International Doctorate in Architecture and Urban Planning (IDAUP)
International Consortium Agreement between University of Ferrara Department of Architecture (DA) and Polis University of Tirana (Albania) and with Associate members 2014 (teaching agreement)
University of Malta / Faculty for the Built Environment;
Slovak University of Technology (STU) / Institute of Management and
University of Pécs / Pollack Mihály Faculty of Engineering and Information Technology.

Anira Gjoni

Adaptation of Climate Change in Albania,
Interpretation of climate Change in Terms of Weather and their effects on urban planning

IDAUP XXXVII Cycle

Università degli Studi di Ferrara | DA Dipartimento Architettura Ferrara | Universiteti POLIS

Adaptation of Climate Change in Albania

Interpretation of climate Change in Terms of Weather and their effects on urban planning

Candidate: Anira Gjoni
POLIS Supervisor: Prof. Assoc. Enkelejda Kucaj
DA Supervisor: Prof. Dr. Roberto Di Giulio

Cycle XXXVII

IDAUP

International Doctorate in Architecture and Urban Planning

Università degli Studi di Ferrara | IUSS

INTERNATIONAL DOCTORATE
IN ARCHITECTURE AND URBAN PLANNING

Cycle XXXVII

IDAUP Coordinator Prof. Roberto di Giulio

"Adaptation of Climate Change in Albania"

Interpretation of Climate Change in Terms of Weather and their effects on urban planning

Curriculum Urban Planning / IDAUP, Planning for local Weather changes (Lezha City)

Candidate

Anira Gjoni

(UniFe Matr. 180060)

(Polis Univ. Reg.N. PL581N100003)

Supervisor POLIS

Prof. Assoc. Dr.Enkelejda Kucaj

Supervisor DA

Prof. Dr. Roberto Di Gulio

(Years 2021/2024)

Acknowledgments

First and foremost, I extend my heartfelt thanks to my supervisors, Prof. Dr. Roberto Di Gulio and Prof. Assoc. Dr. Enkelejda Kucaj, for their invaluable guidance, unwavering support, and thoughtful feedback. Their expertise and encouragement have been crucial to the completion of this work. I am also deeply appreciative of those who have provided insightful advice on specific aspects of this research. Especially, I would want to thank Prof. Assoc. Dr. Enkelejda Kucaj for her continuous mentoring. My gratitude extends to the researchers involved in the project, as well as the members of the local advisory and national steering groups, whose contributions have greatly enriched this study. I would like to acknowledge the members of the Institute of GeoSciences for their ongoing support and for creating an environment conducive to academic growth. A special thank you to my family and friends for their unwavering encouragement and understanding. I extend my sincerest apologies to those whom I may have inadvertently neglected during the course of my work, particularly in relation to the "oblique strategy."

Finally, **to my beloved parents'** words cannot express how grateful I am for your love, sacrifices, and encouragement. This achievement is as much yours as it is mine.

With sincere gratitude!

Anira

ABSTRACT

Integrating adaptation strategies into development planning is now seen as indispensable for long-term sustainability. Though the topic of much scientific and professional focus, adaptation remains behind mitigation in the discussion of climate change. But growing scientific agreement that some consequences of climate change are already unavoidable suggests this scenario will change in the next years. This study intends to show, investigate, and prove how urban planning systems can create adaptation plans and interventions in urban systems in response to climate change using certain professional tools. Urban systems not only contribute disproportionately to climate change but also are expected to suffer greatly from the consequences. Moreover, most of the world's population is now urbanised, indicating that adaptation will be vital to create urban systems that can withstand the consequences of climate change. This chapter looks at the broad effects and fast repercussions climate change is projected to have on cities as well as how nature-based solutions (NBS) could enhance the ability of cities to adapt to shifting climate and reduce their adverse effects.

While we will also cover impacts on hydrological, ecological and social elements, the emphasis is on urban temperatures. We also address issues for planning and design of effective NBS implementation for climate change adaptation inside urban regions. This paper offers an informed knowledge and illustration of adaptation as a reaction to climate change, its application in urban systems, and some of the roles and methods that planning might assume in the development and execution of urban adaptation. Urban planning systems, it finds, play crucial roles in changing urban systems to the several consequences of climate change. Drawing a scientific conclusion on urban planning and climate change calls for an interaction across several disciplines including urban planning, climate, and meteorology. Main subjects include: (1) general climate change effects and implications for urban areas; (2) feasible ways to adapt to climate change using nature-based solutions (NBS); and (3) particular planning and design issues for the efficient application of NBS inside urban areas. The project intends to set a baseline for possible future research on planning decisions for climate change adaptation as well as offer general direction and support for the professional planning community coping with climate change adaptation.

ASTRATTO

L'integrazione delle strategie di adattamento nella pianificazione dello sviluppo è oggi considerata indispensabile per la sostenibilità a lungo termine. Sebbene sia un tema di grande interesse scientifico e professionale, l'adattamento rimane in secondo piano rispetto alla mitigazione nel dibattito sui cambiamenti climatici. Tuttavia, il crescente consenso scientifico sul fatto che alcune conseguenze dei cambiamenti climatici siano già inevitabili suggerisce che questo scenario cambierà nei prossimi anni. Questo studio intende mostrare, indagare e dimostrare come i sistemi di pianificazione urbana possano creare piani e interventi di adattamento nei sistemi urbani in risposta ai cambiamenti climatici utilizzando specifici strumenti professionali. I sistemi urbani non solo contribuiscono in modo sproporzionato ai cambiamenti climatici, ma si prevede anche che ne subiranno gravemente le conseguenze. Inoltre, la maggior parte della popolazione mondiale è ora urbanizzata, il che indica che l'adattamento sarà fondamentale per creare sistemi urbani in grado di resistere alle conseguenze dei cambiamenti climatici. Questo capitolo esamina gli effetti generali e le rapide ripercussioni che si prevede che i cambiamenti climatici avranno sulle città, nonché il modo in cui le soluzioni basate sulla natura (NBS) potrebbero migliorare la capacità delle città di adattarsi ai cambiamenti climatici e ridurne gli effetti negativi. Sebbene tratteremo anche gli impatti sugli elementi idrologici, ecologici e sociali, l'enfasi è sulle temperature urbane. Affrontiamo anche le problematiche relative alla pianificazione e alla progettazione di un'efficace implementazione di NBS per l'adattamento ai cambiamenti climatici nelle aree urbane. Questo articolo offre una conoscenza approfondita e un'illustrazione dell'adattamento come reazione ai cambiamenti climatici, della sua applicazione nei sistemi urbani e di alcuni dei ruoli e dei metodi che la pianificazione potrebbe assumere nello sviluppo e nell'attuazione dell'adattamento urbano. Si rileva che i sistemi di pianificazione urbana svolgono un ruolo cruciale nel modificare i sistemi urbani in risposta alle diverse conseguenze dei cambiamenti climatici. Per trarre conclusioni scientifiche su pianificazione urbana e cambiamenti climatici è necessaria l'interazione tra più discipline. Gli argomenti principali includono: (1) gli effetti generali dei cambiamenti climatici e le loro implicazioni per le aree urbane; (2) modalità praticabili per adattarsi ai cambiamenti climatici utilizzando soluzioni basate sulla natura (NBS);

e (3) problematiche specifiche di pianificazione e progettazione per l'applicazione efficiente delle NBS nelle aree urbane. Il progetto intende gettare le basi per possibili future ricerche sulle decisioni di pianificazione per l'adattamento ai cambiamenti climatici, nonché offrire indicazioni e supporto generali alla comunità professionale della pianificazione che si occupa di adattamento ai cambiamenti climatici.

TABLE OF CONTENTS

Abbreviations

SEA- Strategic Environmental Assessment (SEA)

GHG-Greenhouse Gas (GHG)

NBS-Nature-Based Solution (NBS)

PA-Paris Agreement (PA)

NDC-Nationally Determined Contributions (NDCs)

CCA-Climate Change Adaptation (CCA)

UNFCCC-United Nations Framework Convention on Climate Change (UNFCCC)

IPCC-Intergovernmental Panel on Climate Change (IPCC)

WMO-World Meteorological Organization (WMO).

TABLE OF CONTENTS

LIST OF THE TABLES

LIST OF THE FIGURES

CHAPTER I: INTRODUCTION

The introduction chapter is essential for this thesis because it provides an extensive research study overview. This introduction provides clear information regarding some of this research study's most critical research areas. These include the topic of the research, the problem statement or why this research study is re-searchable, the research's objective or aim, the question hypothesis, and the theoretical framework. Additionally, it summarizes the overall methodology employed in the study and concludes with a detailed outline of the thesis structure.

1.1. Research background

Climate change emerges as a significant challenge in the world and changes has emerged as one of the most pressing global challenges of the 21st century, with profound implications for human health, ecosystems, and socio-economic systems (IPCC, 2021). Even as the world is battling to control this problem, climate change has created relentless problems whose consequences have challenged the status quo and forced humanity to rethink to prevent the consequences. Like other parts of the country, Europe faces the consequences of change. Adaptation to climate change is crucial in addressing the adverse impacts and involves adjusting natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2018). The Intergovernmental Panel on Climate Change (IPCC) has indicated that global net human-caused emissions of CO2 must decrease by 45% below 2010 levels by 2050 to limit global warming to 1.5°C above pre-industrial temperatures (IPCC, 2018).

Adaptation measures encompass changes in practices, processes, or structures of systems to cope with projected or actual changes in climate (Watson et al., 1996). Change is listed as a top priority for every human in the world; the impacts of global climate change threaten human existence and make the world inhabitable. Therefore, “addressing climate change is a significant priority in the world.” At this point, the main global reaction to the danger of climate change is mitigation, particularly in terms of lowering greenhouse gas emissions to different levels. Most of the scientific evidence points to human greenhouse gas emissions as the cause and aggravator of climate change; cutting the amount of gas released will help to control its consequences. The emphasis is on the regulations that can help countries limit the extent of greenhouse gas emissions. Both scientific studies and meteorological research suggest that with a limited amount of the gasses released, there is a high chance that humanity might be able to save the planet from the damaging impact of climate change.

Despite this, there is little evidence of effort to ensure the countries are putting their emission in check. At the same time, research studies show that the effort in place is still not reasonable enough to warrant cases where climate change might shift due to the reduced gas emissions in the world. Thus, there are notable issues with "the effect of climate change is becoming unavoidable." It is becoming one of the most notable areas of particular interest even as the world battles other challenges. Another problem is that even the solutions used today do not provide enough planetary solutions to change the fates of climate change. Humanity, therefore, must devise other means and tools to solve the consequences of constant weather change and save the planet. Unpredictable patterns of weather change are one of the significant challenges facing the current generation. They are a major issue that profoundly affects natural and human systems worldwide.

Particularly Europe is likely to have significant challenges adjusting to and minimizing the effects of extreme weather occurrences, as Kreibich et al. (2014) underlined. Predictions indicate that the effects of weather can disrupt nearly every aspect of life on Earth, necessitating urgent and comprehensive responses (Garnaut, 2008; IPCC, 2007). One of the most straightforward solutions today is the "adaptation to climate change." As the world struggles to uncover new ways to reduce or change the fate of climate change, which is constantly failing, there are new research bodies that reveal the potential success of humanity evolving to adapt to the consequences brought about by the weather changes on a global platform. From this point of view, adaptation "means efforts to develop resilience to anticipated or potential climate impacts and effects before and when they occur" (Garnaut, 2008, p. 23). It also implies that the world will develop new strategies aligned with unpredictable weather changes' emerging challenges.

These include modifying the city centres and urban patterns and developing new tools to protect humanity against the ravaging of these effects. "Given the broad spectrum of possible climate effects and how these might influence human and natural systems, policies have to be created and carried out that operate across several systems and handle climate consequences in locally suitable ways" (Garnaut, 2008, p. 45). The Regional Climate Change Adaptation Framework for the Mediterranean Marine and Coastal Areas aims to increase resilience by assisting policymakers and stakeholders in developing and implementing coherent adaptation policies. Soil pollution remains a critical issue, with high concentrations of pollutants posing risks to public health and agricultural productivity (Kucaj et al, 2023). Trends in rainfall distribution show extremes, with events varying between very dry and rainy conditions throughout several areas (Gjoni et al., 2024). Among the most potential adaption plans now being studied is the use of nature-based solutions (NBS), which use natural processes to reduce climate hazards.

These imply using natural approaches and means to find new ways to adapt. Primarily, they focus on restoring the significant areas that would boost the climate. These include restoring the water catchment areas, planting trees, avoiding deforestation, and finding new ways to restore nature to prevent further deforestation. Whether this approach will become the foremost solution to climate change remains a significant puzzle. Due to a desire to find a solution, studies are focused on new and better ways to handle the consequences of unique climate or weather changes. This research study, therefore, looks to add to this research study by focusing on how critical urban planning could be another way to increase the adaption of the effect of climate change. Urban planning is one of their primary areas of concern as research consistency shows that better and more modern urban planning could be used to manage the impact of the weather in general. Recent climate observations from 11 meteorological stations in Albania indicate that the average annual temperature has risen by 2.8 degrees, and rainfall has decreased by 300 mm compared to the long-term average from 1961-1990.

During the May-September period, only 18-20% of the annual rainfall occurs, adversely impacting water availability. In mountainous areas, snowfall depth varies from 60-120 cm, with peaks reaching 2-3 meters in regions such as Vermosh, Boga, Theth, Valbona, Curraj, and Lure (Lushaj & Kucaj, 2024). In Albania, regions such as Shkodra, Lezha, Lushnja, Fieri, and Vlora have already experienced negative effects on wheat, maize, and other crop yields due to climate change. The Lezha region in north western Albania is particularly vulnerable to climate change due to its geographic and socio-economic characteristics (European Environment Agency, 2020). The development of effective adaptation strategies in Lezha is challenged by uncertainties in climate projections. Thus, this research study focuses on Lezha Albania to uncover the meteorological developments in these areas. Lezha is a well-known city or community within Albania with mixed weather patterns. As a result, significant developments have occurred within this city to adapt to the changing weather patterns. Lezha is an area that has a unique climate with both positive and negative impacts that are well-documented, mainly due to its closeness to the sea and the exceptional weather pattern. The study thus focuses on the strategies the local governments and other organisations are implementing to ensure that the people within these areas adapt to the changing weather patterns.

Furthermore, the research study will uncover the implementation of the adoptable strategies the community is using to shield themselves against the effects of changes in climatic patterns. The purpose is to uncover the best ways human beings can find safety even as these effects occur on the planet. The proposed issues include a strategic understanding of the benefits of the nature-based solution and its utilization within the areas. Eventually, this research project will record the effects of climate change and the measures taken to guarantee the community remains safe from these effects as well as ongoing preparation in the aim to guarantee that there are flexible strategies to protect the community from tragic problems connected with the constant changes in the weather as notable in many regions across the world. Ultimately, this research project will record the effects of climate change and the measures taken to guarantee the community remains safe from these effects as well as ongoing preparation in the hope that there are flexible plans to shield the community from tragic problems linked with the constant changes in the weather as notable in many regions across the world.

1.2 Research Study Scope and Context

Over the past centuries, humanity has struggled to understand the weather variation in the world. In doing so, they have also come up with many ways to reduce the growing concern about the consequences of weather change. Despite that, there is an increasing need to understand how to combat climate change, mostly in urban areas. The focus of this research study is Lezha in Albania. Albania, located in southeaster Europe with a Mediterranean climate and rich biodiversity, is highly vulnerable to changes brought about by the shifting environment. The country "faces significant challenges due to its geographic location, socioeconomic conditions, and reliance on climate-sensitive sectors such as agriculture, energy, and tourism" (Gary Austin et al., 2013, p. 34). Consequently, Albania must adopt "robust adaptation strategies to mitigate the adverse effects of climate change and ensure rising global temperatures and the increasing frequency of extreme weather events drive sustainable development and the urgency"(Gary Austin et al., 2013, p. 21).

Effective adaptation in Lezha necessitates a comprehensive understanding of climate risks, uncertainties, and health impacts (WHO, 2018). Urban regions in Albania, where integrated climate impacts associated to water, energy, transportation, land use, buildings, and insurance call for coordinated adaptation strategies, concentrate most of the population and economic activity (Wilson, 2006). In the Kune-Vaini Lagoon near Lezha, efforts are underway to scale up ecosystem-based adaptation to address more frequent and intense flooding, a serious climate change threat in Albania. Limited financial resources, insufficient technical capacity, and gaps in data and research hinder the country's ability to develop and execute comprehensive strategies. Albania, located in southeaster Europe, has a Mediterranean climate and rich biodiversity but faces increasing climate-related challenges. Rising temperatures, shifting precipitation patterns, and extreme weather events threaten Albania's environmental and socio-economic stability (UNDP, 2019; McMichael et al., 2006).

Albania's climate is characterized by seasonal variations, with 70-80% of annual rainfall occurring between November and April, leading to frequent flooding and soil salination in coastal areas (Lushaj et al., 2024). Conversely, the dry period from May to September sees only 20-30% of annual rainfall, exacerbating water scarcity challenges for various economic sectors. The challenges faced by Lezha in climate adaptation, including financial constraints, community engagement, and institutional barriers, were compared with findings from similar studies in Tirana, Vlora, and coastal cities in Greece and Italy. This comparison highlights whether Lezha's challenges are unique or part of broader regional patterns. While some adaptation barriers are shared across the Mediterranean, Lezha's vulnerability to extreme weather events and reliance on climate-sensitive economic sectors (e.g., agriculture and tourism) suggest some region-specific risks requiring targeted policy responses. Thus, its unique geographical features make it a suitable place for this study.

Specifically, the study is based in Lezha, the main element affecting weather conditions and their consequences in this area. Lezha was chosen as the specific area for this study because of its climatic characteristics and the overriding patterns of the climate, making it both vulnerable and a good place for human habit. At the same time, underlying adaptability triggers are being implemented in these regions, all of which aim to combat the growing concern of change in weather. These, in particular, make it a good place to study. Lezha has many features that make it essential for the study. Among these are "a variety of terrain features and microclimate conditions, different forest formations, large areas with swamps accompanied by lithographs and sandy beaches, geological formations abundant in minerals and groundwater, and a rich hydrographic network" (Garnaut, 2008, p.98). Addressing climate change adaptation in Lezha requires a multi-sectoral approach that engages stakeholders from public health, urban planning, environmental management, and local governance (Adger et al., 2005). Effective adaptation planning and implementation can help build resilience and reduce vulnerability to the changing climate in Albania. Furthermore, "the municipality of Lezha contains various protected areas of national and international importance including Kune-Vain-Tale Nature Reserve offers significant promise for the area. Bërna's protected natural area is also designated as a natural reserve these make it essential for the study. A lot has been in place to ensure there is limited damage and an increase in adaptability. An example is the restriction on industrialization, which tamed the increasing pollution. Even though these restrictions have had a positive impact, immense pressure has led to some cases being unsolved. Natural disasters threaten the "territory of Lezha municipality" in these significant instances of seismic risk, flood risk, geo-hazards in the form of landslides and rock falls, risks from atmospheric factors like snow jams and forest fires, and the risks that follow from climate change" (Garnaut, 2008, p. 34). These key features also make this area an interesting place to study to understand how the area's leadership is working to implement adaptability measures to reduce these risks.

In this context, CCA policies are essential in reducing vulnerability and enhancing alignment to climatic shifts, particularly in regions like Lezha, which face significant environmental and socioeconomic challenges. In its latest report, the IPCC (2022) highlighted a critical knowledge gap regarding the functioning and effectiveness of CCA policies. The report calls for more empirical studies to evaluate these policies, emphasizing the importance of understanding how "they contribute to the broader goals of the Paris Agreement (PA) and nationally determined contributions (NDCs)" (Garnaut, 2008, p. 14). By addressing this knowledge gap, the findings of this research will help "expand the implementation of the Paris Agreement" reason as well as substantive research-based conclusions on the level of the effectiveness of CCA solutions at the local level.

The study aims to support the community of Lezha in identifying, understanding, and utilizing opportunities to increase their adaptive capacity. This will be achieved through social and environmental training and leveraging existing national government policies and those specific to the Lezha district. The research will guide local stakeholders in adapting to climate change by enhancing their capacity to implement effective solutions. This study is grounded in three core bodies of knowledge: policy on Adaptation to climate change in urban areas, which explores various approaches, including infrastructure improvements, nature-based solutions, policy and governance frameworks, and community engagement initiatives. Thus, the present research aims to increase the resilience of city under the study to natural hazards and to create a methodology through the analysis of urban infrastructure, physical interventions in the territory, and environmental potentials by studying and adapting successful case studies in different countries. The conclusions from the analysis show that this area is unprepared to cope with natural hazards that have occurred frequently in recent years, such as floods, heat waves, forest fires, etc., which translate into environmental problems.

The causes of these environmental problems start from floods and intense or very intense rains that occur in short periods. The cause of droughts and heat waves is the increase in maximum air temperatures. Above 35.00C and those min. above 20.00C. The temperature increase in thermal values and their extension for several days is worth noting. These changes in weather conditions are a consequence of the constant shift in the level of precipitation and the changes in the temperatures that have occurred globally. The city and those who are fortunate to inhabit the area are directly exposed to the consequences that these natural phenomena can bring to health and well-being. Findings from this study will provide valuable insights into the region's preparedness for natural hazards, including floods, extreme heat events, and environmental degradation. Given the direct impact of these phenomena on public health and socio-economic stability, effective climate adaptation is imperative for ensuring the long-term sustainability of Lezha and similar urban areas in Albania and the broader Mediterranean region.

1.3 The Problem Statement

Climate change is a significant problem in Lezha and Albania. In this area, increased rising temperatures and unpredictable climate patterns pose more important challenges for urban planners. With the extreme cases of flooding, seismic risk, rock and falls, and landslides, these areas have had significant challenges that have made it difficult for proper urban planning. Lezha has faced an altered precipitation pattern with overall challenges in the distribution and volume of the rainfall in the areas. These have increasingly led to over-flooding in the regions. At the same time, it has become a growing challenge for the city municipal to "create a better drainage system to manage the constant and unpredictable patterns of flooding in the areas"(Garnaut, 2008, p. 4). At the same time, the more prolonged spell of heavy rainfall has also led to the massive distraction of the infrastructure, making it challenging for their city municipal to manage and sustain better infrastructure developments within the urban areas.

At the same time, Lezha and Albania, in totality, have also experienced fluctuating cases of temperatures increasing and dropping, making it unbearable hot during the summer and extremely cold during winter. These have led to multiple public health issues and resulted in many urban activities within the area. The challenges of a change in weather have impacted urban planning. The unpredictable weather patterns, like excessive rainfall and extreme natural events like the seismic tremors and flooding experiences within Lezha, have led to massive instability in urban planning and infrastructures. For instance, there is a need for urban infrastructure resilience, with stability being the priority. However, the rate of destruction that is evident in this array shows that the majority of the infrastructures are not resilient and need more stability. It is an implication that there are limited structures that can withstand irregular weather patterns, prompting the need for more research on how this infrastructure adapts for security and safety reasons. Furthermore, climate change effects have also made land use and planning difficult because of zoning challenges.

Issues such as constant flooding and seismic effects have significantly impacted the land, making it difficult for the municipality to zone the land and make it worthwhile for the residents. Understandably, urban planning also entails a clear plan for transportation issues. These have also been affected by the unpredictable weather patterns within the areas. The unfamiliar weather pattern within these areas has made proper urban planning and development complex, leading to a massive impact on the populace's lives. It is thus important to focus on the solution to develop better ideologies and strategies to reduce the chances of these dangers occurring. Despite research in this area, However points out apparent loopholes in the preparedness and the strategies the municipality has implemented to ensure minimal damages. The research studies in these areas show the extent of the unpreparedness with the limited resources available to combat the regularized weather patterns and reduce the consequences of climate change.

First, evidence shows limited policies that help tackle the ravages caused by climate change. Even though the municipality has put in effort to ensure some policies protect the infrastructure, they are focused on the developments rather than the solution to the impending dangers the people face. Most of these policies "target developments instead of focusing on nature-based strategies that can help people adapt to the challenges posed by changes in weather pattern" (Haaland & van den Bosch, 2015, p. 45). Therefore, there is a clear need for the municipality to develop policies and strategies that reorganize their plan for better urban developments to cater to adjustments due to the shift in the weather within the areas and other parts of the world. The majority of the policies are not people-centric, and this should change. There is a need for better recommendations to ensure that urban planning becomes the centre of the policies made to ensure that there are better ways through which people live and cope with the challenges that come with climate change.

Even though many disasters have occurred, preparedness within these areas is another area that needs some adjustments. There are limited research studies regarding disaster preparedness, mainly among municipalities. Studies show that the strategies put in place are not focused on preparedness. Disaster preparedness is an essential tool that ensures that the residents know the existence of these challenges brought by changes in the climatic conditions within their residential areas and are ready and flexible enough to react when needed. Therefore, although climate change has become a significant concern, there is no specific level of preparedness and a lack of quality strategies to minimize its impact on people. One of the tools for developing plans that let people adjust to "the effects of climate change" is urban planning. But it is clear that in the studied areas (Lezha), the absence of priorities in urban planning is significantly aggravating the effect of climate change on the inhabitants. Municipal planning is "less likely to contribute positively to controlling the impact of climate change" (Haaland & van den Bosch, 2015, p. 13). First, the policies developed in these areas do not include proper urban planning and are less people-centric. This implies that even with them, there is little that the residents can do to limit the damage caused by climate change. At the same time, poor urban planning means high damage rates due to irregular weather patterns and rainfall, sometimes leading to massive flooding in the areas. With poor urban planning and policies, most residents are unaware of how to respond to them, leading to massive casualties. Furthermore, a lack of disaster awareness and preparedness also contributes massively to the high impact of disaster damage. Therefore, there is a need to "improve urban planning and come up with a solution that can help prevent or limit the impact of climate change"(Garnaut, 2008, p. 15).

This research study, therefore, focuses on providing this solution. The present research focuses on the investigating and thus finding solution to improve the resistance of the city under study to natural hazards and to create a methodology through the analysis of urban infrastructure, physical interventions in the territory, and environmental potentials by studying and adapting successful case studies in different countries. The solution provided in this research study will ensure that urban policies limit the damage caused by the constant changes in the climatic condition within the city under the study. At the same time, the solution aims to ensure the safety of the people, their awareness of these potential hazards, and their preparedness is prioritized in the areas. These will ensure that even though climate change remains a significant problem, people can cope with its challenges and thus reduce the impact on their lives.

1.4 States of art and importance of research study

Climate change is a significant challenge for Lezha and Albania as a whole. Sustainable development is not a destination. Rising temperatures and unpredictable climate patterns pose severe challenges for urban planners. Extreme events such as flooding, seismic risks, rockfalls, and landslides have created significant obstacles to effective urban planning and infrastructure development. In Lezha, altered precipitation patterns have disrupted the distribution and volume of rainfall, leading to frequent over-flooding. These conditions present increasing challenges for municipal authorities, who struggle to create efficient drainage systems to manage the unpredictable flooding patterns (Garnaut, 2008, p. 4). This section focuses on the reason for conducting this research study. The section further focuses on the some of the reason why undertaking his research study is paramount based on the events happening today. These include the need for the such a study to be priority as the world prepares to face the consequence of the weather changes.

It also pinpoints the consequences of undertaking the survey or failure to do so in the long run. Additionally, Lezha and Albania have experienced fluctuating temperature extremes, with unbearably hot summers and extremely cold winters. These fluctuations have resulted in numerous public health issues and have severely impacted urban life and economic activities. The challenges posed by changing weather patterns have greatly affected urban planning efforts. Unpredictable weather events, such as excessive rainfall and seismic tremors, have contributed to the instability of urban infrastructure. For instance, urban infrastructure in Lezha lacks resilience, with many structures unable to withstand extreme weather events, highlighting the urgent need for research into more adaptable and sustainable infrastructure solutions. Furthermore, climate change has complicated land use and zoning strategies. Constant flooding and seismic activity have significantly affected land stability, making it challenging for municipal authorities to effectively zone land for development and residential use.

Transportation networks have also been severely impacted, with unpredictable weather patterns disrupting mobility and accessibility within urban areas. These challenges make urban planning increasingly complex, affecting residents' quality of life and economic activities. Evaluating and modelling Climate Change Effects is the initial source of worry. It is vital to note that "advanced techniques and procedures have been established to analyze and model the unique implications of climate change on metropolitan areas, and this is based on diverse studies. " These include the changes in different situation involving the climatic condition, urban climate models, and vulnerability assessments considering the link between climate hazards and urban systems. Advances in spatial analysis and remote sensing technologies have further enhanced the ability to map and analyse climate change risks at the urban scale. The next is the Nature-Based Solutions (NBS). The NBS includes strategies like green infrastructure, urban forestry, and water-sensitive urban design, which have gained increasing recognition as effective and sustainable adaptation strategies (López et al., 2019).

These approaches leverage natural processes to mitigate climate change impacts, enhance urban resilience, and "provide multiple co-benefits, such as improved air quality, reduced urban heat island effect, and increased biodiversity" (Reckien et al., 2023, p. 4) Adaptive governance and institutional frameworks are also another important part of the art issues that must be considered as far as the topic of climate change is concerned. The importance of adaptive governance and flexible institutional frameworks for urban climate change adaptation has been widely acknowledged (Reckien et al., 2023). This involves developing adaptive policies, fostering collaborative partnerships among stakeholders, and "integrating climate change considerations into urban planning and decision-making processes" (Reckien et al., 2023, p32). Participatory approaches that engage local communities in adaptation planning and implementation are also gaining traction. Innovative city technologies, including sensor networks, data analytics, and early warning systems, can enhance the ability to monitor climate change impacts, manage resources efficiently, and respond effectively to extreme weather events, (UNDP Issues Brief on Urban Climate Resilience, 2023). As one of the major solutions, smart cities yards emerging as strong candidate adaptable strategies that are likely to "improve the safety of the people amid the risk of climate change" (UNDP Issues Brief on Urban Climate Resilience, 2023, p. 341). One of the fields still open for exploration and emphasis in the search for improved methods to increase resilience and lessen the influence of climate change is this one. Another area of concern is the focus on equity and social justice. A growing emphasis on equity and social justice in urban climate change adaptation recognizes that the impacts of climate change are not evenly distributed and can disproportionately affect vulnerable populations (Doherty et al., 2016). This has led to a focus on developing adaptation strategies that address social vulnerabilities, promote equitable access to resources, and ensure that all urban residents share the benefits of Adaptation.

The inclusion of "Mitigation and Adaptation is also another key area of concern" (López et al., 2019, p. 45) into urban planning and policy is being pursued more and more as their interdependence is acknowledged. This involves "identifying synergies and trade-offs between mitigation and adaptation measures and developing integrated approaches that maximize both climate and societal benefits" (López et al., 2019, p. 45); Transformative Adaptation is also another area of concern. The concept of transformative Adaptation, which involves fundamental shifts in urban systems and practices to address the root causes of vulnerability, is gaining attention (Revi et al., 2014). This approach recognizes that incremental adaptation measures may not address the long-term challenges of climate change and calls for more systemic and transformative changes in urban development patterns, governance structures, and societal values. Despite these advancements, significant challenges remain in implementing effective urban climate change adaptation strategies. These include limited resources, institutional barriers, lack of data and information, and the need for greater public awareness and engagement. Further research and innovation are needed to overcome these challenges and accelerate the transition towards climate-resilient cities.

1.5 Importance of Research Study

The present research study focuses on the challenges of changes in weather conditions and how well urban planning can be key to curbing the consequences of changes in the weather or climate conditions, which is essential in many aspects. First, this research's primary focus is to help urban and environmental planners as a methodology and working tool that considers the impacts of natural hazards due to climate change. In this case, the aim is to ensure that urban planners incorporate the needed climatic changes into their planning to ensure that the outcome of their plan also has a means of combating the disasters that have become notable due to the constant shifting of weather pattern in the world. By considering the consequences of natural hazards, urban planners can devise a solution that focuses on creating or developing better infrastructure that considers the intensity and extent of these hazards. At the same time, this research study is also important because it is the lovely interpretation of climate change's effects on urban pla, which holds significant importance for several reasons. First, it addresses the local vulnerabilities. For instance, “Lezha, like many urban areas in Albania, faces significant risks from climate change, including rising temperatures, extreme weather events”and flooding; by examining the effectiveness of existing CCA policies and identifying gaps, the study helps develop solutions that address the region's unique vulnerabilities.

Furthermore, there is an emphasis on enhancing adaptive capacity. Understandably, the "ultimate goal of climate change adaptation is to build resilience and enhance the adaptive capacity of communities" (López et al., 2019, p. 56). This study's exploration of how social and environmental instruments can increase adaptive capacity in Lezha is vital for developing sustainable, long-term solutions. By examining the role of local stakeholders, including the community, urban planners, and policymakers, the research can provide recommendations for enhancing collaboration and empowering local actors to take ownership of adaptation efforts. Furthermore, this research study looks to enhance urban resilience. By investigating how weather patterns, altered by climate change, impact urban areas, this study will contribute to developing more effective adaptation strategies. These strategies are crucial for building climate-resilient cities that can withstand an impact from disasters or any other calamities they intend to prevent in the future. Cities face diverse climate risks, and this research seeks to provide tailored solutions for various urban contexts.

Also, the study is important because it helps improve planning in many cities that experience the same problem. The study's findings will inform urban planning and design practices by providing evidence-based insights into the relationship between weather patterns and urban development. "This knowledge will enable planners and designers to create more sustainable and resilient urban environments that can adapt to change brought by the weather or climate" (Bulkeley & Tuts, 2013, p. 12). Similarly, it helps in informing policy and decision-making. The research findings will provide valuable information for local, national, and international policymakers. This evidence-based knowledge will the growth and enhancements of the of effective climatic condition and adaptation policies and adaptation plans that can guide urban development and enhance resilience. The experiences of Copenhagen demonstrate the importance of well-integrated planning and stakeholder coordination, and this research will contribute to such efforts.

Change adaptation is another area of interest and topic that many studies have explored as a solution to the impact of weather changes at the global level. These are changes not only focused on how to approach matters but also on how to plan for the urban system. The research will advance the field by exploring "the complex interactions between weather patterns, urban systems, and planning practices and provide new insights into the challenges and opportunities of building climate-resilient cities" (Bulkeley & Tuts, 2013, p. 19). Lastly, the research study is important because it helps support sustainable development. The importance of this study also lies in its potential to support sustainable development in Lezha and similar regions. As urban areas grow and climate change impacts intensify, ensuring that urban planning integrates climate resilience will be crucial for maintaining economic, social, and environmental sustainability. The research will help align adaptation efforts with sustainable urban development goals, fostering resilient cities to help curb the consequences of disasters. In summary, this research study addresses a critical global challenge, contributes to developing practical solutions, and promotes urban equity and public health, making it one of the most critical research studies today.

1.6 Research of the study, questions, objectives, and hypothesis

1.6.1. Objective

The present study follows formed and well-crafted specific objectives it aims to achieve at the end of the research. These objectives will measure the extent of the research study's success or failure. The present study aims to identify key barriers and challenges to implementing CCA strategies and analyse how these challenges can be overcome to create social and environmental opportunities in Lezha City. The following will be the specific objectives that the research study will pursue.

1. To recognise that rural communities' adaptive capacity depends on climate hazards, socioeconomic shocks, available resources, and livelihood strategies.

2. To evaluate how climate change adaptation (CCA) policies are implemented in Lezha, focusing on social and environmental Adaptation mechanisms.
3. To analyse the features of precipitation, temperature, and their impacts on community livelihoods.
4. To understand the effects of erratic rainfall, floods, and droughts on agriculture, infrastructure, and the local economy, with particular attention to seasonal variations such as the pronounced droughts in July and August.
5. To assess the role of social and environmental tools in increasing the adaptive capacity of the Lezha community, focusing on their effectiveness in fostering resilience to climate change impacts.
6. To assess the knowledge level of the inhabitants of Lezha, primarily on problems such as "social and environmental opportunities brought by climate variability" and how these might be utilized for long-term resilience.

1.6.2 Research questions

The above research study objectives were used to generate multiple research questions. These questions guide the research study and have implications for it.

RQ1: How are climate changes evidenced and interpreted regarding weather patterns and impacts in the Lezha city?

RQ2: What strategies and measures can be implemented to increase the capacity of cities, particularly Lezha, to enhance resilience against natural hazards?

RQ3: How can "green infrastructure" and "nature-based solutions" properly fit cities to climate change and guarantee sustainable urban development?

1.6.3. Hypothesis

Multiple research study hypotheses also guide this research. It hypothesizes that:

1. Climate change significantly influences urban planning practices, necessitating adaptive strategies focused on index assessment, spatial simulation, and urban public health considerations to build climate-resilient cities and resilience of urban and rural communities in Lezha.
2. The impact of change in the global climate disproportionately affects vulnerable populations in Lezha, necessitating the development of effective adaptation measures.
3. Urban planning tools, including green infrastructure and "nature-based solutions," significantly mitigate the adverse effects of disaster vulnerability in Lezha, responding to the dynamic weather challenges.

1.7 Theoretical and Conceptual Framework

The theoretical background lays the groundwork for the entire PhD thesis by establishing the intellectual framework guiding the research. It delves into the core theories, concepts, and frameworks relevant to climate change adaptation and urban planning, critically analysing existing knowledge and setting the stage for the finding's contributions (Pauleit et al., 2015). This involves tracing the evolution of key concepts, highlighting primary debates, identifying areas of consensus, and placing the research within the broader academic discourse. One theory that explains this topic is the urban adaptation theory. The research "of the relationship between cities and climate change" is a developing topic drawing increasing interest lately (While & Whitehead, 2013, p. 45).

Historically, large cities in the Global North have been the main focus of climate change research, given their size, urban form, and high levels of consumption, which contribute significantly to greenhouse gas emissions. (Rosenzweig et al., 2010). However, recent trends show a broader global shift, where climate change and Adaptation effects are receiving increased attention worldwide. Especially following the IPCC's founding in 2010, the activity of groups like the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) has mirrored this change.

The theory is thus important for the study. The devastating effects of hurricanes such as Katrina in the United States clearly showed the need for cities to improve their resilience to climate impacts. This event helped propel the global conversation on urban climate adaptation. "The C40 network, formerly headed by New York City's Mayor Michael Bloomberg and currently led by Anne Hidalgo, Mayor of Paris, is an example of global initiatives focused on urban climate adaptation. Bloomberg now serves as the U.N" (Otto-Zimmermann, 2011, p. 234). Thus, it is paramount for the world to refocus on adapting to the effects of weather changes in case finding a solution to their occurrence has failed in the many attempts. The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards, exposure, and vulnerability. The results of dynamic interactions between climate-related hazards and the exposure and vulnerability of the affected human or ecological system to the hazards. Impact generally refers to effects on lives, livelihoods, health and well-being, ecosystems and species, economic, social, and cultural assets, services, and infrastructure. Impacts can be adverse or beneficial.

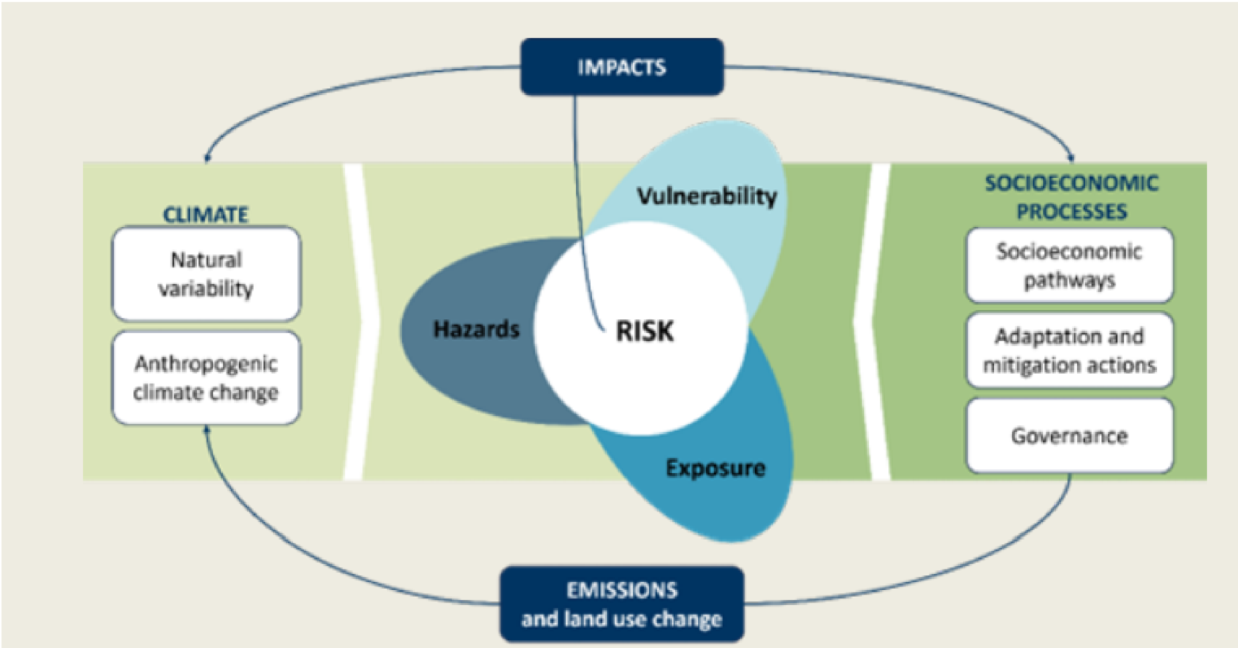


Figure 1. Determinants of climate impacts, Source: Definitions from (IPCC, 2023)

Moreover, the support of "The New Urban Agenda at the third UN Conference on Housing and Sustainable Urbanization (Habitat III) in Quito" underlines the importance of climate-resilient urbanization by stressing low-carbon and sustainable cities as a main tool for tackling climate change (UN-Habitat, 2016). The forward theory regarding urban Adaptation is also crucial for this research study. Urban climate adaptation research can be divided into four interrelated subfields: the first areas are the Climate Hazards, Risks, and Impacts. This subfield focuses on understanding cities' specific climate hazards, including extreme weather events and changing climate conditions directly affecting urban areas. The second areas are the Climate Vulnerability, Resilience, Equity, and Justice. Research in this area explores how climate impacts affect different communities within cities, often linking to urban poverty, social inequality, and the need for equitable resilience strategies. The last area is Planning and Managing Climate Risks. This subfield addresses how cities plan and manage climate-related risks. It includes strategies for ecosystem management, infrastructure planning, and spatial planning that can mitigate or adapt to climate impacts. The last subfield is Governance and Institutional Arrangements, which examines the governance structures that support climate adaptation in urban areas, including institutional arrangements, organizational frameworks, and the role of various stakeholders in cities' key development decisions. Thus, the theory of urban Adaptation provides a clear view of the need to consider the consequences of the shift in the weather pattern around the globe as one attempt to solve the issues of that come as a result of these patterns not only in small geographical places but in more extensive or global areas. The concept supports the necessity for nations and the community to concentrate on the plans enabling climate change adaptation in communication. The theory supports the multiple strategies, including different government bodies' attempts to instil laws that require minimal release of dangerous gases into the air. These also include strategies that attempt to limit the production of chemicals dangerous to the atmosphere. This theory considers that strategies and policies that tame the increasing reliance on prevention rather than Adaptation should be replaced. The focus should be on creating urban planning with cheered strategies to help society adapt to the consequences of unique weather patterns. The below images show the concepts that inform this research study: the conceptual models of Adaptation. At the same time, this framework is also made of proliferating pathways. Part of this framework is also the governance theories, which are also important, mainly when working on solutions to reduce disasters that emerge due to the change in the global weather pattern. This chapter focuses on these key themes to better understand how cities can conceptualize and govern the adaptation process effectively.

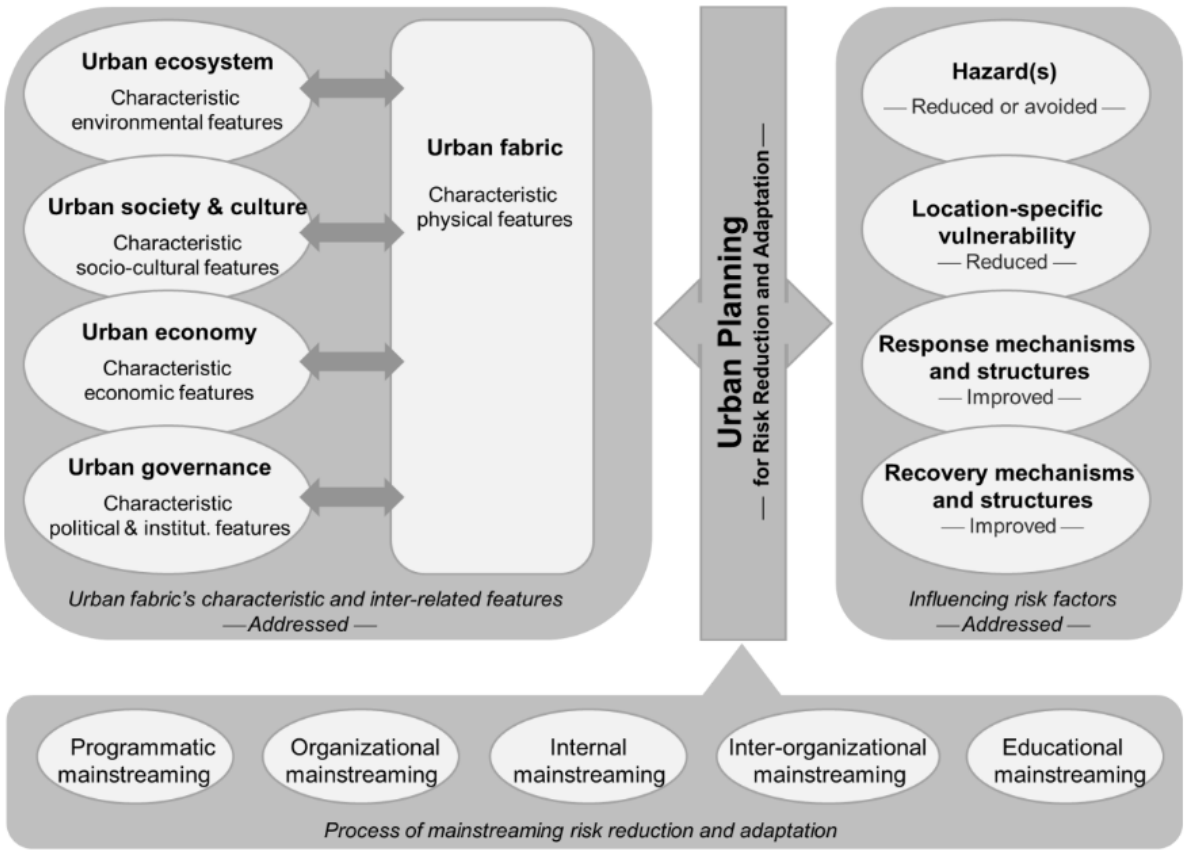


Figure 2. Planning for adaptation-in theory, Sources: Adapted from Wamsler, 2013.

Another conceptual framework is depicted below which also shows how the terms used for this research study relates to each other and this implication for the future of this research study

1.8. Structure of Doctoral Thesis

Five primary chapters make up the framework of this thesis, which are arranged to produce a logical and consistent flow of the research. Each chapter addresses different aspects of the research, including theoretical foundations, methodology, data analysis and final conclusions.

CHAPTER I. The first chapter contains the introduction of the paper, which defines the purpose and significance of the study, establishing the general research framework. This chapter elaborates on the main research objectives, research questions and an analysis of the current state of knowledge (State of the Art) on the topic. This chapter also provides a brief description of the context in which the study is conducted, as well as an argumentation of the need to undertake this research.

CHAPTER II. The second chapter presents a review of the existing literature on climate change adaptation. This section explores how literature has addressed this issue since the beginning of the 21st century and identifies gaps in existing studies. This chapter also highlights future research directions and provides a theoretical rationale for the choice of the study topic. Through the analysis of the literature, it aims to establish the conceptual foundations of the research and identify the most appropriate approaches for analysing the phenomenon of climate change adaptation.

CHAPTER III. The third chapter focuses on the study's methodology, describing the methods and techniques used for collecting and analysing data. This paper uses a mixed-methods approach to thoroughly explore the intricate interaction between climate change, weather patterns, and urban development in the context of adaptation and resilience in Lezha District by combining quantitative and qualitative techniques. An important aspect of this chapter is the description of the questionnaires and procedures followed to collect data from various interest groups. The methodology is designed to ensure a robust analysis addressing the research objectives and questions.

i. **Literature review-** A comprehensive review of existing literature will be conducted to establish a theoretical framework for the study. This will include:

- This review will examine the current state of knowledge on climate change impacts on urban areas, urban climate resilience, climate resilience, and innovative adaptation strategies. The literature review will draw upon academic journals, reports from international organizations, policy documents, and case studies of best practices in urban climate adaptation, to identify gaps in current knowledge and practices. Analysing case studies of best practices in climate change adaptation to derive lessons applicable to the study zone of Lezha.

ii. **Data Collection:**

- **Climate Data:** Historical and projected climate data for the Lezha District are gathered from the Institute of Geosciences, Department of Meteorology. The focus was on weather variables relevant to the region, such as minimum, maximum, and average temperatures, precipitation, and extreme weather events. The analysis is based on data for the two periods 1961-1990 and 1990-2020.

- **Urban Planning Data:** Also, are collected urban planning documents, ASIG maps, and spatial data specific to the Lezha District. This includes land use maps, infrastructure maps, and demographic data from different respective institutions.
- **Local Context Data:** During the period of study are gathered data on 15 points in Lezha city for the air temperature, air humidity and level of CO2. This includes information on water resources, green ecosystems, economic activities, and cultural heritage.
- **Stakeholder Interviews:** Are conducted interviews with local stakeholders, including urban planners, community representatives, and residents of the Lezha District. During the interviews are full-field questionnaires which are focused on the perceptions of climate change impacts, adaptation needs, and the benefits from the green corridors.

iii. Data Analysis:

- **Spatial Analysis:** For the elaborating of the thesis used Geographic Information Systems to analyse spatial data and assess the vulnerability of different areas within the Lezha District to climate change impacts. Also, using a GIS platform evaluate the land use, green infrastructure, etc.
- **Statistical Analysis:** Statistical methods for analysing climate data, socio-economic indicators, and other relevant data have been used to enable the identification of trends, patterns, and correlations between them.
- **Qualitative Data Analysis:** During the development of the interviews, it was deemed necessary to transcribe other qualitative data to understand local perspectives, experiences, and priorities related to climate change adaptation and risk mitigation in the Lezha District.

iv. Case Studies:

- **Case Study of Lezha Region:** This topic focuses on conducting an in-depth study of Lezha Region, focusing on the specific challenges of climate change and adaptation opportunities in the region, ways of mitigating and preventing disasters.

- **Comparative case studies:** The study includes comparative case studies of three other similar regions or cities that have successfully implemented climate adaptation strategies.
- **Impact assessments:** Impact assessments have also been conducted to assess the potential effects of climate change on different sectors in Lezha Region, such as water resources, infrastructure and public health, etc.

v. Stakeholder Engagement

- **Local Forums**: During the study are organize focus group discussions, and public forums in the Lezha District to engage local stakeholders in the research process, and to awareness of the adaption and mitigation of the risk.

CHAPTER IV. The fourth chapter presents the main results of the study and their analysis. Initially, the chapter deals with the demographic characteristics of the Lezha areas and the changes in high and low temperatures, analysing the climatic trends and anomalies observed over the years. Then, it focuses on urban circumstances that are in climate vulnerability, including aspects of urbanization and management of green spaces. Another important topic in this chapter is adaptation to climate change and the impact of urbanization and urban greening on the city's microclimate. Thus, air pollution is discussed as causing the deterioration of environmental conditions in urban areas. A great value of the chapter is a response to the responses from the complaint questionnaires, which looks at an overview of the different perceptions and knowledge on issues in the country, including different interest groups and different institutions.

CHAPTER V. Chapter five concludes the study with a synthesis of the results and by participating in the research in the field of urban design and climate adaptation. This chapter discusses the coherence of the findings with the objectives set at the beginning of the study and highlights the practical implications of the school for environmental outcomes and results. As such, recommendations for improving project approaches and adaptation to climate change are outlined, being made in an analysis of the findings from a global and local perspective. Finally, this chapter suggests research and film goals with some concluding observations on the significance and impact of a study.

CHAPTER 2: LITERATURE REVIEW

The section focuses on the past research studies that have been conducted on the topic. These include the critical review of the different articles, scholarly sources that have undertaken research, and published critical findings concerning the areas of interest in this research study. The aim is to compare the findings with each other. It also aims to provide an in-depth analysis of the implications of the existing research study. Ultimately, the purpose is to understand what the research studies have found regarding the topic and the loopholes that still exist. By the end of the chapter, it should be clear on the reason for conducting this study as to whether to use the information or to bring in new insights that have not been discussed or discovered in the existing literature.

2.1 Climate Adaptation

The cities need to know the outcome of weather shifts and the calamities that come with them. For that reason, this study aimed to explain and showcase the need to develop different mechanisms for adaptation. "The way climate and society relations are conceptualized greatly influences how their co-evolution is interpreted and responded to," as Gillard et al. (2016, p. 252) suggest. "Therefore, the main ideas found in the literature on climate adaptation that are discussed in the next parts of this chapter are: understanding climate adaptation as a process; the conceptual model of climate adaptation as a cycle of sequential steps; the increasing focus on learning and experimentation within the adaptation literature; the conceptual model of climate adaptation as a set of proliferating pathways; and the application of governance theories to explain and address the challenges of climate adaptation." Therefore, there are many themes and key terms that make it easier to understand adaptions to weather changes as far as the topic of discussion or research is concerned.

Table 1, Key Terms and themes about "Climate Change"

NO.	***CLIMATE ADAPTATION***	***CITY SCALE EXPLORES***
1.	**“Climate Adaptation” as a Process:**	A key focus is the understanding of climate adaptation as an ongoing process, rather than a one-off event. This view is emphasized by a conceptual model that frames adaptation series of steps. These steps involve continual assessment, learning, and adjustment as cities face evolving climate challenges. This cyclical approach underscores the need for ongoing adaptation measures that evolve in response to emerging risks and opportunities (Smit & Wandel, 2006).
2.	**Learning and Experimentation:**	"The increasing focus on learning and experimentation in climate adaptation literature reflects the need of flexibility and creativity in urban planning" (Olsson et al., 2006, p 32). As cities face unique challenges, experimenting with different strategies and learning from these efforts is “crucial for developing effective climate adaptation strategies” (Olsson et al., 2006, p 32) This theme highlights the dynamic nature of adaptation and its reliance on iterative processes that refine practices over time (Olsson et al., 2006).
3.	**Climate Adaptation as Proliferating Pathways:**	Another conceptualization of climate adaptation is the idea of multiple, proliferating pathways. This model suggests that adaptation is not a linear process but instead consists of a range of approaches and strategies that cities can pursue simultaneously, depending on their specific contexts and challenges. This flexibility allows urban areas to choose from a variety of options, balancing short-term and long-term adaptation needs (Adger et al., 2005).
4.	**Governance**	The application of governance theories to urban adaptation is a critical area of focus. Governance frameworks help explain how decisions are made, who is involved in adaptation processes,

		and how different actors collaborate across scales and sectors to manage climate risks. Effective governance structures are essential for integrating climate adaptation into urban planning and ensuring that adaptation strategies are inclusive, equitable, and sustainable (Biesbroek et al., 2010).

The above table shows the literature's findings on the significant themes of climate adaptation and the strategies that the majority of the stakeholders implemented to ensure amicable solutions to the consequences of climate change.

2.2. Effects of Climate Change on Urban Systems

Distribute throughout various areas of the planet, climate change has a far-reaching influence focused in certain places. Given the recent debates, it is also reasonable to say that the weight of scientific evidence indicates that human activities are mostly responsible for ongoing global, regional, local, and micro-scale climate change and that the consequences of this event will be extensive and very harmful to both people and animals. Also, for countries "(Olsson et al., 2006, p. 32). Thus, governments must become keen on these effects, mainly in the cities where evidence shows limited strategies put in place to tackle them (IPCC, 2007). The focus should, therefore, be on how the means through which cities can develop strategies to curb these challenges.

Moreover, "the urban system is the constantly changing spatial product of the flow of social, economic, infrastructural and ecological systems that grow and develop around an urban area" (Gleeson, 2008, p. 2656). Understandably, this "pattern tends to be highly resource-intensive and contributes enormously to increased greenhouse gas emissions and, consequently, to climate change" Stern (2006) sees it even more as "the effect of urban systems on climate change is shown by the fact that 75% of all greenhouse gas emissions are produced in the world's urban areas while only about half of the planet's population lives in the closest settlements" (Stern, 2006, p. 21). This system might cause the ever-present threats posed by the changing lifting climatic conditions worldwide.

Research notes that weather changes tremendously impact this city's systems. The first is over-flooding, which is likely brought about by poor management of the city's drainage system ((Davis, 2006, p. 23). The unpredictable weather patterns make it difficult to create a system to contain the overflow of the water. Another potential impact is the disruption of the infrastructure within the city. This is a consequence of multiple disasters, such as seismic effects, that make infrastructures like roads vulnerable. Another predictable impact on these cities includes the shifting temperatures (Condon, Cavens, and Miller, 2008). These not only make the planning effectiveness difficult for the residents, but they also make the cities unbearable cold or hot during the winter and summer. These impacts must be sorted by modifying these cities to ensure adaptable measures can help contain the weather challenges.

2.3. Urban Planning as an Adaptation Agent

Urban planning regimes, with their multidisciplinary, collaborative, and forward-thinking nature, "are well-positioned to meet the challenges presented by the adaptation process" (Condon, Cavens, and Miller, 2009). Urban planning is globally acknowledged as a social technique meant to arrange and minimize disputes inside urban areas; urban planners are essential in guiding and forming the function and structure of urban systems. Based on the evidence of the success of these planning, such as development management, urban design, and zoning are universal and typically operate at the local level; urban planning is particularly suited to contributing to adaptation efforts, mainly when these efforts are driven at the local scale.

2.4 The Role of Planners in Urban Adaptation

Interviews with urban planners for this research revealed a shared understanding of the need for urban adaptation. One public sector planner and one private sector "planner highlighted the importance of adaptation in creating resilient urban environments, emphasizing that well-adapted cities are more resilient and decrease vulnerable to the climate change impacts " (Wilson, 2006, p. 37). This view aligns with Wilson's (2006) assertion that adaptation efforts can reflect the effort invested, with localized adaptation strategies often yielding direct, visible benefits. In contrast, mitigation efforts, although important, may offer limited local benefits even with significant investment. Wilson (2006) further observes that "although including climate change issues into planning procedures can result monetary costs, acting early is far less than reacting to climate change effects once they happen or retrospectively". This emphasizes the importance of integrating adaptation measures early in planning, as noted in interviews with urban researchers.

2.5 Top-Down Planning Policy Support

Top-down policy guidance is crucial for successfully developing and implementing urban adaptation strategies. Well-structured national, state, or regional policy can set clear objectives, define parameters, and support local planning authorities as they design and implement localized adaptation responses (Burton et al., 2002; Wilson, 2006). National policy frameworks can significantly enhance the effectiveness of local urban planning regimes. For England, national policy guidance—including "Planning Policy Statement (PPS) 1: Delivering Sustainable Development (ODPM, 2005), PPS 1: Planning and Climate Change (ODPM, 2007), and PPS 25: Guidance on Development and Flood Risk (ODPM, 2008)" —offers a strong foundation for local governments to create and carry out adaptation plans. These documents not only prioritize adaptation as a national issue but also clarify the responsibilities of local planning authorities in developing and executing adaptation plans.

2.6 Challenges in Implementing Adaptation Plans

Despite the importance of planning-based objectives, challenges persist in translating these objectives into tangible actions. Political influence, budget constraints, and competing demands can obstruct the planning system's ability to coordinate efforts and implement effective adaptation strategies (Climate Impacts Group, 2007; Wolf, 2009). It is also important to note that there should be an effort to pursue both adaptation and planning simultaneously to avoid any issues or confusion that might arise while implementing these strategies and finding the solution.

2.7 Albania Context for Addressing Climate Change in Cities

Science has observed, recognised, and modelled most of human-caused climate change at national and global levels. Nevertheless the local setting greatly influences these factors since most of the hazards, vulnerabilities, and consequences of climate change are experienced locally. Local government has to run at the municipal size if it is to "analyse patterns of climate risks, vulnerabilities, and impacts as well as organize and take action to decrease these through climate adaptation" (Wilson, 2006, p. 341). "Most of Albania's population and economic output live in urban settlements, where a complex web of interconnected climate impacts relating to water, health, energy, transportation and mobility, land use, buildings, and insurance play out" (Wilson, 2006, p. 341). Urban climate adaptation falls within the bounds of Albania's government capacity. Its aim is to preserve the rises in well-being and declines in poverty brought on by development projects in the face of a changing environment. Municipal governments have a major duty as well in "planning and enabling climate change adaptation in Albania's urban areas" (Wilson, 2006, p. 345).

On the other hand, the national government within the country should also support creating an integrated and coordinated strategy. The reason for such support is that most of the reasons for these happening is much broader than the context of the municipality. Before examining the various legislative and regulatory options that local governments have at their disposal for climate adaptation, this chapter provides a brief overview of Albanian cities. It describes the "climate change impacts that have been felt and are anticipated in Albanian cities" (Wolf, 2009, p. 87). The assessment demonstrates how local government may address the matter at and through a range of possible entry points provided by the current legal and policy framework. Moreover, sector-specific laws and policies do not handle "the complexity and interconnectedness of risks, impacts, and adaptation measures as they manifest in urban settings" nor do they offer the tools required to handle several of the practical challenges local governments encounter trying to carry out climate adaptation" (Wolf, 2009, p. 87). These are important as the topic is concerned.

As covered in the chapter's fifth part, political, economic, and organizational factors account for many difficulties. Section 5 describes "several obstacles that currently make the planning and execution of climate change adaptation challenging in practice, including those related to the form and dynamics of Albania's urban areas, the structure and operation of local government, and the nature and framing of the climate change problem " (Wolf, 2009, p. 61). The chapter makes the argument that the main obstacle to climate adaptation in A city is not a lack of laws and policies but rather the incompatibility of these legal frameworks with a much more intricate web of social, political, and economic governance concerns that limit the use and efficacy of these instruments for mitigating climate change. The motivation for the research design of this doctorate thesis is further reinforced by identifying these difficulties, mainly from the perspective of local government practitioners.

2.8 Urbanisation, Urban Greening, and Their Impact on Microclimates

Urbanisation processes, including city expansion, microclimate, population growth, transportation, land use changes, climate change, and the decline of urban greenery, have far-reaching environmental and health implications. These include rising greenhouse gas emissions, increased air temperatures, altered humidity levels, and other microclimatic shifts. This study investigates the relationships between urbanisation, urban greenery, and microclimate indicators, aiming to propose strategies to minimise their environmental and health impacts through a natural-based solution. Different studies are prominent and have elaborated on urban development and urbanization and their correlation between temperature and air pollution. The high heart rate in most of these areas is closely linked to the housing density. Urban green spaces can significantly reduce this phenomenon, playing a vital role in urban climatology as a natural solution to mitigate the adverse effects of urban heat islands (Szkordilisz F, 2014). These green spaces serve as "cool islands," offering localised temperature reductions through their unique climatic influence.

The Climate of Green Space The microclimate created by green spaces is shaped by several key processes, including Evapotranspiration, or Plants release moisture into the atmosphere, which cools the surrounding air, Absorption and reflects Solar Radiation or the vegetation absorbing less heat compared to build environments, reducing surface temperatures. Others include modified wind movement, or the trees and plants influence wind patterns, enhancing ventilation and air circulation, and carbon Dioxide Assimilation, or Plants that absorb CO_2 during photosynthesis, contributing to air quality improvement. Vinayak et al. (2022) have observed that "expanded urban regions transform natural surfaces into urban areas, affecting "various physical and biophysical properties, such as evapotranspiration, albedo, emissivity, anthropogenic heat flux, wind speed, and air pollution" (Czarnecka, M., 2010, p. 45). The adverse impacts of the Urban Heat Island (UHI) effect have been extensively studied globally.

UHI exacerbates energy demand due to increased cooling needs (Akbari, H. 2001; Santamouris, M. 2015), diminishes air quality (Czarnecka, M., 2010; Sarrat, C., 2006), heightens risks of heat-related illnesses and fatalities (Harlan, S.L2006; Tan, J.;2010), and drives up water consumption (Guhathakurta, S.2007). Geo Factsheet (1998) "has documented that the recent research on London's heat island suggests that high levels of air pollution reduce daytime temperatures by blocking solar radiation, yet trap heat at night within urban areas" (Factsheet, 1998). Research by Buyadi et al. (2013) on the effects of vegetation growth on land surface temperatures in urban areas finds a "strong negative correlation between land surface temperature and urbanization, indicating that vegetation helps reduce temperature." Urban areas, particularly during summer, experience higher temperatures than rural areas due to industrial activities, housing, and vehicular emissions that generate heat and pollution. Air pollution in urban areas also impedes the radiation process.

As noted in many research studies, both current and past ", Infrastructure materials such as concrete, glass, brick, and asphalt absorb substantial heat and release it slowly at night, impacting the urban microclimate. (Masakazu, 2020, p. 21) Additionally, evaporation and transpiration processes are higher in urban areas. Amer et al. (2023) explore the relationships between urban trees, their biomass as carbon stores, and their shading potential. Takebayashi and Masakazu (2020) define the "urban heat island as a phenomenon where urban areas are significantly warmer than surrounding rural areas due to human activities" (Kobayashi & Masakazu (2020, 34). Winker & Rudolph-Cleff (2019) present Germany's approach, emphasising that "urban development tools in established districts with competing demands are increasingly important in urban regeneration and planning." The role of urban greening in mitigating urban heat islands is receiving increased attention. Vegetation affects microclimate conditions and human comfort by moderating temperature. "Green areas provide ecosystem services, including carbon sequestration, energy savings, and recreational value" (Gómez-Baggethun & Barton, 2013).

2.9 The Design

Creating and carrying out infrastructure and design criteria that improve urban systems' flexibility and resilience to climate change impacts depends on good urban planning. Planning systems can encourage adaptable characteristics, as mentioned by the IPCC (2007) and Mueller and Rynne (2009), by means of deliberate infrastructure and design interventions. This part investigates particular urban planning techniques. These can emphasize several fields, notably in those more susceptible to the influence of global weather change.

2.9.1 Porous Surface

The first area is Porous Surfaces in Urban Planning. Conventional urban surfaces, such as concrete, asphalt, and paving slabs, are impermeable and prevent water absorption into the ground. As a result, surface water in urban areas relies heavily on piping systems for removal. These systems concentrate "water flow into small spaces, making them vulnerable to overloading during extreme weather events." The reliance on conventional pipelines can exacerbate urban flooding, particularly as climate change increases the frequency and intensity of heavy rainfall events (DEFRA, 2008; IPCC, 2007). Key features of porousSurfaces include porous asphalt, pervious concrete, porous soil, and open-joint blocks, which let water penetrate the surface and into the underlying soil. These materials slow water runoff, reduce transport volumes, and improve flood risk management (DEFRA, 2008). Additional benefits include groundwater Recharge, a porous surface enhancing groundwater supply by allowing rainwater to filter into underground reserves. Another is the biodiversity and urban Amenities whose surface creates habitats for various species and improves urban spaces' visual and functional quality. The last one is heating Island mitigation, which absorbs and cools atmospheric heat; porous surfaces reduce urban heat island effects. Efforts to integrate porous surfaces into urban infrastructure are gaining momentum globally. For example, the Chicago Green Alley Pilot Program, launched in 2006, focused on repairing the city's alleys with porous materials to enhance resilience against heavy precipitation events. The figure below illustrates the design for a porous surface.

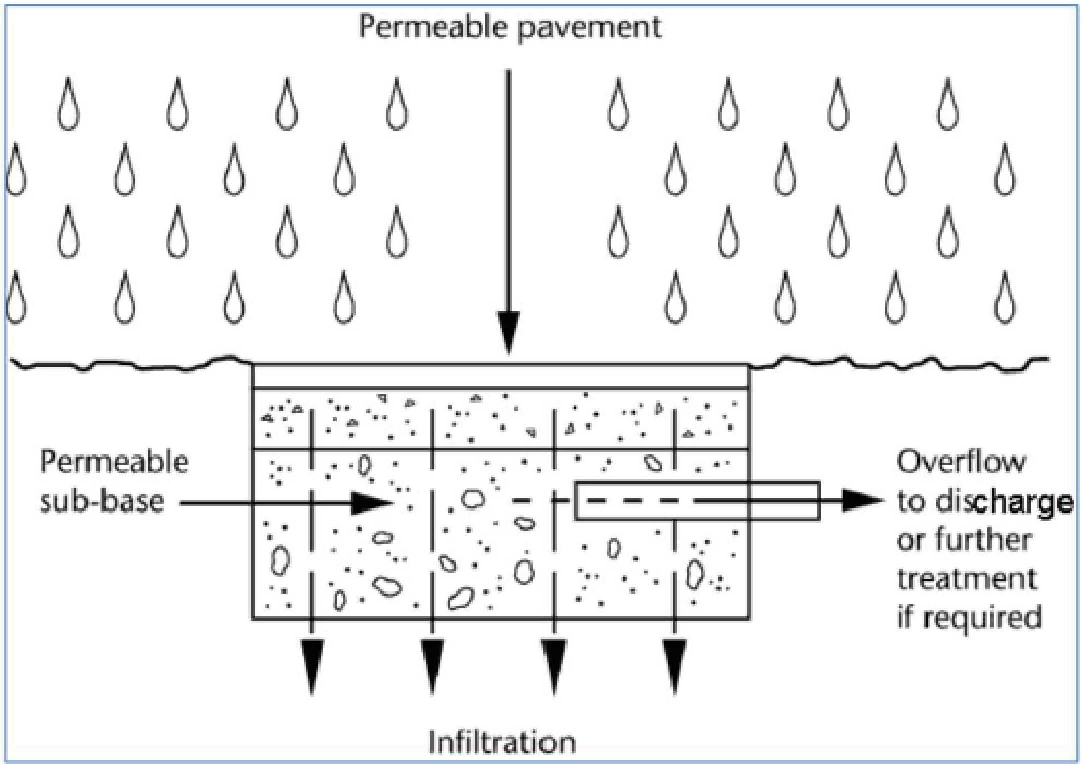


Figure 3. Technical design of the porous surface.

However, the porous system illustrated by the image above poses multiple challenges, as noted by different literature. The first one is the challenges with conventional systems. Increasingly insufficient in handling extreme weather patterns defined by brief, strong rain or more storm activity, which are related to climate change, traditional piping systems are (Lovelock, 2006; IPCC, 2007). Overloaded systems can lead to widespread urban flooding, emphasizing the importance of integrating porous infrastructure as a standard design element. Integrating Porous Surfaces into Urban Planning for Climate Adaptation is the second notable challenge. Notably, urban planning plays a critical role in enhancing adaptation to climate change by implementing infrastructure and design standards, particularly those promoting porous surfaces (Berg, 2009). These surfaces provide a practical solution for managing flooding and groundwater depletion and offer significant potential for integration across various urban systems. Despite this challenge, however, there are notable benefits that such porous ground is likely to create. Notable, the adaptability of porous surfaces makes them suitable for integration into diverse urban systems. Urban areas can facilitate water absorption by replacing impermeable materials with permeable ones. For instance, it can reduce runoff and lower the impacts of urban flooding. At the mean time, it can improve groundwater recharge by increasing water availability for ecosystems and human use. At the same time, it can enhance resilience by strengthening urban systems against climate change impacts. An example of the porous space that generated such benefits is illustrated in the image below.

Figure 4. Porous surface in a car park.

2.9.2 The Role of Green Roofs in Urban Adaptation and Resilience

Green roofs, or vegetative roofing systems, are innovative solutions that integrate plants and vegetation into rooftop designs. They are "suitable for various structures, including residential, commercial, and industrial buildings, and offer significant environmental and urban resilience benefits" (Czarnecka, 2010). These are essential as far as the research study topic is concerned. Many benefits come with an approach to adoption. The first benefit is water Management. Understandably, "traditional roofing materials like slate, tile, and lead channel rainwater directly into drainage systems, creating strain during heavy rainfall or storms" (Buckwalter Berkooz, 2007). Green roofs mitigate these issues by Slowing rainwater flow, absorbing water on their surfaces, reducing stormwater runoff and pollution in drainage systems, and Enhancing water retention and treatment (Buckwalter Berkooz, 2007). There are also urban cooling, heat island mitigation, and water management. Green roofs reduce urban heat island effects by limiting the absorption of solar radiation and promoting evaporation cooling.

Water retained in the vegetation's leaves increases local humidity, reducing ambient temperatures (Buckwalter Berkooz, 2007). Also, biodiversity and ecosystem support are available. Understandably, Green roofs enhance urban biodiversity, which is important primarily for other animals, such as insects and small animals. These animals get their shelter and food from there. These ecosystems contribute to ecological sustainability in urban settings. Aesthetic and Social Value The visual appeal of green roofs enhances the quality of urban environments, fostering psychological well-being and increasing property values. It is crucial to understand the need to put much more emphasis on tackling the changes in weather through the use of adjustments to urban planning. For instance, urban planning regimes have embraced green roofs as part of climate adaptation strategies.

A good example is its implementation in Toronto, Canada. In 2009, Toronto introduced a bylaw requiring that 25% to 50% of new building rooftops be covered by green roofs, depending on the structure's type and use (Alter, 2009). Its efficacy is further demonstrated in Chicago, Boston, and Minneapolis. To assist urban cooling initiatives and stormwater management, many cities have adopted comparable green roof criteria (Buckwalter Berkooz, 2007). They exemplify success stories that prove the extent to which the implementation of this approach could be important for future urban planning and the need to embrace them to the disastrous consequences of climate change. Thus, developing plans and strategies is the best way to use this approach in urban planning. These include Planners integrating green roofs into urban resilience frameworks to address climate adaptation and water management goals. The second approach is to develop Controls, which include regulatory processes to ensure that green roof standards are met in new building projects.

2.9.2.1 Challenges and Opportunities

While green roofs provide clear benefits, their adoption can encounter resistance due to concerns about cost, maintenance, and technical complexity. Urban planning authorities can address these issues by showcasing the economic and environmental benefits of green roofs and offering incentives to developers.

Figure 5. Urban planning by green roofs as part of climate adaptation strategies.

One of the significant challenges that is always eminent is the repair of these greenhouse roofs. It has brought many questions about whether the current experiences and technology available can be costly enough to help maintain these structures. However, it is also important to understand the evolution of technology. Currently, repairing these structures is less costly and time-consuming thanks to the technology that has made it possible for them to be repaired quickly. Thus, it is no longer a problem or challenge to developers because of the ability of these people to buy these materials at a cheaper cost. Also, there is a proposal to reduce the cost of these materials and make them available. These are part of the plan to enhance the speed of integration of these structures into many parts of the world to curb the consequences of weather change at the global level.

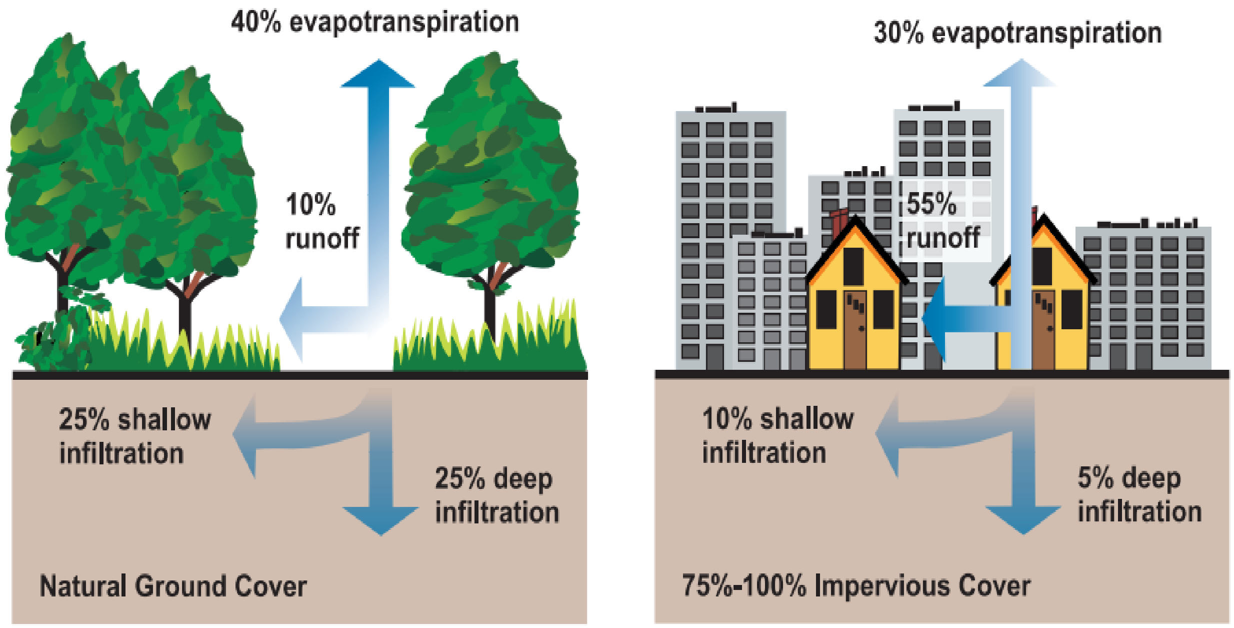


Figure 6. Benefits of Green Corridor, Source: US Environmental Protection Agency Protecting Water Quality from Urban Runoff pp1.

Climate change is one of the main challenges to communities in the twenty-first century. It is also essential to understand that "the frequency and severity of extreme weather events, such as heatwaves, droughts, floods, and storms, are predicted to rise in the future decades due to the rising global surface temperatures" (Alter, 2009, p. 89). The effects and consequences of climate change on metropolitan Europe will be extensive. The outcomes will differ from the direct impact of rising temperatures and altered precipitation dynamics to the indirect effects caused by outside events and events related to climate change. Effects on Urban Temperatures are also another challenge that must be understood and tackled as a way to accrue the benefits that come with these strategies. Changing urban temperatures are driven both by large-scale climate changes and ongoing urbanization (Fujibe, 2009). There is agreement that the current changing climate has to be kept well below an average global increase of 2 °C (EC, 2007; UNFCCC, 2015) to avoid significant future climate-driven catastrophes (Lenton et al., 2008).

Large-scale climate change and continuous urbanization both drive changing urban temperatures (Fujibe, 2009). To prevent major future climate-driven disasters, there is consensus that the present shifting climate must be maintained well below an average worldwide rise of 2 °C (EC, 2007; UNFCCC, 2015). Global development determines the urban temperature. Still, it is usually greatly affected by, e.g., the urban heat island (UHI) effect, which is considered a major concern of urbanization (e.g., Gago et al., 2013; Taha, 1997). Three parameters of urbanization have direct bearing on UHI, according to Taha (1997), namely, (1) increasing number of dark surfaces such as asphalt and roofing material with low albedo and high admittance, (2) decreasing vegetation surfaces and open, permeable surfaces such as gravel or soil that contribute to shading and evapotranspiration and (3) release of heat generated through human activity (such as cars, air-condition, etc.). Due to the unequal distribution of these elements around the city, certain regions will be more affected by the UHI than others. The effect will vary depending on the population inside an urban region; for example, it will be more pronounced in places with a high percentage of built-up land and minimal green space than in leafy suburbs.

Particularly at night, when the UHI is greatest, the urban climate itself is said to exacerbate the heat stress people feel at times of high temperature (Pascal et al., 2005). Studies show that heat has an adaptation element and that early season heat waves or locations with unusual hot weather have more detrimental effects (Anderson & Bell, 2011). People in areas of Europe that have not historically seen extremely high temperatures are less prepared to cope with the rise in temperature. Finally, there is also the Effects on Urban Hydrology. Climate change is anticipated to increase the frequency of flood peaks. Projected on average, Europe's flood peaks with return durations of 100 years will treble in frequency within 3 decades (Alfieri et al., 2015). Furthermore, a rising sea level that, when combined with a forecasted rise in windstorm frequency, will cause more coastal flooding also corresponds to this (Nicholls, 2004). In addition, most of Europe's metropolitan areas are either on floodplains or along the shore, these two forms of flooding will especially affect European cities. Rising sea levels influenced by climate in certain parts of Europe will also result in more regular basement flooding (Arnbjerg-Nielsen et al., 2013). A shifting climate will affect various areas of the continent differently. Projected to get less rain, Northern Europe is likely to have more annual mean precipitation than Southern and Central European nations (Stagl et al., 2014; Olsson et al., 2009). Many models have suggested rising storm strength mixed with dryness and falling overall summer rainfall. Growing high-precipitation events will mean that the present urban drainage system will exceed its capacity more often, hence generating economic loss, more pain, and even loss of life (SemadeniDavies et al., 2008). Urban temperatures rising will also significantly affect evapotranspiration, mostly constrained by rainfall.

Therefore, places with greater precipitation may experience more evapotranspiration whereas those with less precipitation may experience longer drought (Madsen et al., 2014). Northern areas are also predicted to experience seasonal variation in precipitation; more winter precipitation will fall as rain and higher spring temperatures will cause more winter runoff and less late-season snow-melt. The literature reviews showcase how much the existing research has focused on the topic. From the literature, themes emerged and thus are important for this research study. As evident from this research study literature review, climate change has been a major problem for many years and is one of the cases prioritized worldwide. However, many options have been used to tackle it in many countries. One of them is the successful use of urban planning. These include creating an urban plan with strategies that improve adaptability to climate change. The literature documents the successful cases of greenhouse gas control and other mechanisms, such as urban planning to create spaces for planting trees and retaining other catchment areas. Thus, this literature provided a good ground for the research study, specifically focusing on Lezha City in Albania.

CHAPTER 3: METHODS AND METHODOLOGY

This thesis chapter is a critical section that outlines the theoretical framework and practical research approach. Here are explains the rationale behind the chosen methods and provides a detailed description the manner in which this research was conducted. It provides a comprehensive blueprint of the research process and ensures clarity. The research employs a mixed-methods approach. It consists of quantitative and qualitative methods. The aim is to thoroughly explore the intricate interaction among climate change, weather patterns, and urban development in the framework of adaptation and resilience in Lezha District. The methodology is designed to ensure a robust analysis that addresses the research objectives and questions.

3.1 Research Study Design

This research study utilized a mixed method of qualitative and quantitative research studies. For many reasons, a mixed-method approach is the best choice for this research study. First, it enables the research to integrate theoretical and conceptual approaches to the study. These allowed for a comprehensive topic analysis, providing reliable data for the research study. At the same time, a mixed research study is also chosen because it allows for comparison. Researchers need to compare the outcomes of their research studies. Thus, depending on both the qualitative and quantitative research study, it allows them to compare the outcome. The last reason Quantitative research is important in this case is the nature of the topic. This topic includes both theoretical and statistical aspects. It is thus important to analyse from both perspectives to improve the accuracy of the results.

3.2 Research Study Setting

The research study will be conducted in Lezha, Albania. The setting is chosen and is suitable for this research for multiple reasons. "The municipality of Lezha first inherits an incomparably rich natural environment marked by varied forest formations, microclimate conditions, and various terrain features. This region is also selected at the same time for its vast regions with "swamps accompanied by lithographs and sandy beaches; geological formations rich in minerals and groundwater." Lezha is has a rich hydrographic system as well. The map below provides an overview of the study areas for this project.

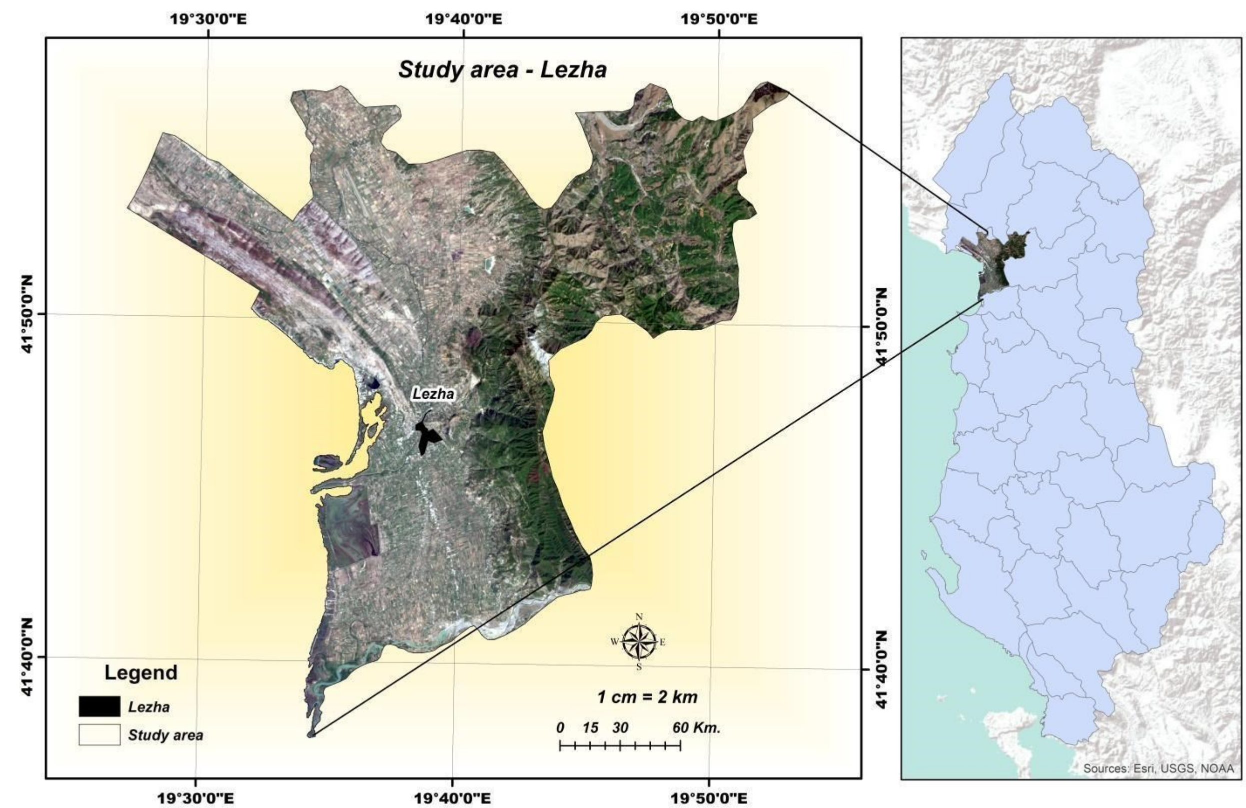


Figure 7. The map of the study zone, Lezha City .

Lezha was chosen as the specific area for this study because of its climatic characteristics and the overriding patterns of the climate, making it both vulnerable and a good place for human habit. At the same time, underlying adaptability triggers are being implemented in these regions, all of which aim to combat the growing concern of change in weather. These, in particular, make it a good place to study. Lezha has many features that make it essential for the study. These consist of "a variety of terrain features and microclimate conditions, different forest formations, large areas with swamps accompanied by lithographs and sandy beaches, geological formations abundant in minerals and groundwater, and a rich hydrographic network" (Buckwalter Berkooz, 2007, p. 45). "The municipality of Lezha also contains a number of protected areas of national and international significance including Kune-Vain-Tale Natural Reserve which offers great promise for the region. Bërna's protected organic area is also designated as a natural reserve.Buckwalter Berkooz, 2007, p. 49. A lot has been in place to ensure there is limited damage and an increase in adaptability. An example is the restriction on industrialization, which tamed the increasing pollution. Even though these restrictions have had a positive impact, immense pressure has led to some cases being unsolved. The "territory of Lezha municipality faces several risks from natural hazards with these notable cases of seismic risk, flood risk, geo-hazards in the form of landslides and rock falls, risks from atmospheric factors such as snow jams and forest fires, and the risks that come as a result of climate change" (Buckwalter Berkooz, 2007, p. 45). These important qualities also help to make this region fascinating to research to know how the leadership of the region is trying to apply adaptation strategies to lower these dangers. The study sites also include many characteristics that matter not only locally but even nationally. These include "Kune-Vain-Tale Nature Reserve is a tremendous potential for the area. protected natural area of Bërzna, which is also classified as a natural reserve" (Le Tissier et al., 2013). These key areas of interest make this study site another place to study this particular topic. Thus, the study areas can be subdivided to allow for an easier understanding of the challenges it faces due to the changes in the weather patterns and make it easier to study. For example, the first one involves damage and destruction of structures. These are "residential purposes, especially buildings built before the 1990s, built informally and without professional expertise, and new buildings where the implementation may have deviated from the original design." Another subdivision is the damage to social and cultural objects. These are mostly the objects that depict the city's culture and should also be protected from damage due to weather changes. Another category is the damage to critical infrastructure. These are key critical infrastructures within the city. These are more and more susceptible to "soil liquefaction which occurs especially in weak soils, mainly sandy ones."

In such cases, the soil becomes weak due to many land movements and natural occurrences such as seismic tremors. When such occurs, their critical infrastructure becomes very vulnerable to damage, as evident in the areas of study for many years. The study areas also face a lot of flooding, which is one of the reasons why it is essential for the study. As an urban region, Lezha has faced constant flooding due to massive heavy rains. The rainfall in these areas does not take specific, predictable patterns, so it has posed a critical challenge to defend against or prevent. With unnatural patterns, predicting when and where the flooding is likely to occur is difficult. At the same time, the constant change in the volume of rainfall has made it challenging to develop better strategies to prevent continuous flooding. Drought is also another challenge that has made it difficult for these residents.

According to the research report, "the municipality of Lezha is predominantly characterized by a mild Mediterranean climate due to its geographical position, great access to the sea and generally low terrains in most administrative divisions. Hot and dry summers, warm and wet winters in the lower part and city, and rainy and chilly winters in the mountainous region define this area. Lezha offers an ideal location for this research project with a special drought pattern, seismic activity, rain, and drought. The finding of this study within the location will provide a comprehensive report on these challenges and the best ways to tackle them now. In the future, these would then act as perfect case studies that many governments in other areas can use to undertake similar strategies to curb or tame the runaway impact of weather changes across the globe.

3.4 Target population and features

The methodology describes a mixed-methods approach to assessing rural depopulation, combining quantitative analysis of demographic data with qualitative insights from affected communities in the study area. The data collected are based on population density and other relevant factors. A framework was used to identify long-term trends and changes and analyse the period. A period of 25-35 years, including the years from 1990 to the present and the last decade, offers the opportunity to compare historical data with current ones, identifying the main developments and impacts that have occurred during this time interval. Adapting the analysis to the available data and census periods is also essential to ensure accuracy and consistency in interpreting the results. Collection and analysis of demographic data on population change, age structure, birth rates, mortality rates, and migration patterns from official sources such as national statistical offices (INSTAT, 2001) (INSTAT, 2024). This research explores the main challenges and opportunities for social, economic, and environmental development in the depopulated rural areas of the Lezhe Region, drawing on knowledge from relevant literature and considering the area's historical context and local specification.

These include the analysis of average temperature and precipitation data for 2000-2022 and the reference norm of 1961-1990. the study will focus on the critical data depicting weather patterns within the chosen region. The study focuses on the climatic data generated between 1961 and 1990. These will then be compared with the other data generated between 1990 and the 21st century. This comparative analysis will likely provide an overview of the change in the precipitation and temperature within the chosen region. Using the World Meteorological

Organization - Commission on Climatology and Climate Variability and Predictability (WMO) guidelines, daily air temperature and precipitation data for 2000-2022 was analyzed against the standards and reference norm of 1960-1990. This provides an overview of the particular trend of factors like maximum and minimum air temperatures, consecutive rainy days, rainfall, and droughts. To evaluate the area's exposure to natural hazards on a metropolitan scale and potential difficulties, all urban components must be taken into account. Using the criteria set out by the World Meteorological Organization - Commission on Climatology and Climate Variability and Predictability (WMO-CCI/ CLIVAR), daily air temperature data for the period 1990-2016 was analyzed in relation to the standards and reference norm of 1961-1990.

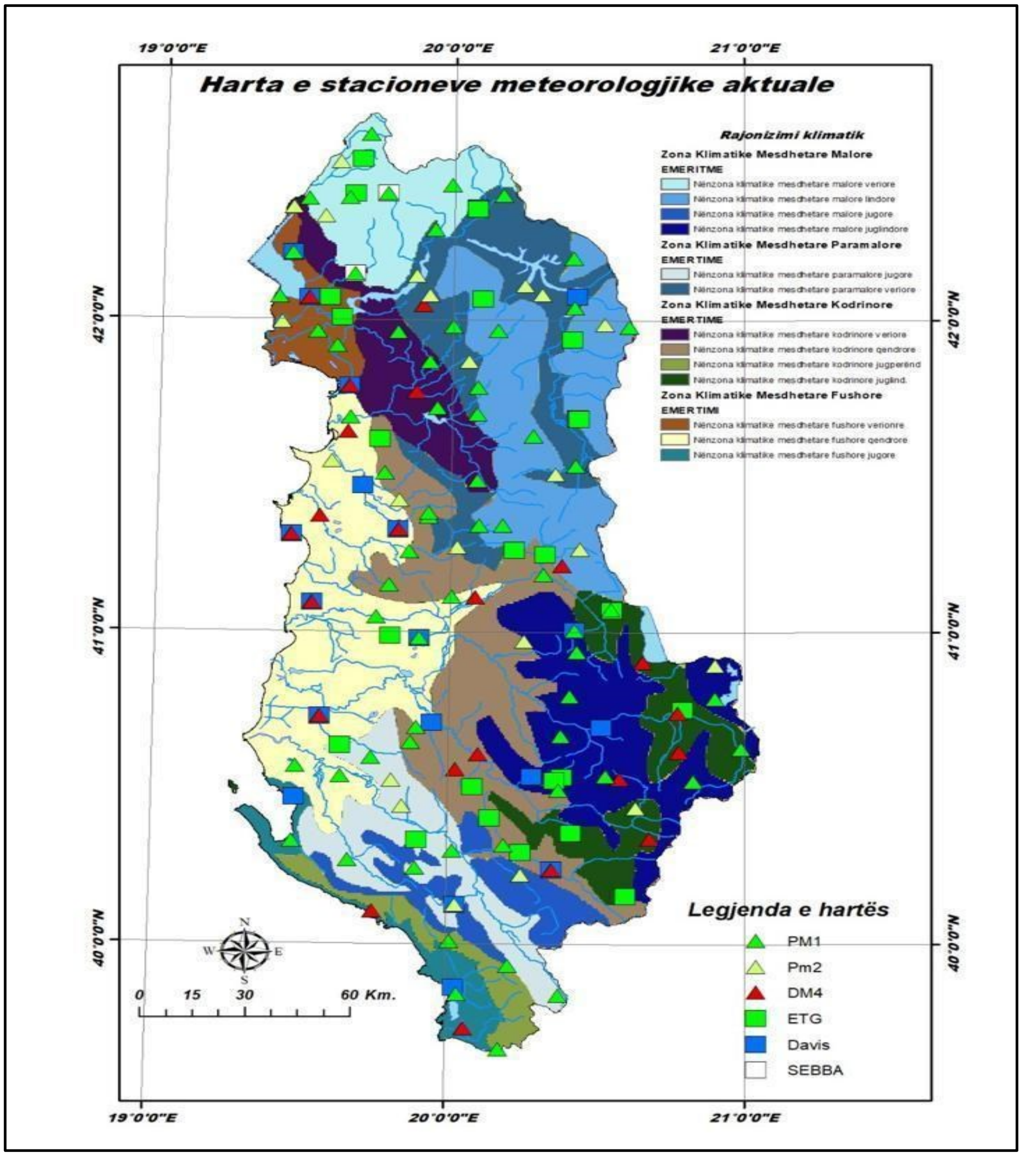


Figure 8. Map of Current Meteorological Stations spread in the territory of Albania.

3.5 Data Collection process (Case Studies)

One of the methods employed for this research study was the use of case studies, mostly depicting similar activities and research studies in different towns or cities. This was part of the qualitative research study that was used to gather data to help make a comparison. The aim was to understand what strategies have been successful in other areas and how they could be used in this case study to come up with a good conclusion on the research study topic.

3.5.1 Benidorm (Spain)

Human activities and the increasing frequency of coastal and riverine floods jeopardize coastal cities' stability and functionality. An international tourist site, Benidorm, Spain, is not exception to the consequences of climate change. Last year, the highest recorded daily precipitation exceeding 30 mm (2017 and 2019) occurred recently. These factors are accelerating beach erosion in the region. Proactive measures have been introduced to address these challenges, emphasizing natural solutions to enhance the city's resilience. Parallel to the promenade, an innovative vegetated urban dune has been proposed. This structure safeguards the area from flood levels reaching up to 3 meters during the most severe maritime storms. Additionally, the dune will facilitate seawater drainage and integrate seamlessly with the surrounding recreational activities. The proposed solutions aim to serve as a global model for public administrations, demonstrating how nature-based strategies can be incorporated into climate adaptation plans effectively.

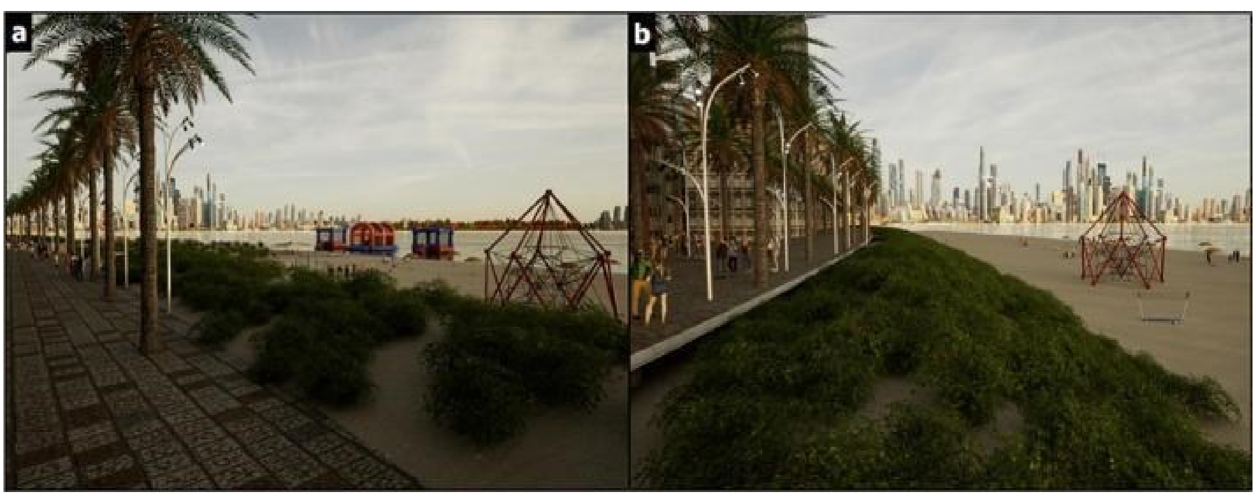
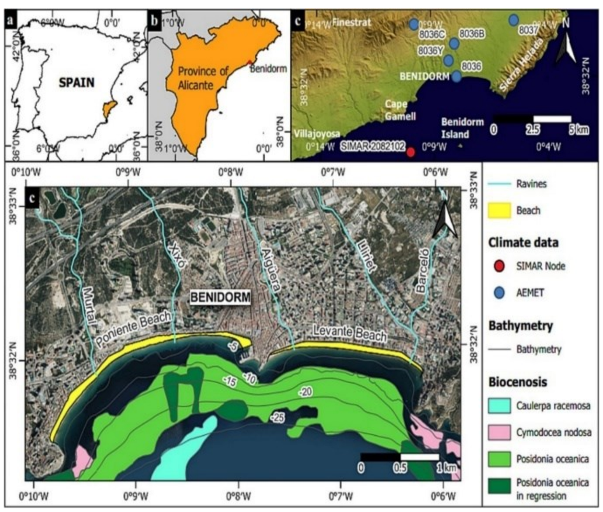
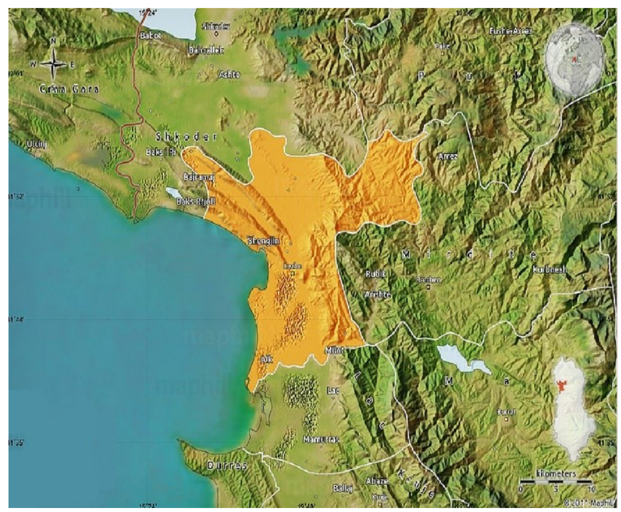


Figure 9. (a) Urban dune at low points of the promenade, (b) Urban dune where the height of the promenade is adequate to control maritime flooding.

Figure 10. High-capacity rainwater collecting components incorporated into the urban setting, (a) Marjal Park in Alicante, (b) the final segment of Lliriet Ravine in Benidorm.





Benidorm features a Mediterranean climate "characterised by mild winters with average temperatures around 10°C, warm summers averaging 25°C, and low annual rainfall of approximately 400–450 mm." Most of the time, though, especially in autumn when deep low-pressure systems and "cold drop" events are common, rain just accumulates for several days and vanishes. Weather patterns like January 2020's storm "Gloria" can concurrently cause severe rainfall and storm surges, hence causing notable coastal damage (Amores et al., 2020).

Historically, such severe weather conditions have significantly harmed Benidorm's coastal infrastructure (Bevacqua et al., 2017).

Flooding is particularly susceptible on the promenade, where waves crash over the promenade wall and waters frequently flood the beach berm. Wave amplification causes water levels in enclosed bays, like Benidorm's, to increase more than in open areas (McInnes et al., 2003). Several suggestions have been made to handle the increasing "frequency and intensity of extreme weather events linked to climate change" based on research results. To stop promenade flooding during marine storms, a vegetated urban dune is suggested on the backshore of Benidorm Beach" (McInnes et al., 2003, p. 23). By means of controlled erosion during storms, the dune would serve as a wave containment system, restricting sand and overflows to the shore.

The dune would require reconstruction, with artificial sand replenishment to maintain the natural sand supply cycle disrupted by human activities. The dune's design includes vegetation with native shrubs to stabilize the sand and prevent wind-driven mobility. The structure of the dune is modelled as a vegetated sand dike, limiting wave overtopping to <2%, as per classical dike safety standards, with height of crest elevation of 3.2 m to protect against maximum flood levels of 3 m during severe storms (Van der Meer et al., 2018). These adaptive measures offer a model for nature-based solutions that can be tailored and implemented in other vulnerable coastal regions worldwide**.**

Table 2. Comparative Analysis of Climate Conditions and Geographic Position: Lezha, Albania vs. Benidorm, Spain

No.	Comparative Analysis	Lezha, Albania	Benidorm, Spain
1.	**GEOGRAPHIC POSITION**	Located in the northwestern region of Albania.	Situated in southeastern Spain, in the province of Alicante within the Valencian Community
		Coordinates: 41.78°N latitude, 19.64°E longitude.	Coordinates: 38.54°N latitude, 0.12°W longitude
		Positioned near the Adriatic Sea with a mix of coastal, lowland, and hilly terrain.	Located on the Mediterranean Sea with a coastal urban setup.
		Close to the Drin River and surrounded by fertile plains.	Features sandy beaches and is surrounded by rugged mountains that create a microclimate
		Elevation: Generally low, with hills and mountains nearby	Elevation: Mostly coastal, with urban development extending inland
2.	**CLIMATE CONDITIONS** Climate Type	Mediterranean (Csa), with influences of humid subtropical climate due to its inland proximity and varying elevation.	Hot-summer Mediterranean (Csa), heavily moderated by the Mediterranean Sea.
	Temperature	● Summer: Hot and dry, average highs around 30–33°C (86–91°F). ● Winter: Mild and wet, average highs around 9–12°C (48–54°F).[1]	● Summer: Hot and dry, average highs around 29–32°C (84–90°F). ● Winter: Very mild, average highs around 15–18°C (59–64°F)[2].

[1] https://www.weatherapi.com/history/q/lezhe-79033?utm_source=chatgpt.com
[2] https://en.wikipedia.org/wiki/Benidorm?utm_source=chatgpt.com

	Precipitation	● Annual rainfall[3]: ~1,500–2,000 mm (59–79 inches). ● Rainfall is heaviest in autumn and winter, with occasional flooding in low-lying areas.	● Annual rainfall[4]: ~300–500 mm (12–20 inches). ● Rainfall is sparse and concentrated in short, intense bursts, often during autumn.
	Seasonality	A perfectly oriented seas with both dry, warm and cold spells	Less pronounced, with mild winters and long, warm summers.
3.	**COMPARATIVE INSIGHTS** Temperature Range:	Both cities have similar summer temperatures, but Lezha experiences slightly cooler winters.	
	Precipitation:	Lezha receives significantly more annual rainfall than Benidorm due to its exposure to Adriatic weather systems, while Benidorm has a drier climate characteristic of southeastern Spain.	
	Seasonality:	Lezha's seasons are more distinct, while Benidorm enjoys a milder transition between seasons.	
	Geography:	Lezha's proximity to rivers and diverse terrain makes it susceptible to seasonal flooding and influences its microclimates.	Benidorm's coastal and mountainous surroundings create a unique microclimate with minimal extreme weather conditions.
4.	Historical Climate Data	**January 28, 2021:** Recorded temperatures ranged from a low of 21°F (-6°C) to a high of 28°F (-2°C).[5]	**March 2022:** Experienced typical spring temperatures, with average highs around 20°C (68°F) and lows near 10°C (50°F).[6]
5.		Needs robust flood management and infrastructure to handle heavy rainfall.	Focus on water resource management due to limited rainfall.

[3] https://en.climate-data.org/europe/albania/lezhe/lezhe-46751/
[4] https://en.climate-data.org/europe/spain/valencian-community/benidorm-56914/
[5] https://www.wunderground.com/history/daily/al/lezh%C3%AB/date/2021-1-28?utm_source=chatgpt.com
[6] https://weatherspark.com/h/m/42557/2022/3/Historical-Weather-in-March-2022-in-Benidorm-Spain

	IMPLICATIONS FOR URBAN PLANNING AND ADAPTATION	Urban planning should consider diverse elevation and seasonal weather variability.	Infrastructure must be resilient to occasional torrential downpours but less prone to flooding compared to Lezha.

3.5.2. Case 2. Nature at the heart of Nice (France)

A lot of busy sports have been constructed to reduce flooding. Furthermore, the "city is formulating a new plan for reclaiming nature and biodiversity, aiming to halt biodiversity loss and landscapes to benefit wildlife and citizens and improve knowledge of an engagement with nature. Green roofs, passages for wildlife, and green corridors are nature-based solutions central to the plan to develop, renovate, and build. This project is to make the city center greener." these adjustments, coupled with the policies put in place to control them, are important in fighting or adjusting to the challenges brought about by the change in weather in the regions. These provide a good case study where other countries or cities can emulate and develop strategies and policies to tackle similar challenges in the future.

Figure 11. Vegetation Plan of Nice (France).

Combating climate change through a sustainable development model and adaption and mitigation of CCA is very important, and this strategic plan is underpinned by a strong political commitment that harmonizes economic growth, job creation, and environmental stewardship. At its core, the plan prioritizes nature and biodiversity, integrating them into urban development to enhance city living. By leveraging nature-based solutions (NbS), the initiative aims to "create new green spaces, such as repurposing old bus lanes, while delivering multiple benefits like mitigating heat stress and reducing flood risks"(Persson & Tanner, 2005). The plan's objectives include halting biodiversity loss, improving habitat connectivity for species, and restoring ecological corridors, both green and blue, to ensure the functionality of the territory for wildlife. Specific actions involve reducing animal collisions, minimizing light pollution near road infrastructure, and rehabilitating land and water networks. To support implementation, the plan incorporates a comprehensive training program, including workshops for elected officials and technical staff, fostering a shared understanding of nature's role in urban development and climate resilience.

Additionally, a metropolitan biodiversity atlas will enhance data-driven decision-making, helping to integrate the creation and preservation of green spaces into urban planning and development initiatives.

3.5.3 Case 3. Sustainability Assessment of Bo01, Malmö, Sweden

Notably, "Urban planning and design case studies are reviews of context, processes, products, and outcomes intended to advance the profession through inspiration and assessment" (Persson & Tanner, 2005). They give innovative professionals in the environmental design fields the confidence to pursue complex projects and dampen the naysayers' enthusiasm through empirical examples of success. Malmö's commitment to sustainability", City of combined with the growing demand for urban development, has resulted in two ground-breaking projects. In 1998, the Swedish government awarded the City of Malmö SEK 47 million through local investment program grants to support various initiatives. One of the most significant projects, Rustenburg, involved revitalizing an existing housing development (Koch & Kersting, 2011). Another significant project, Western Harbor (Foletta & Field, 2011), began with the European Housing Exposition Bo01– The City of Tomorrow, emphasizing sustainability. This development integrates renewable energy systems, waste recovery solutions, advanced IT infrastructure, ecological design elements (Persson & Tanner, 2005), and green transportation.

The initiative was partially funded through a local investment program grant and incorporates biodiversity as a key feature of its open spaces. To address frequent flooding in the area, the project employs cutting-edge stormwater management techniques complemented by the extensive use of green roofs. Western Harbor also showcases the Rustenburg Botanical Roof Garden, a leading example of green roof technology and its ecological benefits. To achieve success, innovative planning strategies were developed (Ritchie, A., & Thomas, R. 2009), emphasizing collaboration among government officials, designers, and developers through

"Creative Dialogues." These collaborative sessions fostered consensus on achievable goals within a limited timeframe (Gary A., 2013). A visionary planner's holistic approach to sustainability ensures a balance between aesthetics, social opportunities, and high technical performance. The project "enhances physical and mental well-being by providing immediate access to open spaces, pedestrian-friendly neighbourhoods, and settings that support social interaction and personal retreat" (Gary, 2013, p. 34). The inviting public spaces attract residents and international visitors, particularly to the seaside. The diverse landscape reflects a thoughtful response to its environmental context. Semi-public courtyards add privacy and intricate details, foster supportive microclimates, and incorporate biodiversity initiatives.

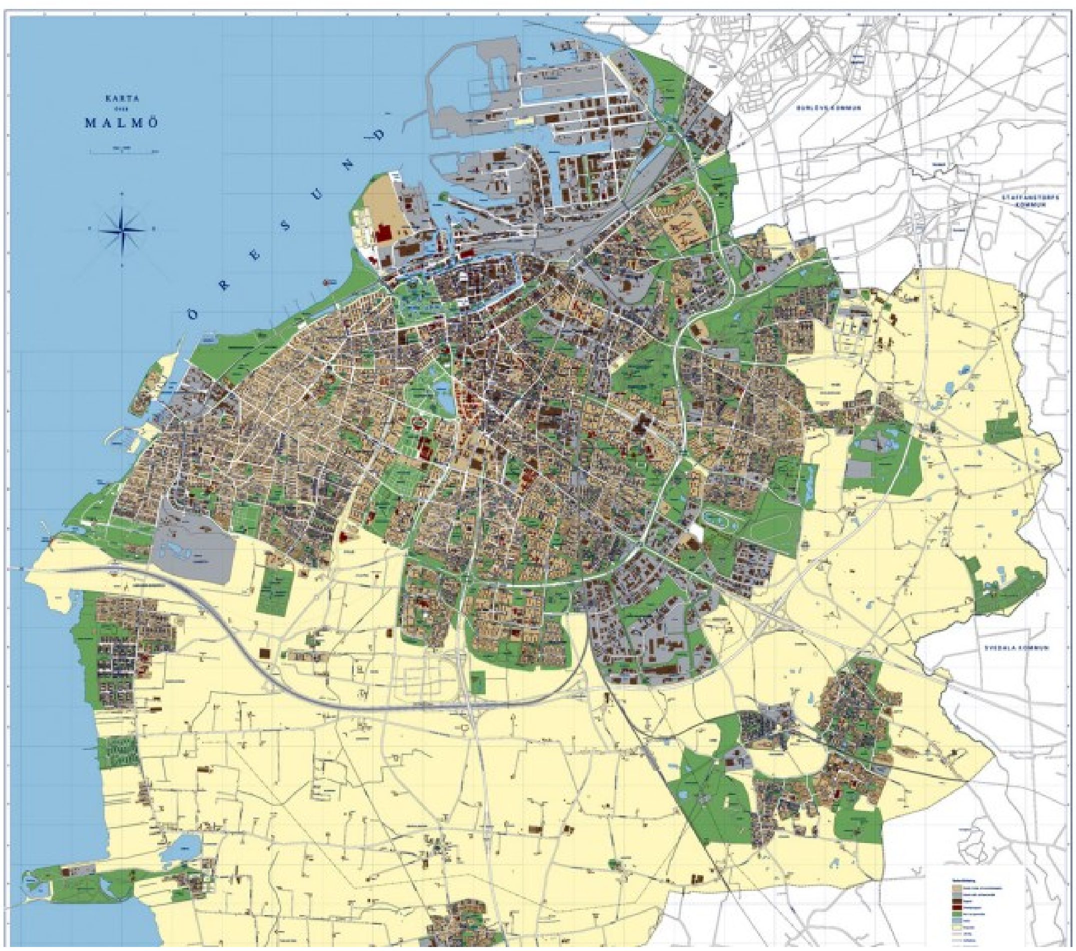


Figure 12. A proposed green network from Green Plan for Malmö 2003.

One of the project's standout achievements is implementing a surface-only storm water management system, which aligns with its sustainability goals. Furthermore, the city has adopted innovative concepts like the green space factor and green points for broader urban applications (Reepalu I., 2013), reinforcing its commitment to environmentally conscious planning.

3.6 Data collection through Quantitative survey

Data collection through questionnaires ensures the survey is "completed with stakeholders and visual field observations as the primary research tools." This survey aims to gain insight into the importance of adaptation strategies in climate context in Lezha District. The "selection of interviewees is designed to cover all groups and different categories of the community of Lezha District." The questions in the survey are intended for professionals, experts, municipal employees, students, and affected people with relevant ideas of the topic under the study and health and climate change adaptation (in general or health specifically). Some questions are general, and some are pretty expertise-specific, "the survey will focus on the possible level of precision for health risk estimates, the fitting adaptation strategy depends on the level of uncertainty and adaptation strategies that are either robust or vulnerable." The interview formats mirror the theoretical depiction of the ideas underlying green infrastructure and how it benefits the people.

Scientific data will be supplemented by household surveys, focus group discussions (FGD), semi-structured questionnaires to offer community perspective and opinion on climate variability and change effects on crops, animals, natural resources and elements their social. The survey for this research project was meant to "produce local information and to support arguments on useful theoretical discussions, as raised earlier in the theoretical deepening chapters." It indicates that the use of the questionnaire helped the researcher to grasp the advantages green infrastructure offers to communities in daily living.. At the same time, the survey was used in urban and rural contexts to compare results in two different contexts. About one hundred and twenty (120) surveys were completed, which is a representative sample of the total population of Lezha District. The sample size may not be fully representative of all demographic groups in Lezha. Qualitative analysis relies on interpretation, which, despite reliability checks, may be influenced by researcher perspectives. The questionnaires were developed over 1 month, having conversations with residents or other stakeholders during the questionnaire completion. This study employed a mixed-methods approach, combining quantitative and qualitative data collection to assess climate change awareness and adaptation strategies in Lezha.

The questionnaire included both closed-ended questions (e.g., multiple-choice, Likert scale) and open-ended questions to capture in-depth perspectives on climate adaptation challenges and strategies. Closed-ended survey responses were analysed using descriptive and inferential statistical methods. Descriptive statistics, such as frequency distributions and mean comparisons, were used to summarize awareness levels and adaptation practices. Inferential analyses, including t-tests and hi-square tests, were conducted to identify large differences among demographic groups. A multiple regression analysis was performed to assess the impact of socio-economic factors on climate adaptation awareness. The open-ended responses were analysed using a thematic analysis approach to identify key themes and patterns related to climate adaptation. The following steps were taken to ensure a systematic analysis such as: Data Transcription and Cleaning, Coding and Categorization, Theme Development and Refinement, to enhance credibility, qualitative findings were cross-referenced with quantitative data (for validation and triangulation), the qualitative data was effectively managed and analysed using NVivo software. This approach provided valuable insights into climate variability, the impacts of climate change on agriculture and natural resources, and the associated social implications.

3.7 Data Analysis

3.7.1 Climatic zones, subzones, and seasonal climate variations

The study provides an overview of the climatic zones. It shows that climate changes and water cycles happen due to the occurrences of almost magic zones. A decline in "normal rainfall over a large region" causes the scenario; other climatic elements, including high temperatures, strong winds, and low relative humidity, can exacerbate its severity. Even though the study area is small, "the country encompasses four distinct phyto-climatic zones and 13 subzones, each with unique climatic characteristics" (Vörösmarty et al., 2000, p. 23). It further means that "Climate indicators in these zones reveal significant variations in extreme weather events and their impacts on the environment, economy, infrastructure, agriculture, public health, and tourism" (Vörösmarty et al., 2000, p. 23). These have had a critical impact on the level of precipitation and the changes in the climate, which have caused notable disasters within the country. Therefore, urban planning within the region must take note of these changes in the climate and consider them as a means of creating stable solutions for the consequences of climate change in the country. These variations in climatic indicators across Albania's phytoclimatic zones necessitate targeted interventions to address summer drought challenges. Measures such as improving irrigation infrastructure, ensuring sustainable water resource management and preserving vegetation cover, and adopting better agricultural practices are crucial to effectively mitigating and combating drought conditions.

Table 3. Climatic zones and subzones in Albania

Climatic zone	Climatic subzone	Average annual temperatures °C	Minimum temperatures °C	Amount of precipitation (mm)	No. of days with precipitation

Mediterranean lowland zone	North	15.0-16.0	4.0-5.0	1500-2000	107-115
	Central	15.0-16.0	6.5-7.5	1500-1700	85-100
	South	16.0-18.0	8.0-10.0	1600-1800	95-100
Mediterranean hilly area	North	11.0-14.0	2.0-4.0	1300-1800	95-100
	Central	11.0-13.0	4.0-6.0	1100-1300	95-105
	Southeasterly	14.0-15.0	4.0-5.0	1500-1700	110-120
	Southwest	13.0-15.0	5.0-7.0	1700-2000	110-120
Mediterranean submontane zone	North	10.0-11.0	(-2.0) - (-3.0)	1700-1900	110-115
	South	9.5-10.5	0.5-2.0	650-750	85-95
Mediterranean montane area	North	4.0-6.0	(-4.0) - (-6.0)	2000-2500	110-140
	Eastern	2.0-6.0	(-4.0) - (-6.0)	1300-1800	100-125
	South-easterly	3.0-6.0	(-5.0) - (-6.0)	900-1200	100-110
	South	6.0-10.0	(-1.0) - (-2.0)	1400-2000	85-95

3.8. Analysis of the progress of land cover and land use in the area of Lezha

The present research study is focused to understand how the values of climatic elements relate to various factors such as the change in land use in city chosen for the study. Coastal countries in the northern part of the country are "very vulnerable to the impacts of climate change, especially sea level rise. However, information on implementing CCA policies in this region is scarce." Changes in weather conditions are a cause of climate change. The territory and the population living in this area are directly exposed to the consequences that these natural phenomena can bring to health and well-being. Heat waves cause the increase of maximum air temperatures above 35.0°C and minimum temperatures above 20.0°C. It is worth noting that the rise in temperatures in thermal values and their extension several days in a row brings negative consequences in people's lives and problems in all sectors such as agriculture, economy, tourism, etc. The methodology for the territory analysis is built on the collection of Geostatistical and Geoinformation data, quality control, adaptation to the study area, and data processing (band combination & data training) for the years 1990-2020.

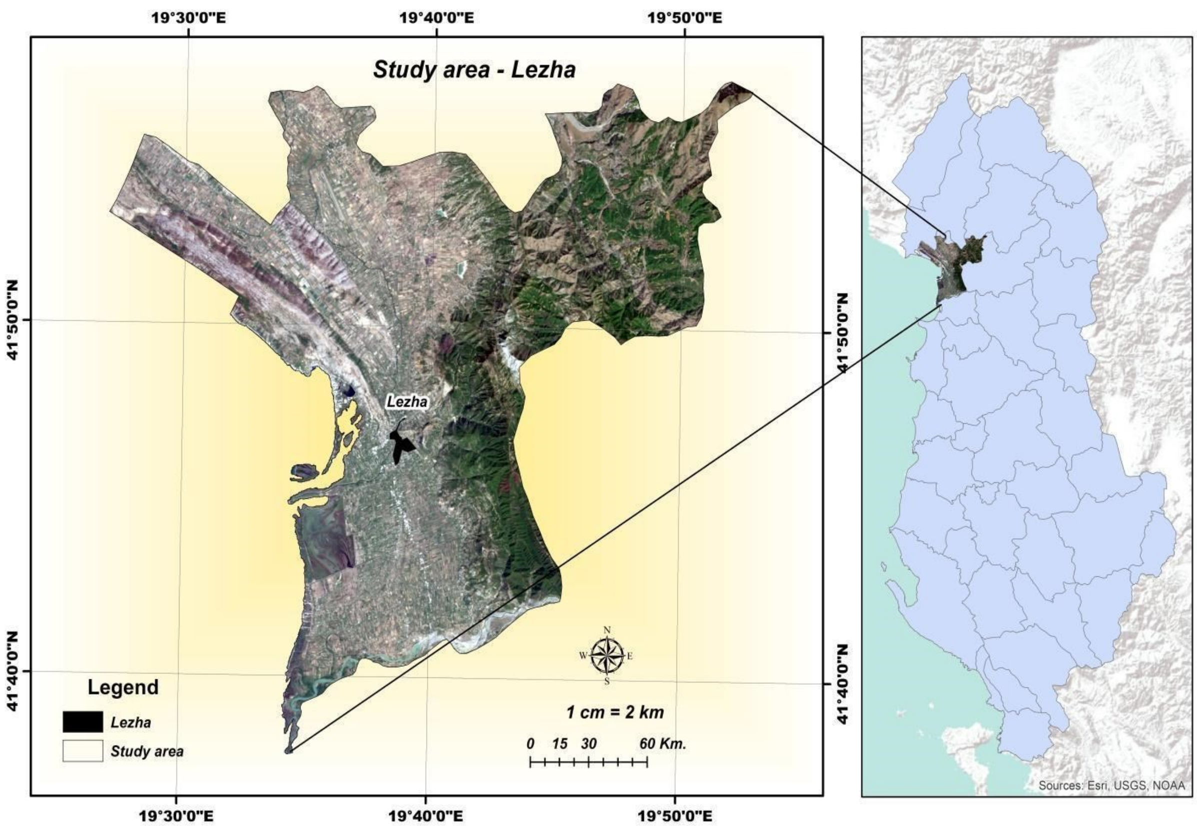


Figure 13. Map of the territory of Lezha City.

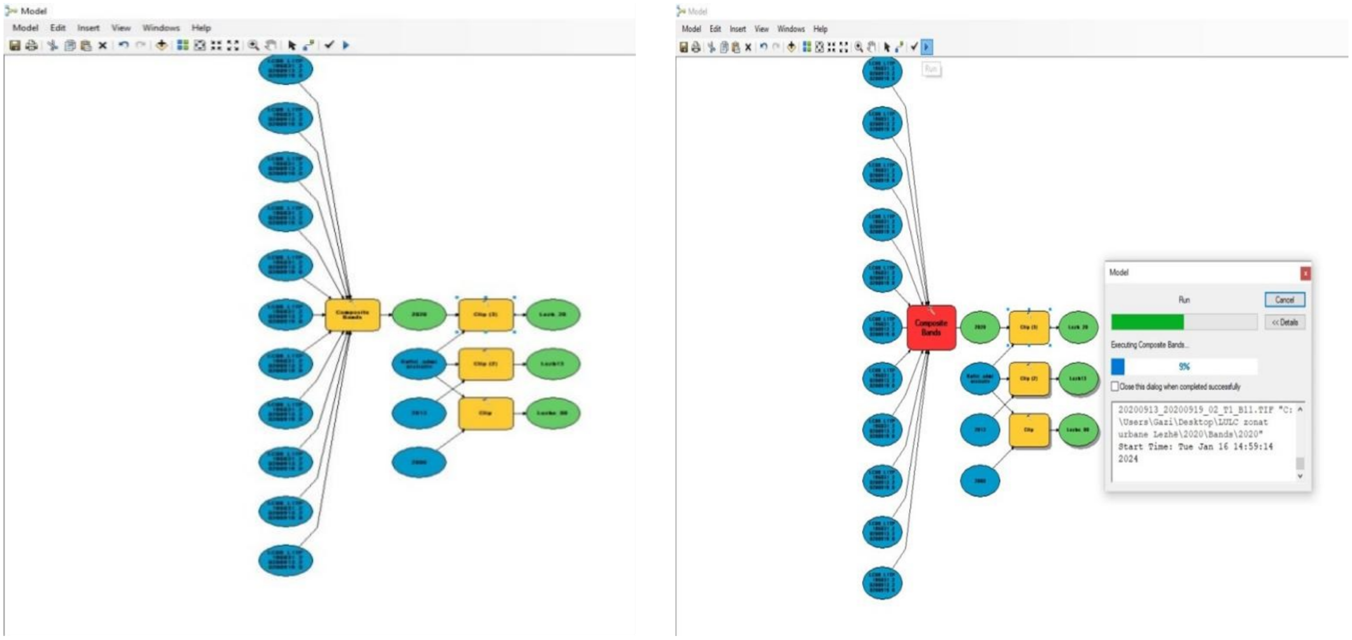


Figure 15. Processing of the data.

Figure 14. Meteorological Manual and Automatic Stations

The database consists of satellite products from 1990-2020 and satellite images from USGS. The meteorological database includes data on minimum and maximum air temperatures collected from the Institute of Geosciences' meteorological stations. This information is the result of manual and automatic monitoring and plays an important role in climatological analysis and weather forecasting.

3.9 Urbanisation and trends of microclimate indicators

Geographical data, including administrative boundaries, land use, and structural units, are taken from the State Authority for Geospatial Information (ASIG). The land use dataset offers comprehensive insights into the distribution and utilization of land across various regions, enabling the analysis of urbanization trends, conservation efforts, and resource management strategies. Meanwhile, the structural unit dataset provides detailed information on building types and quantities alongside key parameters such as land use coefficients and building density. These metrics will be crucial in subsequent stages of the analysis to evaluate urban form and development patterns. Data was collected using a Testo environmental Monitoring Device, capturing measurements across diverse locations that reflected variations in building typologies, densities, and proximities. This approach evaluated microclimatic factors, including CO_2 levels, temperature, and humidity, in distinct urban environments such as shaded zones, sunlit areas, and regions characterised by differing urban densities and green space coverage. Air quality indicators were also analysed and compared against national regulatory benchmarks to assess their compliance and potential impact on urban living conditions. To conduct the correlation analyses between CO_2 concentration, temperature, and humidity, the Pandas library in Python to clarify their relationship. The data was further analysed using ArcGIS, which was utilized to create visualizations and charts, mapping out spatial patterns and connections between land use, urban greening, and microclimate data.

3.10 Preparation of the data for the two periods 1990-2020 and 1961-1990

Daily data of the requested variables (precipitation, extreme temperatures, relative humidity, wind speed, solar radiation, and sunshine duration had to be extracted from the Excel files and arranged into the format needed by the R package Climatic. This task was performed in several stages. First, Excel files were moved to a shared directory, producing daily precipitation and air temperatures. Other multiple problems were notable including the need to digitization of the data from 2016-2020 to fulfil the series of row data. Data availability begins in 1990 and extends to 2020 for minimum and maximum air temperatures and precipitation. Finally, data in CSV files were saved in files with the format needed by Climatol with the help of the function csv2climatol in the development version of that package. The detailed script can be found in the Annex 2.

3.11. Quality Control and Homogenisation

A first Quality Control was performed manually with the help of the R programming environment. All series were read, and their statistical summaries allowed the discovery of strange values in the tails of their frequency distribution. A few lines of R code were used to compare each suspect value with values two days before and two days after in that station and four other stations with similar station codes. (Ideally, reference stations should have been selected by proximity, but that would have implied more unexpected work). A significant problem was not following the basic procedure of distinguishing “no precipitation” from “no observation” since both conditions can be ascribed to empty cells in the Excel files. In front of the impossibility of checking which of them was right in each case, a strategy was followed to minimize the problem: monthly totals were calculated from the daily values, months with zero precipitation were taken as a suspect, and all their daily data were assigned the R missing data code ('NA,' meaning 'Not Available').

This procedure may fail in months when there is no precipitation in a station. However, that can be seen as a minor problem since, during the homogenization process, missing data will be infilled with estimations based on the nearby available data. Those data are expected to be low if the region is dry during the month. The homogenization was performed with the help of the homogeny function in the Climatol package. The procedure consists of normalizing all series by dividing every value by the average of the series (precipitation) or removing the average and dividing by the standard deviation (temperatures) and then calculating all data in the station using data in the vicinity. In this way, a series of anomalies can be computed as differences between observed and estimated values, and these anomalies series can be used to detect spatial outliers and shifts in the mean (break-points) using Alexanderson's Standard Normal Homogeneity Test (SNHT).

The detection of homogeneities was done on the monthly aggregates of the data to avoid too noisy series at the daily scale. Then, the daily series were adjusted by splitting them at the detected break-points and infilling all their missing data, referencing the homogeneous sub-periods of the same station when available and data from nearby stations otherwise. After Quality Control and Homogenisation, the resulting series are supplied as two CSV files per studied variable. The Quality Control and Homogenization of these series have implied a lot of work, but there is much more to be done: The applied corrections were checked to assess whether they were due to digitisation errors or real observations due to extreme local phenomena. Since images of the observation sheets were taken, this checking procedure was done by accessing the archived originals of the observations again.

CHAPTER 4: RESULTS AND DISSCUTIONS

This chapter presents the research study's outcome. It outlines and explains the research study's process's outcome. The results are also compared with findings from the literature review to establish broader insights and draw conclusions related to the study.

4.1 Demographic Indicators in the Lezha area, Albania

Since the 1990s, Albania has undergone significant demographic changes, marked primarily by negative trends. Demographic indicators at the national level show a population decline, reflecting the impact of several key factors. Massive emigration, especially from young and active age groups, has played an important role. Also, falling birth rates and the gradual aging of the population have contributed to this trend, Figure 17. This phenomenon poses significant challenges to the country's economic and social development, including a shrinking labour force and pressure on welfare and pension systems. Analysing these indicators is essential for designing policies aimed at improving socio-economic conditions and promoting demographic stability.

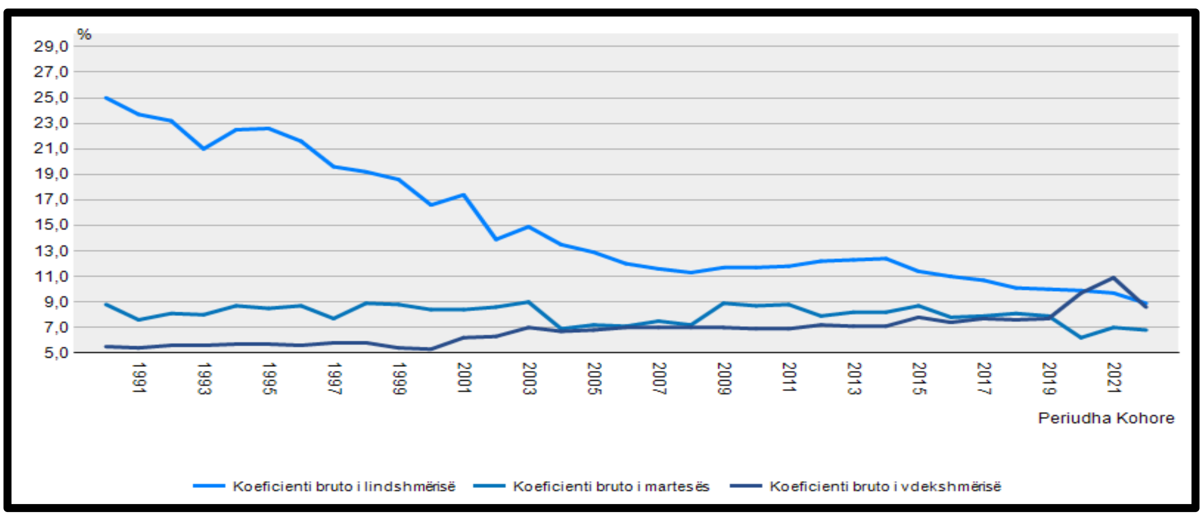


Figure 16. Demographic indicators (crude fertility rate, gross marriage rate and gross mortality rate) for the period 1991-2021.

The Lezhë Region, in particular, has been particularly affected by these shifts, which have influenced birth rates, mortality rates, and migration patterns. As a result, the region has experienced a substantial decline in its resident population, especially in rural areas. This demographic contraction has had notable implications for economic development, social sustainability, and the management of natural resources.

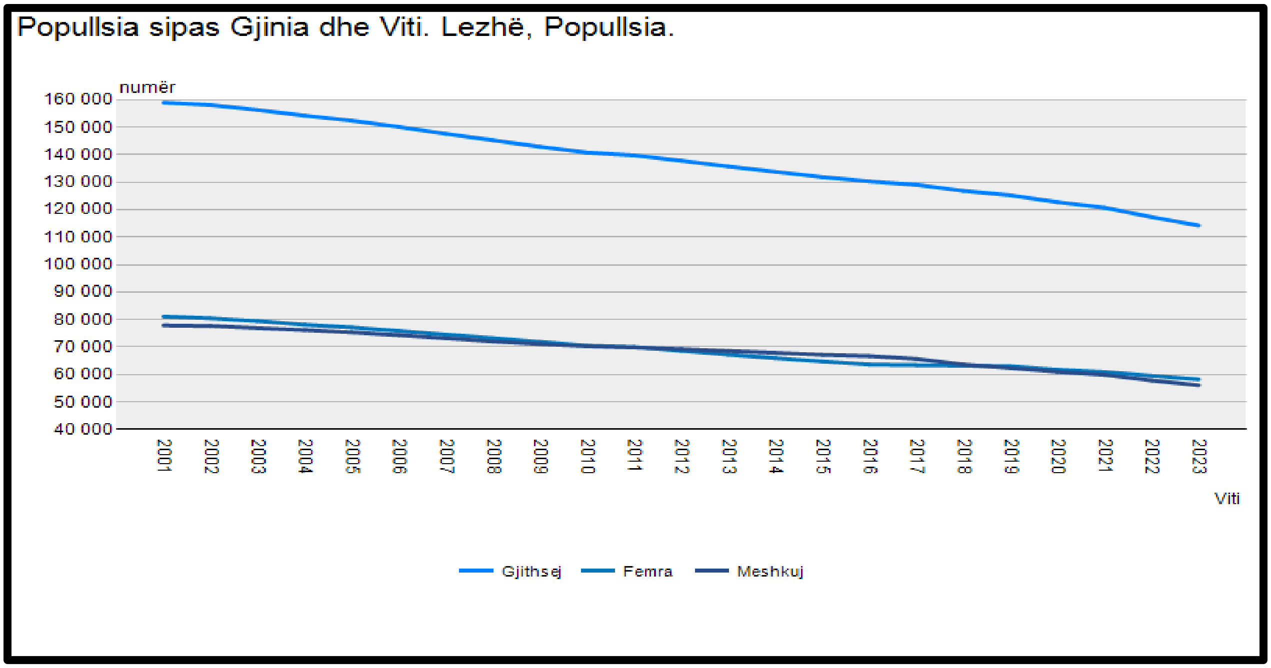


Figure 17. Population by Lezha District by gender, from the period 2001-2023.

The Lezhë Region, which includes the cities of Lezhë, Mirdita, and Kurbini, has undergone significant demographic changes since the 1990s. These changes reflect the broader impacts of Albania's economic and political transition, which have influenced population structure, migration trends, and the geographical distribution of residents.

- **1990-2000: Internal and External Migration**

Many residents of the Lezhë Region migrated to more developed urban areas, such as Tirana and Durrës, or abroad, particularly to Italy and Greece. This period saw significant rural depopulation, especially in the hillside and mountainous regions like Mirdita, which suffered economic hardship and limited opportunities.

- **2001-2010: Population Decline**

According to the 2001 and 2011 censuses, the Lezhë Region experienced a notable population decline, with some rural areas seeing a reduction of over 20%. Urbanization increased slightly, particularly in cities like Lezhë and Laçi, due to internal migration from surrounding villages. However, overall, the population continued to shrink.

- **2011 and Beyond: Ongoing Depopulation**

Post-census data indicates that depopulation trends have continued, driven primarily by economic migration and low fertility rates. The abandonment of agricultural lands and housing in rural areas has increased the number of vacant properties, further hindering the region's economic development.

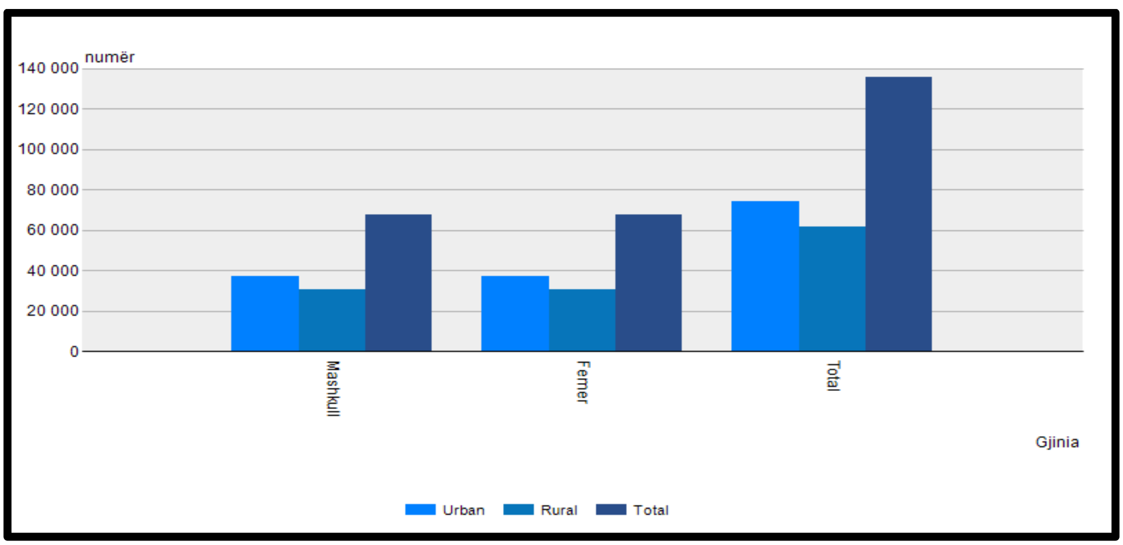


Figure 18. Resident population by Lezhe District in urban and rural areas, by gender, 2011.

The rural areas of Lezhe Municipality are also facing environmental degradation, such as deforestation, soil erosion and climate change impacts. These environmental challenges threaten the livelihoods of rural residents, especially those engaged in agriculture and other activities based on natural resources (Lushaj, et al., 2024). Promoting Sustainable Tourism, Lezha's natural beauty and cultural heritage offer significant tourism potential. The region's diverse flora and fauna are valuable assets. Conservation efforts are essential for protecting biodiversity and maintaining the region's ecological integrity (Lushaj Sh & Kucaj E, 2024).

4.2 Changes in The Regime of Rainfall and Temperatures in Lezha

Air temperature is one of the main elements of the climate. With its average regime, annual and daily performance, as well as extreme values, it affects the life and activity of humans and plants. Referring to the daily air data base and the corresponding calculations, the multi-year average annual air temperature is 11.6 °C referring to the 60-year time period 1961-2020. Referring to figure No. 20 where the annual distribution of average air temperatures is presented, their linear increasing trend is evidenced. From the results of the linear trend calculations, the annual increase for these 60 years is 0.23 °C per year. This trend indicates a gradual warming of the region, although there are still instances of intense cold spells, particularly during the winter months. However, extreme heat events have also become more common, with temperatures exceeding 40°C during the summer. There are many occasions where there is a lot of snowfall, which increases in speed and volume as the season deepens. In some cases, however, high temperatures have also been recorded as unbearable. In some situations, the temperature can be as high as over forty degrees or above the figure, depending on the intensity and the period recorded during the summer. The detailed script can be found in Anexx 2.

Table 4. Temperature change in Lezha

Lezha		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Ave.
Perod 1961-1990	Average Air Temp.°C	6.8	8.1	10.5	13.7	17.9	21.3	23.9	23.7	21.0	17.0	12.2	8.3	15.4
	Max. Air Temp. °C	10.3	11.8	14.7	18.1	22.4	25.9	29.0	28.9	26.0	21.5	16.0	11.7	19.7
	Min. Air Temp. °C	3.3	4.3	6.3	9.4	13.4	16.7	18.8	18.5	16.0	12.5	8.4	4.8	11.0
Period 1990-2020	Average Air Temp. °C	6.9	8.1	11.0	14.7	19.4	23.7	26.2	26.5	22.0	17.6	12.6	8.4	16.4
	Max. Air Temp. °C	10.9	12.3	15.5	19.4	24.4	28.9	31.8	32.4	27.3	22.4	16.9	12.1	21.2
	Min. Air Temp. °C	2.9	3.9	6.5	10.0	14.5	18.5	20.7	20.7	16.8	12.8	8.3	4.6	11.7

The data analysis from the Lezha meteorological station shows an increase in the average maximum air temperature of approximately +1.5°C from the 1961-1990 period to the 1990-2020 period. Additionally, the average minimum air temperature has risen by about +0.7°C. These shifts in temperature are critical indicators of the city's vulnerability to the impacts of climate change.

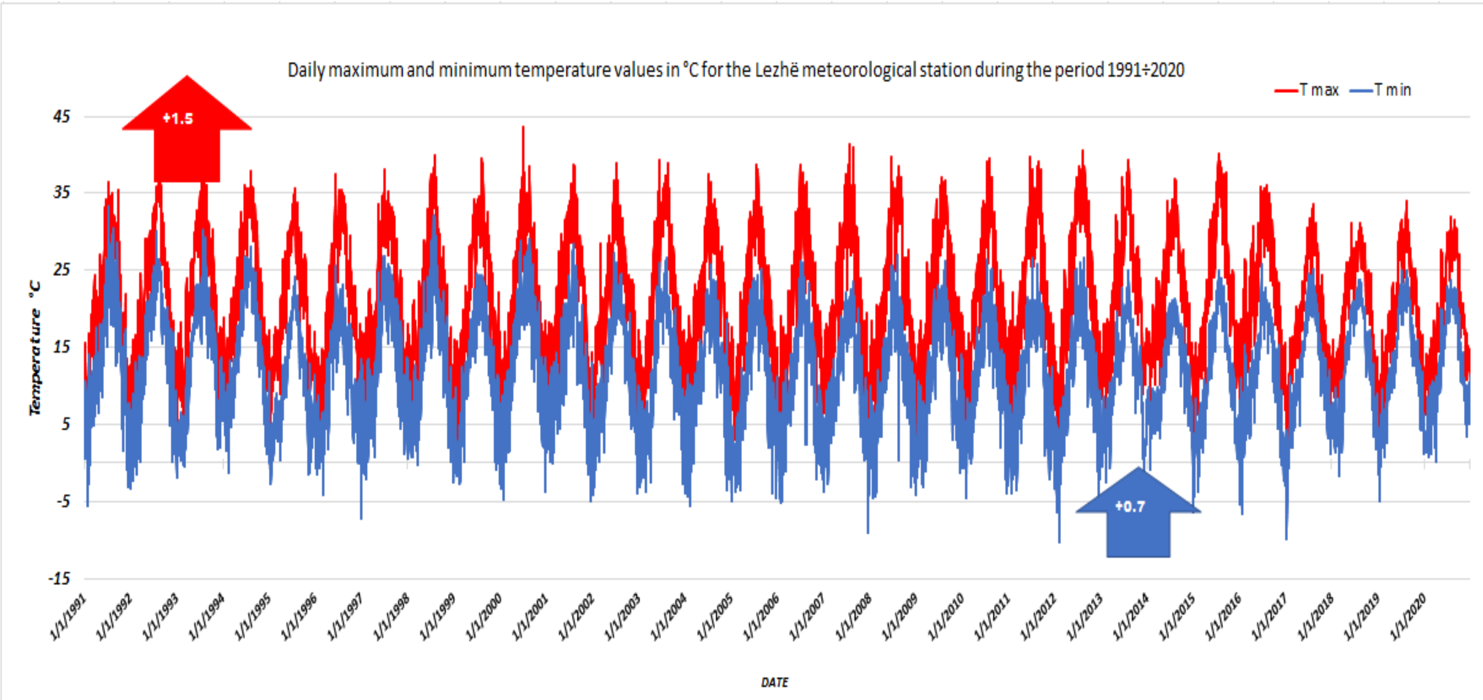


Figure 19. Daily maximum and minimum temperature values in°C for the Lezha meteorological station during the period 1991-2020.

The graph in Figure 19 provides a clear visual of the daily maximum and minimum temperature values recorded over a 30-year period, highlighting the seasonal temperature variations in Lezha.

- Seasonal Variations: The data from the graph shows the typical seasonal cycle, with higher maximum temperatures occurring during the summer months (June to August), and lower minimum temperatures observed in the winter months (December to February). This pattern is consistent with the Mediterranean climate characteristics, where summers are hot and dry, while winters are relatively mild.

- Extreme Temperature Fluctuations: The graph also highlights extreme temperature fluctuations, especially during the summer, where maximum daily temperatures can spike well above 40°C. Conversely, during winter, minimum temperatures can drop significantly, though they do not reach extreme lows. These fluctuations point to the increasing variability in temperature, which is indicative of the broader impacts of climate change.

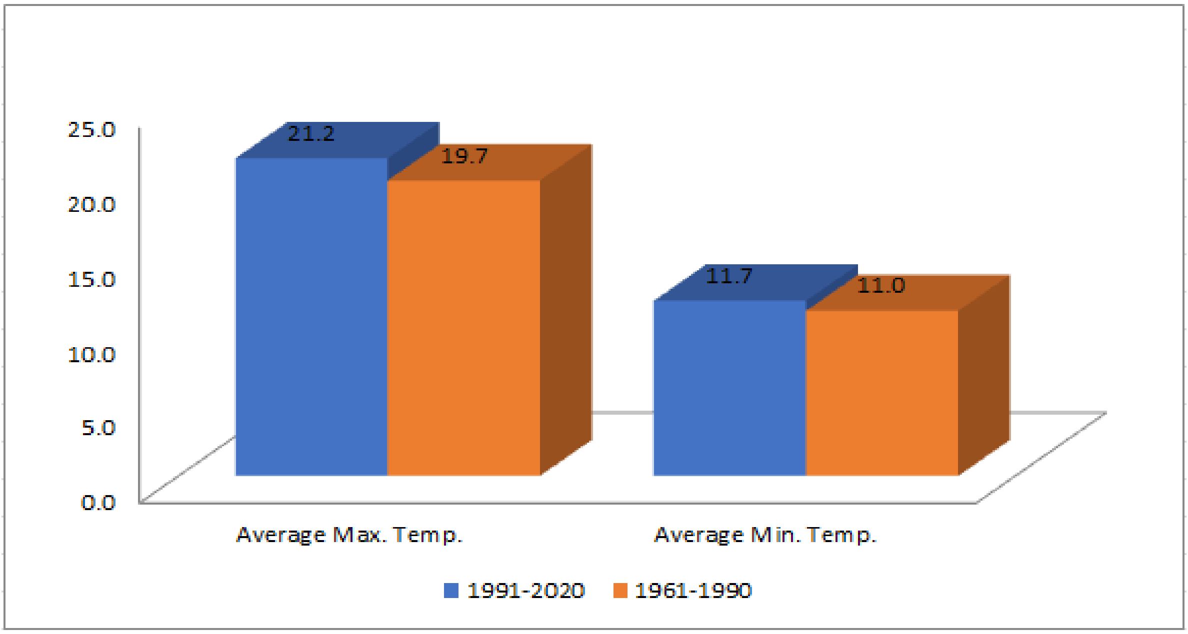


Figure 20. Differences of minimum and maximum air temperatures between two periods.

Figure 20 compares the analysis of the values of average maximum and minimum air temperatures in the 30 years 1990-2020 compared to the 30 years 1960-1990.

- **Increase in Both Maximum and Minimum Temperatures**: The comparison shows that both maximum and minimum temperatures have increased significantly from 1960-1990 to 1990-2020. The average maximum temperature has increased by approximately 1.5°C, and the average minimum temperature has risen by around 0.7°C.
- **Significance of the Temperature Rise**: These temperature increases are significant, as they represent a clear warming trend over the last three decades. The increased temperature gap between the two periods indicates that climate change has had a noticeable effect on the region's temperature regime, with warmer summers and milder winters being more pronounced in recent years.

Figure 21 shows a map of the long-term average maximum air temperature in Lezha from 1990-2020.

- **Spatial Variation by Altitude**: The map reveals that maximum temperatures are higher in the lowland areas of Lezha, with temperatures averaging around 19.7°C in these areas. In contrast, higher altitude regions experience cooler temperatures, with the average maximum temperature reaching around 11.9°C.
- **Impact of Topography**: The spatial distribution of maximum temperatures is influenced by topographical features, such as hills and mountains. Lower-lying areas in the region are more exposed to sunlight and have higher temperatures, while the cooler temperatures in elevated areas can be attributed to altitude and the associated decrease in temperature with height.

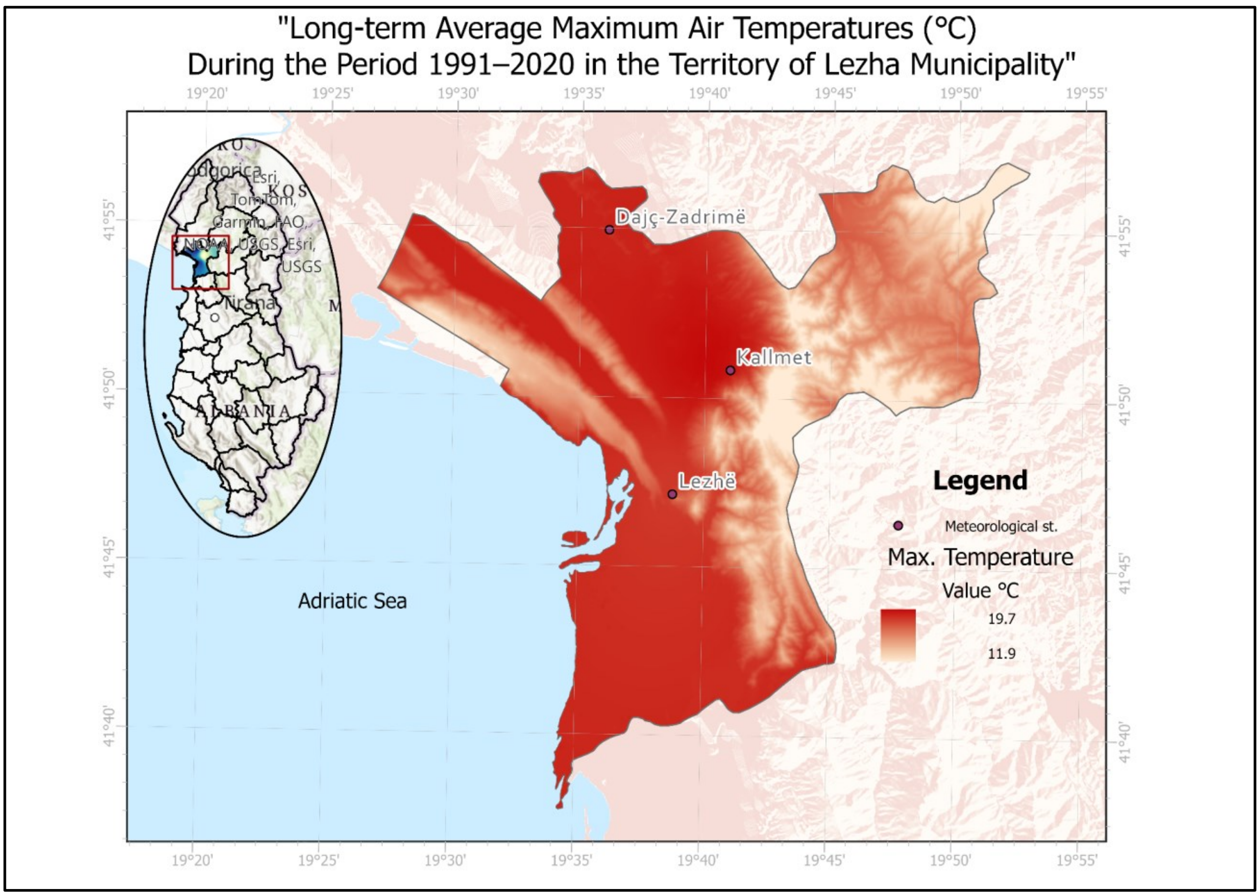


Figure 21. Long term average Maximum air temperature (OC), Lezha 1990-2020.

The physical-geographical distribution of the element is expressed in the form of homogeneity of values. In the north-south direction, the pronounced uniformity of temperatures is evident, while in the eastern direction the situation is presented with slightly lower temperatures as a result of the presence of hilly massifs and mountains. The maps present a detailed temperature distribution, which also takes into account the effect of temperature changes in altitude according to the hypsometric gradient of -0.6°C every 100 m.

Figure 22 illustrates the long-term average minimum air temperature across Lezha from 1990-2020.

- **Temperature Distribution**: Similar to the maximum temperatures, the minimum temperatures are also lower in higher altitude areas. The map shows that the lowest temperatures average around 3.3°C in the highest areas and rise to approximately 11.9°C in the lower-elevation zones.
- **Elevation's Role in Temperature Variation**: The elevation effect is particularly evident here, with mountainous and hilly areas experiencing lower minimum temperatures. This pattern suggests that rural areas situated at higher elevations could be more susceptible to cold-related challenges, such as frost damage to crops during the winter months.

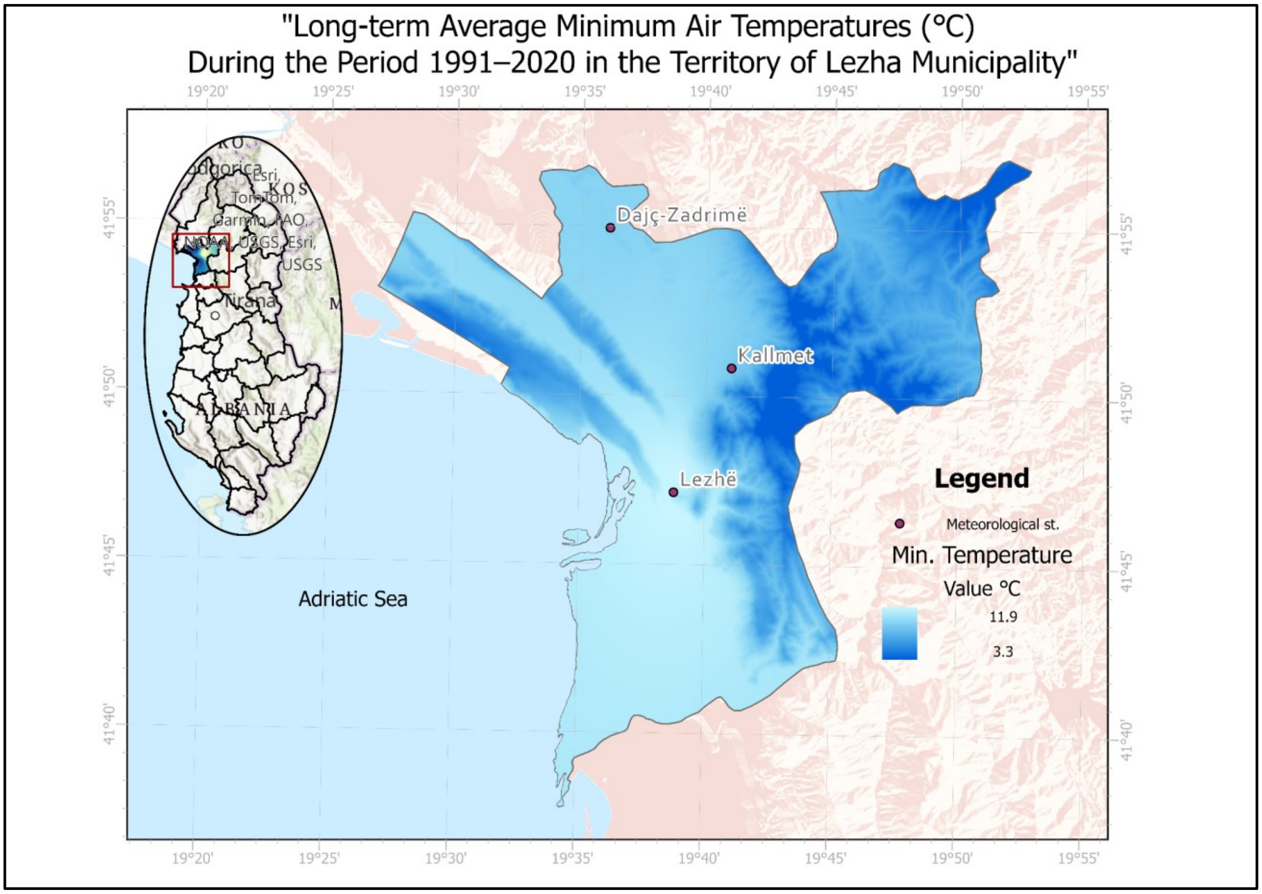


Figure 22. Long term average Maximum air temperature (oC), Lezha 1990-2020.

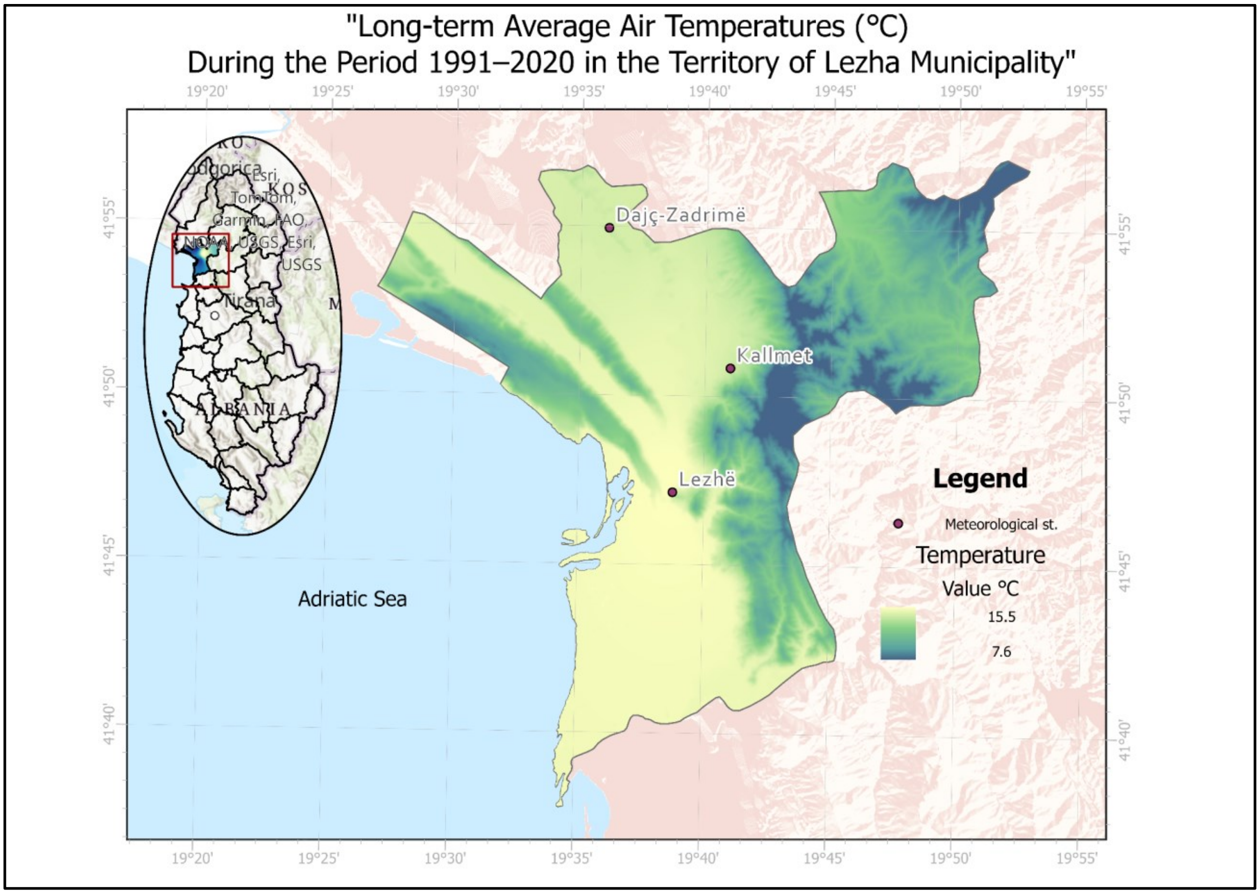


Figure 23. Long-term average air temperature (OC), Lezha 1990-2020.

Figure 23 provides a comprehensive view of the long-term average air temperature throughout Lezha from 1990-2020.

- **Overall Temperature Trends**: The map shows a consistent increase in the average air temperature across the region. The long-term average temperature in Lezha indicates a general warming trend, average around 15.5 °C in the highest areas and rise to approximately 7.6 °C in the lower zones.
- with the region becoming hotter over the past three decades. This trend aligns with the findings from Figure 21 and highlights the regional effects of global warming.
- **Uniform Warming Across the Region**: Unlike the maximum and minimum temperatures, which show more pronounced differences based on elevation, the overall average temperature map suggests a more uniform warming trend across both urban and rural areas. This is concerning, as it suggests that climate change is not only impacting remote, high-altitude areas but is affecting the entire region.

4.3 Anomaly Analysis 1980-2023

The Anomaly Analysis for 1980-2023 presents a comprehensive examination of temperature changes in the Lezha region, focusing on both the trends and shifts observed over the last four decades. The analysis distinguishes two distinct periods with different temperature behaviours, which are crucial for understanding the dynamics of climate change in the region. A detailed analysis to present the trend of temperature anomalies is presented through the figures below no. 25-33.

a) Period of Relative Stability (1980-2000)

Maximum temperatures during this period show relative stability with slight fluctuations between the years. The annual average of maximum temperatures remained within historical climate norms (referred to as the base period 1961-1990), with only occasional positive or negative deviations. Positive deviations were rare, usually appearing during dry years such as 1987, while negative deviations appeared mainly during colder winters (e.g., 1985).

b) Noticeable Increase in Temperatures (2001-2023)

This period is characterized by a slight and continuous increase in maximum temperatures. Recent decades have shown a marked trend towards positive anomalies, especially after 2010. The hottest years: 2010, 2017, 2021 and 2022. In these years, maximum temperatures exceeded the average norm by 2-3°C. The phenomenon of heat waves has become more frequent, especially during the months of July and August. For example, during the 2021 heat wave, maximum temperatures in the Dajç-Zadrimë area reached up to 42°C, breaking historical records. Recent winters have shown a significant reduction in negative deviations. Maximum temperatures during the months of January and February have increased, often exceeding 15°C. Spring and autumn have shown shifts in seasonal boundaries, with maximum temperatures often resembling those of summer. Minimum temperatures also experienced a significant increase, especially in winters and early spring. The most significant anomalies were observed between **2007 and 2017**, with winter and summer nights becoming notably warmer (e.g., winter anomalies exceeding +2°C). **2022** had numerous tropical nights, with temperatures not falling below **22°C** on several occasions, indicating an increased frequency of unusually warm nights.

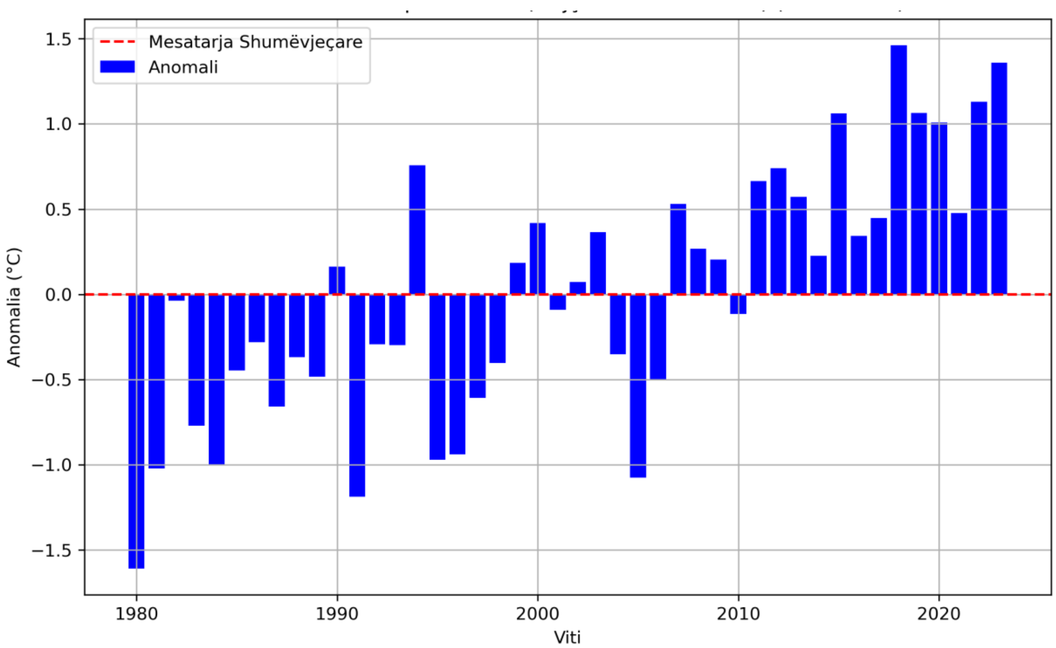


Figure 24. Anomalies of Maximum Temperatures for the Dajç-Zadrimë Area, Lezhë (1980-2023).

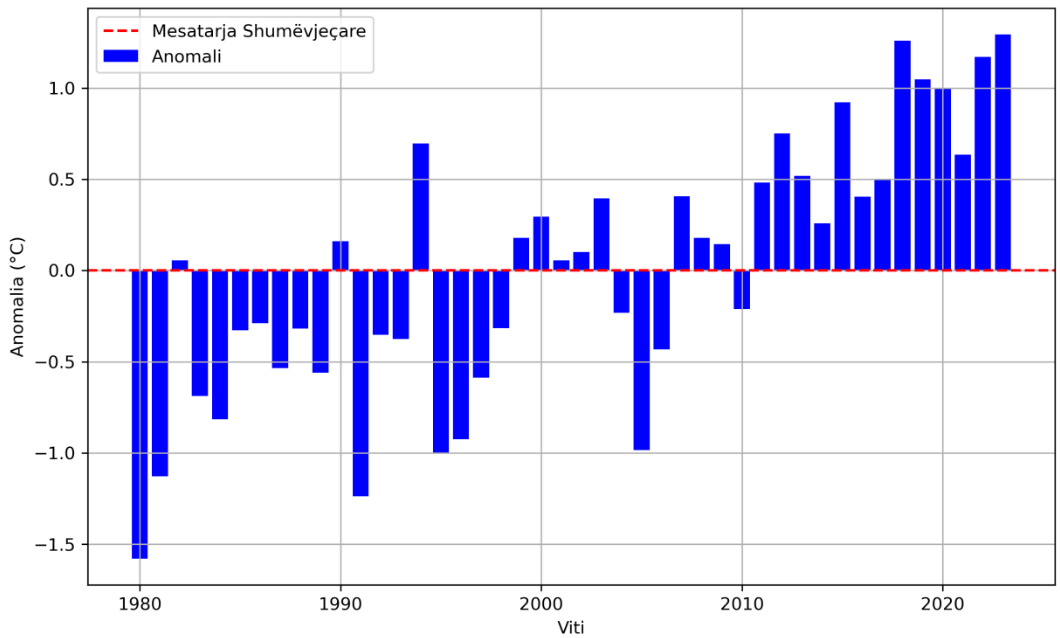


Figure 25. Anomalies of Maximum Temperatures for the Lezha Area, Lezhë (1980-2023).

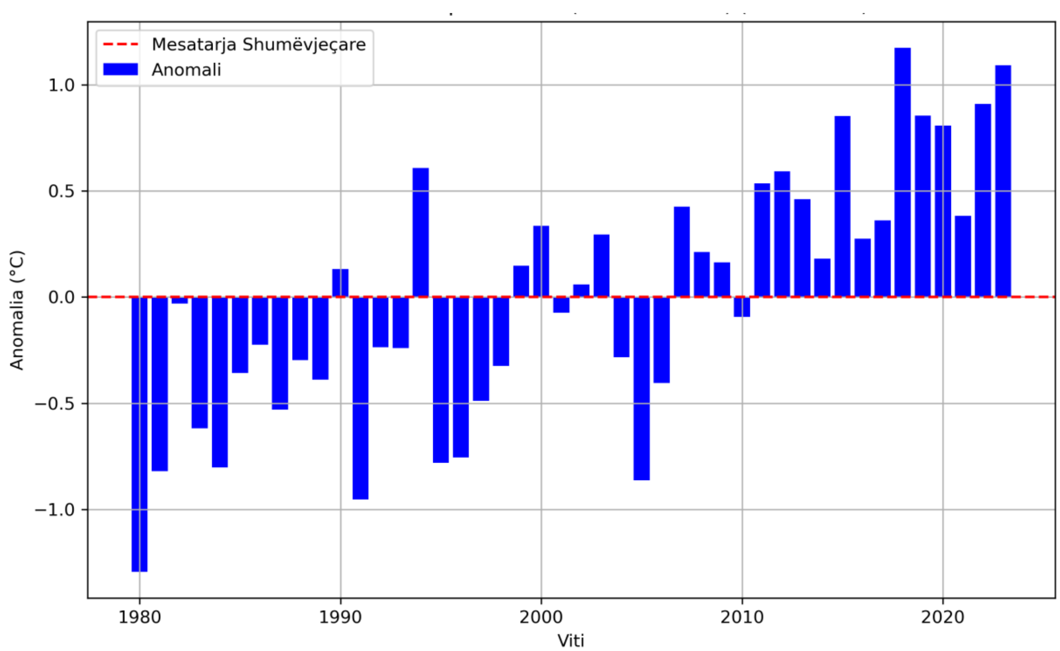


Figure 26. Anomalies of Maximum Temperatures for Kallmet Area, Lezhë (1980-2023).

c) Temperature Anomalies and Multi-Year Averages (1980-2023)

For the period 1980-2023, specific data on maximum temperature anomalies in the Dajç-Zadrimë area, Lezhë, and Kallmet are limited. However, national-scale climate analyses show a general trend of increasing maximum temperatures in Albania. The maximum temperature anomalies for the Dajç-Zadrimë area in Lezha for the period 1980-2023 are a reflection of local climate changes due to natural and anthropogenic factors. This region, located in the western lowlands of Albania, has a Mediterranean climate, characterized by hot summers and mild winters. The temperature anomalies show important trends that reflect the effects of global warming and climate change. The data also highlights how local factors, such as the proximity to the Adriatic Sea and urbanization (urban heat island effect), have intensified these warming trends. The **urban heat island effect** is particularly notable in urbanized areas like Lezha, where changes in land use and urbanization contribute to higher temperatures.

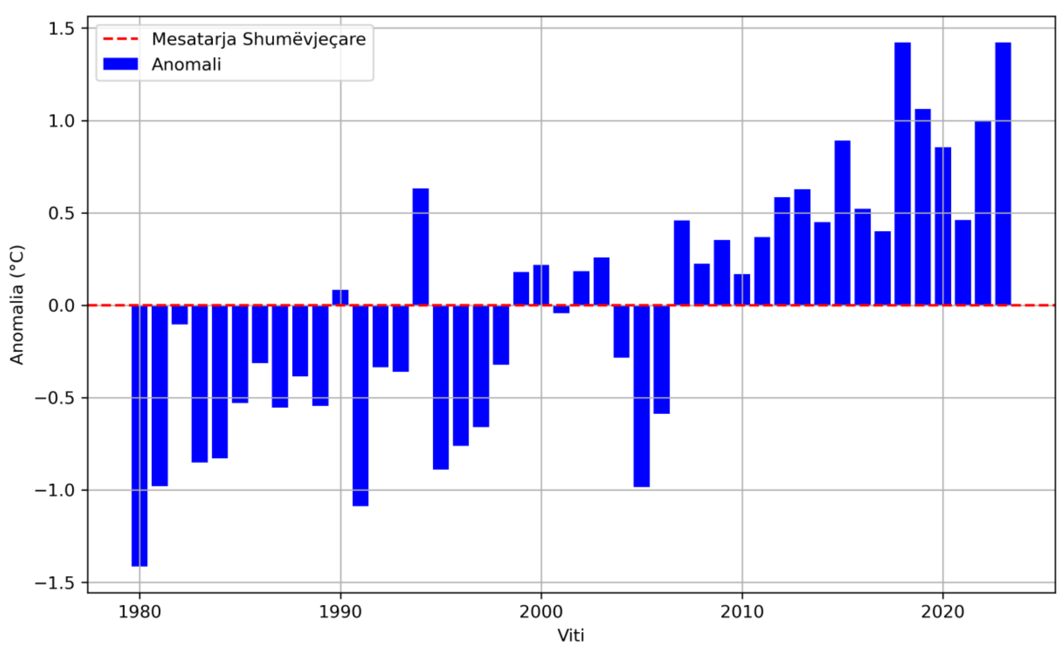


Figure 27. Anomalies of Average Temperatures for the Dajç-Zadrimë Area, Lezhë (1980-2023).

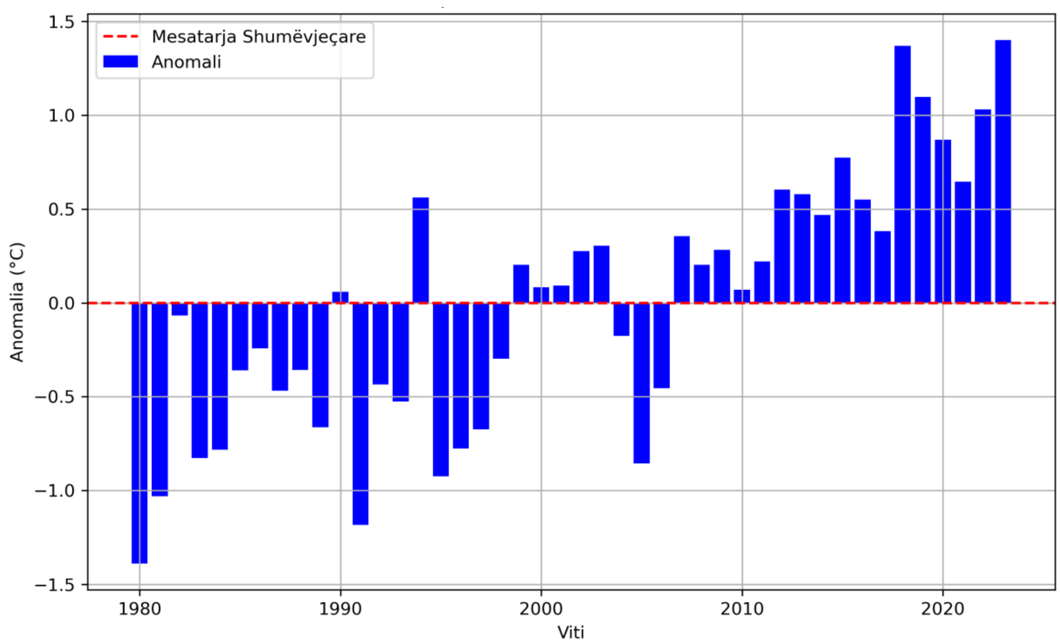


Figure 28. Anomalies of Average Temperatures for Kallmet Area, Lezhë (1980-2023).

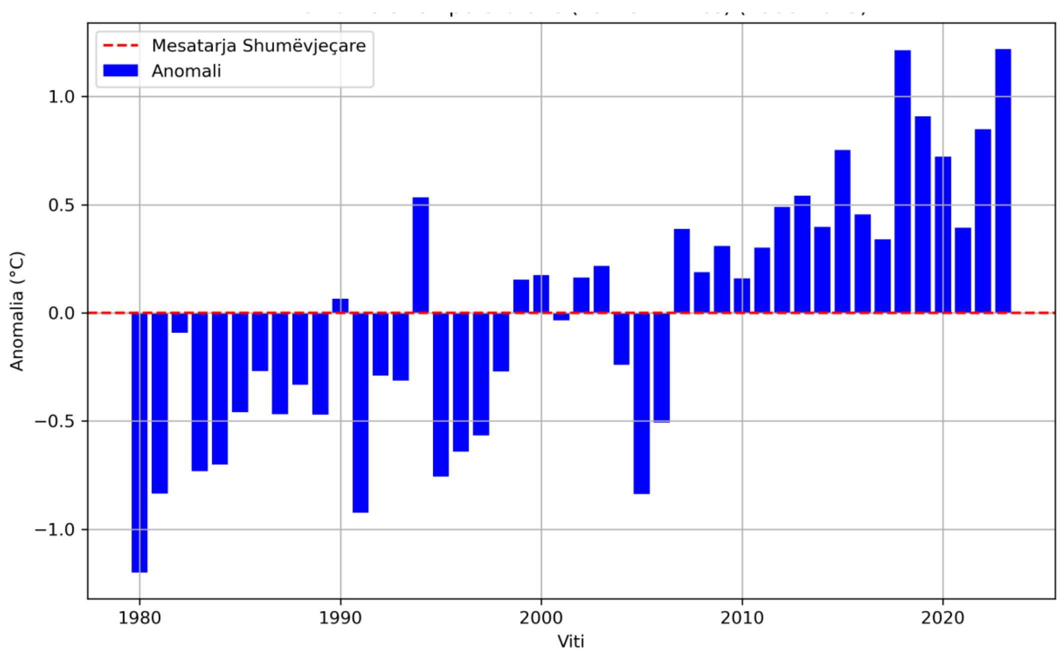


Figure 29. Anomalies of Average Temperatures for the Lezha Area, Lezhë (1980-2023).

The period 1980-2023 has shown a steady and significant increase in average temperatures in the Lezha area, influenced by global warming trends and local factors. The average temperature anomalies in the Lezha area for the period 1980-2000, were relatively stable, with small changes around the climatic norms (1971-2000). The anomalous years were 1994 and 1997, marking an increase in average temperatures by +1.5°C above the climatic norm for summer. Anomalies have become more pronounced after the 2000s, having a wide impact on the climate, ecosystem and human activities. The anomalies were related to atmospheric conditions of drought and high temperatures throughout the year.

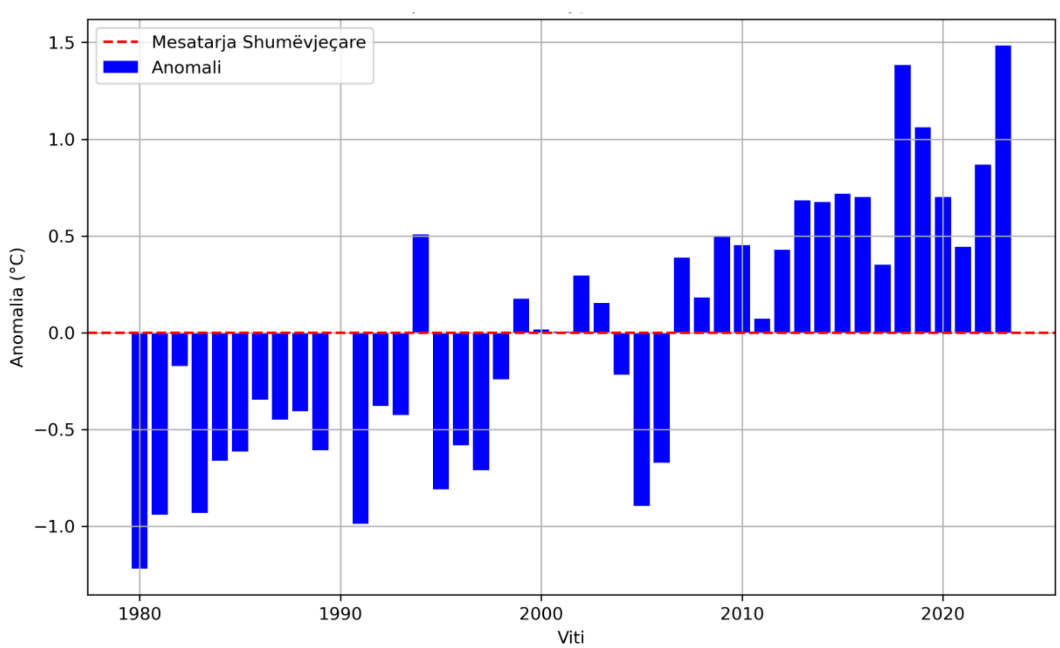


Figure 30. Anomalies of Minimum Temperatures for the Dajç-Zadrimë Area, Lezhë (1980-2023).

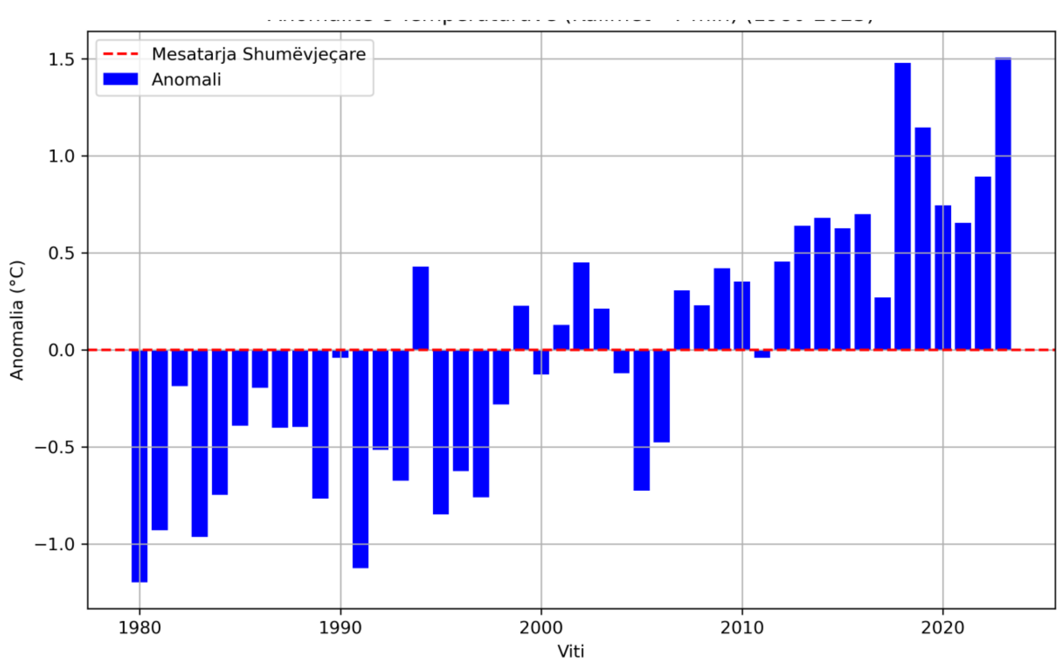


Figure 31. Anomalies of Minimum Temperatures for Kallmet Area, Lezhë (1980-2023).

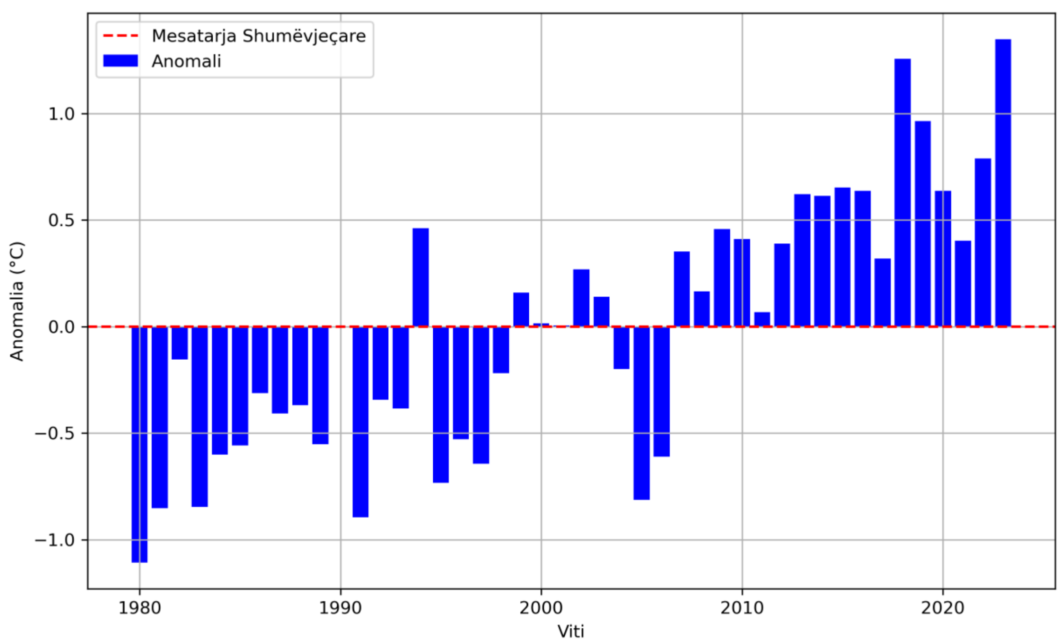


Figure 32. Anomalies of Minimum Temperatures for the Lezha Area, Lezhë (1980-2023).

The minimum temperature anomalies for the Lezha area for the period 1980-2000 are characterized by relative stability of minimum temperatures, with some years showing slight deviations from climate norms (1971-2000). The anomalous years were 1985, a very cold winter throughout the region, with minimum temperatures lower than normal by -2°C to -3°C, and 1994, with a significant increase in minimum temperatures, especially during the winter months, with positive anomalies up to +1.5°C. The period 2001-2023 has marked a significant increase in minimum temperatures, with the largest anomalies recorded during the last decade. Years with significant increases in minimum temperatures, especially during the winter and spring months, where anomalies were up to +2°C were the period 2007 and 2010. The period from 2012 to 2017 marked some of the warmest years, with minimum temperatures exceeding long-term norms by +2.5°C during winter and summer nights. The year 2022 marked a year with numerous tropical nights during the summer months, with minimum temperatures not falling below 22°C on several nights. Also, during this study was analized multi-year average temperature in °C for the Dajç-Zadrimë, Kallmet and Lezha meteorological station for the maximum, mesatares, minimum temperature. T max), presented through the figures below no 31-39, for the period 1980-2023. In the period 1980-2023, the multi-year average temperature data have shown clear changes that reflect the impact of global warming and local factors on the climate of the region. The multi-year average temperature for the period 1980-2023 for Lezha, the multi-year average temperature ranges from 14.5°C to 16.0°C, depending on the analysis methodology and division of specific periods. Compared to the reference period 1961-1990, the period 1980-2023 shows a significant increase in the average temperature, which has been more noticeable after the year 2000.

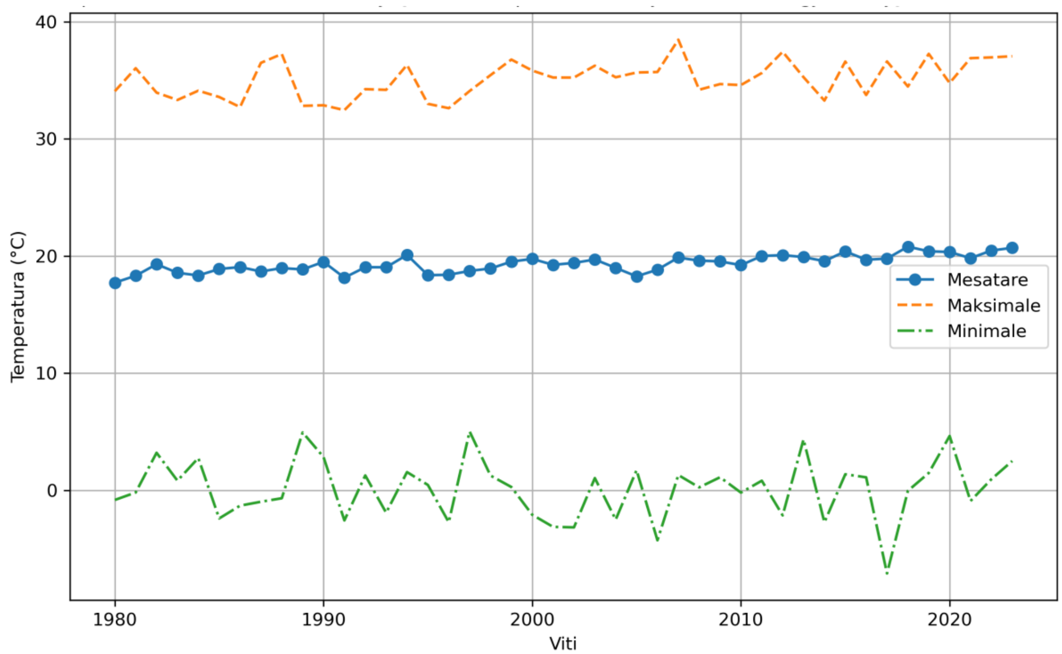


Figure 33. Multi-year average temperature in °C for the Dajç-Zadrimë meteorological station.

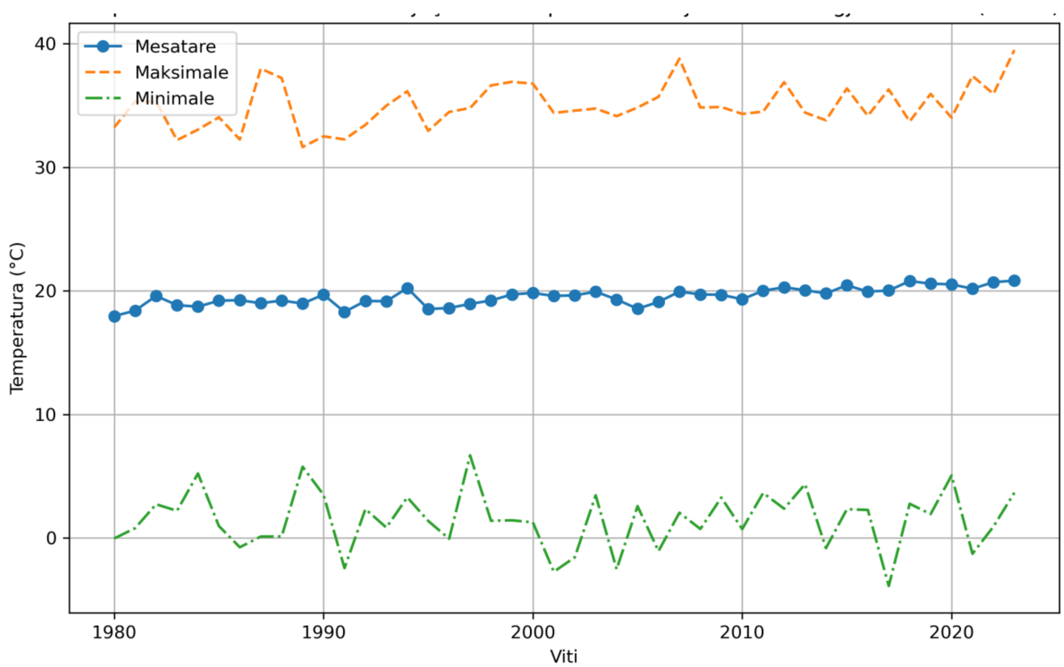


Figure 34. Multi-year average temperature in °C for the Kallmet meteorological station.

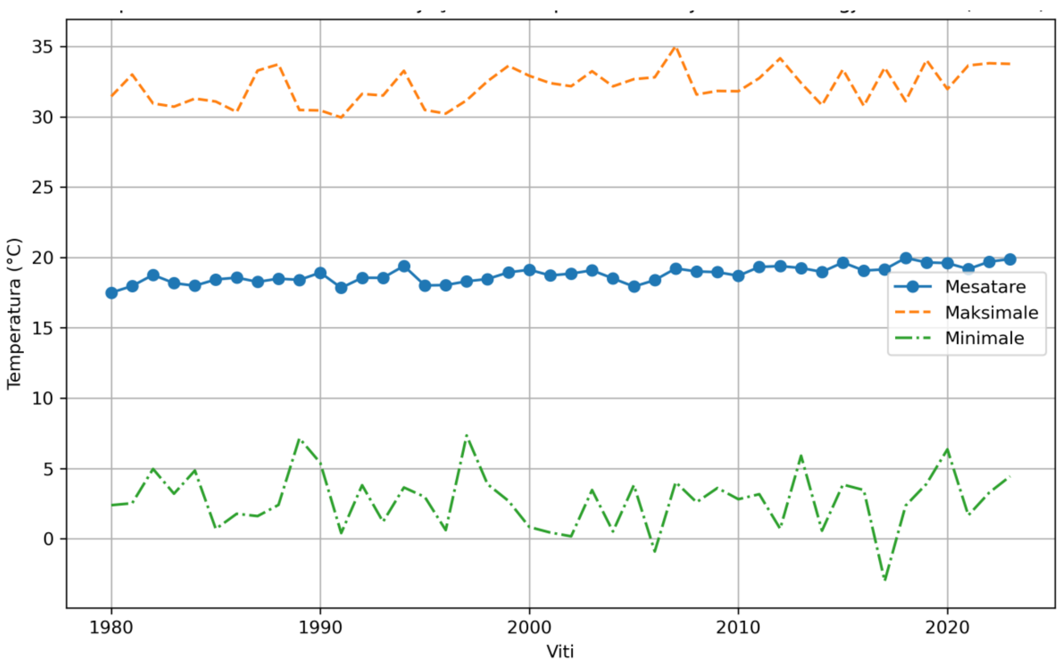


Figure 35. Multi-year average temperature in °C for the Lezha meteorological station.

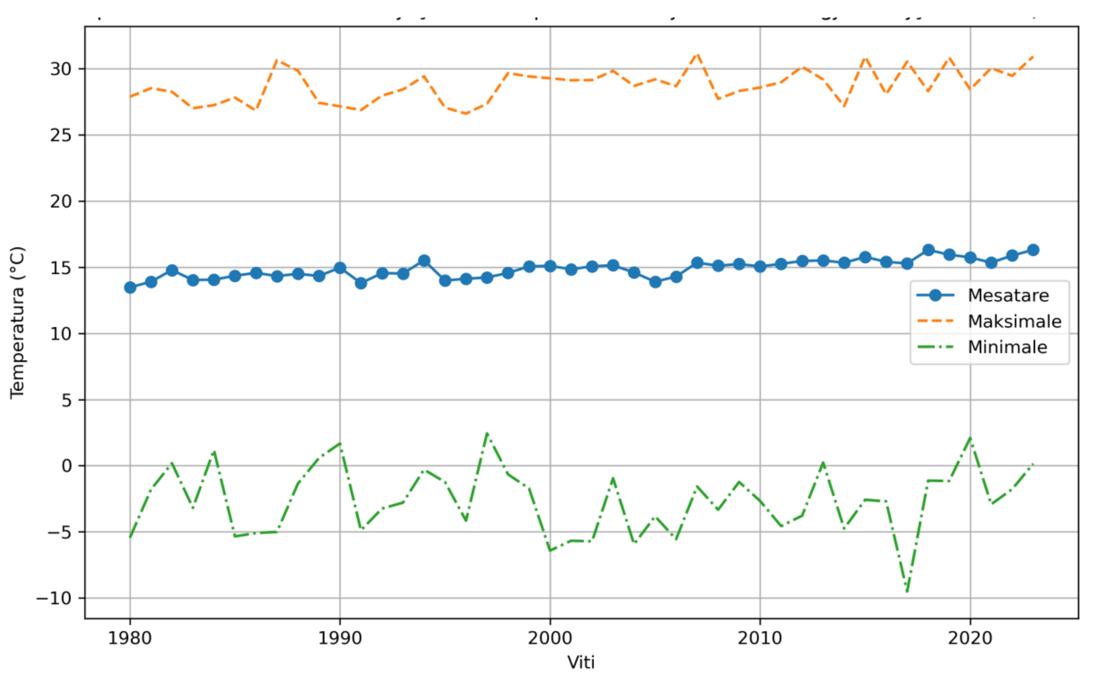


Figure 37. Multi-year average temperature in °C for the Dajç-Zadrimë meteorological station.

The period 2001-2023 has marked accelerated warming, with a high number of years with temperatures above the multi-year norm. In 2019, Lezha recorded one of the highest average temperatures, where the multi-year value was exceeded by over +2.0°C in several months. Local factors affecting average temperatures are the proximity to the Adriatic Sea. The Adriatic Sea moderates' temperatures during winter and summer, making the climate milder and more stable. Land use changes are another influential indicator. Urbanization and intensive land use have contributed to the increase in average temperatures due to the "urban heat island" effect. Global warming trends have amplified local changes, with the intensification of phenomena such as tropical nights and droughts.

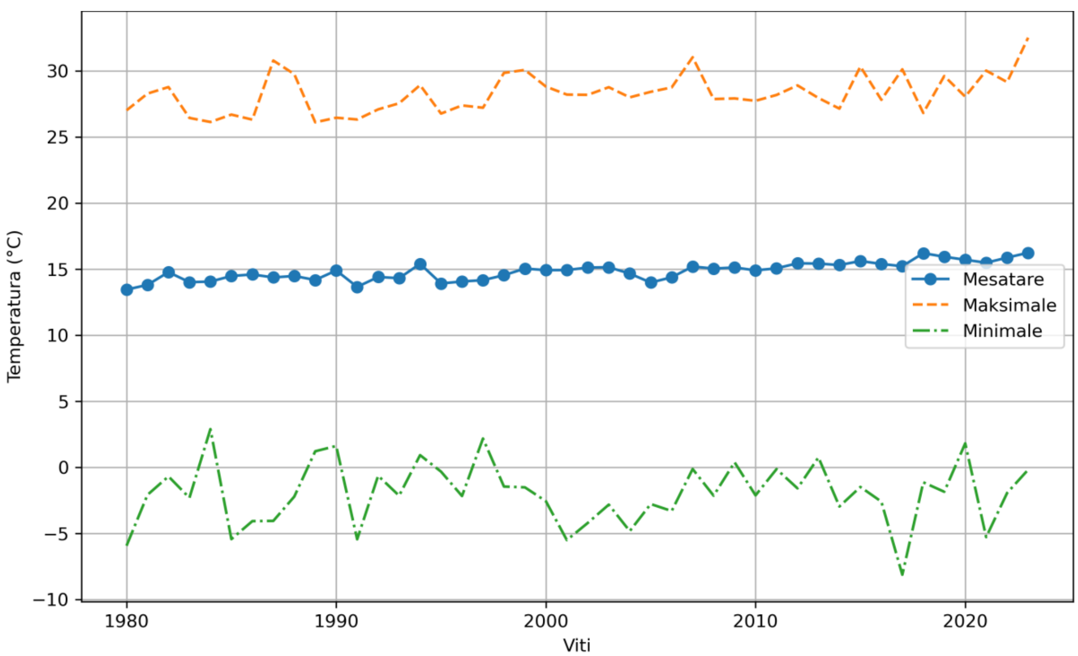


Figure 36. Multi-year average temperature in °C for the Kallmet meteorological station.

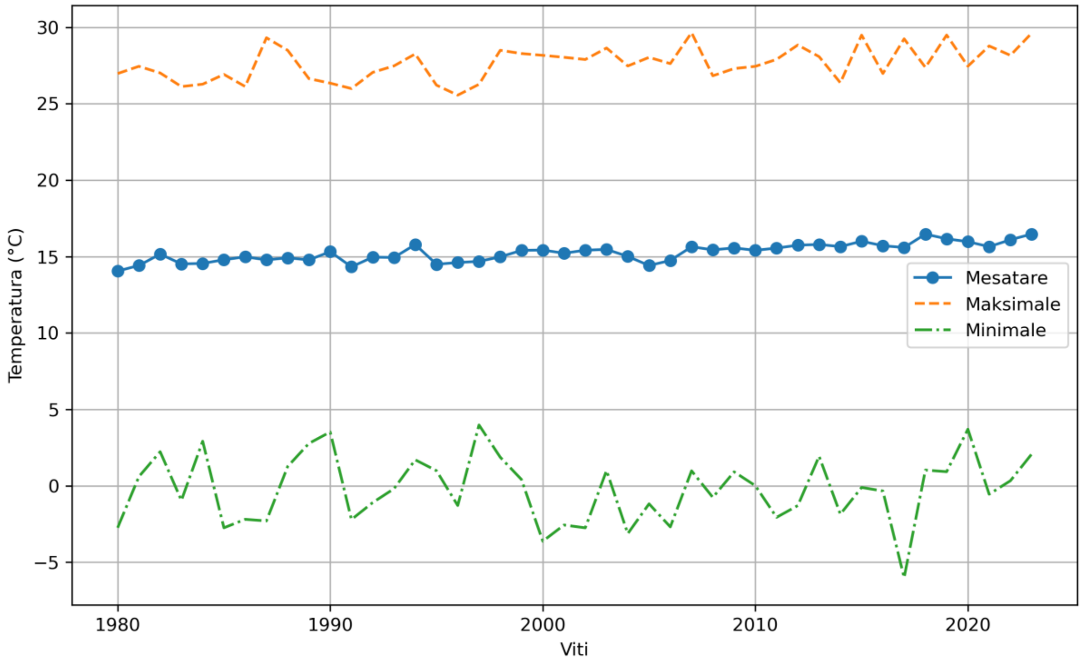


Figure 37. Multi-year average temperature in °C for the Lezha meteorological station.

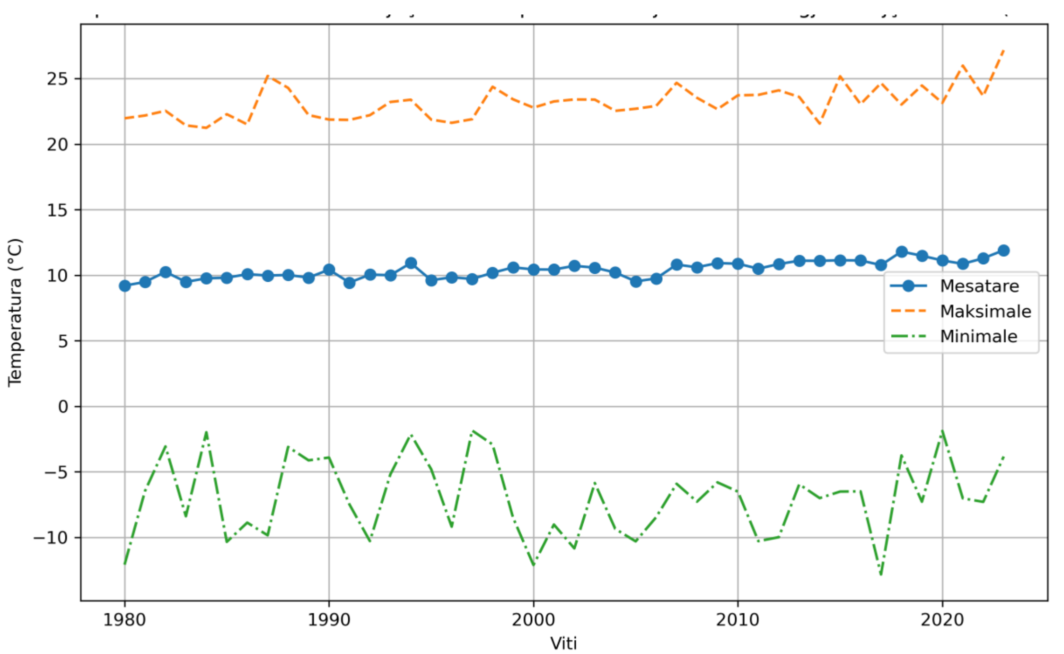


Figure 38. Multi-year average temperature in °C for the Dajç-Zadrimë meteorological station.

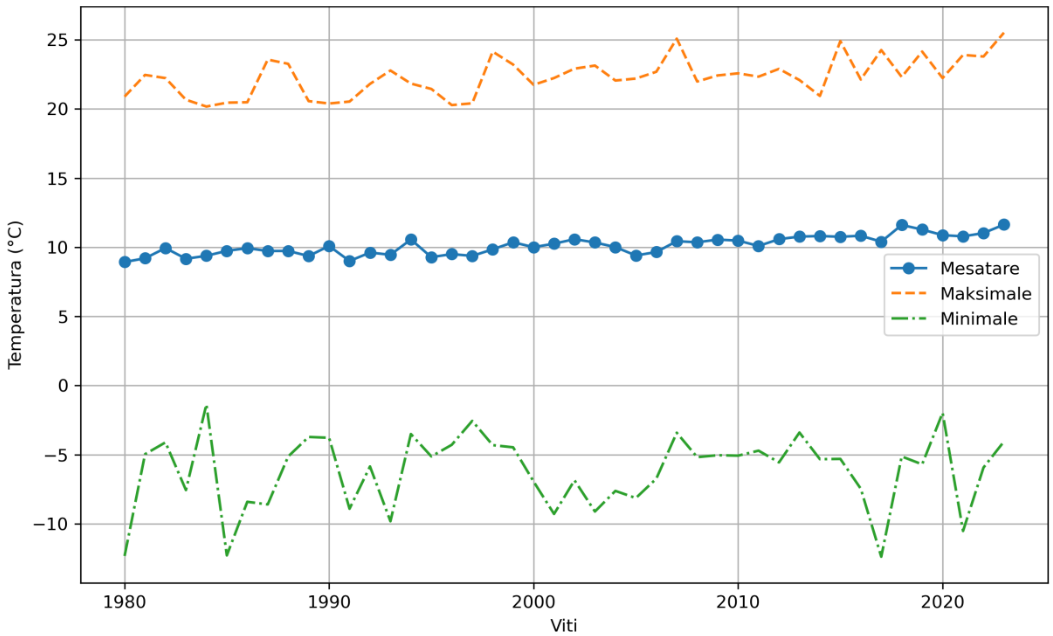


Figure 39. Multi-year average temperature in °C for the Kallmet meteorological station.

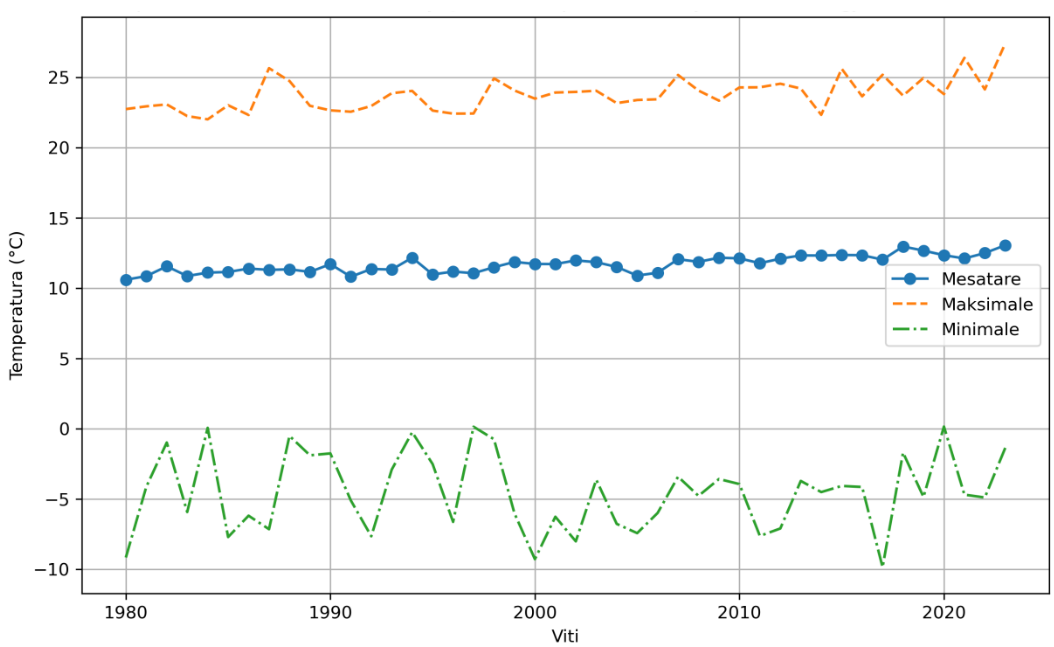


Figure 40. Multi-year average temperature in °C for the Lezha meteorological station.

d) Rainfall and Precipitation Trends (1990-2020)

The rainfall patterns are also notably unique. The average rainfall recorded in the regions is as high as 1800 millimetres. Within the areas, the rainfall sometimes lasts as long as 24 hours and could reach a maximum volume of over three hundred millimetres. These should explain the unique pattern of rainfall in the areas and why flooding is a frequent problem. We can say that the period 1980-2023 has shown a steady increase in average temperatures, reflecting the general trends of climate warming. The most evident seasonality in temperature changes has been summer and winter, as the seasons with the greatest changes, affecting the occurrence of extreme phenomena such as hot days and tropical nights. The consequences that arise from the warming of average temperatures have affected various sectors, including agriculture, biodiversity and public health. Therefore, from the data presented and the consequences that they show, adaptation to these risks is necessary. The increase in temperatures and precipitation requires strategies to adapt to new climatic conditions and reduce negative impacts in this region.

Table 5. Change in rainfall volume (mm), days with rain >= 0.1

Month	Date//Year	Max.24h	No. of days with rain >=0.1	Rainfall (mm)
Jan	4//86	152.8	10.4	154.5
Feb	1//77	76.0	9.7	127.8
Mar	5//69	120.5	9.7	132.7
Apr	29//62	91.5	9.6	121.4
May	30//64	107.4	6.8	89.5
Jun	10//68	160.1	5.6	70.4
Jul	12//82	118.5	3.1	35.8
Aug	6//68	89.7	3.6	58.3
Sep	27//72	129.5	5.4	86.5
Oct	31//76	116.7	7.6	141
Nov	14/63	135.1	11.5	187.6
Dec	8//60	75.8	11.1	157.3

Table 6. Amount of rainfall for the period 1990-2020, of days with rain >=0.1

Period 1990-2020				
Month	**Date//Year**	**Max.24h**	**No. of days with rain >=0.1**	**Rainfall (mm)**
Jan	1/14/1999	88.0	12.8	156.5
Feb	2/26/2001	132.2	13.7	145.4
Mar	3/2/2009	77.2	13.4	147.9
Apr	4/12/2002	80.2	13.2	134.1
May	5/1/2007	70.0	11.0	80.0
Jun	6/6/2006	97.0	7.8	54.9
Jul	7/15/2000	66.3	7.2	52.9
Aug	8/22/2005	74.3	7.5	64.7
Sep	9/18/2006	201	10.0	148.7
Oct	10/5/2010	205.6	12.0	186.8
Nov	11/17/1992	122.4	14.3	208.3
Dec	12/20/2010	202.0	14.1	180.8

During the period 1990-2020, the analysis of precipitation and rainy days (≥0.1 mm) shows significant variations related to climatic influences and regional factors.

From the analysis of the annual rainfall data, we see that we have an increasing trend from 1990 to 2020. This is presented in figure no. 43.

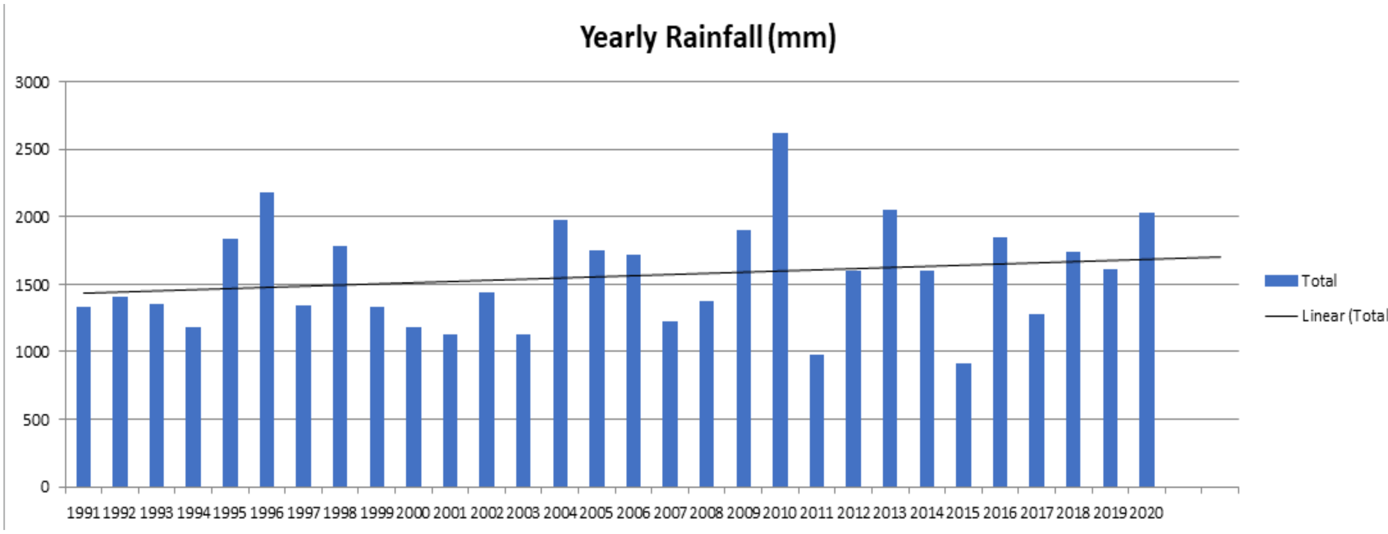


Figure 41. Yearly Rainfall data (mm) for the period 1990-2020.

By detailed analysis of the number of rainy days in the period 1990-2020 and comparing it with the period 1961-1990, we noticed that we have an increase in the number of rainy days. The increase in the number of rainy days is observed every month. This is presented by figure no. 42.

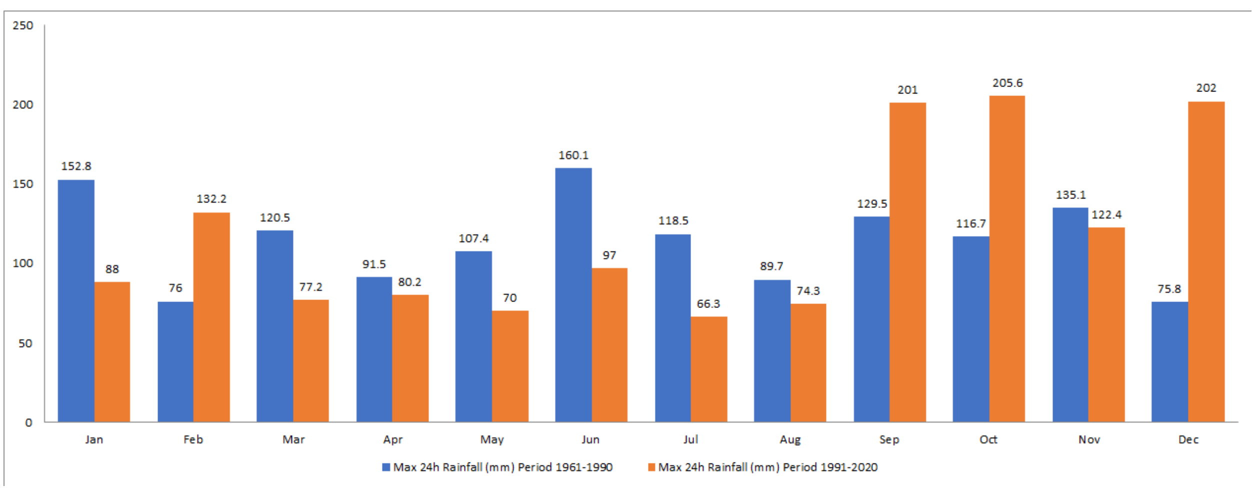


Figure 42. The comparison of the maximum 24 h rainfall (mm) for the periods 1961-1990 and 1991-2020.

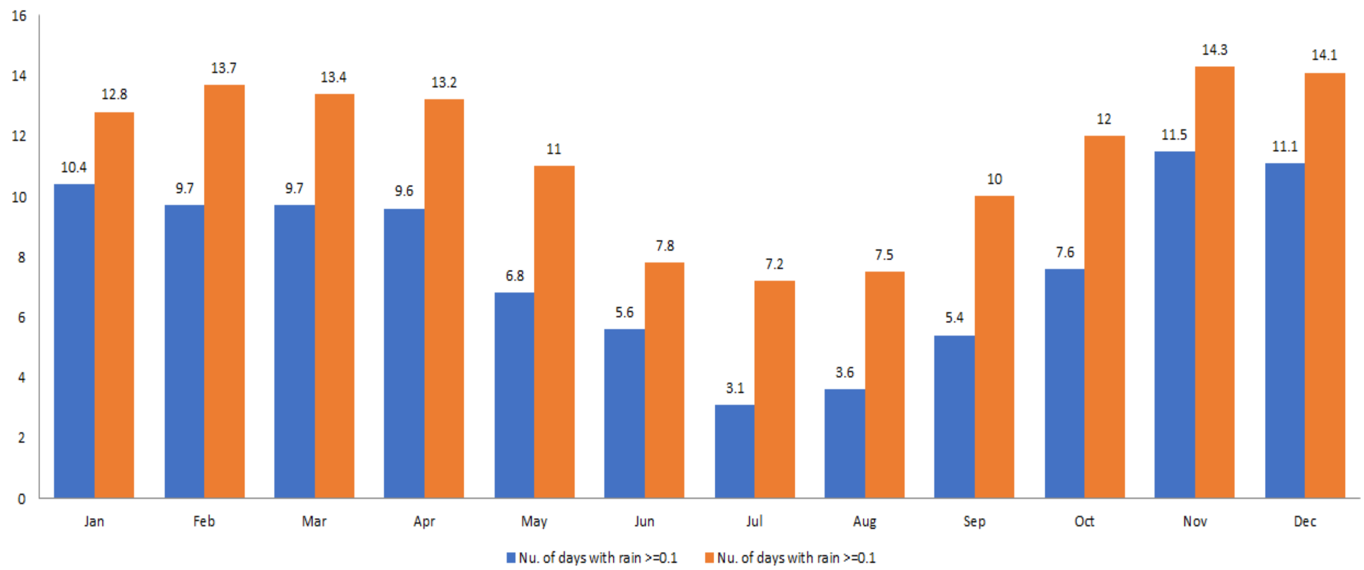


Figure 43. Maximum hourly rainfall (≥0.1 mm) for the period 1961-1990 and 1991-2020.

Regarding the maximum hourly rainfall, we have an increase in their value during the months of September, October, and December. This is shown in figure no. 43. Average annual precipitation in Lezha for the period 1990-2020 is estimated to be between 1200 mm and 1500 mm, following a typical distribution where the wettest months are in autumn and winter. On average, the number of rainy days during the year varies between 90 and 120 days. Rainy days are more numerous during winter and autumn, while summer experiences longer periods of drought.

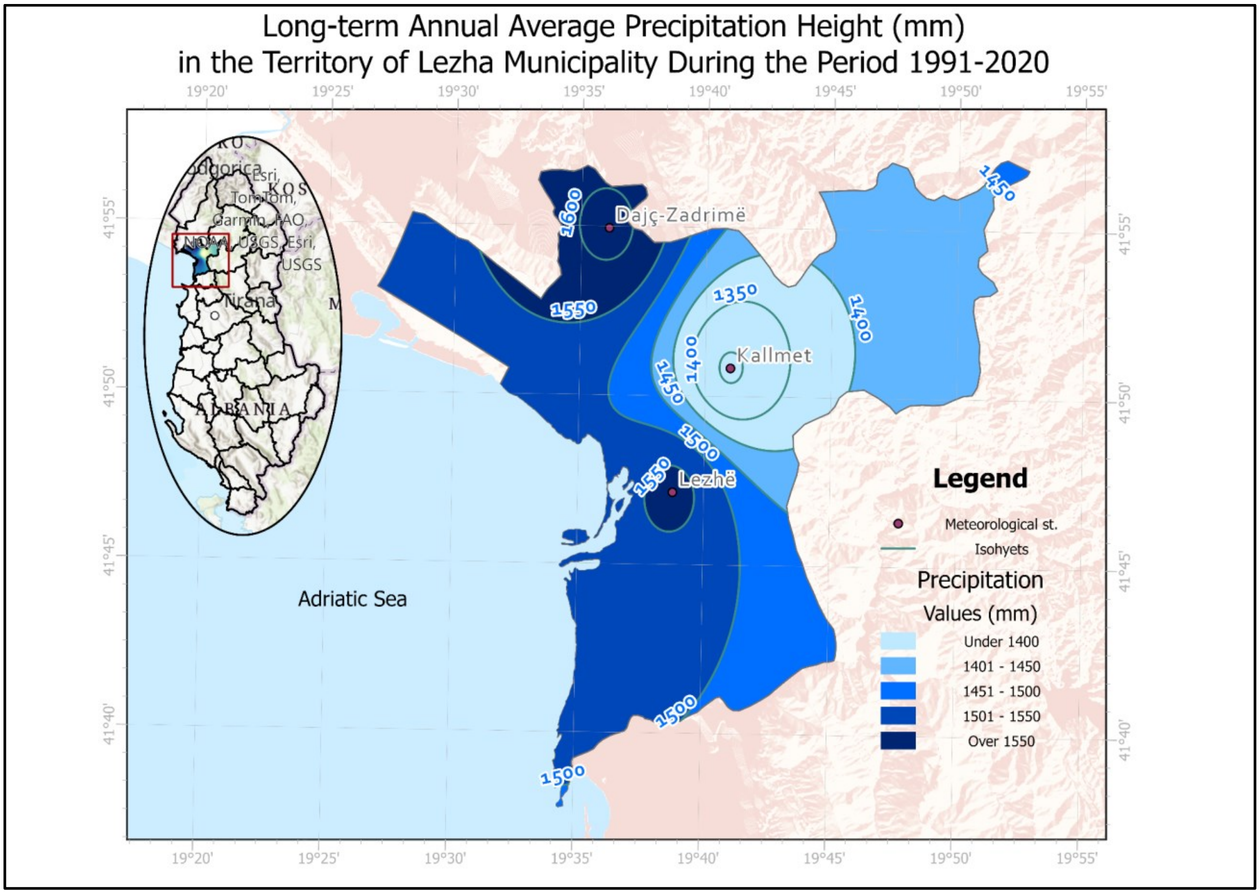


Figure 44. Map of Long-term average precipitation height (mm), Lezha City.

It is crucial to understand the extent of the dangers that the majority of cities around the world face due to the constant disasters that occur due to adverse changes in the global climate or weather patterns. These impacts can disrupt and, in some cases, severely damage various urban functions, such as transportation, housing, energy, and water systems. However, the potential consequences of climate change extend beyond direct effects; urban features and characteristics can intensify these challenges, making cities even more vulnerable.

4.4 Urban Characteristics That Exacerbate Climate Vulnerability

Under stable *“the Urban Heat Island Effect*” is notable. Materials such as asphalt and concrete, common in urban areas, absorb and retain heat from the sun, creating localized temperature increases known as the *“urban heat island effect".* Urban regions, especially expanding cities such as Lezha, encounter heightened vulnerability and exposure to climate-related hazards owing to their constructed environments and socio-economic factors. Various metropolitan characteristics markedly intensify the region's susceptibility to climate change effects, particularly concerning elevated temperatures, severe weather occurrences, and resource strain. The vulnerabilities are exacerbated by fast urbanization, inadequate planning, and insufficient adaptable infrastructure.

1. Urban Heat Island Phenomenon (UHI)

A significant climate-related difficulty in urban regions is the Urban Heat Island (UHI) effect, wherein constructed surroundings absorb and retain more heat than adjacent rural areas. This effect is mostly influenced by materials like asphalt, concrete, and roofing surfaces, which exhibit high heat retention and low reflection. These surfaces absorb solar energy during the day and gradually release it at night, resulting in metropolitan areas being considerably warmer than rural ones.

In cities such as Lezha, the urban heat island effect has exacerbated during heatwaves, resulting in elevated evening temperatures and diminished cooling intervals. The rise in urban temperatures presents significant public health hazards, especially for the elderly, children, and individuals with pre-existing health disorders. Moreover, the need for air conditioning and cooling systems escalates, leading to heightened energy consumption and additional greenhouse gas emissions.

2. Non-Permeable Surfaces and Urban Flooding

Urban development generally supplants natural ground cover with impermeable surfaces, including roads, pavements, and structures. These surfaces restrict the absorption of precipitation into the soil, hence augmenting the amount and velocity of surface runoff. During intense precipitation events, the stormwater drainage system frequently becomes inundated, resulting in recurrent urban floods.

The amalgamation of severe precipitation events and insufficient drainage capacity in Lezha has led to localized flood risks, causing damage to property and infrastructure while interrupting transportation systems. Furthermore, the deficiency of adequate permeable surfaces and green infrastructure results in poor natural flood mitigation, exacerbating the city's susceptibility to flooding.

3. Loss and Pressure on Urban Green Spaces

Green areas, including parks, urban forests, and green corridors, are essential for urban resilience. They assist with temperature regulation, rainwater absorption, air quality enhancement, and offer social and recreational advantages. As urbanization in Lezha intensifies, there is increasing strain on existing green spaces, many of which are being transformed into residential or commercial developments.

Elevated population density diminishes the availability, accessibility, and quality of green spaces per capita. The loss or degradation of these regions diminishes the city's ability to naturally regulate temperature extremes and control water runoff. Moreover, the absence of flora and arboreal cover heightens exposure to air pollution and exacerbates psychological stress in densely populated metropolitan areas.

4. Water Supply Strain

The expansion of urban populations, along with alterations in precipitation patterns, is exerting considerable strain on water delivery infrastructure. In Lezha, seasonal droughts and erratic precipitation have rendered water availability unreliable. Simultaneously, concentrated urban populations elevate the need for home, industrial, and agricultural water, particularly during the summer months when consumption reaches its zenith.

This stress is intensified by inadequate water infrastructure, including antiquated pipelines, leaks, and unregulated water consumption. During instances of diminished precipitation or excessive temperatures, water scarcity poses a significant concern, impacting not just domestic consumption but also public services, agricultural productivity, and energy generation (particularly when water is utilized for cooling or hydropower).

Urban vulnerability is influenced by social disparities and deteriorating infrastructure. Informal settlements, low-income areas, and inadequately maintained dwellings are frequently the most vulnerable to climate-related hazards, including flooding, heat stress, and deteriorating air quality. These settlements often lack sufficient finances, access to cooling systems, and dependable water and sanitation services. Furthermore, public infrastructure in certain urban regions may fail to comply with contemporary climate resilience criteria. Outdated drainage systems, inadequate emergency response capabilities, and insufficient healthcare facilities can severely impede the city's capacity to address climate-induced disasters.

4.5 Adapting to Climate Change

As the effects of climate change escalate, cities such as Lezha must adopt proactive and cohesive adaptation plans to enhance resilience and save their inhabitants, infrastructure, and ecosystems. Adaptation entails planning for the expected impacts of climate variability and extreme weather events by diminishing vulnerability, augmenting resilience, and improving the sustainability of urban systems.

1. Proactive Planning and Risk Management

Climate adaptation commences with efficient risk evaluation, urban development, and readiness. Municipal authorities must integrate climate projections into land-use planning, zoning restrictions, and infrastructure development. This encompasses:

- Identifying flood-prone locations and prohibiting building in high-risk zones.
- Establishing early warning systems for extreme meteorological phenomena, including heatwaves, intense precipitation, and droughts.
- Incorporating climate risk into local development strategies and construction regulations to improve long-term resilience.
- Planning must be proactive, anticipating future hazards and implementing pre-emptive solutions rather than only responding to disasters post-occurrence.

2. Enhancing Green Infrastructure

Enhancing and sustaining green infrastructure is among the most efficacious methods for adapting urban environments to climate change. Green infrastructure denotes natural or semi-natural systems that deliver ecosystem services, including:

- Urban parks, green roofs, vertical gardens, and tree-lined roadways mitigate the Urban Heat Island (UHI) impact.
- Permeable surfaces and green spaces that enhance rainwater absorption, diminish surface runoff, and alleviate urban flooding.

These nature-based solutions manage urban microclimates and enhance quality of life by providing recreational places and improving mental and physical well-being.

3. Enhancing Stormwater Management Systems

Urban drainage systems must be upgraded and expanded to accommodate the heightened frequency and intensity of rainstorm events, which result in higher volumes of runoff. Measures for adaptation encompass:

- Developing detention basins, retention ponds, and bioswales for natural stormwater management.
- Implementing rainwater harvesting systems and rain gardens to alleviate the strain on municipal drainage infrastructure.
- Advocating for low-impact development (LID) methodologies that emulate natural hydrological cycles and diminish impermeable surfaces.

These enhancements are particularly vital in flood-prone areas of Lezha, where severe precipitation has traditionally exceeded the capacity of antiquated drainage systems.

4. Enhancing Urban Flora and Biodiversity

Urban vegetation is essential for climate resilience. The expansion of urban woodlands, communal gardens, and green belts offers:

- Natural cooling at periods of extreme heat.
- Enhanced air quality by the sequestration of contaminants.
- Habitats for pollinators and indigenous species, so enhancing urban biodiversity.
- Engaging communities in urban greening programs can enhance environmental awareness and cultivate a culture of stewardship and sustainability.

5. Ensuring Resilience of Water Supply

Water stress, intensified by droughts and population expansion, necessitates a varied and adaptive water management plan. This encompasses:

- Investing in effective water infrastructure to minimize leaks and wastage.
- Advocating for water saving methods within residential and industrial sectors.
- Investigating alternate water sources, including treated wastewater, rainfall harvesting, and desalination when applicable.

- Public awareness initiatives and intelligent water metering systems can significantly contribute to decreasing use and ensuring equitable distribution, particularly during arid seasons.

4.6 Implications

The examination of urban growth trends in Lezha over the last thirty years indicates a distinct and rapid tendency of spatial expansion. Figures 47–52 and Table 7 illustrate that the urban surface area of Lezha has surged from 22.2 hectares in 1991 to 125.08 hectares in 2020, representing a total growth exceeding 460%. This urban expansion mirrors wider national trends in Albania, where economic growth, demographic shifts, and rural-to-urban migration have resulted in the swift alteration of peri-urban environments.

This expansion, if not directed by sustainable planning and climate-conscious policies, presents considerable climate-related hazards and jeopardizes the city's long-term resilience. Unregulated urban expansion elevates the density of impermeable surfaces, diminishes vegetative cover, and intensifies pressure on already strained ecosystems and infrastructural systems.

- Urban Growth and Climate Susceptibility

The results unequivocally demonstrate that the expansion of urbanized land has not consistently been matched by equivalent investment in climate adaption infrastructure. As the constructed environment expands, the urban heat island (UHI) effect, the likelihood of surface runoff and flooding, and the erosion of natural buffers like wetlands and forests also increase.

Moreover, climate change exacerbates these difficulties. Heightened rainfall intensity, more frequent heatwaves, and water scarcity impose stress on urban systems beyond their designed capability, so exposing communities—particularly vulnerable and low-income populations—to heightened health, safety, and economic threats.

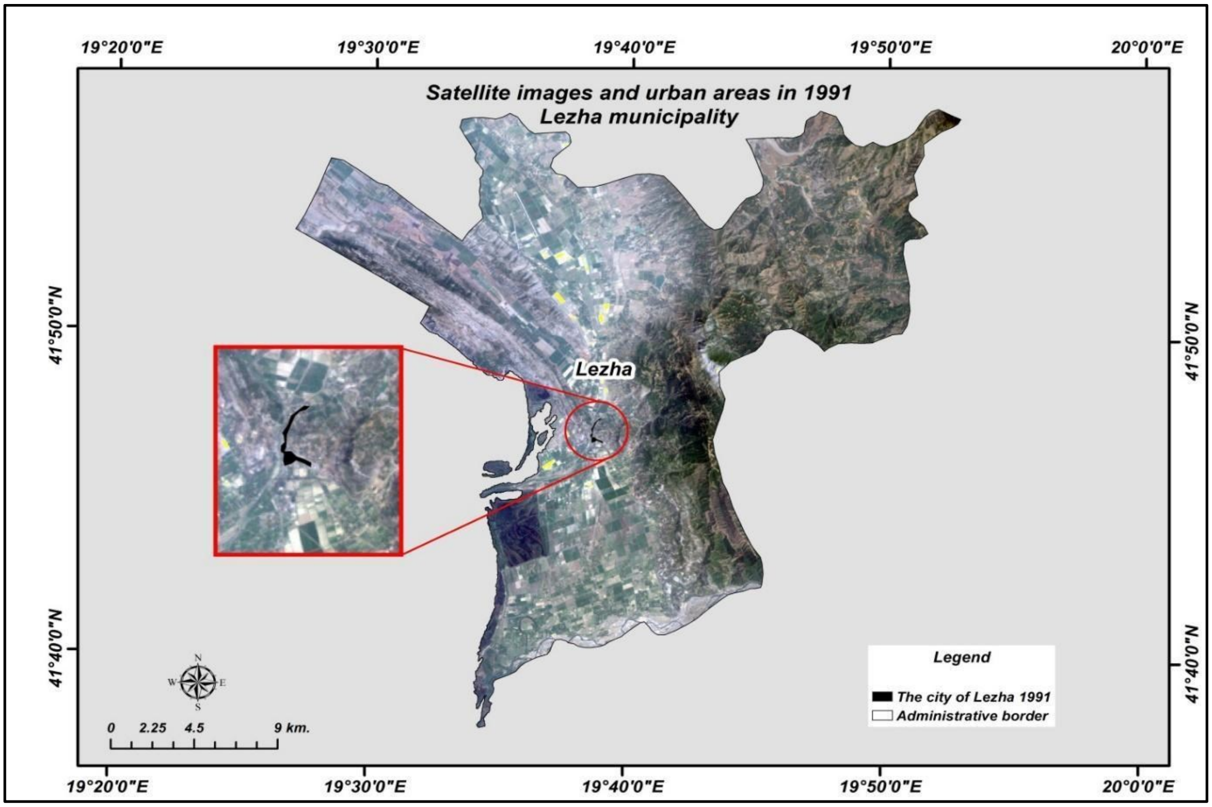


Figure 45. Urban Areas in Lezha 1991.

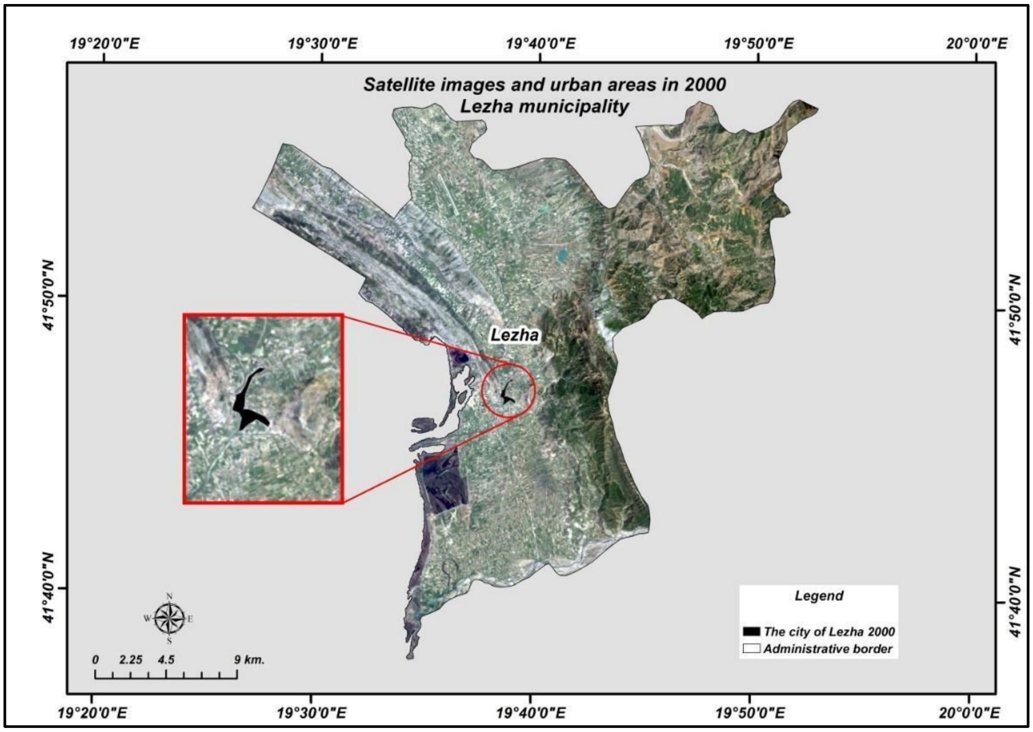


Figure 46. Urban Areas in Lezha 2000.

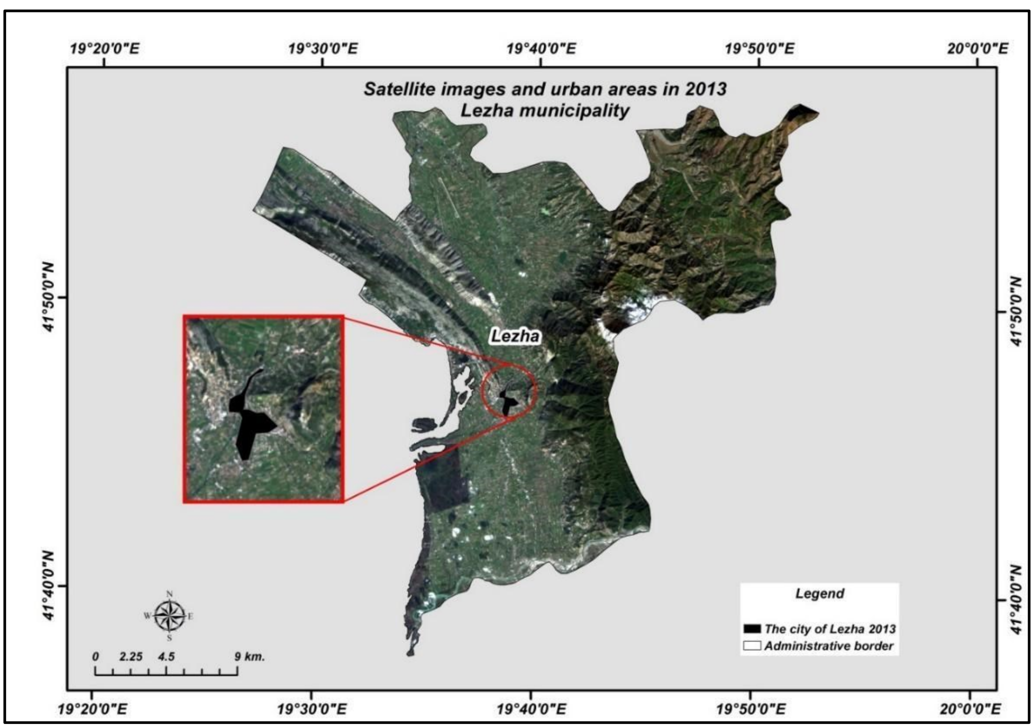


Figure 47. Urban Areas in Lezha 2013.

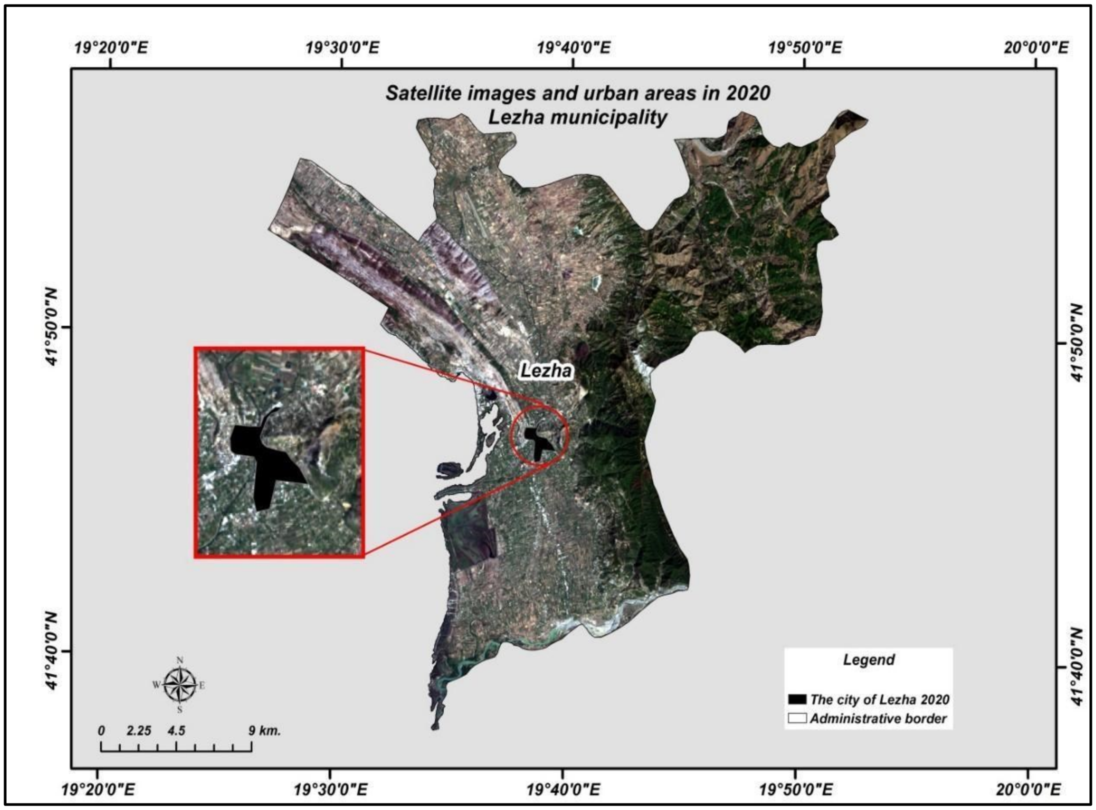


Figure 48. Urban Areas in Lezha 2020.

- Effects on Ecosystems and Land Utilization

The urban expansion of Lezha has intruded upon agricultural regions, river plains, and other ecologically vulnerable areas. This alteration in land use carries significant ramifications such as decreased ecological services including groundwater recharge, natural cooling, carbon sequestration, and flood mitigation. Decline in biodiversity and habitat fragmentation, especially in regions adjacent to the Drin River and surrounding wetland ecosystems. Enhanced landscape fragmentation impacts ecological interconnectedness as well as the aesthetic and cultural significance of the area.

- Consequences for Infrastructure and Public Health

As metropolitan areas expand, existing infrastructure systems (drainage, transportation, housing, water, energy) experience heightened strain. This could lead to overburdened drainage systems and recurrent urban flooding during intense precipitation events.

Increasing energy requirements, especially for cooling amid intense summer temperatures. Water scarcity and sanitation issues during extended dry periods. Public health hazards stem from elevated pollutant levels, intensified heat stress, and vector-borne infections.

In the absence of intentional action, the disparity between the pace of urban growth and the execution of climate adaptation measures would persistently exacerbate social inequality and environmental deterioration.

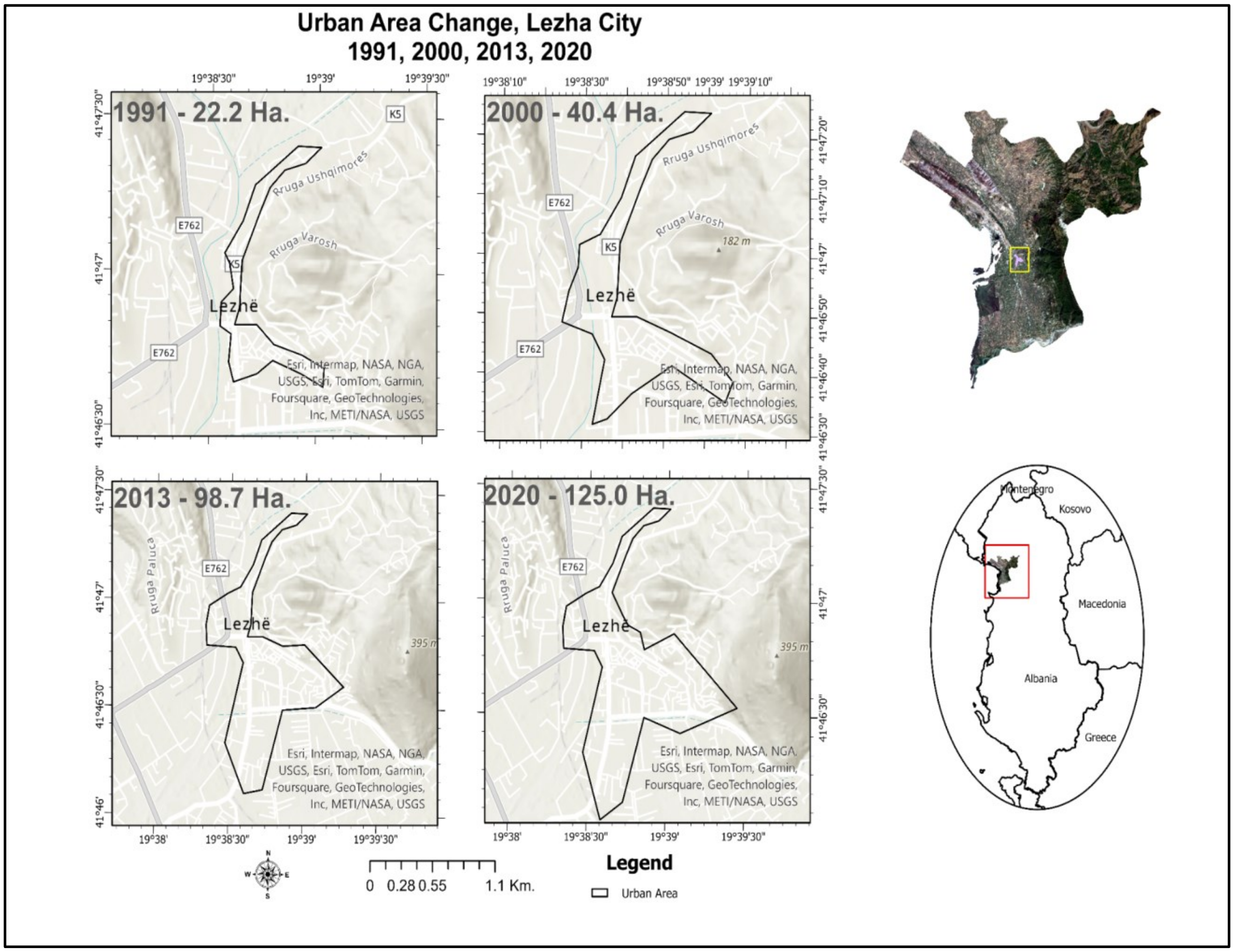


Figure 49. Lezha Urban Area Changes for 30 years.

• Strategic Urban Planning as a Mitigation Measure

These trends indicate that urban development must integrate climate planning. A pressing necessity exists for a more cohesive and interdisciplinary strategy in urban management, incorporating climate risk evaluations into city master plans and land-use zoning. Advocating for compact, mixed-use development that mitigates urban sprawl. Conserving and rehabilitating urban green belts, floodplains, and riparian corridors. Promoting nature-based solutions, including green infrastructure, rain gardens, and green roofs, that enhance resilience and ecosystem vitality.

Table 7 illustrates the substantial growth of urban land in Lezha during a period of nearly thirty years, from 1991 to 2020, figure 52. This increase signifies demographic pressures and developmental changes, with significant implications for urban planning, environmental sustainability, and climate vulnerability.

In 1991, Lezha's total urban surface area was 22.20 hectares. By the year 2000, this had nearly doubled to 40.42 hectares, indicating an augmentation of 18.22 hectares over a span of nine years. The initial stage of expansion is linked to Albania's post-communist transition, characterized by population migration, informal construction, and the decentralization of administration, resulting in swift and frequently unregulated urban sprawl in numerous cities, including Lezha.

The most significant expansion transpired between 2000 and 2013, during which urban space expanded from 40.42 hectares to 98.70 hectares, resulting in an increase of 58.28 hectares. This 13-year period signifies a moment of heightened urbanization, driven by economic liberalization, enhanced infrastructure connection, and augmented investments in housing and public edifices. The construction surge and land-use changes during this century substantially modified the metropolitan landscape, frequently intruding upon rural or natural areas.

From 2013 to 2020, the urban area increased to 125.08 hectares, representing a growth of 26.38 hectares. While this indicates sustained growth, the rate seems to have diminished relative to the prior period. From 1991 to 2020, the urban area of Lezha expanded by 102.88 hectares, representing a total increase of almost 460%. This degree of urbanization exerts significant strain on the natural environment, water resources, and infrastructural systems, highlighting the necessity of integrating climate adaption strategies into land-use management.

Table 7. Changes of urban spaces in Lezha

Lezha		
Ears	Surface (ha)	Change in surface (ha)
1991	22.20	
2000	40.42	18.22
2013	98.70	58.28
2020	125.08	26.38

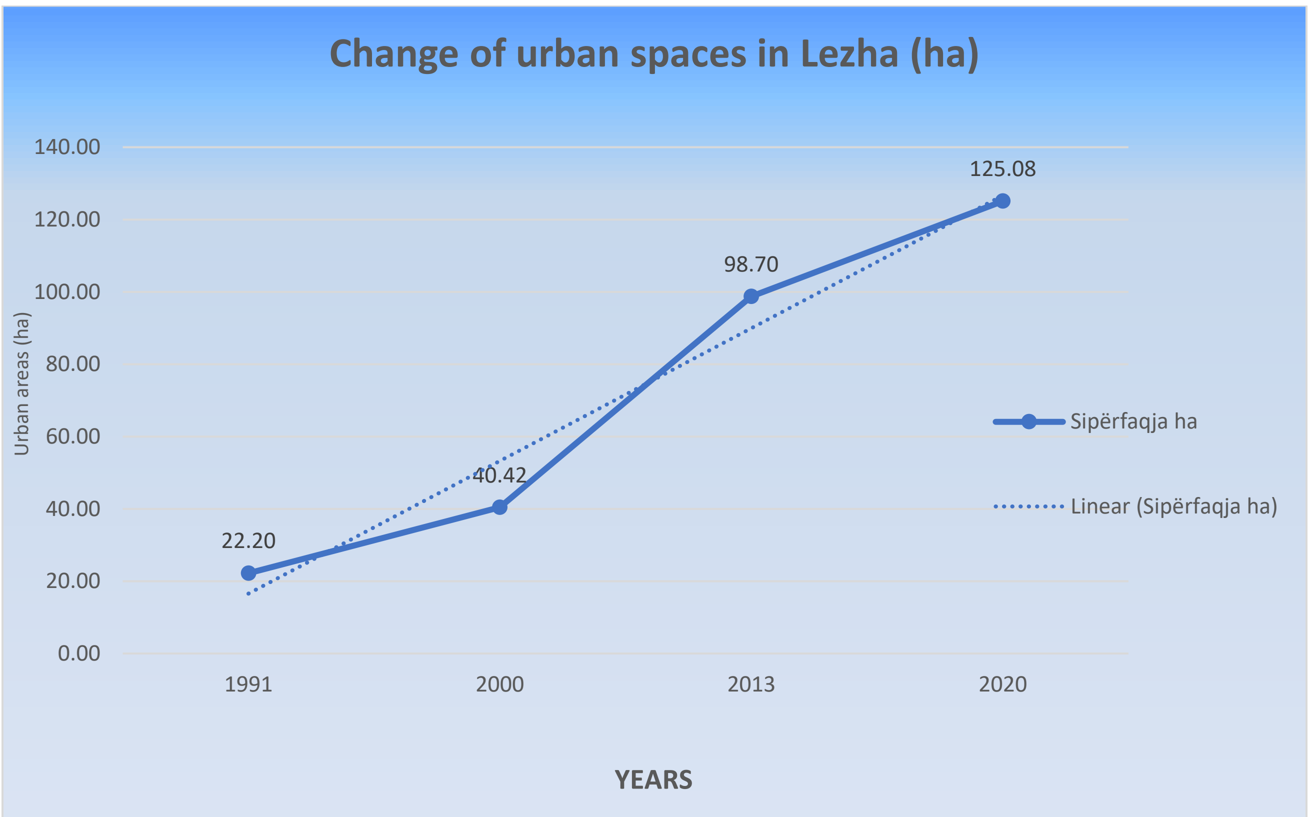


Figure 50. Change of urban spaces in Lezha (ha).

Figures 51 and 52 depict the geospatial and monitoring implications, showcasing the spread of meteorological stations and the three-dimensional geographic mapping of Lezha, underscoring the significance of spatial analysis and environmental monitoring. Precise geospatial data is crucial for evaluating real-time climatic effects at the neighbourhood scale. Additionally, for the design of early warning systems for floods or extreme heat events and for facilitating data-driven decision-making in infrastructure development and disaster response.

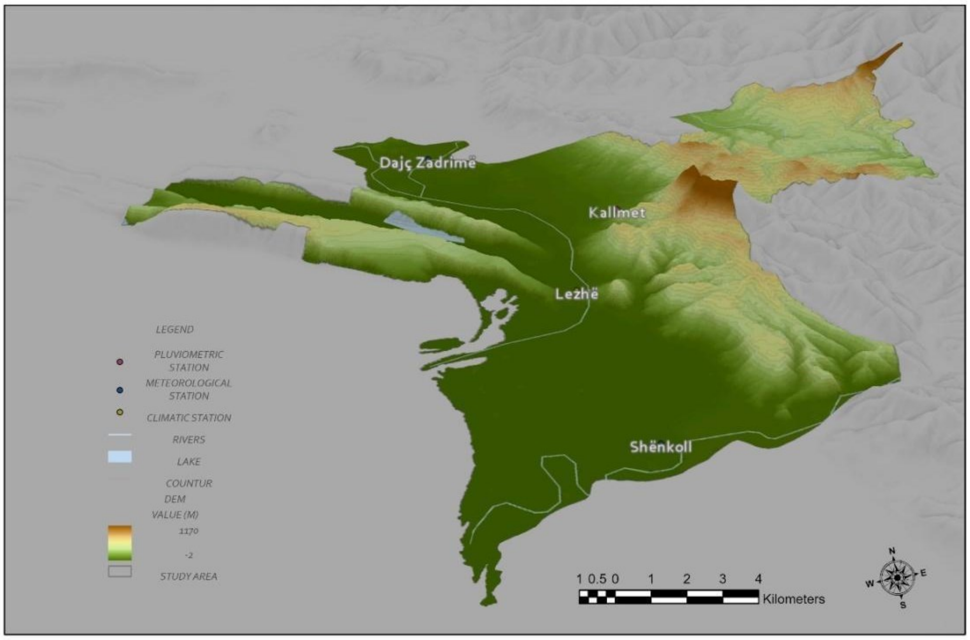


Figure 51. Landscape of the coordinates of the meteorological stations in Lezha.

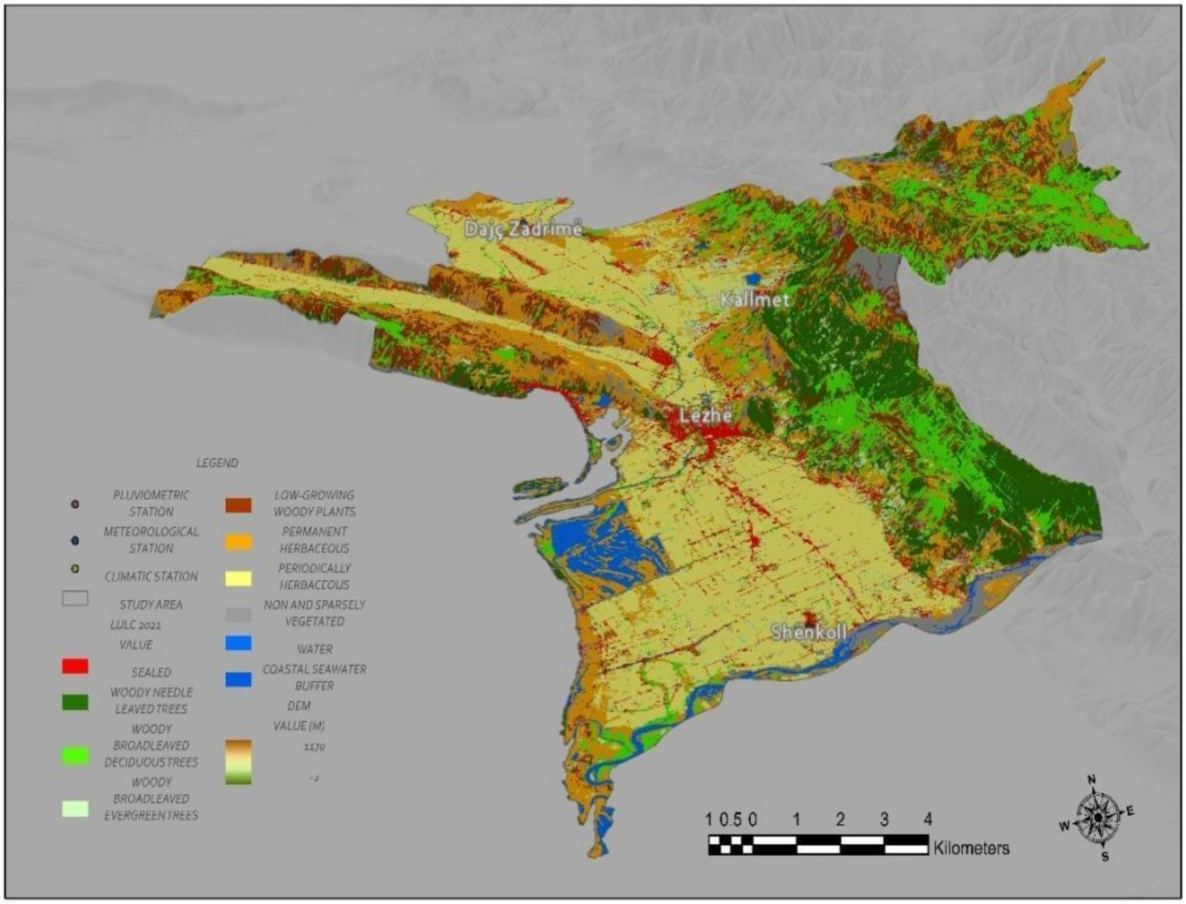


Figure 52. Geographic map 3D of Lezha.

4.7 Urbanisation, Urban Greening, and Their Impact on Microclimates

The city's many problems persist because of hasty, informal, and disorganized growth done without regard for spatial planning or urban planning rules. Amongst these are more pollution in the air, loss of green spaces, and adverse effects on microclimatic markers.

As the effects of climate change escalate, cities such as Lezha must adopt proactive and cohesive adaptation plans to enhance resilience and save their inhabitants, infrastructure, and ecosystems. Adaptation entails planning for the expected impacts of climate variability and extreme weather events by diminishing vulnerability, augmenting resilience, and improving the sustainability of urban systems.

3. Proactive Planning and Risk Management

Climate adaptation commences with efficient risk evaluation, urban development, and readiness. Municipal authorities must integrate climate projections into land-use planning, zoning restrictions, and infrastructure development. This encompasses:

- Identifying flood-prone locations and prohibiting building in high-risk zones.
- Establishing early warning systems for extreme meteorological phenomena, including heatwaves, intense precipitation, and droughts.
- Incorporating climate risk into local development strategies and construction regulations to improve long-term resilience.
- Planning must be proactive, anticipating future hazards and implementing pre-emptive solutions rather than only responding to disasters post-occurrence.

4. Enhancing Green Infrastructure

Enhancing and sustaining green infrastructure is among the most efficacious methods for adapting urban environments to climate change. Green infrastructure denotes natural or semi-natural systems that deliver ecosystem services, including:

- Urban parks, green roofs, vertical gardens, and tree-lined roadways mitigate the Urban Heat Island (UHI) impact.
- Permeable surfaces and green spaces that enhance rainwater absorption, diminish surface runoff, and alleviate urban flooding.

These nature-based solutions manage urban microclimates and enhance quality of life by providing recreational places and improving mental and physical well-being.

3. Enhancing Stormwater Management Systems

Urban drainage systems must be upgraded and expanded to accommodate the heightened frequency and intensity of rainstorm events, which result in higher volumes of runoff. Measures for adaptation encompass:

- Developing detention basins, retention ponds, and bioswales for natural stormwater management.
- Implementing rainwater harvesting systems and rain gardens to alleviate the strain on municipal drainage infrastructure.
- Advocating for low-impact development (LID) methodologies that emulate natural hydrological cycles and diminish impermeable surfaces.

These enhancements are particularly vital in flood-prone areas of Lezha, where severe precipitation has traditionally exceeded the capacity of antiquated drainage systems.

4. Enhancing Urban Flora and Biodiversity

Urban vegetation is essential for climate resilience. The expansion of urban woodlands, communal gardens, and green belts offers:

- Natural cooling at periods of extreme heat.
- Enhanced air quality by the sequestration of contaminants.
- Habitats for pollinators and indigenous species, so enhancing urban biodiversity.

- Engaging communities in urban greening programs can enhance environmental awareness and cultivate a culture of stewardship and sustainability.

5. Ensuring Resilience of Water Supply

Water stress, intensified by droughts and population expansion, necessitates a varied and adaptive water management plan. This encompasses:

- Investing in effective water infrastructure to minimize leaks and wastage.
- Advocating for water saving methods within residential and industrial sectors.
- Investigating alternate water sources, including treated wastewater, rainfall harvesting, and desalination when applicable.
- Public awareness initiatives and intelligent water metering systems can significantly contribute to decreasing use and ensuring equitable distribution, particularly during arid seasons.

evaluates the indicators like building design, infrastructure, land use changes, human activity, density, building materials, which absorb and release ambient heat, and distances between buildings. Urban transportation was also taken into account since it produces carbon dioxide (CO_2), a greenhouse gas with basic influence on global warming.

Land use changes and the removal of natural vegetation with impermeable surfaces that absorb solar radiation and modify local temperature dynamics cause cities to be consistently warmer than rural areas. Territorial planning mistakes, too much concrete, informal urbanization, high traffic, and the absence of balance with green areas have greatly changed the local climate and harmed the environmental state. The quality of life and public health are directly affected by these changes. Improving living circumstances and re-establishing environmental balance depend on finding efficient ways to lower these effects, which is still a top concern. Urban greenery shapes the urban microclimate in many ways and is important for cities and communities since it offers several advantages like better public health, recreational areas, shade, lower environmental pollution, and help with climate change effects.

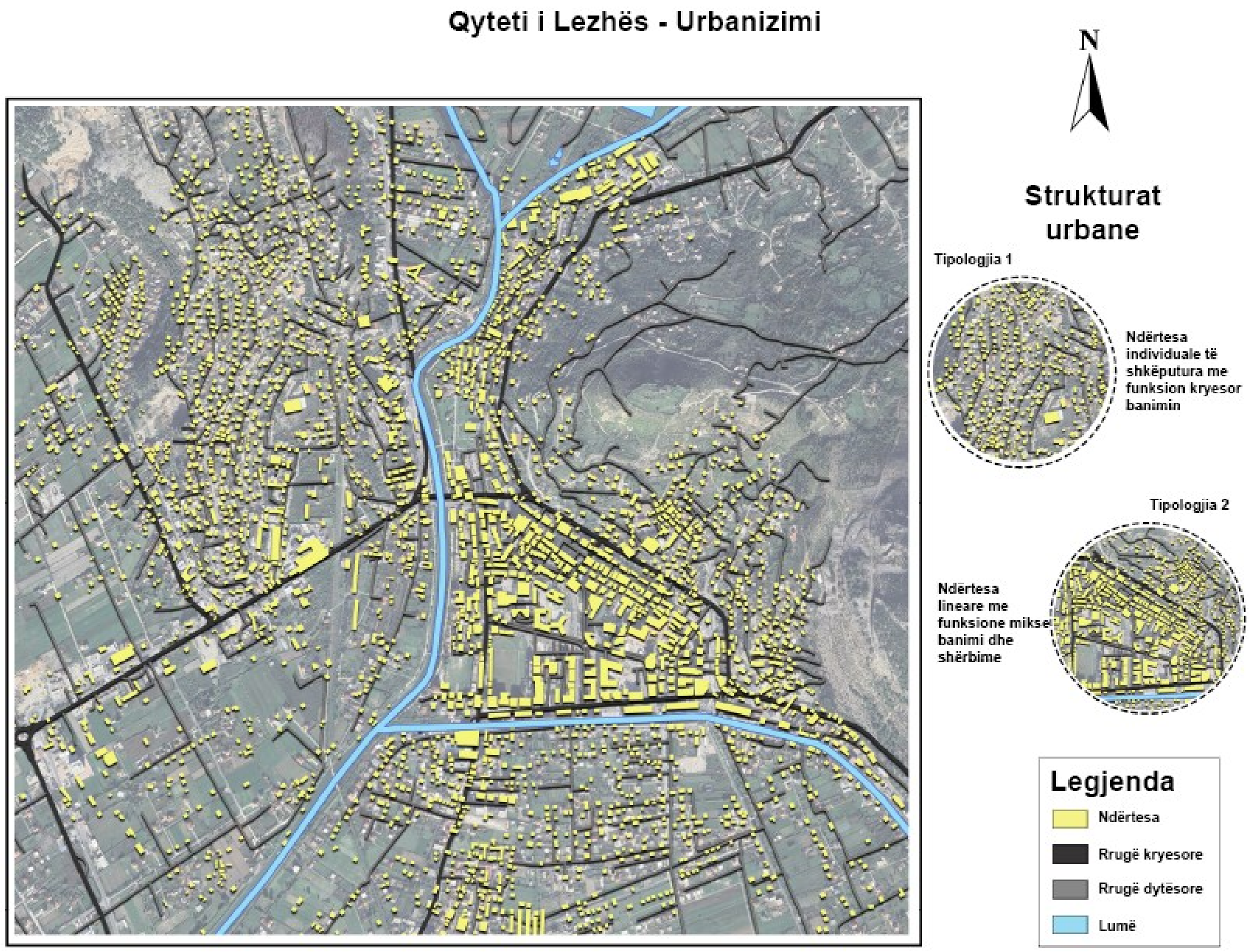


Figure 53. Urbanization of Lezha City.

4.7.1 Temperature, Humidity, and CO_2 Variations in Urban Areas

Direct temperature measurements conducted in August 2024 revealed notable differences in temperature and humidity between urban areas with varying levels of greenery.

Figure 54. Measuring sensor equipment during the analyses.

In densely built urban zones or asphalt streets, especially those with extensive asphalt cover and little to no green spaces, temperatures ranged from 26.5°C to 37.6°C, with humidity levels around 49.5%.

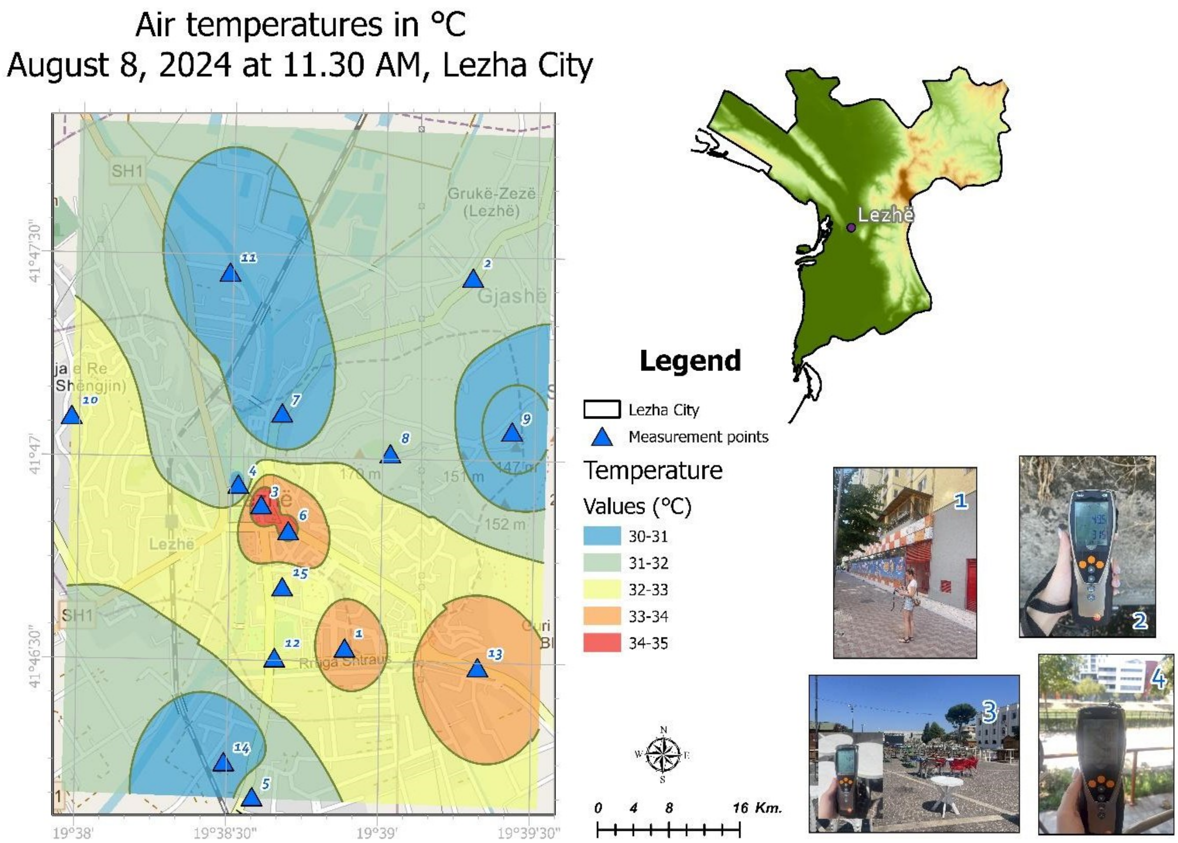
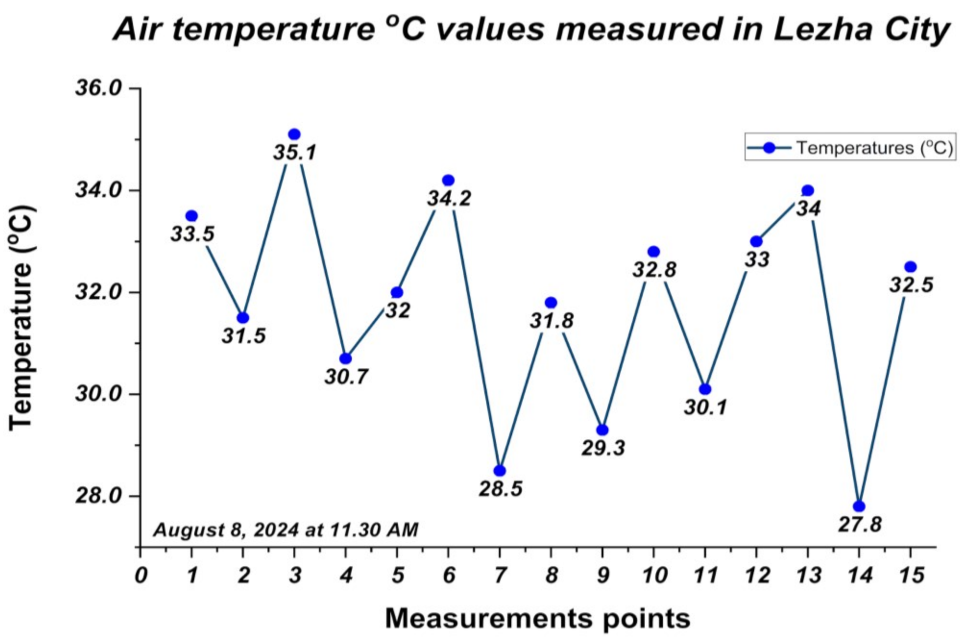


Figure 55. Map of Air temperature August 8, 2024, Lezha City.



By comparison, urban gardens' tree-shaded regions observed lower temperatures—between 21.8°C and 33.5°C—with far greater humidity levels ranging from 56.7% to 64.3%. These results highlight the strong impact of urban plants in changing ambient temperature and improving atmospheric moisture.

Similar patterns were seen in other Lezha areas sampled on the same day. Particularly during heatwave times, these little microclimates have a major impact on cooling energy needs.

In high-density, poorly ventilated areas—defined by closely packed structures and restricted airflow corridors—CO_2 levels were discovered to be notably higher. On the other hand, places with plants showed average temperatures (33.5°C to 37.6°C) and lower CO2 concentrations (482–495 ppm). Temperatures varied from 26.6°C to 35.7°C in densely constructed regions where sufficient separation for air circulation existed. By enhancing air circulation and lowering thermal absorption, our results imply that microclimatic behaviour is greatly influenced by both urban architecture and vegetation.

4.7.2 The Role of Green Spaces in Modulating Microclimates

Urban greening plays a key role in improving the microclimate by increasing vegetation cover and reducing the urban heat island (UHI) effect. The study done in Lezha underlines the need of trees and green areas in controlling temperatures, enhancing air quality, and raising humidity. Vegetation-rich locations tend to be cooler and have more moderate CO_2 levels. On the other hand, very urbanized and asphalted regions have significantly greater temperatures and higher CO_2 levels, which directly affect energy need for cooling, especially during heatwaves. Temperatures on the asphalt were noted at 39.4 degrees Celsius. While temperatures varied between 37.1 and 33.5 degrees Celsius, carbon dioxide levels in high-density building zones with restricted air circulation corridors ranged from 482 to 495 ppm. Humidity was between 42.7% to

50.5%. High-traffic areas had the most carbon dioxide levels, ranging from 408 to 495 ppm. In these locations, asphalt temperatures varied from 28.5 to 39.1.1 degrees Celsius and humidity levels were noted between 36.2% and 42.6%. These results highlight the major impact of urbanisation on microclimatic factors. Using models that recreate urban microclimates, Chaosu Li's 2018 study in Urban Building Energy Consumption/Microclimate Tools and Models reveals the interaction between urbanization and microclimate. Using various data inputs, including building design characteristics (e.g., number of floors, materials, and reflectivity), ground cover type, soil conditions, heat transfer, roof materials, and meteorological variables like solar radiation, regional temperature, humidity, and wind speed—these models produce outputs such the heat energy balance of buildings and air temperature (Tanimoto et al., 2003). A case study in a metropolitan area of India evaluated "the microclimatic effects of urbanization up to 2050" (Tanimoto et al., 2003, p. 4). Maintaining constant weather circumstances, the study included the model for evaluating both the usage of the land and its cover for 2018 and 205ing (Vinayak B., Lee H., Gedam S., Latha R.). Projected temperature rises of 4.9–5.5 degrees Celsius in metropolitan areas by 2050 were found by means of simulated scenarios assuming no mitigation policies. With mitigating measures, though, this rise might be limited to 1–1.7 degrees Celsius. "Integrating gridded urban parameters—such as building heights, anthropogenic heat flux, and air pollution—in future models helps to better understand and address the localized effects of urbanization on microclimates," the researcher’s stress. Effective adaptation and mitigation plans will depend on this synergy. Through processes like shading and evapotranspiration, green infrastructure—including trees, grass areas, green roofs, and permeable surfaces—helps to lower surface and air temperatures. Urban green spaces also help to improve mental and physical health by means of easily available recreational areas and by reducing the harmful consequences of air pollution.

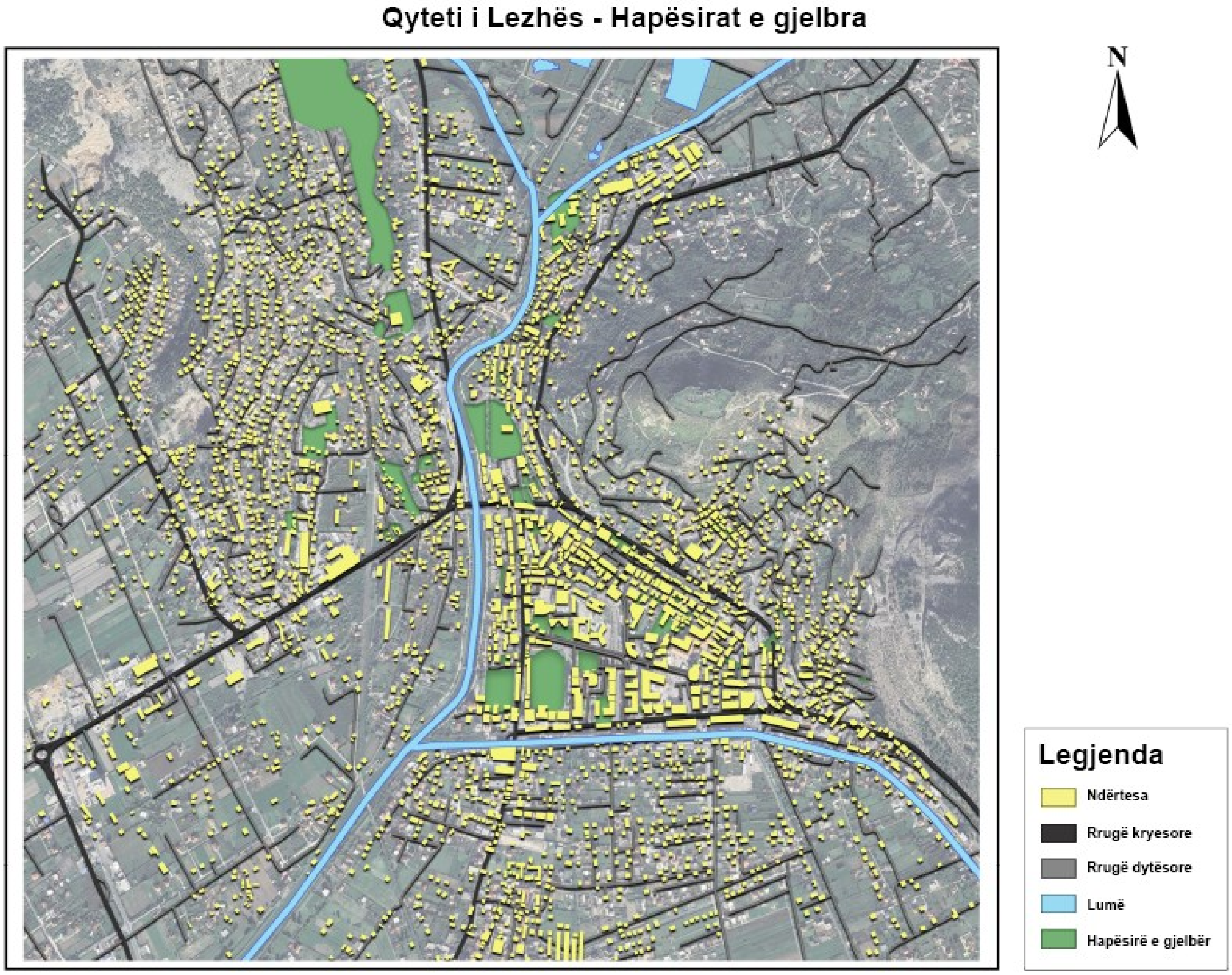


Figure 56. Green spaces spread in Lezha City.

4.8 Air Pollution and Urbanization Factors

The primary contributors to carbon gas emissions in urban areas include private and public transportation, many vehicles, unmanaged traffic flow, and urbanization patterns. High levels of carbon dioxide are typically found at critical points in the city, especially at intersections, major road junctions, and areas with dense traffic. Measurements conducted in August 2024 in Lezha demonstrate a significant relationship between carbon dioxide concentrations, air temperature, humidity levels, traffic flow, land use, and urbanization trends. In August, out of 15 measurement points, 13 exhibited CO_2 concentrations above the permissible standard of 350 ppm. The highest concentrations were recorded in the city centre of Lezha, with lower concentrations observed in peripheral areas. These findings suggest a clear link between CO_2 levels, temperature, and humidity, especially in regions where traffic is dense and urbanization patterns exacerbate pollution levels. On the riverbank, it was observed that the temperature was lower, ranging from 26.3 to 30.7 degrees Celsius. The presence of the river and the lack of buildings also indicate a decrease in air temperature. Meanwhile, Co2 levels were lower than in other measurement locations, it varies 340-399. Humidity ranges from 46% to 52%.

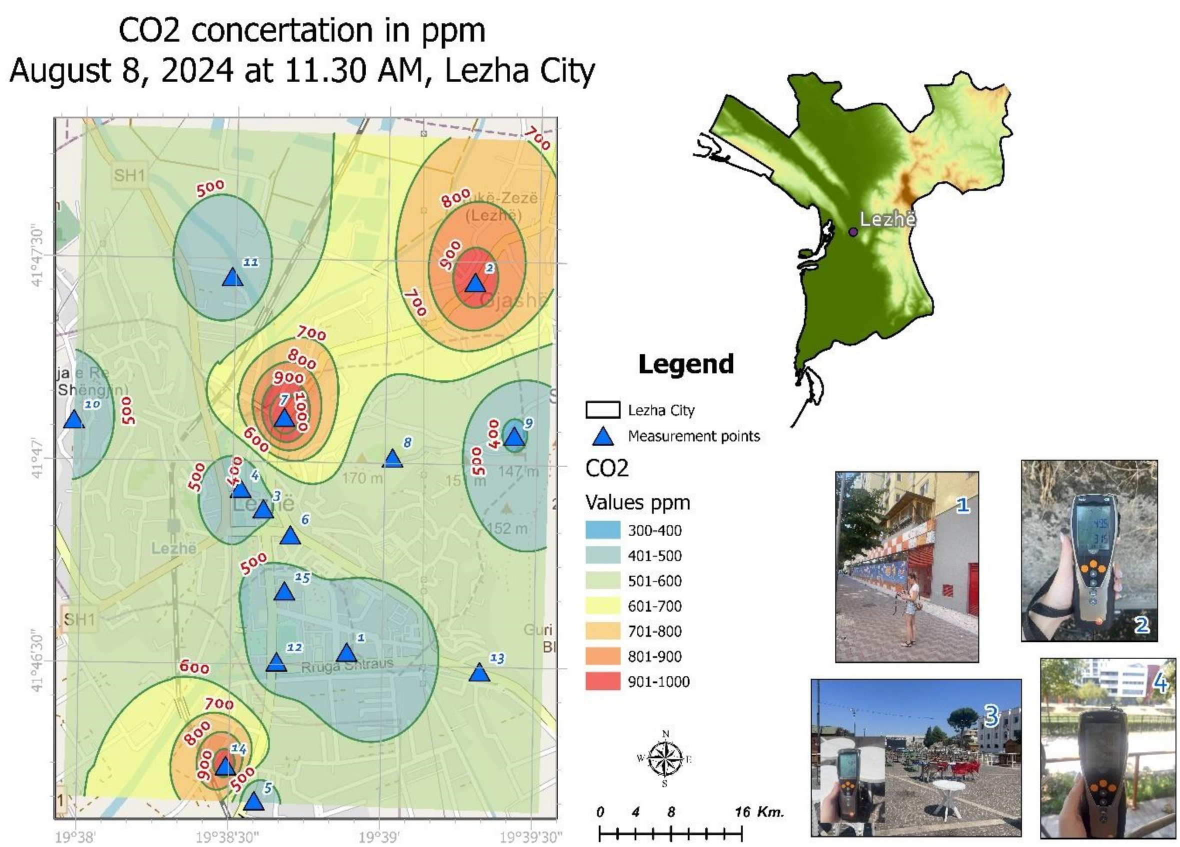


Figure 57. Map of CO2 concentration August 8, 2024, Lezha City.

During the summer months, characterized by a significant reduction in rainfall and drought conditions, the variation in CO_2 concentration, temperature, and humidity between measurement sites became more pronounced, with the highest impact noted in the city centre. This elevated CO_2 level is primarily attributed to the heavy traffic in Lezha, particularly the inflow and outflow of vehicles from surrounding areas, the predominance of oil-powered and aging vehicles, and poor traffic management in congested areas lacking sufficient green spaces. In the square near the municipal offices, the absence of green spaces and high traffic flow contribute to elevated temperatures (Figure 58).

Figure 58. Lezha Main Square (grey infrastructure).

Lezha's housing typology varies. The distribution of building types includes detached individual buildings with the main residential function at 60% and linear buildings with mixed residential and service functions at 40%. These building arrangements influence local microclimatic conditions. The urbanization of Lezha has resulted in a reduction of green spaces and ecological corridors, which in turn has worsened the city's microclimatic conditions. However, urban greening is increasingly recognized as a key factor for sustainable urban development. By promoting the integration of green spaces, urban planners can mitigate some of the adverse effects of urbanisation. Research has shown that strategic urban planning and the creation of green spaces are vital in controlling the UHI effect and reducing overall carbon emissions. Green roofs, permeable pavements, and well-planned parks can help cool urban environments and improve air quality. Therefore, urban planners must incorporate climate-sensitive strategies in future development plans. On August 8, the humidity ranged from 42.7% to 50.5%, and temperatures varied from 30.7°C to 35.1°C at the measured locations. These measurements were taken in shaded areas and open spaces near asphalt or busy intersections. The highest CO2 concentration (495 ppm) was recorded on a road in the city, where heavy traffic contributes to the elevated pollution levels. The correlation between CO_2 levels and temperature showed a moderate negative correlation, with a coefficient of approximately -0.38. The correlation between CO_2 and humidity was weak, with a coefficient of about -0.281. In August 2024, it was observed that humidity levels fell in all locations as temperatures increased, and the second link is that in greener locations, temperatures decreased while humidity increased, further suggesting that temperature and humidity are related.

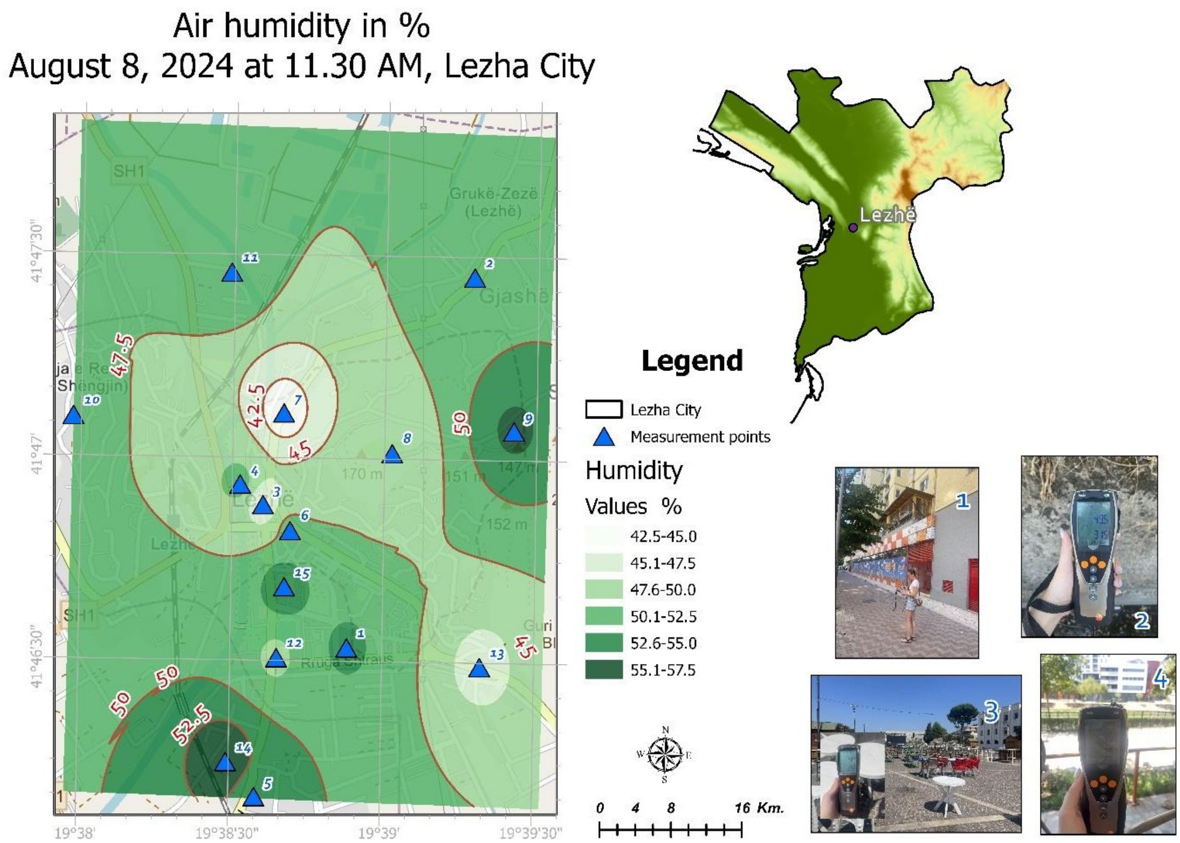


Figure 59. Map of Air Humidity in %, August 8, 2024, Lezha City.

4.9 Urban Greening and its role in improving the microclimate

The greatest average air temperature in Lezha in 2020 was 1.6°C above the thirty-year average from 1961 to 1990; in 2021, this difference increased to +1.8°C. These figures show the local effects of worldwide climate change combined with fast urban expansion and poor mitigation policies. Now acknowledged as vital ways to lower environmental temperatures and cut greenhouse gas emissions are urban greening and traffic management.

Lezha has seen quick and often uncontrolled urban expansion in recent years. Construction has caused more surface sealing, less green area, and more fragmentation of biological corridors.

These changes have greatly affected the urban microclimate, hence strengthening urban heat island (UHI) effects, raising CO_2 levels, and lowering humidity and air quality.

Urban greening is recognized as a fundamental aspect of climate-sensitive urban planning and a crucial component of sustainable urban development. Green spaces—including parks, tree-lined avenues, green roofs, and urban gardens—offer several ecological benefits. These consist of stormwater management, carbon sequestration, cooling effects, evapotranspiration, shading, and air purification. Green areas can help people physically and mentally by providing places for leisure and social contact. Measurements done in Lezha in August 2024 proved the part plants play in reducing air pollution. CO_2 levels at eight key traffic congestion sites varied from 408 to 495 ppm—far over the permissible background concentration of 350 ppm. Particularly in places without green infrastructure, these high carbon dioxide levels coupled with higher temperatures and low humidity. By comparison, places with trees and natural surfaces had lower CO2 levels and more desirable temperature and humidity settings, hence supporting the cooling and purifying role of plants in urban areas.

Driven by EU initiatives encouraging sustainable and resilient urban ecosystems, green cover in European cities has grown by about 38% over the past 25 years. Though it has great potential for urban reforestation and ecological restoration, Lezha nevertheless lags in implementing such policies. Planting native tree species, building linked green belts, and rehabilitating damaged urban areas are all strategies that can help the city to be more resilient to climate change.

Apart from thermal comfort, green infrastructure helps to control urban floods. Implementing nature-based solutions like Lezha's open rainwater runoff system helps to lower surface water runoff after strong rains, hence reducing flood hazards. These systems also improve urban biodiversity and let water penetrate the soil, therefore supporting groundwater recharge and lessening load on the drainage system of the city.

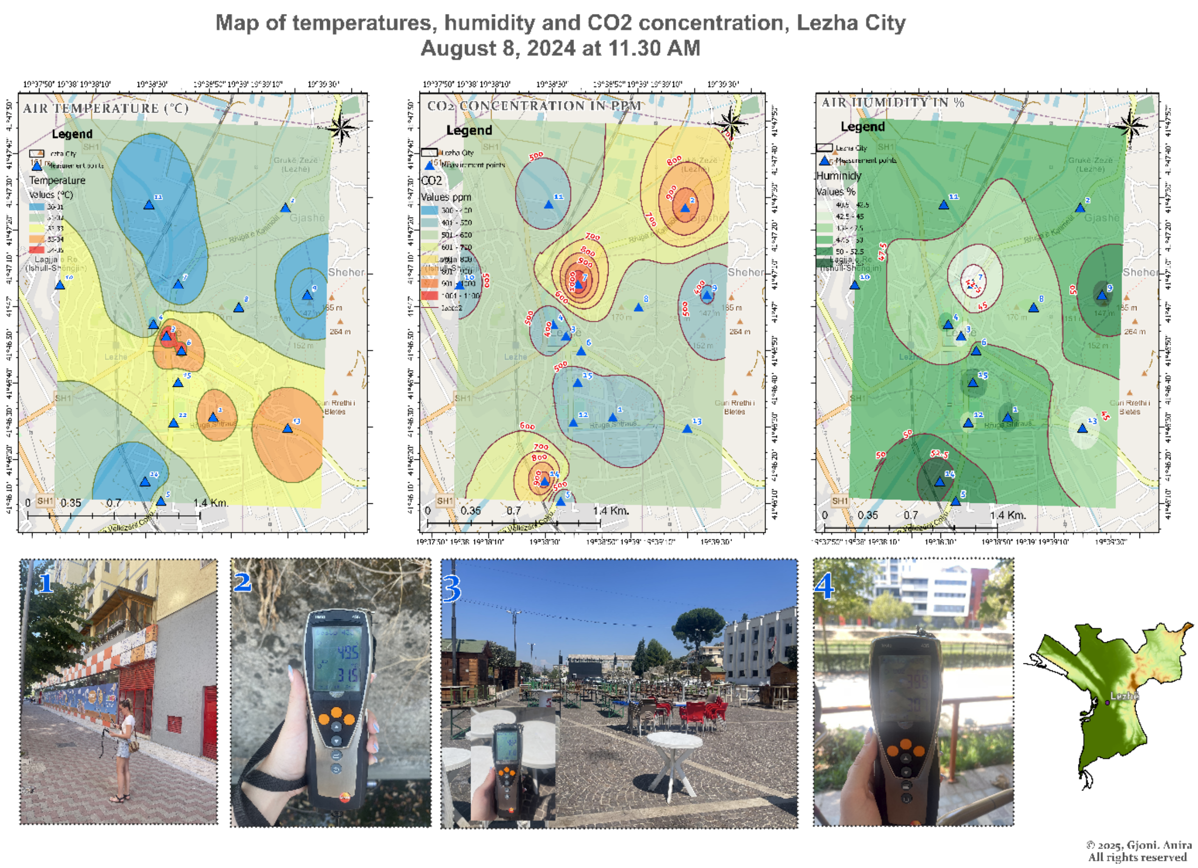


Figure 60. Correlation of air temperatures, humidity and CO2 concentration.

The relationship between air temperature, humidity, and CO_2 content, as shown in Figure 61, underlines the need of integrated urban planning that strikes a balance between development and environmental health. Vegetated regions help stabilize local climate factors as well as serve as carbon sinks, hence lowering the severity and frequency of heatwaves. Urban greening has to be a mainstay of city policies and spatial development plans as cities like Lezha confront growing difficulties from climate change, heat stress, and air pollution. Promoting social fairness and public well-being also depends on fair access to green areas, particularly in low-income and crowded neighbourhoods.

Figure 61. The open rainwater runoff system to solve the flooding problems in the City of Lezha.

4.10 Analyses of responses to survey questionnaires

Responses from individuals engaged in various planning efforts addressing climate adaptation and resilience in Lezha City. The questionnaire was divided into six sections focusing on Demographic information, Awareness and perception of climate change, Climate change adaptation strategies, Uncertainties and challenges, Human health and climate change, and prospects. Participants were voluntary and anonymous, adhering to ethical research principles. Data Collection Methods were based on one-on-one interviews to gain detailed insights into local climate impacts. Participants described climate-related challenges in their communities and adaptation measures implemented. These interviews also served as a form of qualitative validation of general information through climate change's impact in Lezha City. In each interview, individuals were asked to describe climate-related impacts or challenges being realized in their local communities and any adaptation measures used in their local zone.

Detailed Description and Response to the Questionnaire which can find at the Anex no.1.

Section 1: Demographic Information

1. Age: What is your age?

Answers:

- Under 18: Only 3% people in this age group participated in the questionnaire.
- 18-24 years old: 17% people, representing a group of interested young people, perhaps students or young people in the early stages of work.
- 25-34 years old: 11% people, a small group, perhaps due to other commitments.
- 35-44 years old: 23% people, an active age group, often professionally and family-oriented.
- 45-54 years old: 29% people, the majority of respondents. This group is probably feeling the greatest impacts of climate change, especially on health and safety.
- 55 years and older: 16% people, who may have different perspectives, including experience with the long-term impacts of climate change.

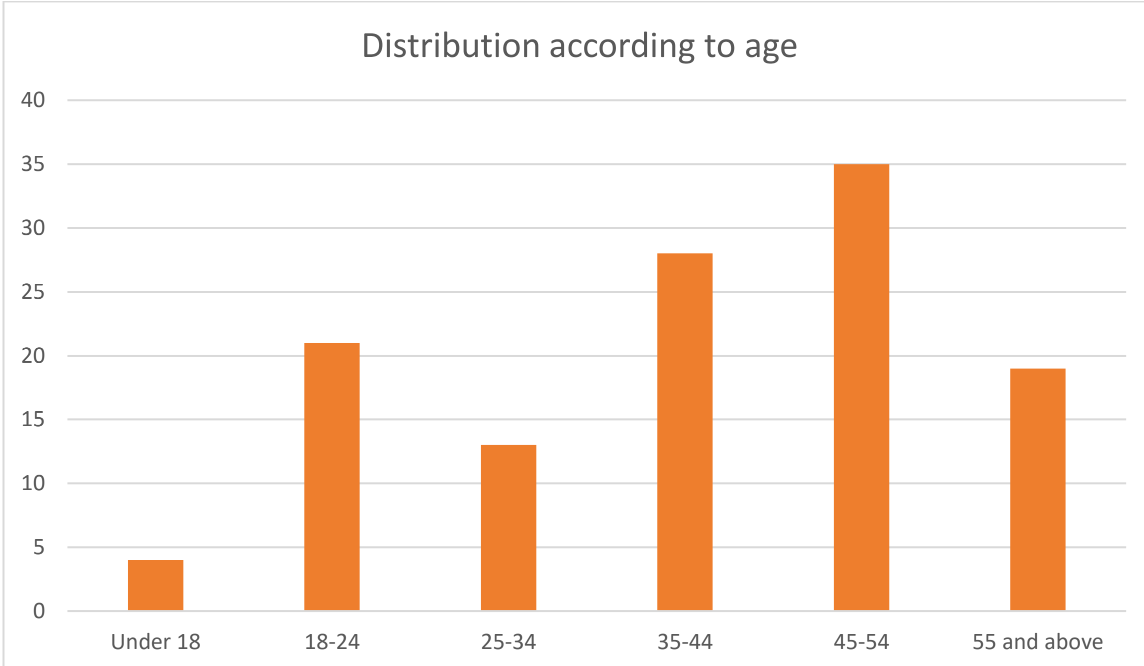


Figure 62. Distribution of respondents by age group, with the largest number in the 45-54 and 35-44 age groups.

The 35-54 age group makes up the majority of respondents (51%). This age group can often be affected by the impacts of climate change for a longer period of time and may be more aware of the long-term impacts on their livelihoods and health and activity. The 18-34 age group represents the younger generation (30.8%), who may have more interest in innovative solutions, while the elderly over 55 (18.2%) may feel more health impacts due to biological vulnerability.

2. Gender, Question: What is your gender?

Answers:

- Male: 39% people, making up a significant portion of respondents. This group may bring perspectives on traditional roles or experiences in different work environments.
- Female: 45% people, making up the largest group. Women are often more affected by climate change in their family and caregiving roles, which may affect their perceptions.

● Prefer not to answer: 16% people, a group that chooses not to answer about gender, perhaps for private reasons or because the issue is not relevant to them.

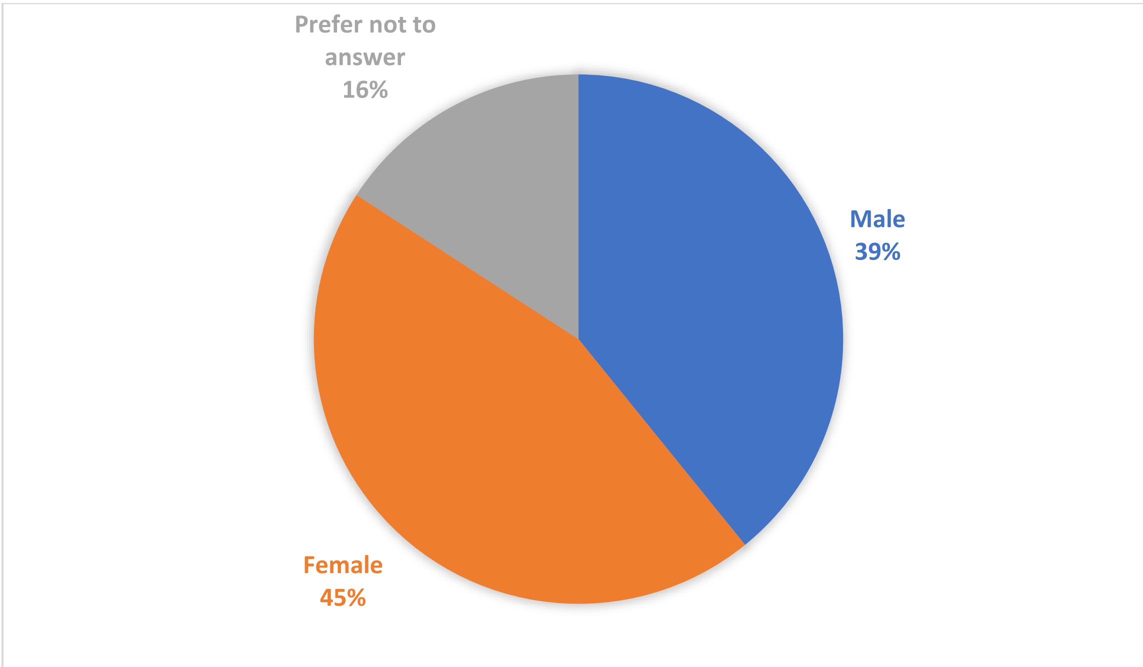


Figure 63. Percentage of respondents.

The number of female respondents (45%) constitutes slightly more than half of the respondents, while males (39%) and those who did not prefer to answer (16%) constitute the rest. This distribution indicates a good gender balance but also suggests the need for a deeper understanding of the role of gender in the perception of and adaptation to climate change.

3. Occupation Question: What is your occupation?

Answers:

● There are 15% farmers. These people are especially aware of how climate change affects natural resources and agricultural output.

- Urban workers: 18% people, representing a group that is likely to be affected by various climate impacts, such as extreme heat or pollution in urban areas.
- Government employees: 31% people, representing the majority of respondents. This group may have more in-depth knowledge of climate change policies and measures.
- Students: 24% people, representing an educated group potentially interested in solutions and innovations for the future.
- Other: 12% people, including occupations or roles that do not fit into the other categories.

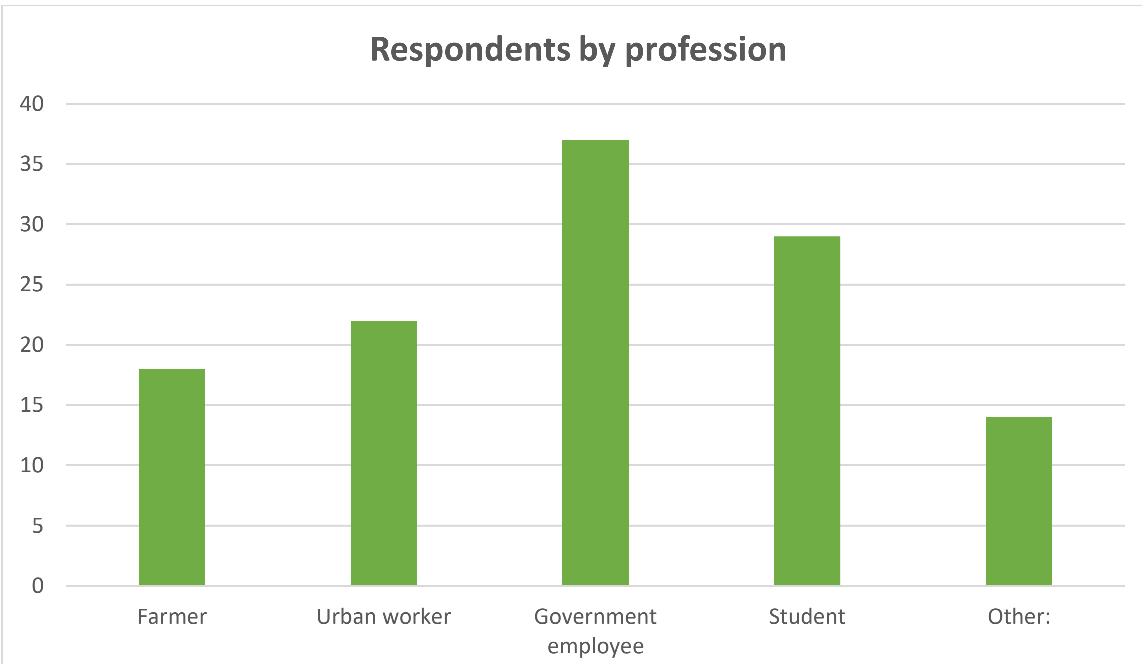


Figure 64. Number of respondents by profession, dominated by employees and students.

The majority of respondents are employees (45%) and students (23%), indicating a strong bias towards educated groups engaged in administrative and scientific matters. Farmers (18%) and urban workers (14%) are less represented, but these are groups that are directly affected by climate change.

4. Location (City or Rural)

Question: What is your location? (Urban or Rural)

Answers:

- Urban: 64.2% people, representing the majority of respondents. Urban respondents may experience challenges such as air pollution, overcrowding, and urban heat.
- Rural: 35.8% people, a smaller group that is more likely to be affected by food insecurity, climate change, and natural resources.

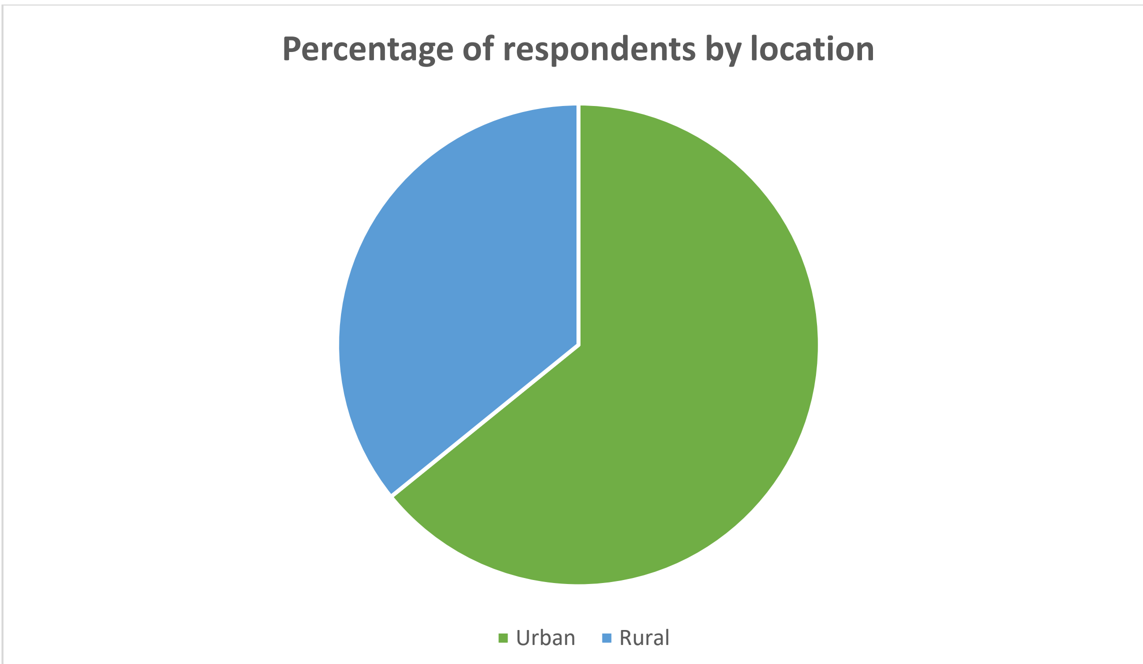


Figure 65. Percentage of respondents by location, with urban areas representing the majority.

The majority of respondents (64.2%) live in urban areas, while the remainder (35.8%) live in rural areas. This split suggests a greater focus on urban impacts, such as extreme heat and pollution, while rural areas feel more agricultural insecurity and changes in natural resources.

Section 2: Awareness and Perception of Climate Change

5. How aware are you of climate change and its impacts?

Response and analysis:

- Very aware (20%): This category consists of those who believe in climate change and its causes. They may be more involved in discussions and actions to adapt to or protect themselves from these changes.
- Somewhat aware (43.3%): This group represents the majority of respondents and shows moderate awareness. They may be aware of some concrete impacts (such as rising temperatures or flooding) but may have limited knowledge of the causes and solutions.
- Not very aware (36.7%): This group represents individuals who have very little knowledge of climate change-related issues. They may not be informed or may not feel the impact in their daily lives.
- Completely unaware (0 people): The fact that no one chose this option suggests that all respondents have at least a minimal level of awareness about climate change.

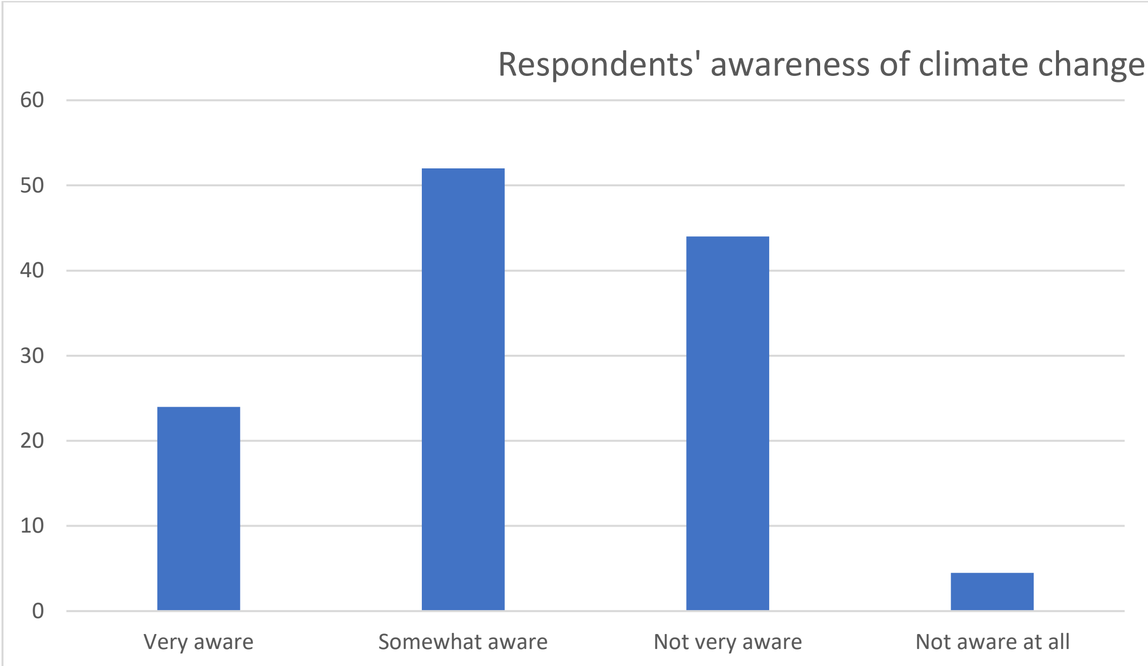


Figure 66. Distribution of respondents' awareness of climate change.

A small group (20%) responded as very aware and knowledgeable about climate change, perhaps due to education, personal experience, or exposure to public information. Somewhat aware represents the majority of respondents and indicates moderate awareness (43.3%), which may include basic knowledge or only some visible aspects of the problem. A large proportion of respondents have little information (36.7%), can be caused by insufficient knowledge sources or limited access to sustainable climate education. Not at all aware (0 people): Indicates that all respondents have at least minimal awareness of climate change.

6. What climate changes have you noticed in your area over the past 5 years? (Select all that apply)

Response and analysis:

- Temperature increases (19.1%): This result shows that a portion of respondents perceive rising temperatures as a noticeable impact.
- More frequent floods (31.6%): This is the most widespread response and suggests that flooding is a major problem for the areas represented. This may be related to intense rainfall and poor water management systems.
- Drought or water shortage (5.8%): A small number of individuals have noticed water shortages, which may occur in specific areas.
- Changes in agricultural seasons (6 people): This response suggests impacts on agriculture, which may cause food insecurity for farmers and rural communities.
- Stronger storms or winds (26.6%): This is a noticeable phenomenon, indicating an increase in climate extremes.
- Changes in biodiversity or local ecosystems (11.7%): Some individuals have noticed changes in the surrounding nature, such as species extinction or environmental degradation.
- Other (0 people): The lack of responses in this category suggests that the list of options includes all major phenomena.

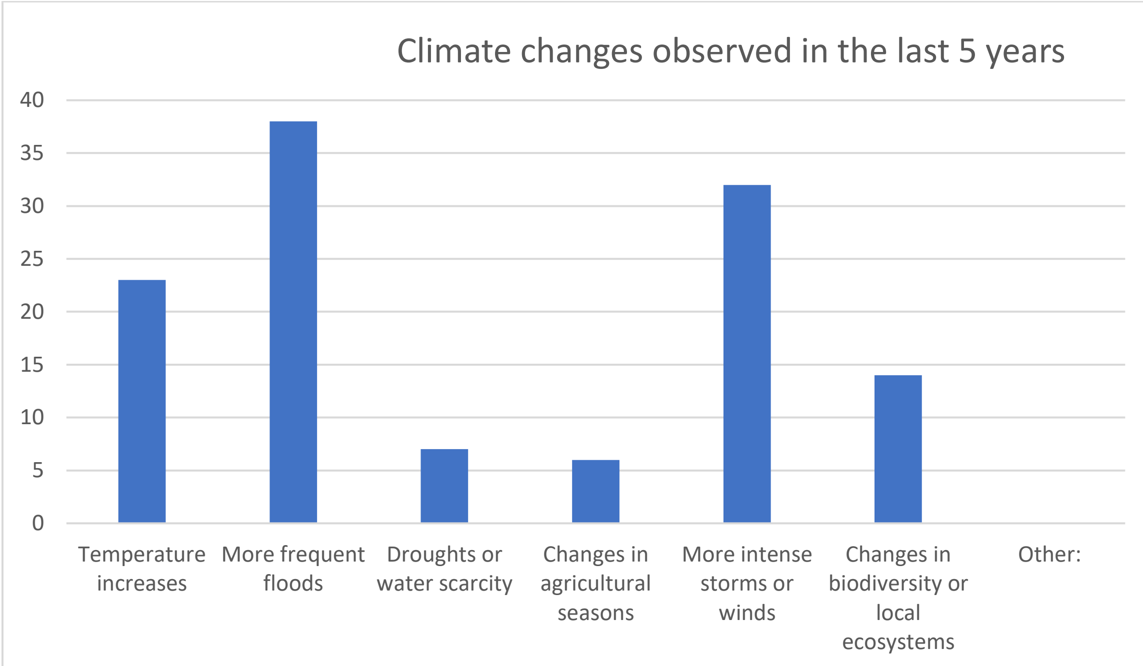


Figure 67. Most frequently observed climate phenomena, with "More frequent floods" and "Stronger storms/winds" being the most common.

The most widespread phenomenon reported, indicating the impact of intense rainfall and water management problems on local communities, is flooding (31.6%). Stronger storms or winds (26.6) reflect the increase in climate extremes in the study area. Rising temperatures (19.1%) are among the first impacts felt by many people. Drought or water shortages (5.8%) and changes in agricultural seasons (5%) are less widespread phenomena, but can be critical for rural communities and agriculture. A significant number (11.7%) have observed changes in the surrounding nature, including the extinction of species or changes in vegetation and animals.

7. How confident are you about the impacts of climate change in your area?

Response and analysis:

- Very confident (18%): This group feels strongly that the impacts of climate change are visible and significant for their area.
- Somewhat confident (69%): Most respondents are confident but not completely convinced, indicating a perception of a moderate and widespread impact.
- Uncertain (10%): A small percentage of people are uncertain about the effects of climate change, maybe because of ignorance or personal link to the consequences.
- Very unsure (3%): This small category indicates a complete lack of belief in the existence or significance of climate impacts.

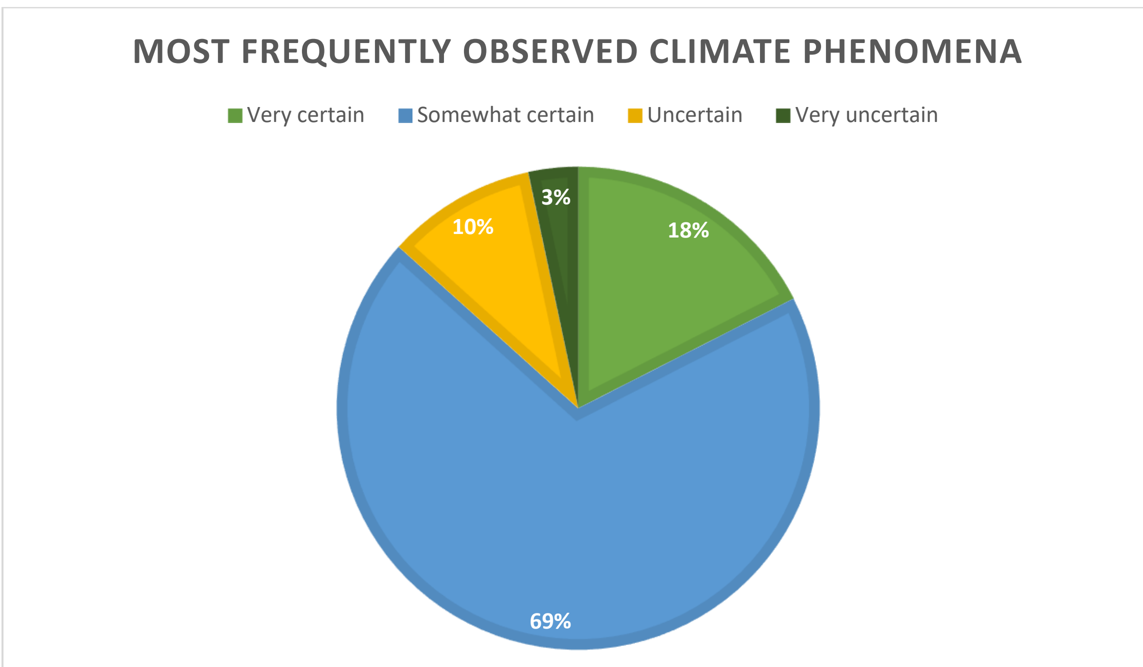


Figure 68. Most frequently observed climate phenomena.

Most frequently observed climate phenomena A group of (18%) feel strongly about the concrete impacts of climate change, which may be the result of personal experience or advanced knowledge. The majority feel impacts (69%), but not with a high level of confidence. This result may suggest a lack of complete information or uncertainty about the direct connection of these phenomena to climate change. A small group is undecided about the impacts (10%), perhaps due to a lack of direct experience or information. A minimal number of individuals (3%) do not feel significant impacts.

Section 3: Climate Change Adaptation Strategies

8. Have you or your community taken any steps to adapt to climate change?

Response and analysis:

- Yes (28.3%): A relatively small proportion of respondents have taken concrete steps to adapt to climate change. This indicates a low level of action relative to the level of awareness.
- No (12.5%): This group has not taken any adaptation measures, perhaps due to a lack of resources or knowledge.
- Not sure (59.1%): Most respondents have no information on the measures taken, suggesting a lack of communication or involvement in local plans.

A group of respondents (28.3%) have taken concrete steps, suggesting limited efforts to adapt. This may be related to awareness and available resources. A group (12.5%) have not taken any action, highlighting a lack of education, resources, or community involvement. The majority of respondents (59.1%) are not informed about local efforts, indicating a gap in communication or transparency in climate strategies.

9. What types of adaptation measures have you implemented or observed in your community?

Response and analysis:

- Afforestation or reforestation programs (35.8%): This is the most common measure and indicates a community focuses on improving biodiversity and reducing temperatures.
- Temperature mitigation (20.8%): Green spaces and reflective surfaces are noted as measures to reduce heat.
- Preparedness plans (17.5%): This result reflects efforts to increase safety against extreme events such as floods.
- Water conservation practices (10%): Limited measures in an attempt to manage water resources in areas suffering from water scarcity.
- Improved infrastructure (6.7%): Limited measures for flood-resistant housing, which may suggest financial constraints.
- Use of climate-resilient crops (7.5%): Low participation indicates the need for education and support for farmers.
- Other (1.6%): Community-specific measures that do not fit into the main categories.

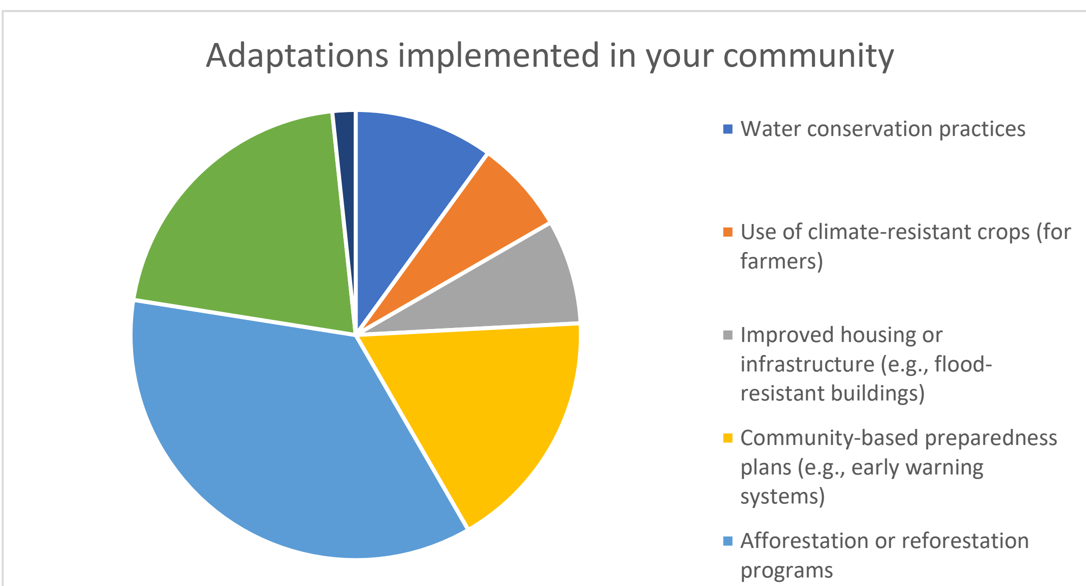


Figure 69. Adaptations implemented in your community.

The most common response measure (35.8%) is afforestation programs, which suggests a focus on improving biodiversity and reducing temperatures. Green spaces and reflective surfaces for temperature mitigation are important but limited measures for dense urban areas (20.8%). Preparedness plans (17.5%) indicate a moderate level of preparedness for emergency situations, but not sufficiently distributed.

Low involvement suggests a lack of resources or attention to drought-affected areas on water conservation practices (10%). Low involvement of farmers in these measures indicates the need for more support and education on climate-resilient crops (6.7%). Resilient housing: Limited measures to improve infrastructure, perhaps due to lack of funds (7.5%). Other (1.6%), specific but rare measures.

10. Do you believe that current climate change adaptation strategies in your area are sufficient?

Response and analysis:

- Yes (37.5%): Some feel that current measures are sufficient, perhaps due to visible improvements in infrastructure or environmental practices.
- No (17.5%): This indicates a negative perception of current strategies and suggests the need for further improvements.
- Not sure (45%): Most respondents are undecided, indicating a lack of transparency or involvement in strategic plans.

A significant portion (37.5%) think that the strategies are sufficient, but this may be related to a lack of knowledge about better alternatives. A group of (17.5%) suggests that there are obvious shortcomings in the strategy and implementation, which may be due to insufficient funds or poor coordination. A group of (45%) represents the majority, indicating that there is a lack of clarity and communication on the current strategies that can be implemented.

Section 4: Uncertainties and Challenges

11. What are the main uncertainties you face regarding the impacts of climate change? (Select all that apply)

Response and analysis:

Participants faced several main uncertainties regarding the impacts of climate change. Some of these include:

- Unpredictability weather patterns (15%) – Climate change has introduced a high level of unpredictability into weather forecasts, making it difficult to predict future weather conditions and their potential impacts.
- Lack of information on how to prepare (31.6%) – Participants feel that there is a lack of information and guidance on how to prepare for and respond to the impacts of climate change, making actions uncertain.
- Insufficient local government support (30%) – Governments and local authorities have not provided sufficient support to address the challenges of climate change, making it difficult for individuals and organizations to deal with the consequences.
- Lack of financial resources to implement adaptation strategies (17.5%) – Participants mentioned that the lack of funds and financial resources to implement adaptation strategies is a significant obstacle.

- Unclear policies or conflicting regulations (5.8%) – There is uncertainty due to unclear policies and regulations that can often contradict each other, creating an unclear environment for implementing strategies.
- Other (0) – No other uncertainties were reported in this category.

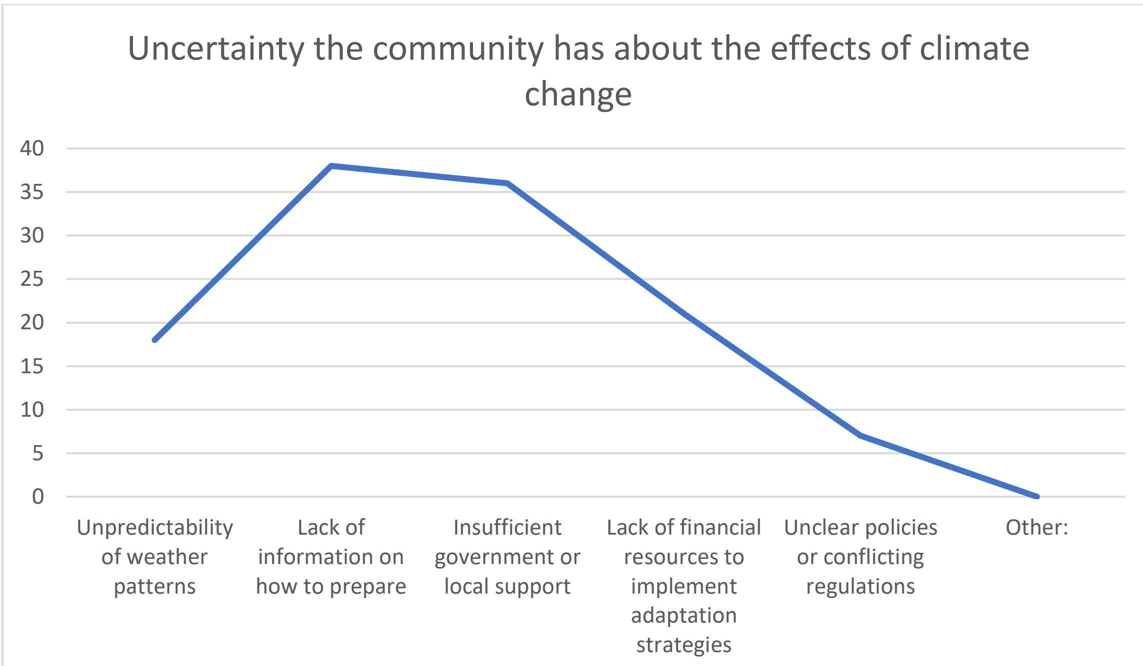


Figure 70. Uncertainties faced by the community regarding the impacts of climate change.

Unpredictability of weather patterns A group of (15%) indicate that there is a lack of reliability in weather forecasts, which makes long-term preparation and planning difficult. The impacts of this factor are unavoidable for sectors such as agriculture, energy and transport. The lack of information on how to prepare (31.6%), is a factor that directly affects the ability of individuals and organizations to take appropriate measures to address the impacts of climate change. The lack of information can create a gap in the implementation of adaptation strategies. Insufficient government or local support (30%) is assessed as another important factor at the level of governments and local authorities, which can have a key role in providing support for adaptation to climate impacts, including financing, information and legal guidance. The lack of financial resources for the implementation of adaptation strategies (17.5%) appears as a critical problem, as many adaptation strategies require significant financial investments that are not always available. Financial resources are a major obstacle to the implementation of sustainable measures. Unclear policies or contradictory regulations (5.8%) are perceived by residents as confusing and hindering for organizations and individuals seeking to develop and implement climate change adaptation strategies.

12. What challenges have you faced when trying to adapt to climate change?

Response and analysis:

- Financial constraints (38.4%) – One of the biggest challenges is the lack of sufficient funds to implement adaptation measures and cope with the consequences of climate change.
- Limited access to technology or expertise (26.7%) – The technologies and expertise needed to respond to climate change are often scarce or unavailable, limiting opportunities for effective adaptation.
- Lack of support from local authorities (15%) – Participants experienced difficulties due to the lack of support and guidance from local authorities, which could provide assistance in developing and implementing adaptation strategies.
- Difficulty in changing personal behaviour or practices (16.6%) – For individuals, changing behaviour and personal practices to adapt to climate change has been a major challenge, especially when it comes to adopting new habits and lifestyles.
- Other (3.4%) – Some individuals have also mentioned other challenges, which were not specified in detail.

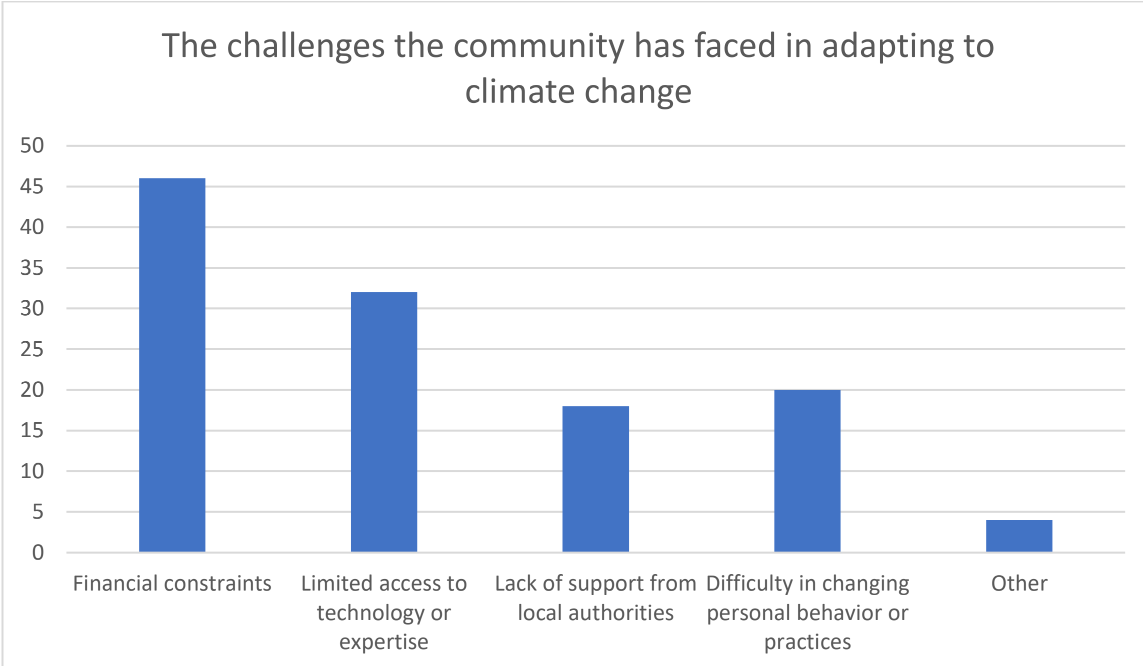


Figure 71. The challenges the community has faced in adapting to climate change.

Financial constraints (38.4%) are identified as the most frequently mentioned factor and indicate that financial resources are a major barrier to implementing adaptation measures. Without adequate financial support, individuals and organizations have difficulty in developing and implementing adaptation strategies. Limited access to technology or expertise (26.7%) indicates that although technologies and expertise are important for adaptation, they are often not available or accessible to individuals and organizations. This challenge is linked to the need to develop infrastructure and train the necessary personnel.

Respondents to the questionnaire (15%) mentioned that without strong support from local authorities, many strategies may fail. Local authorities can provide resources and support at the practical level, such as providing funding and legal guidance. The indicator of changing personal behavior or practices (16.6%) is related to resistance to change and the difficulties that occur when individuals and communities try to adapt to new ways of living and working. This may include psychological and cultural aspects that make this process slower. A few participants mentioned other challenges (3.4%), which may be of a more specific nature to their context.

Section 5: Human Health and Climate Change

13. Have you noticed any health impacts related to climate change in your area? (Select all that apply)

Response and analysis:

- Respiratory issues (e.g., asthma, allergies) (25.8%) – Climate change has worsened respiratory problems, such as asthma and allergies, due to increased air pollution and changes in pollen cycles.
- Heat-related illnesses (e.g., heatstroke, dehydration) (40.8%) – Many participants have noticed an increase in heat-related illnesses, such as heatstroke and dehydration, due to more frequent and severe heat waves.
- Vector-borne diseases (e.g., malaria, etc.) (2.5%) – Participants have reported fewer cases of vector-borne diseases, such as malaria, although this may depend on the geographic and climatic characteristics of the area.
- Mental health impacts (e.g. stress, anxiety due to climate events) (19.1%) – Many individuals have experienced impacts on their mental health due to concerns about the consequences of climate change, including anxiety and stress that extreme weather events may cause.
- Food- or water-borne illnesses (11.6%) – Illnesses related to water and food contamination have also been reported as a consequence of climate change, due to rising temperatures and risks of contamination of water sources and food products.
- Other (0) – No other specific health impacts were reported.

14. To what extent do you think climate change is affecting your health?

Response and analysis:

- Very strongly (9.2%) – Some individuals believe that the impact of climate change on their health is very strong, including direct impacts from heat waves, air pollution, and stresses resulting from climate events.
- Moderately (75.8%) – Most participants believe that the impact is moderate, including impacts such as worsening respiratory diseases or other health concerns related to climate change, but not direct or critical.
- A little (15.8%) – Some individuals believe that the impact is relatively small, perhaps due to favourable climatic conditions in their area or due to not experiencing strong impacts.
- Not at all (0.8%) – One individual reported that they did not think that climate change had affected their health.

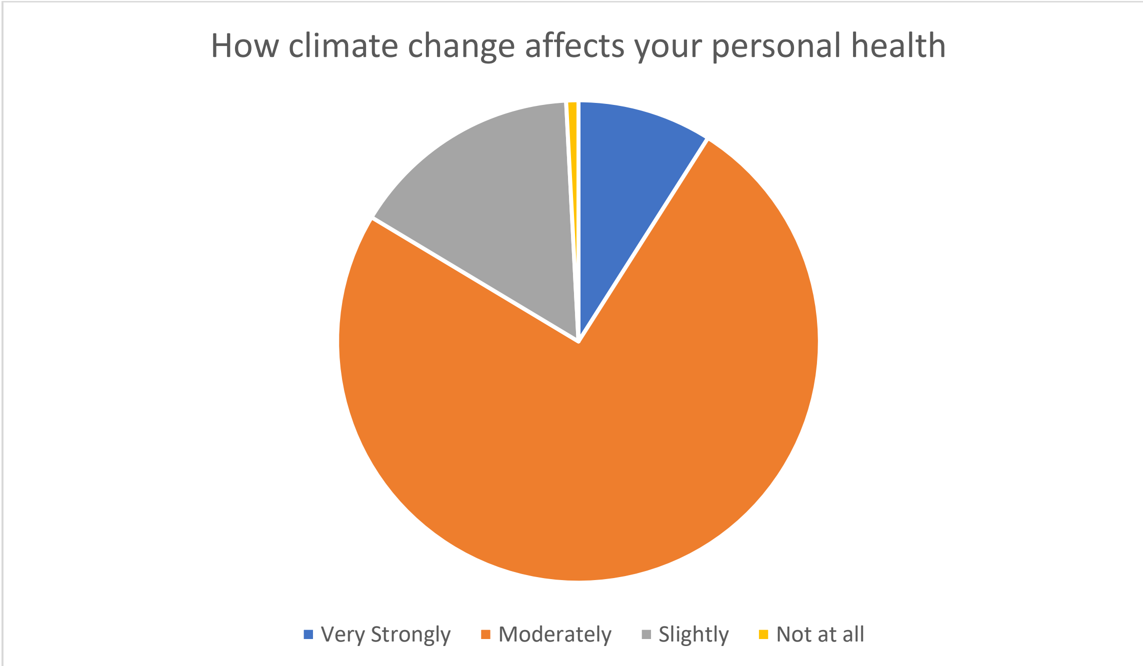


Figure 72. How climate change affects your personal health.

Strong impact is mainly associated with individuals (9.2%) experiencing direct effects of climate change, such as those related to respiratory diseases or health problems from extreme temperatures. The majority of participants (75.8%) perceive the impact as moderate, suggesting that, for many individuals, climate change affects their health indirectly, through worsening existing conditions or pollution-related concerns. A few individuals (15.8%) do not perceive the impact as significant, perhaps due to more favorable climate conditions in their area or due to limited experiences with extreme weather events. One individual (0.8%) reported not feeling any direct impact from climate change, which may be an outlier.

15. Are you taking any steps to protect your health from climate change?

Response and analysis:

- Using air purifiers or masks (5.8%) – Some individuals have used air purifiers or masks to protect themselves from air pollution and worsening respiratory conditions.
- Drinking more water (35.8%) – Participants have increased their water intake to prevent dehydration, especially during periods of extreme heat.
- Avoiding outdoor activities during extreme weather (43%) – A common measure is avoiding outdoor activities during extreme weather, such as heat waves or storms, to reduce the risk of heat-related illnesses and injuries from extreme events.
- Seeking medical help or advice for climate-related conditions (15%) – Some individuals have sought medical advice to manage health conditions related to climate change, such as asthma or other respiratory illnesses.
- Other (2.5%) – Some individuals have mentioned other measures, which are not specified.

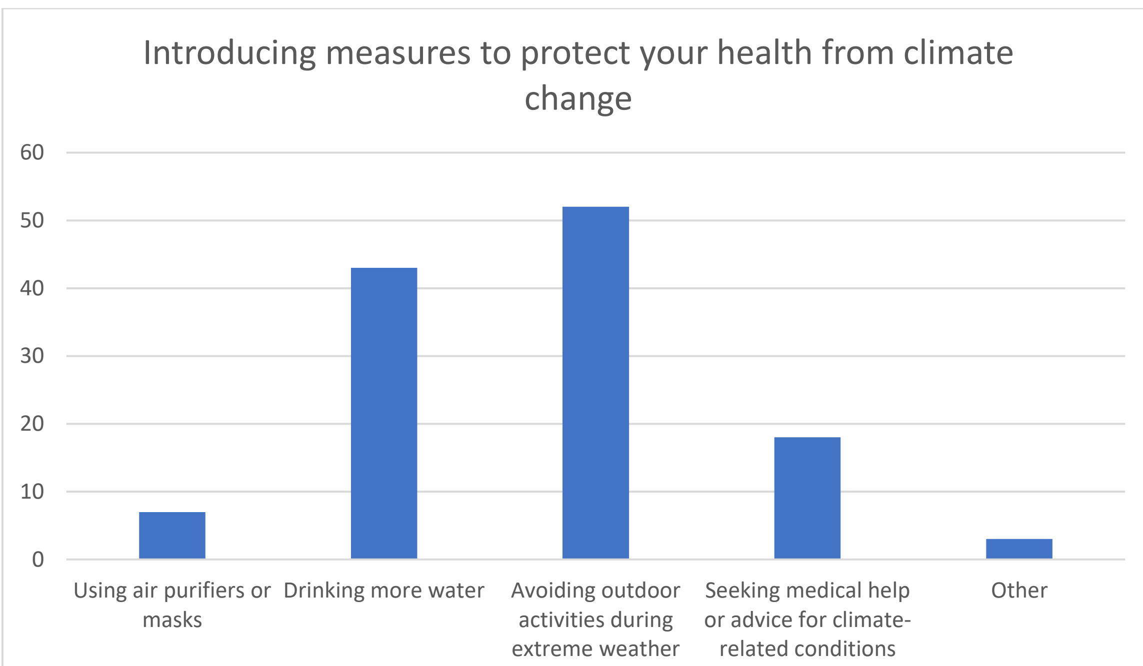


Figure 73. Introducing measures to protect your health from climate change.

Participants who use air purifiers or masks (5.8%) are aware of air pollution and the harm that can be caused by exposure to polluted air, especially during periods of extreme heat. Participants (35.8%) have increased their water intake to prevent dehydration during heat waves, which is a common measure to protect their health. Most participants (43%) avoid outdoor activities during extreme weather conditions, such as hot days or storms, to reduce the risk of heat-related illnesses and weather-related injuries. Some individuals (15%) seek medical advice to treat climate-related illnesses, such as asthma and allergies. Other measures taken by individuals (2.5%) are more personalized in nature and may include other health-preserving practices.

Section 6: Future Outlook

16. How certain are you in your community's capacity to adjust to climate change?

Response Analysis:

- Very confident (10%): Participants who are very confident believe that their community has the resources, plans, and commitment needed to adapt to climate change. These individuals may have positive experiences with government and local resources.
- Somewhat confident (42%): Most participants feel that there is a chance to adapt, but their confidence is limited, perhaps due to other challenges such as lack of financial resources or institutional support. This group may believe that adaptation is possible but requires more effort and cooperation.
- Not sure (33%): This group sees adaptation as a major challenge. They may have concerns about the lack of opportunities, assistance, and organization that could hinder efforts to adapt.

- Not sure (15%): This group is more uncertain and may feel completely uncertain about the community's ability to adapt, perhaps due to a lack of information or unpredictable events related to climate change.

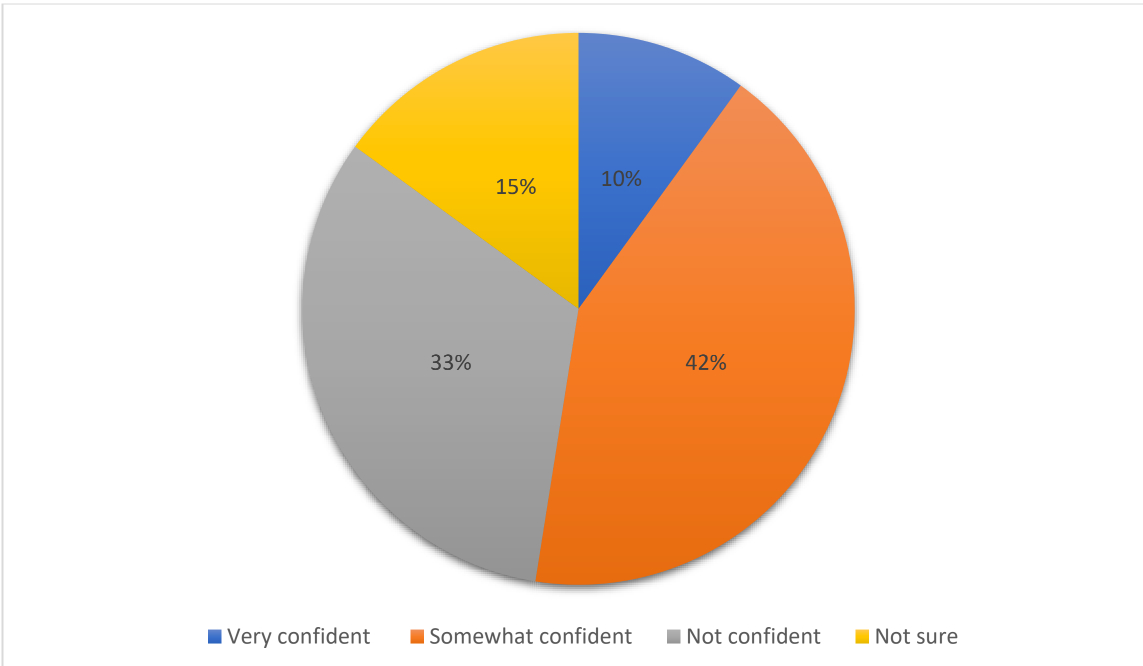


Figure 74. The security that the community presents to adapt to climate change.

This question asks about individuals' confidence in their community's ability to adapt to the impacts of climate change over a long-term period of 10 years. The results show a range of confidence, with most individuals being "somewhat confident" and a significant number being unsure.

17. What additional measures do you believe are necessary to improve climate change adaptation in your area?

Participants gave different answers on the additional and necessary measures to improve climate change adaptation in their area. They stated that it is necessary to improve infrastructure to cope with extreme events, public education and awareness, improved financial resources and government support, international cooperation and support from international organizations, etc.

18. Do you think that local authorities and the government are doing enough to address the impacts of climate change?

Response analysis:

- Yes (54%): These individuals believe that the authorities are making sufficient efforts, perhaps through adaptation policies, investments in infrastructure, and assistance to the most affected communities. They can see some concrete steps and efforts by the government that provide a clear contribution.
- No (13%): This group does not believe that the government is doing enough to address the impacts of climate change. They may be concerned about the lack of concrete actions or the failure to implement appropriate policies to address climate problems.

- Not sure (33%): Participants who are unsure may feel confused by the information they have or by the lack of transparency in the policies and actions that authorities are taking.

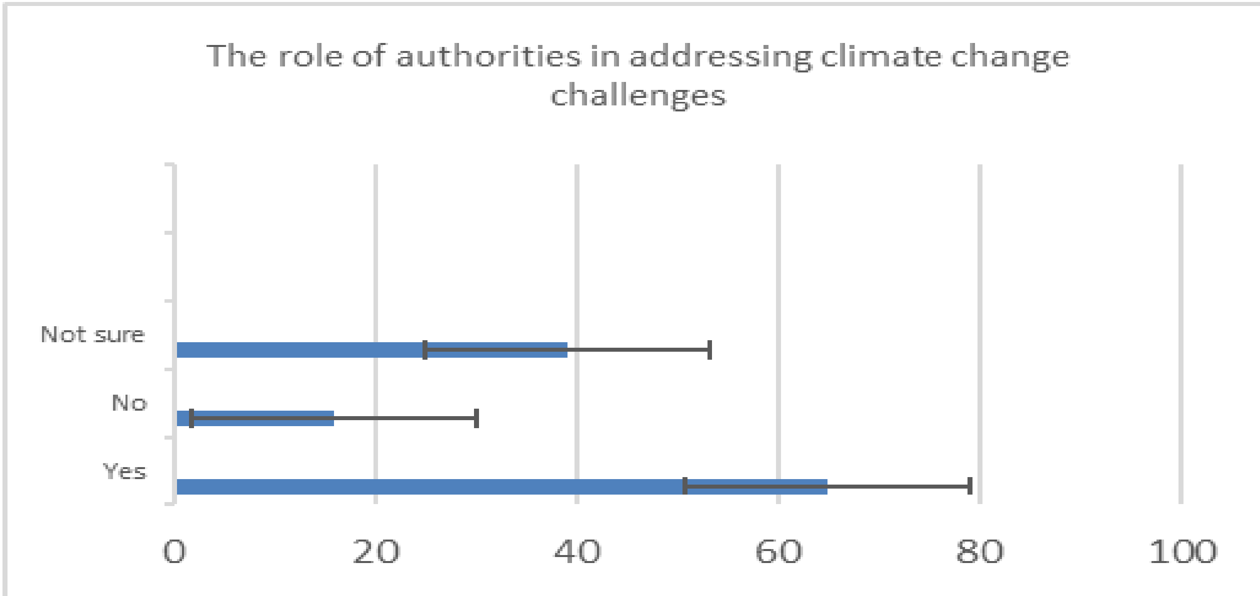


Figure 75. The role of authorities in addressing climate change challenges.

This question addresses participants' assessment of the efforts of local authorities and the government in addressing the impacts of climate change. Most individuals believe that the authorities are making efforts, but there are also a significant number who see this as insufficient. The suggestion for the community on how to improve climate change awareness and education in Lezha, especially given the moderate to low awareness of adaptation strategies among residents is important to: Develop Community Workshops and Seminars to educate residents about climate change impacts and adaptation strategies, promote Ecosystem-based Adaptation (EbA), these strategies can enhance the resilience of local ecosystems and communities Engage Local Environmental Organizations, which focuses on raising public awareness about climate change through various projects and media engagements, etc.

CHAPTER 5: CONCLUSIONS AND RECCOMMENDATION

The Lezhë Region is undergoing profound environmental and socio-demographic transformation. Since the 1990s, it has experienced a steady demographic decline fueled by emigration, an aging population, and declining birth rates. Rural and hilly areas show especially clear signs of this change, which results in less economic activity, deserted homes, and smaller workforces. Although internal migration has caused little development in the city of Lezha, rural lives are growingly vulnerable under the dual load of depopulation and climate stress. Regional sustainability, resource management, and resilience planning are all significantly affected by these changing dynamics.

Thorough anomaly research between 1980 and 2023 verifies the acceleration of this warming trend. Marked by notable rises in both maximum and minimum temperatures, two separate phases emerge: a reasonably stable climatic period (1980–2000) and a warming-dominated age (2001–2023). Along with more frequent tropical nights and severe cold spells, extremes—like the record 42°C in Dajç-Zadrimë—have been more prevalent. The discrepancies in cities like Lezhë draw even more attention to the Urban Heat Island (UHI) effect, hence stressing how constructed surroundings amplify the effects of climate change.

Trends in precipitation from 1990 to 2020 show more instability. Annual rainfall is still important (1200–1500 mm), but especially in autumn and early winter it has grown more unpredictable and severe. Rising has been the incidence of heavy rain events—often over 200 mm in 24 hours—which raises flood hazards in rural and urban environments alike. These patterns endanger general urban livability, infrastructural dependability, and agricultural output.

The results of this study highlight a strong and continuous warming trend in the region. Average annual temperatures have risen significantly over the previous six decades—from 15.4°C during 1961–1990 to 16.4° over 1990–2020. Most especially, summer maximum temperatures sometimes exceed 40°C, increasing the likelihood of drought, wildfires, water shortages, and heat-related health issues. Reflecting spatial variation in the area's climate vulnerability, these shifts are more noticeable in lowland and urban areas than in higher-altitude ones.

Urban development in Lezhë has grown fast, more than 460% from 1991 to 2020. Uncontrolled expansion has greatly changed the natural and physical environment of the city by lowering green areas and raising impervious surfaces. The results are obvious: higher temperatures, decreased humidity, regular flooding, and lower air quality. Variations of up to 6°C between vegetated and non-vegetated areas offer strong evidence of the UHI impact. Moreover, whereas more vegetated or natural areas reported far lower numbers, CO_2 levels in the city center have climbed as high as 600 ppm.

These results validate the vital need of green areas. Vegetation, particularly tree cover, not only reduces heat and increases air moisture but also absorbs CO_2, hence improving urban air quality. While regions with vegetation gain from cooler temperatures, more humidity, and better air circulation, compact urban plans with little green infrastructure have been found to increase microclimatic stress. The Lezhë case study clearly shows how bad spatial design increases environmental vulnerability and climate exposure.

The study also points out places with large CO_2 emissions, mostly from transportation and urban infrastructure. While outer locations with more vegetation and less pollution reveal better environmental indicators, central and traffic-heavy areas are hotspots. Alarmingly, even distant places like the industrial zone and northern districts show elevated CO_2 levels, probably caused by industrial activities and old cars. These trends suggest a focused strategy for sustainable land use, urban plants, and emissions management.

Urban adaptation is based on two worldwide strategies: early warning systems and strengthening regenerative capacity. Albania, on the other hand, is still in the early stages of including resilience into urban and territorial design. Cities like Durrës post-earthquake illustrate the deficiencies in preparation and reaction. Like other urban areas, Lezhë has to see climate adaptation as a constant, integrated process ingrained in government, design, and development planning rather than a separate effort.

Urban planning, this study shows, is a key instrument in this approach. Cities have to adopt aggressive planning techniques whether it's the control of infrastructure development or the inclusion of green zones. Case studies from other Mediterranean cities, including Nice, France, show the success of inclusive, green, and climate-conscious urban design. Making this vision a reality for Lezhë will depend on policy development, community involvement, and creative investment. Sustainable urban design—characterized by green corridors, effective drainage, renewable energy integration, and smart mobility—can lower the vulnerability of the area and improve general quality of life.

In summary, this study provides a multi-layered perspective on climate change and urbanization in the Lezhë Region. It shows the degree of environmental stress, points out at-risk areas, and underlines the possibilities for adaptive change. Although financial and socio-political issues remain, the way ahead is obvious: a dedication to sustainable planning, community-centred solutions, and climate-smart governance. The area has to now adopt resilience as a guiding concept not just for survival but also for the sustained development of next generations.

5.1 Recommendations for Adaptation and Resilience

Considering the results of this study, a thorough list of suggestions is offered to improve climate change adaptation and resilience in Lezha and neighbouring places.

Ranging from population dynamics and socio-economic development to urban infrastructure, agriculture, and environmental awareness, these suggestions seek to tackle the several character of climatic vulnerabilities. Implementing these suggestions calls for concerted effort by local government, community groups, and national organizations to guarantee long-term viability.

Driven by economic pressures and lack of options, rural depopulation has heightened climate change vulnerability. Local governments can provide encouraging rules and incentives such business grants, housing subsidies, and tax exemptions for agriculture and rural entrepreneurship to offset this trend. These initiatives would not only promote demographic stability but also encourage social cohesiveness and local economic regeneration.

At the same time, especially for small and medium-sized businesses (SMEs) engaged in traditional crafts, agrotourism, and sustainable agriculture, it is essential to promote regional economic development by means of support.

Another important pillar of adaptation is investment in public services and infrastructure. Improving digital connectivity, transportation systems, healthcare, and educational services in rural and semi-urban areas can greatly raise the quality of life and help to close the socioeconomic gap between urban and peripheral areas.

The creation of localized adaptation techniques is at the core of climate resilience. Particularly in areas like agriculture, water management, and urban infrastructure, municipalities have to give developing climate-resilient development plans top priority. Zoning and development policies should reflect these plans' inclusion of environmental sustainability, hydrological hazards, and temperature extremes.

A basic component of rural adaptation is climate-smart agriculture. Maintaining food security and livelihoods in the face of changing climatic conditions depends on promoting heat- and drought-resistant crop types, supporting sustainable farming practices, and offering focused farmer education.

Urban places, like Lezhë, have to put greening and cooling policies into place to offset the impact of urban heat islands. Urban comfort and resilience may be greatly improved by strategies such installing reflecting materials, planting urban woods, and developing rooftop gardens. Urban design has to provide sufficient building space, mixed-use zoning, and green corridors to promote airflow and lower pollution levels.

Revamping stormwater and flood control systems is absolutely essential if one is to handle the growing flood and water stress concerns. This calls for building natural infiltration zones, flood barriers, and retention basins. Increasing urban tree canopy coverage and preserving green corridors helps to control stormwater naturally and support biodiversity. Policies on urban planning should give green infrastructure preservation first priority, including community gardens, urban parks, and tree-lined streets.

Raising public knowledge and education on climate change helps to complement these structural initiatives. Increasing knowledge of climate dangers and encouraging adaptive behaviours—such as water conservation and sustainable building practices—can be greatly aided by community-driven initiatives, educational programs, and public media. Providing people the information to make educated decisions improves both personal and group resilience.

Effective planning depends on localised data on temperature variation, flooding, and water availability. Monitoring urban microclimates, modelling future climatic effects, and customizing local responses accordingly can all be aided by using tools such remote sensing and Geographic Information Systems (GIS).

The study results highlight a notable lack of community-level awareness and action. Though majority of those polled showed some knowledge of climate change, just a small number really understood it or had worked to adapt. This calls for thorough awareness efforts and educational initiatives including into community workshops and school curriculum. Using local media and social networks helps to spread easily available, relevant knowledge about climate hazards and adaptive behaviours.

Ultimately, inclusive and fair should be the adaption plans. Often, socio-political and financial constraints impede the execution of climate initiatives in underprivileged communities. Policies have to guarantee that no group is left behind in the quest of resilience and that adaption advantages are spread equally. The evolution of fair and efficient policies depends on an awareness of the intersectionality of climate vulnerability—along economic, gender, regional, and generational lines.

BIBLIOGRAPHY

Amores, M. Marcos, D.S. Carrió, L. Gomez-Pujol Coastal impacts of storm Gloria (January 2020) over the North-Western Mediterranean Nat. Hazards Earth Syst. Sci., 20 (2020), pp. 1955-1968, 10.5194/nhess-20-1955-2020

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). *Successful adaptation to climate change across scales*. Global Environmental Change, 15(2), 77-86.

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2005). *Adaptation to climate change in the developing world.* Progress in Development Studies, 3(3), 179-195.

Akbari, H.; Pomerantz, M.; Taha, H. Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. Sol. Energy 2001, 70, 295–310 *(PDF) Green Infrastructure as an Urban Heat Island Mitigation Strategy—A Review*. Available from: https://www.researchgate.net/publication/347789448_Green_Infrastructure_as_an_Urban_Heat_Island_Mitigation_Strategy-A_Review

Berg, N. (2009). *Green Alley Handbook: Sustainable Solutions for Urban Stormwater*. City of Chicago Department of Transportation.

Bulkeley, H., & Tuts, R. (2013). *Urban Climate Change Adaptation: The Role of Local Governments*. Local Environment, 18(6), 653–661.

Buyadi, S. N. A., Ean Mohd, E. M. N. & Misni, A., 2013. *Green spaces growth impact on the urban microclimate.*

C40. (n.d.). *C40 Cities: About Us*. Retrieved from www.c40.org

Condon, P. M., Cavens, D., & Miller, D. (2008). *Urban vulnerability and climate change: The role of infrastructure and governance in managing impacts*. Environmental Science & Policy, 11(3), 232-245.

Czarnecka, M.; Nidzgorska-Lencewicz, J. Intensity of Urban Heat Island and Air Quality in Gda ́nsk during2010 Heat Wave. Pol. J. Environ. Stud. 2014, 23, 329–340 *(PDF) Green Infrastructure as an Urban Heat Island Mitigation Strategy—A Review*.

Available from: https://www.researchgate.net/publication/347789448_Green_Infrastructure_as_an_Urban_Heat_Island_Mitigation_Strategy-A_Review

Davis, M. (2006). *Planet of Slums*. Verso.

DEFRA (2008). *Future Water: The Government's Water Strategy for England*. Department for Environment, Food & Rural Affairs.

E. Bevacqua, D. Maraun, I. Hobæk Haff, M. Widmann, M. Vrac Multivariate statistical modelling of compound events via pair-copula constructions: analysis of floods in Ravenna (Italy) Hydrol. Earth Syst. Sci., 21 (2017), pp. 2701-2723, 10.5194/hess-21-2701-2017

European Environment Agency. (2020). *Climate change adaptation in Europe. https://www.eea.europa.eu/en/topics/in-depth/climate-change-impacts-risks-and-adaptation*

Flóra Szkordilisz, Mitigation of urban heat island by green spaces, April 2014 Pollack Periodica 9(1):91-100. DOI: 10.1556/Pollack.9.2014.1.10 https://www.researchgate.net/publication/267865640_Mitigation_of_urban_heat_island_by_green_spaces

Garnaut, R. (2008). *The Garnaut Climate Change Review*. Cambridge University Press.

Garnaut, R. (2008). *The Garnaut climate change review: Final report*. Cambridge University Press.

Gary Austin, Gary Dean Austin. Case Study and Sustainability Assessment of Bo01, Malmo, Sweden (2013). July 2013, Journal of Green Building 8(3):34-50, DOI: 10.3992/jgb.8.3.34 https://www.researchgate.net/publication/265162042_Case_Study_and_Sustainability_Assessment_of_Bo01_Malmo_Sweden

Gjoni A., Kucaj E. et.al. *Some specific elements of Albania's atmospheric droughts*. 5th International Conference on Environmental Design and Health (ICED2024), Athens. E3S Web of Conferences 585, 02005 (2024). https://doi.org/10.1051/e3sconf/202458502005

Doherty, M., Klima, K., & Hellmann, J. J. (n.d.). Climate change in the urban environment: Advancing, measuring and achieving resiliency.

Ezeabasili, A. C. C., & Okonkwo, A. U. (n.d.). Climate Change Impacts on the Built Environment in Nigeria.

Enkelejda Kucaj, Marilda Osmani, Anira Gjoni, Azem Bardhi, and Besim Kucaj. *Phytostabilization Potential of Salix alba as Biomonitors of Heavy Metals in Soil Pollution near the Erzeni Riverbank.* International Journal of Environmental Science and Development. Indexing: Scopus (CiteScore 2021: 0.8). February 2023. IJESD Vol. 14, No. 1, ISSN: 2010-0264 (Print). doi: 10.18178/ijesd.2023.14.1.1411, pg. 30-36. https://www.ijesd.org/show-184-1963-1.html

Jiang, Y., Hou, L., Shi, T., et al. (n.d.). A Review of Urban Planning Research for Climate Change.

López, A., Mabe, L., & Cantergiani, C. d. C. (n.d.). Integration of multiple methodologies to evaluate effects of Nature Based Solutions on urban climate mitigation and adaptation.

Lwasa, S. (n.d.). Adapting urban areas in Africa to climate change: the case of Kampala.

Matthews, T. Climate Change Adaptation in Urban Systems: Strategies for Planning Regimes.

Mauree, D., Naboni, E., Coccolo, S., et al. (n.d.). A review of assessment methods for the urban environment and its energy sustainability to guarantee climate adaptation of future cities.

McMichael, A. J., Woodruff, R. E., & Hales, S. (2006). Climate change and human health: present and future risks. The Lancet, 367(9513), 859-869.

Reckien, D., Buzási, A., Olazabal, M., et al. (n.d.). Quality of urban climate adaptation plans over time.

Revi, A., Satterthwaite, D., Aragón-Durand, F., et al. (n.d.). Towards transformative adaptation in cities: the IPCC's Fifth Assessment.

Shalaby, H. A., & Aboelnaga, S. Climate Change Impacts on Urban Planning in the Cities.

(UNDP Issues Brief on Urban Climate Resilience, 2023) (n.d.). UNDP issues brief on urban climate resilience.

Sherif Lushaj, A. Gjoni, E. Kucaj, *The influence of climate change on drought occurrences and the measures taken to alleviate drought in Albania.* Conference: ISSUES OF HOUSING, PLANNING, AND RESILIENT DEVELOPMENT OF THE TERRITORY Towards Euro-Mediterranean Perspectives, January 2024. https://DOI: 10.37199/c41000123.

Sherif Lushaj, E. Kucaj. *Soil Erosion in the Vjosa River Watershed in Albania. Problems and Protective Measures.* 5th International Conference on Environmental Design and Health (ICED2024), Athens. E3S Web of Conferences 585, 09004 (2024). https://doi.org/10.1051/e3sconf/202458509004

UNDP. (2019). National Climate Change Adaptation Strategy. https://www.undp.org/asia-pacific/climate-change-adaptation

WHO. (2018). Climate change and health. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

Wardekker, J. A. Climate change impact assessment and adaptation under uncertainty.

Wilson, E. (2006). *Adapting to climate change at the local level: The spatial planning response*. Local Environment, 11(6), 609–625. https://doi.org/10.1080/13549830600853635

Zhao, L. (n.d.). Urban growth and climate adaptation.

Geo Factsheet, 1998. *Urban Microclimates No.50.*

Givoni, B. (1991). *Climate considerations in building and urban design*. Van Nostrand Reinhold.

Gleeson, B. (2008). *Urban systems and climate change: A socio-ecological perspective*. Environmental Policy and Governance, 18(5), 2656-2668.

Guhathakurta, S.; Gober, P. The Impact of the Phoenix Urban Heat Island on Residential Water Use. J. Am.Plan. Assoc. 2007, 73, 317–329

Haaland, C., & van den Bosch, C. K. (2015). *Nature-based solutions in urban planning: A systematic review of their effects on health and well-being*. Urban Forestry & Urban Greening, 14(4), 460-470.

Harlan, S.L.; Brazel, A.J.; Prashad, L.; Stefanov, W.L.; Larsen, L. Neighborhood microclimates and vulnerabilityto heat stress. Soc. Sci. Med. 2006, 63, 2847–2863

IPCC, (2018). *Global Warming of 1.5 ◦C:* An IPCC Special Report on the Impacts of Global Warming of 1.5 ◦C Above-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty; Intergovernmental Panel on Climate Change: Geneva, Switzerland, 2018; pp. 1–615

IPCC (2007). *Fourth Assessment Report: Climate Change 2007*. Intergovernmental Panel on Climate Change.

IPCC (Intergovernmental Panel on Climate Change). (2007). *Climate Change 2007: Synthesis Report*. Contributions of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC.

IPCC. (2007). *Climate Change 2007: Synthesis Report*. Intergovernmental Panel on Climate Change.

J.W. VanderMeer, N.W.H. Allsop,T. Bruce, J. DeRouck, A. Kortenhaus, T. Pullen, H. Schüttrum pf, K.L. McInnes, K.J.E. Walsh, G.D. Hubbert, T. Beer Impact of sea-level rise and storm surges in a coastal community Nat. Hazards, 30 (2003), pp. 187-207, 10.1023/A:1026118417752

Koch, A., & Kersting, J.-C. (2011). Annex 51: Energy Efficient Communities - Case Studies and Strategic Guidancefor Urban Decision Makers (p. 89). Karlsruhe: European Institute for Energy Research—EIFER. Retrievedfrom http://www.annex51.org/media/content/files/casestudies/subtaskA/SubA_report_110714.pdf

(PDF) Case Study and Sustainability Assessment of Bo01, Malmo, Sweden. Available from: https://www.researchgate.net/publication/265162042_Case_Study_and_Sustainability_Assessment_of_Bo01_Malmo_Sweden

Kreibich, H., et al. (2014). *Adaptation to flood risk in Europe: A comparative analysis of selected countries*. Natural Hazards and Earth System Sciences, 14(9), 2283-2294.

Li, C. (2018). *Urban Building Energy Consumption/Microclimate Tools and Models*. In *Proceedings of the 15th International Symposium on Environmental Protection and Energy Systems*.

Lovelock, J. (2006). *The revenge of Gaia: Why the Earth is fighting back – and how we can still save humanity*. Penguin Books.

Lovelock, J. (2006). *The Revenge of Gaia: Why the Earth is Fighting Back and How We Can Still Save Humanity*. Penguin Books.

Lushaj Sh & Kucaj E. Fires in natural systems and their impact on the environmentin Albania (2024) Period. Mineral. 93, 1-9

Lushaj Sh., Gjoni A., Kucaj E. The influence of climate change on drought occurrences and the measures taken to alleviate drought in Albania. Conference: ISSUES OF HOUSING, PLANNING, AND RESILIENT DEVELOPMENT OF THE TERRITORY Towards Euro-Mediterranean Perspectives, 2024 DOI: 10.37199/c41000123

Mueller, J., & Rynne, S. (2009). *Sustaining Places: The Role of the Comprehensive Plan*. American Planning Association.

Otto-Zimmermann, K. (2011). *The Role of Cities in Global Climate Change Mitigation and Adaptation*. In *Climate Change and Cities* (pp. 1–13). Springer.

P. Troch, B. Zanuttigh. Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application (2018)

Pauleit, S., et al. (2015). *Urban Climate Change Adaptation and Mitigation*. In *The Handbook of Urban Ecology* (pp. 356–365). Routledge.

Persson, B., & Tanner, R. G. (2005). Sustainable city of tomorrow: Bo01—experiences of a Swedish housing exposi-tion. Stockholm: Formas

Preston, B. L., et al. (2011). *Climate Adaptation Planning in the Urban Sector: Insights from a Survey of Metropolitan Areas in Australia*. Urban Climate, 1(1), 29-42.

Reepalu, I. (2013, June 4). Malmö—from industrial waste land to sustainable city. Climate Action.Retrieved September 16, 2013, from http://www.climateactionprogramme.org/climate-leader-papers/ilmar_reepalu_mayor_city_of_malmoe_sweden/ *(PDF) Case Study and Sustainability Assessment of Bo01, Malmo, Sweden*. Available from: https://www.researchgate.net/publication/265162042_Case_Study_and_Sustainability_Assessment_of_Bo01_Malmo_Sweden

Ritchie, A., & Thomas, R. (2009). Sustainable urban design: an environmental approach. (2nd ed.). London; NewYork: Taylor & Francis.

Rosenzweig, C., et al. (2010). *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*. Cambridge University Press.

Santamouris, M.; Cartalis, C.; Synnefa, A.; Kolokotsa, D. On the impact of urban heat island and globalwarming on the power demand and electricity consumption of buildings—A review. Energy Build. 2015, 98,119–124. *(PDF) Green Infrastructure as an Urban Heat Island Mitigation Strategy—A Review*. Available from: https://www.researchgate.net/publication/347789448_Green_Infrastructure_as_an_Urban_Heat_Island_Mitigation_Strategy-A_Review

Sarrat, C.; Lemonsu, A.; Masson, V.; Guédalia, D. Impact of urban heat island on regional atmosphericpollution. Atmos. Environ. 2006, 40, 1743–1758.

Schipper, L. (2007). *Climate change adaptation and development: Exploring the links*. In M. Pelling, C. D. High, & D. R. M. Pradeep (Eds.), *Understanding adaptation to climate change: Lessons from development and policy*. Earthscan.

Semadeni-Davies, A., et al. (2008). *The impacts of climate change on urban drainage systems: A case study in the city of Gothenburg, Sweden*. Water Science and Technology, 57(4), 577-585.

Steffen, W. (2009). *Climate change 2009: Faster change and more serious impacts*. Global Environmental Change, 19(3), 365-373.

Steffen, W. (2009). *Climate change: The global dimension and implications for cities*. Australian Geographer, 40(2), 157-168.

Stern, N. (2006). *The Stern Review on the Economics of Climate Change*. Cambridge University Press.

Stern, N. (2006). *The Stern review on the economics of climate change*. Cambridge University Press.

Takebayashi, H. & Moriyama, M., 2020. *Adaptation measures for urban heat islands.*

Tan, J.; Zheng, Y.; Tang, X.; Guo, C.; Li, L.; Song, G.; Zhen, X.; Yuan, D.; Kalkstein, A.J.; Li, F.; et al. The urbanheat island and its impact on heat waves and human health in Shanghai. Int. J. Biometeorol. 2010, 54, 75–84.

Tanimoto, H., Sato, T., & Kondo, H. (2003). *Urban heat islands and energy balance in cities*. Atmospheric Environment, 37(30), 4427-4434.

UN. (2009). *World Urbanization Prospects: The 2009 Revision*. United Nations Department of Economic and Social Affairs.

UN-Habitat. (2016). *The New Urban Agenda*. United Nations Human Settlements Programme.

Van der Waals, J. (2000). *Urban land development and the potential of brownfields redevelopment*. Land Use Policy, 17(4), 235-243.

Vinayak, B., Lee, H., Gedam, S., & Latha, R. (2018). *Microclimatic effects of urbanization and future projections in metropolitan India*. Urban Climate, 24, 146-160.

While, A., & Whitehead, M. (2013). *Cities and Climate Change: A New Research Agenda*. Urban Studies, 50(7), 1499–1517.

Winker, M. & Rudolph-Cleff, A., 2019. *Greening and cooling the city using novel urban water systems.*

Winker, M. & Rudolph-Cleff, A., 2019. *In Approaches to Water Sensitive Urban Design.*

Appendix 1: Survey

The Research Study Questionnaire

This research study aims to illustrate, examine, and demonstrate how urban planning regimes can use some of their professional tools to develop adaptation strategies and interventions in urban systems in adaptation to climate change. To get answers to research questions and meet the objectives, this study aims to conduct a survey involving potential participants. The survey has six questions, each targeting a different study objective.

How to Respond: You will answer the question by picking your answers and marking them on the survey sheet. This research is essential for tackling the consequences of climate change. Your honesty will be appreciated. The survey has two questions: closed-ended or those you must pick based on the choices provided, and open-ended questions that need you to express your ideas. For the close-ended question, you will like the options, and for the open-ended, you will express your ideas

Section 1:

Demographic Information

1. **Age**:

    - Under 18
    - 18-24
    - 25-34
    - 35-44
    - 45-54

- 55 and above

2. **Gender**:

   - Male
   - Female
   - Prefer not to answer

3. **Occupation**:

   - Farmer
   - Urban worker
   - Government employee
   - Student
   - Other: __________

4. **Location** (City or Rural Area):

   - Urban
   - Rural

Section 2: Awareness and Perception of Climate Change

5. **How aware are you of climate change and its impacts?**

   - Very aware
   - Somewhat aware
   - Not very aware

- Not aware at all

6. **What climate-related changes have you noticed in your area over the past 5 years?** (Select all that apply)
   - Temperature increases
   - More frequent floods
   - Droughts or water scarcity
   - Changes in agricultural seasons
   - More intense storms or winds
   - Changes in biodiversity or local ecosystems
   - Other: __________

7. **How certain are you about the impacts of climate change in your area?**
   - Very certain
   - Somewhat certain
   - Uncertain
   - Very uncertain

Section 3: Climate Change Adaptation Strategies

8. **Have you or your community taken any steps to adapt to climate change?**
   - Yes
   - No

- Not sure

9. **What type of adaptation measures have you implemented or observed in your community?** (Select all that apply)

    - Water conservation practices
    - Use of climate-resistant crops (for farmers)
    - Improved housing or infrastructure (e.g., flood-resistant buildings)
    - Community-based preparedness plans (e.g., early warning systems)
    - Afforestation or reforestation programs
    - Temperature mitigation (e.g., creating green spaces, using reflective surfaces)
    - Other: __________

10. **Do you believe the current climate change adaptation strategies in your area are sufficient?**

    - Yes
    - No
    - Not sure

Section 4: Uncertainties and Challenges

11. **What are the main uncertainties you face regarding climate change impacts?** (Select all that apply)

    - Unpredictability of weather patterns

- Lack of information on how to prepare
- Insufficient government or local support
- Lack of financial resources to implement adaptation strategies
- Unclear policies or conflicting regulations
- Other: __________

12. **What challenges have you faced when trying to adapt to climate change?**
    - Financial constraints
    - Limited access to technology or expertise
    - Lack of support from local authorities
    - Difficulty in changing personal behavior or practices
    - Other: __________

Section 5: Human Health and Climate Change

13. **Have you noticed any health impacts related to climate change in your area?** (Select all that apply)
    - Respiratory issues (e.g., asthma, allergies)
    - Heat-related illnesses (e.g., heat stroke, dehydration)
    - Vector-borne diseases (e.g., malaria, dengue)
    - Mental health impacts (e.g., stress, anxiety due to climate events)
    - Food or waterborne diseases

- Other: __________

14. **To what extent do you think climate change affects your personal health?**

- Very strongly
- Moderately
- Slightly
- Not at all

15. **Are you taking any steps to protect your health from climate change?** (Select all that apply)

- Using air purifiers or masks
- Drinking more water
- Avoiding outdoor activities during extreme weather
- Seeking medical help or advice for climate-related conditions
- Other: __________

Section 6: Future Outlook

16. **How confident are you in your community's ability to adapt to climate change over the next 10 years?**

- Very confident
- Somewhat confident

- Not confident
- Not sure

17. **What additional measures do you believe are necessary to improve adaptation to climate change in your area?**

18. **Do you feel that local authorities and government are doing enough to address the impacts of climate change?**

- Yes
- No
- Not sure

Appendix 2: Data collected in Lezha study zone

	Lat	Lon	Altitude (m)	Area Description	Current Temperature (℃)	CO2 p.p.p	Humidity (%)
1	41°46'32.19"	19°38'53.0"	0	Dense area with buildings in the south of the city	33.5	408	50.5
2	41°47'27.19"	19°39'17.30"	30	Peripheral neighbourhood in the north of the city	31.5	945	49.5
3	41°46'53.19"	19°38'36.10"	10	City centre (Town Hall Square)	35.1	482	42.7
4	41°46'56.19"	19°38'31.52"	5.2	Waterfront area with cafes and restaurants	30.7	399	48.4
5	41° 46' 10"	19°38'35.11"	20	Residential area in the southwest of the city	32	420	51
6	41°46'49.4034"	19°38'41.5098"	25	Commercial area near a busy intersection	34.2	600	48
7	41° 47' 6.795"	19°38'39.9876"	50	Industrial zone on the outskirts of the city	28.5	1100	40.5
8	41°47'1.0068"	19°39'1.4652"		Castle Area	31.8	500	45.2
9	41°47'4.5162"	19°39'25.455"	12	Park area in the eastern part of the city	29.3	390	53
10	41°47'06.1"	19°37'58.4"	18	Residential neighbourhood with low-rise buildings	32.8	475	47.8
11	41°47'27.5"	19°38'29.3"	8	River bank	30.1	420	49.6
12	41°46'30.60"	19°38'39.15"	22	Quiet suburban area with parks and gardens	33	460	46.9
13	41°46'29.6	19°39'19.3"		Traffic-heavy commercial street	34	500	44.2
14	41°46'15.11"	19°38'29.41"		Greenbelt and agricultural zone outside the city	27.8	950	55
15	41°46'41.1"	19°38'40.5"	10	Residential zone near schools and small shops	32.5	425	52.3

Appendix 3: Coding

ANNEX CODE

Air Temperature

1. Reading data

```
import pandas as pd

# File Excel

excel_path = r"E:\AGJ\All days data\Temperaturat.xlsx"

# Leximi i të gjitha sheets

sheets = pd.ExcelFile(excel_path).sheet_names

data = {sheet: pd.read_excel(excel_path, sheet_name=sheet) for sheet in sheets}

# Shfaqja e emrave të sheets dhe disa rreshtave të parë nga secili

for sheet_name, df in data.items():

    print(f"Sheet: {sheet_name}")

    print(df.head())

    print("\n")
```

2. Calculation of annual values and corresponding graphs

```
import pandas as pd

import os

import matplotlib.pyplot as plt
```

```
# Leximi i të dhënave

excel_path = r"E:\AGJ\All days data\Temperaturat.xlsx"

data = {

    "T mes": pd.read_excel(excel_path, sheet_name="T mes"),

    "T min": pd.read_excel(excel_path, sheet_name="T min"),

    "T max": pd.read_excel(excel_path, sheet_name="T max")

}

# Konvertimi i kolonës së datave

for key in data:

    data[key]['Emri'] = pd.to_datetime(data[key]['Emri'])

    data[key].set_index('Emri', inplace=True)

# Krijimi i një folderi për ruajtjen e rezultateve

output_folder = r"E:\AGJ\All days data\Statistika Vjetore"

os.makedirs(output_folder, exist_ok=True)

# Përllogaritje dhe grafikë

for key, df in data.items():

    # Përllogaritja vjetore për secilin vendmatje
```

```
yearly_stats = df.resample('Y').agg(['mean', 'max', 'min'])

# Ruajtja në Excel

excel_output = os.path.join(output_folder, f"Statistika_Vjetore_{key}.xlsx")

yearly_stats.to_excel(excel_output)

print(f"Rezultatet u ruajtën në: {excel_output}")

# Krijimi i grafikëve për secilin vendmatje

for col in df.columns:

plt.figure(figsize=(10, 6))

plt.plot(yearly_stats.index.year, yearly_stats[(col, 'mean')], label='Mesatare', marker='o')

plt.plot(yearly_stats.index.year, yearly_stats[(col, 'max')], label='Maksimale', linestyle='--')

plt.plot(yearly_stats.index.year, yearly_stats[(col, 'min')], label='Minimale', linestyle='-.')


plt.title(f"Temperaturat mesatare shumëvjeçare në °C për vendmatjen meteorologjike {col} ({key})")

plt.xlabel('Viti')
```

```
        plt.ylabel('Temperatura (°C)')

        plt.legend()

        plt.grid()

        # Ruajtja e grafikëve

        graph_output = os.path.join(output_folder, f"Grafik_{key}_{col}.png")

        plt.savefig(graph_output, dpi=300)

        plt.close()

        print(f"Grafiku u ruajt në: {graph_output}")
```

3. **Trend analysis**

```
import numpy as np

from scipy.stats import linregress



for key, df in data.items():

    yearly_stats = df.resample('Y').mean()

    yearly_stats = yearly_stats[(yearly_stats.index.year >= 1980) & (yearly_stats.index.year <= 2023)]

    for col in yearly_stats.columns:
```

```
years = yearly_stats.index.year

values = yearly_stats[col].values

# Regresioni Linear

slope, intercept, r_value, p_value, std_err = linregress(years, values)

trend_line = slope * years + intercept

# Vizualizimi i trendit

plt.figure(figsize=(10, 6))

plt.plot(years, values, label=f"Mesatarja Vjetore ({col})", marker='o')

plt.plot(years, trend_line, label=f"Trend: {slope:.2f} °C/vit", linestyle='--')

plt.title(f"Trend i Temperaturave Vjetore ({col} - {key}) (1980-2023)")

plt.xlabel('Viti')

plt.ylabel('Temperatura (°C)')

plt.legend()

plt.grid()

# Ruajtja e grafikut

graph_output = os.path.join(output_folder, f"Trend_1980-2023_{key}_{col}.png")
```

```
plt.savefig(graph_output, dpi=300)

plt.close()

print(f"Grafiku i trendit u ruajt në: {graph_output}")
```

4. **Comparative analysis**

```
for key, df in data.items():

    yearly_stats = df.resample('Y').mean()

    # Ndarja e periudhave

    period1 = yearly_stats[(yearly_stats.index.year >= 1980) & (yearly_stats.index.year <= 2000)]

    period2 = yearly_stats[(yearly_stats.index.year >= 2001) & (yearly_stats.index.year <= 2023)]

    # Krahasimi i mesatareve

    comparison = pd.DataFrame({

    '1980-2000': period1.mean(),

    '2001-2023': period2.mean()

    })

    # Ruajtja e krahasimit
```

```
        comparison_output = os.path.join(output_folder, f"Krahasim_Periudhash_{key}_1980-2023.xlsx")

    comparison.to_excel(comparison_output)

        print(f"Krahasimi i periudhave u ruajt në: {comparison_output}")
```

5. **The hottest years**

```
for key, df in data.items():

    yearly_stats = df.resample('Y').mean()

    yearly_stats = yearly_stats[(yearly_stats.index.year >= 1980) & (yearly_stats.index.year <= 2023)]

        for col in yearly_stats.columns:

        hottest_year = yearly_stats[col].idxmax().year

        coldest_year = yearly_stats[col].idxmin().year

        hottest_temp = yearly_stats[col].max()

        coldest_temp = yearly_stats[col].min()



        print(f"{col} ({key}): Viti më i nxehtë: {hottest_year} ({hottest_temp:.2f} °C)")

        print(f"{col} ({key}): Viti më i ftohtë: {coldest_year} ({coldest_temp:.2f} °C)")
```

6. Multi-year average

```
for key, df in data.items():
    yearly_stats = df.resample('Y').mean()
    multi_year_mean = yearly_stats[(yearly_stats.index.year >= 1980) & (yearly_stats.index.year <= 2023)].mean()
        # Ruajtja e rezultateve
    mean_output = os.path.join(output_folder, f"Mesatarja_Shumevjecare_{key}_1980-2023.xlsx")
    multi_year_mean.to_excel(mean_output, header=['Mesatarja Shumëvjeçare'])
    print(f"Mesatarja shumëvjeçare u ruajt në: {mean_output}")
```

7. Preparation of graphs

```
import pandas as pd
import os
import matplotlib.pyplot as plt


# Leximi i të dhënave
excel_path = r"E:\AGJ\All days data\Temperaturat.xlsx"
```

```
data = {
    "T mes": pd.read_excel(excel_path, sheet_name="T mes"),
    "T min": pd.read_excel(excel_path, sheet_name="T min"),
    "T max": pd.read_excel(excel_path, sheet_name="T max")
}
# Konvertimi i kolonës së datave
for key in data:
    data[key]['Emri'] = pd.to_datetime(data[key]['Emri'])
    data[key].set_index('Emri', inplace=True)
# Krijimi i një folderi për ruajtjen e rezultateve
output_folder = r"E:\AGJ\All days data\Statistika Mujore"
os.makedirs(output_folder, exist_ok=True)
 # Përllogaritje të statistikave mujore
for key, df in data.items():
        # Përllogaritja mujore
    monthly_stats = df.resample('M').agg(['mean', 'max', 'min', 'std'])
```

```
monthly_stats.columns = ['_'.join(col).strip() for col in monthly_stats.columns]  # Emrat e kolonave

    # Mesatarja shumëvjeçare mujore

monthly_mean_long_term = monthly_stats.groupby(monthly_stats.index.month).mean()

    # Përllogaritja e anomalive mujore

anomalies = monthly_stats.groupby(monthly_stats.index.month).transform(lambda x: x - x.mean())

    # Ruajtja e statistikave mujore në Excel

excel_output = os.path.join(output_folder, f"Statistika_Mujore_{key}.xlsx")

    with pd.ExcelWriter(excel_output) as writer:

  monthly_stats.to_excel(writer, sheet_name="Statistika Mujore")

  monthly_mean_long_term.to_excel(writer, sheet_name="Mesatarja Shumëvjeçare")

  anomalies.to_excel(writer, sheet_name="Anomalitë Mujore")

print(f"Të dhënat mujore për {key} u ruajtën në: {excel_output}")



    # Krijimi i grafikëve për çdo vendmatje
```

```
    for col in df.columns:
plt.figure(figsize=(10, 6))
plt.plot(monthly_stats.index, monthly_stats[f'{col}_mean'], label='Mesatare', marker='o')
plt.fill_between(
    monthly_stats.index,
    monthly_stats[f'{col}_max'],
    monthly_stats[f'{col}_min'],
    alpha=0.2, label='Intervali Min-Maks'
)
plt.title(f"Statistikat Mujore për {col} ({key})")
plt.xlabel('Muaji')
plt.ylabel('Temperatura (°C)')
plt.legend()
plt.grid()

# Ruajtja e grafikëve
```

```
graph_output = os.path.join(output_folder, f"Grafik_Mujore_{key}_{col}.png")

plt.savefig(graph_output, dpi=300)

plt.close()

print(f"Grafiku për {col} ({key}) u ruajt në: {graph_output}")
```

8. Analysis of tropical nights and frosty days

```
import pandas as pd

import os

# Leximi i të dhënave

excel_path = r"E:\AGJ\All days data\Temperaturat.xlsx"

data = {

    "T mes": pd.read_excel(excel_path, sheet_name="T mes"),

    "T min": pd.read_excel(excel_path, sheet_name="T min"),

    "T max": pd.read_excel(excel_path, sheet_name="T max")

}

# Konvertimi i kolonës së datave

for key in data:
```

```
    data[key]['Emri'] = pd.to_datetime(data[key]['Emri'])
    data[key].set_index('Emri', inplace=True)
# Krijimi i një folderi për ruajtjen e rezultateve
output_folder = r"E:\AGJ\All days data\Analiza Specifike"
os.makedirs(output_folder, exist_ok=True)
# Analiza e Netëve Tropikale, Ditëve me Ngrica dhe Ditëve mbi 35°C
results = {}
for key in data:
        df = data[key]
        if key == "T min":
      # Netë Tropikale (T min > 20°C)
      tropical_nights = (df > 20).resample('M').sum()
      tropical_nights_yearly = (df > 20).resample('Y').sum()
      # Ditë me ngrica (T min < 0°C)
      frost_days = (df < 0).resample('M').sum()
      frost_days_yearly = (df < 0).resample('Y').sum()
```

```
results[f"{key} - Tropical Nights Monthly"] = tropical_nights

results[f"{key} - Tropical Nights Yearly"] = tropical_nights_yearly

results[f"{key} - Frost Days Monthly"] = frost_days

results[f"{key} - Frost Days Yearly"] = frost_days_yearly

    if key == "T max":

# Ditë me temperatura maksimale mbi 35°C

hot_days = (df > 35).resample('M').sum()

hot_days_yearly = (df > 35).resample('Y').sum()

results[f"{key} - Hot Days Monthly"] = hot_days

results[f"{key} - Hot Days Yearly"] = hot_days_yearly

# Ruajtja në Excel

excel_output = os.path.join(output_folder, "Analiza_Specifike.xlsx")

with pd.ExcelWriter(excel_output) as writer:

    for name, result in results.items():

result.to_excel(writer, sheet_name=name[:31])  # Maks. 31 karaktere për emrin e sheet-it

print(f"Të dhënat u ruajtën në: {excel_output}")
```

PRECIPITATION

9. Calculation of overall indicators

```
import os

import pandas as pd

 # Path i file-it të modifikuar

modified_excel_path = r"E:\AGJ\All days data\Reshjet_Modifikuar\Reshjet_Modifikuar.xlsx"

# Leximi i të dhënave nga file i ri

rain_data = pd.read_excel(modified_excel_path, sheet_name=None)  # Lexon të gjitha sheets

# Krijimi i folderit për rezultatet

output_folder = r"E:\AGJ\All days data\Analiza Reshjet"

os.makedirs(output_folder, exist_ok=True)
```

```
# Përpunimi i të dhënave për çdo sheet
for sheet_name, df in rain_data.items():
    if 'Emri' in df.columns:  # Kontrollo nëse kolona 'Emri' ekziston
        df['Emri'] = pd.to_datetime(df['Emri'], errors='coerce')  # Konverto 'Emri' në datetime
        df.set_index('Emri', inplace=True)  # Vendos 'Emri' si indeks
        # Hiq rreshtat pa data valide
        df.dropna(inplace=True)
        # 1. Shuma mujore dhe vjetore
        monthly_sum = df.resample('M').sum()
        yearly_sum = df.resample('Y').sum()
        # 2. Maksimumi 24-orësh
        max_24hr_monthly = df.resample('M').max()
        max_24hr_yearly = df.resample('Y').max()
        # 3. Ruajtja e rezultateve në Excel
        output_path = os.path.join(output_folder, f"Analiza_Reshjet_{sheet_name}.xlsx")
```

```
        with pd.ExcelWriter(output_path) as writer:
            monthly_sum.to_excel(writer, sheet_name="Shuma Mujore")
            yearly_sum.to_excel(writer, sheet_name="Shuma Vjetore")
            max_24hr_monthly.to_excel(writer, sheet_name="Maksimumi Mujore")
            max_24hr_yearly.to_excel(writer, sheet_name="Maksimumi Vjetore")
        print(f"Të dhënat për {sheet_name} u ruajtën në: {output_path}")
    else:
        print(f"Sheet '{sheet_name}' nuk ka kolonë 'Emri'.")
```

10. Anomalies and comparisons

```
import os
import pandas as pd
# Path i file-it të modifikuar
modified_excel_path = r"E:\AGJ\All days data\Reshjet_Modifikuar\Reshjet_Modifikuar.xlsx"
# Leximi i të dhënave nga file i ri
rain_data = pd.read_excel(modified_excel_path, sheet_name=None)  # Lexon të gjitha sheets
```

```
# Krijimi i folderit për rezultatet
output_folder = r"E:\AGJ\All days data\Analiza Reshjet"
os.makedirs(output_folder, exist_ok=True)
# Analiza për çdo sheet
for sheet_name, df in rain_data.items():
    if 'Emri' in df.columns:  # Kontrollo nëse kolona 'Emri' ekziston
        df['Emri'] = pd.to_datetime(df['Emri'], errors='coerce')  # Konverto 'Emri' në datetime
        df.set_index('Emri', inplace=True)  # Vendos 'Emri' si indeks
        # Hiq rreshtat pa data valide
        df.dropna(inplace=True)
        # Kontrollo nëse index ka të dhëna
        if df.empty:
            print(f"Sheet '{sheet_name}' nuk ka të dhëna pas pastrimit!")
            continue
        # 1. Mesatarja mujore për gjithë periudhën
```

```
monthly_sum = df.resample('M').sum()  # Shuma mujore

monthly_mean = monthly_sum.groupby(monthly_sum.index.month).mean()  # Mesatarja mujore për të gjithë periudhën

# 2. Analiza krahasimore për çdo 10-vjeçar

df['Decade'] = (df.index.year // 10) * 10

decade_monthly_mean = df.groupby(['Decade', df.index.month]).mean().unstack(level=0)

# 3. Numri i ditëve me reshje mujore dhe vjetore (≥ 0.8 mm)

monthly_rainy_days = (df >= 0.8).resample('M').sum()

yearly_rainy_days = (df >= 0.8).resample('Y').sum()

 # 4. Ditët pa reshje të pandërprera për çdo vit

yearly_dry_periods = []

for year, group in df.groupby(df.index.year):

   dry_streak = 0

   max_dry_streak = 0

   for val in group.iloc[:, 0]:

      if val < 0.8:
```

```
                dry_streak += 1
                max_dry_streak = max(max_dry_streak, dry_streak)
            else:
                dry_streak = 0
        yearly_dry_periods.append({"Year": year, "Max_Dry_Period": max_dry_streak})
    yearly_dry_periods_df = pd.DataFrame(yearly_dry_periods)
    # Ruajtja e rezultateve në Excel
    output_path = os.path.join(output_folder, f"Analiza_Reshjet1_{sheet_name}.xlsx")

    with pd.ExcelWriter(output_path) as writer:

        monthly_mean.to_excel(writer, sheet_name="Mesatarja Mujore")

        decade_monthly_mean.to_excel(writer, sheet_name="Krahasimi 30-Vjeçar")

        monthly_rainy_days.to_excel(writer, sheet_name="Ditet me Reshje Mujore")

        yearly_rainy_days.to_excel(writer, sheet_name="Ditet me Reshje Vjetore")

        yearly_dry_periods_df.to_excel(writer, sheet_name="Ditët Pa Reshje")

    print(f"Të dhënat për {sheet_name} u ruajtën në: {output_path}")

else:

    print(f"Sheet '{sheet_name}' nuk ka kolonë 'Emri'.")
```