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Geocoding of fire events in the mountainous region of Ymittos using GIS

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Abstract Wildfires in Greece constitute a major environmental challenge with significant ecological, economic, and social impacts. In recent years, their frequency and intensity have increased due to climate change, urban expansion, and lack of integrated planning, making effective management a critical priority. This study develops a comprehensive geodatabase based on official Fire Service records, aimed at analyzing the characteristics of fire events. It includes data on fire causes, behavior, meteorological conditions, topography, and consequences. The study focuses on the mountainous region of Ymittos near Athens, which is highly vulnerable due to dense vegetation and urban proximity. Fire events in this area were geocoded and maps were generated using Geographic Information Systems (GIS) to analyze spatial parameters and estimate fire risk. The analysis explores contributing factors such as temperature, seasonality, land use and proximity to roads. Special emphasis is placed on the number, duration, and spatial distribution of fire events across high- and low-risk zones. Fire frequency maps were, also, created to highlight susceptibility areas. The outcomes aim to enhance understanding and preparedness, offering a valuable decision-support tool for authorities in forest fire prevention and response.

Keywords: wildfires, GIS, geocoding, database, spatial analysis

1. Introduction

Wildfires are a growing environmental threat in southern Europe, and Greece continues to lack a unified framework for systematically recording and analyzing such events. While countries like Australia maintain updated and detailed databases that support both response and long-term planning, Greek fire data remains fragmented. This limits effective prevention and informed decision-making.

At a first level, the study addresses this gap by proposing a geospatially enhanced fire event database, based on official records from the Greek Fire Service. At a second level of analysis, the study focuses on Mount Ymittos—a forested region bordering the metropolitan area of Athens—selected for its ecological importance and pronounced vulnerability to wildfires. This phase explores spatial correlations between past fire events and a range of environmental and social factors. Historical fire events in the region were geocoded using Geographic Information Systems (GIS), allowing spatial correlations with variables such as vegetation type, elevation, land use, and proximity to infrastructure.

Given the two levels of analysis in this study, we aim to improve the understanding of wildfire dynamics in peri-urban zones and support targeted risk mitigation strategies through spatial analysis and mapping tools.

2. Study Area

Mount Ymittos is a protected mountainous ecosystem in the Attica region that acts as a natural buffer for the city of Athens. It belongs to the Natura 2000 network and hosts diverse habitats and significant biodiversity. The area spans thirteen municipalities and is subject to overlapping zoning regulations that include strict conservation and limited development zones. Ymittos has experienced repeated wildfires due to dry Mediterranean vegetation, steep terrain, and urban proximity. These conditions, combined with fragmented land ownership and increasing development pressure, heighten fire risk. Its ecological value and administrative complexity make it a representative case study for spatial fire risk analysis using GIS and enriched fire databases.

3. Materials and Method

3.1. Structure and Enrichment of the Wildfire Database

The initial phase of the study involved the design and organization of a fire event database based on raw incident records provided by the Greek Fire Service. The database was structured to integrate additional parameters beyond those in the original dataset, including fire duration, weather conditions during the event, vegetation type, topography, and estimated environmental impacts. The goal was to create a uniform data schema that allows consistent analysis across time and space. Fire records were categorized according to variables such as date, time, location, cause, and response resources. These fields were selected to facilitate multi-dimensional analysis of fire behavior and risk. Data tabulation, cleaning, and organization were conducted using Microsoft Excel prior to geospatial processing, ensuring structured and

consistent input for subsequent spatial analysis. Although several isolated fire incident records exist in Greece, to the best of our knowledge, no system currently offers a unified, spatially enriched, and operationally relevant fire database. The proposed framework enhances data accessibility and organization, facilitating timely access to critical fire information. This supports more coordinated planning among stakeholders and strengthens the operational capacity of fire services, enabling better-informed decision-making in wildfire prevention and response.

3.2. Spatial Analysis and Mapping Using GIS

The spatial analysis focused specifically on the study area of Mount Ymittos, aiming to identify spatial patterns and fire-prone zones through geospatial techniques. The spatial component of the analysis was performed using Geographic Information Systems (GIS) tools. Fire event coordinates were geocoded and overlaid on thematic layers including land use, elevation, road networks, and vegetation cover. This allowed for the visualization and spatial correlation of fires with environmental and anthropogenic variables. Topographic data were sourced from national geospatial datasets and processed in ArcGIS Pro. Proximity analyses were conducted to assess the relationship of fire ignition points with features such as roads and urban zones. In addition, kernel density estimation (KDE) was used to identify fire-prone hotspots. The cartographic output included fire frequency maps and zoning diagrams indicating high-risk areas, which can support strategic planning and targeted prevention efforts by local authorities. Despite previous research efforts on wildfires in Greece, no study has spatially documented the full set of wildfire incidents in Mount Ymittos. This makes the current work the first comprehensive geospatial mapping initiative focused exclusively on this high-risk region.

4. Results and Discussion

The geospatial analysis of fire events in Mount Ymittos revealed distinct patterns of fire occurrence concentrated in areas with dense vegetation, steep slopes, and proximity to the urban fringe. Kernel density estimation identified high-risk zones primarily along the eastern and southern slopes, where land use conflicts and human access are more intense. Proximity analysis showed a clear association between ignition points and road networks, indicating the influence of human activity. The database structure allowed the integration of non-spatial data, highlighting seasonal peaks in fire incidents, especially during the summer months. As shown in Figure 1, the heatmap illustrates concentrated clusters of fire events, especially in the eastern and southern areas of Mount Ymittos. These zones correspond to regions with dense vegetation and greater human access, highlighting their heightened susceptibility. These findings confirm the value of GIS tools in identifying spatial trends and guiding targeted prevention strategies in peri-urban forest environments.

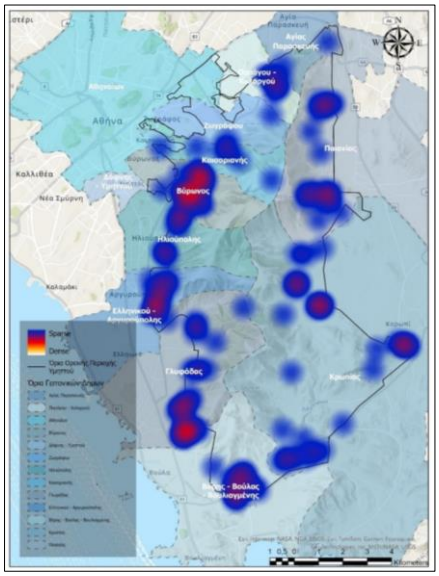

Figure 1. Heatmap of wildfire incidents in the mountainous region of Ymittos (2000–2023)

5. Conclusions

This study highlighted the importance of integrating spatial and descriptive data in the analysis of wildfire events. The development of a geospatially enriched database, combined with GIS techniques, enabled the identification of high-risk zones in Mount Ymittos and provided insights into key environmental and social drivers of fire activity. The findings demonstrate the potential of GIS as a decision-support tool for fire prevention planning in peri-urban areas. Future research should expand the database across broader spatial and temporal scales and explore the integration of real-time environmental data to enhance fire prediction and early warning systems.

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