Climate Change Impacts on Forest Ecosystems: Sensitivity Assessment in the Imereti Region (Georgia)

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ABSTRACT

The preservation of forest ecosystems is a critical component of global environmental sustainability, particularly under conditions of accelerating climate change. This study assesses the sensitivity of forest ecosystems in the Imereti region of Georgia to climatic variability and anthropogenic pressures. Using indicator-based analysis, including forest fire frequency and forest area dynamics, the research identifies key threats such as rising temperatures, increased drought frequency, pest outbreaks, and forest degradation. The findings indicate a high level of ecosystem vulnerability and highlight the urgent need for sustainable forest management strategies.

Keywords: Forest ecosystems; Climate change; Biodiversity, Ecosystem sensitivity.

INTRODUCTION

The conservation of natural resources and biodiversity has become one of the foremost challenges of the 21st century. Forest ecosystems play a fundamental role in maintaining ecological balance, regulating climate, and supporting biodiversity. In Georgia, and particularly in the Imereti region, forests are of exceptional ecological importance as they represent one of the largest refugia of relic, Tertiary-period flora in Western Eurasia.

These ecosystems are characterized by a high diversity of mesophilic and thermophilic species, many of which are sensitive to environmental changes. However, increasing anthropogenic pressures and ongoing climate change have significantly altered forest dynamics. Rising temperatures, changes in precipitation patterns, and the increased frequency of extreme climatic events pose serious threats to forest stability and resilience.

The aim of this study is to evaluate the sensitivity of forest ecosystems in Imereti to climate change and to identify key environmental and anthropogenic factors influencing their transformation.

METHODOLOGY

This research employs a qualitative and quantitative assessment framework based on indicator analysis. Due to limitations in comprehensive long-term datasets, the study relies on two primary quantitative indicators widely used in Georgia:

1. **Forest Fire Indicator** – measured by the number of forest fires at the municipal level and normalized on a scale from 1 to 10;
2. **Forest Area Indicator** – calculated as the ratio of forest-covered land to total municipal area, also normalized on a scale from 1 to 10.

In addition to these indicators, the study incorporates:

- Analysis of climate trends (temperature increase, precipitation variability, drought frequency);
- Assessment of pest and disease distribution;
- Review of national reports and scientific literature related to climate change and forest ecosystems in Georgia.

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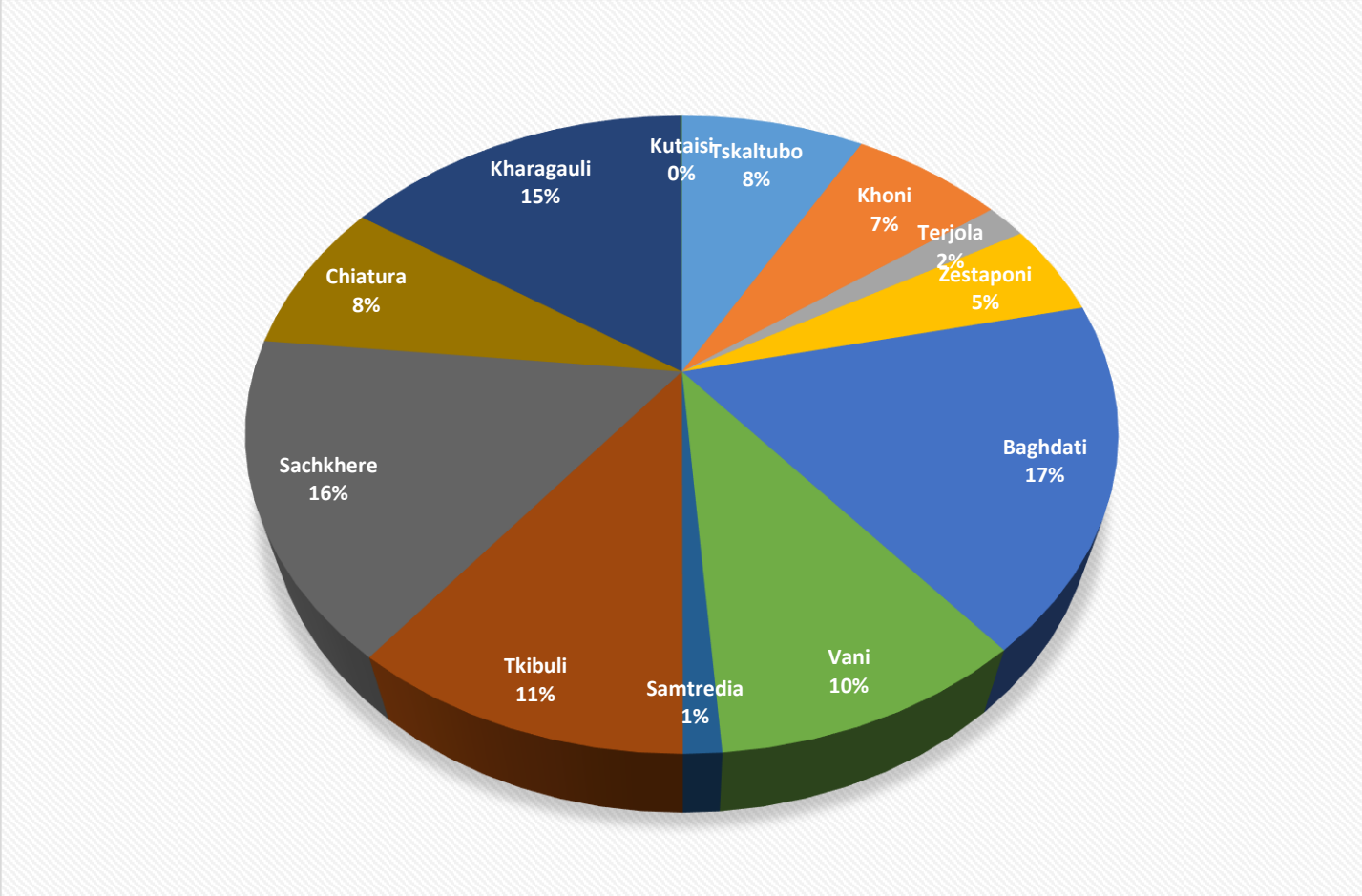
This combined approach enables an integrated evaluation of forest ecosystem sensitivity to both climatic and anthropogenic drivers.

Distribution of forest areas in Imereti by municipalities

Graph #1



RESULTS

Climate Trends and Forest Sensitivity

The analysis reveals a clear increase in average air temperature in the Imereti region, particularly during the summer season. Heatwaves have become more frequent, contributing to increased stress on forest ecosystems. In contrast to the Kolkheti Lowland, Imereti shows a more pronounced warming trend.

The frequency of drought days has increased approximately threefold, further intensifying ecosystem vulnerability. Additionally, late frosts pose a significant threat, especially to young forest stands.

Forest Fires and Disturbance Regimes

Forest fires have emerged as a major disturbance factor. The lack of effective fire prevention measures since the 1990s has increased fire risks. Climate change, combined with human negligence, has contributed to the rising number and intensity of forest fires, resulting in significant damage to forested areas.

Forest Area Changes and Anthropogenic Impact

Forest cover in Imereti has declined significantly due to anthropogenic activities, particularly illegal logging during the socio-economic crisis of the 1990s. This reduction has weakened the carbon sequestration capacity of forests, contributing to increased greenhouse gas concentrations.

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Pests and Diseases

The study identifies a growing prevalence of forest pests and diseases. Among the most significant is chestnut blight (*Endothia parasitica*), affecting approximately 16,960 hectares. Boxwood blight has also caused extensive damage, with widespread dieback observed since 2011.

Other harmful species include bark beetles, gypsy moths, and various defoliators, which increase the risk of large-scale ecological degradation.

Projected Ecosystem Changes

Climate projections suggest that a 1.5°C increase in average annual temperature will significantly alter forest composition. Moisture-dependent species are expected to decline, while drought-tolerant species may expand. Oak forests may increase in extent, whereas alder forests are likely to contract.

Precipitation changes, ranging from −25% to +15%, will further influence vegetation dynamics, creating regionally variable impacts on forest ecosystems.

DISCUSSION

The results demonstrate that forest ecosystems in Imereti are highly sensitive to both climatic and anthropogenic factors. Temperature increase and drought frequency emerge as the primary drivers of ecosystem stress, directly influencing forest health, species composition, and resilience.

The interaction between climate change and human activities amplifies ecosystem vulnerability. Illegal logging, insufficient forest management, and lack of fire prevention measures have reduced the adaptive capacity of forests. At the same time, increased pest activity and disease outbreaks further weaken ecosystem stability.

The projected shift in species composition indicates a gradual transformation of forest ecosystems, with potential loss of relic and endemic species. This poses significant ecological risks, as well as economic and cultural consequences.

To mitigate these impacts, a comprehensive and integrated forest management approach is required. Strengthening monitoring systems, improving forest governance, and enhancing adaptive capacity are essential for ensuring long-term sustainability.

CONCLUSION

Forest ecosystems in the Imereti region are facing significant threats from climate change and anthropogenic pressures. The study highlights their high sensitivity to temperature increases, precipitation variability, droughts, and biological disturbances.

Effective conservation and management strategies are urgently needed, including:

- Sustainable forest management planning;
- Forest resource inventory and monitoring;
- Capacity building in the forestry sector;
- Improved pest, disease, and fire management;
- Restoration and afforestation initiatives.

Ensuring the resilience of forest ecosystems is essential not only for biodiversity conservation but also for climate regulation and sustainable development.

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