Research Article

Climate perception and adaptability in rural and urban settlements on the Tosagua canton (Manabí - Ecuador)

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1. **Introduction**
2. **Methodology**
   - 2.1. Location
   - 2.2. Diagnosis of climate perception and adaptation in urban and rural communities in the canton of Tosagua.
   - 2.3. Determination of the level of vulnerability and response capacity of urban and rural communities of the canton of Tosagua.
   - 2.4. Adaptation strategies for urban and rural communities in the canton of Tosagua using an ecosystem-based adaptation (EbA) approach.
3. **Results and discussion**
   - 3.1. Analysis of meteorological data
   - 3.2. Overview of climate change
   - 3.3. Participants' perception of the climate
   - 3.4. Determining vulnerability in communities
   - 3.5. Response capacity in urban and rural communities
   - 3.6. Adaptation strategies for urban and rural communities in the canton of Tosagua using an ecosystem-based adaptation (EBA) approach
4. **Conclusions**

Keywords: climate variability; climate change; human settlements; perception; adaptability.

Abstract. *This study evaluates climate change perception and adaptability in the settlements of Tosagua, Manabí, Ecuador, highlighting the region's extreme vulnerability, exacerbated by a lack of risk awareness, shortcomings in territorial planning, and limited adaptive capacity. Using a non-experimental approach encompassing exploratory, descriptive, and analytical methods, climate data from 2014 to 2024 were collected from the National Institute of Meteorology and Hydrology. Four structured surveys were administered to a sample of 398 participants. A vulnerability matrix, considering exposure, sensitivity, and adaptability variables, was used to integrate Ecosystem-Based Adaptation into the proposed local strategies, tailored to urban and rural contexts. The results show that 52% of the population is female, with 27% aged between 20 and 29 years. Ninety-two percent reported being aware of climate change, although only 36% perceived an adaptive capacity. Vulnerability is exacerbated by deficiencies in sanitation (63%), increasing the risk of flooding, identified by 92% of respondents. Adaptation priorities focus on public health (58%) and infrastructure improvement (57%), while nature-based solutions, such as shading, received lower ratings (44%). In conclusion, this indicates an urgent need to strengthen practical education on climate change adaptation and social and structural resilience in the region.*

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1. Introduction

Climate change is one of the main challenges facing governments and nations worldwide (Ferrera & Pérez, 2020). Currently, urban areas are home to nearly 4.2 billion people of the global population; between 2015 and 2020, the urban population increased by more than 397 million people, with more than 90% of

this growth concentrated in less developed regions (Intergovernmental Panel on Climate Change [IPCC], 2022). Therefore, the rapid growth of cities maximizes the effects of climate change in urban areas, increasing their vulnerability, deteriorating the quality of urban life, and aggravating the impacts on the environment as a structural socio-environmental problem (Villalpando & Bustos, 2024).

Extreme weather events have a significant impact on Ecuador, as droughts have affected 66.7% of agricultural areas and 53.7% of livestock areas. On the other hand, extreme rainfall could increase flood-prone areas by 15.9%, directly impacting 49.5% of the population living in these areas (Ministry of Environment, Water, and Ecological Transition [MAATE], 2022). In Manabí, 22% of the territory is exposed to flood threats, affecting approximately 35% of the population living in areas where the threat level is high and 32.6% of the rural area under the jurisdiction of the Provincial GAD (Manabí Development and Land Use Plan [PDOT], 2023).

The impact of climatic events in the canton of Tosagua depends not only on the magnitude of the threat, but also on exposure, risk perception, and the population's capacity to adapt, since, having a relatively small threatened area, these areas are frequently affected due to their location and urban configuration (Provincial Government of Manabí [GPM], 2022). Other factors include topo diversity (75% highlands and 25% lowlands), winter flooding, and periodic agricultural losses, revealing critical vulnerability, exacerbated by low-risk perception and limited community adaptation (Jaramillo K., 2020). In urban areas, on the other hand, lack of drainage, informal expansion, and poor planning intensify the impact of extreme rainfall and river flooding, directly affecting families and homes (Lucas, 2017).

Therefore, the purpose of this study is to analyze climate perception and adaptation in rural and urban settlements in the Tosagua canton, identifying their levels of vulnerability and capacity to respond to adverse weather events, with the aim of designing more effective, sustainable, and inclusive local adaptation strategies that strengthen community resilience and promote informed land-use management in the face of the effects of climate change.

2. Methodology

2. 1. Location

The research was conducted in the canton of Tosagua, located in the province of Manabí, Ecuador, considering its political-administrative division, which includes the cantonal capital of Tosagua and the rural parishes of Bachillero and Ángel Pedro Giler.

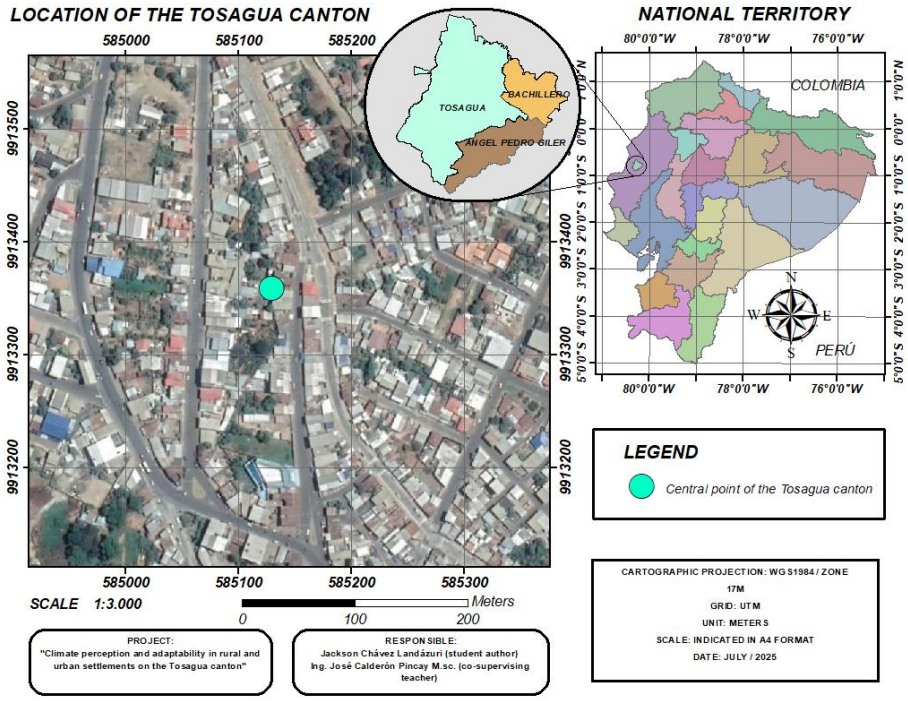

Figure 1. Location of the Tosagua Canton

This analytical, descriptive, non-experimental study (Tipaz & García, 2023; Del Valle & Guerrero, 2022; Sánchez et al., 2021; Veloz, 2019) evaluated data on the impact of climate change in urban and rural areas of the Tosagua canton over a ten-year period (Sandoval et al., 2023; Hernández, 2019; Venegas, 2020). A documentary review was conducted to identify socio-environmental dynamics, followed by structured surveys with closed questions administered to a sample of 385 participants (Chulim et al., 2020), as well as participatory mapping to

analyze the responses of the urban and rural population to climate risks (González & López, 2023; Angulo, 2023).

Secondary climate data from official sources such as the National Institute of Meteorology and Hydrology of Ecuador [INAMHI] and the Ministry of Environment, Water, and Ecological Transition of Ecuador [MAATE] were used to analyze the historical and current climate behavior in Tosagua, as well as its impact on the vulnerability of human settlements (Vega et al., 2020). The variables collected included average temperature, precipitation, seasonal variability, and frequency/intensity of extreme events (floods, droughts, etc.) over the last decade (Bárbara et al., 2019; Tello, 2020).

2.2. Diagnosis of climate perception and adaptation in urban and rural communities in the canton of Tosagua

For the diagnosis, the canton's climate conditions were analyzed, focusing on temperature and precipitation variables (Bermeo & Vázquez, 2022) over a 10-year period (2014-2024), comparing them with data from Ecuador's National Institute of Meteorology and Hydrology (INAMHI) (Kuffó, 2021). To assess climate perception and adaptation in the canton of Tosagua, a 16-question questionnaire was administered covering three key dimensions: recognition of climate change, perceived impacts on the community, and the means by which they access information about the phenomenon (Table 1 – See Appendix A) (Contreras et al., 2019). The surveys were conducted during times of high pedestrian traffic, with the prior authorization of the participants, who responded on a 4-point Likert scale (1: Strongly disagree, 2: Disagree, 3: Agree, 4: Strongly agree) (Cruz & Páramo, 2020; Mendoza & Rodríguez, 2021).

2.3. Determination of the level of vulnerability and response capacity of urban and rural communities in the canton of Tosagua

The level of vulnerability was assessed using a survey of 24 dichotomous questions (Yes/No) (Table 2 – see Appendix B), divided into 14 items on sensitivity, 6 on exposure, and 4 on adaptive capacity (Bohórquez, 2015; Aristizábal et al., 2019; Muñoz, 2021).

The capacity to respond to climate change was measured using a system of 24 indicators detailed in Table 3 (see Appendix C) on a Likert scale (Rosales et al., 2020), with values ranging from 1 to 5, facilitating classification using a traffic light system (Andrade, 2022) as shown in Table 4 (see Appendix D).

2.4. Adaptation strategies for urban and rural communities in the canton of Tosagua using an ecosystem-based adaptation (EBA) approach

A matrix of strategies was developed that encompasses conservation and restoration activities under the Ecosystem-based Adaptation (EbA) approach aimed at strengthening the adaptation process in the urban and rural sectors of the Tosagua canton (Álava & Guerrero, 2021; Angón et al., 2021; Godoy 2017; Valdivieso, 2021; Ariza & Cubi 2020; Hernández, F., 2022).

3. Results and Discussion

3.1. Analysis of meteorological data

The meteorological data record for the period 2014-2024 shows marked stability in thermal variables, such as maximum, minimum, and ambient temperatures, which exhibit moderate interannual variations and relatively constant ranges, typical of a warm climate. However, precipitation shows high variability, with significant increases in specific years such as 2017, 2021, 2023, and 2024, and a low value in 2020, representing the main source of climate variability in the period analyzed, which has relevant implications for environmental, agricultural, and water resource management.

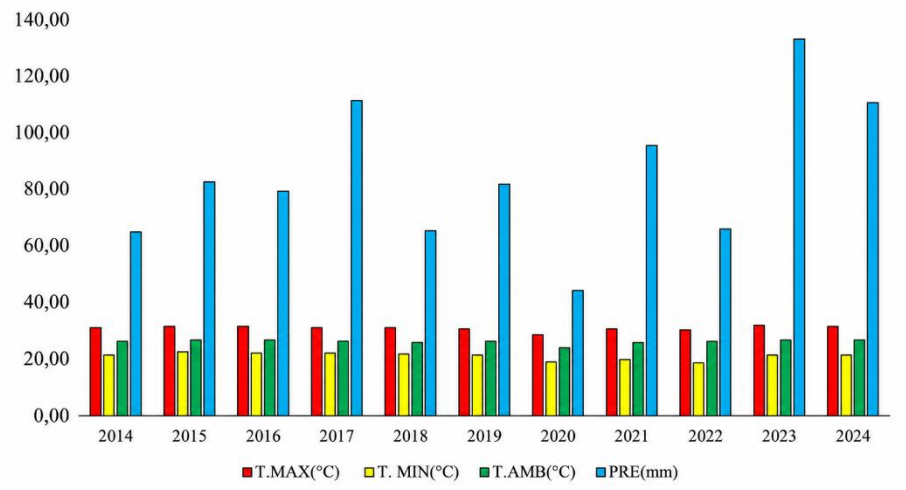

Figure 2. Meteorological data history

The interannual irregularity of rainfall is a defining characteristic of this region, which coincides with studies covering longer periods and highlighting climate variability as an inherent feature (Jaramillo & García, 2020; Meseguer-Ruiz et al., 2022). However, the perception of rural and urban communities corroborates that rainfall has decreased and that the onset of the rainy season has been delayed, forcing changes to agricultural calendars (Delgado et al., 2025). Likewise, there is a widespread perception of an increase in temperatures and a greater sensation of heat, an observation that is consistent with studies such as that by Escandón and Alfaro (2023), which document gradual increases in temperature. On the contrary, the stability observed in thermal variables between the rainy and dry seasons differs from records indicating warming, especially during the rainy season (Carreño, 2020).

3.2. Overview of climate change

The participant profile shows a predominantly young population, with 27% between the ages of 20 and 29. There is a higher female participation rate (52%) and a basic education level of 52%, reflecting a limited educational context. Forty-nine percent of participants are single, consistent with the predominant age, while 32% belong to households with four members, typical of medium-sized households.

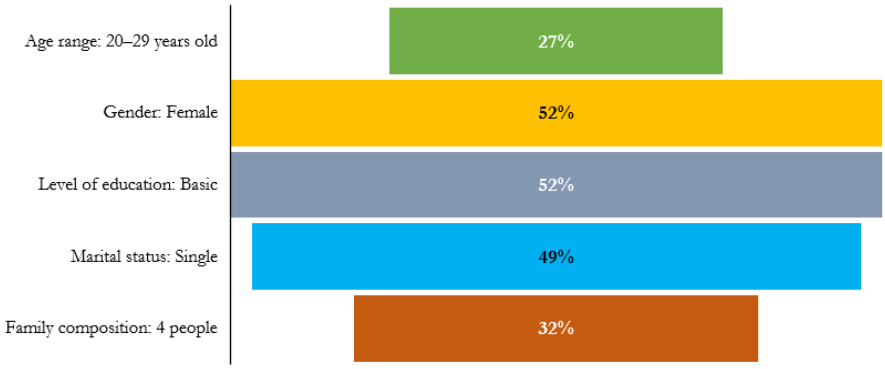

Figure 3. Diagnosis of participants

The results of the sociodemographic characterization obtained are consistent with the findings of Colindres & Bámaca (2022) and Olivares et al. (2012), whose studies show that female participation was higher and that young women have a greater understanding of climate vulnerability and can influence behavioral changes within the family unit. However, the lack of formal education among the population suggests a potential barrier to fully understanding the complex science of climate, despite their lived experiences with environmental change (Logroño & Muñoz, 2020). This demographic profile also indicates greater susceptibility to the impacts of climate change, as women and people with limited education tend to be more vulnerable to environmental changes (Colindres & Bámaca, 2022; Villafuerte et al., 2018).

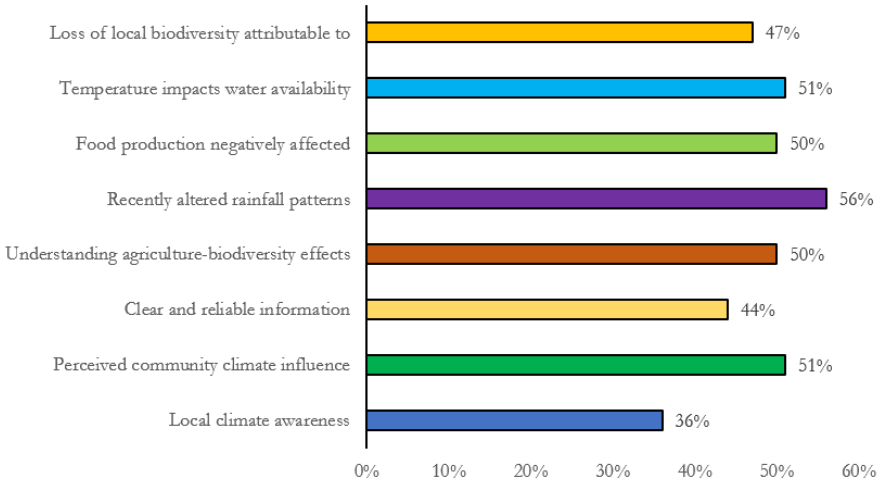

Figure 4. General knowledge about climate change.

There is evidence of moderate awareness of the impacts of climate change at the local level. Changes in rainfall patterns (56%) and the impact of rising temperatures on water availability (51%) are the most widely recognized effects. Similarly, 50% identify negative impacts on food production and understand the relationship between agriculture and biodiversity. However, the loss of local biodiversity (47%) and access to clear and reliable information (44%) are at intermediate levels, while local climate awareness (36%) is low. These results highlight the need to strengthen community climate education and awareness.

The perception of changes in rainfall patterns and rising temperatures, recognized by 90% of respondents, coincides with the results of González et al. (2017), whose research in indigenous communities reports an appreciation of significant climate changes, such as decreased rainfall and increased frost. This is consistent with the studies by Forero et al. (2014) and Luna et al. (2021), whose results present scientific projections that anticipate greater climate variability and extreme events. However, this perception does not always translate into a deep understanding of the underlying causes or long-term implications of climate change, as terms are often used incorrectly and without clarity about their sources and consequences (Gutiérrez et al., 2021). For example, indigenous communities in Guatemala have stated that the impact of climate change has been evident in a reduction in soil moisture, affecting the availability of water for crops and livestock (Forero et al., 2014).

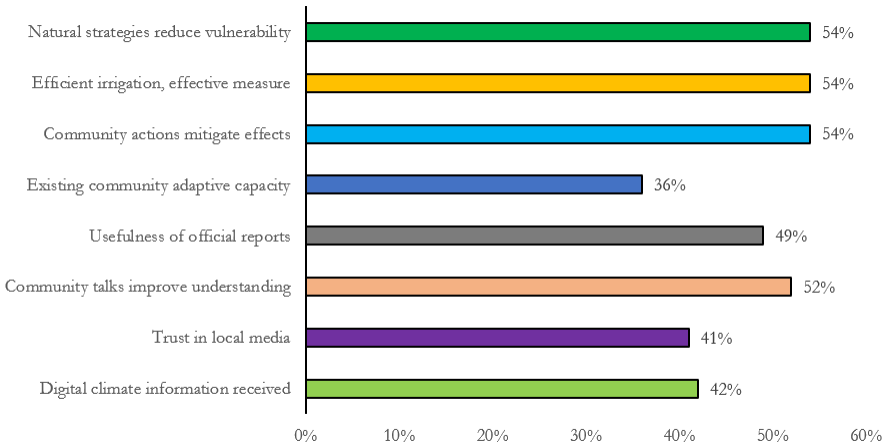

Figure 5. Community environmental awareness

The analysis shows a positive assessment of adaptation strategies, with 54% recognizing the effectiveness of nature-based strategies, efficient irrigation, and community actions to reduce climate vulnerability. However, existing community adaptive capacity is perceived as low (36%), which highlights limitations in its practical application. Likewise, community talks (52%) and official reports (49%) are considered relevant sources of information, while trust in local media (41%) and digital climate information (42%) are at moderate levels, highlighting the need to strengthen communication channels and local capacities.

The positive assessment of nature-based adaptation strategies and efficient irrigation as practices for climate resilience is consistent with the findings of Barbara et al. (2019). On the other hand, the low perception of community adaptive capacity highlights a significant gap between the theoretical recognition of these strategies and their effective implementation in practice (Chimi et al., 2025). However, communities' direct experience with extreme weather events, such as prolonged droughts or heavy rains, often encourages the adoption of adaptive measures and the creation of community gardens, even without a formal understanding of climate science (Colindres & Bámaca, 2022).

3.3. Participants' perception of the climate

Public perception reveals high recognition of climate change as a global and local phenomenon (92%), as well as concern about its effects on water supply (77%) and infrastructure (72%). There is marked confidence in community resilience strategies (89%). However, there is a significant gap between this global awareness and understanding of the impacts on local ecosystems (51%), and a moderate assessment of the role of protected areas in the territories (69%). This suggests a need to strengthen communication about the connections between climate change, local environmental degradation, and nature-based solutions.

The high perception of climate change as a global and local phenomenon, along with concern about water supply and infrastructure, is consistent with studies indicating growing public awareness of climate risks (Cruz & Páramo, 2020). However, this awareness often coexists with a limited understanding of specific local ecological impacts and the critical role of conservation efforts (Casanova et al., 2018); (Weibel, 2021). Nevertheless, the disconnect between general concern about climate change and low valuation of protected areas suggests a need for more effective communication that explicitly links the health of local ecosystems to climate impact mitigation and water security (Alrhmoun et al., 2025). Furthermore, research consistently highlights that while people recognize global climate change, their perception of local impacts can vary, influenced by factors such as community organizations and access to information (Núñez & Carmona, 2023). This discrepancy highlights a critical challenge in translating general climate awareness into concrete support for localized conservation initiatives, particularly in regions where direct experiences of climate impacts are less pronounced (Nash et al., 2019).

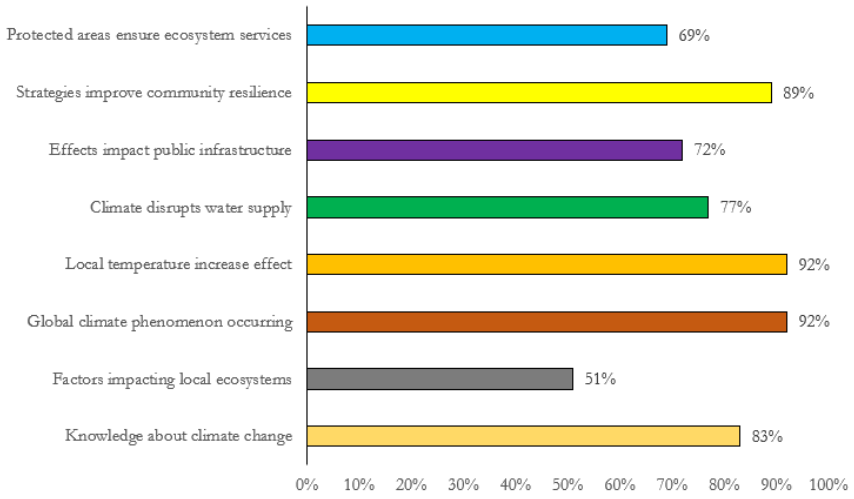

Figure 6. Community environmental perception.

3.4. Determining vulnerability in communities

The perception reveals a community that almost unanimously experiences the effects of local climate change, with 97% noticing an increase in temperature and 94% noticing an increase in rainfall. There is high coverage of basic household services such as water, electricity, and waste collection (97-98%), but critical gaps are identified in sanitation (sewerage - 63%) and green spaces (68%). The combination of perceived heavy rainfall and poor drainage infrastructure represents a systemic risk that contributes to flooding, while the scarcity of green spaces exacerbates vulnerability to heat, highlighting the need to prioritize investments in green infrastructure focused on resilient sanitation with nature-based solutions.

The perception of the local effects of climate change, such as rising temperatures and precipitation, is consistent with findings in other regions, where vulnerable populations recognize the interconnection between global warming, extreme weather events, and their direct consequences (Gutiérrez, 2020). However, this awareness does not always translate into a deep understanding of the underlying causes or effective mitigation and adaptation strategies, highlighting the gap between the perception of the problem and the understanding of its solutions

(Torres et al., 2021). Therefore, concerted action is needed to improve environmental education and the dissemination of information on practical adaptation measures that empower communities (Sandoval et al., 2023). Furthermore, the discrepancy between local perceptions of extreme events and official meteorological data underscores the importance of integrating local knowledge and community perspectives into the design of adaptation strategies and climate policies, recognizing that lived experiences may differ from technical measurements (Abril & Infante, 2022).

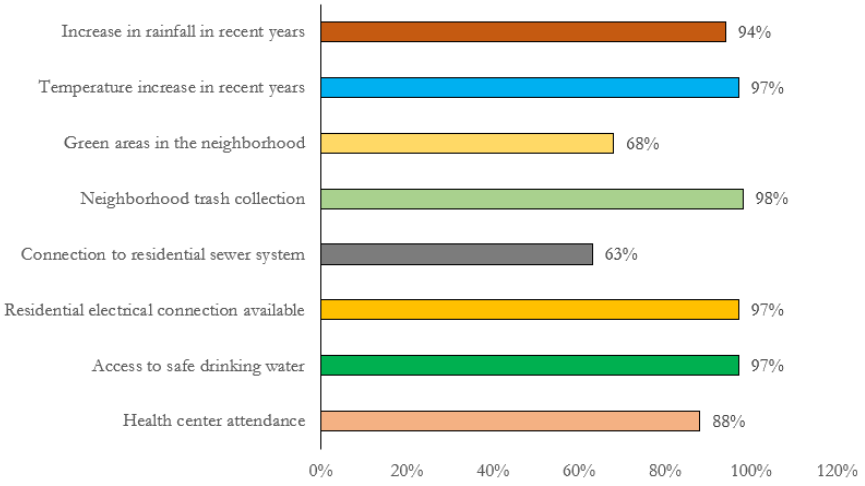

Figure 7. Vulnerabilities in urban/rural communities.

The analysis reveals a community with a high perception of climate risks, especially floods (92%) and droughts (83%), but with insufficient preparedness. There is a clear disconnect between recognition of threats and the knowledge applied to manage them; while 79% say they know about climate change and 72% know about evacuation plans, only 64% have participated in training and 59% know about risk management. This creates a critical vulnerability where awareness of the danger does not translate into effective response capacity, pointing to the urgent need to close this gap through practical training programs that prioritize comprehensive risk management, particularly in the face of flooding.

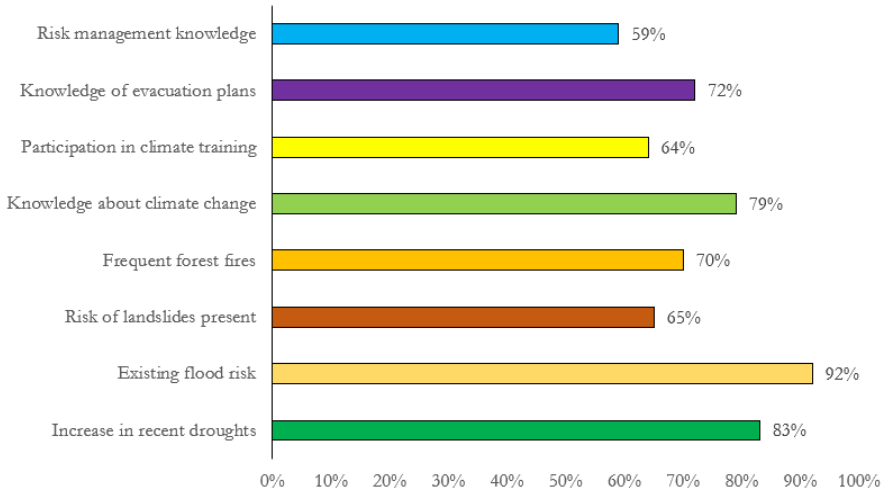

Figure 8. Perception of climate risks.

The high perception of climate risks, especially floods and droughts, coupled with insufficient preparedness, reflects a common gap between recognition of the problem and effective response capacity in vulnerable communities (Salcedo, 2023). However, the disconnect between knowledge about climate change and participation in specific training or risk management knowledge creates a critical vulnerability that requires targeted intervention to translate awareness into tangible and resilient actions (Balbé et al., 2024). Nevertheless, studies show that, despite a general understanding of the risks, the population often confuses climate change with other environmental problems or lacks formal information about its causes and solutions, which hinders the development of adaptive capacities (Rodríguez et al., 2021; Ortiz, 2023).

3.5. Response capacity in urban and rural communities

The prioritization of urban climate resilience strategies focuses on three main measures: rainwater harvesting systems are the measure with the highest consensus (58%), followed in second place by climate evacuation alerts and flood defense, both with 55%. This pattern indicates that proactive rainwater management, combined with human protection mechanisms and containment

infrastructure, are perceived as the fundamental pillars of urban adaptation to climate risks.

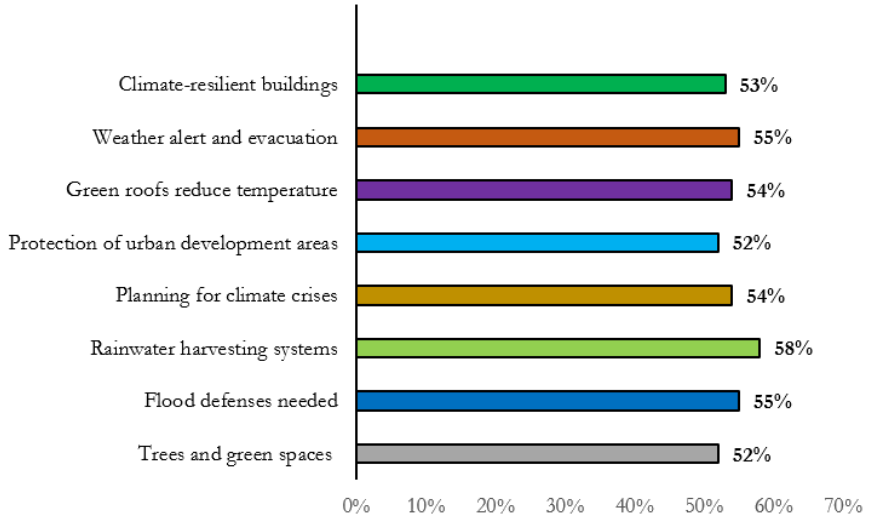

Figure 9. Responsiveness in urban/rural communities

This hierarchy of urban climate resilience measures reflects an implicit recognition of the interconnection between water management, civil protection, and physical infrastructure as pillars for adaptation to extreme events (Bossio et al., 2018). Furthermore, it is crucial to consider that the effectiveness of these strategies depends largely on risk communication and education, which do not always increase short-term risk perception, but do increase knowledge and coping capacity in the face of disasters, with cognitive factors such as environmental awareness and cost-benefit beliefs influencing these perceptions at the individual level (Cuadra et al., 2023). Active community participation and information sharing between different levels of government are essential elements for the success of adaptation strategies and building resilience to climate challenges (Olcina & Morote, 2025; Marchezini et al., 2022). However, the effective implementation of these measures is often hampered by significant barriers, including financial constraints, weak enforcement mechanisms, and deficiencies in technical capacity (Plange et al., 2025).

Climate strategy preferences reveal a remarkable multidimensional consensus: all measures receive very similar support (between 49% and 53%), indicating that

the community prioritizes a comprehensive package of actions over a single solution. Water security (supply diversification - 53%) emerges as the central focus, followed by physical adaptation, mitigation, and citizen participation measures. The relatively low ranking of projects for vulnerable populations (49%) suggests that, while a systemic approach is valued, the dimension of climate equity requires greater emphasis in communication and policy design, recommending the implementation of synergistic programs that combine resilient water infrastructure with participatory governance and differentiated social protection.

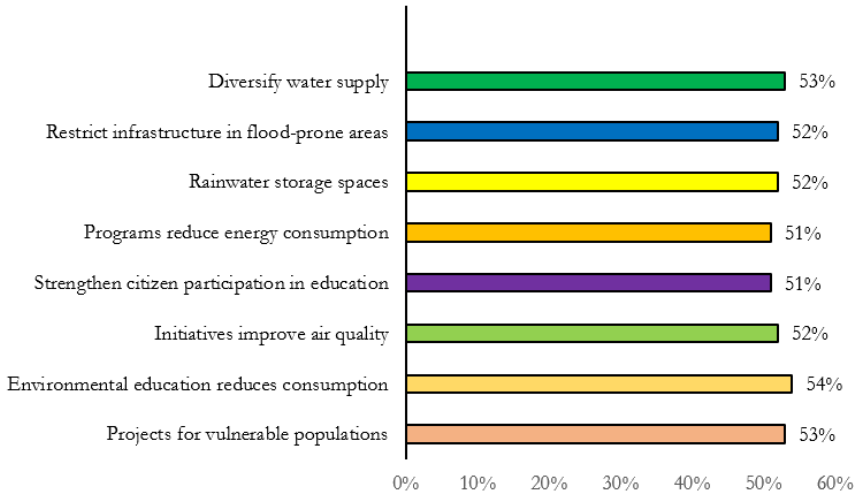

Figure 10. Climate strategies in urban/rural communities.

This integrated approach is in line with the understanding that effective climate action requires the simultaneous implementation of various strategies to address the multifaceted nature of climate change impacts (Forero et al., 2014). This comprehensive prioritization underscores a community-driven demand for synergistic interventions that go beyond isolated approaches to foster holistic resilience to environmental change (Amérigo et al., 2019). However, despite this integrated perspective, a significant portion of the population may still lack a clear understanding of practical adaptation and mitigation strategies, hindering their direct participation (Abril & Infante, 2022). Nevertheless, the lack of clear

information and uncertainty about the individual and collective actions that can be implemented to address climate change persist, leading to a defeatist attitude in some segments of the population (Gómez et al., 2017).

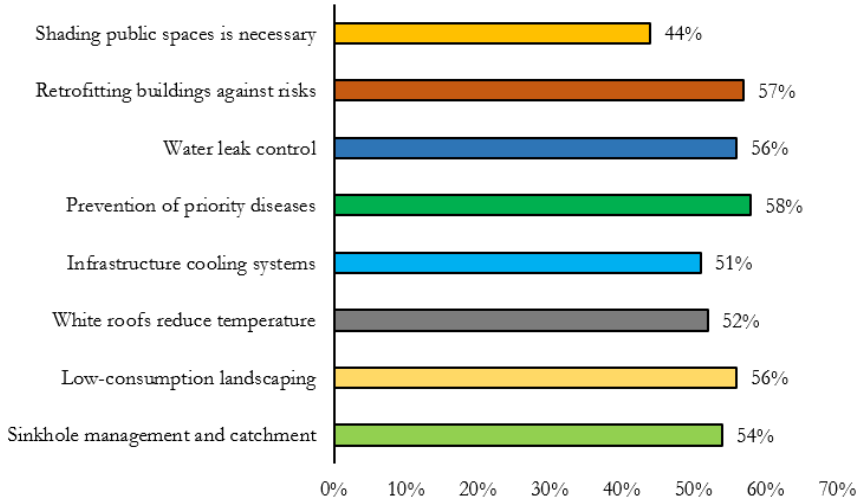

Figure 11. Climate adaptation measure in urban/rural communities.

The analysis reveals that the prevention of priority diseases (58%) is perceived as the most urgent climate adaptation measure, highlighting public health as a central concern. There is a marked preference for technical and hard infrastructure solutions (retrofitting buildings 57%, leak control 56%) over nature-based interventions, such as shading public spaces (44%), which receives the lowest support. This hierarchy indicates an undervaluation of passive and bioclimatic design solutions, despite the sustained consensus around water efficiency (measures between 54%–56%). It is recommended to strategically integrate green infrastructure into physical adaptation projects to close this perception gap and capitalize on socio-environmental benefits, building on the strong social mandate to protect health.

The findings of this study, particularly the disconnect between high-risk perception and low effective preparedness, align with research by Philipps et al. (2023), which emphasizes the need to move from awareness to concrete action in managing the risk of climate change-induced disasters. This transition requires a deeper commitment to community-level adaptation strategies, particularly

those focused on strengthening urban resilience and mitigating vulnerabilities exposed by climate change (Zulaica & Vazquez, 2021). However, the effectiveness of these strategies is intrinsically linked to the active participation of local actors, from community leaders to social organizations, in the planning, implementation, and monitoring of interventions (Cevallos & Parrado, 2018).

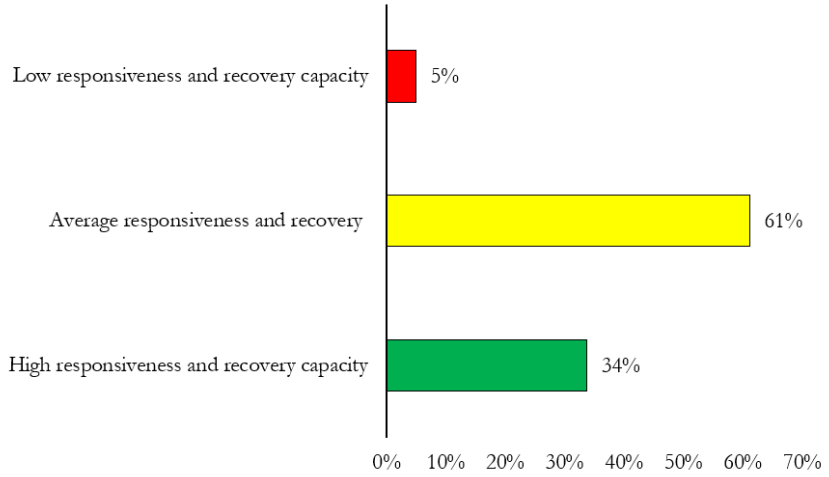

Figure 12. Traffic light system for response capacity in urban/rural communities.

From the application of the 24 indicators of response capacity in the canton of Tosagua, it was found that 61% of participants demonstrated, based on the categorization of the indicators, a medium response and recovery capacity; which coincides with the study by Álvarez et al. (2021) and Sturiale et al. (2023), which highlights the imperative need to improve inter-institutional coordination and citizen collaboration to implement sustainable solutions that address the challenges of climate change. Public participation and coordination among various actors are crucial for the design, implementation, and monitoring of adaptation strategies, especially in the context of nature-based solutions that are not always prioritized by planners (Giannotti et al., 2021; Karis & Mujica, 2023). However, resistance from some citizen groups to regulatory changes, coupled with limited knowledge about climate change and adaptation strategies among the population and decision-makers, hinders a smoother implementation of adaptation initiatives (Nissanka et al., 2024; García, 2019). On the other hand, the lack of effective coordination between financing, institutional frameworks,

and inclusive participation represents a significant challenge for climate planning in the region (Barros et al., 2025).

3.6. Adaptation strategies for urban and rural communities in the canton of Tosagua using an ecosystem-based adaptation (EbA) approach

Table 5. Adaptation strategies with an EbA approach (see Appendix E)

4. Conclusions

It is concluded that, during the meteorological analysis period, the Tosagua canton experienced its highest rainfall in 2017, with 111.58 mm of rain, and its lowest rainfall in 2020, with 44.05 mm of rain, while the average ambient temperature between 2014 and 2024 was 25.89°C, with a maximum temperature of 30.63°C and a minimum of 20.83°C. For this reason, 90% of respondents in urban and rural communities in the canton of Tosagua, Manabí, clearly perceive the local effects of climate change, such as changes in rainfall patterns and rising temperatures. Regarding resilience, it reached 61%, revealing a significant gap between perception and understanding of the underlying causes, as well as preparedness for risks. Furthermore, community vulnerabilities are linked to unmet basic needs (lack of access to drinking water, electricity, waste collection, health centers, green spaces, among others), all of which exceed 60%. Regarding the proposed adaptation measures, the most viable options are aligned with the strengthening and restoration of green and blue infrastructure, as a key pillar of ecosystem-based adaptation, such as the creation of green spaces with native, low-water-use species in urban areas, rainwater harvesting for local consumption, and reforestation with native species integrated with agroforestry systems in the rural part of the canton. Therefore, it is recommended to implement comprehensive ecosystem-based adaptation strategies, prioritizing resilient water management, climate education, and the strengthening of participatory local governance as transformative pillars for the region. This will enable communities and local government to develop cooperation projects with stakeholders such as academia or international cooperation agencies.

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