CRECIMIENTO URBANO Y VULNERABILIDAD AL CAMBIO CLIMÁTICO DE LA CONURBACIÓN DE QUEVEDO, ECUADOR
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URBAN GROWTH AND VULNERABILITY TO CLIMATE CHANGE OF THE QUEVEDO CONURBATION, ECUADOR [1]

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El cambio climático es un desafío global con impacto desigual. En Ecuador, el Cantón Quevedo, por su ubicación geográfica y características topográficas, es vulnerable a riesgos climáticos. Este estudio identificó la vulnerabilidad al cambio climático vinculada al crecimiento urbano del Cantón Quevedo, se utilizaron herramientas de sistemas de información geográfica (sig) para generar mapas de amenaza, exposición, sensibilidad, adaptación y riesgo climático, a través de un diseño cuasiexperimental y de enfoque cuantitativo. Los resultados indican un alto riesgo climático en general; 32,62 % del territorio presenta una exposición muy alta, especialmente en zonas con pendientes pronunciadas. Las zonas con alta sensibilidad y baja capacidad adaptativa son principalmente rurales y periféricas. En conclusión, el crecimiento poblacional causa la expansión urbana no planificada, que genera impactos ambientales negativos, como la degradación de la cubierta vegetal, que disminuye la resiliencia ecológica y la provisión de servicios ecosistémicos. esto incrementa la exposición y la sensibilidad (asociada a infraestructuras inadecuadas), y reduce la capacidad de adaptación. Se propone mejorar la infraestructura de drenaje, construir viviendas más resilientes y programas de educación y capacitación en cambio climático, así como promover soluciones basadas en la naturaleza.

Palabras clave: resiliencia, adaptación, riesgo, vulnerabilidad, cambio climático.

Climate change is a global challenge with uneven impact. In Ecuador, the Quevedo Canton, due to its geographical location and topographical characteristics, is vulnerable to climate risks. This study identified the vulnerability to climate change linked to urban growth in the Quevedo Canton. Geographic information system (GIS) tools were used to generate maps of threat, exposure, sensitivity, adaptation, and climate risk through a quasi-experimental design and a quantitative approach. The results indicate a high overall climate risk, with 32.62% of the territory being highly exposed, particularly in areas with steep slopes. Areas with high sensitivity and low adaptive capacity are mainly rural and peripheral. In conclusion, population growth leads to unplanned urban expansion, resulting in adverse environmental impacts, including degradation of vegetation cover, which reduces ecological resilience and the provision of ecosystem services. This increases exposure and sensitivity (associated with inadequate infrastructure) and reduces adaptive capacity. It is proposed to improve drainage infrastructure, build more resilient housing, implement climate change education and training programs, and promote nature-based solutions.

Keywords: resilience, adaptation, risk, vulnerability, climate change.

I. INTRODUCTION

Rapid and unplanned urban growth has been a global phenomenon that has transformed the spatial and social organization of cities, becoming a key ecological and human challenge of the 21st century (Jordán et al., 2017). By 2045, the global urban population is expected to increase 1.5 times (United Nations Organization [UN], 2024), driven by factors such as rural-urban migration, industrialization, and globalization (Jordan et al., 2017). However, in Latin America, this accelerated urbanization has not guaranteed sustainable economic development or a significant reduction of poverty and inequality (UN, 2024). On the contrary, environmental degradation has consumed agricultural lands and habitats by fragmenting ecosystems (World Health Organization [WHO], 2022). It has also left an estimated million species at threat of extinction if important ecological changes are not made in the coming years (Díaz et al., 2019).

As a result, deforestation and the loss of green spaces are reducing carbon sequestration and leading to poor air and water quality. The alteration in the natural water cycle is behind more prolonged droughts and intense rainfall, leading to increased runoff and reduced infiltration. This, in turn, has led to water shortages and floods (Gómez-Guerrero et al., 2021). Unsustainable anthropogenic development, especially urban growth, is the primary driver of this climate change. Cities are primarily responsible, as they consume more than two-thirds of the global energy and emit 70% of the greenhouse gases (Masson-Delmotte et al., 2019). Furthermore, within these cities, urban populations are the most vulnerable, as they experience temperatures 3°C to 5ºC higher than the surrounding rural areas, due to the so-called urban heat island effect generated by their large concrete surfaces and the lack of vegetation cover (Lane et al., 2024).

According to this argument, informal settlements are the most vulnerable to risks arising from weather patterns. As such, analyzing vulnerability in areas with high demand for land and significant ecological impact (Duque & Montoya, 2021) is particularly relevant, given its importance in reducing thermal contrasts and humidity (Mendes et al., 2020). Along these lines, the destruction of 85% of the world's wetlands has been reported, and 23% of the planet's land is considered ecologically degraded. The destruction of coastal mangroves is threatening 300 million people (Díaz et al., 2019) due to the ecosystem's vulnerability associated with low resilience capacity. Therefore, unplanned urbanization represents unsustainable development, which amplifies climatic or geological hazards (UN, 2024).

New intermediate cities, such as the conurbation of Quevedo, have emerged in Ecuador, along previously non-existent lines (Narváez Quiñonez et al., 2020). With its metropolitan area, as well as intermediate parishes and cities, the functionality and operation of this conurbation is confirmed, although it is neither administratively nor politically defined (EcuRed, 2025). However, Quevedo is exposed to natural, geological, and hydrometeorological threats, with risks of soil degradation and water scarcity (Narváez Quiñonez et al., 2020). Annual rainfall patterns have led to increased saltwater intrusion, sea level rise, and a higher frequency and intensity of extreme weather events, such as floods and hurricanes (Song et al., 2023).

A phenomenon that has been documented in coastal provinces such as Manabi and Guayas, damaging more than 6,900 homes and destroying 72 of them (Fan & Zhao, 2025).

Therefore, it is crucial to examine how unplanned urban expansion exacerbates climate vulnerability in Quevedo by generating threat, exposure, sensitivity, adaptation, and climate risk maps, utilizing advanced data processing tools in geographic information systems (GIS). A research goal is established from this perspective, namely, to identify the vulnerability to climate change linked to urban growth in the canton of Quevedo, to generate data to understand specific challenges, and to facilitate effective adaptation strategies. Similarly, the environmental information obtained can help improve the interpretation of these spaces and their consideration in local resilience calculations (Hernández Aja et al., 2020), thereby contributing to sustainable urban planning. This local approach could then be extrapolated to a national or even regional level.

II. THEORETICAL FRAMEWORK

Urban growth refers to the change in land use that necessitates planning, design, and construction of spaces and structures to improve the quality of life for its inhabitants and ensure sustainable urban development. However, rural-urban migration fosters the development of unplanned, informal cities (Jordan et al., 2017), which contribute to climate change. The latter is the prolonged variation of weather patterns due to natural causes or, primarily, due to the burning of fossil fuels and deforestation (UN, 2024). In informal urbanization, land use and land-use change are the most significant sources of net CO_2 emissions (Ghosh et al., 2022; Kim & Park, 2023; Bufalo et al., 2024).

In this context, planning is crucial for mitigating the effects of climate change by creating resilient structures that are informed by environmentally friendly and sustainable policies (Murillo Delgado et al., 2023). This, in practice, presents a challenge in itself, particularly in areas that should be protected due to their ecosystem contributions or greater vulnerability to changes. Therefore, urban and environmental development planning must be based on the benefits that ecosystems offer to guarantee human well-being, known as ecosystem services, which include the provision of indispensable resources (water, food, and medicine), as well as their contributions to climate stabilization, the regularization of the water cycle, their protective function against floods, soil erosion, and landslides, among others (Córdoba-Hernández, 2021).

For efficient planning, areas of high ecosystem value that require protection and conservation should be identified and prioritized. Ensuring the integration of environments into mitigation and adaptation strategies is also necessary. This includes the implementation of nature-based solutions (NbS), which are actions to protect, sustainably manage, and restore natural or modified ecosystems, effectively and adaptively addressing socio-environmental challenges, and simultaneously providing benefits for human well-being and biodiversity (Rojas Morales, 2024). Therefore, it is essential to note that climate vulnerability refers to the susceptibility to damage from climate change, encompassing both sensitivity and responsiveness. Ecosystem vulnerability is associated with the loss of habitats and the replacement of ecosystems with less future resilience. On the other hand, vulnerability arises when ecosystems lose their ability to provide essential goods, functions, and services, ultimately affecting territorial recovery in the face of an environmental crisis (Córdoba-Hernández, 2021).

Considering all the above, it is important to define ecosystem resilience. This refers to a system's ability to maintain or return to its desired functions in the face of a disturbance, adapting and transforming systems despite limitations (Meerow et al., 2016). This should be considered in conjunction with the transformation of the habitat, climate change, the overexploitation of resources, the introduction of invasive species, pollution, and nutrient enrichment (Córdoba-Hernández, 2021), both in urban planning and in territorial urban development and housing strategies for the years to come. Hence, climate vulnerability considers the exposure of goods, infrastructure, assets, people, species, or ecosystems in affected environments, and the degree to which a system is affected by climate change, directly or indirectly, is referred to as sensitivity. Finally, adaptive capacity refers to the faculty that ecological, social, or economic systems, human institutions, and other organisms have to take advantage of opportunities or respond to climatic consequences.

III. CASE STUDY

The Canton of Quevedo is located in the province of Los Ríos and encompasses both urban and rural areas (Figure 1). It is located at 74 meters above sea level. Quevedo has a surface area of 303 km2 and borders the cantons of Buena Fe and Valencia to the north, El Empalme to the east, Mocache to the south, and Quinsaloma to the west. Its projected UTM coordinates are East (X) 670965 and North (Y) 9886264. The central city is Quevedo, which has seen substantial population and economic development. Among the ecosystem factors, the Quevedo River, which crosses the city's urban area and practically the entire canton, and other water sources that influence climate and biodiversity, which favor ecosystem services, stand out. Landscape fragmentation has been identified as a result of the conversion of forests into agricultural or urban lands, which alters ecological connectivity and hinders the movement of species (Villavicencio-Ordóñez et al., 2024). Due to intense agricultural activity, these water bodies can be affected by the use of fertilizers and pesticides (EcuRed, 2025).

The breakdown of the rainfall timeline (Figure 2) for Quevedo Canton (Figure 2.A.) exhibits a well-defined rainy seasonal precipitation pattern. The rainfall has reached significant peaks, especially around the turn of the century (2000), due to extreme weather events such as El Niño. Similarly, the temperature timeline depicted in Figure 2B describes a seasonal pattern with accentuated annual variations. Since the 1940s, temperatures have gradually increased, followed by fluctuations around a constant level. Occasionally, extreme temperature events, such as heat waves, are observed.

Quevedo is the tenth most populous city in Ecuador; according to the National Institute of Statistics and Census [INEC] of 2022, its population has risen considerably. In 2010, 150,827 inhabitants were registered, and by 2022, it was 177,792 inhabitants (INEC, 2022). The population estimate for 2024 was 208,000 people. In 2000, the urban sprawl of Quevedo covered a population of 932.55 inhabitants. When representing the 2010 population and housing census in the urban area, Narváez Quiñonez et al. (2020) indicated a growth rate of 41.72%. Similarly, through their simulation research between 1998 and 2019, they revealed that organic growth is more than fourfold, with a surface area of 304.67 km^2 by 2020. Moreover, they warned about a likely increase, based on the population growth in the area, which is estimated to be 251,922 inhabitants by 2030 (Villavicencio-Ordóñez et al., 2024).

The area is characterized by being almost flat, which facilitates the development of urban infrastructure, roads,

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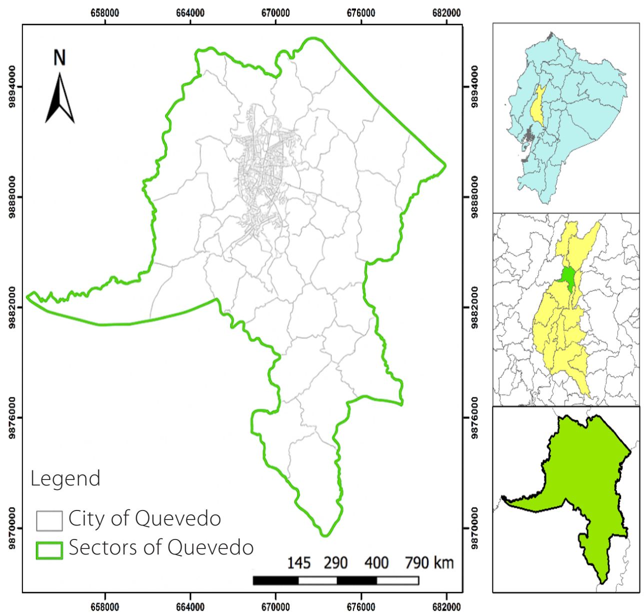

Figure 1: Map of the canton of Quevedo. Source: Prepared by the Authors based on data in shape format from 2023 of the Ecuador Military Geoportal (2024).

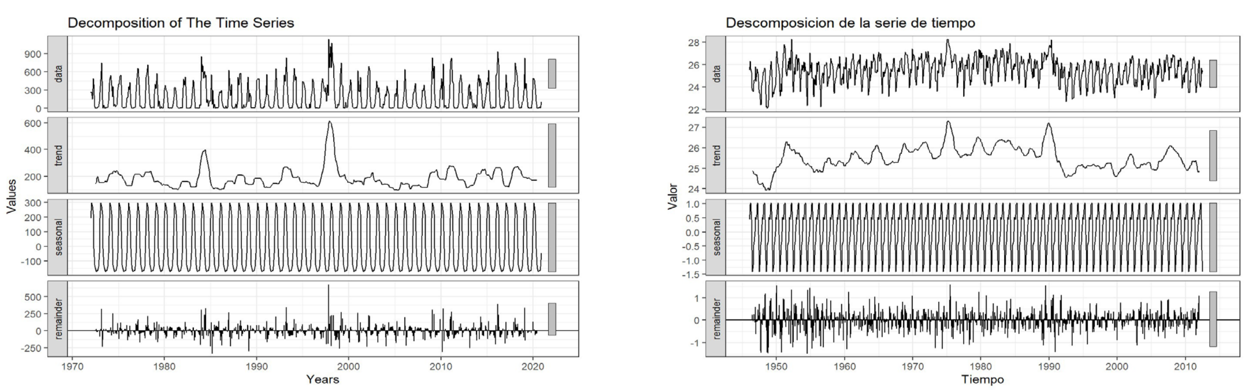

Figure 2: A. Rainfall records. B. Temperature records timeline. Source: Preparation by the Authors based on data from 2023 of the Ecuador Military Geoportal (2024).

and agricultural areas without facing significant geographical challenges, such as mountains or steep slopes. Despite having a large number of gorges and bodies of water, the slopes do not exceed 10 degrees, conditions that make the area prone to flooding (EcuRed, 2025). Low-lying swaths of the canton's western area are also prone to flooding in the rainy season (Flores & Vlassova, 2022). The urban sprawl of the canton has expanded towards these threatened areas, disregarding the physical-natural realities such as proximity to water bodies, slopes, lack of services, or the frequency of adverse events in the area, which impacts the environment and increases the risk of disasters (Narváez Quiñonez et al., 2020; Flores & Vlassova, 2022).

Two seasons of a sub-humid-tropical climate are marked out: rainy and dry. The annual temperature ranges from 22 °C to 31 °C, and abundant rainfall exceeding 2,600 mm per year is recorded, with a regular pattern (EcuRed, 2025). These meteorological data are considered for the exposure variable. In terms of sensitivity, population density, access to basic services, the expansion area, and vegetation cover were evaluated. Finally, for the adaptation capacity, the National Climate Change Adaptation Plan (PLANACC) of Ecuador, 2023-2027 (MAATE, 2023) was considered.

IV. METHODOLOGY

This study employed a quasi-experimental design and a quantitative approach to identify the vulnerability to climate change associated with urban growth in the Quevedo canton. For this reason, an applied and exploratory research was conducted.

GIS software with shapefiles from the National Institute of Statistics and Censuses (INEC, 2022) was used to determine the level of exposure to climate risk. Layers were added and adjusted to the canton's boundaries by using the "Clip" tool. The slope layer (derived from a Digital Elevation Model, MDE) and the layer of cantons and provinces, limited to the Quevedo canton, were considered to calculate threat and exposure. In addition, a Geodatabase of Quevedo's sectors (a shapefile of analysis units) was used to assign values by sector, and a table of Redatam attributes (2022 census variables) was linked using a "Join" operation for sensitivity and adaptability (Nieto Cañarte et al., 2023). First, the exposure of each type of soil was calculated based on its slope, classifying them by degree of exposure, as described in Table 2. The final layer was converted to raster and reclassified to obtain the exposure scale.

The climatic threat was also determined using GIS software and the study area layer, where a new column called "Threat" was added to its attribute table (Table 1). Using the "Field Calculator" tool, a value of four (4) was assigned to the entire canton based on weather conditions. This value was used to classify the threat level according to the degree of exposure. As for the analysis of the climatic exposure range, this was based on the aspects established by MAATE (2019) (Table 2).

To assess vulnerability to environmental risks, a sensitivity analysis was performed with socio-economic data processed in "Red7 Process". Two Excel files were created: one for sensitivity analysis (considering the type of housing and construction materials) and another for adaptability (which included factors such as illiteracy and access to services). Percentages and averages were calculated, and this information was added to the shapefile of the canton's sectors to classify the variables later and transform them to a raster format for

Degree of exposure			Ranges
	1	Very low	≤5%
	2	Low	>5 - 12%
	3	Moderate	>12 - 25%
	4	High	>25 - 50%
	5	Very high	>50

Table 1: Attributes according to the Degree of exposure. Source: MAATE, 2019

Exposure	Interpretation of the degree of exposure
The estimation of the degree of exposure considers the proportion of the element susceptible to climatic threats, changes in exposure over time, and the frequency of extreme weather events and their direct physical effects, such as landslides and floods.	Very low. Proportion of the area: 0% to 20%.
	Low. Proportion of the area: 21% to 40%.
	Moderate. Proportion of the area: 41% to 60%.
	High. Proportion of the area: 61% to 80%.
	Very high. Proportion of the area: 81% to 100%.

Table 2: Levels of climate exposure. Source: MAATE, 2019.

Sensitivity	Interpretation of the degree of exposure
The susceptibility of an element to climatic threats depends on its characteristics and increases if the threats impact key resources for the project. It is also influenced by "non-climatic pressures" (environmental, social, political, or economic), identifiable during the diagnostic phase of the PDOT.	Very little susceptibility, allowing the program or project to operate normally.
	Little susceptibility, allowing the program to operate relatively normally.
	Moderately susceptible, limiting the normal operation of the program/project.
	Highly susceptible, causing temporary but frequent closures of the project.
	Very high susceptibility, causing permanent closures of the programs.

Table 3: Considerations for sensitivity analysis. Source: MAATE, 2019.

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their analysis, following the guidelines of MAATE (2019). Following this, the vulnerability analysis considered susceptibility to climate change, encompassing sensitivity to damage and response capacity.

To estimate vulnerability, it is crucial to analyze the relationship between "sensitivity" and "adaptive capacity". In the case of Quevedo canton, sensitivity is evaluated according to the criteria outlined in Table 3, which considers the degree of exposure for the sensitivity analysis.

The adaptive capacity was analyzed when evaluating the response potential of the Quevedo Canton, which considers the capacity of systems, institutions, human beings and other organisms to adapt, prepare, and respond to possible damages, take advantage of opportunities, or face the consequences of climate threats or their effects and the projects with the best responses to climate threats (Table 4).

Finally, to determine the climate risk, the calculation of the raster is carried out with the "raster calculator" tool, applying the formula (1):

$$\text{Climate risk} = \left\{ (\text{Danger})(\text{Exposure}) \left[\frac{(\text{Sensitivity})}{(\text{Adaptive Capacity})} \right] \right\}$$

The results are transformed into a raster and reclassified to analyze the climate risk levels of the canton, classifying them according to the degree of exposure.

V. RESULTS

The threat level, calculated based on the slope layer and meteorological records, indicates that Quevedo Canton is an area prone to heavy rainfall, suggesting a high probability of flooding. Figure 3 shows that most of the canton has a moderate threat level (yellow). There are some scattered areas with a high threat (orange), which are characterized by steeper slopes, making them more susceptible to landslides, erosion, and runoff. As for the level of exposure, also valued by the slope layer and the presence of elements (population, infrastructure, goods), 32.62% of the territory is at a very high level of exposure (red). This area, primarily the canton's central and southeastern sectors, has significant slopes (indicating potential danger) with a high concentration of population and/or infrastructure, which exacerbates the vulnerability. The rest of the territory, a rural area, is at a moderate level of exposure (orange) with 39.24%, which highlights a considerable threat due to the terrain's morphology and the

Ability to adapt	Interpretation of the degree of exposure
The capacity of systems, institutions, human beings, and other organisms to adapt, prepare, and respond to possible damages, seize opportunities, or face the consequences of climate threats or their effects.	Very little. It would not reduce the damage.
	Little capacity. It would not reduce the full extent of the damage.
	Moderate. It would partially reduce the damage.
	High capacity. It would significantly reduce the damage.
	Very high. It would completely reduce the damage.

Table 4: Considerations for the analysis of adaptive capacity. Source: MAATE, 2019.

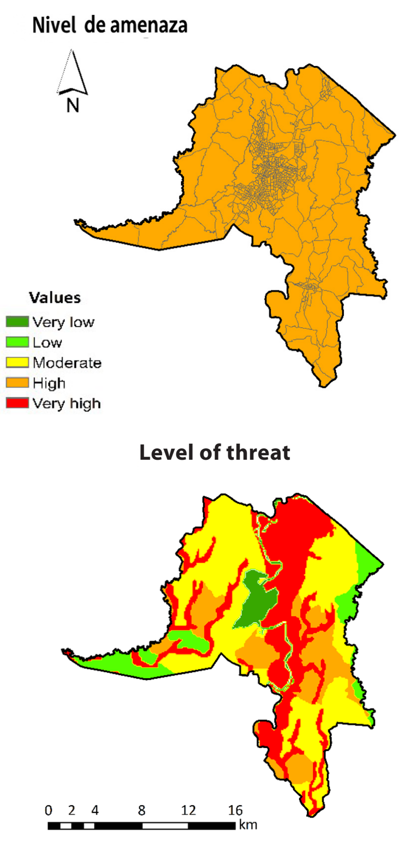

Figure 3: Threat and exposure map of the Quevedo canton. Source: Prepared by the Authors based on data in shape format from the INEC (2022).

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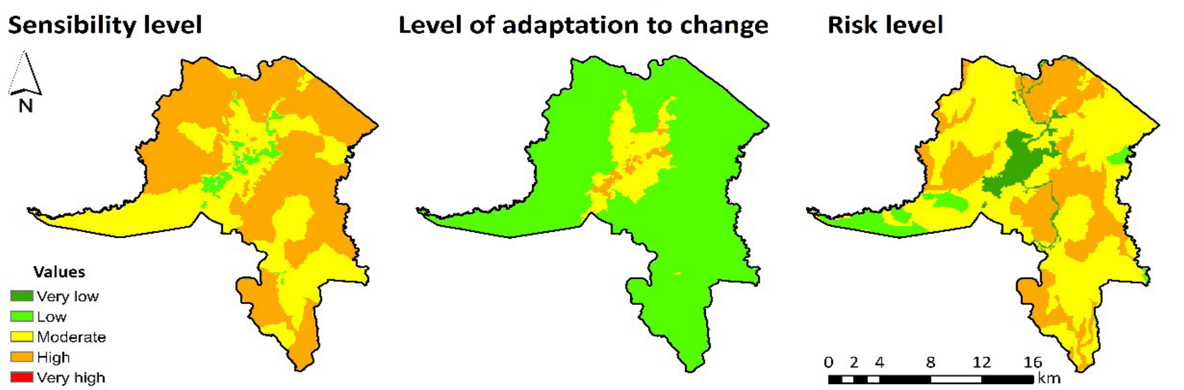

Figure 4: Maps of the sensitivity, level of adaptation to climate change, and climate risk in the Quevedo canton. Source: Prepared by the Authors based on data in shape format from the INEC (2022).

lack of urban planning. The low and very low levels represent only 13.41%, which reflects relatively safer, but smaller areas (Figure 3).

On the other hand, Figure 4 shows sample areas with different levels of sensitivity. An extensive area of the canton, encompassing rural regions, exhibits moderate sensitivity (yellow), indicating an intermediate susceptibility to the impacts of climate change, in conjunction with socio-economic and biophysical factors. However, the areas with high sensitivity (orange), concentrated in the center and southeast regions, are characterized by high population density and intensive agriculture, making them more vulnerable to climate change. Regarding the level of adaptation, the green areas on the map indicate a low capacity for adaptation, resulting in increased vulnerability due to a lack of resources, education, and infrastructure. On the other hand, in some urban and developed areas (yellow), there is a greater capacity for adaptation, suggesting better living conditions; rural and some less-favored urban areas are at a disadvantage in facing climate challenges.

Finally, the climate risk map (Figure 4), which combines threat, exposure, sensitivity, and adaptation, highlights that the high-risk areas (orange) are concentrated in the central and southeastern areas of the canton. This is probably due to an unfavorable combination of high threat, high exposure, high sensitivity, and low adaptability. Research indicates that the most pressured ecosystems are urban areas, crops, and hydrological sources. The projections suggest that the impacts will be most evident in the central and southeastern areas of the canton. Climate change will have a moderate effect, but urbanized land, agricultural lands, and the Quevedo River will be the most vulnerable to temperature and precipitation variations, with a greater probability of extreme events. Urban areas pose the highest level of danger, and pollution and nutrient enrichment will significantly impact both urban and agricultural ecosystems, as well as Quevedo's primary water source.

VI. DISCUSSION

To mitigate climate change, particularly in developing countries, it is essential to comprehend the accelerated urban growth. The creation of intermediate cities without proper planning dismantles the natural vegetation cover, increasing the need for services and resources, which in turn contributes to environmental pollution (Duque & Montoya, 2021). This study corroborates that unplanned urban expansion in Quevedo leads to the progressive degradation of natural ecosystems, as manifested in the loss of riparian forests, alterations in land use, and the degradation of wetlands. This transformation of the urban landscape inherently reduces the ecological resilience of the area by compromising the ability of natural systems to regulate the water cycle and mitigate the intensity of extreme weather events. Thus, the results of this research revealed a relationship between unplanned urban growth, climate change, and climatic vulnerability, indicating a trend towards growth in threatened flood-prone areas, thereby increasing exposure and climatic vulnerability (Song et al., 2023; Lane et al., 2024). It is essential to recognize that informal urbanization not only increases physical exposure but also aggravates pre-existing social inequalities by leaving the most vulnerable populations with less access to basic resources and services to cope with climate impacts (UN, 2024).

On the other hand, it was necessary to outline the spatial distribution of threat and exposure levels, sensitivity, adaptation, and climate risk, which facilitates the identification of vulnerable areas in the canton. The results are similar to those reported by other researchers (Ghosh et al., 2022; Kim & Park, 2023; Fan & Zhao, 2025; Kythreotis et al., 2024) who state that the main vulnerability risks are water and soil pollution, the emergence and increase of poverty, the confirmation of diseases caused by climate change, and climate variability. Similarly, it is confirmed that the study area has a moderate risk, consistent with that stated by Burgos Choez et al. (2019) in their study, carried out in the province of Manabi, Quevedo, Ecuador. Through the analysis of the physical, social, economic, and ecological components, they estimated an average global vulnerability of 55%, influenced mainly by the social aspect due to the lack of preparedness to the risk on the part of local government institutions and inhabitants. This is followed by the physical aspect, due to the proximity of a large part of the housing to the river; then the ecological aspect, due to the decrease in vegetation cover and soil sealing, which negatively impacts the provision of vital ecosystem services such as water regulation and erosion protection (Córdoba-Hernández, 2021) and finally, to a lesser extent, the economic aspect, due to the location of the commercial zone on an area with slopes of less than 2.5 degrees. This interconnection between biophysical, social, and economic factors necessitates a holistic approach to vulnerability assessment, which not only maps risks but also understands the underlying socio-economic dynamics that amplify or mitigate climate impacts.

The connection between these findings highlights the importance of planning urban growth sustainably, incorporating strategies that address climatic vulnerability (Ávila, 2024). Based on the literature (Burgos Choez et al., 2019; Mendes et al., 2020), the need to carry out studies of climatic variability, historical in the region, was confirmed, especially in the face of extreme events (droughts, floods, heat waves), to determine vulnerabilities and the capacity of communities to face these risks (Gómez-Guerrero et al., 2021; Murillo Delgado et al., 2023). Climate risk studies, in conjunction with spatial planning plans, response/emergency and adaptation strategies, are crucial for generating knowledge and skills in the most vulnerable communities (Dey & Lewis, 2021; Duque & Montoya, 2021). To address this vulnerability and strengthen ecological resilience, it is essential to implement SBNs that contribute directly to climate change mitigation and the improvement of ecosystem services (Rojas Morales, 2024) in the Quevedo canton.

VII. CONCLUSIONS

In short, the unplanned urban expansion in Quevedo is a key factor that degrades local ecosystems and, consequently, weakens the ecological resilience of the canton by increasing its vulnerability to climatic threats. The cartographic analysis reveals that the Quevedo canton faces a high level of climatic threat, particularly in areas with steep slopes that increase its susceptibility to flooding. Rural areas, with moderate exposure, are equally susceptible to natural disasters, which increases climate vulnerability. When considering sensitivity and adaptive capacity, it is noted that peripheral areas and some rural areas exhibit moderate to very high levels of sensitivity, associated with inadequate housing conditions and construction materials, and have a low adaptive capacity due to limitations in economic resources, educational levels, and access to services. The loss of vegetation cover in these areas also affects the provision of crucial ecosystem services such as water cycle regulation and soil protection, further decreasing their capacity to face the risks. The absence and non-compliance of land use regulatory frameworks exacerbate this vulnerability yet further.

Therefore, to mitigate climate risks in the Quevedo Canton, it is essential to continuously monitor the areas of high exposure and improve the drainage infrastructure by integrating principles of sustainable urban drainage. The construction of more resilient housing and the improvement of existing ones in areas of high sensitivity should be encouraged by using local materials and employing resilient/efficient techniques. It is also crucial to implement participatory education and training programs on climate change and risk management to increase the community's adaptive capacity, preparing them to face future climate challenges. Ultimately, the reforestation and conservation of the natural environment are crucial for improving ecological resilience and strengthening ecosystem services. The implementation of territorial planning policies that restrict development in high-risk areas and protect key ecosystems will also be crucial to ensure the long-term success of these measures.

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Conceptualization, C.A.N.C.; Data Curation, V.M.G.S.; Formal analysis, M.C.V.R.; Acquisition of financing, C.A.N.C.; Research, P.H.L.M.; Methodology, M.C.V.R.; Project management, W.M.D.Z.; Resources, C.A.N.C.; Software, P.H.L.M.; Supervision, M.C.V.R.; Validation, P.H. L.M.; Visualization, W.M.D.Z.; Writing – original draft, V.M.G.S.; Writing – revision and editing, W.M.D.Z.

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