natural resources. However, they also reveal inequalities in the responsiveness and applicability of adaptation strategies, indicating that some community members may be more exposed to climate change impacts and have fewer resources to cope with them. Therefore, the community that participated in implementing participatory methodologies agrees that climate conditions have changed in the past, expressing a series of similar characteristics.

In conclusion, 100% of the interviewed people consider climate change adaptation activities involving their production systems and the natural resources they use to develop their livelihood strategies.

7.12 Agricultural climate vulnerability analysis

The analysis of agricultural vulnerability to climate change in the Guayabal community is linked to the farmers' perception chapter results, considering exposure, sensitivity, and adaptation.

Based on the above results, the identification of climate vulnerability is carried out. Therefore, the following three factors and their respective conditions determine the vulnerability to climate change: exposure, sensitivity, and adaptive capacity (see vulnerability analysis explanation in methodology).

This analysis considers the main production systems in Guayabal. Coffee and plantains are the main income sources for most community families. These crops are valued in the market and generate monetary income for the families. In addition, coffee and plantains have a long agricultural tradition in the region, and their production has been consolidated as a fundamental economic activity.

Beans, vegetables, and chicken eggs are other products that contribute to family income. These products are marketed to a lesser extent than coffee and plantains but still represent an additional source of income. However, it is important to note that the income generated by these products is relatively minor compared to the two main crops.

It is important to mention that the availability and distribution of land play a crucial role in diversifying income sources. Not all families have large tracts of land to cultivate, which limits their ability to diversify their production and rely heavily on the main crops. This situation can influence families' vulnerability, as dependence on a single livelihood exposes them to greater risks in the event of shocks or changes in climatic conditions that affect coffee and plantain production.

Table 12: Living strategies by community-Guayabal

Community	Living strategy
Guayabal	Coffee + Plantain + beans + Vegetables + Hens + household duties

Thus, using the information collected, the level of exposure was determined by analyzing the main agricultural product identified by the inhabitants of the two villages. The analysis was corroborated and complemented by applying productive systems checklists to identify the livelihoods, strategies, and adaptation measures carried out by the inhabitants of the two villages (**Table 12**).

In terms of exposure, farmers perceive decreased water availability, crop deterioration, damage from excess rainfall, and constant and unpredictable changes in climate. These

changes have affected production systems, including land preparation, seed loss, decreased yields, and decreased household income. In addition, the heavy rains of the last ten years have affected water availability due to damage to the hoses of the artisanal distribution network. These adverse weather events have significantly affected agricultural systems, crops, livestock, water resources, and infrastructure.

Agricultural exposure has also influenced socioeconomic factors, such as poverty, lack of access to resources and technologies, and lack of crop diversification. These factors have increased farmers' and agricultural systems' vulnerability to climate change impacts. However, exposure provides a basis for understanding the risks and magnitude of climate change's potential impacts on the agricultural sector.

According to the location order in Table 12, the most important products in income generation are coffee and bananas for families. These crops represent a fundamental source of economic sustenance for the families, allowing them to obtain income through their sale. However, exposure to climate change threatens the subsistence of these families and the viability of their livelihoods. For example, coffee and banana production are affected by high temperatures that reduce coffee quality and yields, while droughts can affect the development and productivity of bananas. Furthermore, while the sensitivity of coffee cultivation to climate change is high, meaning that it is highly susceptible to the negative impacts of changing climatic conditions, banana cultivation has a low sensitivity.

Adaptation is essential to reduce the vulnerability of families that depend on coffee and bananas for their livelihoods. This has meant implementing strategies and measures for farmers to cope with the impacts of climate change and maintain their crops' sustainability. Some adaptation measures are the coffee seed bank, implemented mainly by large producers, diversification of agroforestry crops as an alternative to the low productivity of other crops, planting dates as an option to climate variability, live fences to control pests that have become more frequent due to climate changes, and community crops.

Beans, tomatoes, and blackberries are products of medium importance to household income, and their vulnerability to climate change can also significantly impact household livelihoods and well-being. Although these crops may generate less income than coffee and bananas, they still represent an important part of household livelihoods. Exposure to climate change,

such as variability in rainfall or increased temperatures, can affect the production and quality of these crops, resulting in reduced household income and increased food insecurity.

To ensure household livelihoods, it has been necessary to address the vulnerability of these crops through adaptation strategies. These have included planting dates to try to coincide with the rainy season, crop rotation and tillage to improve soil conditions, pest control, and crop location to take advantage of drip irrigation or live fences.

Finally, although products with little importance to household income, such as vegetables, may not represent a major source of income, they can still be important for household livelihoods and well-being. These crops provide essential nutrients, diversify diets, and ensure food security at the household level. Exposure to climate change has affected the availability and quality of vegetables, putting household livelihoods and well-being at risk.

In this context, the main differences in livelihoods' exposure to climate change were that in the Guayabal village, plantain and bean crops, vegetables, and minor species have moderate exposure. On the other hand, bean, tomato, and blackberry crops have extreme exposure.

As a result, it was found that only two of the two villages' productive systems, casava and livestock, have not yet been affected by climate change. On the other hand, with moderate perception, the inhabitants perceive climate change in 4 of their main livelihoods (Banana, Corn, Vegetables, and Minor species). Finally, extreme changes are perceived in the livelihoods of coffee, beans, tomatoes, blackberries, flowers, and fruit trees, related to the heavy and unpredictable rains and increased temperature in the communities.

Subsequently, a **sensitivity** assessment was carried out to continue with the analysis to determine the impact on livelihoods because of changes in the climate within the research area.

Sensitivity has been a key component of vulnerability to climate change in the agricultural sector. The assessed sensitivity demonstrates how the capacities of agricultural systems in the community have been affected by climate change, suffering damages, losses, or negative changes due to those impacts.

In the agricultural context, sensitivity relates to the capacity of agricultural systems to adapt to and withstand changes in climatic conditions. This agricultural sensitivity to climate change is influenced by several factors, such as crop diversity, soil quality, access to resources and

technologies, the ability of farmers to make informed decisions and adapt, and the availability of support services, such as agricultural advice.

When agricultural sensitivity is high, as with coffee, bean, tomato, and blackberry crops, these farming systems are more prone to damage and loss due to the impacts of climate change. This has manifested in decreased crop yields, reduced water availability for irrigation, the spread of pests and diseases, soil degradation, and loss of agricultural biodiversity.

On the other hand, when sensitivity is low, as in banana and vegetable farming systems, farmers have a greater capacity to resist and adapt to the impacts of climate change. This has been due to crop diversification, appropriate knowledge, and farmers' ability to make timely and adaptive decisions. Therefore, it is important to address agricultural sensitivity through adaptation strategies to reduce vulnerability to climate change in the agricultural sector.

As a result of the livelihood sensitivity analysis, it was possible to identify that the climatic variables of temperature and precipitation play a determining role in crop yields due to the need for irrigation, soil moisture, and ideal temperature conditions. Then, farmers show sensitivity to their livelihoods with periods of lack of rain, excessive rainfall, and increased temperatures.

Therefore, according to the producers' perception, the livelihoods most affected in terms of sensitivity are coffee, beans, tomatoes, and blackberries, which coincides with an affectation of the most important livelihoods. Cassava, flowers, and fruit trees were identified as the most affected livelihoods at the medium level of impact. The plantain crop is less affected because it is currently better adapted to the temperature conditions; vegetables are grown for food security. Therefore, they are monitored almost daily and have a short harvesting period for minor species because there is space for them.

Additionally, in the participatory workshops, producers were asked to mention the adaptation measures they are implementing and to indicate their effectiveness, thus completing the information for the vulnerability assessment, including **adaptive capacity** as the last component of the formula.

The scale of "+", "++" and "+++" refers to the level of effectiveness of adaptation strategies implemented by Guayabal farmers in the face of climate change. A single "+" indicates low effectiveness, implying that the strategies may have limitations and not provide solid protection against climate impacts. A "++" represents medium effectiveness, suggesting that the strategies implemented provide some protection and adaptive capacity but could still be improved to address climate challenges more effectively. Finally, a "+++" indicates high effectiveness, meaning that the strategies implemented by Guayabal farmers have proven successful and efficient in adapting to climate change, providing strong protection and significant capacity to address climate impacts.

Farmers have developed adaptation strategies for climate change, such as implementing new crops resistant to warmer temperatures and adjusting crop varieties according to the new conditions (**Table 13**). However, these strategies are constrained by socioeconomic factors and need more access to adequate resources and technologies, perpetuating the community's vulnerability to climate change. In addition, the migration of young people to urban centers searching for employment in industrial or commercial sectors also affects the community's adaptive capacity.

Adaptive capacity has been represented by farmers' ability to adjust and respond effectively to the changes and challenges that have arisen due to climate change to minimize risks and take advantage of opportunities.

At the community level, farmers have used information sharing to improve crop adaptation to changing climate conditions, crop diversification to reduce dependence on a single crop, and increased resilience of farming systems to the impacts of climate change. In addition, the organization and active community participation of farmers in community networks has helped in the collective adoption of adaptation measures.

Table 13: Agricultural vulnerability analysis: exposure, sensitivity, and adaptation in Guayabal

Livelihoods	Climate change perception		
	Exposure	Sensitivity	Adaptation
Coffee	High	Medium	Seed bank +
			Agroforestry crop diversification ++
			Planting date ++
			Live fences ++
			Community crops +++
Plantain	Low	Medium	Crop diversification according to altitude above sea level +++
			Tillage +
			Sowing date ++
Bean	High	High	Planting date ++
			Pest control ++
			Tillage ++
Tomato and Blackberry	High	High	Crop rotation ++
			Tillage ++
			Date of sowing +
			Planting location +++
Vegetables	Low	Medium	Tillage +
			Date of sowing +++
			Intercropping +
Categories	Low (1)	Medium (2)	High (3)

The livelihood with the highest number of adaptation measures (coffee, with five) presents a medium level of adaptive capacity due to only one measure having high effectiveness and one having low effectiveness, with the majority (three) having measures of medium effectiveness.

Additionally, not all of these adaptation practices help to adapt to climate change, as there are additional dynamics to which households need to adjust. In addition to the practices mentioned above, it is important to recognize that farm households also face other challenges in climate change. These dynamics include economic aspects, such as the availability of

agricultural credit, input costs, and market prices of agricultural products, which can also influence the vulnerability of households and the viability of their livelihoods. It is, therefore, critical to consider and address these additional dynamics when designing effective adaptation strategies.

Fluctuations in prices and demand for agricultural products can significantly affect household incomes. For example, if crop prices decline due to increased market supply or changes in consumption patterns, households may experience economic hardship even if they have implemented effective climate adaptation practices. In addition, economic and trade policies can impact the viability of agricultural livelihoods, and households must be prepared to cope with these changes.

Soil erosion is another challenge facing farming families, especially in Guayabal, where intensive agricultural practices have historically existed and land use changes have occurred. Soil erosion can reduce soil fertility and negatively affect crop productivity. To adapt to this challenge, families can implement soil conservation practices, such as no-till farming, terrace construction, or agroforestry systems that help reduce erosion and improve soil quality. However, economic resources and technical assistance are necessary for their implementation.

In addition to these economic and environmental dynamics, there are other variables to consider, such as social and cultural aspects. For example, traditional crop management practices and local knowledge can be valuable in adapting to climate change. Knowledge sharing and collaboration among farming families can also strengthen collective resilience to climate challenges.

Thus, taking up the IPCC definition in which the vulnerability of a system is analyzed according to its level of exposure, sensitivity, and adaptive capacity, an estimate of the livelihoods of the two communities about climate vulnerability is carried out (

Table 14).

Table 14: Vulnerability of livelihoods to climate variability in Guayabal

Livelihoods	Exposure	Sensitivity	Adaptive capacity	Vulnerability
Coffee	3	3	2	High
Plantain	2	1	2	Medium
Bean	3	3	2	High
Tomato	3	3	0	High
Blackberry	3	3	2	High
Vegetables	2	1	2	Medium
Minor species	2	1	0	Medium
Criteria: Two or three orange factors: High Vulnerability One orange factor or two yellow factors: Medium vulnerability One factor or no yellow factors: Low vulnerability.				

The analyses indicate that the livelihoods most vulnerable to climate variability are coffee, beans, tomato, and blackberry due to high exposure and sensitivity, even though adaptation measures have medium effectiveness and require constant modification due to changing climate conditions. As a result of the semi-structured interviews and the subsequent analysis of livelihoods and livelihood strategies, in addition to the activities with producers developed in the focus groups, producers are more vulnerable within the two communities because they depend on a single livelihood.

Analysis reveals that certain groups are more vulnerable to climate change for various reasons. One of the key factors is dependence on a single livelihood. For example, farmers whose livelihoods are based primarily on one of the following production systems (coffee, beans, tomatoes, and blackberries) are more vulnerable due to the high exposure and sensitivity of these crops to climate variability. By relying heavily on a single crop, these

groups face greater risks, as any adverse change in climatic conditions can severely affect their ability to generate income and meet their basic needs.

In addition to dependence on a single livelihood, other factors contribute to certain groups' vulnerability, mainly farmers with less land available for cultivation. Therefore, if farmers have limited access to arable land, their ability to diversify their crops and adapt to changing climatic conditions is compromised. Also, the need for access to modern agricultural technologies and sustainable practices limits the ability of these groups to implement effective adaptation strategies.

It is important to note that the adaptation measures implemented so far are only moderately effective and require continuous adjustments due to constantly changing climatic conditions. This adds a layer of vulnerability for those groups facing limitations regarding resources, knowledge, and capacity to implement and adapt these measures effectively.

The livelihoods of plantain, vegetables, and minor species present a medium vulnerability due to low exposure and sensitivity, even though some do not have adaptation measures.

The livestock livelihood is the only one with low vulnerability because it has low exposure and sensitivity and highly effective adaptation measures.

Thus, the vulnerability analysis of livelihoods to climate variability shows that there are practices to adapt to climate with different effectiveness levels. However, it is necessary to fill the gaps in the adaptation coverage of the other livelihoods that lack actions to face climate change. In addition, many of the practices carried out by the inhabitants of the two communities are the product of traditional actions, evidencing the need for more support from local and regional institutions where capacity building is strengthened.

7.13 Community Capital Integration and Basic Needs: An Analysis of Vulnerability to Climate Change-Guayabal

Vulnerability Analysis

In this chapter, the results of analyzing the capitals of the Guayabal community were integrated to understand their relationship with vulnerability and basic human needs in climate change. The socio-spatial component was examined through the results of the collective mapping conducted in the community. In addition, the main challenges faced by the community in different areas were identified, using the analysis of capital as a guide. I

analyzed how one type of capital can help overcome the challenges of another type of capital or how the lack or deterioration of capital can worsen the negative effects of climate change.

The Guayabal community faces significant challenges in terms of vulnerability to climate change. For example, the decrease in water resources due to deforestation in the reserve zone where the water sources are located threatens water availability, directly affecting the community's natural capital. In addition, the lack of waste management contributes to soil contamination, further worsening the situation and increasing the community's vulnerability. Thus, deforestation, involving the removal of trees and vegetation in a specific area, can have diverse adverse consequences.

Firstly, deforestation reduces forests' ability to retain water and regulate the hydrological cycle. This translates to fewer trees to absorb rainwater and release it gradually, resulting in diminished groundwater recharge and increased surface water scarcity. This decrease in water resources directly jeopardizes water availability for the community, which is particularly critical in climate change, where variations in precipitation patterns are more pronounced and unpredictable.

Secondly, the absence of waste management mentioned in the text contributes to soil contamination. Deforestation can exacerbate this issue by exposing the soil to erosion and runoff. Rain can carry sediments and surface contaminants into the soil and nearby water bodies without vegetation acting as a natural barrier. This negatively impacts soil and water quality, which, in turn, can impair the land's capacity to yield crops and generate income for the community.

Climate change also threatens agricultural productivity, a key income source for the community. The lack of institutional and political support hinders the implementation of sustainable agricultural practices, negatively affecting the community's human and social capital. In addition, soil erosion, partly caused by inadequate agricultural practices, further aggravates the effects of climate change on agricultural productivity, generating a vicious cycle of diminishing natural and physical capital.

In some cases, mutually supportive relationships between different types of capital were identified. For example, community solidarity networks can compensate for the municipality or department's lack of political/institutional support. These social support networks strengthen

the community's social capital and can help overcome challenges in other areas, such as lack of access to financial or technological resources.

On the other hand, the lack of investment in adequate physical infrastructure, such as irrigation and drainage systems, has negatively affected both physical and human capital. Lack of access to quality water and appropriate technologies limits agricultural productivity and, in turn, affects the ability to generate income and meet basic needs, affecting both physical and human capital.

For example, there was evidence of an interrelation between natural capital and financial capital through the conservation of natural resources and the generation of economic benefits through the sale of native trees produced in the village nursery and through ecotourism tours, thus strengthening the community's financial capital.

In addition, there is an interrelation between physical capital, human capital, and social capital, related to the availability and quality of physical infrastructure, such as rural roads and basic services, which are represented in the social capital through the community work for the adequacy of roads that favor mobility in the village, facilitating community members' access to educational and employment opportunities. Adequate infrastructure can facilitate access to schools and markets, thus improving the community's human capital.

On the other hand, the interrelationship between political capital and social capital, regarding influence and access to decision-making processes related to climate change, shows how social capital promotes citizen participation and collaboration among members. For example, through participation in local governance spaces on climate change, the community has mobilized collective resources and knowledge to implement mitigation and adaptation actions, thus fostering community resilience.

Finally, the expression and promotion of community culture have strengthened social capital by fostering cohesion and a sense of community among members. For example, the celebration of cultural festivals or participation in sports events generates spaces for meetings and collaboration, thus strengthening social ties and mutual trust.

The socio-spatial dynamics identified through the collective mapping revealed the geographic distribution of the components of interest to the community. For example, by mapping sites of cultural interest, deforestation zones, threats, and water sources, among others, it was

possible to identify areas with contamination, which is crucial to understanding the community's vulnerability to drought or lack of access to drinking water. The mapping also helped to identify areas prone to landslides or flooding, which allows for a more accurate assessment of the impacts of climate change on the physical security of the community.

By combining the results of the collective mapping with the analysis of capital and basic needs, clearer relationships were established between socio-spatial aspects and vulnerability. For example, a high concentration of substandard housing was identified in flood-prone areas, with increased community vulnerability to extreme weather events. In addition, the mapping revealed the location of basic services such as schools, meeting centers, and transportation infrastructure. This allowed the assessment of the community's resilience regarding access to these services in climate change situations.

Thus, the analysis of community capital revealed the main challenges faced by the Guayabal community in the context of climate change. These challenges include diversifying livelihoods, promoting sustainable and appropriate technologies, improving physical infrastructure, strengthening community solidarity and cooperation networks, and increasing access to financial resources.

To overcome these challenges, it is crucial to recognize the interrelationship between different capitals and seek integrated solutions that address multiple aspects. For example, promoting livelihood diversification can help reduce dependence on a single crop and increase community resilience to climate change impacts. In addition, strengthening solidarity networks can compensate for the lack of political or institutional support by providing shared resources and knowledge to adapt to climate change.

Therefore, analyzing the Community Capitals and their relationship with Vulnerability and Basic Human Needs in the Guayabal Community in the face of Climate Change revealed various strategies and actions needed to strengthen resilience and improve the population's living conditions. Next, the results obtained in each capital and their implication in reducing vulnerability will be analyzed:

Human Capital: Improving access to technical assistance and training related to climate change is critical to strengthening community adaptive capacity. This will enable farmers to acquire the knowledge and skills necessary to implement sustainable agricultural practices and address climate challenges.

Social Capital: Developing productive alliances within and between communities will strengthen the collective response capacity to climate change. In addition, improving the organization of producers for marketing will facilitate market diversification and access to better prices. Strengthening internal and external communication channels will allow for greater coordination and collaboration in implementing adaptation strategies.

Physical Capital: Improving access roads will improve the mobility and marketing of products and strengthen the community's resilience to the impacts of climate change. The acquisition of equipment and infrastructure for irrigation, cultivation, and post-harvest through the municipal administration will optimize the efficiency of production systems. In addition, strengthening basic services such as water and energy will contribute to the security and well-being of the population.

Natural Capital: Adopting sustainable agricultural practices is fundamental for conserving and improving natural capital. The use of organic fertilizers, the expansion of community seed banks, and the reduction of agrochemical use will promote biodiversity and healthy ecosystems. Implementing biological pest control, rainwater harvesting, drip irrigation systems, and the construction of small water reservoirs will contribute to more efficient water resource management.

Cultural Capital: Recovering local traditions will strengthen the community's sense of identity and belonging, fostering cultural resilience in climate change. In addition, transmitting farmers' knowledge and experiences to new generations will ensure the continuity of sustainable and adaptive practices.

Political Capital: Institutional support through projects is crucial to strengthen the community's adaptive capacity. Improving local authorities' participation levels and promoting youth participation in local political structures will facilitate effective decision-making and policy implementation.

Financial Capital: The availability of financing is essential to support agricultural and livestock activities. Access to bank loans and expanding government subsidy programs will facilitate investment in sustainable technologies and practices and diversification of income sources.

7.14 Pavitas

7.14.1 Human capital

In the analysis of human capital in the rural community of Pavitas, an unequal distribution in terms of gender and age is observed among the interviewees. The fact that 75% of the interviewees are men and 25% are women suggests possible imbalances in access to opportunities and resources, as well as in participation and decision-making in the community. This may influence how climate change issues are addressed and understood, as women's perspectives and experiences may differ from those of men.

The predominant age of respondents, ranging from 40 to 65 years, indicates a significant presence of middle-aged and older people. This may affect climate change adaptation, as these generations may have different knowledge and awareness of current environmental challenges. The low presence of young people in the sample suggests the need to actively involve younger generations in planning and decision-making related to climate change adaptation.

Most families comprise between 3 and 4 inhabitants, although there are also cases of smaller families with two members and larger families with five members. This aspect may influence families' adaptive capacity in the face of climate change since the size of the family may determine the availability of labor and resources to implement adaptation strategies.

Basic primary education predominates, followed by secondary education, and some have studied technical programs beyond high school. While basic education provides a knowledge base, it is important to consider strengthening education. The availability of post-baccalaureate technical programs may be an opportunity to promote specific skills and knowledge in areas related to climate change adaptation, such as sustainable agriculture or natural resource management.

Health is reported to be generally good; the main illnesses are colds and diabetes. However, it is important to recognize that climate change may impact community health. Rising temperatures and changes in disease patterns may influence the prevalence of vector-borne diseases. The community should consider integrating public health measures and the promotion of healthy lifestyles into their climate change adaptation strategies.

The school and the Canoas town council's promotion of the teaching of the Nasa Yuwe language is a strength in terms of human and cultural capital. Preserving and promoting the indigenous language contributes to valuing cultural identity and traditional knowledge. This can play an important role in climate change adaptation by recognizing and building on local knowledge about the natural environment and sustainable practices.

The strengths in human capital, such as basic primary education and constant technical assistance from organizations like the United Nations, SENA, and the Coffee Growers' Federation, provide a foundation for knowledge and skill development. The presence of multi-skilled producers suggests a certain level of adaptability within the community. However, the high presence of the illiterate elderly population poses a challenge. This demographic may have limited capacity to understand and respond to climate change, so it is crucial to implement targeted educational programs and awareness campaigns tailored to their needs. Furthermore, having more than one teacher in the school implies limited educational resources and highlights the need for additional support and resources in the education sector.

Regarding vulnerability to climate change, the human capital aspects mentioned above may have significant implications. Gender inequalities in representation and participation may affect inclusive decision-making and the implementation of equitable adaptation strategies. The age of the interviewees suggests the need to transmit knowledge and awareness of climate change to younger generations. Family size and education level may influence the ability of families to adapt and respond to climate change impacts. In addition, promoting indigenous languages can strengthen cultural resilience and local knowledge to address environmental challenges.

7.14.2 Social Capital

The Community Action Board (Junta de Acción Comunal-JAC) and committees by component demonstrate community organization and social cohesion. These structures can serve as avenues for collective decision-making and resource mobilization, strengthening the community's adaptive capacity. However, the low presence of public institutions hampers the availability of resources and support for climate change adaptation efforts. Strengthening relationships and collaboration between the community and public institutions is crucial to foster better cooperation and facilitate access to resources, funding, and technical expertise.

Moreover, enhancing community participation in meetings and decision-making processes can promote inclusivity and ensure that diverse perspectives are considered.

There is a strong relationship between capitals, particularly concerning social capital, in the rural community of Pavitas; for example, the JAC and committees play a vital role in conserving and managing natural resources. They raise awareness about the importance of preserving the forests, water sources, and other natural assets in Pavitas. By promoting sustainable practices and advocating for responsible resource use, these community organizations can contribute to preserving natural capital and enhancing the community's resilience to the impacts of climate change.

The Pavitas community has a strong internal organization through the Junta de Acción Comunal (JAC). This institution plays a key role in strengthening political capital within the community. The JAC acts as a meeting point for community members, facilitating collective decision-making and promoting citizen participation in matters of common interest. Through the JAC, the Pavitas community can consolidate their demands, express their concerns, and establish a platform for dialogue with government authorities. The importance of strengthening relationships and collaboration within the community and with government authorities to leverage political capital is recognized. However, the relationship with government authorities is limited. This direct interaction with local authorities allows the community to significantly influence the development of policies and programs that address climate change challenges at the local level. The existence and effective functioning of the CAB strengthen the community's ability to leverage its internal political capital and establish constructive linkages with government authorities to benefit climate change adaptation in Pavitas.

Social capital is fundamental in promoting community work and collective decision-making in the Pavitas community. The Junta de Acción Comunal (JAC) is an outstanding example of this dynamic, as it facilitates the participation of community members in the planning and execution of joint projects. The JAC fosters collaboration and mutual support, allowing individual and family needs to be addressed collectively. This community approach strengthens social ties and promotes solidarity among Pavitas residents.

However, social disparities are also observed in the community, as some people own larger farms and have greater access to resources. These disparities can influence the

opportunities and resources available. It is important to recognize these differences and work towards equity, inclusion, and active participation of all community members, regardless of their socioeconomic conditions.

7.14.3 Physical Capital

While Pavitas benefits from certain aspects of physical/built capital, such as public transport and an electric power grid, challenges persist. The low internet coverage and cellular signal hinder access to information and communication technologies, limiting opportunities for learning, market access, and connectivity with the outside world. Improving internet infrastructure and expanding cellular coverage are essential to bridging the digital divide. The absence of a health center and potable water sources highlights vulnerabilities in healthcare and basic amenities. Developing health infrastructure and ensuring access to clean and safe water are crucial for safeguarding community well-being, particularly in the face of climate change-related health risks.

The physical capital in the Pavitas rural community has key aspects, such as public transportation and the electric grid, that benefit the community. However, persistent challenges have also been identified, such as the low internet and cellular signal coverage due to mountainous geographic conditions, which limit access to information and communication technologies and opportunities for learning, market access, and constant connectivity with the outside world.

This lack of access to information and communication technologies has been a limiting factor for the economic and social development of the community, which has also brought implications for its ability to adapt to climate change. Additionally, the Pavitas village lacks a health center and potable water sources, which highlights vulnerabilities in terms of healthcare and the community's basic needs. The lack of access to healthcare services and clean and safe water increases the risk of climate change-related diseases, such as vector-borne diseases, diarrheal diseases, and respiratory infections.

In this sense, lacking physical capital, such as healthcare infrastructure and potable water sources, can increase the community's vulnerability to climate change. Therefore, it is important to improve healthcare infrastructure and ensure access to clean and safe water to protect the community's well-being and improve its capacity to face the challenges of climate change. Additionally, the need for access to information and communication technologies,

such as the internet and cellular signals, can limit the ability of the Pavitas community to access relevant and updated information about climate change and its impacts. This can make informed decision-making and implementing adaptation and mitigation measures more difficult.

On the other hand, physical infrastructure, such as public transportation and the electric grid, positively impacts the community's ability to adapt to climate change. For example, public transportation has facilitated evacuation in case of natural disasters, such as landslides. However, these access roads require constant maintenance due to their steep slope conditions, mainly in the rainy season.

This constant maintenance implicates the need for collaboration and cooperation between the communities of Pavitas and Guayabal to keep these shared roads in good condition. This is an example of how physical capital relates to social capital and demonstrates how these social factors are fundamental to ensuring access to services and resources that are important for climate change adaptation.

In this sense, maintaining shared access roads is important for ensuring mobility and access to services, but it is also crucial for fostering collaboration and cooperation between communities. Social capital understood as the network of relationships and resources possessed by communities, is essential for addressing the challenges of climate change and ensuring community resilience. Therefore, collaboration and cooperation between the Pavitas and Guayabal communities are critical to maintaining shared access roads and access to important services and resources for climate change adaptation.

The analysis of physical capital in this situation showed that although public transportation exists, its frequency is low, and respondents rate it as regular or good at best. This lack of frequency in public transportation has had a negative impact on people's mobility and accessibility to important services and resources.

As a result, many opt to own motorcycles or pay for transportation on these motorcycles, which can be costly and only sometimes a viable option for everyone. In addition, the low frequency of public transportation can also affect product transportation, limiting communities' ability to market their products and generate income.

Therefore, improving public transportation infrastructure is required to ensure greater frequency and accessibility to the services and resources necessary for climate change adaptation. This would improve people's mobility and positively impact the local economy by allowing for greater product marketing and income generation.

It is worth noting that the access roads from Santander de Quilichao to this area are four kilometers of paved roads and four kilometers of gravel and dirt roads. This mix of road types can also contribute to the local population's challenges regarding transportation and mobility. The unpaved sections of the road can become difficult to navigate during heavy rainfall, which can further limit access to important services and resources. Therefore, it is essential to consider the frequency of public transportation and the quality and condition of the roads that provide access to these services and resources.

Finally, the analysis of physical capital in the Pavitas community reveals a combination of characteristics and challenges. Most houses are built with wood and mud, reflecting a traditional construction approach. However, a transition towards new houses built with brick and cement is observed, indicating a shift in construction practices and greater durability of the structures. This evolution can provide greater stability and resistance to the impacts of climate change.

Despite these advances, there is a clear need to strengthen physical capital in the Pavitas community. The limited availability of adequate educational institutions and insufficient infrastructure suitable for productive activities represent significant challenges. The presence of a primary school and a communal hall for the Community Action Board meetings and cultural celebrations are positive steps in building physical capital, but further infrastructure development is required to support the community's educational, productive, and social needs.

The lack of educational and productive infrastructure can affect other capitals, especially human capital. The availability of adequate educational facilities is crucial to ensure quality education and provide learning opportunities to community members. In addition, the lack of productive infrastructure can limit local economic development and diversification of economic activities, thus affecting financial capital and job creation.

7.14.4 Natural Capital

Pavitas has extensive natural resources, particularly water, and forests, which provide the foundation for livelihoods and ecosystem services. These resources can contribute to the community's resilience by supporting agricultural activities, biodiversity, and water availability. However, deforestation poses a significant threat to the local environment and exacerbates the impacts of climate change. Developing sustainable land management practices, reforestation initiatives, and conservation efforts is essential to preserve and restore natural capital. Furthermore, reducing the high use of agrochemicals can minimize environmental degradation, protect water sources, and safeguard human health.

However, it is important to address the significant threat of deforestation in the area. Deforestation not only leads to the loss of valuable forest resources but also exacerbates the impacts of climate change. It contributes to increased greenhouse gas emissions, soil erosion, and wildlife habitat loss. Therefore, it is imperative to implement sustainable land management practices, such as reforestation initiatives and forest conservation efforts, to protect and restore the natural capital in Pavitas. These measures can help mitigate climate change, preserve biodiversity, and maintain the provision of ecosystem services that are crucial for the community's well-being.

Additionally, reducing the high use of agrochemicals is essential to prevent further environmental degradation in Pavitas. Excessive use of agrochemicals can contaminate water sources, damage biodiversity, and present risks to human health. By promoting sustainable agricultural practices and adopting alternative methods that minimize the reliance on agrochemicals, the community can mitigate negative environmental impacts and protect the natural capital upon which their livelihoods depend.

The relationship between natural and political capital in the community of Pavitas presents a particular dynamic due to its location outside the area of influence of the Quilichao River micro-watershed and the Munchique nature reserve, where conservation projects led by the Procuencia Foundation and the municipal mayor's office are being developed. Despite this geographic separation, the Pavitas community recognizes the importance and benefits of its natural capital.

The presence of several water sources in the village is valued by those interviewed as vital for human consumption and the development of their agricultural and livestock systems,

strengthening their financial capital. These water resources are considered fundamental for the subsistence and economic development of the community. In addition, the inhabitants recognize the scenic beauty (cultural capital) and ecosystem services provided by the Munchique Natural Reserve, even though they are not directly linked to it.

Although there is no potable water in the area, interviewees rate the water resource quality as good. However, productive activities related to contamination are identified, such as the application of agrochemicals, the discharge of gray water directly into the soil or water sources, and the burning of solid waste. Despite this, the interviewees point out that the village has lower contamination levels than other areas. This awareness of the importance of preserving and maintaining the quality of natural resources demonstrates a connection between natural capital and political capital.

Respondents also highlighted the need for training on natural resource issues. Among the topics suggested were conservation, reforestation, sustainable tourism, and water quality. This demand reflects a willingness to strengthen political capital through knowledge and active participation in managing and protecting the community's natural resources.

In addition, there is ancestral knowledge (human and cultural capital) about the importance of preserving natural capital, as it provides resources and services that are fundamental for the sustenance and subsistence of the community. For example, interviewees repeatedly mentioned that water resources from water sources are vital and, therefore, are highly conserved. This conservation and proper management of natural capital can improve the inhabitants' quality of life and strengthen their human capital. This consciousness of the importance of preserving natural resources can foster social cohesion (social capital) and promote community collaboration in managing and conserving the natural environment.

7.14.5 Cultural Capital

Maintaining popular celebrations indicates a strong sense of cultural capital within the community, fostering social cohesion and identity. However, the need to change agricultural products due to low productivity reveals a vulnerability. Adapting to new crops and farming techniques requires technical knowledge and willingness to embrace change. Preserving cultural traditions while incorporating innovative and sustainable practices can help the community adapt to climate change without losing its cultural heritage. Empowering local

farmers with knowledge and skills in climate-smart agriculture can improve productivity and resilience.

The cultural capital in the Pavitas community goes beyond the festivities and popular celebrations such as the *corrida de Jaula*, *Semana Santa*, and Christmas. These cultural events bring happiness and roots to the interviewees, creating a sense of belonging and connection with their community. This is also reflected in promoting the Nasa Yuwe indigenous language in the school, demonstrating an interest in preserving the cultural heritage and ancestral traditions. This linguistic promotion strengthens human capital by fostering education and knowledge of the local culture.

In addition to impacting identity and social cohesion, cultural capital is also related to the development of community projects. Interviewees emphasized the importance of working together to address individual and family needs, which implies active collaboration in decision-making and project implementation. This collaboration strengthens social capital by promoting participation and shared responsibility.

Cultural capital also has a direct connection to the community's financial capital. Fundraising activities during festivities and cultural events reinvest economic resources in the community. These funds can be used to improve infrastructure, support productive initiatives, or provide assistance in cases of need. In this way, cultural capital acts as an engine for economic development and improving the living conditions of the inhabitants of Pavitas.

Likewise, cultural capital is linked to natural capital in the community. Interviewees recognize the Munchique nature reserve's scenic beauty and value its ecosystem services. This recognition reflects a deep connection to the natural environment and an understanding of the importance of its conservation. Strengthening cultural capital can drive the adoption of sustainable practices and respect for natural resources, which contributes to preserving natural capital and mitigating the negative impacts of climate change.

However, the need to change agricultural products due to low productivity reveals a vulnerability in terms of cultural capital and financial capital. Adapting to new crops and farming techniques requires technical knowledge (human capital) and a willingness to embrace change. It is important to balance preserving cultural traditions and incorporating innovative and sustainable practices that help the community adapt to climate change without losing its cultural heritage.

There is also a relationship between political capital and cultural capital in the Pavitas community, particularly through the influence of the Canoas indigenous cabildo. As an internal political structure, the cabildo is fundamental in preserving traditions and community decision-making. Following its internal rules and governance system, the community maintains its cultural identity and strengthens its cultural capital.

7.14.6 Political Capital

The presence of local organizations, such as the Junta de Acción Comunal, and the intervention of the indigenous organization demonstrates a significant strength in Pavitas' political capital. These organizations serve as platforms for collective action, advocacy, and resource mobilization. They play a crucial role in representing the community's interests, voicing their concerns, and promoting their welfare.

Through these organizations, the community actively advocates for its needs and priorities. They can engage in dialogue with public institutions, policymakers, and relevant stakeholders to raise awareness of their specific challenges and influence the development of policies, programs, and initiatives that address them.

However, it is important to address community leaders' weak connection with public institutions. Fostering stronger involvement and cooperation between local leaders and public institutions is essential to ensure that the community's voices are heard and their needs are properly attended to. This can be achieved by establishing regular communication channels, fostering partnerships, and promoting dialogue between community leaders and relevant government agencies.

Building the capacity of local leaders is also essential for effective participation in political dialogue and decision-making processes. Providing training and support to community leaders can equip them with the knowledge and skills necessary to navigate the political landscape, effectively communicate their concerns, and advocate for their community's interests. By improving the capacity of community leaders, Pavitas' political capital can be further strengthened, leading to more meaningful engagement with public institutions and better access to resources, policies, and programs that support climate change adaptation efforts.

The structure of the Canoas indigenous cabildo, to which the Pavitas village belongs, provides a space for the active participation of the inhabitants in decision-making and

problem-solving. This fosters collaboration and a sense of community belonging, strengthening social capital and promoting community cohesion. The participation of the inhabitants in decisions that affect their lives and culture provides them with a sense of empowerment and autonomy.

In addition, the indigenous cabildo also acts as an intermediary between the community and external political institutions on a few occasions. The Pavitas community can exert influence and negotiate with government authorities and other organizations through its political structure. This interaction strengthens political capital by allowing the community to defend its needs, interests, and cultural perspectives before external bodies.

The relationship between political and cultural capital is mutually reinforcing. On the one hand, the indigenous cabildo promotes and protects the community's cultural traditions, safeguarding its identity and cultural heritage. On the other hand, cultural capital enriches political capital by providing a solid base of shared values, beliefs, and practices that guide political decisions and actions.

7.14.7 Financial Capital

A series of productive activities by the households interviewed sustain financial capital in the Pavitas village. These activities are mainly related to agriculture, livestock, and the sale of labor both within the village on larger farms and outside the community. In addition, occupations related to services and various trades diversify the community's income sources.

Commercializing agricultural and livestock products occurs mainly in Santander de Quilichao during market days, held twice or thrice weekly. This proximity to an urban center gives them an advantage in terms of access to markets and sales opportunities; however, it is only sometimes possible to transport the products due to the poor condition of the roads. The interviewees also mentioned that part of the production is destined for self-consumption, which satisfies their food needs and strengthens food security in the community.

These productive activities and local commerce generate economic income for households in the Pavitas neighborhood, strengthening the community's financial capital. However, it is important to recognize the need to diversify income sources further and seek additional opportunities for wealth generation. This may include exploring new crops, improving agricultural and livestock practices, and developing skills and knowledge in emerging economic sectors.

The financial capital strengths of the Pavitas community provide a foundation for economic resilience. Diversified production and the cultivation of economically important crops such as coffee, plantain, cassava, and vegetables provide income-generating opportunities for community members. These agricultural activities contribute to the local economy and provide a source of livelihood for many households.

However, limited employment opportunities pose a vulnerability to the community's financial capital. Relying solely on traditional agricultural and livestock practices and a few crops can lead to income fluctuations and economic instability.

Access to credit, technical assistance, and market linkages are key factors to support and diversify the local economy. However, these are not a constant in Pavitas, either because of economic instability or crop production losses that prevent access to bank loans. On the other hand, technical assistance has focused on coffee cultivation rather than throughout the year. Therefore, facilitating access to financial resources and providing training or technical support to community members can enable them to explore new business initiatives, improve their farming practices, and increase their overall productivity. In addition, establishing market linkages with local buyers, cooperatives, or businesses can help create stable and sustainable market opportunities for the community's products.

7.14.8 Capital Analysis and its Interconnections in the Pavitas Community

The analysis of the different capitals in the Pavitas community highlights their interplay and relative importance. Among the capitals, Human, Natural, and Cultural capital emerge as the strongest in the community. Human capital is strong due to the community members' level of knowledge and skill sets, which contribute to their adaptive capacity and ability to engage in diverse activities.

Natural capital is another significant strength, as Pavitas is located in an area with extensive natural resources, including water sources and forests, near the Munchique nature reserve. These resources provide the foundation for livelihoods, agricultural activities, and ecosystem services, fostering the community's resilience to a certain extent. The presence of the nearby Munchique Natural Reserve further enhances the value of natural capital in terms of its scenic beauty and the ecosystem services it provides.

Cultural capital also plays a vital role in the community, fostering social cohesion, a sense of identity, and preserving traditions. Maintaining popular celebrations and promoting the Nasa

Yuwe indigenous language in the school demonstrate a strong cultural capital that strengthens community bonds and enhances well-being.

Social and political capital also show some strengths within the community. The presence of the Community Action Board (Junta de Acción Comunal) and the indigenous organization (Cabildo) reflects a level of community organization and social cohesion, providing opportunities for collective decision-making and resource mobilization. The internal governance structures and adherence to indigenous norms and traditions contribute to the overall functioning of the community.

However, it is important to note that financial and built capital are identified as the weakest in the community. Financial capital is limited, with few employment opportunities and a dependency on a few economically important crops. Diversifying income sources and exploring alternative economic activities can strengthen the financial capital of the community. Similarly, the built capital, including housing and infrastructure, requires improvement to align with the community's productive activities and provide adequate educational facilities, roads, and services.

There is an interrelationship and interdependence between capitals; for example, social capital is closely related to human capital, as social relationships influence education, health, and access to employment opportunities. In addition, social capital can affect political capital, as social networks can facilitate civic participation and influence political decisions. For example, the Pavitas community has strong social ties through the Junta de Acción Comunal and the Cabildo Indígena, which makes it more capable of mobilizing to address common problems, such as natural resource management or the provision of public services.

The interrelationship is thus represented by cooperation among Pavitas community members in common agricultural activities, such as planting and harvesting, strengthening social ties, and building mutual trust. Interdependence is reflected in participation in local social networks to access shared resources, such as agricultural tools or knowledge about farming techniques, thus improving their ability to generate income and sustain their livelihoods.

Thus, the interconnection of the different capitals in the Pavitas community significantly shapes the community's overall resilience, well-being, and adaptive capacity. The strengths and weaknesses identified in each capital affect the community's ability to cope with change and effectively address challenges, particularly climate change-related ones.

In conclusion, the interplay of the different capitals in the Pavitas community is dynamic and interconnected. By recognizing and building upon their strengths, addressing their weaknesses, and fostering synergies among the capital, the community can enhance its resilience, adaptive capacity, and sustainable development. Emphasizing human capital development, preserving and managing natural resources, strengthening cultural and social ties, engaging in inclusive governance, and promoting economic diversification are key strategies for the Pavitas community to navigate the challenges of a changing environment while maintaining its unique identity and improving the well-being of its residents.

Based on the data presented in **Table 15**, the assessment of capitals in the Pavitas community reveals a distinct pattern. Human, natural, and cultural capital demonstrate considerable strength, while social and political capital exhibit notable resilience. However, financial and built capital show vulnerabilities and limitations. The interconnections and dynamics between these capitals have significant implications for the community, particularly in adapting to climate change, fostering economic development, and building resilience to external pressures. These findings underscore the importance of addressing the weaker capitals and leveraging the strengths of the more robust ones to enhance the overall well-being and sustainability of the community.

The general results from the interviews are presented in the following **Table 15**:

Table 15: Characteristics of the communities for each capital - Community Capitals Framework (CCF) - Pavitas

CAPITAL	STRENGTHS/ WEAKNESSES	GUAYABAL
HUMAN	Strengths	Basic Primary Education Constant technical assistance: United Nations, SENA, Coffee Growers' Federation Multi-skilled producers
	Weaknesses	High presence of an illiterate elderly population Only one teacher in the school
SOCIAL	Strengths	Presence of the Community Action Board (Junta de Acción Comunal-JAC) Low presence of public institutions Presence of committees by component

	Weaknesses	Low participation in community meetings
NATURAL	Strengths	Extensive availability of natural resources, mainly water and forest
	Weaknesses	Deforestation High use of agrochemicals
CULTURAL	Strengths	Maintain popular celebrations
	Weaknesses	Need to change agricultural products due to low productivity.
PHYSICAL/BUILT	Strengths	Public transport Electric power grid Low internet coverage and cellular signal Elementary school
	Weaknesses	Poor internet and cellular signal coverage No health center No potable water
FINANCIAL	Strengths	Diversified production Economically important crops: coffee, plantain, cassava, and vegetables
	Weaknesses	Few employment opportunities
POLITICAL	Strengths	Local organizations, with the intervention of the indigenous council
	Weaknesses	Low connection of leaders with public institutions

7.15 The general perception of Basic Human Needs

The village of Pavitas, according to the checklists applied, reports a total satisfaction level of 4.0 points, which, according to the satisfaction scale, shows that they have an overall "Good satisfaction." Locals' most important aspects of life are good communication, recreational spaces, freedom, self-esteem, responsibility, and living in a safe and quiet environment. These perceptions were obtained from 10 participants (six men and four women) who responded to the checklist.

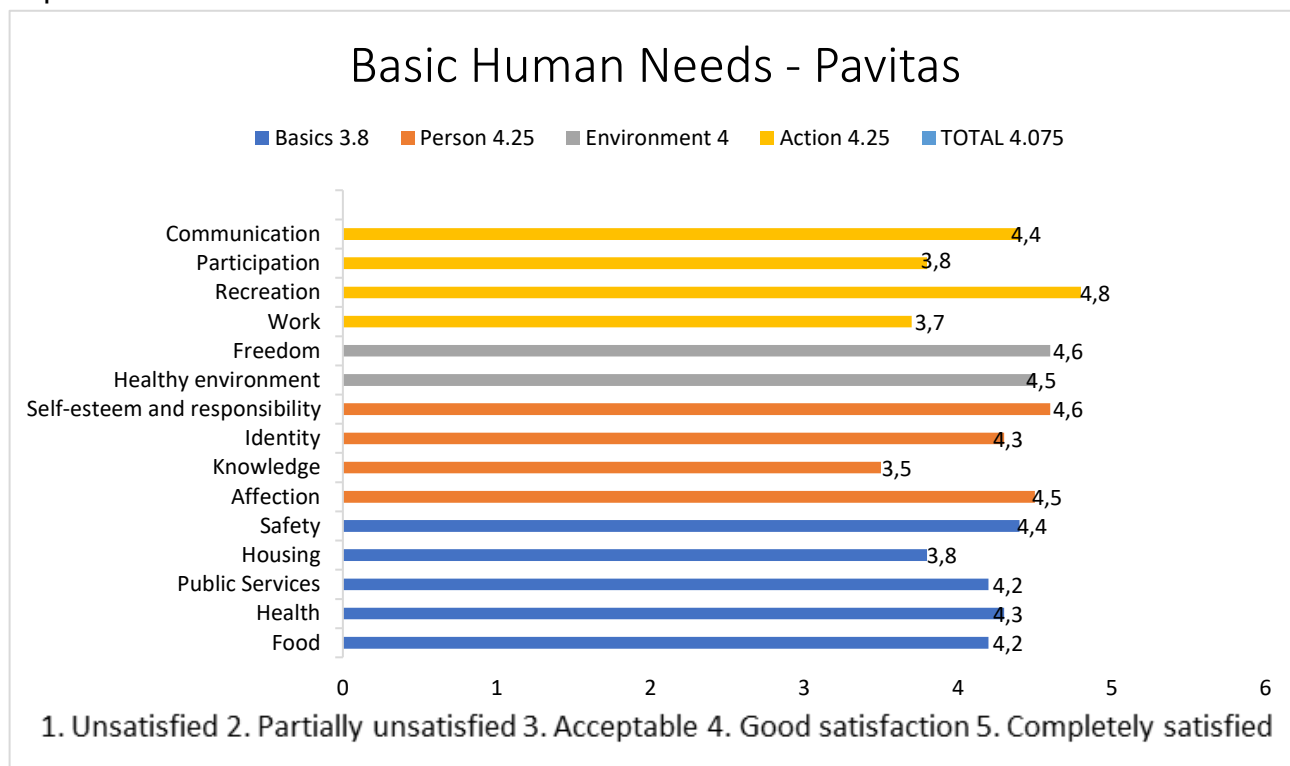


Figure 23: Basic Human Needs Analysis – Pavitas

In Pavitas, **Figure 23** shows that women have five higher levels of satisfaction than men, mainly concerning affection, public services, environment, freedom, and communication. On the other hand, men think that their level of satisfaction is higher in areas such as health, security, identity, self-esteem, and recreation options.

Based on the findings depicted in the **Action** group analysis, as shown in **Figure 23**, communication and recreation emerge as the most highly rated satisfaction aspects. However, while these aspects are satisfactory, they do not reach the "Complete satisfaction." This suggests that although there is some degree of communication and recreation within the community, there is still room for improvement to enhance satisfaction in these areas. For

instance, residents participate in community board meetings, workshops, and local events, indicating a certain level of engagement. However, there may be a desire for greater involvement in decision-making processes and implementing projects directly impacting the community. This highlights the need to foster increased participation and give residents more opportunities to contribute and shape their community's development.

The analysis of the **Environment** group indicates that freedom and a healthy environment are rated at a level of Good satisfaction in the rural community of Pavitas. However, they need to reach complete satisfaction due to the presence of pollution in the area. While the residents of Pavitas experience considerable freedom in exercising their rights and responsibilities, some limitations still need to be addressed. For instance, although they can express their opinions and participate in community decision-making, certain restrictions may hinder their full exercise of civil rights.

Regarding the environment, the community benefits from the natural reserve that provides abundant natural resources and a picturesque landscape. However, pollution poses a challenge to maintaining a completely healthy environment. Despite this, residents can still appreciate the beauty of their surroundings and avail themselves of some clean air, water, and nature, contributing to their overall well-being. Efforts should be made to address and mitigate pollution issues to ensure a healthier and more satisfying environment for the community.

The analysis of the **People** group reveals that affection, identity, self-esteem, and responsibility are aspects in which the rural community of Pavitas demonstrates a rating of Good satisfaction. These elements are integral to the overall quality of life and resilience within the Pavitas community, especially in light of the challenges posed by climate change.

The residents of Pavitas, who are members of the Cabildo of Canoas, demonstrate a strong sense of identity and belonging to their community. They value their cultural heritage and traditions, including active Cabildo participation. Festivals, local cuisine, and involvement in the Cabildo foster social cohesion and resilience and reinforce their cultural and historical ties. These collective efforts further strengthen the community's ability to navigate challenging circumstances, including extreme weather events, as they stand united under the guidance of the Cabildo and their shared cultural values.

Although evaluated at a lower level of satisfaction as acceptable, knowledge holds significance in the Pavitas community. While not all community members have completed primary or secondary education, there is value placed on the experience accumulated over generations, which is transmitted through oral tradition and participation in educational activities. However, it is important to note that the knowledge gained primarily focuses on coffee cultivation, needing more diversity in other areas. Expanding the range of training topics could enhance the community's ability to adapt to a wider range of challenges and promote resilience.

The analysis of the Basic needs group in the rural community of Pavitas reveals several important aspects regarding satisfaction and quality of life. Among these aspects, security stands out as the highest level of satisfaction in the core group. Residents expressed that there is no presence of illegal armed groups or frequent robberies in the community, which generates an atmosphere of tranquility and trust in daily life. This situation significantly strengthens the residents' sense of belonging and quality of life.

The community is very satisfied with public services, health, and food. Despite the instability in the quality of public services, such as water supply or access to electricity, residents value the existence of these services in the village. These basic services satisfy some of the community's fundamental needs and contribute to their overall well-being.

Although the village has no health center, the inhabitants appreciate the health days they visit the community. These days, they provide basic medical care, consultations, and medicines, which allows them to access basic health services. Despite the limitations in terms of medical infrastructure, the presence of these health days is valued and contributes to maintaining an acceptable level of satisfaction in this aspect.

Residents rated their housing conditions with an acceptable level of satisfaction. The community's housing is mainly built with wood and shows signs of poverty. Despite the less favorable infrastructure conditions, residents find shelter and a place to live in their homes. However, it is important to note that improving housing conditions could contribute to greater well-being and satisfaction in this area.

In the Pavitas community, it is crucial to highlight the gender disparities that are revealed in the analysis of fundamental human needs. As shown in **Figure 24**, there is a differentiated distribution of satisfaction between men and women with the needs of the action group.

Women report feeling more satisfied with communication and participation, while men recognize greater satisfaction regarding recreation and work. In addition, a significant difference is observed between men and women in terms of satisfaction in the environment group, with women expressing a higher level of satisfaction.

However, a marked gender gap is evident in the group, especially in terms of identity, knowledge, self-esteem, and responsibility. Historically, men have actively participated as members of community action boards, received training, and assumed economic responsibility for the household, which is reflected in their higher level of satisfaction in these aspects. On the other hand, in this same group, women mentioned having greater satisfaction in the affection component since they dedicate more time to being with their families, especially with their children.

Regarding the basic group, both men and women are satisfied with housing and food. However, regarding public services, women express higher satisfaction than men. On the other hand, in the case of health, men express greater satisfaction than women.

These gender disparities in the Pavitas community reflect differences in the opportunities, roles, and responsibilities assigned to men and women at the community level. Addressing these gender inequalities and promoting equity by ensuring that men and women have equal access, participation, and satisfaction in all areas of their lives is important. This will strengthen the community's well-being and quality of life in the face of climate change and vulnerability.

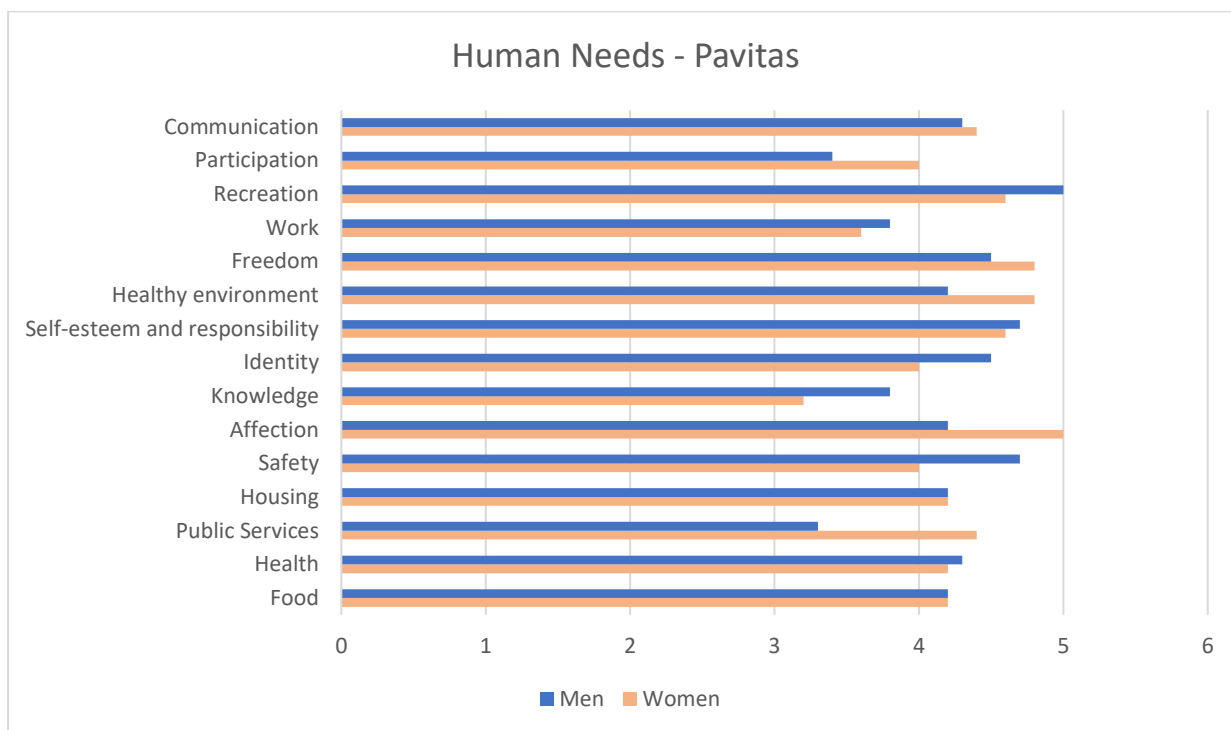


Figure 24: Gender comparison of basic needs Pavitas

7.16 Collective mapping data analysis-Pavitas

The analysis of collective mapping in the rural community of Pavitas within the context of climate change and vulnerability reveals significant findings and important connections between the identified activities and the different capitals present in the Pavitas community. The results obtained from the collective mapping exercise in Community No. 2, as illustrated in **Figure 26** and **Figure 28**, provide a broader understanding of the key activities and components that shape the community's territory.

Firstly, the inhabitants most identified the sociocultural component in the collective mapping exercise through aerial photographs, highlighting activities such as sports, traditional festivals, and community meetings concentrated in a specific area without occupying the entire community territory. Mainly centered around the community house, soccer field, and school, this demonstrates the strength of cultural and social capital within the community. These activities foster social cohesion, cultural identity, and community participation, key elements for resilience in times of adversity.

Furthermore, the identified places of interest, such as the community house, cemetery, school, and local store, are closely related to built and social capital. These physical spaces facilitate interaction and resource exchange among community members, promoting

solidarity, trust, and collaboration. They play a fundamental role in community life, serving as spaces for socialization, learning, and food provision. However, it is important to note that some of these components are affected by environmental and social challenges, primarily deforestation, water pollution, road deterioration due to excessive rainfall, and loss of crop production.

Key environmental components, such as the Munchique reserve area, water sources, and agroecosystems, show a close interrelation between natural and cultural capital. These natural resources are essential for the community's subsistence and well-being, providing food, water, and ecosystem services. Furthermore, the conservation and sustainable use of these resources are closely linked to preserving cultural identity and traditions related to agriculture and the natural environment.

However, it is important to highlight the threats and challenges faced by these environmental components. Water pollution, inadequate solid waste management, and deforestation cause a direct threat to the community's natural capital, compromising its availability and quality. Additionally, the concentration of monocultures in agricultural production limits diversity and resilience in local food systems, generating conflicts and tensions within the community.

These environmental and social issues emphasize the importance of strengthening the connections between the different capitals in the Pavitas community to address the challenges of climate change and vulnerability. On the one hand, promoting community participation and inclusive decision-making and benefitting from social and political capital to drive collective actions favoring environmental conservation and sustainable development (Figure 25).



Figure 25. Identification of components with aerial photographs

On the other hand, investment in enhancing natural and built capital is required. This requires implementing water conservation measures, reforestation, and sustainable agricultural practices promoting productive systems' diversity and resilience. Additionally, improving infrastructure and the quality of public services is necessary to guarantee access to clean water, electricity, and other basic amenities, thereby strengthening built capital and enhancing the quality of life for the inhabitants of Pavitas.

This analysis of collective mapping provides a solid foundation for developing strategies and policies adapted to the specific needs and challenges of the Pavitas community in their pursuit of a more sustainable and resilient future.

Therefore, in analyzing collective mapping in the Pavitas rural community, based on the five components (sociocultural, environmental, threats, pollution, and places of interest), they have been identified as changing degrees of representativeness through aerial photographs. Easier identification of some components compared to others has been observed. The sociocultural component has been widely recognized, as locations for engaging in sports activities, traditional festivals, and community meetings are easily identifiable in the images. Additionally, places of interest such as the community hall, cemetery, school, and local store have been prominently highlighted.

On the other hand, environmental components such as mountainous areas, rivers, and agroecosystems have been identified, although to a lesser extent. Understanding these components requires a more detailed observation and contextual interpretation of the aerial images. Likewise, threats and pollution have been identified in the collective mapping, although their visual representation may be more subtle and necessitate a critical and analytical approach.

Spatial relations of the principals components - Pavitas

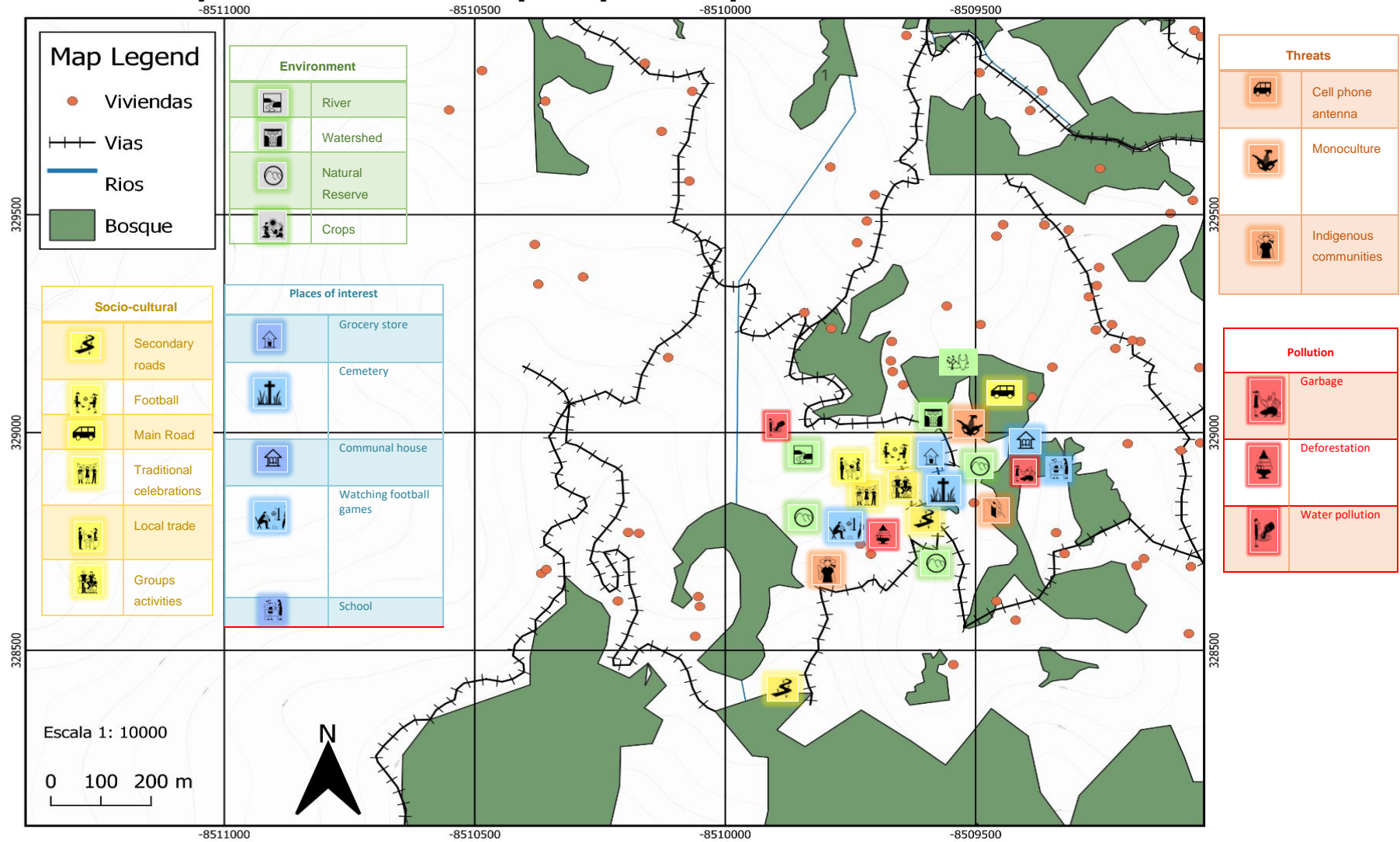


Figure 26: Mapping components-community No. 2

These findings demonstrate that some components of the Pavitas community are more representative and easily identifiable through collective mapping with aerial photographs. However, it is important to emphasize that the interpretation of the images should be complemented by the information provided by community members and other research methods to obtain a more comprehensive and accurate understanding of the local reality. This combined analysis of the different components will allow for a better understanding of their interrelationships and mutual influence, laying the groundwork for implementing actions and strategies that promote sustainability, resilience, and well-being in the Pavitas community.

In line with the above, the analysis was complemented by identifying greater and lesser interest variables based on the collected results and conducting a graphical representation using word clouds (**Figure 28**). This analysis of the Pavitas community revealed important perceptions of the inhabitants regarding their environment and the issues they face. The most prominent terms in the word cloud reflected concerns related to climate and the environment, including intense summers, heavy rains, deforestation, and climate change. These aspects demonstrated the community's awareness of vulnerability and the need to adapt to climate changes and their impacts on the Pavitas community.



Figure 27: Word cloud main interests – Pavitas

Additionally, variables related to security, livestock, water, agriculture, natural reserves, and local celebrations were identified, indicating the importance of these aspects for the community and its well-being. The mention of poor road conditions also highlighted the need to improve infrastructure and accessibility in the area. Happiness also emerged as a relevant

word, indicating that the inhabitants value well-being and satisfaction in their community, particularly related to the tranquility of the community and local celebrations.

It was interesting to observe that, to a lesser extent, aspects such as lack of clean water, solid waste burning, absence of a health center, low productivity, poor quality of public services, community organization, lack of government support, and forests were identified. These terms reflected additional challenges and needs that require attention and action from the community and the relevant authorities.

Regarding empowerment and decision-making, the word map showcased the inhabitants' active voice in identifying and communicating their concerns and priorities. The inclusion of local narratives in the form of keywords reinforced the importance of community participation and the construction of a narrative that reflects the reality of the Pavitas community.

This analysis of the word map provided a comprehensive overview of the topics that were significant to the Pavitas community, allowing for the identification of key areas on which to focus climate change adaptability and community well-being promotion. These findings can be used to guide local strategies and policies that address the identified concerns and needs, thereby strengthening the capacity of the community to face current and future challenges.

A graphic design was proposed in collaboration with the community to visually represent the interrelationships between water resources, forest resources, and productive activities (**Figure 28**). It was adjusted according to their interests and interpretations from collective mapping and climate vulnerability analysis. This design symbolizes water resources as the fundamental basis of the territory for the development of community activities, highlighting its importance for human consumption, agricultural production, and livestock. Forest resources also provide essential ecosystem services for the community, such as water regulation and biodiversity conservation. The graphic design includes the participation of inhabitants from different ethnic groups living in the territory, reflecting the cultural and ethnic diversity present in the community. These inhabitants play a fundamental role in producing coffee, plantain, and maize, with these agricultural activities being the community's main sources of economic livelihood. However, due to climate variability, the territory has experienced significant changes and challenges in agricultural production, affecting food security and the community's economic stability.

TERRITORY – LOCAL PERCEPTION

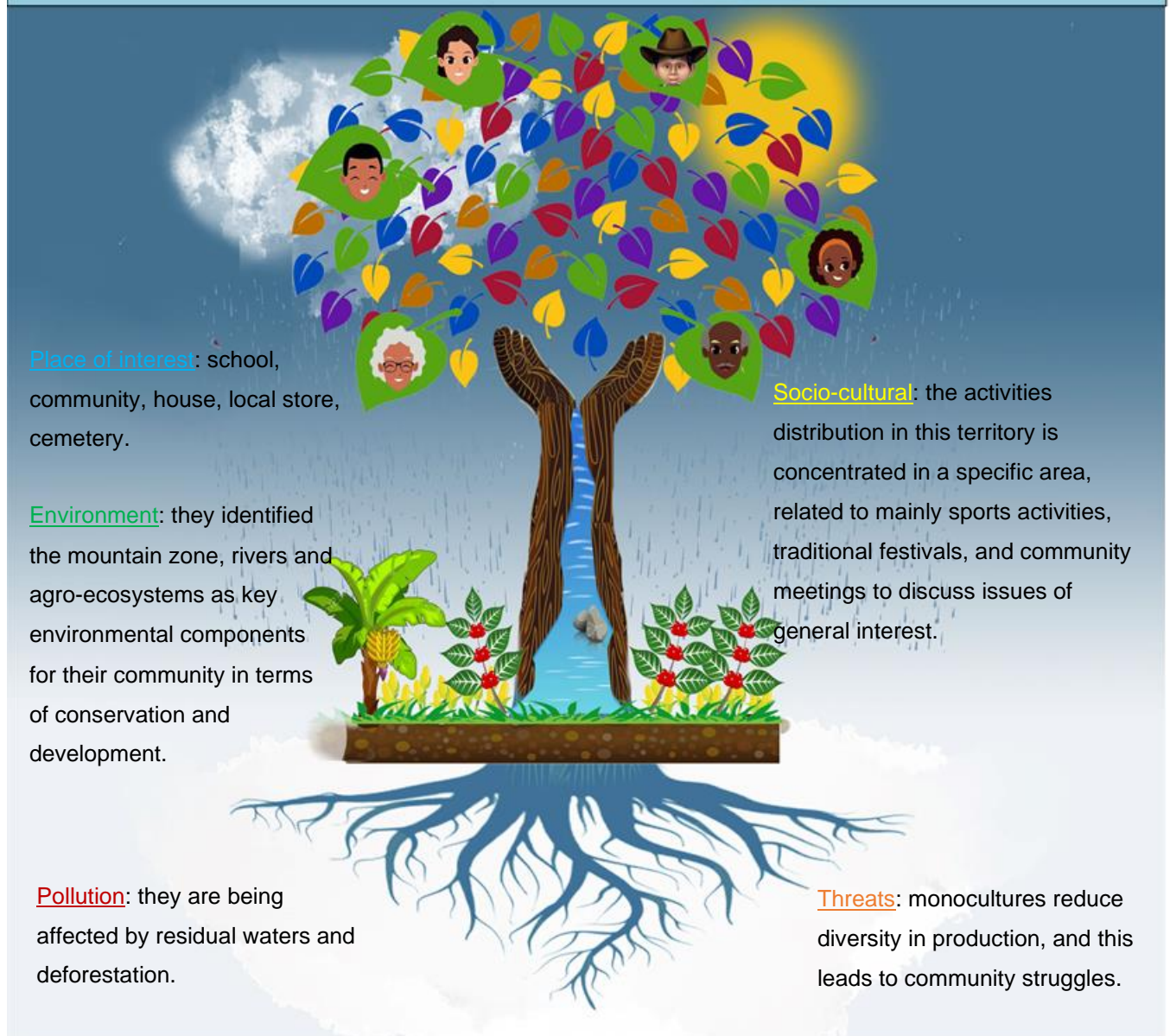


Figure 28: Collective mapping result-community Pavitas

The graphic design developed with the Pavitas community highlighted the interdependence between water resources, forest resources, and productive activities. This visual representation aims to raise awareness about the importance of protecting and sustainably managing these natural resources and promoting climate change adaptation and community resilience. This graphic design also serves a communication function by raising awareness among external stakeholders about the situation and challenges faced by the community regarding climate variability and associated vulnerability.

Regarding the identified places of interest by the community, the school, community center, and local store stand out. These places play a central role in the inhabitants' daily lives and reflect the importance of community ties in Pavitas.

Regarding the environment, it is acknowledged that the community is located within the influence area of a natural reserve, highlighting the presence of forest and water resources as key elements in their surroundings. These resources are crucial for plant material production and the sustainability of local activities. The community also recognizes the issue of water pollution, indicating an awareness of the challenges they face regarding water quality and the need to address this problem.

In the socio-cultural realm, a significant portion of the community's activities occur around the school, emphasizing the importance of relationships among the inhabitants and social cohesion in Pavitas. These relationships contribute to preserving local identity and culture. The community has identified thefts. However, they are not frequent, and the presence of a cellphone tower antenna raises concerns in the community regarding potential health issues it may cause.

In summary, the analysis of this information reveals the interrelation between environmental, socio-cultural, threats, and community concerns in Pavitas. The graphic representation developed by the community becomes a valuable tool for communicating and addressing the challenges they face about climate change, natural resource management, and the promotion of community resilience.

7.17 Participatory community diagnosis

The timeline tool represents the participatory diagnosis of the Pavitas community over the past ten years. Both positive (green) and negative (red) aspects have shaped the community's trajectory (**Table 16**).

The positive aspects identified by the residents of Pavitas include significant developments such as the expansion and adaptation of the main road, the completion of housing repairs, and the electrification expansion, which have contributed to improved infrastructure and enhanced accessibility. Additionally, the strengthening of coffee growing, aided by favorable coffee prices and support for coffee growers by installing processing plants and tanks, has positively impacted the local economy and livelihoods. The ability to conduct shopping in the village using loudspeakers has also facilitated community engagement and convenience.

However, the community has faced several challenges and negative experiences in the past decade. Adverse weather events, such as heavy rains, hailstorms, and strong winds, have caused significant damage to the road infrastructure, housing, and crops, leading to losses and reduced productivity. The perception of global warming and prolonged summers resulting in droughts further exacerbated agricultural losses and impacted the availability of water resources. The COVID-19 pandemic has also had a detrimental effect on the community, leading to the cancellation of festivities and disrupting social interactions.

Furthermore, the division of the village into two parts and the absence of a summer season, which prevented the coffee from flowering, have affected the community's ability to plan and sustainably utilize natural resources.

Overall, the participatory diagnosis highlights the strengths and challenges faced by the Pavitas community over the past ten years. The improvements in infrastructure, coffee production, and electrification signify positive advancements. However, the negative impacts of extreme weather events, the COVID-19 pandemic, and the changing climate underscore the need for strategies to enhance resilience, adaptability, and sustainable resource management in Pavitas.

Table 16: Timeline - Positives and negatives aspects of Pavitas

	2010	2011	2012	2013	2015	2017	2018	2019	2020	
POSITIVE	2010 to 2014 Aid for coffee growers in coffee processing plants with the installation of tanks				Annual local festivals		Electrification expansion	Completion of housing adequacy	Purchase of equipment (loudspeaker) for communicating information of interest	Road expansion
NEGATIVE		Heavy rains caused damage to roads and hail that affected crops.	High winds affected the housing infrastructure .	Global warming perception		It is a very long summer, causing river drought and crop losses.		Strong winds that caused damage to homes	There was no summer season (weather), and therefore, the coffee did not flower.	
			Hailstorms damaged crops, such as tomato crops.	Division of the village in two					No festivities were held due to the COVID-19 pandemic.	

The results of the community's participatory diagnosis and the chronological representation of the positive and negative events made it possible to establish the relationship between the respective dynamics and elaborate on the corresponding interactions.

Electrification has increased access to electricity, reinforcing economic prospects and improving residents' overall quality of life, strengthening the community's human and social resources. However, inclement weather conditions, such as heavy rainfall and strong winds, have negatively impacted the electrical infrastructure, resulting in power outages and disrupting daily routines, affecting human and structural resources. Despite the setbacks caused by weather-related damages, the community's social resources facilitated collaborative efforts to repair and restore the electrical infrastructure efficiently. Moreover, investing in human resources through technical training programs could enhance local capacity for infrastructure maintenance and resilience in the face of future climate-related challenges.

On the other hand, the growth of coffee production has brought economic prospects and improved natural and cultural resources due to favorable market conditions and better infrastructure. Nevertheless, the COVID-19 outbreak has caused supply chain disruptions, resulting in market uncertainties and impacting the coffee industry. This has affected both economic and cultural resources in the sector. Despite these challenges, the community's cultural capital has enabled them to implement coping mechanisms such as direct-to-consumer sales and local marketing initiatives. Moreover, investing in natural capital through sustainable agricultural practices could help alleviate the economic effects of market disruptions and improve the coffee industry's long-term resilience.

Moreover, the infrastructure enhancement, including road upgrades and housing renovations, has positively impacted community connectivity and quality of life, contributing to human and built capital development. However, division caused by geographic or infrastructure obstacles has hindered social cohesion and collective action, negatively impacting social and cultural capital. Despite physical barriers, communication networks, community events, and shared decision-making processes have enabled the community to utilize their social capital to overcome geographic divisions. Additionally, investments in cultural capital, such as preserving traditional knowledge and practices, have fostered a sense of unity and identity among residents, mitigating the social impacts of physical separation.

Upon conducting a participatory workshop to identify the characteristics of the Pavitas community and complement the previously created timeline, a comprehensive analysis was conducted using specific components such as economics, organizational, education, environmental, technical, public order, and others (**Table 17**). This approach allowed for a deeper understanding of the community's dynamics and interactions between these components. The insights gathered from the workshop shed light on the challenges and opportunities that have emerged over the years, enabling the formulation of targeted strategies to foster sustainable development and resilience within the Pavitas community.

The community highlighted several positive economic aspects, including cash crops such as coffee, onion, cassava, banana, and orange and milk production. Additionally, the availability of work options within the village and favorable coffee prices were beneficial. However, no negative aspects were identified in this component by the participants.

Regarding the organizational component, a well-organized Community Action Board (Junta de Acción Comunal - JAC) and the establishment of control and management committees were viewed positively. The high level of participation in community work and the Sports Committee's successful management of the soccer field's lighting were also recognized as strengths. No negative aspects were identified in this component.

In the education component, the presence of a school in the village and its adequacy, including painting, were seen as positive factors. The teaching of the Nasa Yuwe mother tongue and the presence of good teachers at the school were also highlighted. However, it was noted that the education level provided was very elementary, and there needed to be more soccer teachers or coaches to enhance the team's knowledge and competitiveness.

Regarding the environmental component, the community recognized the good soil quality for crops as a positive aspect. However, trees need to be planted in water source areas, and natural resources have deteriorated along the banks of rivers and streams. Additionally, no environmental training or capacity-building initiatives have been provided.

In the technical component, the community mentioned positive aspects such as training on coffee planting, access to water and energy services, and a good cell phone signal. No negative aspects were identified in this component.

The public order component was viewed positively, with no reported problems and a peaceful community. Years ago, intentions to plant illicit crops were noted but successfully prevented. No visible presence of armed groups was reported.

Finally, in the "Others" component, it was highlighted that there is no food shortage in the community, and there is a soccer field for sports and a recreation site for young people. However, it was noted that there is a lack of a playground for children, which is considered a negative aspect.

Thus, this participatory analysis provided valuable insights into the community's strengths and challenges across different components. It is a foundation for developing targeted strategies and actions to promote sustainable development and resilience in the Pavitas community.

Table 17: Participatory Diagnosis Pavitas

COMPONENT DIAGNOSIS – PAVITAS / Community characteristics (positive and negative)							
	<u>Economics</u>	<u>Organizational</u>	<u>Education</u>	<u>Environmental</u>	<u>Technical</u>	<u>Public Order</u>	<u>Others</u>
POSITIVE	Variety of cash crops (coffee, onion, cassava, banana, orange) as well as milk production	There is a well-organized Community Action Board (Junta de Acción Comunal - JAC)	School in the village	Good soil quality for crops	Training on coffee planting	No public order problems	No shortage of food
	Work options within the village	Control and management committees	Adequacy of the school (painting)		They have water service, Energy service, and a good cell phone signal	Peaceful community	Soccer field for sports and recreation site for young people
	Coffee production is the main crop.	High participation in community work	Nasa Yuwe's mother tongue teaching			Years ago, there were intentions to plant illicit crops, but they were prevented.	
	Good coffee prices	The Sports Committee managed 50% of the lighting of the soccer field	Good teachers at school			No armed groups are visible.	
NEGATIVE			Very elementary education	Trees need to be planted in water source areas.			Lack of a playground for children
			Lack of soccer teachers or coaches to have more knowledge and a more competitive team.	Deterioration of natural resources on the banks of rivers and streams.			
				No training sessions			

7.18 Climate Change Effects from local actors' perspective-Pavitas

According to the inhabitants of Pavitas, changes in the climate have been observed in recent years, indicating a local awareness of the climate change phenomenon. The main changes identified are the increase in temperature, droughts during the summer, and increased rainfall in winter. These perceived climate changes reflect the community's high vulnerability to the effects of climate change.

When asked about the causes of climate change, the inhabitants mention factors such as burning, destruction of forests, production of polluting gases, and global warming. They even mention that it is God's will. These causes are related to human activities that contribute to climate change and, therefore, to the vulnerability of the Pavitas community.

Thus, it is important to recognize that deep-rooted religious and cultural beliefs influence local perceptions of the causes of climate change. Some farmers may interpret extreme weather events as a manifestation of God's will or supernatural forces, which may condition their understanding of the underlying reasons and human causes of climate change. A small number of producers (six) attributed these changes to "God's wishes, only he decides when it rains and when it does not" (D.L. Canas, personal communication, January 2021). In a similar situation, a comment was received that this situation with the weather (excessive rainfall, extreme heat, landslides) "is the end of times, it is the end of the world by the wishes of the messiah" (A. Muñoz, personal communication, March 2021).

The community's perception of threats is significant, as most people feel threatened by the climate. Threats identified include crop damage, drought of water sources, the need to switch to more heat-resistant crops, diminishing water reservoirs, and the need to use more agrochemicals to compensate for the lack of water and nutrients. These threats highlight the community's vulnerability regarding food security, availability of water resources, and sustainability of agricultural practices.

Although some positive aspects are mentioned, such as the possibility of growing crops that were not previously viable, it is also pointed out that these changes imply

investments in infrastructure and land adaptation, which not all farmers can afford. This economic inequality amplifies the vulnerability of those who cannot access the necessary investments to adapt to climate change.

Faced with these challenges, farmers have developed adaptation strategies to cope with climate change. However, these strategies are limited by socioeconomic factors and the need for access to adequate resources and technologies, perpetuating the community's vulnerability to climate change. For example, concerning crops, they have had to make changes: "We have had to implement new crops that are resistant to warmer temperatures, such as plantain" (J.A. Barco, personal communication, June 2020), and "We no longer plant as much blackberry or lulo, which are cold climate crops, because of the high temperatures they do not grow so well" (J.J. Aguirre, personal communication, June 2020). Moreover, the situation is reflected in the more significant efforts of the older population to counteract climatic changes and the impacts they generate on the productive systems. Furthermore, there are more situations to control, such as excess humidity, lack of water for irrigation, or a more significant presence of pests, with fewer people to operate them.

In addition, uncertainty about the right times to plant due to altered rainy and dry periods and the perception of neglect by government institutions also contribute to the community's vulnerability. The lack of external support and the deterioration of infrastructure affect the community's capacity to face the challenges of climate change.

Therefore, the perception of climate change in the Pavitas village is closely related to the community's vulnerability. The observed changes in climate, the identified causes, the perceived threats, and the lack of external support reinforce the need to adopt climate change adaptation measures and strengthen the community's resilience. It is essential to address vulnerability comprehensively, considering social, economic, and environmental aspects to achieve sustainable development and reduce the negative impact of climate change in Pavitas.

Likewise, Pavitas's local perception of climate change shows clear differences between the past and the present (**Table 18**). In the past, there was less rainfall, absence of

droughts, low use of agrochemicals, low crop variety, established dates for planting and harvesting, and a planting system based on beliefs and phases of the moon. In addition, there were more abundant water reservoirs. However, in the present, we observe heavier rainfall, severe droughts, intensive use of agrochemicals, crop diversification (as a positive factor), uncertainty in planting and harvesting dates, the persistence of a planting system based on beliefs and climatic data, and a decrease in water reservoirs. These contrasting changes in climate and farming practices reflect the perception of a more challenging climatic environment and the need to adapt to new conditions to ensure sustainability and food security in Pavitas.

Table 18: Community climate perceptions-Pavitas

Past	At present
Less rainfall	Heavy rainfall
No droughts	Severe droughts
Low use of agrochemicals	Intensive use of agrochemicals
Low variety of crops	Crop diversification
Established planting and harvesting dates	Uncertainty in planting and harvesting dates
Planting based on beliefs (phases of the moon)	Planting based on beliefs (moon phases) and climatic data
Higher water reserves	Water reservoirs are decreasing.

7.19 Rural Climate Resilience: External Perspectives on Vulnerability

The analysis of vulnerability perception from the four external organizations interviewed reveals several crucial aspects that can be leveraged in the formulation process of climate policies. These key points begin with observations regarding climate variability, followed by perceptions of the impact on water resources, effects on agricultural productivity, infrastructure vulnerability, financial challenges, resilience, and community adaptation. This panorama underscores the necessity of robust political support, as it is essential to implement adaptation strategies and climate protection policies to reduce vulnerability and promote sustainable development.

To achieve this, it is imperative to address the inherent challenges in effectively implementing these policies, which are hindered by resource limitations, logistical difficulties, and the need for greater coordination among stakeholders at various levels of governance.

Consequently, it is crucial to work with integrated and coordinated efforts to confront the multifaceted challenges of climate change in the rural communities of Guayabal and Pavitas. This entails implementing policy interventions, fostering community participation, investment in infrastructure, capacity development, and financial support to effectively build resilience and adapt to changing climatic conditions.

7.20 Agricultural climate vulnerability analysis

The analysis of agricultural vulnerability to climate change in the Pavitas community is related to the findings obtained in the chapter that examines farmers' perceptions, addressing the elements of exposure, sensitivity, and adaptation. Based on the previous results, we proceed to assess climate vulnerability. Three fundamental factors and their corresponding conditions determine vulnerability to climate change: exposure to the phenomenon, sensitivity to its impacts, and adaptive capacity (see detailed explanation of the vulnerability analysis in the methodology).

In the Pavitas community, the productive systems are characterized by key crops, with coffee, bananas, and livestock being the main pillars sustaining most families' income. Rooted in regional agricultural tradition, these crops have become essential economic activities, highly valued in the local market, and generate household monetary income.

In addition, other agricultural products, such as cassava, corn, and fruit trees, contribute in a complementary manner to household income. Although their commercialization is less predominant than coffee, plantain, and livestock, they continue to represent an additional source of income for families in the community. However, it is important to note that the income generated by these crops tends to be proportionally lower than the main crops.

In Pavitas, there is a marked difference in the size and focus of farms. On the one hand, there are farms with large extensions of land that are mainly dedicated to cattle

raising. Due to their scale and investment capacity, these farms usually have the resources and technology to implement measures to adapt to climate change, such as irrigation systems, adequate pasture management, and the diversification of livestock species that are more resistant to climate variations.

On the other hand, small-scale producers in the community focus on traditional crops such as plantain, coffee, maize, and cassava. These producers, often with smaller farms, face additional challenges adapting to climate change. Their dependence on traditional crops and the limited availability of financial and technological resources hinder their ability to implement adaptation measures. In addition, their exposure to extreme weather events, such as droughts or heavy rains, significantly impacts their harvests and household food security.

In the Pavitas village, the livelihood strategies of its inhabitants are based on a combination of activities and crops that allow them to ensure their subsistence. These strategies include various key elements, such as the cultivation of coffee, plantain, yucca, corn, fruit trees, livestock, and domestic responsibilities (**Table 19**).

Along with productive activities, domestic chores, and household care are central to the daily lives of Pavitas' inhabitants. These responsibilities include food preparation, childcare, and household maintenance, among other tasks.

Table 19: Living Strategies by community-Pavitas

Community	Living strategy
Pavitas	Coffee + Plantain + Casava + Corn + Fruit trees + Livestock + household duties

Therefore, in terms of exposure, Pavitas producers face vulnerabilities to climate change due to the characteristics of their production systems. First, their dependence on specific crops such as coffee, bananas, and maize exposes them to risks associated with climate variations. For example, extreme events such as prolonged droughts or heavy rains negatively affect the production and quality of these crops, which in turn impacts household incomes.

In addition, the lack of diversification in production systems can increase producers' sensitivity to climate change, either due to a lack of knowledge or mainly due to a lack of resources. Thus, excessive dependence on a single crop or activity limits the options available in case of a decrease in profitability or productivity due to adverse weather conditions. This leads to greater economic exposure and makes it difficult to adapt to new conditions.

Lack of access to adequate resources and technologies makes producers more vulnerable to climate change. For example, water scarcity and lack of efficient irrigation systems affect farmers' ability to cope with droughts and maintain production during periods of low rainfall. Likewise, lack of access to information and training on climate-resilient agricultural practices limits farmers' ability to adapt to changes and adopt more sustainable approaches.

Moreover, of the specific vulnerabilities associated with the production systems in Pavitas, the community also faces several challenges related to exposure to climate change. First, the geographic location of Pavitas makes it more susceptible to certain climatic phenomena. For example, being located in an area prone to droughts or floods, the community has experienced the impacts of these extreme events more intensely.

The region's topography influences exposure to climate change. It is in a mountainous area with several bodies of water, making it more vulnerable to landslides, soil erosion, or flooding. These climatic events have had repercussions on Pavitas' productive systems and infrastructure.

In addition, dependence on natural resources such as water and land for agriculture and livestock also increases the community's exposure to climate change. Decreased rainfall, depletion of water bodies, and soil degradation due to climatic factors directly affect the availability and quality of these resources, which in turn impacts the ability of producers to maintain their livelihoods.

It is important to note that exposure to climate change may vary among different socioeconomic groups within the community. For example, smallholder farmers with

limited resources face greater difficulties adapting to climate change than those with greater resources and technologies. Therefore, equity and social justice are also important aspects to consider when addressing climate change exposure in Pavitas, which currently has a high exposure level.

Through the livelihood sensitivity analysis, it was possible to determine that climatic variables, such as temperature and rainfall, are key factors influencing crop yields and livestock in Pavitas. These climatic elements are especially relevant due to the need for an adequate water supply for irrigation, soil moisture, and optimal temperature conditions. Therefore, farmers and ranchers in the community are highly sensitive to periods of low rainfall, excess rainfall, and increased temperatures. These adverse climatic conditions can significantly impact crop and livestock production, putting the livelihoods of producers at risk and highlighting the importance of implementing climate change adaptation strategies to mitigate these negative effects.

Despite the strategies implemented, such as the seed bank, agroforestry crop diversification, choice of planting dates, live fences, and community crops, coffee and corn in Pavitas continue to show a high sensitivity to climate change. These crops require special attention due to their dependence on climatic conditions. Despite efforts to mitigate impacts, they remain vulnerable to lack of rainfall, extreme temperature variations, and other adverse climatic events (**Table 20**).

As for the cassava crop, moderate sensitivity is observed. Farmers in Pavitas have implemented strategies such as irrigation, diversification of varieties, tillage, and choice of harvest dates, among others, to mitigate the impacts of climate change. These actions have helped reduce the sensitivity of cassava to changing climatic conditions, although there are still challenges to overcome.

On the other hand, banana crops and livestock in the community have a relatively low sensitivity to climate change. Strategies such as the diversification of plantain crops according to altitude above sea level, tillage, planting date, and availability of water reservoirs, as well as the rotation of corrals and the implementation of agrosilvopastoral systems, have contributed to maintaining a lower level of sensitivity in

these productive activities. However, it is important to continue monitoring and adapting these strategies to ensure long-term resilience to climate challenges in Pavitas, as these strategies implemented in Pavitas to mitigate climate change impacts are not technified; they reflect the need and capacity of producers to face climate challenges practically and affordably.

Therefore, the analysis of Pavitas's adaptive capacity to climate change reveals different levels according to the production systems. In the case of coffee, plantain, and maize, a medium level of adaptive capacity is observed. Farmers have implemented strategies that reflect an active response and awareness of climate change, allowing them to face challenges and minimize negative impacts.

On the other hand, cassava cultivation and livestock show a high level of adaptive capacity. Producers have developed more advanced strategies, such as irrigation, diversification of varieties, adequate soil and water management, and implementing agroforestry systems.

The Pavitas area generally shows a considerable adaptive capacity, with medium and high levels in its different production systems. This results from the experience accumulated over time and the traditional knowledge transmitted from generation to generation. However, it is important to continue strengthening these adaptive capacities by promoting good agricultural practices, sharing knowledge, and improving infrastructure and access to resources to ensure the sustainability of livelihoods in a changing context.

Table 20: Agricultural vulnerability analysis: exposure, sensitivity, and adaptation in Pavitas

Livelihoods	Climate change perception		
	Exposure	Sensitivity	Adaptation
Coffee	High (3)	High (3)	Seed bank +
			Agroforestry crop diversification ++
			Planting date ++
			Live fences ++
			Community crops +++
Plantain	Medium (2)	Low (1)	Crop diversification according to altitude above sea level +++
			Tillage +
			Sowing date ++
Cassava	High (3)	Medium (2)	Irrigation ++
			Variety diversification +++
			Tillage ++
			Harvest date ++
Livestock	High (3)	Low (1)	Water reservoirs ++
			Corral rotation +++
			Agrosilvopastoral systems +++
			Pasture rental ++
Corn	Medium (2)	High (3)	Planting date +
			Pest control ++
			Tillage ++
Categories	Low (1)	Medium (2)	High (3)

In addition to these economic and environmental dynamics, it is essential to consider other social and cultural aspects in analyzing vulnerability to climate change. Traditional crop management practices and local knowledge are of great value in adapting to climate challenges. Knowledge sharing and collaboration among farming families also play a crucial role in strengthening collective resilience to climate impacts.

In this sense, taking up the IPCC definition, which assesses the vulnerability of a system based on its exposure, sensitivity, and adaptive capacity, an estimation of the climate vulnerability of Pavitas' livelihoods was carried out. This is presented in Table 16, where the levels of exposure, sensitivity, and adaptive capacity of the productive systems were analyzed, providing an overall assessment of the level of vulnerability of each community to climate change. These results are fundamental to understanding farmers' specific challenges and opportunities and designing effective adaptation strategies focused on each context (**Table 21**).

Table 21: Vulnerability of livelihoods to climate variability in Pavitas

Livelihoods	Exposure	Sensitivity	Adaptive capacity	Vulnerability
Coffee	3	3	2	High
Plantain	2	1	2	Medium
Cassava	3	2	3	High
Livestock	3	1	3	High
Corn	2	3	2	Medium
Criteria: Two or three orange factors: High Vulnerability One orange factor or two yellow factors: Medium vulnerability One factor or no yellow factors: Low vulnerability.				

Finally, when analyzing the production systems' exposure, sensitivity, and adaptive capacity levels in the Pavitas area, coffee, cassava, and livestock are highly vulnerable to climate change (**Table 21**). These production systems are highly sensitive to variations in climatic conditions, such as water availability and extreme temperatures. In addition, their adaptive capacity is limited, which makes them more susceptible to the negative impacts of climate change.

On the other hand, bananas and maize show a medium level of vulnerability. Although they are also sensitive to climate change, strategies and local knowledge have allowed partial adaptation to changing conditions. However, these systems still face challenges in achieving greater resilience. Notably, productive systems in the Pavitas community

need to show higher vulnerability. All are exposed to significant climate risks and require adaptation measures to ensure their long-term sustainability.

7.21 Community Capital Integration and Basic Needs: An Analysis of Vulnerability to Climate Change - Pavitas

The vulnerability levels of the production systems in the Pavitas village are closely related to the community's capital. For example, economic factors influence coffee vulnerability, such as dependence on the income generated by this crop. Livestock vulnerability is related to pasture availability and livestock management capacity. On the other hand, Cassava is affected by the availability of water resources and appropriate cultivation techniques.

Analyzing the vulnerability of production systems to community capital allows for a better understanding of farmers' challenges and opportunities in adapting to climate change. These findings can serve as a basis for developing specific mitigation and adaptation strategies, promoting community resilience, and ensuring the sustainability of their livelihoods.

Based on the human capital analysis, it is evident that the rural community of Pavitas faces gender and age imbalances. Most interviewees are men, indicating possible inequalities in access to opportunities and resources and decision-making processes. This may impact community understanding and response to climate change, as women's perspectives and experiences may differ from men's. In addition, the predominance of middle-aged and older people suggests the need to pass on knowledge about environmental challenges to younger generations. Involving youth in climate change planning and decision-making is crucial for effective adaptation.

Family size and educational level also influence community adaptive capacity. Family size affects the availability of labor and resources to implement climate change adaptation strategies. Although basic primary education is prevalent in the community, education needs to be strengthened, especially in areas related to climate change adaptation. Technical training programs can provide specific skills and knowledge in sustainable agriculture and natural resource management.

Human capital strengths, such as education and organizational technical assistance, provide a foundation for knowledge and skills development. However, challenges include the presence of an illiterate elderly population and limited resources in education. Specific educational programs and awareness campaigns are needed to address the needs of the elderly population. In addition, only one teacher in the school highlights the need for additional support and resources in the education sector.

These human capital vulnerabilities have implications for climate change adaptation. Gender inequalities can hinder inclusive decision-making and equitable adaptation strategies. Age distribution suggests the need to pass on knowledge to younger generations. Family size and education level influence families' ability to adapt to climate change impacts. Strengthening education and involving younger generations is crucial to improving the community's adaptive capacity.

Regarding social capital, the Community Action Board (CAB) and committees demonstrate community organization and cohesion. These structures facilitate collective decision-making and resource mobilization. However, the limited presence of public institutions hinders access to resources and support for climate change adaptation. Relationships and collaboration between the community and public institutions must be strengthened to foster cooperation and access to resources and expertise. Increasing community participation in meetings and decision-making processes fosters inclusion and diversity of perspectives.

The Cabildo strengthens political capital by acting as a meeting point for community members and facilitating collective decision-making. It allows the community to voice concerns, consolidate demands, and establish a platform for dialogue with government authorities. Strengthening relations with government authorities enables the community to influence local policies and programs that address climate change challenges. The effective functioning of the Community Action Board strengthens the community's ability to leverage political capital and collaborate with authorities for climate change adaptation.

Social capital plays a key role in promoting community work and collective decision-making. The Cabildo fosters collaboration and mutual support, collectively addressing individual and family needs. However, social disparities exist, as some individuals have greater access to resources. It works for equity, inclusion, and active participation of all.

The analysis of the Pavitas community reveals the existence of various vulnerabilities in different areas that are related to climate change and the basic needs of the community. The main vulnerabilities identified are detailed below:

Vulnerability in agricultural production: Although the community of Pavitas has strengths in human and natural capital, agricultural production faces challenges due to climate change. Extreme weather events such as heavy rains, hail, and high winds have caused significant damage to road infrastructure, housing, and crops, resulting in losses and decreased productivity. These adverse weather events represent a community's vulnerability to agricultural production and food security. The Pavitas community relies heavily on crops such as coffee, bananas, and corn, which are sensitive to climatic variations. The lack of diversification in agricultural production systems increases farmers' sensitivity to climate change. In addition, the lack of access to adequate resources and technologies limits farmers' adaptive capacity and makes them more vulnerable to the negative effects of climate change.

Vulnerability in financial and built capital: The analysis highlights that financial and built capital are the weakest in the Pavitas community. The lack of adequate infrastructure and the quality of housing built with precarious materials, such as wood, are vulnerabilities. In addition, the quality of public services, such as access to potable water and electricity, also needs improvement. These deficiencies in built and financial capital limit the community's ability to meet the challenges of climate change and improve their quality of life.

Vulnerability in natural resource management: Although the Pavitas community has significant natural resources, such as water sources and forests, it also faces threats to its natural capital. Water contamination, inadequate solid waste management, and

deforestation pose direct risks to the community's natural capital, compromising its availability and quality. These resources' conservation and sustainable use are fundamental for the community's subsistence and well-being and for preserving its cultural identity and agricultural traditions.

Vulnerability to climate change exposure: Pavitas's geographic location in a mountainous area with bodies of water makes it more susceptible to climatic phenomena such as landslides, soil erosion, and flooding. These extreme weather events have affected the community's productive systems and infrastructure. In addition, dependence on natural resources, such as water and land, for agriculture and livestock also increases the community's exposure to climate change.

Vulnerability in adaptive capacity: Although the Pavitas community shows considerable adaptive capacity in general, there are limitations regarding access to resources, knowledge, and technologies. Lack of diversification of crop varieties, choice of planting and harvesting dates, and lack of adequate infrastructure hinder farmers' adaptive capacity. In addition, lack of access to information and training on climate-resilient agricultural practices also limits community adaptive capacity.

These identified vulnerabilities are intertwined with the negative and positive dynamics the community perceives about climate change. On the one hand, extreme weather events and changes in weather patterns represent negative dynamics that impact agricultural production, infrastructure, and the community's quality of life. These perceived threats reflect the community's vulnerability to climate change, especially regarding food insecurity, availability of water resources, and sustainability of agricultural practices. On the other hand, awareness and appreciation of natural resources and traditional agricultural practices represent positive dynamics in the community and contribute to its resilience to climate change. However, the lack of external support and the deterioration of infrastructure limits the community's capacity to face these challenges.

In terms of the main challenges for the community in all areas due to climate change, the following can be highlighted:

The Pavitas community faces a series of challenges related to climate change that require specific actions and strategies to strengthen its resilience. First, it is necessary to strengthen financial and built capital by investing in adequate infrastructure, such as resilient housing and quality public services. This implies improving access to drinking water, electricity, and other basic services and the capacity to respond to extreme weather events.

In addition, sustainable natural resource management is essential. The community must develop strategies and policies to protect and sustainably manage its natural resources. This involves taking measures to preserve biodiversity, promote sustainable agricultural practices, and avoid overexploitation of natural resources.

To strengthen the Pavitas community's adaptive capacity to climate change, it is necessary to provide the community with access to appropriate resources and technologies. This includes improving infrastructure and access to information and training on climate-resilient agricultural practices. In addition, encouraging diversification of agricultural production systems can reduce farmers' sensitivity to climate change and increase their resilience.

Another important aspect is improving infrastructure and basic services in the community. Deficiencies in infrastructure and basic services, such as access to clean water and the quality of housing, limit the community's ability to cope with the impacts of climate change. Improving infrastructure and basic services is critical to strengthening community resilience and ensuring sustainable development.

Finally, promoting collaboration and knowledge sharing among farming families is essential to strengthen collective resilience to climate change impacts. Collaboration and knowledge sharing can help overcome challenges and promote more sustainable and climate-resilient agricultural practices. Shared knowledge and collaboration are key elements in driving the development of adaptive and sustainable solutions in the Pavitas community.

Finally, it can be seen how social capital can help overcome economic and natural capital challenges. Strengthening social networks and collaboration among farmers

can facilitate access to economic and technological resources and promote conservation practices and sustainable use of natural resources.

Human capital can help overcome the challenges of social capital and physical capital. Access to education and training on climate-resilient agricultural practices can strengthen community human capital, which in turn can foster collaboration and the generation of innovative solutions to address climate change challenges. In addition, trained human capital can contribute to improved planning and management of the physical infrastructure needed to address climate change impacts.

In summary, the Pavitas community faces several vulnerabilities related to climate change, agricultural production, and basic needs. Overcoming these challenges will require strengthening the community's adaptive capacity, improving infrastructure and basic services, and fostering collaboration and knowledge sharing among farmers. In addition, developing different types of capital, such as social, human, and economic, can help overcome the challenges associated with climate change and promote sustainable development in the Pavitas community.

7.22 Community Comparisons: Assessing the Effectiveness of CCF in Identifying Climate Change Adaptation Strategies and Reducing Vulnerability

By examining the specific vulnerabilities and adaptation strategies of different production systems, it was possible to identify how the Community Capitals framework helps identify and develop suitable adaptation strategies. The comparative analysis of the Guayabal and Pavitas communities provides valuable insights into their challenges in adapting to climate change and reducing their vulnerabilities. The analysis considers the factors of exposure, sensitivity, and adaptive capacity in determining the overall vulnerability in each community.

Additionally, anonymously including information about the third community was valuable to strengthen the research without delving into an exhaustive case analysis. Rather than examining their situation, discrete mentions, comparisons, or specific points where the community in question was not explicitly identified were included in

the thesis. These discrete references strengthened the argument while respecting the privacy and anonymity of the third community in question.

The CCF assessment includes the relationships between capital and specific situations, such as human capital, which is closely related to social capital and cultural capital, as education and knowledge transmission often occur within social networks and cultural contexts specific to the communities of Guayabal and Pavitas. Human capital influences financial capital, as skills and education can increase employment opportunities and incomes. This interrelationship, for example, with the education provided in local schools in both Guayabal and Pavitas, contributes to developing skills and knowledge among young people, which can influence innovation and adoption of more efficient agricultural practices. Interdependence is reflected in the health status of the inhabitants of Guayabal and Pavitas, provided they have access to a quality health system and access to information, as an educated population can be more informed about preventive health practices and better nutritional decisions.

In terms of natural capital, a relationship with physical capital was observed since both villages share the natural resources of the nature reserve and provide the basis for the infrastructure and physical development of the communities. Natural capital also influences financial capital, as the sustainable exploitation of natural resources generates income through activities such as agriculture, ecotourism, or conservation. For example, the community of Guayabal carries out ecotourism activities. It promotes the conservation of the natural reserve, representing the preservation of ecosystem services and the possibility of receiving extra income from this economic activity.

In this context, it is key to achieve sustainable land and natural resource management in Guayabal and Pavitas to contribute to the conservation of local biodiversity and the maintenance of healthy ecosystems that support agriculture, livestock, and wildlife, as well as to promote equitable access to land, forest, and water in Guayabal and Pavitas, which is fundamental to ensure food security and the livelihood of rural families, since land ownership provides a basis for food production and income generation.

In addition, both communities' strong internal political structure was evident, with a close relationship to social and human capital. Political capital influences financial capital, as government policies and decisions can affect the distribution of resources and economic opportunities. However, the relationship with governmental bodies must be strengthened in both communities to prevent limited access to political resources from affecting the challenges of adaptation to climate change. This is the case of the decision-making processes in allocating resources and public services in Guayabal and Pavitas, which are in conditions of low quality in rural infrastructure, development programs, and access to health and education services.

Therefore, the interdependencies and interrelationships between different types of capital are complex and multifaceted. Understanding these relationships is crucial for designing climate change adaptation strategies and promoting community well-being.

On the other hand, establishing a relationship between production systems, CCF, and vulnerability, it was observed that in Guayabal, the main agricultural products are coffee and plantains, which contribute significantly to household income. The exposure analysis reveals that farmers in Guayabal perceive reduced water availability, crop deterioration, damage from excess rainfall, and unpredictable climate changes. These factors have negatively impacted production systems, decreasing yields and household income. Coffee and banana crops are particularly vulnerable to climate change, with high temperatures affecting coffee quality and yields and droughts affecting banana development and productivity. Beans, tomatoes, and blackberries also face vulnerabilities to climate change, affecting household livelihoods.

To cope with these vulnerabilities, farmers in Guayabal have implemented adaptation measures such as coffee seed banks, crop diversification, adjusted planting dates, live fences for pest control, and community crops. These strategies aim to mitigate the impacts of climate change on agricultural productivity and income. The sensitivity assessment reveals that coffee, bean, tomato, and blackberry crops have high sensitivity to climate change, resulting in decreased yields, reduced water availability, the spread of pests and diseases, and soil degradation. Banana and vegetable farming

systems show lower sensitivity due to crop diversification and farmers' adaptive decision-making abilities.

Adaptive capacity refers to farmers' ability to adjust and respond effectively to climate change challenges. Farmers in Guayabal have shown adaptive capacity through information sharing, crop diversification, and active community participation. However, socioeconomic factors, limited access to resources and technologies, and youth migration to urban areas affect the community's adaptive capacity. Economic aspects, fluctuations in agricultural product prices, access to credit, and environmental challenges like soil erosion further influence vulnerability and adaptive capacity. Social and cultural aspects, including traditional crop management practices and knowledge sharing, play a role in adapting to climate change.

In Pavitas, the agricultural sector's vulnerability is closely linked to the community's capital. The economic factor of coffee dependence influences its vulnerability, while livestock vulnerability is related to pasture availability and management capacity. Cassava vulnerability is affected by water resources and cultivation techniques. The analysis of human capital reveals gender and age imbalances, highlighting the need to involve youth in planning and decision-making processes. Strengthening education, providing technical training programs, and addressing the needs of the elderly population are crucial for enhancing adaptive capacity.

Social capital is demonstrated through the presence of the Community Action Board (CAB) and committees in Pavitas, facilitating collective decision-making and resource mobilization. Strengthening relationships with public institutions is necessary to enhance access to resources and support climate change adaptation. The analysis reveals vulnerabilities in agricultural production, financial and built capital, natural resource management, climate change exposure, and adaptive capacity. Extreme weather events have damaged infrastructure, housing, and crops, affecting agricultural production and food security. Access to resources, knowledge, and technologies helps adaptive capacity.

Thus, a general perspective on the comparative analysis of exposure refers to:

Comparative analysis of exposure:

Guayabal: Farmers in Guayabal perceive reduced water availability, crop deterioration, damage from excess rainfall, and unpredictable climate changes. These factors have negatively impacted production systems, particularly coffee and banana crops. High temperatures affect coffee quality and yields, while droughts affect banana development and productivity.

Pavitas: The dependence on specific crops like coffee, bananas, and maize makes Pavitas vulnerable to climate variations. Geographic factors such as the community's location prone to droughts, floods, and topographical features contribute to exposure. Extreme weather events have damaged infrastructure, housing, and crops.

Comparative analysis of sensitivity:

Guayabal: Coffee, bean, tomato, and blackberry crops exhibit high sensitivity, resulting in decreased yields, reduced water availability, the spread of pests and diseases, and soil degradation. Due to crop diversification and adaptive decision-making abilities, banana and vegetable farming systems show lower sensitivity.

Pavitas: Coffee, corn, and cassava display varying sensitivity to climate change. Banana crops and livestock exhibit relatively low sensitivity due to strategies like crop diversification and agrosilvopastoral systems. However, limited access to resources, knowledge, and technologies hinders adaptive capacity.

In a comprehensive assessment of the anonymous community, it becomes evident that the village faces significant vulnerability. Poverty conditions are highly pronounced, with substandard housing and poorly maintained roads. The prevalence of diseases in both children and adults further adds to their vulnerability.

Regarding agriculture, coffee crops show moderate exposure to changing climate conditions, while bean, tomato, and blackberry crops face extreme exposure. On the other hand, crops like cassava and livestock remain relatively unaffected by climate change at present.

The community's livelihoods, particularly those of coffee, beans, tomatoes, blackberries, flowers, and fruit trees, have drastically changed due to the increasingly heavy and unpredictable rainfall patterns and rising temperatures. Farmers are particularly sensitive to these fluctuations, experiencing periods of drought, excessive rainfall, and amplified temperatures. Consequently, based on the producers' perceptions, the most vulnerable livelihoods, in terms of sensitivity to climate changes, are coffee, corn, tomato, and blackberry, aligning with the most critical affected livelihoods in the community, and adaptation measures have medium effectiveness and require constant modification due to changing climate conditions.

Comparative analysis of adaptive capacity:

Guayabal: Farmers in Guayabal have shown adaptive capacity through information sharing, crop diversification, and active community participation. However, socioeconomic factors, limited access to resources and technologies, and youth migration to urban areas affect the community's adaptive capacity.

Pavitas: The Community Action Board (CAB) and committees in Pavitas facilitate collective decision-making and resource mobilization, strengthening social capital. However, gender and age imbalances, limited access to resources, and deficiencies in public services hinder adaptive capacity.

Role of Community Capitals:

Guayabal: The analysis of Guayabal's capital reveals challenges in natural capital (water availability, deforestation), human capital (limited access to resources and technologies), and political capital (lack of institutional and political support).

Strengthening social capital through community solidarity networks and investing in physical infrastructure can compensate for these vulnerabilities.

Pavitas: In Pavitas, vulnerabilities are observed in agricultural production, financial and built capital, natural resource management, climate change exposure, and adaptive capacity. Strengthening human capital through education and technical training, enhancing physical infrastructure and basic services, and fostering collaboration and knowledge sharing can help address these vulnerabilities.

Anonymous community: The anonymous community presents a series of noteworthy characteristics in its different capitals. In the human aspect, it stands out for having a solid basic primary education (bilingual) and producers with extensive experience. However, one of its weaknesses is the presence of children with health problems.

In the social aspect, the community has strengths such as the presence of the Community Action Board (Junta de Acción Comunal - JAC) and the indigenous council, as well as high participation in meetings and community work. However, they face challenges related to drug use and robberies.

Regarding the natural environment, the community enjoys strengths such as the extensive availability of natural resources, mainly water, and forests. However, they are affected by illegal mining and deforestation.

In the cultural aspect, the community stands out for maintaining popular celebrations and the strong intervention of the indigenous cabildo to establish their laws within the territory.

The community has physical advantages, such as public transport, an electric power grid, and an elementary school. However, it faces challenges related to low internet coverage and cellular signal, poor road conditions, a lack of a health center, infrequent transportation, and no potable water.

In the financial aspect, the community has strengths in economically important crops such as coffee, plantain, flowers, and vegetables and has access to bank loans. However, it has experienced decreased productivity.

Finally, in the political aspect, the community is characterized by an organized and defined political structure, but they need help connecting leaders with public institutions.

Comparative resilience strategies:

Guayabal: Adaptation measures implemented in Guayabal include coffee seed banks, crop diversification, adjusted planting dates, live fences for pest control, and community crops. Strategies for vulnerable crops like beans, tomatoes, and

blackberries involve adjusting planting dates, crop rotation, pest control, and optimizing irrigation methods.

Pavitas: Strategies in Pavitas can include investments in resilient housing, quality public services, and response capacity to extreme weather events. Promoting biodiversity preservation, sustainable agriculture, resource conservation, and enhancing collaboration and knowledge sharing among farmers are crucial.

Overall, the comparative analysis highlights the specific vulnerabilities and adaptive capacities of Guayabal and Pavitas. The Community Capitals framework provides insights into the different forms of capital and their interrelationships, guiding the development of tailored adaptation strategies. By addressing exposure, sensitivity, and adaptive capacity through targeted interventions, communities can enhance their resilience to climate change and reduce agricultural vulnerabilities.

Therefore, specific strategies must be developed for each community to address these vulnerabilities. In Guayabal, the focus should be on diversifying livelihoods, strengthening adaptive capacity through access to resources and technologies, and promoting sustainable agricultural practices. Investments in resilient housing, quality public services, and response capacity to extreme weather events are necessary in Pavitas. Strategies for biodiversity preservation, sustainable agriculture, and resource conservation should be developed, along with improving infrastructure and basic services.

Hence, through the implementation and analysis of community capital, a solid foundation was established to identify and address vulnerabilities in integrated adaptation processes while creating trade-offs to mitigate the impacts of climate change. By understanding the strengths and weaknesses in each form of capital, specific strategies that leveraged existing capacities and overcame constraints were designed.

Regarding the trade-offs between capitals, the approach recognized that the different types of capital were interconnected. By identifying gaps in the different capitals, trade-offs were established to strengthen community resilience. For example, when a

constraint in natural capital, such as water availability in summer, was identified, measures for its conservation and sustainable management were implemented. This included the construction of infrastructure for water storage and distribution and promoting agricultural and land use practices that conserved this resource.

Regarding the improvement of adaptive capacity, the analysis of community capital made it possible to identify the areas where the community had strengths in its adaptive capacity and those with limitations. Recognizing the strengths of human, social, physical, and financial capital helped to continue addressing the barriers to climate change adaptation. For example, collaborative networks were established, knowledge was shared to strengthen social capital, and access to appropriate technologies was provided to increase physical capital.

On the other hand, the integrated approach to adaptation using community capital analysis also facilitated an integrated approach to adaptation, considering multiple dimensions and sectors. By assessing capital and vulnerabilities in each sector, synergies and opportunities were identified to reduce vulnerabilities jointly. For example, sustainable agricultural practices and biodiversity conservation benefited natural and human capital by improving agricultural productivity and ecosystem health.

Ten leaders were surveyed in the anonymous community, which we will call the village. They unanimously agreed that climate changes have been observed, particularly concerning temperature, drought, and rainfall. These changes are primarily attributed to factors such as population growth, mining activities, the use of agrochemicals in agriculture, and inadequate management of solid waste. Consequently, the community perceives a significant threat posed by climate variations, leading to reduced water availability, lower crop yields, and increased health issues such as frequent colds.

The alterations in climate conditions have also impacted cultural practices in the area. Farmers must employ more agrochemicals for fertilization and pest control, deviating from previous years when production was mostly organic.

Regarding climate change perceptions, the community acknowledges that there have been changes in temperature and rainfall. Specifically, 90% of respondents notice

increased rainfall and temperature, whereas only 10% observe more frequent droughts during the summer. Consequently, 62.5% of the villagers feel slightly or not threatened by these climate changes. In contrast, 37.5% expressed concern about the dwindling water availability over the past decade, prompting a community relocation project to address this situation. The changing weather patterns also impact agricultural practices. For instance, frosts during the rainy season can damage crops, affecting coffee and flower production.

Interestingly, all interviewees believe climate change has not significantly affected the health of the community members. However, they do acknowledge experiencing frequent colds, which they treat using traditional local remedies. While water quality remains perceived as constant, there is a consensus that water quantity has diminished, primarily due to prolonged summers.

Soil quality has also been affected, necessitating the use of agrochemicals to maintain expected yields. Manual soil cleaning is now replaced by chemical products for preparation. Despite this, farmers note that production times have extended compared to the past.

In light of these climate-related challenges, the village's inhabitants recognize the importance of implementing climate change adaptation activities in their production systems and resource utilization to improve their livelihood strategies.

While natural capital is considered one of the community's most representative assets, environmental impacts such as untreated water, inadequate solid waste management, deforestation, and mining activities (limited to the village) are evident. Addressing these issues will be crucial for sustainable development and resilience against further climate changes.

In summary, by using community capital analysis, it was possible to reduce vulnerabilities in integrated adaptation processes by creating trade-offs. This approach allowed identifying strengths and weaknesses in each form of capital and the development of specific adaptive strategies to improve community resilience. By

strengthening capital, adaptive capacity was improved, and the challenges of climate change were addressed comprehensively, thus promoting sustainable development.

7.23 Statistical analysis

Upon conducting a qualitative assessment of Guayabal and Pavitas, their community capitals and vulnerabilities were analyzed to uncover their differences. A multivariate statistical analysis was carried out to achieve a deeper understanding. This approach provided empirical evidence and statistical rigor, complementing the qualitative analysis and supporting the conclusions drawn. A set of variables, presented in **Table 22**, were identified to characterize better the systems studied, focusing on community capitals. These variables were not randomly selected but were based on input from the community members, who shared their perceptions and experiences. Ultimately, the statistical analysis aimed to provide a nuanced understanding of both communities by examining specific factors considered significant by the inhabitants.

Integrating quantitative analysis into qualitative research enhanced the rigor and depth of the research process. A more comprehensive understanding was achieved by investigating complex social phenomena such as community capital and vulnerabilities. This understanding went beyond the descriptive level of community members' experiences, perceptions, and behaviors and extended to quantifying and comparing different aspects of these experiences. For instance, while qualitative methods highlighted social cohesion within a community, quantitative analysis enabled the measurement of social connections or networks between community capitals. This approach also helped to identify disparities in access to resources between communities and to validate the results through triangulation of multiple data sources. Finally, this increased the reliability of the research results, making them more compelling to stakeholders and policymakers.

Table 22: Representative variables according to community capitals

CAPITAL	VARIABLE	CÓDIGO
HUMAN	Technical Assistance	Tech_Assis
	Son's interest	Son_Inter
	Health	Health
	Diseases	Diseases
	Training	Training
SOCIAL	Peace of mind	Peace_Mind
	Participation in organizations	Parti_Orga
	External organizations	Ext_Orga
	Community activities	Comm_Act
	Access information	Acces_Info
ENVIRONMENT	Principal natural resources	Princ_Natu_Res
	Protected areas	Prot_Areas
	Water availability	Water_Availa
	Water quality	Water_Quali
	Pollution	Pollution
	Solid Waste	Solid_Waste
CULTURAL	Belonging	Belonging
	Happiness	Happiness
	Local Celebrations	Loc_Celebra
	Popular beliefs	Popu_Beliefs
	differentiating Factor	Diffe_Factor
PHYSICAL	Transport	Transport
	Roads	Roads
	Electricity	Electricity
	Internet	Internet
	Cellphone Signal	Cell_Signal
	Health Center	Health_Cent
	School	School
	Drinking Ater	Drink_Water
FINANCIAL	Productive Activities	Produ_Activi
	Trade	Trade
	Labor Sales	Labor_Sales
	Credits	Credits

	Subsidies	Subsidies
POLITICAL	Authorities	Authorities
	Participation in Decisions	Parti_Decisi
	Government Participation	Govern_Part
	Effectiveness	Effectiveness
	Community Leaders	Comm_Lead
	Local Management	Local_Manage
	Conflict Resolution	Confl_Resol

Therefore, the statistical analysis of principal components (**Figure 29**) identified a lower relationship between the communities and physical capital, making it the weakest due to insufficient coverage of public services, poor roads, and unsuitable housing conditions. Financial capital is strong in productive activities, commercialization, and the sale of labor; however, in terms of access to credit and obtaining subsidies from the national government, it needs to be representative of the communities.

There is a more significant internal relationship with political capital due to the strength of the local authorities' management. However, externally, because the support from the national and local government, according to the communities, is not constant, they recognize it as little. Remarkably, human capital has a wide distribution in the analysis, which means it is not the strongest. Still, neither is it the weakest since they have received technical assistance, but their children show little interest in continuing with rural production.

Finally, the social, environmental, and cultural capitals are the most representative of the communities, thanks to their internal organizations, variety of natural resources, and preserved customs.

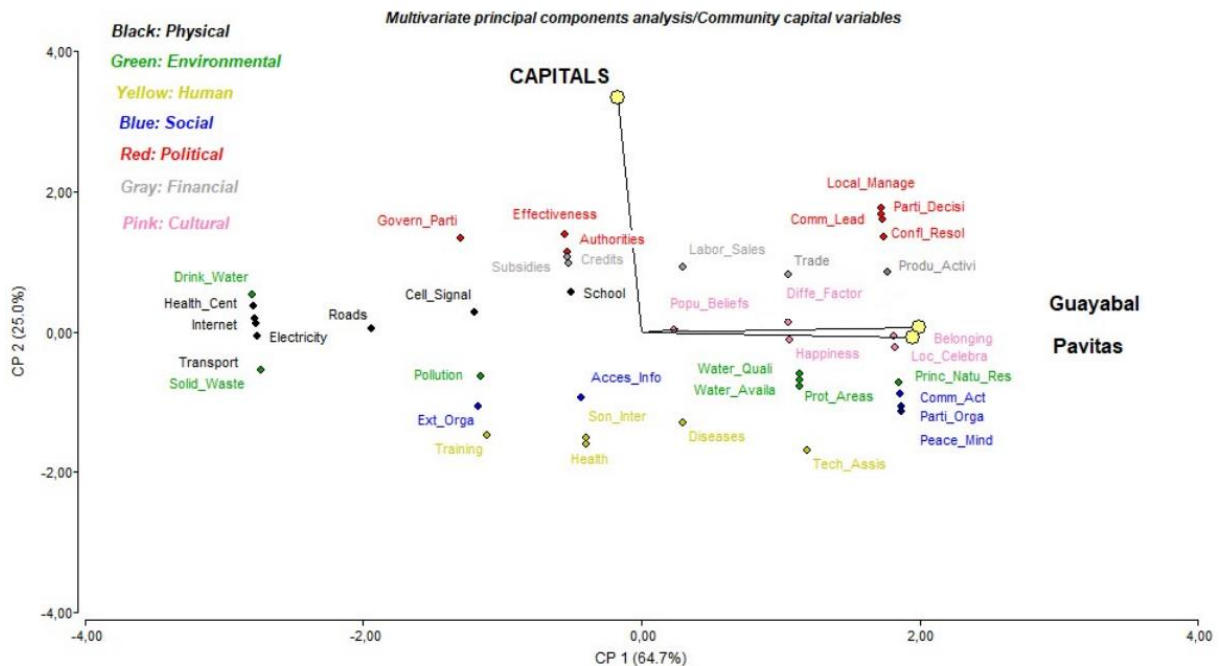


Figure 29: Principals components analysis according to community capitals

In this context, knowing the state of the community's capitals and the vulnerability level, it is also necessary to identify the factors that need to be improved in each capital (**Table 23**) to promote the implementation of adaptation strategies and, therefore, the improvement of local living conditions.

Accordingly, on the strengths of social capital, the objective is strategically planning the factors that need improvement in collective community activities. By harnessing the existing social networks, relationships, and shared values within the community, it becomes possible to identify and prioritize areas for enhancement. This approach encourages collaboration, mutual support, and active participation among community members, fostering a sense of ownership and empowerment. Through collective action, the community can effectively address challenges, implement sustainable solutions, and enhance resilience in the face of climate change impacts.

Table 23: Factors to be improved according to the community's capitals

Human Capital	Social Capital	Physical Capital	Natural Capital	Cultural Capital	Political Capital	Financial Capital
<ul style="list-style-type: none"> • Improve access to technical assistance and training related to climate change. • Develop a support system between the academic sector and producers for project implementation. 	<ul style="list-style-type: none"> • Develop productive alliances within and between communities. • Improve the organization of producers for commercialization. • Strengthen internal and external communication channels 	<ul style="list-style-type: none"> • Construction of health centers • Equipment or infrastructure for irrigation, cultivation, and post-harvesting • Strengthening basic public services (water, energy) 	<ul style="list-style-type: none"> • Use of organic fertilizers • Expand community seed banks • Reduce agrochemical use • Implement biological pest control • Expand the use of rainwater harvesting • Use of drip irrigation • Construction of small geomembrane water reservoirs • Establish live fences with fodder trees and protein banks • Implement a solid waste management plan • Develop a system of payment for environmental services 	<ul style="list-style-type: none"> • Develop a strategy for the recovery of local traditions • Take advantage of farmers' experience and traditional knowledge that can be passed on to new generations. 	<ul style="list-style-type: none"> • Improve and continue institutional support through projects. • Improve levels of participation of local authorities • Promote youth participation in local political structures 	<ul style="list-style-type: none"> • Need for financing for agricultural and livestock activities • Strengthen access to bank loans • Expand the government subsidy program

7.24 Gender analysis

The analysis of gender played a crucial role in evaluating the disparities between households and their impact on community assets, which in turn affect vulnerability. These socioeconomic differences create substantial discrepancies in the availability of vital resources and opportunities in the communities of Guayabal and Pavitas. As a result, there are noticeable variations in fulfilling fundamental human necessities and adapting to environmental and climatic difficulties.

In areas such as Guayabal and Pavitas, women are commonly met with extra challenges regarding securing education, paid work, and involvement in community decision-making. This inequality not only hinders the personal growth of these women but also diminishes the collective social capital of the community by neglecting the valuable skills and expertise they offer.

Age differences play a significant role in the allocation of resources and opportunities. Children, youth, and older people have distinct needs and capabilities. For instance, the youth may need help pursuing higher education or formal employment, limiting their capacity to contribute to the economy and community resilience. Similarly, older people are often more susceptible to the adverse effects of climate change and other risks, particularly when they lack access to adequate health care or social support systems.

To enhance communities' ability to confront environmental and climate-related obstacles, it was crucial to tackle disparities in gender, income, access to land, and household age discrepancies. An all-encompassing strategy that prioritizes people's well-being is essential for driving fair, inclusive, and sustainable development in rural areas like Guayabal and Pavitas.

Guayabal

Regarding the gender situation, historically, gender inequality in community participation in Guayabal is due to sociocultural norms that assign women domestic and caregiving roles, limiting their participation. In addition, low youth participation generates a generation gap in community development. To address this inequality, equal opportunities must be promoted, stereotypes challenged, access to resources and education provided, and inclusive spaces created to encourage the participation of women and youth in community decision-making and activities.

Although challenges persist in women's participation in community activities, women's involvement has increased in the last decade. This increased participation not only contributes to gender equality but also has a positive impact on the community by ensuring a more equitable representation of women's voices and needs and promoting inclusive and sustainable development.

In Guayabal, an income inequality situation is observed in which precarious land tenure plays a relevant role. Community members with limited access to productive resources due to lack of land face difficulties in generating sufficient income to meet their basic needs, access health and education services, and improve their quality of life. In addition, these economic disparities may generate social tensions and lead to the exclusion of certain groups within the community. To address this inequality, policies that promote a more equitable distribution of land and encourage economic empowerment of those with precarious tenure, as well as measures that promote gender equality, are needed. This would strengthen community resilience and move towards more inclusive and sustainable development.

These gender differences have significant implications for vulnerability to climate change. Lower levels of housing satisfaction for both genders suggest inadequate infrastructure or living conditions that could exacerbate community vulnerability to climate-related events. In addition, disparities in the action group indicate potential barriers to women's access to and benefit from recreational activities, participation in decision-making, and effective communication channels. This may limit their ability to respond effectively and adapt to climate change impacts.

A marked gender difference in satisfaction with the need for work is observed. While men report higher satisfaction levels, women express dissatisfaction in this area. This disparity can have significant implications for vulnerability to climate change, as the lack of satisfactory employment opportunities limits women's economic capacity and ability to cope with climate impacts. Addressing this gender gap in access to and quality of employment is crucial for promoting equity and strengthening community resilience in climate change.

Addressing these gender disparities is crucial to improving community resilience and reducing vulnerability to climate change. It requires targeted interventions that address the specific needs and challenges women face regarding housing, access to resources, and opportunities for active participation. By promoting gender equality and empowering women

in decision-making, the Guayabal community can leverage their diverse perspectives, knowledge, and skills to develop more inclusive and effective climate change adaptation and mitigation strategies.

The analysis of gender inequality in the Guayabal community reveals persistent challenges rooted in sociocultural norms that assign women domestic and caregiving roles, thereby limiting their participation in community activities. Moreover, youth's low participation contributes to a generational gap in community development. To address these disparities, it is crucial to promote equal opportunities, challenge stereotypes, provide access to resources and education, and create inclusive spaces that encourage the active involvement of women and youth in community decision-making and activities.

Despite these challenges, there has been an encouraging increase in women's participation in community initiatives over the past decade. This rise in engagement not only contributes to gender equality but also has a positive impact on the entire community by ensuring a more equitable representation of women's voices and needs and fostering inclusive and sustainable development.

Addressing these gender disparities directly is imperative to improving community resilience and reducing vulnerability to climate change. Targeted interventions are needed to address the specific needs and challenges women face regarding housing, resource access, and opportunities for active participation. By promoting gender equality and empowering women in decision-making, the Guayabal community can leverage their diverse perspectives, knowledge, and skills to develop more inclusive and effective climate change adaptation and mitigation strategies.

Pavitas

In the analysis of the rural community of Pavitas, an unequal distribution of gender and age was observed among the interviewees, with a greater representation of men than women. This disparity suggests potential imbalances in access to opportunities, resources, and decision-making power within the community, influencing how climate change issues are addressed and understood. Women's perspectives and experiences may differ from men's, highlighting the need for gender-inclusive approaches to adaptation to climate change.

Moreover, the predominant age range of respondents, which falls between 40 and 65 years, indicates a significant presence of middle-aged and older individuals. This generational composition has implications for climate change adaptation, as different age groups may have varying knowledge and awareness regarding current environmental challenges. The sample's low representation of young people underscores the importance of actively involving younger generations in the planning and decision-making processes related to climate change adaptation.

The identified gender disparities and age composition have significant implications for vulnerability to climate change. Gender inequalities in representation and participation can hinder inclusive decision-making and the implementation of equitable adaptation strategies. The age distribution highlights the need to transfer knowledge and raise awareness of climate change among younger generations. Furthermore, family size and education level may influence families' ability to adapt and respond effectively to climate change impacts. Promoting the preservation of indigenous languages can also strengthen cultural resilience and local knowledge in addressing environmental challenges.

Historical patterns show that men have actively participated in community action boards, received training, and assumed economic responsibility within households, which is reflected in their higher satisfaction levels. In contrast, women express greater satisfaction in the affection component, as they dedicate more time to their families, especially their children.

These gender disparities in the Pavitas community reflect differences in opportunities, roles, and responsibilities assigned to men and women at the community level. Addressing these gender inequalities and promoting equity by ensuring equal access, participation, and satisfaction for both genders across all aspects of life is crucial. This approach will enhance the well-being and quality of life for the entire community while enhancing resilience against climate change impacts and vulnerability.

7.25 Climate change adaptation strategies

Addressing the challenges posed by climate change requires a comprehensive and coordinated approach at the community level. Farmers have observed the detrimental effects of changes in temperature and precipitation patterns on their agricultural production. However, the response to these challenges has been driven mainly by individual initiatives based on farmers' production systems, knowledge, economic capacity, and interests. This

decentralized approach indicates a need for more defined planning and collective action to effectively address climate change impacts within the community. To overcome this limitation, it is crucial to explore strategies that leverage the strengths of each community's capital to foster collective activities and identify factors that can be collectively improved within the community.

Thus, the current adaptation measures being implemented by producers in the two villages are natural capital (reforestation, nursery plant production, and crop diversification), human and cultural capital (ancestral knowledge of climate and crop behavior), and social capital (group activities for road adaptation).

The main reason for implementing measures to deal with the challenges of climate change does not necessarily lie in a thorough understanding of this phenomenon, especially in the two communities mentioned. In many cases, the 'climate change adaptation' concept has yet to be discovered, although it is familiar to these territories. Instead, they focus on the search for alternatives to optimize the performance of their production systems. Since most of the inhabitants rely heavily on agricultural production, their economic income is closely linked to the yield of their land and their ability to cope with the current changing conditions.

7.25.1 Collaborative adaptation measures: Producers and researchers addressing climate variability

The implemented adaptation measures were conceived and executed in close collaboration with the local communities based on the results obtained through a participatory analysis of needs and available resources (workshops, focus groups). This process was characterized by a participatory and community-oriented approach, ensuring the measures were tailored to their specific conditions and challenges. Furthermore, external organizations provided invaluable support, contributing technical and financial resources to implement these measures. In some cases, existing measures, such as the nursery, were further reinforced as part of a comprehensive approach to addressing the challenges of climate change and enhancing the resilience of local communities.

In addition to strengthening existing measures, innovative solutions, such as rainwater harvesting systems and basic meteorological stations, were introduced. The researcher funded and implemented these initiatives with active and enthusiastic community support.

These measures, designed to address specific challenges related to climate change, have proven to be valuable additions to the array of adaptation strategies, enhancing water management and the capacity to monitor local weather conditions. This collaborative, community-oriented approach ensured that the solutions were precisely tailored to local needs, strengthening the resilience of these communities in the face of the effects of climate change.

Despite the significant progress in implementing adaptation measures in these communities, examining the equitable inclusion of all demographic groups is crucial. In this process, special attention must be paid to gender relations. In addition to their prominent role in agriculture, women actively participate in decision-making and serve as members of community action boards, representing a significant stride toward gender equity. However, it is imperative to address the challenges that some women may still encounter in achieving full participation in decision-making. Furthermore, it is important to note that the younger population is displaying a tendency toward migration and limited interest in agricultural processes, raising concerns about the continuity of agricultural knowledge and practices in the future. The ethnic component is also noteworthy as these communities are affiliated with indigenous councils, possessing ancestral knowledge and unique regulations that promote active community involvement. A comprehensive analysis of these dynamics will strengthen community resilience against climate change, ensuring that all voices are heard and that no one is excluded from the benefits of adaptation measures.

Rainwater harvesting. Currently, the demand for water resources is increasing. However, the availability of fresh water is decreasing due to the discharge of organic pollutants, climate change, and the waste of resources, limiting community development (Pandey et al., 2020a, b). Therefore, it is necessary to think of alternatives for efficient water use, particularly in the two villages, since water availability in summer is low and the lack of irrigation systems makes obtaining water for both domestic and productive systems necessary. Therefore, rainwater harvesting systems proved an attractive and practical option for farmers.

Six rainwater collection systems were installed, two in each community, with producers who expressed their interest in obtaining them and making them sustainable over time. Each system collects 105 liters of water, with a capacity that can be modified according to the needs and possibilities of each producer. The producers with the systems installed must follow up on the system's functionality for one year and then socialize with their community on

the benefits and difficulties of using the rainwater systems. The information should be expanded with the farmers' opinions on how the system worked for them.

Basic meteorological stations. Producers find it more convenient to use data from weather stations in the communities to substitute measurements from external weather stations (Freitas et al., 2006). In addition, these stations allow for more approximate data, and access to information is more significant; in the past, communities did not have data on climatic variables available due to a lack of knowledge of their availability (Freitas et al., 2006).

At the research site, ten basic meteorological stations were installed in the two villages, each composed of a thermometer and a rain gauge. These temperature and rainfall variables were chosen because their behavior has changed the most in the area according to the perception of the inhabitants and the municipal meteorological data, which makes it necessary to establish local monitoring of these variables to make more accurate decisions on production systems about the type of crop, planting and harvesting dates.

In addition, the effortless installation, understanding of the station's operation, and ease of access to the data have allowed the farmers to clearly understand the adaptation strategy and transmit the information for processing and subsequent group analysis.

Nursery. The Guayabal inhabitants have developed a community nursery to access endemic plant material. Thus, it is clear that deforestation has had an impact on their community, and humans living in rural environments significantly impact the existing forest area in the tropics (Wright & Muller-Landau, 2006).

Therefore, having a site promotes not only community work but also assigns responsibilities for its maintenance, promotes conservation, and is a source of income since, through Corpopaló, sales are managed by private companies that need trees to reforest other areas. In addition to planting the 1300 trees, Corpopaló purchased the seedlings from the community of Guayabal and thus received money that they could use to develop community projects. In turn, they are receiving the trees planted in their village.

Hence, the idea is to promote the implementation of one nursery in Pavitas. Thus, the positive Guayabal village experience seeks to promote conservation, generate other community workspaces, and promote strategies for adaptation to climate change that, in turn,

contribute to the generation of income for the inhabitants of the communities, becoming an alternative that motivates farmers to be carried out and can be maintained over time.

Reforestation. Globally, an average of 1.6 billion people depend on forests for subsistence, livelihood, employment, and income generation (Chao, 2012). Therefore, the forest resource is a crucial ecosystem for the two communities because natural regeneration processes are evident and can be more economically and ecologically a better option to mitigate climate change (Cook-Patton et al., 2020; Chazdon et al., 2017). Thus, it is necessary to implement reforestation actions, considered one of the most effective natural climate solutions for cost-effective global climate mitigation (Griscom et al., 2017).

Thus, with the Corpopalo Foundation's support, the reforestation of approximately 1300 trees was done on a private farm near the Munchique nature reserve. In the activity, Guayabal village inhabitants participated, who were in charge of planting the trees and, later, must take care and ensure that the trees developed correctly, a situation with which they were very pleased and willing to collaborate in future implementations of measures to adapt to climate change.

External visibility of productive systems. As an alternative for further promoting productive systems in the two communities, the strategy of visiting homes with orchards, coffee plantations, medicinal plants, flower crops, poultry systems with laying hens, etc., was carried out.

The purpose is for each producer to explain how they carry out the production activities in each system. So, people outside the community, mainly from the urban sector, can learn, for example, how coffee is grown, from germination through planting, care, harvesting, drying, and marketing. Thus, an exchange of interests is achieved since not only knowledge is shared, but also people outside the villages can learn about the type of production systems that the communities have and, in this way, become more visible to expand the market. In this sense, the idea is that the producers' activities are made known through video interviews and tours of the farms.

Mobile application. In addition to the previously mentioned efforts, a mobile application is currently under development, thanks to the support of the Corporación Universitaria Comfacauca through the Systems Engineering and Agroenvironmental Engineering programs. The development of this application is contingent upon the initial collection of

meteorological data from both the local communities and the University, which are sourced from meteorological stations. Furthermore, this initiative is part of classroom projects collaboratively undertaken by students, faculty, and community members. Consequently, the project monitors data from the meteorological stations and seeks approval to construct the mobile application.

The use of electronic devices in communities is becoming increasingly common. Therefore, developing a mobile application is appropriate for producers to access information more. Thus, the primary objective of this application is to enhance producers' access to vital information, with a specific focus on data related to climate measurements from both local and regional meteorological stations. This data will enable farmers to make more informed decisions regarding their production systems, reducing uncertainty concerning weather-related factors. This information will be regularly updated as new meteorological data becomes available.

Crop rotation and variation. Currently, it is common to see in the communities the variation of crops; this is due to climatic conditions that do not allow to continue with crops susceptible to high temperatures; for example, previously, one of the favorite crops in the area was the blackberry. However, its performance was considerably affected by the decrease in temperature. Similarly, it has happened with lulo cultivation. Therefore, they have decided to implement banana, cassava, and sugar cane crops that are better adapted to high temperatures. Moreover, this measure allows them to produce several crops and obtain income from their commercialization at different times of the year.

Therefore, the adaptation strategy is already in place and was complemented with actions such as applying organic fertilizers and biological pest control, allowing a cost reduction in the purchase of fertilizers and pesticides and the optimal use of organic waste and chemical-free production.

Best practices in land preparation: When peasants prepare the land for planting, they avoid burning weeds. This practice protects the soil from wind or rain, favors the development of beneficial organisms, and improves soil quality.

Also, it is important to create an adaptation strategy for groups vulnerable to climate change. This entails addressing the specific needs and challenges of those groups that often rely on a

single livelihood. Therefore, a general approach is proposed to develop an adaptation strategy:

a. In-Depth Vulnerability Assessment:

Understand the specific characteristics of vulnerable groups and their relationship with climate change.

Identify the primary impacts of climate change on the livelihoods of these groups.

b. Priority Identification:

Determine critical areas for intervention, focusing on the primary sources of vulnerability (e.g., exposure, sensitivity).

Set priorities to address the most pressing challenges.

c. Design of Adaptation Measures:

Develop specific adaptation measures that address identified needs and reduce the vulnerability of the groups.

Implement measures that enhance the resilience of livelihood systems, such as crop diversification, water conservation techniques, early warning systems, reforestation, and ecosystem restoration.

d. Community Engagement:

Actively involve vulnerable groups in the design and decision-making process to ensure culturally appropriate and relevant measures.

e. Implementation and Monitoring:

Implement adaptation measures and ensure ongoing monitoring of their effectiveness.

Make adjustments as necessary to address evolving challenges.

f. Capacity Strengthening:

Provide training and capacity-building for vulnerable groups to enhance their adaptive capacity and promote self-reliance.

g. Coordination and Collaboration:

Work collaboratively with local, regional, and governmental organizations to ensure effective implementation and coordination of efforts.

7.26 Critical evaluation of adaptation strategies

The Community Capital Framework (CCF) serves as a valuable resource and asset identification tool and an analysis and monitoring tool to measure the impact of adaptation strategies to climate change and other environmental disturbances. It provides a framework for tracking changes in community capitals over time, allowing for the identification of positive or negative trends in the availability and quality of community resources and the community's ability to harness them for climate change adaptation effectively. The CCF approach is currently being utilized in the communities of Guayabal and Pavitas to evaluate the impact of the implemented adaptation measures.

CCF aims to facilitate the identification of adaptation measures that may not yield the intended outcomes or potentially have unintended adverse effects on local communities. Areas that require adjustments or further interventions can be pinpointed by closely monitoring shifts in community capital resulting from specific adaptation measures. This empowers decision-makers and development planners to create more impactful interventions catering to marginalized communities' needs.

Guayabal

The results of climate change adaptation practices in the rural community of Guayabal reveal that some of these measures are effective, while others still need to achieve their purpose. Local knowledge can be crucial in adaptive capacity, but its effectiveness depends on several factors. Active community participation, strengthening community capital, and satisfying basic needs, among other aspects, are essential for adequate adaptation. In addition, the support of governmental organizations is vital to ensure the effective implementation of adaptation measures.

Therefore, it is essential to critically evaluate the effectiveness of these strategies, as some may need to provide the expected results. Implementing adaptation practices based on local knowledge only sometimes guarantees an effective response to climate change. It is important to note that many of these strategies are designed primarily to maximize crop productivity without explicitly considering the context of climate change adaptation.

It is important to mention that although some authors mention that climate change adaptation processes in rural territories are essential for the optimal development of local livelihoods, especially considering the significant impacts climate change generates on small producers in developing countries (Dhakal et al., 2022). Additionally, it is important to highlight that local knowledge provides the necessary skills to understand the environment and recognize changes in the territory over time, which allows the development of different adaptation strategies (W. Adger et al., 2007); in many cases, the decisions of farmers and rural communities are focused on maintaining or improving the productivity of their crops in the short term, without fully considering the possible impacts of climate change in the long term. This can lead to implementing practices that may be beneficial in the present but not sustainable in an ever-changing climate change context.

Therefore, an integrative approach that combines local knowledge with scientific support and promotes greater awareness of climate change's specific challenges is necessary. This involves promoting strategic planning considering short-term productivity and long-term resilience to climate change impacts.

The integrative approach seeks to develop adaptation strategies that are contextually relevant and sustainable. This involves considering the specific needs of the rural community of Guayabal, as well as scientific projections of potential changes in climate and their impact on agriculture and local livelihoods.

The need for adjustments and improvements can be identified by critically evaluating existing adaptation strategies to better integrate climate change adaptation into local decisions and practices. This ensures that the rural community is better prepared to meet the challenges of climate change while maintaining its long-term productivity and sustainability.

Therefore, one option to improve adaptation to climate change would be to continue strengthening collaboration between local and scientific knowledge. Local knowledge provides valuable information on the community's specific dynamics and challenges. By combining it with scientific support, better insights can be gained into the impacts of climate change and the most effective measures to address them.

This integrative approach involves generating sound scientific evidence to support local adaptation practices and contribute to their continuous improvement. In addition, it is essential to promote active community participation in the decision-making process, fostering

local ownership and empowerment. This can be achieved by creating spaces for dialogue and collaboration between different actors, such as scientists, community leaders, non-governmental organizations, and governmental entities.

Pavitas

The results of climate change adaptation practices in the rural community of Pavitas reveal a combination of effectiveness and limitations. Although private institutions have received technical training mainly focused on coffee cultivation, government support has been limited.

However, it is critical to evaluate the effectiveness of these strategies critically, as some may need to provide the expected results. Due to the support and technical training of private institutions, it is important to recognize that many of the adaptation practices implemented in the Pavitas community are designed primarily for coffee cultivation. Although coffee cultivation is an important activity in the community, it is necessary to consider other aspects of climate change adaptation beyond this sector.

It is essential to recognize that government support has been limited in general terms and even more so regarding climate change adaptation in Pavitas. This has led to a heavy reliance on private institutions for technical training in coffee cultivation. While these trainings are valuable, there is a need to broaden the focus and address other aspects of adaptation relevant to the community, such as crop diversification, water management, soil conservation, and resilience to extreme weather events.

To improve climate change adaptation in Pavitas, it is crucial to strengthen collaboration between local knowledge, private institutions, and government support. There is a need for greater government support in terms of funding, policies, and specific programs for climate change adaptation in the community. This will address local needs and challenges more comprehensively and sustainably.

By critically evaluating existing adaptation strategies in Pavitas, it is possible to identify the need to expand adaptation options and measures beyond coffee cultivation. This implies strategic planning that considers crop diversification, sustainable natural resource management, and the promotion of agroecological practices. Strengthening the community's active participation in decision-making and promoting training in various aspects of climate change adaptation is also essential.

In addition, it is essential to recognize the importance of coordination and collaboration between the indigenous cabildo and the Junta de Acción Comunal in the Pavitas community. Both institutions represent the community and have specific roles and responsibilities in decision-making, which would help coordinate actions to implement strategies related to climate change adaptation. The Junta de Acción Comunal, as the community's governing body, has had the task of representing and watching over the general interests of the community. Its active and coordinated participation with the indigenous cabildo is essential to ensure effective and equitable adaptation in the Pavitas community.

Collaboration between the indigenous cabildo and the Junta de Acción Comunal can strengthen climate change adaptation efforts by leveraging the knowledge and experience of both institutions. This involves sharing information, jointly identifying priorities, and planning actions that address the community's specific needs and challenges related to climate change. Working together, therefore, can facilitate the implementation of integrated and holistic adaptation measures that address the community's individual and collective needs. It can also promote equity and inclusiveness by ensuring that decisions and actions related to climate change adaptation are made participatory and representative.

7.27 Proposed adaptation measures to mitigate climate variability

The strategies proposed below were identified in a collaborative process in which the community and the researcher worked together to propose solutions that can be considered by the communities and subsequently implemented in the short, medium, or long term. This collaboration involved the joint creation of proposals to address the challenges raised. Some of these strategies arise from joint visits made to other areas in the department of Cauca, where climate change adaptation measures have been successfully implemented and can be adapted to the local situation.

In addition, other strategies were generated from the community participatory diagnosis, which involved observing the impacts of climate change in the area and identifying the community's specific needs. Thus, the participatory and collaborative approach allowed the community and the researcher to contribute to formulating solutions that address their challenges in climate change.

According to the identification of activities carried out by farmers in collaboration with organizations, mainly to seek development options and improve the quality of life, the great

challenge is developing, reinforcing, and integrating climate change adaptation measures into local dynamics through policy formulation.

However, during research development, a receptivity to adopting new adaptation measures was identified, either for improving their economic income, obtaining information, and acquiring skills, considering that they have a responsibility to their environment to seek improvement, and for the search for sustainability.

Living Fences. This adaptation strategy has been implemented in some farms in rural areas, mainly as a boundary delimitation method. Thus, wire lines are fixed on the trees to divide the land or are established as a method to delimit paddocks and live fences have been established either by direct planting or natural regeneration.

However, the economic impact needs to be more representative; the forage is not used for livestock; it is an area of mainly agricultural vocation. The same happens with the non-use of the wood and its shoots in the living fence; they prefer another tree. However, living fences save 8% to 13% compared to dead fences (Morantes-Toloza & Renjifo, 2018). Plus, due to its long life, it saves money. In addition to ecosystem services, it provides carbon sequestration, scenic beauty, and the promotion of conservation among grazing and protected areas.

Minimum tillage. Land preparation is generally without the use of machinery as there are no large extensions of crops. Hence, plowing is minimal; it is only done to smooth the soil and facilitate root development. Thus, it shortens planting times between the previous and current crops, contributing positively to production and production costs (FAO, 2019). However, it also exposes soil pests to the sun or birds.

Water reservoirs. Climate change, lack of water (mainly in summer), uncertain rainfall in winter, and lack of technical support to establish irrigation systems have led to a lack of sustainable use of resources. Thus, the water reservoir construction could be simple, i.e., digging in the ground according to the needs and available space, taking advantage of the ground conditions. So, rainwater overflow can be used, and then a geomembrane can be used to prevent ingress of collected water. Thus, multiple benefits for producers and ecosystems are part of implementing irrigation systems and maximizing the sustainable use of water resources.

Irrigation system: The productive systems in the two villages are characterized by being developed in small farms, in addition to the low level of economic income, which makes it uncommon to see irrigation systems; however, having access to an irrigation system allows programming harvests, a more significant number of crop rotations and planning plantings in search of better prices and to be more competitive. This strategy would allow irrigation to be intercalated or only when necessary, effectively using water resources and adapting to climate conditions, especially with variable rainfall that does not ensure resource availability.

Stubble incorporation. By not burning the soil on the farms in the communities, the decomposed weed residues can be used during soil preparation or minimum tillage; once the weeds are cut, they are left in the sun, and a week later, the soil is tilled. This practice improves soil structure (Mercado, 2018).

Seed Bank: The producers of Pavitas village have a seed bank, which allows them to resist climate variability and contributes to the territory's food security. Thus, the Guayabal community must implement seed banks that strengthen their community resilience and have strategies to adapt to climate change according to local livelihoods.

Marketing strategies: The "Rural Sustainability: Our Community, Our Future" strategy aims to create a marketing strategy that promotes sustainable practices and raises awareness among the rural community about climate change and its impacts. Combining education, promoting organic agriculture, highlighting local products, adopting renewable energy, waste management, and rural tourism, it seeks to empower residents to take sustainable actions. Through information campaigns, local fairs, and collaborations with experts, it aims to promote adopting environmentally friendly agricultural practices, clean energy generation, responsible waste management, and sustainable rural tourism, thus boosting the economic and environmental well-being of the community.

The strategies described above would play an essential role in the adaptation processes to climate change, allowing changes in their production systems to improve yields, make adjustments, and take individual and collective decisions. Hence, all aimed to reduce vulnerability to climate change and enhance its eventual benefits.

Thus, adaptive capacity is associated with developing social capital when local systems are threatened, as well as natural capital through the sustainable use of natural resources to develop livelihood strategies. On the other hand, human capital, through the management of

knowledge and information to make sound decisions, political capital determines the levels of internal organization and relations with external institutions, and economic capital reflects household income.

Consequently, the linkage between community capital relates to community development and planning. Therefore, it must be ensured that investments in one capital do not lead to the depletion of other capitals. This is even more so in the two communities where most households depend on subsistence agriculture for their income and staple food production, which is very sensitive to weather phenomena such as droughts and floods directly related to climate change. The relationships between community development and livelihood dynamics could serve as a bridge between creating public policies that improve local living conditions.

Therefore, although adaptive capacity depends on many endogenous factors, it is clear that strengthening community capital and livelihoods based on adaptation strategies in line with local conditions contributes to improving levels of adaptation to climate change and reducing vulnerability.

1.2 Strengthening community features in the Adaptation process

As the issue of adaptation to climate change is relatively new, communities are implementing alternatives to cope with the changes. However, planning and equalization of existing measures are needed. However, what is new and exciting is to identify producers and residents in general in the ongoing search to strengthen their adaptive capacity, also develop practices to deal with changes, and, at the same time, take advantage of the different forces of capital. This adaptation process, in turn, must be complemented with the support of public institutions that strengthen decision-making and local organizational structures.

In this context, the producers identified the factors to be improved by applying participatory methodologies. Thus, implementing programs or projects to strengthen the community's capital complements the current adaptation measures.

Finally, this research contributes to the identification of the levels of vulnerability to climate change according to the livelihoods and livelihood strategies of the two communities based on the methodology of the community capitals. This study allowed a detailed analysis of the great social, economic, political, cultural, physical, and environmental importance of the management of the territory. Although the methodology allowed the description of the capitals, future research needs to increase the sample size. Thus, community participation is

more significant when it comes to applying protocols, which would allow more exhaustive coverage of the conditions of the territory.

Despite a large sample size and extensive data collection, the study was conducted during the tense COVID-19 pandemic. Therefore, it did not allow for building a close relationship of trust with the communities and an intensive research process based on personal encounters and group processes. In doing so, various methods were applied - in line with the research design - and they collected essential data to answer the research question. Admittedly, setbacks continued due to the ongoing pandemic (cancellation of agreed meetings, withdrawal of participation commitments, etc.). However, due to the extended fieldwork in the region, stable relationships were successfully established in two communities (some of which are indigenous and thus require an even more sensitive approach), which made the research possible.

There were also limitations, such as the need for economic resources for the research development, mainly in implementing adaptation strategies that required acquiring materials and labor. However, with the farmer's interest and the University of Hamburg's support, the objective of promoting the strategies implemented to reduce vulnerability to climate change was achieved.

Additionally, these strategies can have excellent coverage and strengthening if the municipal administration and non-profit organizations invest significantly in the area. Therefore, this research makes these communities visible, and it is expected that the results will serve as a management tool for decision-making and policy formulation in the search for development, more remarkable adaptation, and reduced vulnerability to climate change.

8 Discussion and Recommendations

For both communities under study, endogenous and exogenous factors have influenced the historical development of the territory, influencing their social, economic, cultural, and environmental characteristics, which has led them to search for the improvement of their basic needs. Therefore, along this path, they have been able to perceive changes in the climate mainly through the effects generated on their production systems, i.e., there is already a relationship between climate change and productivity. In this sense, some producers have developed individual adaptation strategies and openly express the need to continue implementing more structured strategies and strengthen the current ones to reduce the risks generated by this climatic phenomenon.

These perceptions of climate change go hand in hand with scientific data on climate variables collected by local weather stations. For example, the period 1997-2020 (23 years) shows changes in precipitation and temperature, which coincide with inhabitants' perceptions of the two communities and the unpredictability and increase in pluviosity throughout the year.

In this context, the data collected from the Santander de Quilichao weather station and the farmers' perceptions of the two communities through the various participatory methodologies coincide with the projections of the new IDEAM scenarios, specifically for the Department of Cauca.

This study has highlighted the value of the community capital approach as a comprehensive method for addressing climate change adaptation in rural communities. The results obtained support the effectiveness of this approach by allowing the individual assessment of each community capital and considering the impact of climate change on each of them (Berkes & Ross, 2013; Folke, 2006). This has been fundamental to identifying key vulnerability areas and prioritizing the actions needed to strengthen community resilience (Folke et al., 2001).

In addition, it has been suggested that the community capital approach can strengthen information and monitoring systems in rural communities affected by climate change. Collecting more accurate data on the state of each community's capital and the specific impacts of climate change provides a more complete picture of the community's current situation and adaptation needs (Carpenter et al., 2001).

Informed decision-making has significantly benefited the community through the community capital approach (Berkes & Ross, 2013; Sayer et al., 2017). The information gathered has enabled decision-makers to understand the community's challenges better and design more effective strategies to address them (Armitage et al., 2009; Folke et al., 2001).

Despite this study's significant contributions, it is important to recognize its limitations. The research has focused on two rural communities, which limits the generalizability of the results to other communities with different characteristics (Berkes & Ross, 2013; Gallopín, 2006). In addition, the community capital approach may require a more comprehensive level of analysis and evaluation, which implies additional time and resources (Armitage et al., 2009; Olsson et al., 2014).

Finally, this study presents a discussion that addresses the methods used and provides a methodological reflection. It examines the strengths and limitations of the approaches employed and discusses the relevance of the methods used in the research in the rural communities of Guayabal and Pavitas. In addition, the implications of the findings for understanding and addressing climate change adaptation are highlighted, and possible directions for future research in this field are suggested.

8.1 Participatory community diagnosis

The application of Participatory Community Diagnosis in Guayabal and Pavitas provided a methodological reflection on its strengths and limitations. The communities' perception of the effects of climate change revealed that the main impacts were observed in crop yields, leading to low market prices and reduced income for local producers. The farmers acknowledged temperature changes, decreased rainfall resulting in summer droughts, and increased heavy rains during winter as direct consequences of climate change. These changes disrupted the traditional rainy and dry season patterns, making the climate more unpredictable. Coffee production was identified as the primary livelihood system in all two villages, with no illicit crops. The organizational capacity, particularly through the Community Action Boards, was a positive factor in coordinating community activities and addressing local dynamics. However, a significant challenge was the absence of secondary education in all two villages, which required youth to relocate to other communities if they wished to pursue further studies. These findings highlighted the need for targeted interventions to enhance

adaptive capacity and promote sustainable development in the face of climate change in these rural communities.

Thus, by using qualitative analysis, starting with an extensive literature review, key informant interviews, knowledge-sharing workshops, and a participatory diagnosis, it was possible to analyze the rural situation in a developing country concerning the communities' behavior and the subsequent creation of public policies led by the local actors. Therefore, face-to-face communication with peasants is possible and simultaneously builds partnerships of trust between the different actors to promote local development (Zuin et al., 2019). Moreover, exploring the possibility of motivating peasants to implement rural development processes through a participatory diagnosis, despite the lack of different perceptions, finally suggests some adaptation policies (Tripathi & Mishra, 2017).

The application of Participatory Community Diagnosis in Guayabal and Pavitas provided a methodological reflection on its strengths and limitations. One of the strengths of the participatory approach was its ability to engage community members in the research process, allowing their voices to be heard and their knowledge to be incorporated into the analysis. This ensured a more comprehensive and contextualized understanding of the effects of climate change on the communities. For example, through participatory discussions and mapping exercises, the farmers were able to identify specific climate-related impacts on their crop yields and income.

However, the participatory approach also had certain limitations. One challenge was ensuring equal participation and representation of different community social groups, particularly regarding gender and age. In some instances, women and younger community members may have needed more involvement or opportunities to contribute their perspectives. This could result in a partial understanding of the gender-specific impacts of climate change and the needs of younger generations in adapting to these challenges.

Another limitation of the participatory approach was the potential for power dynamics and unequal decision-making processes within the community. Despite efforts to create inclusive spaces for dialogue, certain individuals or groups with more influence or authority could dominate discussions or guide the direction of the analysis. This could undermine the participatory nature of the research and limit the diversity of perspectives included.

It is important to continually assess and adjust the participatory process to address these limitations to ensure meaningful participation, inclusivity, and equitable representation. This may involve implementing strategies to actively involve marginalized groups, such as women and youth, in decision-making and ensuring their voices are valued and considered. Fostering a supportive and empowering environment where community members feel comfortable sharing their experiences and ideas is crucial for a successful participatory approach.

Overall, the Participatory Community Diagnosis provided valuable insights into the effects of climate change on Guayabal and Pavitas's communities. It highlighted the strengths of engaging community members in the research process and incorporating their knowledge while shedding light on the challenges and areas for improvement regarding inclusivity and power dynamics. By addressing these limitations, the participatory approach can contribute to more effective and equitable climate change adaptation strategies tailored to the specific needs and contexts of the communities.

8.2 Basic Human Needs perception

Applying the Basic Human Needs perception in Guayabal and Pavitas provided a methodological reflection on its strengths and limitations. One of the strengths of analyzing basic human needs was its ability to capture the participants' perspectives and understand the specific needs identified by the community members. This participatory approach ensured that the research focused on the essential requirements and priorities expressed by the local population. For example, discussions and interviews revealed that land ownership and access were crucial for indigenous communities, highlighting the need for equitable land distribution.

Another strength of the analysis was its ability to identify positive developments regarding inclusion and equity. Despite facing climate vulnerabilities and economic challenges, the villages' empowerment was evident. Gender equality was observed as a facilitating factor, enabling greater participation of women in agricultural and association activities. This shift significantly changed traditional gender roles and created a more inclusive and equitable community.

However, analyzing basic human needs also had limitations. One challenge was ensuring the representation of diverse perspectives and voices within the community. Although efforts were made to include the views of different social groups, there may have been limitations in

capturing the experiences and needs of marginalized or less visible individuals or groups. This could result in an incomplete understanding of the community's overall needs and hinder the development of targeted strategies for adaptation to climate change.

Promoting inclusive and participatory processes that actively engage all community members, including those traditionally marginalized, is crucial to addressing these limitations. This may involve creating spaces for dialogue, ensuring equal opportunities for participation, and valuing diverse perspectives. Additionally, strategies that promote gender equality and challenge existing social norms and practices can further enhance inclusion and equity.

8.3 Climate Change Effects from local and external actors' perspective

Applying the perceptions of local and external actors in Guayabal and Pavitas provides a methodological reflection on its strengths and limitations. One of the strengths of analyzing these perceptions is the rich understanding they offer of the observed climate change effects from different perspectives. The insights provided by local actors highlight the direct impacts on their daily lives, such as decreased water availability, reduced crop productivity, and increased illnesses. On the other hand, the perspectives of external organizations offer a broader view of the implications for food sovereignty, employment opportunities, and the effectiveness of their interventions.

The communities and organizations involved in this analysis recognize the importance and urgency of addressing climate change impacts. While there may be partial agreement on all aspects, there is a general acknowledgment of the need for climate change adaptation activities. This shared recognition creates a common ground for collaboration and the potential development of effective adaptation strategies. By building upon this partial consensus, it is possible to foster dialogue and collective action toward addressing climate change challenges in Guayabal and Pavitas.

However, there are also limitations to consider. One potential weakness is the reliance on subjective perceptions, which may vary among individuals and organizations. While these perceptions provide valuable insights, they may sometimes align with objective data or scientific assessments. Balancing local knowledge and scientific evidence is crucial to ensure comprehensive and informed decision-making.

Furthermore, the unpredictability of climate events challenges organizations' effectiveness and ability to plan and implement climate change interventions. The altering of intervention

schedules and the disruption of access roads due to excessive rainfall and landslides exemplify the difficulties external organizations face. These challenges underscore the importance of adaptive management approaches that allow flexibility and the ability to respond to changing climate conditions.

To address these limitations, it is necessary to integrate multiple sources of information and knowledge, including scientific data, local perceptions, and external expertise. A more comprehensive understanding of climate change impacts can be achieved by combining different perspectives. This interdisciplinary approach can enhance the effectiveness of climate change adaptation and mitigation strategies, ensuring they are contextually relevant, scientifically sound, and responsive to the needs and priorities of the communities.

8.4 Climate Change Effects According to Community Capitals Framework (CCF)

Applying the community capital method allowed gaps in understanding the relevance of local knowledge and traditions of resource use and the importance of power roles and relationships with decision-makers regarding the use of natural resources.

The community capital framework (CCF) allows for identifying strategies, roles, and the impact of capital on a community's well-being and contribution to development (Keefe, 2006). Moreover, to evaluate the social context, qualitative methods can be applied to assess the vulnerability of the agricultural sector in rural communities. Working with farmers and their intention to participate in processes of sustainable rural development, qualitative studies can be based on the application of methods according to local agreements and disagreements (Saptutyningsih et al., 2020).

Therefore, different studies argue that qualitative methods allow the identification of communities' livelihoods, referring to the importance of their differentiation to respect decision-making dynamics and management processes according to local perspectives and assess the climate crisis and the precariousness of livelihoods in rural communities (Berchoux & Hutton, 2019).

This study helped stakeholders as an essential tool in the planning, monitoring, and evaluation processes of climate change adaptation initiatives.

The research results show that the participants' experience is vital and positively impacts the development of daily activities since it allows them to project themselves as autonomous and

empowered subjects according to their needs. However, there are low levels of education and low access to economic resources, which is reflected in problems that hinder the real possibility of accessing the complete satisfaction of basic needs, making these people subjects of permanent vulnerability.

Although the Community Capitals Framework (CCF) has been implemented in several rural communities to assess its social, economic, and environmental impact, aspects still need to be fully explored in its application. Therefore, the impact on equity and social justice in rural communities was evaluated, as it was evidenced that they face economic and social inequalities. Since the CCF does not fully consider these inequities, they were complemented with other methods (gender analysis, checklists, collective mapping, basic human needs, and vulnerability assessments). Hence, equity and social justice measures were explored in the CCF approach.

Firstly, it was important to identify and measure the existing inequalities in the rural community regarding access to key resources and services. This allowed for the inequities in the CCF assessment to be addressed. Additionally, the voices and needs of marginalized groups were included by actively involving marginalized groups in the community, such as women, older people, and ethnic minorities. This helped to consider their needs and concerns in the evaluation process and ensure the CCF approach was equitable. Specific meetings and consultations with these groups were conducted to obtain their opinion and listen to their needs and concerns.

Furthermore, the combined execution of the CCF method with other methodological tools allowed various ways to assess and promote innovation and entrepreneurship in rural communities, for example, by identifying opportunities for innovation and entrepreneurship through market analysis and identifying unmet needs and demands of the local population. Creativity and innovation were also promoted by conducting workshops in the rural community. Once opportunities were identified, creativity and innovation were encouraged, and interest in receiving training and mentoring programs for entrepreneurs and small businesses increased. Therefore, these activities not only close a gap in the CCF approach but could also focus on developing business skills and creating networks. The CCF and its adjustments drive rural development initiatives. They focus on technology, including precision agriculture, using drones and basic weather stations, marketing medicinal plants, and implementing information and communication technologies.

Therefore, the information and monitoring systems were strengthened in rural communities affected by climate change. This allowed for more accurate data collection on the different community capitals' status and climate change's impacts. Moreover, as a result of the research, the Municipal government considered it essential to implement an effective early warning monitoring system in the area to help mitigate the risks of flooding, river swells, and other impacts to which the communities and the municipality of Santander de Quilichao have been exposed.

Additionally, it was proposed that the CCF method could serve as a constant monitoring and evaluation tool. Continuously monitoring and evaluating the impact of the CCF on equity and social justice was essential. This will allow adjustments and improvements in the CCF approach as it develops and is applied. This could involve collecting follow-up data and evaluating the impact at regular intervals, such as annually or every two years, leading to more structured decision-making and developing adaptation strategies in line with current reality.

Finally, through this participatory and community-based approach, a key innovation would be to involve the community in the monitoring and evaluation process, whereby community members themselves execute the protocols through the CFCC and its adjustments combined with other methods, increasing their commitment and empowerment to address the challenges of climate change. Additionally, this community participation could help identify more effective and relevant adaptation solutions and strategies for the community.

8.5 Collective Mapping

Applying the Collective Mapping method in Guayabal and Pavitas has provided valuable insights and opportunities for community participation and dialogue. Creating visual representations of the villages through collective mapping has allowed for a different narrative beyond previously used conventional protocols. Actively involving community members in the mapping process has facilitated their active participation and engagement in identifying and discussing various aspects of their villages.

Historically, participatory mapping has sought to create an enabling environment for public participation beyond software and hardware, seeking access to relevant information, analysis of complex data, and ways to solve problems (Barndt, 1998). In the face of sustainable rural development and its socioeconomic impacts, the decision-making process has many

uncertainties and complexities (Mehryar & Surminski, 2022). Moreover, community participation in using participatory mapping tools has clear potential to generate benefits for capacity-building and management and planning initiatives by the communities (McCall & Dunn, 2012).

Hence, one of the strengths of the collective mapping approach is its ability to highlight shortcomings and inequalities concerning external actors' support and access to technical resources. For example, the absence of maps in local institutions reveals a need for more necessary tools and resources for effective planning and decision-making. By bringing attention to these issues, the collective mapping process empowers communities to advocate for improved support and resources from external actors.

Moreover, the socio-cultural component of the collective mapping has been particularly insightful in identifying and strengthening community inclusion. It has highlighted the significance of community activities and the preservation of traditional practices as essential factors for achieving internal goals. By recognizing and valuing their socio-cultural heritage, the communities can enhance their resilience and maintain a sense of identity and cohesion in the face of environmental and social challenges.

However, it is important to acknowledge some limitations of the collective mapping method. For instance, visual representations may only partially capture the complexities and nuances of certain issues or perspectives. Complementing the mapping process with in-depth qualitative data and dialogues is crucial to ensure a comprehensive understanding of community dynamics and needs. Additionally, ensuring the sustainability of collective mapping initiatives requires ongoing support, capacity-building, and engagement from local and external stakeholders.

In conclusion, the collective mapping approach has proven to be a valuable tool in Guayabal and Pavitas, enabling community participation, highlighting inequalities, and fostering a sense of ownership and empowerment. By addressing the identified limitations and building upon its strengths, the collective mapping method can continue to serve as an effective means for community engagement and collaboration in addressing environmental challenges and promoting sustainable development.

8.6 Vulnerability Analysis

Applying vulnerability analysis in Guayabal and Pavitas has provided valuable insights into livelihood strategies and the sensitivity of communities to climate change impacts. By analyzing the climatic variables of temperature and precipitation, it became evident that these factors play a crucial role in crop yields and livelihoods. The sensitivity of farmers to periods of drought, excessive rainfall, and increased temperatures highlights the vulnerability of their livelihoods to changing climate conditions.

In addition, several authors have highlighted the importance of addressing vulnerability and adaptation to climate change in rural communities. According to (Lazzari et al., 2021), understanding the socioeconomic and environmental factors that influence the vulnerability of communities is critical to developing effective adaptation strategies. Furthermore, (W. Adger et al., 2007) highlight that assessing the adaptive capacity of communities is essential to identify barriers and opportunities that may affect the implementation of adaptation measures. On the other hand, (Smit & Wandel, 2006) emphasizes that the active participation of communities in the vulnerability analysis and adaptation planning process is key to promoting long-term sustainability.

However, one of the strengths of the Vulnerability Analysis is its ability to identify adaptation measures that communities have already implemented for certain livelihoods. The effectiveness of these measures demonstrates the resilience and adaptive capacity of the communities in the face of climate change. It indicates that they have been proactive in finding ways to mitigate the impacts and maintain their livelihoods. However, it is important to note that not all livelihoods have adaptation measures, highlighting potential vulnerabilities and the need for further attention and support.

Furthermore, evaluating adaptation measures and estimating adaptive capacity provide valuable information for understanding the effectiveness of existing strategies and identifying areas for improvement. By assessing the effectiveness of implemented measures, it becomes possible to identify which strategies are successful and which ones need adjustment or additional support. This information can guide future adaptation planning and decision-making processes.

However, it is essential to acknowledge some limitations of the Vulnerability Analysis. The analysis focuses primarily on the climate-related aspects of vulnerability, and other

dimensions, such as socio-economic factors, governance, and institutional capacities, may need to be fully captured. It is crucial to consider a multi-dimensional approach to vulnerability assessment to ensure a comprehensive understanding of the communities' challenges and needs.

In conclusion, the Vulnerability Analysis applied in Guayabal and Pavitas has provided valuable insights into the sensitivity and adaptive capacity of the communities' livelihoods. Identifying effective adaptation measures and evaluating their effectiveness contribute to the communities' resilience to climate change. However, addressing the vulnerabilities of all livelihoods and considering a broader range of factors in vulnerability assessment will enhance the effectiveness of adaptation strategies and support more comprehensive and sustainable approaches to climate change adaptation in the communities.

Hence, based on the results obtained from the various methods applied, the need to develop adaptation strategies to climate change in the communities of Guayabal and Pavitas has become evident. These strategies are based on understanding existing vulnerabilities, perceived impacts, and identified socioeconomic, cultural, and environmental strengths. By considering these dimensions and taking advantage of local strengths, the aim is to promote community resilience and ensure the sustainability of livelihood systems in climate change.

9 Conclusion

This research represents one of the initial steps in addressing climate change adaptation in two communities. A crucial element in this process has been the consideration of local perceptions, which proved instrumental in determining the current vulnerability conditions to this phenomenon. This allowed for a deeper understanding of local dynamics related to climate change, enriched by a review of available literature on climate change adaptation.

In these communities, the perception of climate change is becoming increasingly evident due to changes in climatic variables and their impacts on productive systems. This awareness fosters a greater willingness to confront climate change, reduce vulnerability, and enhance living conditions. Efforts are underway to make agricultural systems more adaptable to climate variability, optimizing the use of strategies and livelihoods.

Local perceptions of climate variability indicate that summers have become hotter with droughts and irregular rainfall, while floods characterize winters. Residents attribute these changes to deforestation, river contamination, and pollution from the business sector.

The constant pursuit of economic resources to meet basic needs has led farmers to implement adaptation alternatives. These measures have primarily been designed in response to specific climatic events rather than considering long-term climate change trends. However, these strategies have contributed to family economic sustainability and reduced vulnerability to climate change, although continuous technical adjustments are required to maintain their effectiveness.

Therefore, more substantial intervention from external institutions is essential to support agricultural management practices and address the risks generated by climate change. Transformational strategies based on cooperation, information exchange, and active engagement of local stakeholders can promote an understanding of climate change risks and leverage these processes to foster community development.

Producers must have access to more detailed weather forecast information to ensure that climate changes do not adversely affect agricultural and livestock production. This access enables informed decision-making and the development of more climate-resilient production systems. The transition to irrigation systems could improve their productivity by reducing their dependence on precipitation.

The vulnerability assessment provides significant insights. Livelihood activities such as coffee cultivation, bean farming, tomato production, and blackberry cultivation appear particularly vulnerable to climate variability due to their high exposure and sensitivity. Although adaptation measures have been moderately effective, it is essential to recognize that they require constant adjustments due to the changing nature of the climate. This analysis also underscores the presence of highly vulnerable producer groups within the communities, which heavily rely on a single activity. These groups have experienced extreme changes related to heavy and unpredictable rainfall and rising temperatures. From these observations, it becomes evident that addressing the vulnerability of these groups is crucial for effective climate change adaptation in these communities. Specific and collaborative strategies involving these communities in identifying challenges and implementing solutions are necessary to build strong resilience and reduce vulnerability in the future. These measures

protect the most affected groups and contribute to overall well-being and long-term sustainability in the face of ongoing climate change.

In the fight against climate change, addressing the vulnerability of the most affected groups, especially those whose livelihoods heavily depend on climate-sensitive sectors, is essential. The adaptation strategy designed for these groups must be inclusive and participatory, involving communities in identifying challenges and implementing solutions. Through training, the implementation of specific measures, and collaboration, it is possible to strengthen the resilience of these groups and reduce their vulnerability to climate change. Effective adaptation protects vulnerable communities and contributes to overall well-being and long-term sustainability. Early action is crucial to tackle the challenges of climate change and ensure a safer and more sustainable future for all.

One of the most notable challenges is implementing climate change adaptation measures. This is largely attributed to the need for more knowledge about the phenomenon and the low level of education in these communities. Furthermore, the limited presence of external organizations committed to developing long-term productive and sustainable projects also acts as a constraining factor. As a result, the vulnerability of these communities to climate change is closely linked to their adaptive capacity and the effectiveness of implemented measures, which, in turn, depends on the optimal development of their livelihood activities and subsistence strategies.

Regarding community assets, these communities possess valuable assets in terms of social, natural, and human capital. However, it is essential to recognize that these assets must be fully strengthened and exhibit weaknesses that hinder realizing their full potential. Factors such as limited access to information, low participation of the younger population, and the limited presence of public authorities and organizations focused on productive projects contribute to weakening the less robust capitals, including built, political, financial, and cultural capitals. This situation underscores the need to strengthen these aspects to achieve greater resilience to climate change.

The relationship between status and cultural capital is complex, and its management can be both a strength and an obstacle. Changes over time, especially concerning traditional practices and current needs, can generate tensions among the adult generations. In this regard, finding a balance between traditional practices and new practices adapted to the

demands of climate change becomes crucial while always preserving the cultural capital of these communities.

Regarding the fundamental needs of the communities, despite an overall satisfaction level ranging from "Acceptable" to "Good Satisfaction," some areas require additional attention. The lack of access to technical information to acquire specialized knowledge, the precariousness of housing infrastructure, limited access to roads, and the low quality or absence of public services are areas demanding improvements. This highlights the importance of supporting these communities regarding access to technical resources and basic infrastructure development.

Finally, it is heartening to observe the empowerment of these communities in their relationships of trust and the increased participation of both genders, including women's involvement in leadership positions. This contributes to reducing inequalities and strengthens community cohesion. The active participation of women in leadership roles is particularly relevant in rural environments, where traditional gender norms often limit women's access to decision-making spaces. These communities promote diversity and inclusion in local governance by breaking down these barriers. This not only reduces gender inequalities but also enriches the collective perspective and wisdom in decision-making, which can be especially beneficial in the context of climate change, where various approaches are required to address challenges.

In summary, these findings not only underscore the importance of gender inclusion in climate change adaptation but also indicate that these communities are on the right path toward building long-term resilience. Strengthening community assets and active and equitable participation of all members is crucial for addressing ongoing climate challenges. This solid foundation promises a more sustainable and climate-resilient future in a world where local action plays a vital role in shaping a better future.

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Appendices

Appendix A. Semi-structured interview protocol

Formulario de entrevista para familias sobre los Medios de Vida y Capitales de la Comunidad

Presentación y consentimiento informado:

Mi nombre es Juan Fernando Mendoza Ledezma, estudiante de doctorado de la Universidad de Hamburgo, Alemania, estoy desarrollando mi tesis. Para dicha investigación es necesario recolectar información proveniente de las familias de la zona de estudio.

La idea, forma parte de una investigación que busca conocer mejor sobre el funcionamiento de las comunidades en relación a sus medios de vida, toma de decisiones y acciones frente a los cambios. Los resultados serán socializados y discutidos en talleres grupales comunitarios, procurando definir estrategias que podrían ayudar a tener una mayor preparación frente a fenómenos naturales, en especial con relación al cambio climático.

Me gustaría pedirle permiso para entrevistarle y aclararle algunos aspectos importantes:

- Su participación en esta entrevista es totalmente **voluntaria**
- Si en algún momento **se incomoda y no quiere continuar**, por favor me lo hace saber
- Sus respuestas son **anónimas** (el análisis de resultados es grupal)
- Si desea **alguna explicación adicional** por favor no dude en preguntarme
- Se tomarán notas (o fotos) de nuestra entrevista para no perder la información y poderla analizar, esperamos que esto no le incomode, si le incomoda, por favor me lo hace saber.

Queremos estar seguros de que ha quedado claro el procedimiento de la entrevista y que está participando de manera **voluntaria**.

SECCIÓN II: IDENTIFICACIÓN DE LA ENTREVISTA

- a) Comunidad: _____ Fecha: _____
- b) Nombre del entrevistado: _____
- c) Edad: _____
- d) Sexo: 1. Masculino 2. Femenino
- e) Estado civil: 1. Soltero/a 2. Casado/a 3. Unión libre 4. Divorciado/a 5. Viudo/a

SECCIÓN II: CAPITAL HUMANO. Vamos a hablar un poco de la gente, usted y su familia, la salud, la educación y la población.

1. Composición familiar: Jefe de hogar (1)/ Jefa de hogar (2), hijo o hija (3), etc. (incluyendo el/la entrevistado/a):

Rol Familiar	Edad	Escolaridad	Ocupación	Otras habilidades o actividades

2. ¿Se han capacitado en su familia?: si es así ¿en qué?

Actividades de capacitación	Organizador	¿Quién participó?	¿Cuándo?	¿Qué ha aplicado?

3. ¿Recibe asistencia técnica? ¿Cada cuánto tiempo recibe?
 No recibe cada 2 años Una vez al año Cada 6 meses Cada mes Otro, especifique

4. ¿Qué tan interesados e involucrados están sus hijos en el trabajo que realiza en la casa/finca?
 Nada Poco Algo Bastante Demasiado

5. ¿Cuántos de sus hijos están interesados en mantenerse trabajando en la casa/finca en el futuro?

6. ¿Cuál es el estado de su salud?

	Muy Mala	Mala	Regular	Buena	Muy Buena
Jefe/a del hogar					
Esposa/o					
Hijo 1					
Hijo 2					
Otro 1					
Otro 2					

7. ¿Cuáles son las enfermedades más comunes que han afectado a su familia y cuáles son las enfermedades más comunes en la zona?

Enfermedades comunes en la familia	Enfermedades comunes en la zona

SECCIÓN II: CAPITAL SOCIAL. Ahora hablemos de las relaciones entre la gente dentro de la comunidad y las organizaciones presentes en la zona (sean gubernamentales, no gubernamentales, comunitarias o privadas), que trabajen por el bienestar de la gente y la conservación de los recursos.

8. ¿Cree usted que su comunidad es un lugar tranquilo para vivir? Si ____ No ____
 ¿Por qué? _____

9. De 1 a 3 ¿qué valor le da a la tranquilidad en su comunidad (siendo 1 el valor más bajo- NADA tranquila y 3 el más alto- ES MUY tranquila)

Valor		X
1	Nada Tranquila	
2	Más o menos Tranquila	
3	Muy Tranquila	

Observaciones: _____

10. ¿Pertenece a alguna organización? Si ____ No ____

¿Cuáles son las organizaciones	¿Pertenece usted o alguien de la	¿Qué lo motiva a participar en la	Beneficios que obtiene (personal	Grado de Efectividad (Nada,

comunitarias? (marcar la más importante)	familia? (¿quién?)	organización?	es P – familiares F – comunidad C	Poco, Efectivo)

11. De 1 a 5 ¿qué valor le da al nivel de organización de su comunidad?:

Valor		X
1	Nada Organizada	
2	Poco Organizada	
3	Más o menos Organizada	
4	Muy Organizada	
5	Totalmente Organizada	

Observaciones: _____

12. Presencia de organizaciones e Instituciones externas (Cívicas: C, religiosas: R, políticas: P; ONG: O empresa privada: E, etc.)- Existen organizaciones e Instituciones que se dediquen a fomentar el manejo sostenible de recursos naturales.

Organización o Instituciones	Actividades que realizan	¿Quién participa?

13. De 1 a 4 que tan importante es la presencia de organizaciones o instituciones externas en su comunidad.

Valor		X
1	Nada	
2	Poco Importante	
3	Importante	
4	Muy Importante	

14. Actividades comunitarias:

¿Qué actividades han realizado de manera comunal o colectiva?	¿Cómo lo organizaron?	¿Qué otras actividades propondría para que se realicen?

Observaciones: _____

15. ¿Tiene acceso a información que le permite hacer cambios o mejoras en su casa/finca por amigos, vecinos o grupos organizados?

Nada Poco Regular Bastante Demasiado

16. ¿Recibe dinero o remesas por relaciones con personas u organizaciones fuera de su núcleo familiar (remesas, dineros de negocios o convenios)?

Nada Poco Regular Bastante Demasiado

SECCIÓN III: CAPITAL NATURAL. Analicemos los elementos de la naturaleza que pueden ser aprovechados y que tienen importancia para la biodiversidad, actividad productiva y seres humanos (p.ej. agua, aire, suelo, bosque, biodiversidad, etc.)

17. ¿Cuáles son los recursos naturales con los que cuenta su familia y la comunidad?

Nivel		Recursos Naturales más importantes	¿Por qué?	Observaciones
Familiar	Comunitario			

18. ¿Qué importancia tiene para usted y su familia los recursos naturales?

Nada Poco Bastante Demasiado

19. ¿Sabe cuáles áreas protegidas están cerca de su comunidad? Si _____ No _____
 ¿Cuál? _____

AGUA

20. ¿Cuál es el grado de disponibilidad de agua que tienen para la producción?

Nada Poco Bastante Demasiado

21. ¿Cuál es su opinión en relación con el agua de los ríos, quebradas o pozos de la comunidad?:

CANTIDAD (en valor de 1 a 5)

- Valor**
1 Muy poca
2 Poca
3 Regular
4 Suficiente
5 Abundante

CALIDAD (en valor de 1 a 5)

- Valor**
1 Muy mala
2 Mala
3 Regular
4 Buena

5 Excelente

CONTAMINACIÓN

22. ¿Cuáles actividades productivas en la zona cree que contaminan el ambiente? ¿Por qué?

23. ¿Qué tan contaminada está su comunidad? Califique de 1 a 5

- Valor**
1 Muy Contaminada
2 Contaminada
3 Medianamente contaminada
4 Poco contaminada
5 Nada contaminada

24. ¿Cómo realiza el manejo de los residuos sólidos su familia y en la comunidad ?

25. ¿A dónde van las aguas servidas (negras/grises) de la familia y de la comunidad?:

SECCIÓN IV: CAPITAL CULTURAL. Hablemos un poco de las costumbres, tradiciones y creencias que los identifican como comunidad

26. ¿Hay algo de su comunidad con lo que se siente identificado y feliz?
¿Por qué?:

27. De 1 a 5 ¿cómo califica la felicidad de su familia?.

Valor		X
1	Infeliz	
2	Poco feliz	
3	Más o menos feliz	
4	Feliz	
5	Muy feliz	

28. ¿Qué actividades culturales o (fiestas) celebran todos los años? ¿Cómo y cuándo las hacen?

Actividades	¿Cómo?	¿Cuándo?	¿Quién las organiza?

29. De 1 a 4 ¿qué tan importante es celebrar actividades culturales (o fiestas) en su Comunidad?

Valor		X
1	Nada	
2	Poco importante	
3	Importante	
4	Muy importante	

¿Por qué?

30. ¿Cuáles han sido los principales cambios en los últimos 10 años en la comunidad? ¿Por qué?

31. ¿Aún se mantienen algunas creencias populares en la zona (fiestas religiosas, otras)?

Nada Muy poco Poco Bastante Completamente

32. ¿Qué características hacen diferente a su comunidad de las otras comunidades de la zona?

SECCIÓN V: CAPITAL FÍSICO/CONSTRUIDO. Pensemos un poco en los recursos físicos o construidos en esta comunidad.

33. ¿Qué tipo de transporte es más utilizado en su comunidad?

Bus
Moto
Vehículo Automotor
Caballo
Bicileta
Otro: _____

34. ¿Existe disponibilidad de transporte en la zona?

En caso que sí, la calidad es:

Muy mala Mala Regular Buena Muy buena

35. De 1 a 5 ¿cómo considera que son los servicios de transporte público?

Valor
1 Muy Malo
2 Malo
3 Regular
4 Bueno
5 Excelente

36. ¿Cuál es el estado de las vías de acceso a la comunidad?

Muy mala Mala Regular Buena Muy buena

37. ¿Cuál es el estado de acceso a la electricidad?

Muy mala Mala Regular Buena Muy buena

38. ¿Cuál es el estado de acceso a internet?

Muy mala Mala Regular Buena Muy buena

39. ¿Existe cobertura de telefonía celular?

NO:

SI:

Muy mala Mala Regular Buena Muy buena

40. ¿Existen centros de salud en la comunidad?

1. NO

2. SI ¿Cuántos? _____ Distancia en Km: _____

41. ¿Cuál es el estado de la construcción del centro de salud?

- Muy mala Mala Regular Buena Muy buena
- _____
42. ¿Quién atiende el centro de salud?
Médico Enfermera(o) Auxiliar de Enfermería Otro Nadie
- _____
43. ¿Existen centros educativos en la comunidad?
1. NO
2. SI ¿Cuántos? _____
44. ¿Cuál es el estado de la construcción del centro educativo?
Muy mala Mala Regular Buena Muy buena
- _____
45. ¿La familia tiene acceso a agua potable?
1. NO 2. SI la calidad es: Muy mala Mala Regular Bueno Muy Buena
- _____

SECCIÓN VI: CAPITAL FINANCIERO. Vamos a referirnos ahora a lo que se hace para asegurar la satisfacción de las necesidades básicas.

46. ¿Qué tipo de actividades productivas desarrolla usted y otros miembros de su familia? (marcar la actividad más importante entre las mencionadas)

Actividad Productiva	Marque la más importante	Qué cultivos, animales, etc	Consumo (porcentaje, proporción)	Venta (porcentaje, proporción)
Agricultura				
Ganadería (especies mayores) especies menores (gallinas, cerdos, cabras, etc)				
Forestal				
Huertas				
Otras				

47. ¿Dónde comercializa sus productos? En la comunidad (local): _____
Fuera de la comunidad (regional): _____
Otros (trueques, intercambios, etc.) _____
48. ¿Qué otras actividades productivas tiene usted o algún miembro de la familia?
Comercio (tiendas, pan, comida, etc.)
Ecoturismo Otro (cuál: albañil, carpintería, etc.)
49. Venta de mano de obra ¿usted se emplea como jornalero? SI:
NO:
¿Por qué?
¿Donde?
50. ¿Usted tiene acceso a créditos bancarios?

1. NO
2. SI

51. ¿Cuál es la facilidad para acceder a créditos bancarios?

Muy difícil Difícil Regular Fácil Muy fácil

52. ¿Tiene acceso a subsidios?

1. NO
2. SI

SECCIÓN VII: CAPITAL POLÍTICO. Ahora vamos a referirnos a la toma de decisiones y las organizaciones que cumplen con la función de tomar o facilitar las decisiones.

53. ¿Qué autoridades tienen en su comunidad, cómo son elegidas y cada cuánto?

54. ¿Cuál es su participación en la toma de decisiones de la comunidad? ¿Participan otros miembros de su familia en dichos procesos? Describa el proceso de la toma de decisiones

55. ¿Interviene el gobierno municipal en el desarrollo de la comunidad?

Si es sí de qué forma?: _____

56. ¿Qué tan efectivo es el gobierno local en implementar sus decisiones?

Nada Poco Regular Muy efectivo Excelente

57. ¿Qué tanto los líderes (públicos, políticos, cívicos) de la comunidad se encuentran conectados con organizaciones fuera de la comunidad?

Nada Muy poco Regular Bastante Completamente

58. ¿Sabe si existe una relación entre el Gobierno Nacional y su comunidad? ¿Cuál?

1. NO
2. SI

59. De 1 a 5 ¿cómo califica usted la gestión de las autoridades locales?

- Valor**
- 1 Muy Malo**
 - 2 Malo**
 - 3 Regular**
 - 4 Bueno**
 - 5 Excelente**

¿Por qué?

60. ¿Cuál es la participación de los habitantes en actividades relacionadas al desarrollo comunitario? ¿Quiénes participan? (Marcar con una X)

- Mujeres
- Hombres
- Jóvenes
- Tercera Edad

61. ¿Cuándo existen situaciones difíciles en su comunidad cómo las resuelven?
62. ¿Quién participa en la resolución de esas situaciones difíciles?
63. ¿Con qué frecuencia se dan conflictos en la comunidad? (a diario, semanal, mensual, una vez al año, nunca). ¿Cuáles suelen ser los motivos más frecuentes de los conflictos?
64. ¿Quiénes participan en los conflictos? (Marcar con una X)
- Mujeres
 - Hombres
 - Jóvenes
 - Tercera Edad

Appendix B. Survey climate change perception protocol

INFORMACIÓN SOBRE LA PERCEPCIÓN DE IMPACTOS DEL CAMBIO CLIMÁTICO SOBRE LOS CAPITALES DE LA FAMILIA

1. ¿En los últimos años ha observado cambios en cuanto a clima?

1. NO
2. SI Si ha existido cambios responder la siguiente pregunta.

2. Cambios en:

	Cambios	Si/ No	Más o menos
Temperaturas			
Inundaciones			
Sequías			
Lluvias			
Otros			

3. ¿Cuáles cree son las causas?

Capital Humano

4. ¿En la actualidad existe?

Mas lluvia	Menos lluvia	Hace más calor	Hace menos frío
_____	_____	_____	_____

5. ¿Usted se siente amenazado por la variación del clima?

Nada	Poco	Regular	Bastante	Demasiado
_____	_____	_____	_____	_____

¿Porqué? _____

6. ¿Considera usted que el clima ha afectado la salud de la población?

Nada	Poco	Regular	Bastante	Demasiado
_____	_____	_____	_____	_____

¿Porqué? _____

7. ¿En qué grado los niños han dejado de asistir a la escuela debido al cambio del clima?

Nada Poco Regular Bastante Demasiado

Capital Natural

8. ¿Considera usted que la variación del clima ha afectado la calidad del agua que utiliza para su producción?

Nada Poco Regular Bastante Demasiado

¿Porqué? _____

9. ¿Considera usted que la variación del clima ha afectado la cantidad de agua que utiliza para su producción?

Nada Poco Regular Bastante Demasiado

¿Porqué? _____

10. ¿Considera que la variación del clima ha afectado la calidad del suelo?

Nada Poco Regular Bastante Demasiado

¿Porqué? _____

Capital Físico

11. ¿Considera usted que la variación del clima ha afectado el estado de los caminos y/o carreteras?

Nada Poco Regular Bastante Demasiado

¿Porqué? _____

12. ¿Considera que la variación del clima ha afectado el acceso al agua potable?

Nada Poco Regular Bastante Demasiado

¿Porqué? _____

Capital Financiero

13. ¿Considera que en los últimos años la variación del clima ha afectado el rendimiento de su producción?

Nada Poco Regular Bastante Demasiado

¿Porqué? _____

14. ¿El acceso a créditos se ha visto afectada por la variación del clima?
Nada Poco Regular Bastante Demasiado _____

¿Porqué? _____

15. ¿Sus ahorros familiares se han visto afectados por la variación del clima?
Nada Poco Regular Bastante Demasiado _____

¿Porqué? _____

Capital Social

16. ¿Cuánto la variación del clima ha afectado la presencia de organizaciones en la zona?
Nada Poco Regular Bastante Demasiado _____

¿Porqué? _____

17. ¿Cuánto la variación del clima ha afectado la efectividad de las organizaciones?
Nada Poco Regular Bastante Demasiado _____

¿Porqué? _____

18. ¿Cuánto la variación del clima ha afectado las relaciones en las organizaciones?
Nada Poco Regular Bastante Demasiado _____

¿Porqué? _____

Capital Político

19. ¿En qué grado la efectividad de la implementación de acciones del gobierno local se ve afectado por la variación del clima?
Nada Poco Regular Bastante Demasiado _____

¿Porqué? _____

Capital Cultural

¿Considera usted que por la variación del clima ha tenido que cambiar sus prácticas tradicionales?
 Nada _____ Poco _____ Regular _____ Bastante _____ Demasiado _____

¿Porqué? _____

20. ¿Considera usted que la variación del clima ha afectado las creencias populares de la zona?
 Nada _____ Poco _____ Regular _____ Bastante _____ Demasiado _____

¿Porqué? _____

21. ¿Cree usted que son necesarias actividades de adaptación al cambio climático en relación con sus sistemas productivos y los recursos naturales? Si _____ No _____

Despedida

22. ¿Existen preguntas o dudas que deba aclarar? Si _____ No _____

¿Cuáles? _____

Quiero de nuevo agradecer por el tiempo y las atenciones y sobre todo por permitir conocer un poco de su comunidad.

Nombre del entrevistador: _____

23. OBSERVACIONES GENERALES DE LA ENTREVISTA (entrevistador/ entrevistado)

Appendix C. Gender Productive Activities Checklist

Actividades Productivas de Género						
Medio de Vida	Tipo de Actividad	Actividad	Mujeres	Hombres	Niñas	Niños
Productivo	Agricultura					
	Venta Mano de Obra					
	Servicios					

Reproductivo	Hogar					
	Educación					
	Recreación					
	TOTAL					

Appendix D: Fundamental human needs Checklist

Fundamental Human Needs				
Group	Human Needs	Current Status		
		Women	Men	Others
Basics	Food			
	Health			
	Housing			
	Reproduction			
	Safety			
	Sub-total			
Person	Affection			
	Knowledge			
	Identity			
	Self-esteem and responsibility			
	Sub-total			
Environment	Healthy environment			
	Freedom			
Action	Work			
	Recreation			
	Participation			
	Communication			
	Sub-total			
	TOTAL			
1. Unsatisfied 2. Partially unsatisfied 3. Acceptable 4. Good satisfaction 5. Completely satisfied				

Modified from Imbach 2012

Appendix E. Impressions from the field research (Photos)



Landslides, deforestation, and burning in rural communities



Interview, collective mapping workshop, community minga



Exchange of successful experiences,
installation of adaptation
measures (basic weather station, harvesting system for rainwater).





Community tree planting, drone photography for collective mapping

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Ich versichere, dass dieses gebundene Exemplar der Dissertation und das in elektronischer Form eingereichte Dissertationsexemplar (über den Docata-Upload) und das bei der Fakultät (zuständiges Studienbüro bzw. Promotionsbüro Physik) zur Archivierung eingereichte gedruckte gebundene Exemplar der Dissertationsschrift identisch sind.

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Hamburg, November 16, 2023

X 

Juan Fernando Mendoza Ledezma