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WILDFIRE HAZARD AND ACTIVITY PATTERNS IN SHKODRA, ALBANIA

SUMMARY

Wildland fires frequently affect Albania, causing varying degrees of economic and ecological losses each year. The paper presents a survey of the wildfires in Shkodra Qark District, one of the largest in Albania and one of the most vulnerable to various types of natural hazards. Shkodra Qark-District is situated in northern Albania, with a border of 304 km in length, 149 km of which are shared with Montenegro. The study's primary objective was to understand the characteristics of the Shkodra District in terms of fire risk, focusing not only on prioritizing the wildfire hazard level but also on the susceptibility of the local population.

During the study timeframe, Shkodra Qark-District dominated with the most frequent fires, followed by Vlora. The yearly distribution of fire occurrence showed significant fluctuations, reflecting a substantial difference between Shkodra and country averages during Hot Summers, with exceptionally higher occurrence during low-control conditions (summer 2020); similar fire occurrence rates during Quiet Summers. The results demonstrated a significant dominance of fires lit during moderate-risk days, but a reduced number of fires lit during high-risk days compared to the country averages.

However, the repressed value of fires on high-risk days was revealed due to the low number of days with high-risk exposure, despite the significantly high hit probability, except in the year 2021. The revealed results reflected, as well, a better response of the community to the media warnings and control forces, reflected in summer 2021, while a higher activity of the community, not responding to the alerts for different levels of risk during low-control conditions by state forces (as in 2020).

Keywords: wildfires, forecast, risk, natural hazards

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INTRODUCTION

Natural forest fires worldwide often have numerous adverse consequences that impact the environment and human beings. While presenting significant risk to lives and well-being of the affected communities by threatening their health and property (Archibald. S. 2018; Bedia *et al.* 2018), the fires also threaten the environment, influencing the increase of the greenhouse effect, deteriorating the condition of soils, and reducing the soil microbiota (Jaupaj *et al.* 2023a), to name a few. Exposed to diverse natural hazards, including hydrological, geophysical, climatological, and meteorological risks, the country stood out as the highest indexed risk in Europe, according to the 2019 annual report of the WorldRiskReport (WRR) (Jaupaj *et al.,* 2023a). Floods have the most impact amongst natural disasters in the country (Toto & Massabo, 2014; Zaimi & Jaupaj, 2020). Nevertheless, the increasing risk of wildfires in Albania is a pressing concern, exacerbated by both climatic factors and human activities. The geographical features of Albania, combined with a Mediterranean climate, create a conducive environment for wildfires, which have significant economic and ecological consequences (Jaupaj & Zaimi, 2021). The biophysical landscape of Albania, characterized by dense forests and a variety of fuel types, plays a crucial role in wildfire propagation. Increased temperatures and drought conditions are expected to heighten the risks associated with fuel types and their propensity to ignite.

Stefanidis *et al*. (2022) identify several factors that favor the ignition and spread of wildfires in Southern Europe (Stefanidis *et al.*, 2022). The team of authors highlights that the Mediterranean-type climate and vegetation, the complex topography, and the high levels of human activity in summer in this area are crucial factors. In turn, San-Miguel-Ayanz et al. (2003) indicate that natural wildfires are one of the components of the Mediterranean region's ecosystems, including the increased ignitions resulting from the use of the areas for recreational purposes.

On the other hand, the team of De Rigo *et al.* highlights the likelihood of an increase in the frequency and severity of wildfires worldwide, with a particular emphasis on the Mediterranean region (De Rigo *et al.* 2017).

Given those conditions, the ability to predict the likelihood of hazard occurrence, including the timing and intensity, is a crucial asset, enabling timely resource allocation to minimize potential consequences. Fire probability (including fire behavior and the possibility of its occurrence in a particular place), as well as fire impacts and consequences in the area, are the main components that frame the magnitude of the risk. Based on these key points and the historical data collection on fires that have occurred, it is possible to see the preconditions for a natural fire in the future (Depicker *et al.* 2020).

Data on fires began to be collected in different countries around the 1970s. At the time, the collection was performed in a scattered manner. Their systematization was somewhat problematic, given the various classifications, fragmentation, and questionable validity of the criteria. The first attempts at fire

prediction were more likely to expand information on the spread of already identified cases (European Fire Database, 2023). Nowadays, the most commonly used is the Canadian Fire Weather Index (FWI), which was developed by Wagner and Pickett, within the framework of the Canadian Forest Fire Detection and Rating System (CFFDRS). European Forest Fires Information System (EFFIS) adapted this index for European conditions, which Albania has used since 2016 to deliver warnings about Fire Hazards. The National Centre for Forecasting and Monitoring of Natural Hazards (NCFMNH), a subdivision of the Institute of Geosciences (IGEO), operates daily to deliver a forecasted level of risk of fire hazards nationwide (Jaupaj *et al.,* 2023, a). The study is part of a series of studies undertaken in this field by the authors. In two recent studies, Jaupaj & Zaimi (2021) and Jaupaj *et al* (2023b) try to establish the degree of reliability of the forecasts obtained using the FWI system for the Counties of Albania (named Prefectures or Qark Districts) with different levels of fire risk, according to the NCFMNH classification: high, moderate, low, and zero. In another study, Jaupaj *et al* (2023a) investigated the experience of 5 years on wildfires occurrence and forecasting in each different county in Albania (Jaupaj & Zaimi (2023a). These scientific studies are concerned with the high risk of wildfires in Albania, which necessitates investigating the causes of such situations and finding objective ways to mitigate them.

The recent study undertakes an insightful analysis of one of the largest counties in Albania, Shkodra (according to administrative units in Albania named as Prefecture or Qark). It is situated northwest of Albania, sharing the border with Montenegro, along Lake Shkodra. The study aims to investigate the occurrence of fires at the administrative level. The primary purpose of this analysis is to understand the characteristics of the Shkodra District regarding fire risk, while paying special attention to evaluating the threat level of natural fire hazards and their exposure. From this perspective, assessing social vulnerability in terms of the susceptibility of Albanian inhabitants to natural hazards and the population's ability to overcome them was deemed crucial.

The results would significantly help decision-makers regarding resource allocation, especially in situations of high-risk alerts throughout the country. The analysed Qark-District is ranked among the country's largest and most threatened by natural hazards.

MATERIAL AND METHODS

Study area

Shkodra Prefecture (Figure 1) is situated in the northwest of Albania, extending from the Northern Alps to the Adriatic coast. In the northern part of the county, a section of the National Park of the Albanian Alps is located, which spans over 82,000 ha and shares borders with the "Proteklije National Park" in Montenegro and "The Cursed Mountain National Park" in Kosovo. In the western part, on the other hand, lies Lake Shkodra, which is known as the largest lake in the Balkan Peninsula and is shared between Albania and Montenegro. The area

surrounding the lake is a protected zone in both countries. While in the Montenegrin part, it was officially designated as a national park in 1983 and was later recognized as a Ramsar site in 1995 (Radović *et al.,* 2007), the protection was extended to the Albanian side where the area was officially designated as a Managed Nature Reserve, in 2005 and reaffirmed with the new decision on natural protected zones in 2020 (KKT, 2020). The map shows the Shkodër Prefecture/Qark in northern Albania, divided into its five municipalities: Malësi e Madhe, Shkodër, Vau i Dejës, Pukë, and Fushë-Arrëz. An inset map locates the region within Albania, highlighting its position near the border with Montenegro.

Figure 1. Position of the Study area

The National Park of the Albanian Alps, established only in 2022, is also characterized by notable geological features and biodiversity. Gawlick & Schlagintweit, (2019) highlight the striking geological formations, including steep cliffs and karst landscapes, shaped by its complex geological history, primarily dominated by carbonate platform deposits from the Triassic to the Jurassic periods (Gawlick & Schlagintweit, 2019). Note the presence of the flora species representing three biogeographic zones in the Albanian Alps:

Mediterranean, Central-European, and Central-South European (Mustafa *et al*., 2015). Strasser *et al.,* (2015) also accentuate the ecological richness of the park, evidenced by the presence of many endemic species (Strasser *et al.,* 2015).

Study timeframe

This analysis builds upon a previous study conducted by the authors Jaupaj *et al.* (2023a), in which they attempted to assess wildfire risk by investigating the high-risk level as forecasted by NCFMNH on a prefecture-district basis. The authors analyzed Hazard Exposure, assessing the forecast alerts at the High-Risk level, and Vulnerability, assessing Prefecture Hit Probability during High-risk exposure days and the Average quantity of Fires per Hit during High-risk exposure days.

This study undergoes an in-depth analysis examining each risk-level as forecast-alerted by NCMNH for Shkodra Qark-District, aiming at obtaining a complete understanding of fire hazard exposure and community vulnerability against it, aiming thus at understanding the fire occurrence and the population behavior towards each forecast alert as warned by NCFMNH during five years of study (2017-2021). The analysis was conducted on a yearly basis over a 5-year timeframe, followed by a comparison of prefectural data with the country's average data. In the analysis the timeframe of the study, was conceived as demonstrative of three summer-typologies where: summer-type-1 (represented by years 2017 and 2021) distinct for a high quantity of fires occurrence and high quantity of forecast alerts warning high-risk-level exposure (Forecast Alerts High or FA_{High}); summer-type-2 (represented by years 2018 and 2019) distinct for a low quantity of fires occurrence and low or absent quantity of FA_{High}; summer-type-3 (represented by year 2020), particular to understand the behavior of population in conditions of low observance by the state, which was low during restrictions put over the country due to pandemic issues caused by covid-19.

The data from July and August, as months of increased risk, were processed and analyzed. Four levels of forecast alerts (FA), prefecture hit probability (HitP), and prefecture hit frequency (HitF) were generated (FA_{High}, $HitP_{High}$ and $HitF_{High}$; $FA_{Moderate}$, $HitP_{Moderate}$ and $HitF_{Moderate}$; FA_{Low}, $HitP_{Low}$ and $HitF_{Low}$; FA_{NoRisk}, $HitP_{NoRisk}$ and $HitF_{NoRisk}$). $HitP_{Level}$ and HitF were calculated using the following formulas:

$$\mathrm{HitP_{Level}} = \sum_{i=0}^{n} \frac{n^0\,\mathrm{HitP_{Level}}}{n^0\,\mathrm{FA_{Level}}} * 100\% \qquad [1]$$

$$\mathrm{HitF_{Level}} = \sum_{i=0}^{n} \frac{n^0\,\mathrm{FO_{Level}}}{n^0\,\mathrm{Hit_{Level}}} \qquad [2]$$

Where:

i - the summation index, which represents the individual days being considered in the analysis; n - the total number of days in the analysis; ∑- a summation operation, indicating that the values within the expression should be summed up. HitP in equation (1) refers to the probability of level-risk exposure on each day. HitF in equation (2) refers

to the frequency of level-risk exposure in terms of average fires per hit, FA_{Level} refers to the number of Forecast Alerts warned per respective Level, and FO_{Level} refers to the number of Fires occurred per respective Level

Observations of the event occurrence and location of fires were recorded every day throughout the summers 2017-2021. The results of the observations were compared with FWI data obtained by the Centre for Forecasting and Monitoring of Natural Hazards (CFMNH) on fire risks in the respective prefectural area. This information was posted on the center's website in the open access format "today for tomorrow", i.e., one day in advance Jaupaj *et al*. (2023, a&b), Jaupaj & Zaimi (2021). Data on fire occurrences were provided daily by the National Agency of Civil Protection (NACP) as part of a collaboration and memorandum of understanding with the Institute of Geosciences.

Terms $HitP_{Level}$ and $HitF_{Level}$ in the referred papers (Jaupaj et al. 2023a) were named as Prefecture Hit Probability and Average Fires per Hit (respectively PHP_{Level} and $HITF_{Level}$), which have been decided to be changed due to a better representation of the analysed components. Additionally, in a recent paper, the Prefecture-District was referred to as Qark-District (QD). In concrete terms, a Prefecture was an administrative unit of Albania from 1913 to 1953, as well as from 1992 to 2002. During the periods 1953-1992 and after 2002, the term "Prefecture" was replaced by "Qark" due to the government's restructuring of nomenclature for districts. Both terms are commonly used in population, though.

RESULTS

A total of 447 data points on daily Fire Occurrence (FO) and Forecast Alerts (FA) were considered for analysis in the 5-year timeframe for Shkodra-QD. Each year of the study timeframe, 90 to 92 FA were considered for analysis, except for 2020 (82 forecast alerts), when the data were not delivered daily due to updates the EFFIS platform was undergoing.

The fire occurrence over the country varied from very low in 2018 to very high in 2017 (2 fires and 52.2 fires Al-QD_{av} respectively). The highest fire occurrence average per country (Al-QD_{av}) was recorded over the summers of 2017 and 2020. The same trend was observed in Sh-QD but with significantly higher occurrence records over each year, exceptionally significant in summer 2020, where more than twice the average number of fires as compared to Al-QD_{av} were registered (fig.2a). Actually, during the study timeframe, Shkoder Qark District (Sh-QD) dominated with the most significant number of fires (figure 2a), followed by Vlora QD and Fier QD.

The yearly distribution of fire occurrence (FO) (fig. 2b) showed significant fluctuations year by year. A detailed yearly analysis on fire ocurrence is undergone as per the three tipologies of summers as discribed in the methodology: where first group 2017, 2021, which could be called as Hot Summers, 2020 which could be also called as low-control summer, and 2018, 2019 which could also be called as Quiet summers. The analysis shows a significant difference between Sh-QD and Al- QD_{av} during Hot Summers (2017 and 2021), where 75 fires in Sh-QD vs 52 fires on country average Al-QD_{av} were

recorded in summer 2017 while 47 fires Sh-QD vs. 25 fires Al-QD_{av} were recorded in summer 2021, thus, exceptionally higher occurrence records in Sh-QD as compared to Al-QD_{av}; During the so-called low-control Summer (2020) with FO values almost triple the values of the country averages (125 fires in Sh-QD vs 45 Al-QD_{av}); very similar rates of fire occurrence in Sh-QD was to Al-QD_{av} during the so-called Quiet Summers (2018 and 2019).

Fire Occurrence is shown through graphs in Figure 2, where the fire events distribution in a five-year average for each district in Albania (graph a) and fire events distribution by year (graph b) in Shkodra Qark-District (Sh-QD) as a comparison to Albania Qark-District Average (Al-QDav).

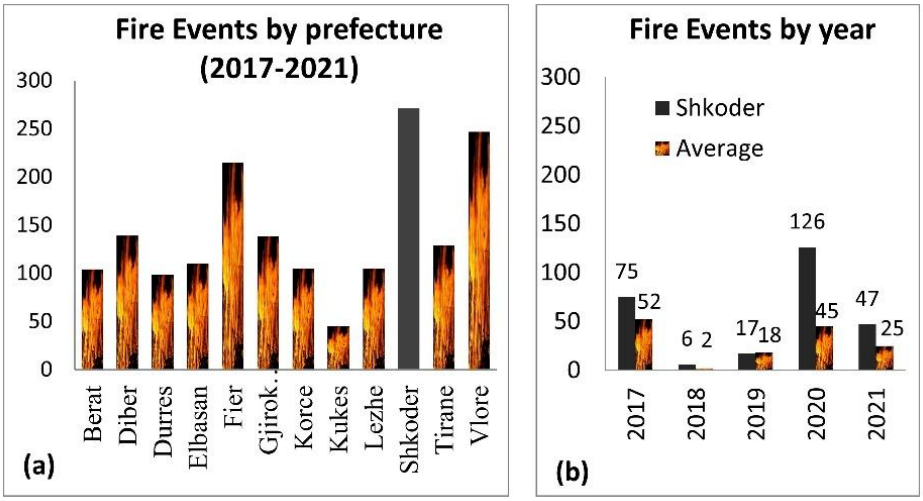

Fig. 2**.** Fire Events in Albania by Prefectures and by Years, during 2017-2021

Figure 3 illustrates the shares of FA_{Level} and FO_{Level} against the total quantity of forecast alerts (FA_{Total}) and the total quantity of fires (FO_{Total}), respectively. The Shkodra District is shown in Figure 3a, and the average for Albania Districts is presented in Figure 3b.

A **5-year timeframe analysis** for forecast alert rates per level (FA_{Level}) reflects significantly lower risk exposure in Sh-QD as compared to country averages, which consisted of a share of 67% in Sh-QD vs 84% in Al-Qd_{av} while counting together FA_{High} and $FA_{Moderate}$ (3% and 65% respectively for Sh-QD) (11% and 73% respectively for Al-QD_{av}). A significantly higher rate of FA_{NoRisk} on the other side is observed in Shkodra District as compared to country averages (16% vs 2%). (fig. 3, graphs a&b).

As for the FO_{Level} regards, much lower rates of FO_{High} were recorded in Sh-QD as compared to country averages (3% vs. 22% respectively) but significantly higher rates of $FO_{Moderate}$ (85% vs. 73%) (fig.3 graphs a&b). As for FO_{Low} and $FO_{NoRisk.}$, nearly similar rates were recorded in both Shkodra and the country averages. In concrete terms a quite minor share of the fires was recorded in the

High-Level exposure in Shkodra District (FO_{High} 3%). In contrast, the majority share was $FO_{Moderate}$ (85%) (graph 3a), with the other shares of 11% being FO_{Low} and FO_{NoRisk} (7% and 4%, respectively), (graph 3a). While on the other hand, the shares for country averages stand as 22% and 75 % for respectively FO_{High} and $FO_{Moderate}$ and only 4% and 1% for FO_{Low} and $FO_{NoRisk.}$

Meanwhile, the yearly analysis, considering the three summer typologies, revealed the following results. During the so-called Hot Summers as compared to country averages a huge controversy stood out regarding both HitP and FA for High and Moderate Levels of risk. FO_{High} revealed significantly lower values in Sh-QD as compared to country averages. In concrete terms: during 2017 summer, the share of FO_{High} in Sh-QD was nearly a quarter of the share revealed in country average, but the difference was particularly high in summer 2021 when the share of FO_{High} consisted of 0% in Shkodra District while in country average revealed 30%. $FO_{Moderate}$ share on the other side revealed significantly higher as compared to country averages in both years. Actually, the FA_{High} share in Shkodra District was lower as compared to country averages, but the difference was less (nearly half) than in FO_{High} component. As far as Moderate level regards the share of $FO_{Moderate}$ was significantly higher as compared to country averages even though the share of $FA_{Moderate,}$ was slightly lower. In explicit terms, the distribution during summer 2017 consisted in a share of 8% of days warning for FA_{High}, 65% warning for $FA_{Moderate}$ and the rest of 24% of days warning for FA_{Low} and FA_{NoRisk} (respectively 12% and 12%). Meanwhile the distribution of FO consisted in a major share for $FO_{Moderate}$ (85%) and a minor share for FO_{Low} and FO_{NoRisk} days (5% both). Only a share of 10% of the total number of fires recorded in Shkodra QD were FO_{High} (set in FA days), (graph 3). As for summer 2021, the distribution consisted in a share of 5% for FA_{High}, 62% for $FA_{Moderate}$ and another share of 32% for FA_{Low} and FA_{NoRisk} (each one 16%). In the meantime, the distribution of FO consisted in No FO_{High} recorded during this summer and a major share of 91% to be $FO_{Moderate}$. During the so-called quiet Summers (summers 2018, 2019) but even during the so-called low-control summer (2020), all of them reflected significant similarity regarding FA_{Level} shares of risk. FA_{High} consisted in a share of 0% to 1% (60%, 72%, 65% respectively) while a share of 60 to 72% were $FA_{Moderate}$ warnings (60%, 72%, 65% respectively).. A huge share of warnings went for FA_{Low} and FA_{NoRisk} (39%, 28%, 34% respectively for summers 2018, 2019 and 2020).

As far as FO_{Level} regards a share of 5% of fires were FO_{High} during 2018 and a share of 2% during 2020. The other rest of FO were all in the frame of moderate risk. The fires occurrence was recorded in a rate of 95% during 2018, 100% during 2019 and 80% during 2020 summer. No FO were recorded during Low and NoRisk days in 2018 and 2019 summers while 28% of fires were recorded during summer 2020.

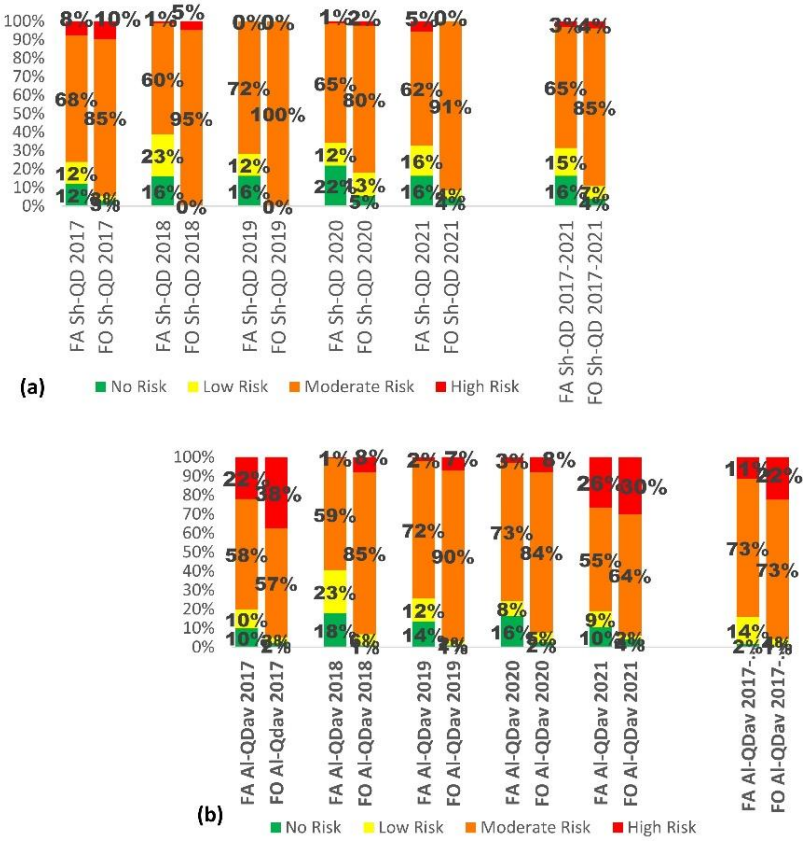

Figure 3. The distribution of alert forecasts and fire occurrence in Shkodra District and in Albania by Risk Levels

A better view and understanding can be performed by analyzing the following graphs where are shown: the Forecast Alert rates by Risk Level in a year bases as compared to country level (Figure 4, graphs a-e); the Prefecture/Qark District Hit Probability rates by Risk Level ($HitP_{Level}$) in a year bases as compared to country level (Figure 5, graphs a-e); the Hit Frequency rates by Risk Level ($HitF_{Level}$) in a year bases as compared to country level (Figure 6, graphs a-e); The graphs in Figure 7, on the other hand, show the downward trend of FA_{Level} $HitP_{Level}$ and $HitF_{Level}$ in Shkodra Qark-District compared to Country Districts Average, aiming to have a more descriptive view between them, where a and b relate to FA recorded for SH-QD_{av} and Al-$QD_{av,}$ respectively, c and d relate to HitP recorded for SH-QD_{av} and Al-QD_{av} respectively and e and HitF for SH-QD_{av} and Al-QD_{av} (data averages in a five-year bases graphs a-f).

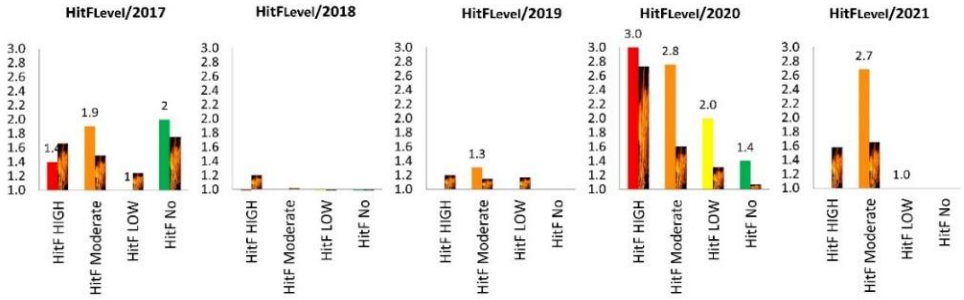

Figure 4: (graphs a-e): Forecast Alert rates by Risk Level on a yearly basis

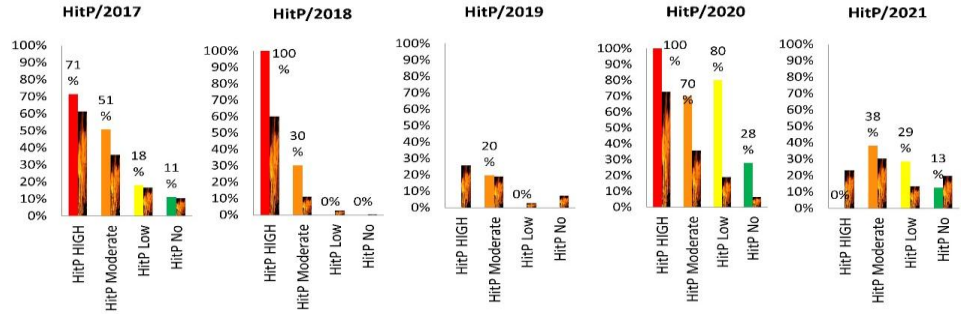

Figure 5. (graphs a-e): District Hit Probability rates by Risk Level on a yearly basis

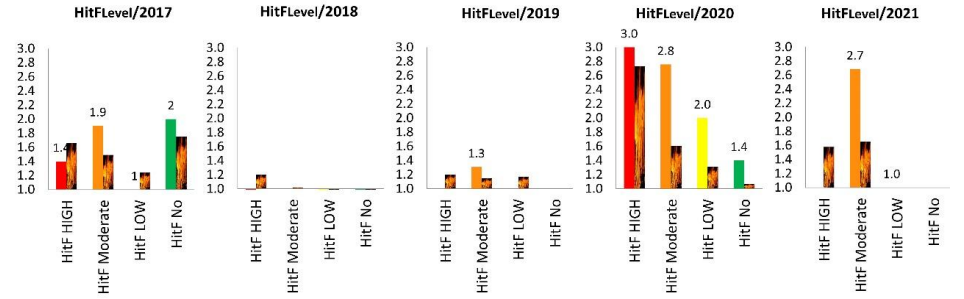

Figure 6. (graphs a-e): District Hit Frequency rates by Risk Level on a yearly basis

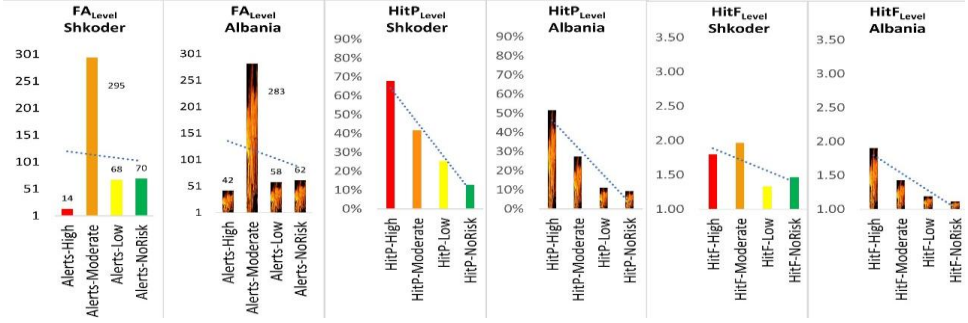

Figure 7 (graphs a-f): Alert, HitP, and HitF distribution rates by risk levels in a five-year basis

Graphs in figure 3-5 once more reflects: the significantly lower rates of FA_{High} in Shkodra District and the higher rates of $FA_{Moderate,}$ FA_{Low} and FA_{NoRisk} as compared to Country averages (fig.4); The higher rates of the $HitP_{High}$ and $HitP_{Moderate}$ with exceptions only for summer 2021 (when $HitP_{High}$ revealed much lower rates).(fig.5); The lower rates of $HitF_{High}$ as compared to country averages with exception observed only during summer 2020 (when $HitF_{High}$ in Shkoder revealed a higher value than average (3 vs. 2.7)). Exceptionally higher values $HitF_{Moderate}$ with an exceptionally higher dominance during the years 2020 and 2021 (fig.6).

Graphs in Figure 7, on the other hand, reflect 1) Similarity in FA_{Level} rates trend, between Sh-QD and Al-QD_{av}, standing out with a domination of $FA_{Moderate}$ compared to other FA_{Levels}, even though differing with significantly lower FA_{High} values in Shkodra District as compared to Country Averages; 2) Similarity in $HitP_{Level}$ trend, downward from highest to lowest risk-level (respectively High to NoRisk); 3) Dissimilarity in $HitF_{Level}$ trend, where a significant difference exists between Sh-QD and Al-QD_{av}. The decreasing trend observed in Al-QD_{av} rate isn't observed as well in Sh-QD, where stands out a significant increase in values of $HitF_{Moderate}$ and $HitF_{NoRisk}$ and a non-decreasing trend of $HitF_{Level}$ (Figure 7).

The overall revealed results demonstrate the dominance of the quantity of fires burned in the Moderate Risk days in Shkodra District, which was quite in contrast to the country averages, while a reduced number of burned fires occurred in the days of high-risk alerts, as compared to the country averages. Anyway, as detected by figures 3 to 6 this repressed value comes due to the low number of days having high-risk forecast alerts even though the district Hit probability for Shkodra was 100% in years 2018 and 2020 and 71% in year 2017 but 0% in year 2021. On the other side during the so-called low-control summer the number of fires was really massive with e distinct difference in all the components, HitP and HitF and this stood out for all levels of risk alerted.

Meanwhile, in summer 2021, despite five forecast alerts being delivered to warn of high risks, there were no incidents over the district during those days. That seeems to align with a better responding of the community to the media warnings for high-risk exposure over the qark district (as for 2021) but a higher activity of the community in the area during low-control conditions by state forces (as for 2020), which besides was not responding to the alerts for different levels of risk.

DISCUSSION

The probability of wildfires is a pressing issue in Europe and globally, especially during periods of heightened danger, during which, historically, more incidents have occurred in the respective regions. In this context, forest fire prevention is one of the most important tasks of today; no less important is public awareness. When fires are intentionally set by people, it is essential to enhance the knowledge of the public, experts, and administrative institutions in protected areas regarding the characteristics and composition of forest types, ecosystem characteristics, fire intensity, and technical information on fire properties in the

forest. Additionally, to understand their effects on various environmental elements and to prepare infrastructure for fire prevention and suppression. San-Miguel-Ayanz *et al.* (2003) indicate in a joint scientific work that using natural forests as recreation areas in the Mediterranean region contributes to a significant increase in fires caused by human faults. In this context, the authors emphasize the importance of developing comprehensive strategies to mitigate wildfire risk in these regions. In turn, Papagiannaki *et al.* (2020) highlight that effective wildfire risk forecasting in the Mediterranean requires coordinated ground-level actions. The authors stress the importance of ensuring fire safety at a regional scale, highlighting the critical role of data-driven assessments in supporting this goal. Bozovic *et al.* (2022) in their scientific research study are concerned about the threatening issue of wildfires in Montenegro, which, according to the authors, as part of the Mediterranean region, have been intensifying in recent years. The authors highlight the need to develop an integrated Forest Fire Information System in Montenegro, which could potentially align with other NFFIS in Balkan countries, enabling the exchange of risk data and the minimization of fire risk in the region. The concerns driven by researchers are entirely consistent with the objectives and results of this scientific work in evaluating the prospects for minimizing fire risk.

A study by Lushaj and Kucaj (2024) estimates that fires were responsible for 42% of the vegetation cover loss in Albania between 2001 and 2021. The authors name out several crucial factors, such as the height above sea level, slope, plant cover, and mountainous terrain, which make the territory of Albania vulnerable to fires and the difficulty of extinguishing them. Specifically, the belt of pine and beech forests lies at an altitude of 1000-1600 m above sea level, where firefighting equipment cannot circulate. The summer pastures, which occupy 85% of the total surface, are located at 1600-2700 m above sea level, the target land for fires by shepherds. |Furthermore, according to the authors, fires have become a tradition for clearing the land for cultivation and second planting in Albania. The damages are long-term and, in some cases, irreversible. The authors' concerns align with the results of this scientific study, highlighting the need to examine fire risk from multiple perspectives, not only as a hazard but also as a habit related to the issue, and furthermore, not being limited to just that.

In an editorial paper Mugnoza (2021) states “the high likelihood that natural events of high intensity can cause cascade effects, multiplying the impacts on and the damage to human communities and activities, even thousands of kilometers away from the triggering event.” The editorial emphasizes that, despite numerous studies and projects undertaken by researchers in this field, considerable work remains to be done regarding multi-hazard assessments and cascading events. He concludes, accentuating the necessity to give a strong impetus to investigating, predicting, and preventing the effects of these events and mitigating the risk of so-called “natural disasters”. Many researchers have observed that wildfires can have various cascading effects, including erosion, water quality issues, and landslides triggered by heavy rainfall events. They

highlight the need to assess and understand the cascading effects of wildfires more comprehensively (Pouyan *et al.,* 2021; Sutanto *et al*., 2024), while also acknowledging the challenges of managing wildfires and flood risks as separate entities, despite their potential interdependence. The findings of this study align with the concerns of the researchers and teams, recommending a multi-hazard assessment. The theme of the Shkodra District is of the highest interest because Shkodra is also hugely affected by the floods.

Lushaj & Kucaj (2024) find out that during the period (2001-2021), Shkodra District picked out with the largest area of forests and the highest rate of plant cover loss due to fires, with an average of 158 ha lost per year, followed by Korca District with 154 ha. The authors' findings suggest that not only the number but also the surface burned dominates in this district. From this perspective, the authors' findings align with the results of this scientific study, which highlights the predominance of fires in the Shkodra district. Additionally, the findings highlight the need to further examine the fire phenomena within the district in terms of spatial distribution, considering the areas most affected and the extent of the fires as key components to better understand the risk of fires within the district. The study finds that the Shkodra District shows problems specifically in conditions of low control by the state forces, showing a low awareness in the population regarding the fires' ignition and the consequences that the community itself may suffer, but even beyond this community and beyond the current time in the future. Awareness campaigns should be undertaken in the communities of this district, focusing on those consequences and showing the communities, particularly the cascade effects of this type of hazard in a multiple-hazards picture regarding current and future. Thus, the discussion of the results obtained in this scientific study, in terms of their comparison with the results and conclusions of several researchers on problematic aspects of understanding wildfire risks, demonstrated their fundamental correspondence in key. This is evidence of the scientific reliability of the work results, as well as the admissibility and practicality of their application in the development and introduction of forecasting and alert systems.

Calheiros *et al.* (2020), in a joint scientific study on the spatial and temporal patterns of burned areas and fire risk in the Iberian Peninsula, note that knowledge-building on weather variability characteristics in this region enables a better understanding of the statistical variability in fire occurrence data. Sakhatsky *et al.* (2020) and Cherunova *et al*. (2021), pay particular attention to this issue as well. From this perspective, the following research necessitates a comprehensive examination of the variability in weather characteristics in this region. Additionally, more in-depth studies are needed to examine the Qark-District at a lower administrative unit level, providing a more detailed understanding of the issue from a lower spatial perspective. The authors Toto and Massabo (2014) in their joint review study of the Historical Collection of disaster loss data in Albania found that Puke Rreth-District was the most problematic Rreth-District within Shkodra Qark-District regarding the number of fires. The

study examined the number of events during the period from 1913 to 1946; however, the analysis was not conducted using a risk-level-based approach, as the forecast system in Albania didn't exist before 2011, when the Center for Forecasting and Monitoring of Natural Hazards was established within IGEO. Additionally, more detailed studies should investigate the severity of the ignited fires, including their spatial extent and the time required to be extinguished by state forces and/or volunteer teams. Several studies have demonstrated the effectiveness of satellite imagery in assessing burned areas and fire extent (Güzel *et al.*, 2021; Laosuwan *et al.* 2023) while emphasizing the importance of remote sensing technologies in monitoring not just fire extent, but also post-fire ecological effects. These approaches support environmental assessments and guide restoration strategies. Given this evidence, incorporating satellite data into future studies would be crucial to understanding not only fire outbreak frequency but also the spatial patterns and extension of fire spread within the county once the blaze begins

CONCLUSIONS

The study provides a comprehensive assessment of wildfire risk in the Shkodra Qark District, a region with distinct geographic and administrative characteristics that shares borders with two protected zones in Montenegro. Through the analysis of wildfire occurrence in connection with forecasted hazard levels, this study provides valuable insights into the interplay between environmental hazards, community susceptibility, and overall societal vulnerability. The findings highlight a unique trend in Shkodra, where most wildfires occurred during Moderate Risk days —a pattern opposite to the national averages. Conversely, high-risk alert days in Shkodra were characterized by reduced wildfire activity, likely due to the limited number of such forecasted days, which again differed from national trends. The summer of 2021, in particular, demonstrated a more effective community response to high-risk alerts, resulting in no wildfire incidents during such periods. In contrast, during the summer of 2020, a surge in wildfire events coincided with reduced state control and community negligence during periods of lower risk.

These patterns underscore the importance of tailoring fire risk management strategies to local conditions. While media alerts appear to have positively influenced public behavior in 2021, the widespread fire activity during low-control conditions highlights the need for greater public engagement and preparedness. The study emphasizes the urgent need for targeted awareness campaigns in the Shkodra region to foster understanding of wildfire ignition risks and their cascading impacts. Lastly, further research is needed at finer administrative scales, especially at the municipality level, to deepen understanding of how wildfire risk manifests within smaller communities. Such localized analyses would support more precise mitigation efforts, ensuring that both hazard intensity and population susceptibility are addressed with greater nuance and effectiveness. Furthermore, additional long-term research is needed to

investigate the temporal dynamics of wildfire occurrence in the region. Such an approach would enable the disaggregation of risk components at finer spatial and temporal scales, shedding light on the interplay between hazard dynamics, community susceptibility, and governance role across local contexts.

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