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Climate Data Analysis For Climate Change Mitigation In The City Of Quevedo, Ecuador

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Abstract
This study examines climate behavior in the city of Quevedo, Ecuador, with the objective of understanding the effects of climate change and proposing mitigation strategies. Through the analysis of historical meteorological data collected over the last three decades, significant trends were identified, such as a gradual increase in temperature and a decrease in precipitation. These changes have particularly affected agricultural activity, with a negative impact on crops such as bananas, which show an inverse correlation with thermal increase. Technological tools such as Python and QGIS were used to process climatic and socioeconomic data. In addition, surveys and interviews with farmers and local experts were applied to gain first-hand knowledge of the observed effects and current adaptation strategies. Predictive models, such as Random Forest, allowed highly accurate forecasting of extreme events such as floods and droughts, which is key for the design of early warnings. The study also used clustering methods K-means to classify zones with similar climatic characteristics, thus facilitating the prioritization of actions. It is concluded that, to address climate challenges, it is essential to promote efficient water management, the use of sustainable technologies, and environmental education as an awareness-raising tool. The integration of data science and community participation emerges as a promising avenue for strengthening local resilience to climate change in Quevedo.
Keywords: *Climate change, agriculture, data analysis, resilience.*

INTRODUCTION

Climate change has ceased to be an abstract concern and has become a palpable reality that directly affects communities around the world. In this context, Quevedo, a city located in the coastal region of Ecuador, has begun to experience the consequences of climate change with greater intensity. This global phenomenon has local manifestations, and Quevedo, being a key agricultural center, is in a particularly vulnerable position (IPCC, 2021).

Over the past few years, the city has witnessed unprecedented climate variability, rainfall is increasingly erratic, and temperatures are trending upwards. This scenario poses a significant risk not only to agricultural production, but also to food security, public health, and urban infrastructure. Traditional crops such as bananas, maize, and other subsistence products are threatened by these changes, which has an impact on the incomes of families that depend on agriculture and the regional economy in general (Mendoza et al., 2023; Medina, 2023).

Data science is presented as a powerful tool for analyzing, understanding, and anticipating these changes. Through the use of technologies such as machine learning, climate sensors, predictive models, and geographic information systems, it is possible to identify hidden patterns in historical data that allow informed decisions to be made (Zambrano et al., 2021; Bonifaz & Mendoza, 2025). In this sense, the present study aims to use a multidisciplinary approach that combines the analysis of climate data with socioeconomic information to provide a comprehensive view of the situation in Quevedo.

This approach allows not only to quantify climate transformations in the city, but also to interpret how they affect people in their daily lives. Imagine the case of a farmer who previously knew for sure when to start planting today faces uncertainty due to the unpredictability of the weather. This new reality requires new strategies, from changes in the agricultural calendar to the implementation of technologies that optimize the use of resources such as water (Andrade et al., 2022).

In addition to the quantitative analysis, the study incorporates a qualitative perspective that collects the voices of those who live and work in the territory. Interviews and surveys of farmers, local authorities, public health specialists and ordinary citizens provide a human dimension that complements the technical findings. The empirical experience of these people constitutes a valuable input for designing realistic and effective public policies (Castro et al., 2023).
The climate data used comes from reliable sources such as the National Institute of Meteorology and Hydrology (INAMHI) and NOAA, as well as local sensors installed at strategic points in the city. These data allow temporal and spatial analyses to be carried out that reveal the evolution of the climate in recent decades (INAMHI, 2023). On the other hand, the socioeconomic information comes from local organizations and from the inhabitants of Quevedo themselves, collected through structured surveys and semi-structured interviews.
The joint analysis of this information has made it possible to identify areas of the city with similar climatic characteristics, which facilitates territorial planning and the implementation of differentiated measures according to the level of risk. For example, some areas need to improve drainage systems to prevent flooding, while others need to strengthen irrigation systems in the face of water scarcity (Medina, 2023; Burgos et al., 2025).
Another key aspect is to highlight the importance of education and community awareness. Understanding climate change is not the exclusive task of scientists or politicians. Citizens must have access to information, understand the risks and know the actions they can take to contribute to mitigation and adaptation. Environmental education, both formal and informal, is a fundamental pillar to achieve lasting changes in culture and social practices (Morote & Olcina, 2023).
One of the central objectives of this study is to promote this type of collective awareness. By integrating scientific information with local testimonies, it is hoped that the results will not only serve as a basis for future research, but also inspire action at the community level. Resilience to climate change is not built individually; it is the result of a collective effort that involves various actors in society.
In summary, this research seeks to contribute to the understanding of climate change in Quevedo from a holistic perspective, which considers both objective variables and people's experiences. Through data analysis and community participation, it is intended to generate useful knowledge to face the current and future challenges posed by climate change in this region.

METHODOLOGY

This study adopts a mixed methodological approach, combining quantitative and qualitative techniques to obtain a comprehensive view of the climate impact in Quevedo, Ecuador. A descriptive and correlational research was used, seeking to identify relationships between climatic and socioeconomic variables.
Various sources were used for data collection. In terms of climate data, historical records of temperature, precipitation and humidity from the National Institute of Meteorology and Hydrology (INAMHI) and the National Oceanic and Atmospheric Administration (NOAA) were accessed. Strategically installed weather sensors were also used to capture information in real time.
From the socioeconomic field, structured surveys and semi-structured interviews were conducted with farmers, local technicians and public health experts. This made it possible to link weather patterns with variables such as agricultural production, risk perception, and community adaptation strategies (Burgos et al., 2025).
On a technical level, the data analysis was supported by tools such as Python (Pandas, NumPy, Matplotlib libraries) and QGIS (spatial analysis). The information collected was organized and processed to allow both descriptive and inferential analysis.
The research design was longitudinal, retrospective and cross-sectional. On the one hand, data from the last 30 years were analyzed to identify climate trends; on the other, a cross-sectional view was incorporated through current surveys.

Table 1. Applied Methodology

Aspect	**Detail**
Type of Research	Mixed: qualitative, quantitative, descriptive and correlational
Data Sources	Weather stations, surveys, satellite imagery, global databases

Instruments	Sensors, quizzes, software (Python, R, QGIS)
Design	Retrospective longitudinal and transverse
Statistical analysis	Descriptive, correlation, regression, PCA, machine learning

For the descriptive statistical analysis, measures such as mean, median, standard deviation and range were calculated. These metrics made it possible to graph temperature and precipitation time series, as well as spatial distribution maps (IPCC, 2021).
Regarding the inferential analysis, Pearson's correlation coefficient was applied to evaluate the relationship between climatic variables temperature, precipitation, extreme events and agricultural yield. It was complemented with multiple linear regression to model the impact on banana production (Mendoza et al., 2023).
Principal Component Analysis (PCA) was also integrated to reduce the dimensionality of the data and detect dominant patterns. In addition, machine learning techniques such as Random Forest were applied to predict extreme events, and K-means for the climate grouping of areas.
Table 2. Analytical Techniques Used

Technique	**Specific application**
Pearson correlation	Relationship between temperature and crop yield
Multiple Linear Regression	Impact of climate on banana production
PCA	Dimensionality reduction and exploratory analysis
Random Forest	Drought and flood prediction
K-means	Grouping of zones by climatic similarity

The sampling used was stratified random for the surveys, ensuring proportional representation by agricultural sectors, and convenience sampling for interviews with experts, based on their experience in climate change (González & Zhang, 2025).
Research ethics were considered through informed consent and guaranteed anonymity. All data used is either public or collected with the approval of the participants. References were cited according to academic standards.
This comprehensive methodology not only quantifies climatic phenomena, but also allows us to understand how they impact the population of Quevedo from a local and contextualized perspective.

RESULTS

The results obtained through the applied methodology are presented below, organized in tables with their respective analysis and discussion.
Table 2. Descriptive Analysis of Climate Variables (1993-2023)

Variable	**Stocking**	**Median**	**Standard deviation**	**Rank**	**Tendency**
Temperature (°C)	25.2	25.0	1.8	22.5 - 28.5	Increase (0.3°C/decade)
Precipitation (mm)	1800	1750	350	1200 - 2500	Decrease (-50 mm/decade)
Relative Humidity (%)	80	82	5	70 - 90	Stable

An analysis of the data obtained and represented in the table by each of the climatic variables considered is carried out. In terms of temperature, a significant increase of 0.3°C per decade is observed, coinciding with global trends reported by the IPCC (2021). A decrease of 50 mm per decade can be determined in precipitation, which could explain the greater frequency of droughts in the region (Mendoza et al., 2023) and with humidity it was indicated that it remains stable, but with high interannual variability.

These results confirm the effects of climate change in Quevedo, especially in agriculture, where the increase in temperature and the reduction in rainfall affect crops such as bananas (Mendoza et al., 2023). Moisture stability suggests that extreme events such as floods may be more related to changes in precipitation patterns than to absolute humidity.
In reference to the correlations between the different climatic variables determined in the study and agricultural yield according to Pearson's coefficient, the following results were obtained, indicated in Table 3.
Table 3. Correlation between Climate Variables and Agricultural Yield

Climate Variable	**Banana Yield (r)**	**Corn Yield (r)**	**Significance ($p < 0.05$)**
Temperature	-0.65	-0.45	Yes
Precipitation	0.72	0.60	Yes
Droughts (frequency)	-0.58	-0.50	Yes

The results demonstrated in the table indicate that temperature shows a strong negative correlation with banana yield, indicating that heating reduces productivity. On the other hand, precipitation is positively correlated with both crops, highlighting their importance for agriculture in Quevedo.
These findings support previous studies (Zambrano et al., 2021) on agricultural vulnerability to climate. The strong dependence on precipitation underscores the need to optimize water use, as proposed by Bonifaz & Mendoza (2025) through predictive models.
Applying multiple linear regression to determine the climatic impact on banana production, we find the variability in the production of this agricultural product, as indicated in table 4.
Table 4. Results of the Multiple Linear Regression Model

Predictor Variable	**Coefficient**	**Standard Error**	**P-value**	**R^2 Adjusted**
Temperature	-1.2	0.3	0.001	0.78
Precipitation	0.8	0.2	0.005	
Droughts	-0.5	0.1	0.01	

The model applied in the research determines 78% of the variability in banana production ($R^2 = 0.78$) and that temperature is the most critical factor by virtue of the high negative coefficient.
This validates the hypothesis that climate change threatens food security in Quevedo (Mendoza et al., 2023). It is recommended to implement resilient agricultural practices, such as heat-tolerant crops (Andrade et al., 2022).
Then, clustering was applied using K-means to be able to have groupings of zones by the different climatic characteristics, as shown in table 5.
Table 5. Grouping of Zones by Climatic Characteristics

Group	**Characteristics**	**Representative Areas**	**Climate Risk**
1	High precipitation, stable temperature	North of Quevedo	Floods
2	Low precipitation, high temperature	South and East	Droughts
3	Extreme variables	Town centre	Heat island, disease

It was determined that group 2 coincides with the areas reported in the literature in relation to the highest water stress (Medina, 2023) and that group 3 reflects the urban impact on the local climate (Morote & Olcina, 2023).
The identification of critical areas allows interventions to be prioritized. For example, group 2 would require efficient irrigation systems, while group 3 needs public health plans for vector-borne diseases (Burgos et al., 2025).
With all this information obtained, a predictive model based on Random Forest was generated to be able to predict extreme events and the results are visualized in table 6 below

Table 6. Extreme Event Prediction

Event	Model Accuracy (%)	Key Variables
Floods	85	Accumulated precipitation, soil moisture
Droughts	80	Temperature, water deficit

According to these results, it can be determined that high accuracy in the prediction of extreme events is useful for early warnings.

These models, integrated with socioeconomic data (González & Zhang, 2025), can improve community resilience, as suggested in the introduction.

The results confirm that climate change in Quevedo manifests itself in an increase in temperature and a decrease in precipitation, a negative impact on agriculture, especially in key crops and in areas with differentiated risks that cause floods, droughts, diseases. To avoid this, predictive models for water management can be implemented, agricultural policies based on climate data can be developed, and educational programs for community adaptation can be strengthened.

CONCLUSIONS

The analysis confirms that Quevedo faces critical climate challenges, with a sustained increase in temperature and reduced rainfall that threaten its food security and public health. The negative correlation between temperature and agricultural yield underlines the vulnerability of the sector, while the spatial grouping obtained with K-means reveals priority areas for intervention. Predictive modeling based on Random Forest proves to be an effective tool to anticipate extreme events, supporting their integration into public policies. However, mitigation requires comprehensive actions such as optimizing water use, resilient crops, and educational programs that empower communities, as Morote & Olcina (2023) point out. The combination of climate and socioeconomic data, along with technologies such as machine learning, offers a robust framework for decision-making. This study shows the urgency of adopting evidence-based strategies, with interdisciplinary collaboration, to guarantee sustainability in Quevedo in the face of climate change.

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