

Mendoza Ledezma, Juan Fernando

Article

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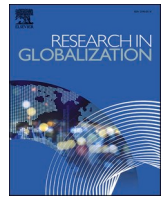
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Rediscovering rural territories: Local perceptions and the benefits of collective mapping for sustainable development in Colombian communities

Juan Fernando Mendoza Ledezma

Working Group Critical Geographies of Global Inequalities, Institute of Geography, Department of Earth System Sciences, University of Hamburg, Bundesstraße 55, 20146 Hamburg, Germany

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ABSTRACT

Territorial analysis contributes to sustainable rural development practices and social action. Based on the qualitative methodological principle in the application of collective mapping, where peasants are the main actors in identifying local realities from a participatory geographic perspective, it is possible to characterize multiple rural realities and their community diversity. Firstly, recent qualitative methodological tools are identified to evaluate the scope of application and level of satisfaction of local actors in a Colombian rural context. Secondly, an explanation of the collective mapping method with communities is addressed for its subsequent application. Finally, local perspectives are examined based on the documentation of sociocultural and environmental components, threats, pollution, and places of interest within the territory that allow for the construction of the visual tool in active community participation workshops. Therefore, the article's purpose is to discuss the benefits of collective mapping as a playful and visual option for the rediscovery of the territory from local perspectives, leading to reflection on the need to create sustainable rural development strategies.

Introduction

Participatory and community mapping is a process that attempts to make visible the links between land and local communities and allows to identify and communicate needs as a way to support social change by using the recognized language of cartography through a tool for deconstructing colonial territory and its power (Cochrane & Corbett, 2018). This method also contribute with comprehension of the social context, capturing what became invisible or imperceptible for both the makers of "official" maps and the local actors; in this sense, participatory diagnoses promote the territory reconstruction using stories and memories to rethinking present and future possibilities of a community (Fenner-Sánchez, et al., 2019).

Therefore, the use of collective mapping as a practical tool to consider space and social relations, power relations, and the actors that shape them is very useful. In this way, focusing on everyday interactions can contribute only through aspects of social processes that other methods cannot access. Furthermore, qualitative research answers very different questions from those addressed by quantitative research; some criticisms directed against qualitative research have sometimes failed to consider this aspect (Barbour, 2014).

The process of collective mapping not only recognizes the material

aspects present in the territory but also can project the feelings, desires, and needs of researchers and the community population. The qualitative sampling plan describes how many methodological instruments, protocols, or information are needed to collect sufficient data to analyze local perceptions and characterize multiple rural realities and community diversity. The key features of qualitative sampling include different situations that capture the perception of various participants to define the information to be collected. The amount of information collected in the communities is appropriate when actors and settings are interested in providing the information needed to identify and understand the dynamics, achieve the aims, and satisfy their needs (Moser & Korstjens, 2018).

Rural areas are multifunctional and often have production, living, and ecological functions, and require a holistic approach to understand its territorial complexity (Li et al., 2022). In this context, a holistic approach means considering and understanding all these dimensions together. It is recognized that the planning, development, or management of these areas cannot be fragmented. Instead, it is necessary to understand how these diverse functions are interconnected and how changes or interventions in one function can have impacts on others. This entails integrating social, economic, and ecological aspects of rural areas, and recognizing the interdependencies and linkages among these

E-mail address: juan.mendoza.ledezma@studium.uni-hamburg.de.

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different aspects. This enables a better understanding of the challenges and opportunities in rural areas to support decision-making and strategies that more effectively address the complex needs and realities of these communities. The Brundtland report of 1987 defines sustainable development as meeting the present generation's requirements while ensuring that future generations are not hindered from meeting their own needs; in a rural context it is important to consider the economic development because inhabitants of rural areas often have limited economic opportunities, so promoting economic development is critical for sustainable development. Additionally, social development in rural areas involves addressing issues such as access to healthcare, education, and social services. Finally, the community engagement requires involve local communities to understand their needs and perspectives. This can include promoting community participation in decision-making processes and supporting local initiatives and organizations. Rural areas playing an essential role in the socioeconomic development process, then sustainable development in rural areas should promote economic, social, and environmental progress while also addressing the unique challenges and opportunities of rural communities (Liu et al., 2010). Rural development have defined as a collection of initiatives aimed at reducing the disparities between urban and rural areas while enhancing the standard of living and financial well-being of rural communities. It appears that promoting rural development is vital in order to improve local conditions (Abreu et al., 2019).

Sustainable rural development presents significant challenges; According to the Food and Agriculture Organization of the United Nations (FAO), it is estimated that approximately 25% of greenhouse gas emissions come from the agricultural sector. However, at the same time, this sector also provides about 50% of the solutions to address global climate challenges. Climate change is also causing the loss of ecosystems and a decrease in biodiversity, which poses a threat to food production and survival (FAO, 2019). It is therefore crucial to implement adaptive measures in forests, soils, water and food systems to reduce emissions and remove atmospheric carbon, while supporting rural communities who are the main food producers and those most affected by the impacts of climate change. Small farms, which form the basis of the global food chain, guarantee food supply and generate income for a large part of the most vulnerable populations on the planet (Bogdanski, 2012). In this regard, it is important to note that a greater impact has been observed in terms of greenhouse gas emissions from industrial agriculture compared to family farming. This further emphasizes the urgent need to look closely at the underlying causes associated with industrial agriculture while urging the promotion of adaptations and emission reductions by the family farming sector (Mizik, 2021). At the same time, Sustainable Ecosystem Management (e.g., ecosystem restoration, avoiding degradation and deforestation, biodiversity management, and sustainable aquaculture), and local/indigenous knowledge can contribute to climate change adaptation processes and sustainable rural development (IPCC, 2022).

This approach uses different qualitative methods of active community participation, with a particular emphasis on collective mapping, to understand behaviors, accessing "embedded" processes by focusing on the context of people's daily lives in which decisions are made and enacted. Therefore, beyond of features or situations content, this work consider agrarian-based economy and how farmers and rural people have to adjust agricultural systems to seek a sustainable rural development. Moreover, 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 and reduce the possibilities to achieve a sustainable rural development (Coutou & Rahmstorf, 2012).

Collective mapping with rural communities and stakeholders allows to create maps and reflect their perceptions, experiences, and knowledge of the socio-environmental conditions, helping to characterize the multiple realities and community diversity that exist within rural areas (Vanwindekens et al., 2013). Subsequently, it is important to analyze

four key points into the sustainable rural development and collective mapping (1) To capture local knowledge about natural resources, land use patterns, and cultural and historical sites to get a more accurate and comprehensive representation of rural areas, (2) To identify community needs and priorities involving stakeholders in the mapping process, it is possible to identify areas of agreement and disagreement about what issues are most important to different groups. This information can be used to planning and decision-making processes, (3) Recognizing cultural and social diversity to represent more equitable and inclusive their own perspectives and experiences on maps, (4) Finally, empowering communities, giving them a voice in the sustainable rural development planning process that affect their lives, and say how the issues are addressed in the decision-making activities.

In this article, I aim to discuss the benefits of the collective mapping tool as a visual option for the rediscovery of the territory from local perspectives using the description of components. I first analyzed the qualitative methodological tools used in recent socio-environmental rural studies to evaluate their application areas and the satisfaction level of local actors. Then, I explained in detail the procedure of the methodological tool to reach the conclusions, with a specific focus on the perception of peasants in obtaining information for the rediscovery of the territory.

Data and methods

Collective mapping – explanation of the method and its implementation: local perspectives on climate change adaptation

The methodological instrument of semi-structured interviews of the community capital framework (CCF) was used in the first instance to compile the initial information to make a diagnosis of the territory, as well as the checklists application and structuring of focus groups for collection of empirical information.

Therefore, the creation of collective mappings was approached to visually describe each village, promote participation, and have a different narrative from the protocols previously implemented in the face of the dynamics of the territory. In addition, the development of collective mapping allowed the identification of shortcomings concerning equity from external actors to the villages, and access to technical resources, starting from the fact that it was not possible to use maps because local institutions do not have them. This highlights the importance of addressing power asymmetries and promoting equity in the uses and access to cartographic information to achieve a more inclusive and participatory approach to territorial planning and management.

In addition, at the socialization time of the project in the two villages, the attendees agreed to participate; however, since not all the inhabitants attended these meetings, the community leaders decided that I would take walks and visit the homes and ask if they wanted to participate in the workshops. Therefore, 20 interviewees per community were selected according to availability; most were people over 40 years old, including men and women with an agricultural vocation and homemakers.

The map as a visual analysis tool allows for evaluation of the territory at a social, subjective, and geographical level; it is the opportunity to socialize knowledge with the active participation of the actors, identifying power relations and interests, promoting imagination and obtaining information for decision making. Therefore, maps, as a didactic tool for analyzing the territory, accompanied by ludic activities, promote debate, exchanges, consensus, and appropriation within an organizational process (Risler & Ares, 2013).

Thus, collective mapping is considered a creative process based on narrative, the use of graphic and visual tools that allow understanding of each experience and knowledge of the participants (Risler & Ares, 2013). According to (Spinelli, 2010) p. 280:

"The idea of the 'plan' is very close to modernity and the subject of Cartesian reason. That idea of plan refers to the future, and therein lies

the trap of the future. The future dehierarchizes the action of the present by placing it in the hands of someone who carries out the plan, which in the end, the plan, who in the end is the one who would end up defining, or so it is believed, the action that the worker will perform. The action that the worker will carry out. The supposed certainty about the future is the greatest weakness of planning since it ignores that certainty belongs to the imaginary. That certainty belongs to the imaginary, and on the contrary, uncertainty is what constitutes the real".

As a result, collective mapping implies strengthening the territory with an integrated vision of social, cultural, economic, environmental, political and physical factors. In this way, better use and defense of the territory are promoted based on implementing the participatory action method with community ownership that strengthens the identification of crucial aspects for developing climate change adaptation measures that align with local interests.

This qualitative tool allows the elaboration of strategies that can be used in rural social struggles, as a group reflection activity, as a tool for local intervention, or to build collective rural visions. Ideally, collective mapping can emerge from a collective creation and learning process through dialogue, generating greater visibility for local interests. These dialogues also generate spaces for silenced experiences, divergent points of view, and the possibility of engaging in a debate around them. Therefore, through the use of this tool, power structures can be identified, turning collective mapping into a powerful option for society and its decision-making so that it can be understood as a tool for diversity from an application with respect and constant reflection on the results (kollektiv orangotango+, 2018).

In this way, collective mapping encourages dialogue and strengthens community cohesion and identity, helps to build governance in the local community framework, both in self-determination, in their organizations, institutions, and regulatory systems, to implement and mobilize different strategies and socio-cultural articulation experiences with which problems concerning expansion and its social impacts are analyzed (Jiménez, 2018).

Method application

The study was developed in two rural communities (Guayabal and Pavitas) in the Cauca department, located in south-western of Colombia (Figs. 1 and 2), with a lowland coastal region, two mountain ranges, and a central valley in the Andes Mountain with abundance of natural resources one of the largest concentrations of indigenous people in Colombia (Instituto CISAIVA, 2003).

Collective mapping was implemented to collect the knowledge and daily experiences of the peasants as a tool for creative dialogue, which promoted participation and visual identification of community characteristics, ending with local reflections related to the provision of guidelines to the actors in the creation of sustainable rural development measures. Moreover, to enhance the understanding of the territory-local perceptions relationship was essential to work with a qualitative perspective analysis, which involved a detailed interpretation of the material collected in the two communities. Therefore, the qualitative information was structured as follows (1) To carry out a historical participatory community diagnosis, (2) To frame the existing environmental impacts, (3) To analyze the application of the collective mapping method and thus make participatory proposals for sustainable rural development measures.

Thus, it is important to mention the need for base maps for dynamics development to apply collective mapping as a qualitative tool. In case failing that, to 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.

However, the satellite images available in the earth satellite systems that were consulted presented cloud cover, which makes the image not a

very accurate representation; additionally, in the points where clouds were not present, the spatial resolution was of low quality and did not allow the identification of the points of interest of the participatory exercise, therefore, in this research collective mapping was based on aerial photographs taken by a drone. The images were taken using a DJI Mini 2 reference drone, piloted by the researcher and with the presence of community leaders who recommended the best sites for the operation. The images were taken in August 2020, in Guayabal and Pavitas, at an altitude of 120 mt (maximum allowed by the Colombian authorities), which limited the capture of the entire study area in a single photograph; therefore, several images were used specifically as a tool for the identification of sites of interest in the development of the collective mapping activity. Some of the images show, for example, the distribution and type of crops (Fig. 3), deforestation areas, and houses (Fig. 4), which were taken for the development of the participatory activity (Fig. 5). Subsequently, street map was used as a base map to cover the entire study area for each community.

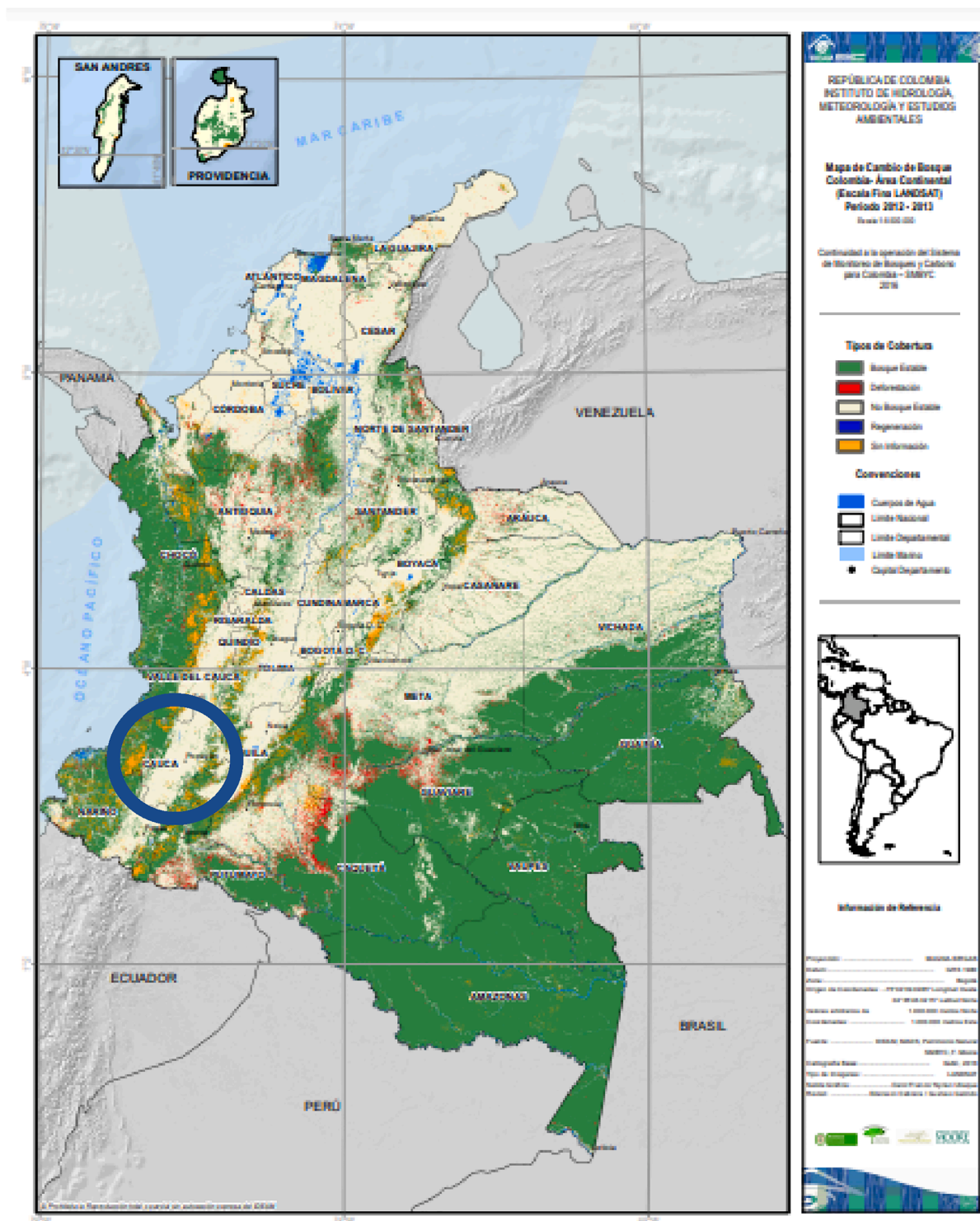
The collective mapping method was implemented as a dialogue tool to have a historical description of each village. The participating social groups in each village were represented mainly by the adult population, with a minority of young people, most of the participating population were indigenous, represented by 55% men and 45% women. The total number of men and women was almost equal. It became a playful instrument that motivated the population's participation. During the two-collective mapping development, 17 people participated in the first village, and 11 in the second, people between the ages of 16 and 70, all inhabitants of the place, including farmers, homemakers, merchants, and leaders with good satisfaction in the development of the method. With the help of the method, a process could be initiated to jointly reflect on 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 Fig. 6 consisted first of the groups' organization, then a brief members presentation 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 proceeded to locate icons in aerial photographs to socialize later; the work was carried out; this led to an identification of differences between the mappings, note-taking, response to concerns, and closure of the activity with the finished map.

As it is a visual tool, Fig. 7 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.

These icons served as visual tools for the participants in the collective mapping workshop to identify and represent clearly and concisely the different elements in each of the components mentioned. By using the icons, communication and understanding of the information gathered was facilitated, allowing for greater participation and involvement of the participants in the elaboration of the collective map. In addition, it helped to visualize in an integrated manner the socio-cultural, environmental, contamination, places of interest and threats in the territory, which was fundamental for the subsequent analysis and identification of adaptation strategies (Table 1).

In this context, to capture local information through participation, a sampling method of voluntary participants, expert sampling and convenience sampling were used to analyze and deepen the research in the crucial development of participatory community workshops using *collective maps* as a dialogue tool (Hernández et al., 2010).



Cauca Department - Study area

Fig. 1. Study area – Cauca, Colombia.

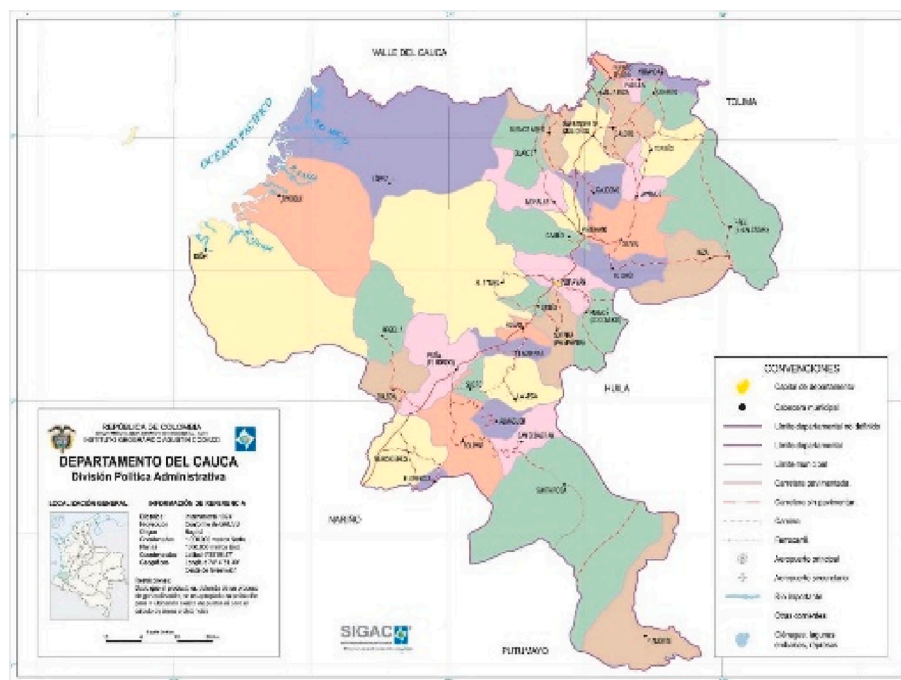


Fig. 2. Cauca department. Source: Instituto Geográfico Agustín Codazzi.



Fig. 3. Drone capture of crop distribution.



Fig. 4. Drone capture deforestation areas.



Fig. 5. Collective mapping using drone like base map.

Results

Participatory mapping was a powerful tool for promoting sustainable rural development in the two villages, as it can help to ensure that development efforts are rooted in local knowledge and perspectives. It was important to involve local people in the process of mapping, to gain a better understanding of the local environment, resources, and infrastructure, as well as the needs and priorities of the people who live there. This help to ensure that development efforts are tailored to the specific needs of the community and are designed in a way that is sustainable over the long term.

Moreover, participatory mapping also helped to promote social inclusion, by giving marginalized groups a voice in the planning and decision-making process because not just the leaders took part from the participatory activity. By involving these groups in the mapping process, they were able to become more aware of their territory and the components and play a more active role in shaping their own future.

Thus, empowerment played a crucial role in promoting sustainable rural development within the communities of Guayabal and Pavitas. It involved enabling individuals and communities to recognize and utilize their strengths, resources, and local knowledge to address challenges and shape their development pathways.

The unique knowledge and perspectives held by community members in Guayabal and Pavitas, stemming from their close connection

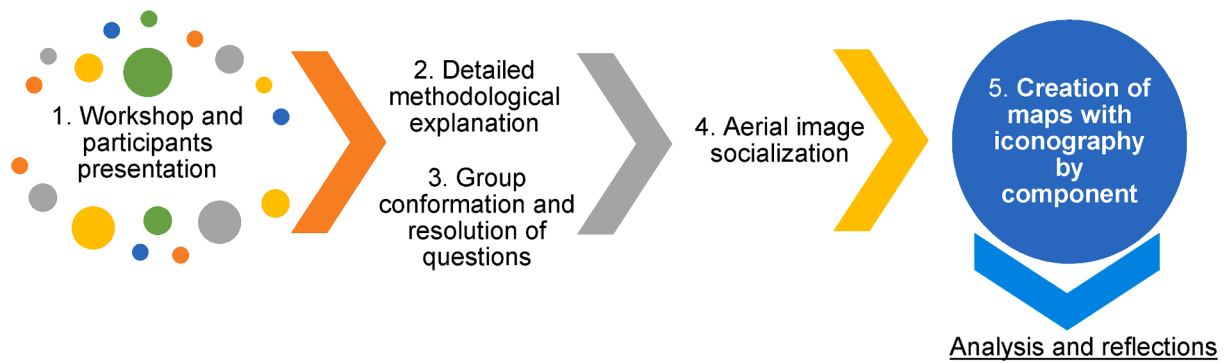


Fig. 6. Collective mapping process.

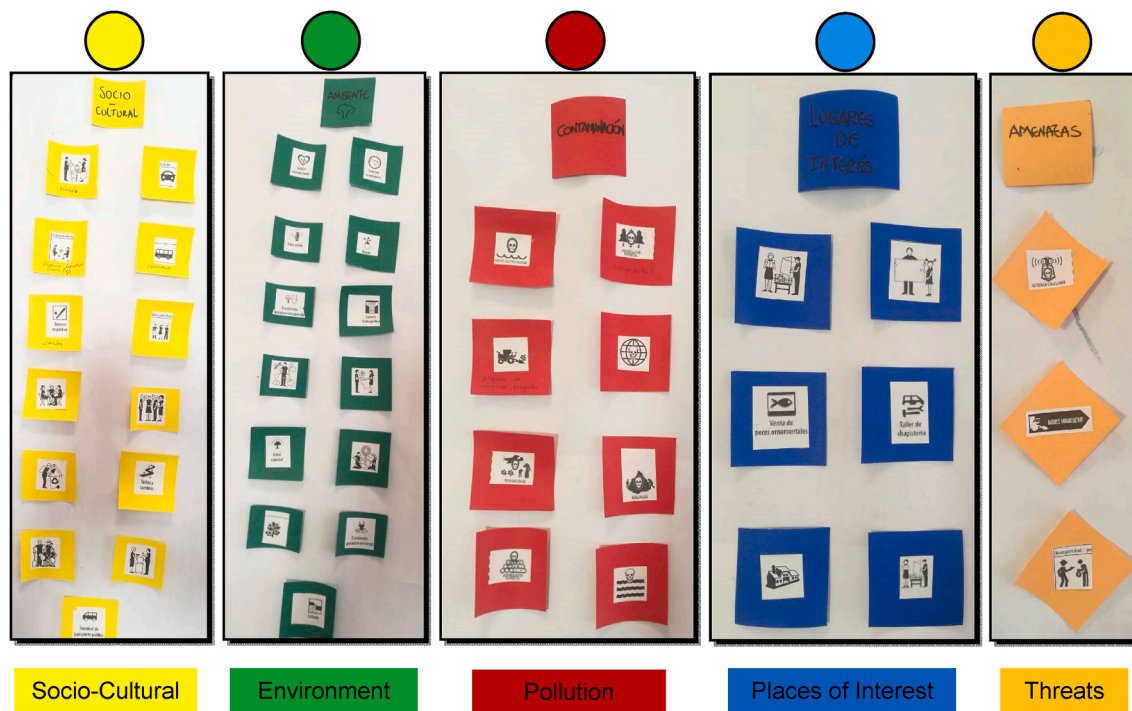


Fig. 7. Collective mapping components.

Table 1
Components and icons explanation.

Component	Icon	Aim
Socio-cultural		Represent aspects related to the social and cultural life of the community, such as festivities, traditions, customs and organization.
Environment		Identify elements of the natural environment, such as rivers, mountains, trees and other elements that contribute to the ecological balance.
Pollution		Highlight sources of pollution or negative impacts on the environment, such as garbage dumps, toxic waste or areas with environmental deterioration.
Places of interest		Point out places of importance to the community, such as schools, meeting centers, churches or recreational spaces.
Threats		Identify potential hazards or risks affecting the community, such as landslides, floods, droughts or security problems.

with the local environment, culture, and socio-economic dynamics, were valued and incorporated in the empowerment process. This allowed for the identification of context-specific solutions to

environmental degradation, resource management, and socio-economic inequalities.

Through empowerment, the communities gained a sense of ownership and agency over their development processes. They actively participated in decision-making, planning, and implementation, ensuring that their voices were heard and their needs were considered. The participatory approach acknowledged community members as experts of their own context, respecting and valuing their knowledge and perspectives.

Therefore, empowerment also facilitated capacity building and skill development, equipping individuals with the tools and knowledge needed for active engagement in sustainable rural development initiatives.

Furthermore, empowerment in these communities fostered social cohesion and collective action. By strengthening social networks and promoting community solidarity, empowerment enhanced their ability to tackle common challenges, mobilize resources, and implement sustainable development initiatives collaboratively.

In summary, it became evident that collective mapping can be an efficient tool to promote sustainable rural development because that development efforts are rooted in local knowledge and perspectives, and

by promoting social inclusion and empowerment.

Components analysis

Internally in the two villages, from the five mapping components (Socio-Cultural, Environment, Pollution, Places of interest, and Threats), the one related to the Socio-cultural theme also helped to identify that inclusion is strengthened with the community activities implementation and maintaining their traditional practices. It becomes a key factor for the achievement of internal goals.

In the case of the first village, the socio-cultural 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. In the second village, many participants also identified socio-cultural conditions, followed by environmental factors and places of interest. However, within the exercise of identifying daily experiences, the component of threats was not widely identified.

According to the five components, socio-cultural through organizational structures and celebrating their traditions were the factors most quickly and easily identified by the participants. The environment component with the wealth of water and environmental conservation is the most important factor for the two communities. However, despite considering the environmental topic as one of the most representative ones, there is evidence of environmental impacts (Pollution) such as lack of water treatment, inadequate solid waste management, deforestation, mining, and excessive use of agrochemicals. In addition, the lack of participation and the loss of traditional practices is evidence of weaknesses in the social and cultural component.

Thus, there is a relationship between the identified impacts and sustainable rural development, specifically, with the lack of water treatment, because of the increase in rainfall, water sources contain more sediment and turbidity, with a growing risk of wastewater overflow, and an evident worsening of water quality, in addition to the implications for public health and economic losses. In relation to solid waste management, it is a practice that has been developed for years in rural communities, due to cultural traditions, but also due to the lack of intervention of government programs that promote the optimal management of solid waste; this is reflected in the burning, burying or open-air disposal of waste in rural areas, being contributors as generators of environmental impacts. In addition, the practice of illegal mining involves deforestation, water and soil contamination, making them less productive and requiring the use of agrochemicals in greater proportions. Finally, a growing body of research indicates that in tropical countries, lack of water treatment and deforestation are reducing the possibilities to achieve a sustainable rural development (Wolff et al., 2021). Thus, impact assessments are necessary to seek the sustainable rural development with a participatory identification process.

Additionally, variables of greater and lesser interest were identified based on the results collected in each village through a collective mapping application. The results of the graphic representation using word clouds in Figs. 8 and 9 lead to identifying that the life experience of the participants has a positive impact on their lives, as it allows them to project themselves as autonomous and empowered subjects. In addition, the importance of the natural resources and ecosystem services offered by the nature reserve is evident, with the high availability of water resources, which promotes agricultural and livestock practices.

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. In addition, 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 satisfaction of basic needs, which makes these people subjects of permanent vulnerabilities.



Fig. 8. Word cloud main interests – 1st Village.



Fig. 9. Word cloud main interests – 2nd Village.

Collective mapping design-results

After the method explanation, resolution of concerns, and materials preparation, the collective mapping was constructed, resulting in the following observations. First, in community No.1, Figs. 11 and 12 show a distribution of the five components throughout the territory, surprising the inhabitants, who thought most of their activities took place around the school. In this analysis, the socio-cultural component is the most identified, 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, as well as an unequal distribution of resources and the presence of 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, so it is still fundamental for the community. In addition, the nature reserve is home to a diversity of fauna and flora species, which contributes to the richness and ecological value of the area. 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, there were points of forest damage that they did not know about, which were observed in the aerial photographs and the collective mapping.

On the other hand, the environmental component is located throughout the community since it is located in the area of influence of a

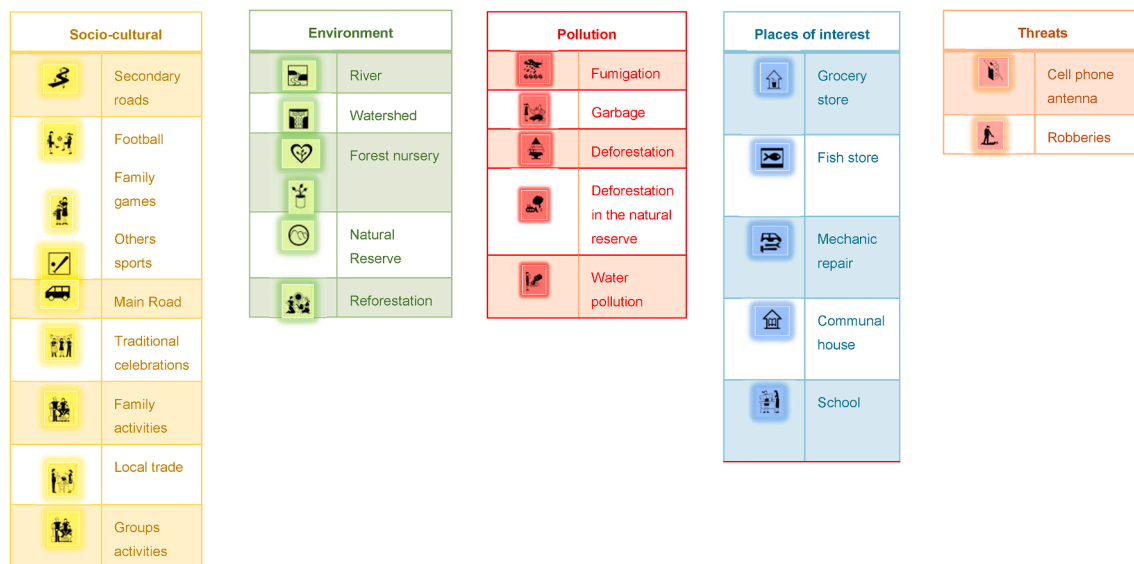


Fig. 10. Components identified in the map-Guayabal.

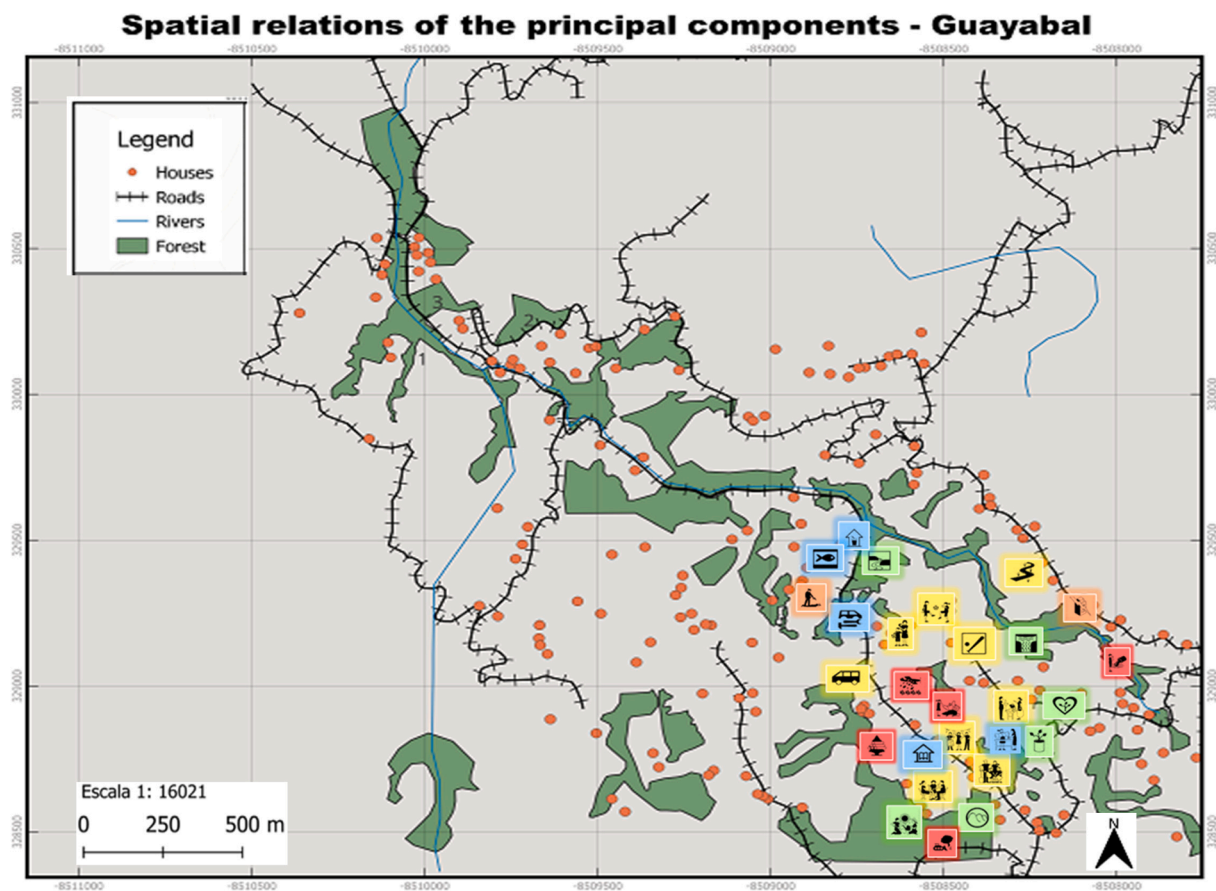


Fig. 11. Mapping components-community No. 1.

natural reserve; the primary resources are the forest, water, and the production of vegetable material. Finally, about pollution, there is a clear idea that they have problems with water contamination and deforestation; however, there were points of forest damage that they did not know about, which were observed in the aerial photographs and were located in the collective mapping. There are few threats, but the community has suffered robberies, and a cell phone antenna is also

considered a threat due to its constant exposure.

In the socio-cultural component, there are family gathering places, soccer fields, traditional celebrations and local markets. These places are distributed in various sectors of the village, but given the size of the village, 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.

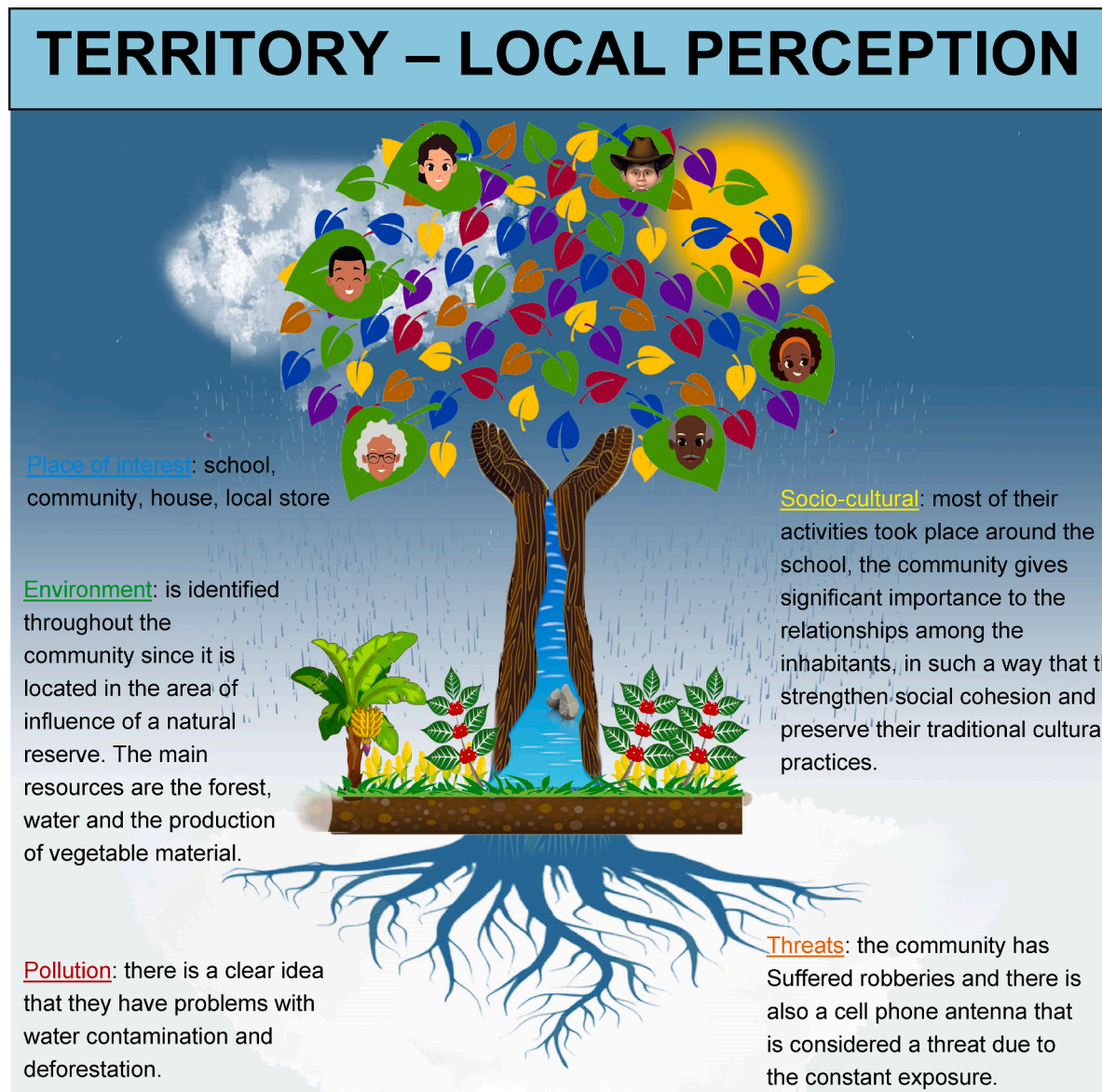


Fig. 12. Collective mapping result-community No. 1.

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.

On the other hand, 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 component includes stores, workshops, community houses and schools. These spaces are fundamental for the economic and educational development of the community, as well as for the promotion of 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 have an impact

on 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 faced by certain people or sectors. For example, those who rely heavily on natural resources may be more vulnerable to environmental impacts, while 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.

The legend of the map in the collective mapping identified the following components: socio-cultural, environment, pollution, places of interest, and threats. The socio-cultural component represented cultural diversity, traditions, and community practices. The environment component encompassed the description of natural resources, such as rivers, forests, and protected areas. The pollution component referred to the identification and mapping of sources of pollution, such as garbage dumps or factories. Places of interest included the location of significant

places for the community, such as community centers or recreational spaces. Lastly, the threats component sought to identify and map potential threats to the community, such as landslides or flood-prone areas. These components of the map legend allowed for a comprehensive and detailed visual representation of the socio-environmental reality of the community, facilitating the identification and understanding of relevant aspects for decision-making and sustainable development (Figs. 10 and 13).

Community No. 1

The collective mapping results in community No. 2, Figs. 14 and 15 illustrate that the activities distribution in this territory is concentrated in a specific area, without the total community area occupation. The socio-cultural component is the most identified during the exercise, mainly sports activities, traditional festivals, and community meetings to discuss issues of general interest. In addition, the places of interest are the community hall, the cemetery, the school, and the food purchase house. And to a lesser extent, they identified the mountain zone, rivers, and agroecosystems as key environmental components for their community in terms of conservation and development. However, they are being affected by water contamination and deforestation and threatened by monocultures that reduce diversity in production, leading to community struggles.

These locally perceived factors, such as the reduction in agricultural production diversity due to the prevalence of monocultures, can have significant consequences for communities and trigger community struggles. Monocultures, focusing on a single large-scale crop, limit the variety of agricultural products available, thereby reducing the resilience of local food systems. Dependence on a single crop increases communities' vulnerability to adverse climatic events, pests, and diseases, as well as fluctuations in prices and market demand.

This decrease in agricultural production diversity can lead to tensions and community struggles. Communities dependent on monocultures face increased competition for limited resources, as intensive agricultural practices can deplete soils and water, affecting resource availability for the entire community. Moreover, the concentration of land and resources in the hands of a few actors can generate economic and social inequalities, which may lead to conflicts and tensions in rural communities.

However, many communities identify mountainous areas, rivers, and agroecosystems as key environmental components for their community in terms of conservation and development. These elements are recognized as essential resources for maintaining biodiversity, ecosystem services, and community livelihoods. By valuing and protecting these environmental components, communities can promote sustainable and diversified agricultural practices that preserve biodiversity and enhance local food security.

Regarding the identified key environmental components such as the

Munchique reserve area, water sources, and agroecosystems, a close interrelation between natural capital and cultural capital is evident. 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 the preservation of 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 present in the Pavitas community to address the challenges of climate change and vulnerability. On one hand, it is crucial to promote community participation and inclusive decision-making, and benefit from social and political capital to drive collective actions in favor of environmental conservation and sustainable development.

The identification of mountainous areas, rivers, and agroecosystems as key components reinforces the importance of promoting agricultural development approaches that integrate the conservation of natural resources and the well-being of local communities. This entails promoting the adoption of agroecological practices, supporting diversified production systems, and fostering community participation in decision-making processes related to the use and management of agricultural and environmental resources. By doing so, it is possible to drive more sustainable and resilient agricultural production while strengthening bonds and community cohesion around conservation and development.

Overall, these findings underscore the intricate dynamics within the community, highlighting the importance of the identified components such as the school, community center, and natural resources. Community awareness of environmental problems and the presence of illegal armed groups highlights the need for effective interventions by the government and the scientific community to address these issues and promote sustainable development while ensuring the safety and well-being of community members.

The findings of the research in community No. 2 identify several key components. First, the community is located in the zone of influence of a nature reserve, which underlines its importance in terms of environmental conservation and biodiversity. The main resources highlighted by the community are forest, water, and the production of plant material. This indicates the community's dependence on natural resources for their sustenance and livelihoods.

Furthermore, the research reveals that the school plays a central role in the community's activities. The community places considerable importance on the relationships among its inhabitants, recognizing the

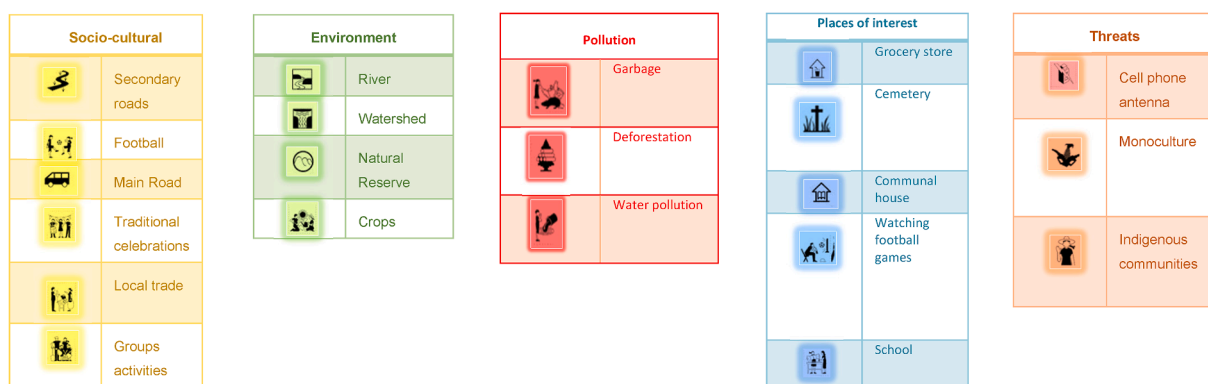


Fig. 13. Components identified in the map-Pavitas.

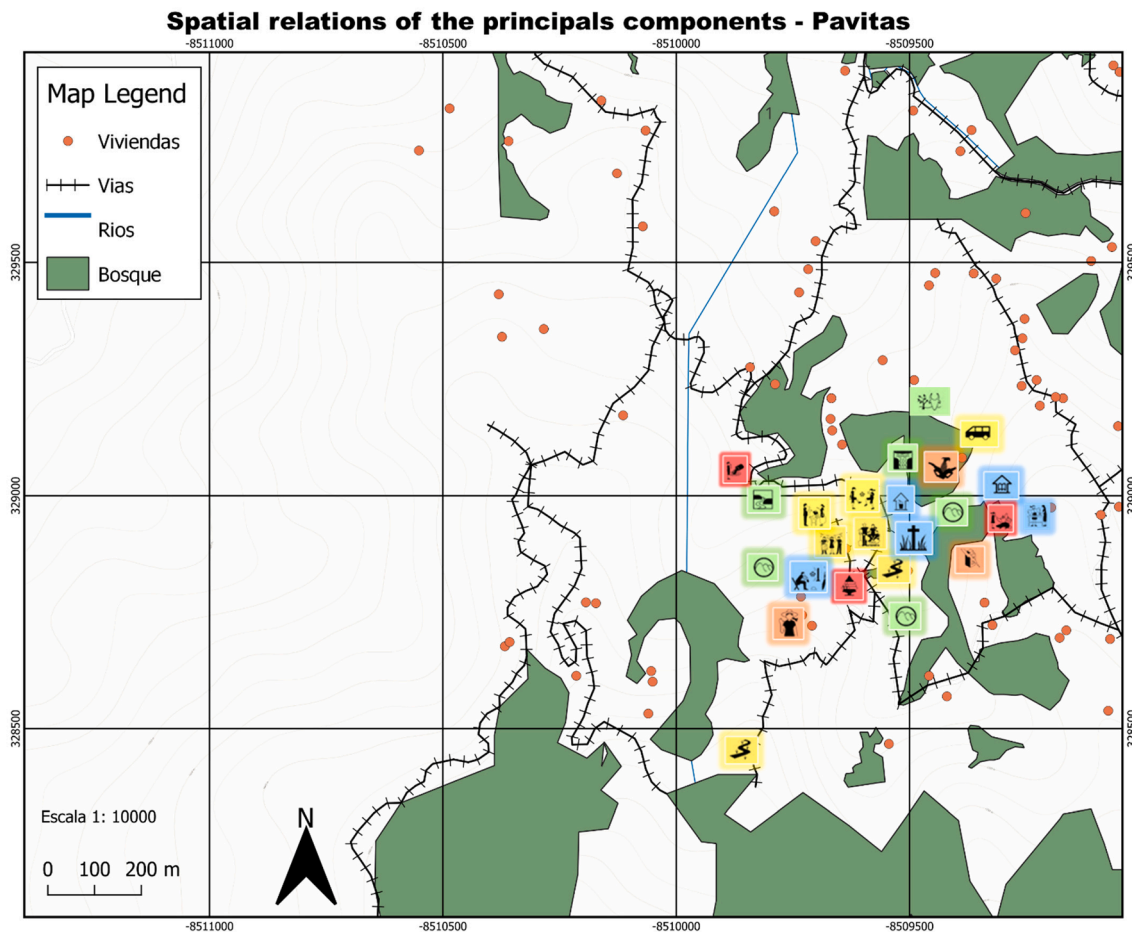


Fig. 14. Mapping components-community No. 2.

role of social cohesion in preserving their traditional cultural practices. This emphasis on social connections indicates a strong sense of community identity and the importance of maintaining cultural heritage.

However, the research also highlights some challenges faced by the community. The community has experienced incidents of theft, which has impacted their sense of security and well-being. Additionally, the presence of a cell phone antenna is perceived as a threat due to concerns about constant exposure. These factors contribute to a sense of vulnerability within the community.

Moreover, there is a clear recognition among community members of issues related to water contamination and deforestation. This awareness demonstrates an understanding of the environmental challenges faced by the community and reflects their concern for the preservation of natural resources.

Overall, these findings shed light on the complex dynamics within the community, highlighting both its strengths in terms of cultural preservation and social cohesion, as well as the challenges it faces in terms of security, environmental degradation, and the potential health risks associated with technological infrastructure. Understanding these components is crucial for developing effective interventions by the state and the climate change adaptation strategies that address the community's needs and promote sustainable development.

Community No. 2

The analysis of sustainable development and its relationship with the communities of Guayabal and Pavitas in the context of collective mapping and rural development revealed a series of crucial aspects that contributed to forging a path towards a more sustainable and resilient

future. Collective mapping, as a participatory process for visually representing socio-environmental components and community needs, served as a valuable tool for planning and decision-making geared towards sustainable development.

Through collective mapping, the communities of Guayabal and Pavitas were able to gain a better understanding of their socio-environmental reality. This process allowed them to identify and map natural resources, community spaces, areas of cultural interest, environmental threats, and other relevant features of their surroundings. By having a visual representation of these elements, the communities developed a heightened awareness of available resources, existing needs, and potential actions to promote more equitable and sustainable development.

Furthermore, the collective mapping process shed light on the pressing issues of pollution and the lack of support from public institutions in addressing these challenges. The communities identified pollution sources, such as water pollution from improper waste disposal and deforestation for timber, which directly impacted their environment and livelihoods. Additionally, they expressed frustration over the inadequate support and assistance received from public institutions in tackling these problems effectively.

In the realm of rural development, collective mapping emerged as a key tool for addressing the intertwined social, economic, and environmental dimensions. It helped identify community needs in terms of infrastructure, access to basic services, economic opportunities, and natural resource conservation. Additionally, collective mapping facilitated the identification of synergies and potential conflicts among different activities and stakeholders in the territory, leading to more efficient and equitable planning processes.

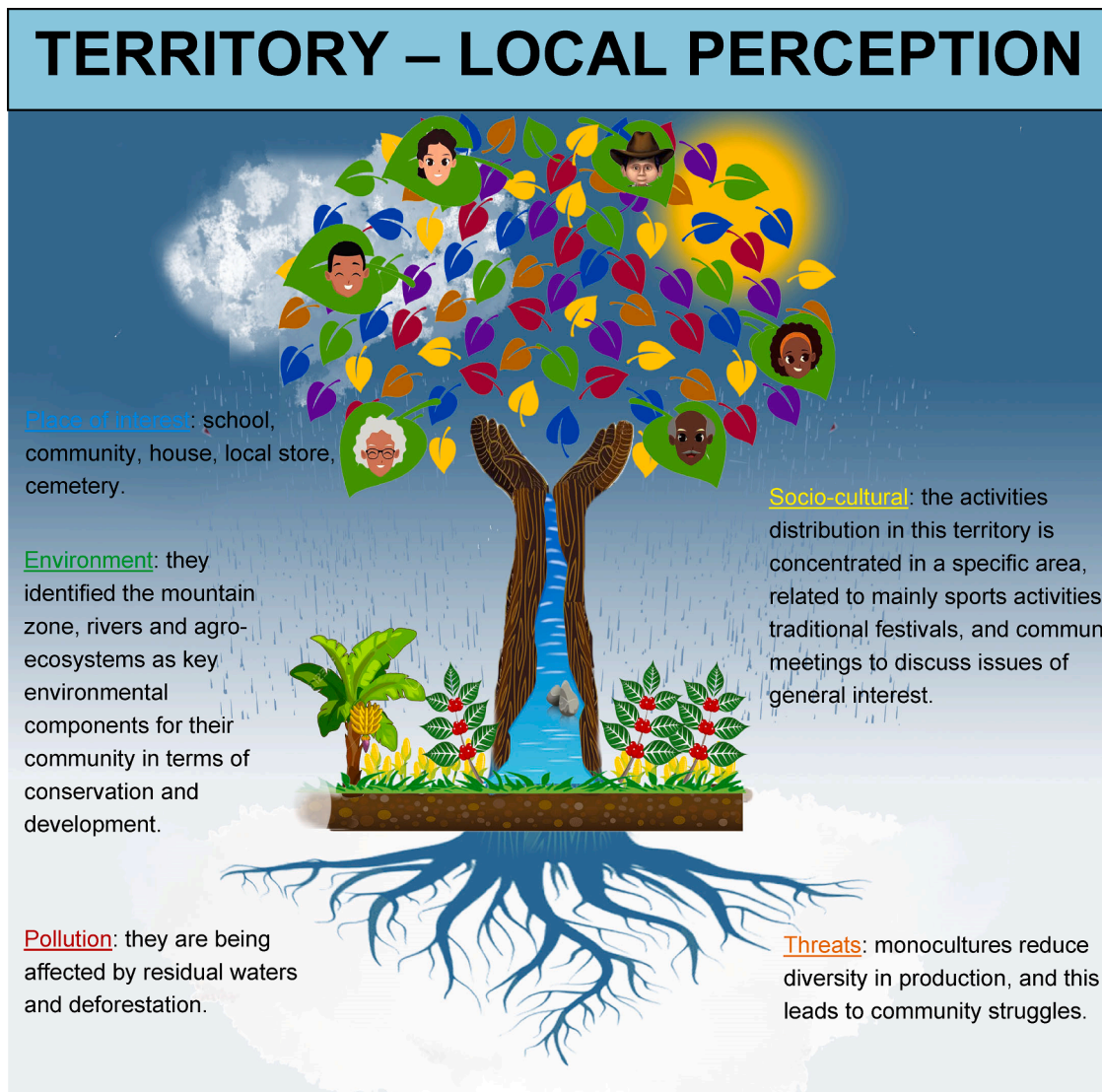


Fig. 15. Collective mapping result-community No. 2.

Collective mapping also fostered community resilience in the face of environmental challenges and threats. By identifying and mapping natural hazards such as floods, droughts, or landslides, the communities were able to develop adaptation and mitigation strategies. Furthermore, collective mapping served as a monitoring and tracking tool for environmental changes over time, enabling the assessment of the impact of implemented actions and adjustment of strategies as needed.

Discussion

The literature review allows the exploration through documentary research; a total of 55 documents were identified from searches in databases. The selection of scientific articles was carried out through the Scopus tool, prioritizing 2 general themes: Social Sciences (1.1 Geography, Planning and Development, 1.2 General Social Sciences, 1.3 Gender Studies, 1.4 Development), 2. Environmental Sciences (2.1 General Environmental Sciences, 2.2 Global and Planetary Change, 2.3 Management, Monitoring, Policy and Law), selecting the search with subtopics to give more focus within the bibliographic review. Scientific articles were searched in journals indexed using Science Direct and Google Scholar according to the variables chosen for the analysis of methodologies applied in relation to adaptation to climate change in rural areas. Out of the 55 scientific articles examined, a total of 33

qualitative methodological tools were identified, specifically chosen due to their recurring presence across multiple articles. These tools were selected based on the observation that several methods were repeated across different scientific studies, indicating their significance and relevance in the field of climate change adaptation in rural areas. The review primarily focused on the methodological section of the selected articles, aiming to understand the functionality, operability, and effectiveness of these commonly used tools in each of the studies where they were implemented. According to the articles consulted, different studies have been developed using qualitative methods in the rural sector (Table 2).

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). Historically, participatory mapping has sought to create an enabling environment for public participation, beyond the use of software and hardware, seeking access to relevant information, analysis of complex data, as well as ways to solve problems (Barndt, 1998). In the face of sustainable rural development and its socioeconomic impacts, the decision-making process has been associated with many uncertainties and complexities (Mehryar & Surminski, 2022). Moreover,

Table 2
Qualitative methods identified.

Method	Research Title	Author
Anthropological Analysis	What does it mean to be poor? Investigating the qualitative-quantitative divide in Mozambique	Sam Jones and Inge Tvedten (2019)
Brainstorming	Transformative social innovation for sustainable rural development: An analytical framework to assist community-based initiatives	Karina Castro-Arce, Frank Vanclay (2020)
Choice Experiments	Confronting Tradeoffs Between Agricultural Ecosystem Services and Adaptation to Climate Change in Mali	Kurt B. Waldman, Robert B. Richardson (2018)
Classification of means of adaptation/inventory	What does it mean to be poor? Investigating the qualitative-quantitative	Sam Jones and Inge Tvedten (2019)
Collective mapping	Geo-grafías comunitarias. Mapeo Comunitario y Cartografías Sociales: procesos creativos, pedagógicos, de intervención y acompañamiento comunitario para la gestión social de los territorios	Jiménez, D. (2018)
Community Capitals	Does social capital matter in climate change adaptation? A lesson from agricultural sector in Yogyakarta, Indonesia	Saptutningsih et al., (2020).
	Spatial associations between household and community livelihood capitals in rural territories: An example from the Mahanadi Delta, India	Tristan Berchoux, Craig W. Hutton (2019)
	Agricultural shocks and drivers of livelihood precariousness across Indian rural communities	Berchoux & Hutton (2019)
Conference attendance	Policy Diffusion in the Rural Sanitation Sector: Lessons from Community-Led Total Sanitation (CLTS)	Zuin et al. (2019)
Document analysis	Rural social enterprises as embedded intermediaries: The innovative power of connecting rural communities with supra-regional networks	Ralph Richter (2019)
Ecosystem services approach	Effects of industrial plantations on ecosystem services and livelihoods: Perspectives of rural communities in China	D. D'Amato et al., (2017)
	A place-based approach to payments for ecosystem services	M.S. Reed et al., (2017)
Ethnographic Approach	Traditional agricultural knowledge in land management: the potential contributions of ethnographic research to climate change adaptation in India, Bangladesh, Nepal, and Pakistan	M.G Rivera et al., (2021)
	Using Narrative Research to Explore the Welcoming of Newcomer Immigrants: A Methodological Reflection on a Community-Based Research Project	Glynis George & Erwin Dimitri Selimos (2018)
Expert opinion	Assessment of selected climate change adaptation measures for coastal areas	Audrey Baills et al., (2020)
Focus groups	Knowledge and passive adaptation to climate change:	Amarnath Tripathi, Ashok K. Mishra (2017)

Table 2 (continued)

Method	Research Title	Author
	An example from Indian farmers	
	Role of community based local institution for climate change adaptation in the Teesta riverine area of Bangladesh	Md. Rezaul Karim, Andreas Thiel (2017)
	The place and voice of local people, culture, and traditions: A catalyst for ecotourism development in rural communities in Ghana	Dickson Adom (2019)
	Resource mobilization for community-managed rural water systems: Evidence from Ghana, Kenya, and Zambia	Nikki L. Behnke et al., (2017)
Fundamental basic needs	Medios de Vida Adaptativos: Una Propuesta para Fortalecer la Capacidad Adaptativa	Natalia Ruiz-Guevara et. al, (2018)
Knowledge Exchange Workshops	Decentralization of Forest Management, Local Institutional Capacity, and Its Effect on Access of Local People to Forest Resources	Mahdi, G. Shivakoti, M. Inoue (2017)
	An institutional analysis to address climate change adaptation in Tenerife (Canary Islands)	
Literature Review	What does it mean to be poor? Investigating the qualitative-quantitative	Sam Jones and Inge Tvedten (2019)
Livelihoods	Análisis de vulnerabilidad social y ambiental ante el cambio climático de la comunidad indígena Cabécar, Grano de Oro, Turrialba, Costa Rica	Gutierrez et al., (2016)
Mapping	Decentralization of Forest Management, Local Institutional Capacity, and Its Effect on Access of Local People to Forest Resources	Mahdi, G. Shivakoti, M. Inoue (2017)
	An institutional analysis to address climate change adaptation in Tenerife (Canary Islands)	Yeray Hernandez et al., (2018)
	Social Mapping in the Context of a Community-build Day: Strategy to Strengthen Links with Community in a Small Rural School	Odet Moliner et al., (2017)
Multi-criteria qualitative analysis	Multi-criteria decision making methods to address rural land allocation problems: A systematic review	Sintayehu Legesse Gebre et al., (2021)
Participant Observation processes	Participant Observation in Migration Studies: An Overview and Some Emerging Issues	Paolo Boccagni & Mieke Schrooten (2018)
Participating Research Action	Social Mapping in the Context of a Community-build Day: Strategy	Odet Moliner et al., (2017)
Participatory Photography Workshop	Social Mapping in the Context of a Community-build Day: Strategy	Odet Moliner et al., (2017)
Participatory Rural Appraisal	Social Mapping in the Context of a Community-build Day: Strategy	Odet Moliner et al., (2017)
Participatory Social Diagnosis	Social Mapping in the Context of a Community-build Day: Strategy	Odet Moliner et al., (2017)
Participatory Workshop	Social Mapping in the Context of a Community-build Day: Strategy to Strengthen Links with Community in a Small Rural School	Odet Moliner et al., (2017)

(continued on next page)

Table 2 (continued)

Method	Research Title	Author
Rapid Rural Appraisal	To what extent is climate change adaptation a novel challenge for agricultural modellers?	R.P. Kipling et al., (2019)
Semi Structured Interviews	The adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana	Majeed Abdul-Razak, Sylvia Kruse (2017)
Social indicators	Motivations and decisive factors in women's entrepreneurship. A gender perspective in education and professional guidance	Magdalena Suárez-Ortega, Rocío Gálvez-García (2017)
	The adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana	Majeed Abdul-Razak, Sylvia Kruse (2017)
Surveys	The adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana	Majeed Abdul-Razak, Sylvia Kruse (2017)
Triangulation	The adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana	Majeed Abdul-Razak, Sylvia Kruse (2017)
Weather data	Assessing farmers' perceptions about climate change: A double-hurdle approach	Patrick Hitayezu et al., (2017)
Word Counter	Citizens' preferences for tackling climate change. Quantitative and qualitative analyses of their freely formulated solutions	Endre Tvinnereim et al., (2017)

community participation in the use of participatory mapping tools has clear potential to generate benefits for capacity-building, and management and planning initiatives by the communities (McCall & Dunn, 2012).

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). Collective mapping in its applications in community development 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).

According to (Haklay, 2013) and (McCall & Dunn, 2012), equity is related to power asymmetries in the uses and access to maps. In their study "Neogeography and the delusion of democratization" (Haklay, 2013), they discuss how geospatial technologies can generate the illusion of democratization, but, there are inequalities in the access and control of cartographic information. On the other hand, the article "Geo-information tools for participatory spatial planning: Fulfilling the criteria for 'good' governance?" analyzes how geo-information tools can contribute to participatory spatial planning, but also reveals disparities in access to technical resources and the role of local institutions in the availability of maps.

Hence, granting more power to the communities of Guayabal and Pavitas would entail recognizing and amplifying their agency, voice, and decision-making authority in matters concerning their own development. This power should be granted upon the community members themselves, as they possess the local knowledge, perspectives, and expertise necessary to address the unique challenges and opportunities they face.

The purpose of this power is to ensure that the communities have a

genuine influence in shaping their own future and achieving sustainable rural development. By granting them decision-making power, they can actively participate in determining the direction of development initiatives, prioritize their needs and aspirations, and mobilize resources accordingly. This power allows them to take ownership of their development processes and fosters a sense of empowerment, self-determination, and autonomy.

The concept of power in this context is multifaceted. It encompasses the power through collective mapping to make informed decisions, the power to allocate resources, and the power to shape policies and programs that directly affect the communities' well-being. It also includes the power to challenge and transform existing structures and systems that perpetuate inequalities and marginalization.

The relationship between empowering these communities and existing or proposed public policies that benefit them is crucial. Empowerment aligns with the principles of participatory and inclusive governance, where communities are recognized as key stakeholders in decision-making processes. By giving communities more power, public policies can be designed and implemented in a way that genuinely addresses their needs, promotes their interests, and ensures equitable distribution of resources and opportunities.

Furthermore, empowering these communities can complement and reinforce existing public policies aimed at sustainable rural development. By incorporating local knowledge and perspectives, policies can be tailored to the specific context, promoting environmental stewardship, social cohesion, and economic resilience. Empowerment can enhance the effectiveness and sustainability of these policies by fostering community ownership, engagement, and accountability.

In this context, the creation of collective cartographies to visualize and describe each village was addressed, with the purpose of fostering participation and presenting a different narrative to previous approaches in relation to territorial dynamics. In addition, the development of collective mapping allowed identifying gaps in terms of equity in access to technical resources by actors external to the villages, considering that local institutions lacked available maps.

On the other hand, the *collective mapping* implementation in the sustainable rural development process in the framework of conditions of poverty, lack of basic facilities, and environmental problems to identify risk situations it is important for the participatory planning process (Busayo et al., 2019). Furthermore, to define local structures, social relations and dynamics using these visual and ludic tools to strengthen discussion and decision-making in community management from a qualitative emphasis (Mahdi et al., 2017).

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. The absence of maps in local institutions, for example, reveals a lack of 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 inclusion within the communities. 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, the reliance on visual representations may not fully capture the complexities and nuances of certain issues or perspectives. It is crucial to complement the mapping process with in-depth qualitative data and dialogues 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 both 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.

According to (Paneque-Gálvez et al., 2017) and (Colloredo-Mansfeld et al., 2020) the use of drones has brought various benefits in participatory studies conducted in rural communities. These investigations have demonstrated that drone technology provides a powerful tool for participatory mapping, enabling communities to access and utilize geospatial information effectively, showcasing how drones can be used as a tool to map their agricultural knowledge and monitor their territories. These communities have been able to accurately document and visualize their natural resources, cultural sites, and areas crucial for their sustenance. The use of drones has allowed them to gather and exchange detailed and up-to-date information, strengthening their local knowledge and capacity to advocate for the protection and sustainable management of their lands and decision-making.

In the two communities analyzed, empowerment can be understood as the process by which individuals and communities gain a sense of control, agency, and decision-making power over their own lives and territories. The use of drone technology played a significant role in fostering this empowerment. Participants recognized that drones provided them with valuable tools to gather accurate and timely geospatial data, allowing them to better understand and address environmental issues, particularly deforestation. Through participatory studies and engagement with drone technology, community members were able to reflect upon their own circumstances, take ownership of the challenges they faced, and actively participate in decision-making processes aimed at promoting sustainable practices and protecting their natural resources. This empowerment process enabled them to become agents of change in their communities and take proactive measures to address environmental concerns.

In the communities of Pavitas and Guayabal, it is important to note that the use of drones as a tool for empowerment does not imply that it will single-handedly solve all the challenges they face. While drones have proven to be valuable in gathering geospatial data and enhancing community engagement, they are not a panacea for all the issues affecting these communities. Empowerment goes beyond the technological aspect and requires comprehensive approaches that address social, economic, and cultural dimensions. Drones serve as a facilitator, providing valuable data and insights that inform their actions, but they are just one tool among many in the larger framework of empowerment.

Workshop participants expressed concern about the impacts of deforestation on their communities and the environment. They stressed the importance of understanding the underlying causes and identifying those responsible for deforestation. Some participants noted that it was not only the local community that was involved in deforestation practices, but external actors with illegal logging operations. This raised questions about the role of government institutions, both at the local and national levels, in controlling and regulating activities that contribute to deforestation.

The workshops raised reflections on the need for collaborative efforts between communities, government agencies and other stakeholders to address deforestation. Participants stressed the importance of community-led initiatives and the role of local knowledge in developing sustainable solutions. They called for stronger enforcement of regulations and policies, as well as the inclusion of communities in decision-making processes related to land management and natural resource protection.

Overall, participatory studies using drone technology fostered a

deeper understanding of the complexities surrounding deforestation and its impacts on rural communities. The discussions provided a platform for participants to raise concerns, express their perspectives and propose strategies to mitigate deforestation. The involvement of community members in these discussions highlighted the importance of their voices and agency in shaping policies and actions that promote sustainable rural development.

The utilization of drones has significantly enhanced the generation of precise and up-to-date geospatial data, thereby providing rural communities with valuable insights into their territories. This data serves as a foundation for well-informed decision-making processes, enabling these communities to effectively address crucial challenges such as land management, resource conservation, and sustainable development. Moreover, the participatory nature of drone research has fostered heightened community engagement and active involvement in data collection and analysis. Through their direct participation in mapping activities, local residents have developed a sense of ownership and agency regarding their knowledge and territories. This participatory approach not only reinforces social cohesion and community resilience but also promotes a collective sense of responsibility towards sustainable development.

Furthermore, the use of drones has played a pivotal role in bridging information and communication technology (ICT) gaps prevalent in rural areas. Conventional mapping methods often face limitations or are inaccessible within these regions, impeding communities' access to accurate and timely geospatial information. Consequently, the integration of drone technology provides a cost-effective and efficient alternative, empowering communities to surmount such barriers and obtain crucial data necessary for informed decision-making.

Through qualitative methods such as interviews, focus groups, and participatory observation, these tools enable researchers to engage directly with community members and gather their unique insights. Local perceptions are invaluable in identifying the specific challenges and opportunities related to sustainable development and climate change adaptation in Colombian communities. By exploring these perceptions, researchers can gain a deeper understanding of how the community experiences and interprets environmental changes, resource management, and socio-economic dynamics.

Moreover, the use of collective mapping as a participatory method within these qualitative tools further enhances the importance of community engagement and empowerment. Collective mapping involves involving community members in the mapping process, allowing them to spatially represent their knowledge, resources, and vulnerabilities. This collaborative approach enables the community to actively contribute their understanding of their own territory, fostering a sense of ownership and agency in decision-making processes.

By integrating participatory methods using collective mapping, researchers can harness the power of local knowledge, enhancing the relevance and effectiveness of sustainable development initiatives. The active involvement of community members ensures that their voices are heard and their priorities are taken into account. Additionally, collective mapping facilitates the identification of local resources, traditional practices, and potential solutions that can contribute to sustainable development and socio-environmental action.

Sustainable development processes in rural territories are essential for the optimal development of local livelihoods and their components, considering that productive activities are generating significant impacts on small producers in developing countries (Dhakal et al., 2022). Therefore, the analysis of local knowledge provides the skills to understand the environment and identify the changes in the territory over time, allowing them to develop different strategies and thus adapt to new conditions (Adger et al., 2007). Therefore, local knowledge is valid as a strategy (Tengö et al., 2014) and can be complemented with scientific support as an integrative method for reducing vulnerability to environmental impacts (Salite, 2019; Tengö et al., 2014).

For the 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 territory mainly through the effects generated on their production systems, i.e., there is already a relationship between lack of water treatment, deforestation, inadequate solid waste management, agrochemical and pesticide overuse, illegal mining 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 these environmental impacts and seek sustainable rural development.

The current study presents the local perception in a sustainable rural development context. It is important to take into account the social, cultural, economic, environmental, political, and physical components according to local perceptions in order to promote sustainable development that meets the needs of the community.

Local perceptions of social dynamics can influence the success of rural development efforts, as community members may have different priorities and values that need to be taken into account. In the cultural component the perception from peasants can influence development efforts, as traditional practices may need to be considered in order to ensure that development is culturally appropriate and respectful. In connection with economic perceptions, opportunities and challenges can help guide development efforts, as economic development strategies need to be tailored to the specific needs of the community. Furthermore, environment can also influence development efforts, as environmental sustainability is important for the long-term well-being of the community because of the optimal management of natural resources. And finally, political, and physical components can take part in the different ideas about who should be involved in decision-making and how decisions should be made, and about what types of infrastructure and services are needed.

Therefore, this study has revealed the challenges and opportunities for sustainable development in the communities of Guayabal and Pavitas. The underlying causes, dynamic pressures, and concrete solutions identified through collective mapping point to the need to address the lack of economic resources, weak infrastructure, limited education, and climate change. It is emphasized that implementing these potential solutions is crucial. These solutions include strengthening education and training through educational programs that address the specific needs of the communities, including training in sustainable agricultural techniques, natural resource management, and entrepreneurship development. Additionally, promoting environmental education to raise awareness about the importance of conservation of natural resources. Improving infrastructure by investing in the enhancement of basic infrastructure such as roads, water services, and electricity to improve the quality of life for residents and facilitate access to essential services. Furthermore, promoting economic diversification by supporting economic diversification initiatives that allow communities to reduce their dependence on a single economic activity, such as agriculture. This may include promoting sustainable tourism activities, supporting local crafts, and fostering small businesses and community enterprises. Finally, strengthening local governance is key, where active community participation in decision-making and natural resource management is encouraged. This involves strengthening community organizations such as community action boards and promoting gender equity in decision-making processes. Therefore, the challenges and lessons learned from this study highlight the importance of integrated and participatory approaches in the planning and implementation of sustainable development initiatives.

In summary, local perceptions of the social, cultural, economic, environmental, political, and physical components of rural development are important to consider in order to promote sustainable development that meets the needs of the community. By understanding and incorporating these perspectives into development efforts, planners and

policymakers can help ensure that development is responsive to the needs and priorities of the community.

Participants perspectives

As a project implementer, it has been a constant learning process for the local participants and me. This section highlights how collective mapping implementation as a qualitative action-participation tool allows for a better territory understanding and the farmers' perspectives in the understanding, application, and collective mapping analysis.

The use of participatory mapping turned out to be novel for the participants because they have usually worked for hand in hand with local organizations and the accompaniment in tours to take GPS points; however, on this occasion, they felt they were participants in the rediscovery of their territory. Likewise, the use of a drone to photograph the communities, besides being a practical and helpful tool, was striking and generated great expectations to see the result and to have another perspective. They were interested in taking more photographs of their territory and using them to promote their community, as well as input for the application to calls for projects.

It was interesting for the farmers to have a different image; they had not seen the community like this (from the air). Furthermore, the analysis led them to identify unaware situations, such as areas in the nature reserve with environmental deforestation impacts and threat factors of possible landslides, among others.

The teamwork helped to know the territory better, the participants helped each other locate the components, and it was more evident for them to know their problems. Furthermore, they defined collective mapping as a tool that allows working on the solution of negative factors from a fun vision; the mere fact of identifying each house was fascinating, and the use of colored icons promoted an easy understanding of the exercise very clear and playful.

Finally, this activity had active actors' participation; all felt comfortable developing the exercise; they did not consider it so technical since the language used was simple. Moreover, it was considered more like a game or group dynamics that developed without understanding complications. Even stating that "despite seeing that aerial image for the first time, as a farmer I could easily identify my village and the situations that developed in it and guide some colleagues who were not located in the photos."

Moderator perspective

The social cohesion in the communities facilitated teamwork, creating a respectful environment between participants and facilitator, a space in which all participants had the opportunity to give their opinions on the development of the tool. The initial moment of explanation of the methodology was tense because it did not generate enough attention. Still, when words such as drone, aerial photography, maps, and colored icons appeared, the level of attention changed. The concentration of the participants was higher.

Although collective mapping was not part of the project's initial planning, it turned out to be the most attractive method for local actors at the time of data collection. Following the explanation of the methodology, participants quickly chose partners with whom they felt greater empathy at the time of forming the groups. This group creation identified the definitive turning point to give free rein to create the maps. Once the groups were formed, it was asked that the participants each locate their house in the aerial photograph (Fig. 16). It was striking how all the participants surrounded the photographs, and they began to become familiar with the tool, to later proceed with identifying the five components.

In addition, it was interesting to see how a question-answer dynamic was created; when a question arose, the participants themselves resolved them and the intervention as moderator was specific to clarify or keep the order; for example, at some point, the excitement was so



Fig. 16. Identification of key elements with drone photography.

great that it was difficult to maintain the concentration and focus of the activity on the part of the local actors, to the point that some conversations went out of context of the topics to be analyzed and it was necessary to intervene to redirect the activity to the interests initially raised. Finally, when generating a space for discussion and feedback regarding the application of collective mapping as a method of information gathering, one of the participants stated, “they should use this type of activity more; they are more entertaining and easier to understand.”

Conclusions

When analyzing the type of methodologies to be implemented in the communities, it is not enough to characterize the territory through technical diagnostics; but is essential to know the people and their interests. As a facilitator, we must think about the information we want to collect and how it is more pleasant for the main actors to share their local realities.

Regarding the technical maps concerning the collective maps, it is evident that they are intrinsically related. Despite their “complexity” in the technical maps, the actors better know these. Nevertheless, it was easier to create participatory maps through collectivity. However, as developed in the study, these two tools can be worked together, balancing the technical conditions versus the communities’ perception. Moreover, the local perception that only specialized personnel can elaborate maps changed; now, they have the basis for gathering information with alternative methods such as collective mapping that allow them to define physical and social spaces, generating geographic transformation processes.

The communities’ organizational structure allowed the methodology’s successful development, with active participation and generating appropriation by searching for alternatives to rediscover their territory from dynamism and playfulness, which contributed significantly to the generation of clear options for a sustainable rural development.

As a result, the aerial photographs and drone use, the participatory construction of maps, and the rediscovery of the territory, generated spaces for discussion that led the inhabitants to develop strategies for adaptation to minimize environmental impacts, for instance, the need to implement rainwater harvesting systems to reduce the excessive use of the resource and supply the lack of water in times of drought; as well as local communities develop reforestation campaigns with native trees, in the points of deforestation identified in the aerial photographs. In addition, spaces for dialogue are being generated for the implementation of biological pest control systems, organic fertilizer production, and sustainable solid waste management, all components identified in the development of the collective mapping.

Finally, the constitution of a heterogeneous territory is in line with the local historical knowledge and the recognition of community relations, which promote dialogue and allow the creation of bridges between disciplines that increasingly emphasize the importance of qualitative methods in research processes.

CRedit authorship contribution statement

Juan Fernando Mendoza Ledezma: Conceptualization, Methodology, Writing – original draft, Visualization, Investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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