OPEN ACCESS
Journal of Integrated Engineering & Applied Sciences
Volume 3, Issue 1, pp. 183-198, 2025
ISSN: 2960-2661 DOI: https://doi.org/10.5281/zenodo.15178644
Received: 23.02.2025 / Revised: 30.03.2024 / Accepted: 08.04.2025

Analyzing Land Use Changes and Climate Trends in Lezha Region from 1991 to 2020 Using GIS and Remote Sensing

Anira Gjoni*, Enkelejda Kucaj, Azem Bardhi

Department of Meteorology, Institute of Geosciences, Polytechnic University of Tirana, Tirana, Albania

* **Corresponding Author**: a.gjoni@geo.edu.al

Abstract

Land use methods, particularly in urban areas, have become a significant challenge in developing countries. The potential impact of land cover change, driven by global warming, is a subject of study by scientists worldwide. The methods used to simulate the dynamics of land use changes and the forms of modelling this phenomenon are of considerable interest to urban and city planners. This study aims to recognize and analyse the progress of land cover and land use in the Lezha area. Specifically, the objective of this paper is to analyse the correlation between climatic elements, such as temperature and precipitation, and land use changes in the Lezha region. Temperature and precipitation parameters on the land surface are considered critical indicators of the environmental consequences of land use/land cover change. The methodology employed in this study is based on both quantitative and qualitative methods for land use classification. Satellite images, remote sensing (RS), and Geographic Information Systems (GIS) have been used to simulate land use development in Lezha's urban area during the period from 1991 to 2020. RS and GIS techniques have proven effective in various environmental and hydro-meteorological applications. These techniques have been utilized to examine changes in land use and land cover patterns, along with their effects on temperature and hydrological changes. However, the complexity of urban growth remains a key factor limiting the effectiveness of such simulation methods. Among the various available methods, agent-based models have gained popularity in simulating land use development and modelling urban sprawl.

Keywords: Climate; Geographic Information Systems; Remote Sensing; Urban Space; Urban Systems.

1. Introduction

In this paper climate change is understood as an immediate threat, with early effects evident in climate change now occurring at various scales across the planet [1-4]. Despite recent controversies, the weight of scientific evidence suggests that ongoing climate change at the global, regional, local, and micro scales is largely caused by human actions, and that the effects of this phenomenon will be widespread and extremely harmful to both humans and animals. also, for countries [3, 4]. The majority of the world's population now lives and works within urban systems and the trend is increasing [5, 6].

Urban systems are understood as "the continuously evolving spatial product of the flow of social, economic, infrastructural and ecological systems that grow and develop around an urban area" [7]. This settlement pattern tends to be extremely resourced intensive and contributes enormously to increased greenhouse gas emissions and, consequently, to climate change. In 2007, the United Nations Intergovernmental Panel on Climate Change (IPCC) released its Fourth Assessment Report (AR4), comprehensively evaluating climate change, its impacts, and potential mitigation strategies. In quantitative terms, the impact of urban systems on climate change is illustrated by the fact that 75% of all greenhouse gas emissions are generated in the world's urban areas [8]; while only approximately half of the planet's population lives in the nearest settlements. In other words, urban systems are the main source of emerging climate threats [7].

The urban climate often differs from the surrounding rural area, as it is generally more polluted warmer, rainier and less windy [9]. This suggests that the effect of climate change with projected temperature increases and more extreme weather events will be experienced to a greater extent in urban areas compared to the surrounding landscape. A changing climate may also exaggerate the negative effects of urbanization already experienced, such as rising urban temperatures and flooding [10].

How we use the land may be the key to adapting to climate change, for better or for worse. "Human use directly affects 70 percent of the land surface that is not covered by ice, and we are leading to degradation of about a quarter of it," the report of the United Nations Intergovernmental Panel on Climate Change is quoted as saying.

Changing urban temperatures are driven both by large-scale climate changes and ongoing urbanization [11]. There is agreement that the current changing climate has to be kept well below an average global increase of 2 °C [12, 13] to avoid major future climate-driven catastrophes [14]. The urban temperature is dependent on global development but is in general highly influenced by, e.g. the urban heat island (UHI) effect which is seen as a major problem of urbanization [15, 16]. 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.

Urbanization is one of the most significant global trends of the 21st century, transforming landscapes, economies, and ecosystems at an unprecedented rate [17, 18]. The interplay between land use changes in urban systems and the evolution of climate elements has become a crucial subject of study due to its implications for sustainability, human well-being, and the environment. Land use in urban systems encompasses a wide range of activities including residential, commercial, industrial, recreational, and transportation infrastructures [19, 20]. These activities directly influence climate elements such as temperature, precipitation, humidity, and air quality [21, 22]. This paper aims to explore the dynamics of land use in urban settings and analyse how these dynamics interact with the evolution of climate elements, emphasizing both local and global implications [14].

Urbanization leads to the conversion of natural and agricultural land into built-up areas. This conversion, often referred to as land use change, is characterized by several key processes including deforestation, agricultural intensification, and the construction of urban infrastructure. The consequences of these changes extend beyond the mere alteration of the landscape; they have profound impacts on local and global climate systems. Urban areas, due to their high density of built-up structures, experience what is known as the "urban heat island" (UHI) effect, where temperatures in cities are higher than in surrounding rural areas [23]. This phenomenon results from the absorption and retention of heat by buildings, roads, and other impervious surfaces, combined with the reduction of vegetation that typically cools the environment through evapotranspiration.

Land use changes also affect the local hydrological cycle [24]. Urbanization often leads to increased impervious surfaces, such as concrete and asphalt, which inhibit water infiltration and lead to higher runoff. This increased runoff can contribute to flooding, reduce water quality, and alter local precipitation patterns. The expansion of urban areas also has implications for ecosystems and biodiversity, as natural habitats are fragmented or destroyed [25]. The loss of green spaces reduces the capacity of urban environments to act as carbon sinks, exacerbating climate change.

The evolution of climate elements in urban systems is shaped by both natural and anthropogenic factors. Urban heat islands are a direct result of the concentration of human activity in specific areas, and they have been linked to increases in local temperature [26]. Rising temperatures in urban areas not only exacerbate heat-related health issues but also increase energy consumption, as residents and businesses rely more on-air conditioning. The changing temperature patterns, particularly in megacities, influence the broader climate system by contributing to the amplification of global warming [27].

Moreover, land use changes can alter local precipitation patterns. Urban areas, through the increased release of greenhouse gases, aerosols, and particulate matter, can influence cloud formation and precipitation rates. Cities can alter wind patterns, which in turn affect weather systems on a larger scale [28]. For example, the "urban plume," a zone of warm air and pollutants, can extend far beyond the city centre, affecting regional air quality and weather systems.

Urban systems also contribute to the evolution of climate elements through their energy consumption patterns. The demand for energy in cities is often met by burning fossil fuels, which releases significant amounts of carbon dioxide (CO_2) into the atmosphere, contributing to the global warming phenomenon. The carbon emissions from transportation, industry, and buildings are major drivers of climate change. Consequently, urban areas not only influence local climate elements but also contribute to the broader global climate crisis.

The relationship between land use and climate change is reciprocal. As urban systems expand and evolve, they contribute to climate change through greenhouse gas emissions and land use alterations. In turn, climate change further exacerbates the challenges associated with urbanization, including rising temperatures, more extreme weather events, and flooding. The impact of climate change on urban systems is multifaceted. Rising sea levels, for example, pose a direct threat to coastal cities, while changing precipitation patterns can lead to either more intense droughts [29] or severe flooding in some areas [30]. These climate risks require adaptive measures in land use planning to ensure the resilience of urban systems.

Furthermore, land use decisions can play a role in mitigating the effects of climate change. For instance, the implementation of green infrastructure, such as parks, green roofs, and urban forests, can help cool urban areas, absorb carbon, and manage stormwater. Sustainable urban planning that integrates renewable energy sources, energy-efficient buildings, and low-carbon transport systems can significantly reduce the carbon footprint of cities and contribute to global efforts to combat climate change.

1.1. Urban ecosystems, the epitome of liveable cities

Natural ecosystems provide a wide range of essential services that significantly benefit human societies, yet their full value extends beyond mere utilitarian functions and remains inadequately mapped, assessed, and integrated into urban planning processes. These ecosystems—whether forests, wetlands, or green spaces—offer benefits such as air purification, water regulation, biodiversity preservation, and climate moderation, all of which are critical for the functioning and livability of cities [31]. However, these services are often underappreciated in urban development, as cities tend to prioritize economic growth and built infrastructure over the preservation and enhancement of natural systems. To promote sustainable urban development, it is essential to recognize that natural ecosystems are integral components of the urban fabric. They should not be viewed as separate or secondary to urban areas but should coexist with city infrastructure—whether in the form of public parks, green roofs, urban forests, or green corridors. As green infrastructure, these ecosystems can be seamlessly integrated into the urban environment, providing both ecological and social benefits. The inclusion of natural ecosystems within urban spaces promotes public health, enhances the quality of life and fosters a sense of community involvement. It is crucial that these spaces are maintained collectively by the public, as their preservation is a shared responsibility that contributes to overall societal well-being [32]. The spatial interaction between natural ecosystems and urban areas is vital for ensuring the health and resilience of cities. The presence of natural areas within urban settings supports not only the physical and mental well-being of residents but also the long-term sustainability of the city. These ecosystems help mitigate the negative impacts of urbanization, such as heat islands, poor air quality and flooding. Moreover, they provide essential ecosystem services that make urban spaces more resilient to climate change, enhancing the ability of cities to adapt to environmental challenges and recover from disturbances. However, the ongoing commodification of urban space, driven by development pressures and the expansion of built environments, often comes at the expense of natural ecosystems [33]. As urban areas grow, these natural spaces are frequently encroached upon or eliminated, reducing the services they provide [34]. This trend results in the loss of important ecological functions and diminishes the overall quality of life for urban residents.

The economic value of land and the focus on development often overshadow the less tangible, yet highly critical, benefits offered by nature. The Covid-19 pandemic further highlighted the vital role that natural ecosystems play in supporting urban populations.

During lockdowns, many urban dwellers turned to green spaces for physical and mental relief, underlining the importance of access to nature in maintaining public health [35].

Additionally, expert reports have shown that individuals living in areas with higher levels of air pollution were more vulnerable to severe outcomes from the virus, while those in cleaner, greener environments had better health outcomes. This underscores the intersection of environmental quality and public health, demonstrating that access to natural ecosystems can be a key factor in enhancing resilience to not only pandemics but also other urban challenges. Beyond their role in supporting human health, natural ecosystems provide critical protection from a wide array of environmental hazards. These include floods, landslides, and the effects of climate change, such as extreme weather events. For instance, wetlands and mangroves act as natural buffers against flooding, while forests and vegetation help prevent soil erosion and landslides [36]. The preservation of such ecosystems is not just an environmental concern; it is a matter of urban safety and resilience. Therefore, the sustainable integration of nature into urban spaces is essential for creating cities that are not only livable but also resilient to the growing challenges posed by climate change and other global risks.

2. Materials and Methods

Analysis of the progress of land cover and land use in the area of Lezha. The objective of this paper is to analyse the correlation between the values of climatic elements with the change of land use in the area of Lezha.

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 the implementation of CCA policies in this region is scarce. Figure 1 shows a map of the area studied, clearly showing the geographical position of this area.

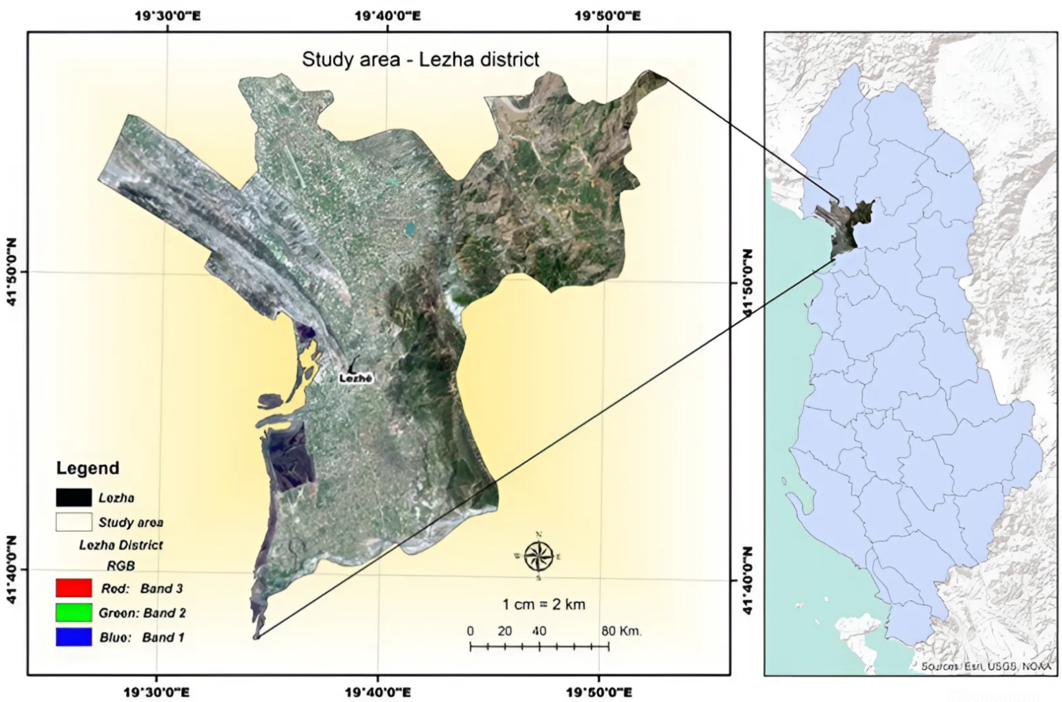

Figure 1. Geographical position of the Lezha district

Changes in weather conditions are a consequence of climate change. Not only the territory, but also the population living in this area is 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 not only the increase of temperatures in thermal values, but 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 analysis of the territory is built on the collection of Geostatistical and Geoinformation data, quality control, adaptation to the study area, data processing (band combination & data training) for the years 1990-2020.

Analysis of daily air temperature data for the period 1990-2016 compared to the standards and reference norm of 1961-1990, using the guidelines provided by the World Meteorological Organization - Commission on Climatology and Climate Variability and Predictability (WMO-CCI/ CLIVAR). Figure 2 shows the running data process model.

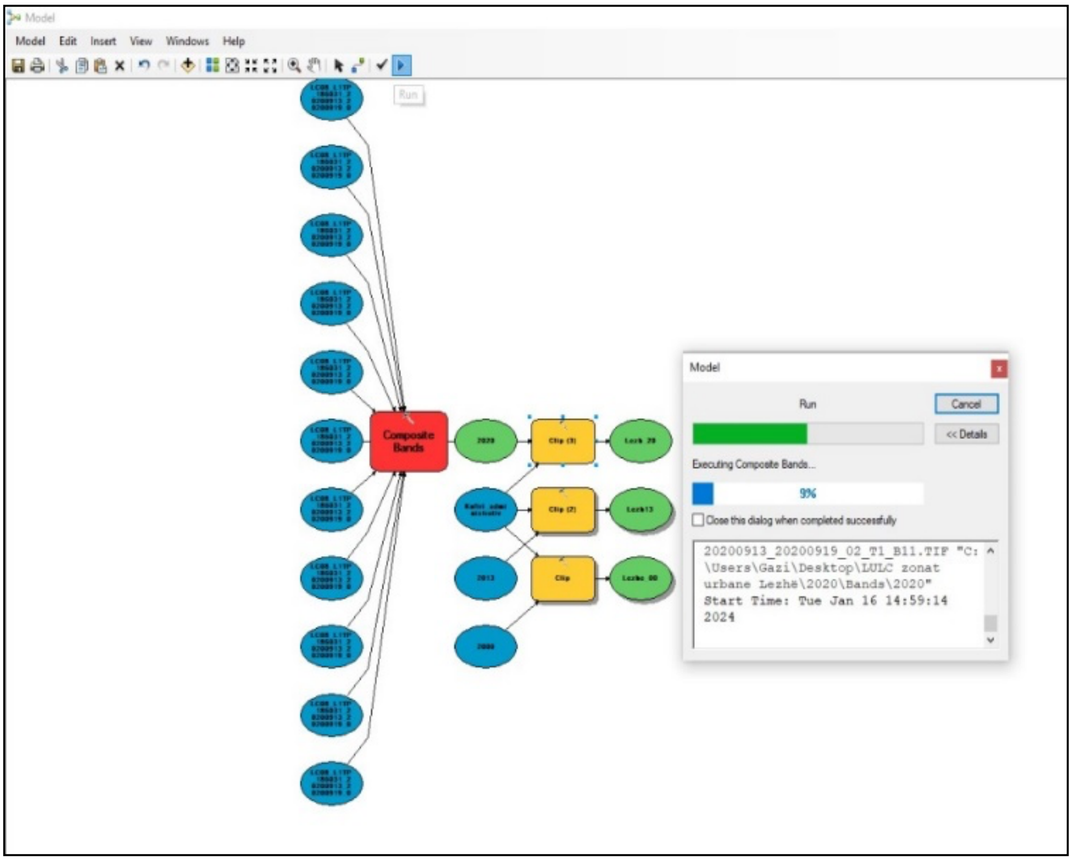

Figure 2. Running data process

The database used in this study consists of satellite products that span from 1991 to 2020, providing a comprehensive set of images for analysing urban growth, land cover changes, and environmental transformations over nearly three decades. The satellite imagery is sourced from reputable platforms, including the United States Geological Survey (USGS) and the Copernicus program, which offer high-quality, publicly available data. These sources allow for detailed, long-term monitoring of land use dynamics, urbanization, and environmental impacts.

USGS Satellite Imagery: The satellite data from the USGS is available through the Earth Explorer platform (https://earthexplorer.usgs.gov/), which offers access to various Landsat missions:

Landsat 5 (1991–2005): Landsat 5 provides imagery with a spatial resolution of 30 meters, which is ideal for observing large-scale land cover changes over time. This dataset covers the period from 1991 to 2005, capturing a critical phase in urban expansion and environmental change at the end of the 20th century and the early years of the 21st century.

Landsat 8 (2013–2020): Landsat 8, launched in 2013, continues to provide high-resolution imagery with the same 30-meter resolution, ensuring consistency in spatial analysis. The data from this satellite covers the period from 2013 to 2020, offering a more recent perspective on urban development and environmental shifts, and enabling the identification of trends in land use and vegetation changes in the most recent decade, see Figure 3.

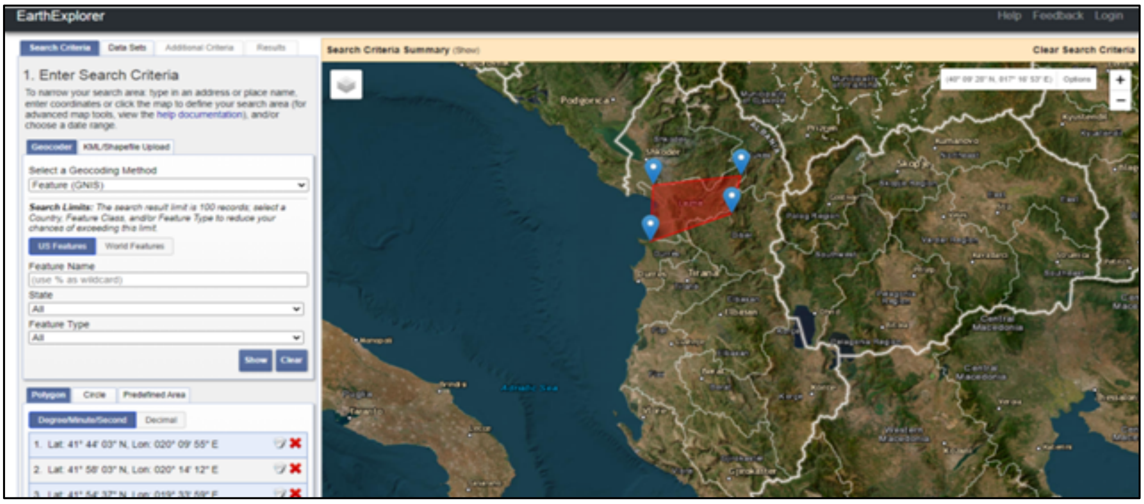

Figure 3. Workload process with satellite data

Sentinel-2B (2020): The Sentinel-2B satellite provides imagery with a spatial resolution of 10 meters, offering higher precision for analysing fine-grained land cover changes compared to Landsat's 30-meter resolution. Sentinel-2B captures detailed data on vegetation, water bodies, and urban areas, enhancing the ability to assess environmental conditions with greater accuracy. The 2020 data helps complete the temporal coverage of the study, allowing for an up-to-date snapshot of land use changes in the most recent years, see Figure 4.

Cloud Cover: An important factor in satellite-based remote sensing is the presence of cloud cover, which can obscure the Earth's surface and reduce the quality of the imagery. For this analysis, the cloud cover was limited to no more than 10% to ensure the clarity and reliability of the satellite images. This restriction minimizes the likelihood of significant interference from clouds, allowing for more accurate land cover classifications and urban growth assessments. Figures 4 and 5 show images during the processing of the satellite data used in this study.

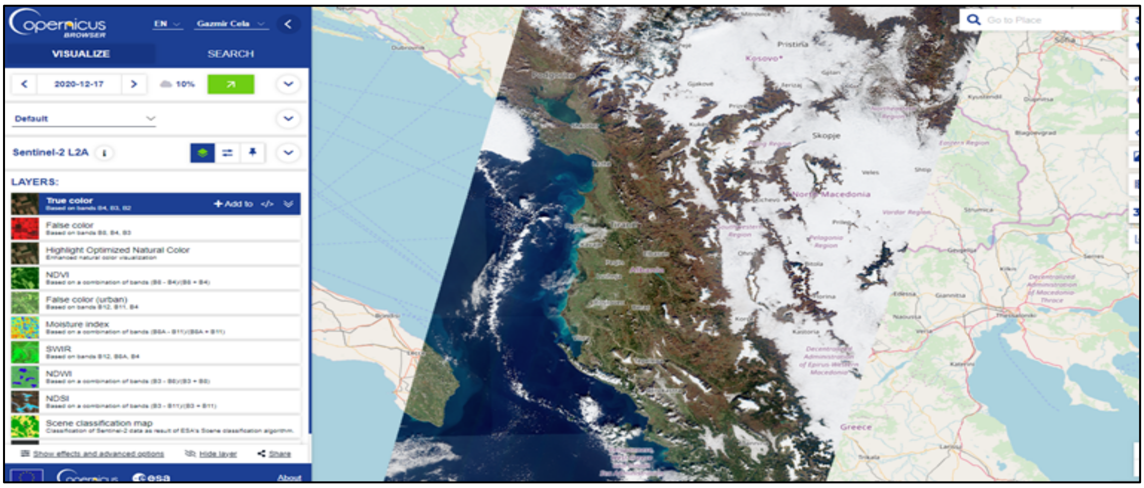

Figure 4. Workload process with satellite data

By combining data from Landsat 5, Landsat 8, and Sentinel-2B, the database provides a rich and varied set of images with different spatial resolutions and time frames. This extensive dataset allows for a detailed analysis of urbanization patterns and climate changes over the 1991–2020 period, ensuring that the study captures both historical and contemporary dynamics of urban growth and climate impacts.

Figures 5 provide views of the manual and automatic meteorological stations from which the meteorological data used in this study were obtained.

(a) (b)

Figure 5. Meteorological station Albania; (a) manual, and (b) automatic

The meteorological database used in this study includes detailed data on both minimum and maximum air temperatures, which are collected from meteorological stations managed by the Institute of Geosciences. These temperature readings are obtained through a combination of manual and automatic monitoring techniques, ensuring accuracy and consistency in the data over time. Manual monitoring involves trained meteorologists taking regular measurements, typically using calibrated instruments, while automatic monitoring relies on advanced sensors and automated systems that record temperature data continuously or at set intervals.

This dual approach of data collection provides a robust and reliable dataset, capturing a broad range of atmospheric conditions. The resulting temperature data plays a crucial role in climatological analysis, as it enables the identification of long-term trends in temperature variation, such as seasonal and annual fluctuations, as well as the detection of any anomalies linked to climate change. Furthermore, the accurate and consistent temperature records are essential for weather forecasting, as they contribute to the development of predictive models that inform short- and long-term weather forecasts. By providing a detailed understanding of temperature dynamics in the region, this meteorological data helps inform various fields of research, including climate science, environmental studies, and urban planning.

2.1 Results and discussions

All urban systems will face some vulnerability to the effects of climate change. These effects can disrupt or even destroy a wide variety of urban functions. Such direct effects do not exhaust the potential impacts that climate change may have on urban systems. It is possible and indeed likely that urban features can exacerbate these impacts and the vulnerability of urban spaces.

The Guide [37] provides insights into integrating climate change adaptation into urban planning, emphasizing sustainable community design.

- Asphalt, concrete and other hard surfaces absorb heat from the sun, causing an 'urban heat island' effect, which adds to rising urban temperatures.
- Hard surfacing also reduces rainwater absorption, which can overwhelm storm water systems and increase flood risks.
- Population density in urban areas can reduce or put pressure on green spaces that can reduce heat, water runoff and air pollution.
- Population density can also put pressure on water supplies, leading to an increased potential for shortages

Adaptation to climate change is understood as taking direct action to minimize and manage the predicted or expected negative consequences of climate change before and when they occur [3, 38].

The maps shown in Figure 6 illustrate the results of the data analysis regarding the changes in urban areas within the study region. Following the analysis presented in these maps, the changes in the surface area of Lezha district are summarized in Table 1 and Figure 7.

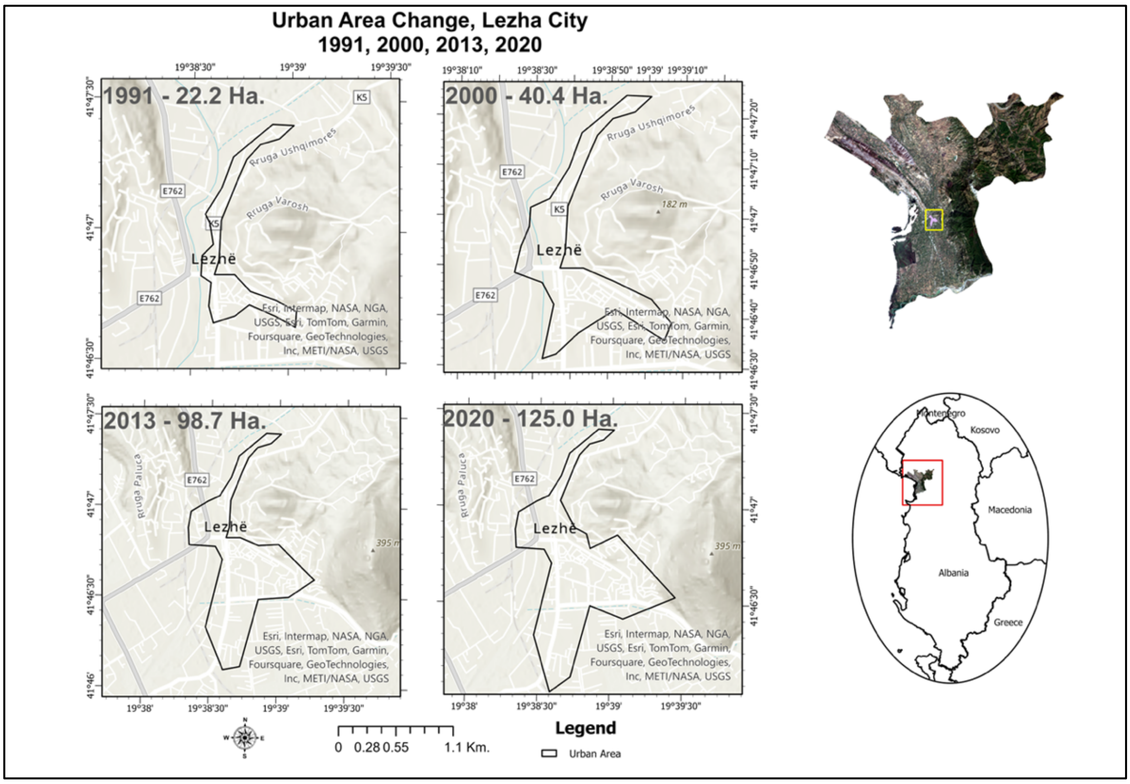

Figure 6. Urban Area Change in Lezha district

Table 1 Changes in urban area in ha in Lezha

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

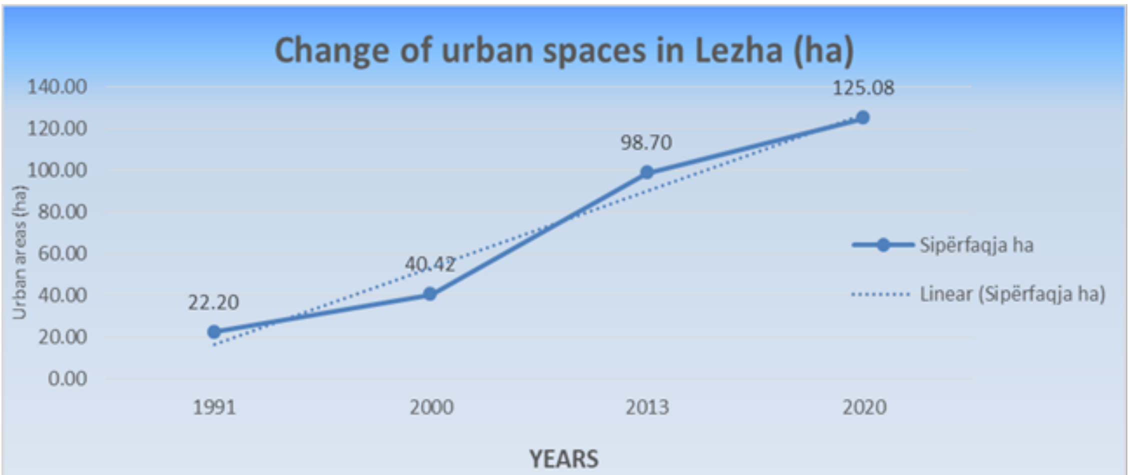

Figure 7. Changes in urban area in (ha) in Lezha district

The analysis of the average maximum and minimum air temperatures during the last three decades, 1990-2020 given in Figure 8, reveals notable changes in temperature patterns. Analysing these thirty years, highlights a clear trend of warming in recent decades [39]. The data shows an increase in both the average maximum and minimum air temperatures in the more recent period, with a greater rise in maximum temperatures than in minimum temperatures.

The Maximum Average Air Temperature have an increase with +1.5 ºC and Minimum Average Air Temperature has an increase with +0.7ºC. This shift indicates that the region is experiencing more warming and a greater amplitude in air temperatures which aligns with global patterns of increased nocturnal temperatures. These findings are significant for understanding how air temperature dynamics have evolved.

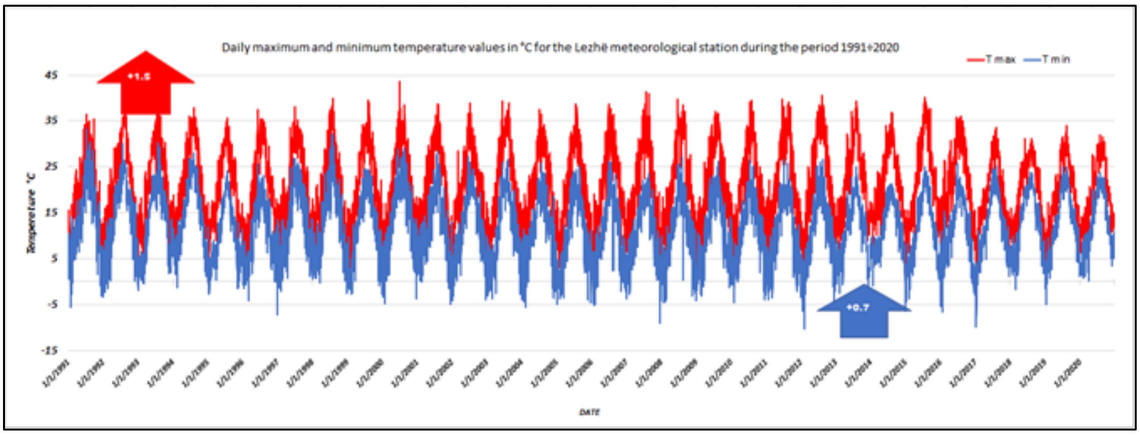

Figure 8. Daily Minimal and Maximal Air Temperatures in Lezha district

The analysis of the average maximum and minimum air temperatures over two norms 30-year periods, 1990-2020 [39] and 1960-1990 [40], given in Figure 9, reveals notable changes in temperature patterns. Comparing these periods highlights a clear trend of warming in recent decades [40]. The comparison between the two periods underscores the broader impact of climate change, suggesting that the rate of warming has accelerated over the past few decades. These findings are significant for understanding how regional climate dynamics have evolved and how they are impacting the local clime patterns as well as for predicting future climate scenarios in the area.

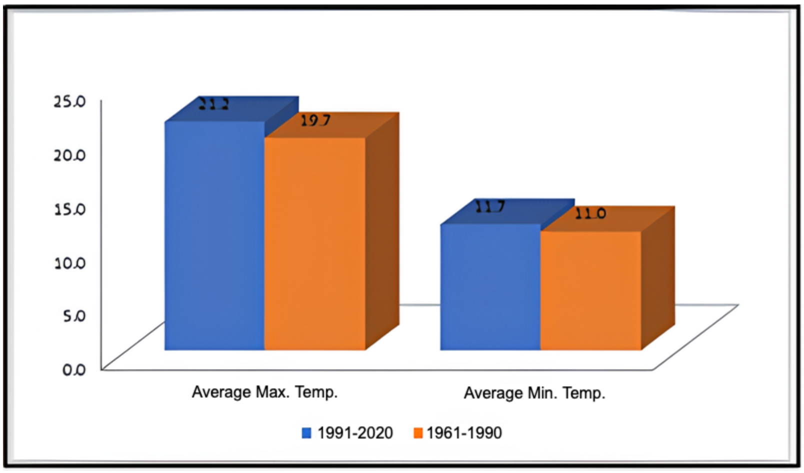

Figure 9. Changes in temperatures for the two norm periods '91-2016 and '61-'90

3. Conclusion

Soil is the most important non-renewable geo-resource of planet earth. The land supports most of our economic and social activities, while with the increase in social-economic activities; the negative education towards the land (loss of fertility, surface pollution, etc.) also increases. The green economy aims to preserve fertility, prevent soil erosion, reduce soil surface pollution and ensure fair distribution of land between different economic activities.

Over the years, the geographic space of Lezha district has seen an increase in spontaneously constructed urban areas with a continuous upward trend throughout the respective geographic space. Urban areas present new challenges in the reality of increasingly expanded urban spaces and climate change in the coming years. The average maximum and minimum temperatures have increased compared to the period 1961-1990, but there is a trend of increasing daily amplitude of extreme temperatures. Through the use of geographic information technologies, this study aims to offer a more in-depth analysis in the future, focusing on the administrative territory of the Municipality of Lezha.

From the analysis of the urban surface and the increasing indicator of the air temperature, we focus on taking immediate measures, since with the progress of urban growth that our cities are taking, combined with climate change, they will bring a deterioration in the lives of citizens and negative consequences for the sectors different such as agriculture, economy, tourism, etc.

Urban sprawl as a concept in Albania is still in its embryonic stage as it is still a term used in various documents or mainly theoretical laws as it has not yet been put into practice in the field of territorial planning and governance. It is enough to look at how our cities suffer to return to their original state in the event of facing natural hazards such as floods, forest fires, or seismic events such as the earthquake that hit the city of Durrës in November 2019. For this reason, the increase in urban renewal capacity cannot be considered simply as a project for one or a few specific areas, but as a continuous process present at every step of territorial planning, from the first steps of drafting a development plan.

Tools such as plan drafting, stakeholder engagement, development management and design standards are available and used by urban planning regimes around the world. All these are important for the development and provision of urban adaptation at different scales.

Urban planning regimes can perhaps best establish an evolving role in adapting urban systems to the effects of climate change by using planning tools in locally appropriate ways. Planning can be an important tool for defining overall objectives and strategies for urban adaptation. This can be achieved through development plans and through independent adaptation action plans. These plans can then be used to set specific, appropriate standards for local infrastructure and design to ensure that new developments have adaptive capacity and that existing developments can be adequately repaired. In doing so, planning regimes can create a basis for integrating urban adaptation into the development management process and planning-led urban design schemes.

The dynamics of land use in urban systems and the evolution of climate elements are intricately linked, with urbanization both influencing and being influenced by changes in climate. Urban land use changes, particularly the conversion of natural landscapes into built environments, have far-reaching consequences for local climates, including the urban heat island effect, altered precipitation patterns, and air pollution. These climate changes, in turn, affect the resilience and sustainability of urban systems. As the global population continues to urbanize, it is essential to integrate climate-conscious planning and sustainable land use strategies to reduce negative environmental impacts and enhance urban resilience. By understanding the reciprocal relationship between land use and climate change, cities can be designed to minimize their ecological footprint while fostering human well-being in the face of evolving climate challenges.

Acknowledgement

This study is supported or funded by Project EURO123456 from the European Union's Programme. The authors would like to thank Polytechnic University of Tirana (PUT) for supporting this research project.

Conflict of interests

The authors would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

References

[1] R. Garnaut, *The Garnaut Climate Change Review: Final Report*, Cambridge University Press, 2008.

[2] J. Rockström, W. Steffen, K. Noone, Å. Persson, F. S. Chapin, J. Lambin, and J. Foley, "Planetary boundaries: exploring the safe operating space for humanity," *Ecology and Society*, vol. 14, no. 2, p. 32, 2009.

[3] *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*, 2021.

[4] N. Stern, *The Economics of Climate Change: The Stern Review*, Cambridge University Press, 2006.

[5] D. Guggenheim, *An Inconvenient Truth*, Paramount Classics, 2006.

[6] United Nations Secretary-General, *Climate Change and Its Possible Security Implications*, United Nations, 2009.

[7] M. Gleeson, "Preceptorship: Facilitating student nurse education in the Republic of Ireland," *Br. J. Nurs.*, vol. 17, pp. 376–380, 2008, doi: 10.12968/bjon.2008.17.6.28903.

[8] Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report*, 2007.

[9] B. Givoni, "Impact of planted areas on urban environmental quality: A review," *Atmos. Environ. Part B: Urban Atmos.*, vol. 25, no. 3, pp. 289–299, 1991, doi: 10.1016/0957-1272(91)90001-U.

[10] A. Semadeni-Davies, C. Hernebring, G. Svensson, and L.-G. Gustafsson, "The impacts of climate change and urbanisation on drainage in Helsingborg, Sweden: Suburban stormwater," *J. Hydrol.*, vol. 350, no. 1–2, pp. 114–125, 2008, doi: 10.1016/j.jhydrol.2007.11.006.

[11] F. Fujibe, "Detection of urban warming in recent temperature trends in Japan," *Int. J. Climatol.*, vol. 29, no. 12, pp. 1811–1822, 2009, doi: 10.1002/joc.1822.

[12] European Commission, *Commission Decision 2007/589/EC of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC*, Official Journal of the European Union, L 229/1, 2007.

[13] United Nations Framework Convention on Climate Change, *Adoption of the Paris Agreement*, UNFCCC, 2015.

[14] T. M. Lenton, H. Held, E. Kriegler, J. W. Hall, W. Lucht, S. Rahmstorf, and H. J. Schellnhuber, "Tipping elements in the Earth's climate system," *Proc. Natl. Acad. Sci.*, vol. 105, no. 6, pp. 1786–1793, 2008, doi: 10.1073/pnas.0705414105.

[15] E. J. Gago, J. Roldán, J. Ordóñez, and J. A. González, "The city and urban heat islands: A review of strategies to mitigate adverse effects," *Renew. Sustain. Energy Rev.*, vol. 25, pp. 749–758, 2013, doi: 10.1016/j.rser.2013.05.065.

[16] H. Taha, "Urban climates and heat islands: Albedo, evapotranspiration, and anthropogenic heat," *Energy Build.*, vol. 25, no. 2, pp. 99–103, 1997, doi: 10.1016/S0378-7788(97)00009-9.

[17] K. C. Seto, B. Güneralp, and L. R. Hutyra, "Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools," *Proc. Natl. Acad. Sci.*, vol. 109, no. 40, pp. 16083–16088, 2012, doi: 10.1073/pnas.1211658109.

[18] United Nations, *World Urbanization Prospects: The 2014 Revision*, United Nations, Department of Economic and Social Affairs, Population Division, 2014. [Online]. Available: https://www.un.org/en/development/desa/population/

[19] J. A. Foley, R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter, et al., "Global consequences of land use," *Science*, vol. 309, no. 5734, pp. 570–574, 2005, doi: 10.1126/science.1111772.

[20] E. F. Lambin and P. Meyfroidt, "Global land use change, economic globalization, and the looming land scarcity," *Proc. Natl. Acad. Sci.*, vol. 108, no. 9, pp. 3465–3472, 2011, doi: 10.1073/pnas.1100480108.

[21] T. R. Oke, "The energetic basis of the urban heat island," *Q. J. R. Meteorol. Soc.*, vol. 108, no. 455, pp. 1–24, 1982, doi: 10.1002/qj.49710845502.

[22] E. J. Gago, J. Roldán, J. Ordóñez, and J. A. González, "The city and urban heat islands: A review of strategies to mitigate adverse effects," *Renew. Sustain. Energy Rev.*, vol. 25, pp. 749–758, 2013, doi: 10.1016/j.rser.2013.05.065.

[23] A. Semadeni-Davies, C. Hernebring, G. Svensson, and L.-G. Gustafsson, "The impacts of climate change and urbanisation on drainage in Helsingborg, Sweden: Suburban stormwater," *J. Hydrol.*, vol. 350, no. 1–2, pp. 114–125, 2008, doi: 10.1016/j.jhydrol.2007.11.006.

[24] J. Yang and W. Li, "Effects of urbanization on surface runoff and streamflow in the Beijing metropolitan area, China," *J. Hydrol.*, vol. 542, pp. 238–247, 2016, doi: 10.1016/j.jhydrol.2016.08.026.

[25] G. Blöschl and M. Sivapalan, "Scale issues in hydrological modelling: A review," *Hydrol. Processes*, vol. 9, no. 3–4, pp. 251–290, 1995, doi: 10.1002/hyp.3360090305.

[26] R. A. Pielke Sr, A. Pitman, D. Niyogi, R. Mahmood, C. McAlpine, F. Hossain, et al., "Land use/land cover changes and climate: Modeling analysis and observational evidence," *Wiley Interdiscip. Rev. Clim. Change*, vol. 2, no. 6, pp. 828–850, 2011, doi: 10.1002/wcc.144.

[27] C. Vancutsem and D. Gielen, "Climate change and urbanization: The challenge of mitigating the urban heat island effect," *Environ. Sci. Policy*, vol. 13, no. 6, pp. 564–576, 2010, doi: 10.1016/j.envsci.2010.05.004.

[28] M. L. McKinney, "Urbanization, biodiversity, and conservation," *BioScience*, vol. 52, no. 10, pp. 883–890, 2002, doi: 10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2.

[29] Sh. Lushaj, A. Gjoni, and E. Kucaj, "The influence of climate change on drought occurrences and the measures taken to alleviate drought in Albania," presented at the Issues of Housing, Planning, and Resilient Development of the Territory Towards Euro-Mediterranean Perspectives Conference, Jan. 2024, doi: 10.37199/c41000123.

[30] C. L. Arnold and C. J. Gibbons, "Impervious surface coverage: The emergence of a key environmental indicator," *J. Am. Plann. Assoc.*, vol. 62, no. 2, pp. 243–258, 1996, doi: 10.1080/01944369608975688.

[31] R. Costanza, R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, et al., "The value of the world's ecosystem services and natural capital," *Nature*, vol. 387, no. 6630, pp. 253–260, 1997, doi: 10.1038/387253a0.

[32] E. Gómez-Baggethun and D. N. Barton, "Classifying and valuing ecosystem services for urban planning," *Ecol. Econ.*, vol. 86, pp. 235–245, 2013, doi: 10.1016/j.ecolecon.2012.08.019.

[33] T. Elmqvist, M. Fragkias, J. Goodness, B. Guneralp, and K. C. Seto, *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*, Springer, 2013, doi: 10.1007/978-94-007-7088-1.

[34] C. Bullock and D. Waughray, "Integrating ecosystems into urban development: The case of London," *Environ. Sci. Policy*, vol. 9, no. 4, pp. 368–381, 2006.

[35] S. Guha, H. Govil, and M. Besoya, "An investigation on seasonal variability between LST and NDWI in an urban environment using Landsat satellite data," *Geomatics Nat. Hazards Risk*, vol. 11, no. 1, pp. 1319–1345, 2020.

[36] K. Tzoulas, K. Korpela, S. Venn, V. Yli-Pelkonen, A. Kaźmierczak, J. Niemelä, and P. James, "Promoting ecosystem and human health in urban areas using green infrastructure: A literature review," *Landscape Urban Plan.*, vol. 81, no. 3, pp. 167–178, 2007, doi: 10.1016/j.landurbplan.2007.02.001.

[37] R. Shaw, M. Colley, and R. Connell, *Climate Change Adaptation by Design: A Guide for Sustainable Communities*, Town and Country Planning Association, 2007.

[38] W. N. Adger, N. W. Arnell, and E. L. Tompkins, "Successful adaptation to climate change across scales," *Global Environ. Change*, vol. 15, no. 2, pp. 77–86, 2005, doi: 10.1016/j.gloenvcha.2004.12.005.

[39] Institute of Geosciences, *Meteorological Data, Years 1990–2020*, Archive.

[40] *Climate of Albania*, Academy of Sciences, Hydrometeorological Institute, 1975.

Cite this article as: Gjoni A., Kucaj, E., Bardhi A., Analyzing Land Use Changes and Climate Trends in Lezha Region from 1991 to 2020 Using GIS and Remote Sensing, Journal of Integrated Engineering and Applied Sciences. 2025; 3(1); 183-198.