Working Paper No. 09-2023

Spatiotemporal Clustering, Hotspot Analysis and Fire Risk Assessment in the Northern Region of Khyber Pakhtunkhwa (KPK), Pakistan

Rida Naseer
Salman Tariq
Muhammad Nawaz Chaudhary

Innovation and Technology Centre
Lahore School of Economics

Innovation and Technology Centre (ITC)

Dr. Azam Chaudhry
Professor, Dean & Head of Department (Economics)
Pro-Rector
Co-Director

Dr. Theresa Chaudhry
Professor (Economics)
Co-Director

Innovation and Technology Centre,
The Lahore School of Economics,
Intersection of Main Boulevard, Burki Road,
Phase VI, DHA, Lahore 53200, Pakistan
Tel: +92-(0)42-3656-0969
URL: https://itc.lahoreschool.edu.pk
Email: ayeshakh@lahoreschool.edu.pk

Working Paper No. 09-2023

Spatiotemporal Clustering, Hotspot Analysis and Fire Risk Assessment in the Northern Region of Khyber Pakhtunkhwa (KPK), Pakistan

Rida Naseer
Teaching and Research Fellow
Lahore School of Economics
Email ID: ridanaseer94@gmail.com
ORCID ID: 0009-0004-0444-4546

Salman Tariq
Assistant Professor
University of the Punjab
Email ID: salman.spsc@pu.edu.pk
ORCID ID: 0000-0002-9935-4516 (*Corresponding Author*)

Muhammad Nawaz Chaudhary
Head of Department,
Lahore School of Economics
Email ID: muhammadnawazchaudhry@yahoo.com
ORCID ID: 0000-0002-9935-4516

Abstract: *The increasing incidents of forest fires in Pakistan are alarming for the forest ecosystem and human society. Pakistan has a scarce forest area, out of which 40% of the forest wealth lies in the Khyber Pakhtunkhwa (KPK) province. This study analyzes the active fires from 2001 to 2022 in the northern region of KPK to evaluate the hazards of forest fires. To understand the spread of fire events descriptive statistics were used and Getis-Ord G hotspot analysis was performed to outline the spatial pattern displayed by the fire occurrences. Kernel density estimation was used to analyze the probability distribution of fire events. Assessment of the spatiotemporal clustering of fire points and the study of space-time interaction was done using the K function. MODIS data obtained from FIRMS revealed 1830 fire points in the study area. The statistical analysis revealed that a peak (10.32%) of fire events was recorded in 2016 and fires are mostly observed in the months of May, June and July. Most fires (57.14%) that occurred in northern KPK had a radiative power with less intensity, displaying a mean value of 21.55 Mega Watts. The hotspot region for active fires was identified in the South-Eastern part of the study area concentrated around Buner, Swabi, Mansehra, Haripur and Abbottabad. Our results will help the decision-makers better understand the hotspot regions for fires leading them to take proactive steps over time and space to minimize and control damage caused by the increasing fire events.*

Keywords: Climate change, conservation, forest fires, hotspots, forestry

JEL Classification: Q23, Q26, Q28.

First Printing: November, 2023

Funding: There is no funding for this research.

Compliance with ethical standards: The authors have complied with ethical standards.

Conflict of interest: The authors declare no conflict of interest.

Data availability statement: The data is available on request.

Spatiotemporal Clustering, Hotspot Analysis and Fire Risk Assessment in the Northern Region of Khyber Pakhtunkhwa (KPK), Pakistan

1. Introduction

Wildfires are a major disaster damaging both, the forest ecosystem and human society(Elia et al., 2020). Uncontrolled forest fires can spread to large areas damaging the ecosystem which has a significant ecological, social and economic impact (Kim et al., 2019). The damage caused by forest fire alters the vegetation composition, structure and biogeochemical cycles (Chaparro et al., 2016). Forest fires may help to clear the land and give space to new forests, however it is difficult to ensure that uncontrolled wildfires do not spread to ecologically sensitive areas or damage infrastructure and human life (Yuan et al., 2015).

Forest fires can be considered a mixed blessing. Although it helps clear the land and releases nutrients in soil making conditions favorable for new plants to grow, uncontrolled forest fires damage the entire forest ecosystem (Chandra & Bhardwaj, 2015). Controlled and low-intensity forest fires opens the canopy cover, removes dead wood, releases vital nutrients into the soil and clears the land for new plants to grow (Joshi et al., 2018). This process helps rejuvenate the forest growth and provides suitable conditions for new ecological niches to emerge inhabiting diverse wildlife (Banerjee, 2021). The practice of controlled fires has been done by local and indigenous groups for centuries to clear the land for agricultural purposes(Pivello, 2006). However, climate change and forest degradation and fragmentation have caused sensitive conditions for occurrence of forest fires. Global warming has led to drier, warmer and more intense climatic conditions (Flannigan et al., 2000). Increased drought and eroded soil due to deforestation lead to a longer fire season and uncontrolled forest fires causing damage to extensive areas (Littell et al., 2016) .

The cause and frequency of forest fires is governed by a complex combination of natural and anthropogenic factors (Kwak et al., 2012). Over 90% of wildfires are caused because of human activities and 10% forest fires occur due to lightning and weather conditions.(Coogan et al., 2019). Human activities and carelessness such as lighting campfires and discarding lit cigarettes in the forest are majorly responsible for the starting fires. The dry conditions and hot weather evaporate moisture from the soil, making the vegetation more flammable. The changing meteorological patterns shift the rain away from areas sensitive to wildfires, making the conditions drier and warmer (Venkatesh et al., 2020).

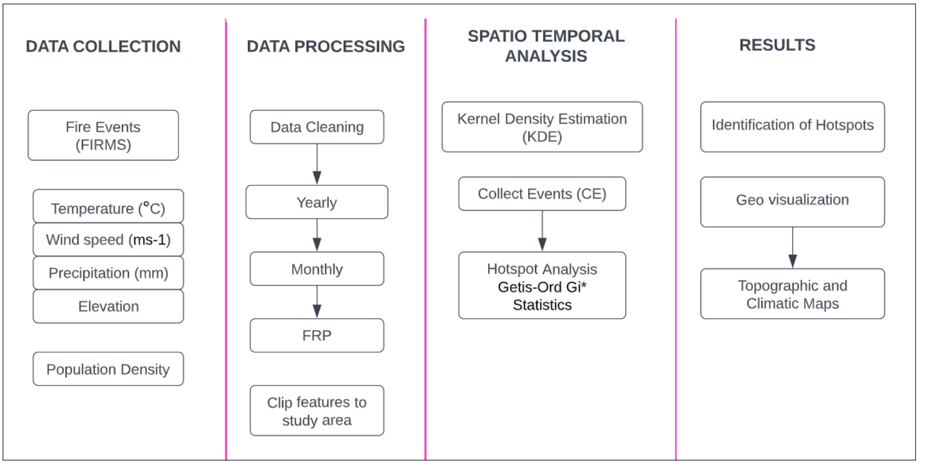
Pakistan has a total forest area of approximately 4.5 million hectare out of which 40% of the forest wealth lies in KPK Province (Nazir & Ahmad, 2018). Despite the extensive irrigation system, Pakistan has very little forest wealth. Arid and semi-arid climatic conditions prevail in most post of the country because of which Pakistan has a poor forest cover. Forest area decreases with population growth. According to the Forest Sector Master Plan (FSMP) of 1992, the natural forest cover in the country accounts for only 4.8% (4.2 million hectares) of the total land area (Ullah et al., 2022). The majority of forested areas are located in the northern regions of Pakistan, specifically in Azad Jammu and Kashmir (AJK) and Khyber Pakhtunkhwa (KPK), where coniferous and scrub forests are predominant. Additionally, there are other types of forests, such as Juniper, Chilghoza, riverine, and mangrove forests. Furthermore, irrigated plantations play a significant role as a timber source and are primarily found in Punjab and Sindh (Rasheed et al., 2017). Forest fire covers the area mainly in the hot, dry season in shrub areas and tropical Chir forests and in Himalayan subtropical pine forests (Tariq et al., 2022).

For over three decades, the combination of remote sensing imagery and GIS has been instrumental in providing information about the spatiotemporal functions of fire events at both national and local (Mannan et al., 2019; Petropoulos et al., 2014; Riebau & Qu, 2005). It serves to characterize fires, assess their spatial and temporal distribution, and determine their frequencies, ultimately enhancing the benefits and guiding management strategies (Grégoire et al., 2003). Given the extensive coverage and logistical challenges, spatial remote sensing emerges as the most efficient approach to conduct regular inventories of fire events. This method enables the identification of fire locations, dates, and timestamps, thereby contributing to effective fire management.

The aim of this research is to locate, characterize, quantify fire occurrences and identify spatiotemporal clustering patterns by distinguishing hotspot and coldspot areas. This will help facilitate the development of an effective fire management plan. The findings will provide valuable insights for policy makers to incorporate into their decision-making processes.

2. Methodology

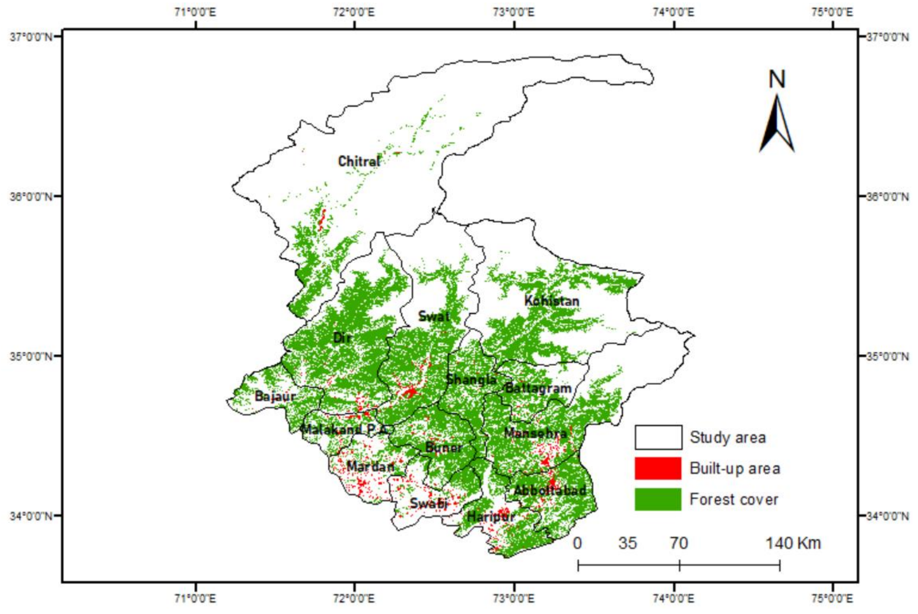
Figure 1 Methodology flowchart



2.1 Study Area

The focus of this study was on the northern region of the Khyber Pakhtunkhwa province, situated in the northwest of Pakistan, between 31°15′ and 36°57′ N and 69°5′ and 74°7′ E. The total area under study spans 50,537.413269 square kilometers, with 32.30% designated as forest area, encompassing both open and closed forests (figure 2). The province exhibits a diverse range of ecological conditions due to significant variations in altitude. Altitude levels range from 250 meters above sea level (a.s.l.) in Dera Ismail Khan in the southern region to 7,708 meters a.s.l. in Tirich Mir and Chitral in the northern region. Temperature gradients also vary, with the lowest recorded at -14°C in the north and the highest reaching 51°C in the south. Furthermore, there are variations in precipitation levels, ranging from approximately 130 mm per year in the south to around 3,200 mm in the north (Jehan et al., 2020).

Figure 2 Map of study area (northern KPK)



2.2 Active Fires Data

The forest occurrence data was obtained from Fire Information for Resource Management System (FIRMS) (https://www.earthdata.nasa.gov/learn/find-data/near-real-time/firms).

The usefulness of thermal remote sensing in collecting fire occurrence points and assessing the extent of fire has been highlighted in numerous studies. The fire data is generated by NASA's FIRMS (Fire Information for Resource Management System). One of the primary sources for global mapping of fire locations and burned areas is the MODIS sensor. Although MODIS data has a lower resolution but its acquisition frequency is high which provides with daily fire updates. (Giglio et al., 2006). The ability to detect a fire is greatly influenced by factors such as the fire's temperature, the extent of its spread, and the satellite's viewing angle in relation to the nadir point. Additionally, local weather conditions play a role in determining the likelihood of fire detection (Giglio et al., 2003).

The observations of active fires obtained from MODIS satellites provide us with multiple information that includes the geographical coordinates of the fire, the radiative power in megawatts (MW), and the date and timestamp of fire detection.

2.3 Climate Data

The climate data was downloaded from WorldClim archive (http://www.worldclim.org/). It is a widely used global climate dataset that is based on interpolated weather station data. For this study, the 2.5 minutes spatial resolution data of average monthly climatic variables was taken. The environmental variables included average temperature (°C) and wind speed (ms^{-1}).

Data Processing:

After the extraction of fire data, it was organized and cleaned to remove any outliers. The active fires were identified by considering a confidence scale ranging from 1 to 100. In order to establish a reliable fire database, fire incident points with a confidence level below 30% were excluded, as they were deemed unreliable. (Cizungu et al., 2021).

For characterization and quantification of fire data, excel descriptive statistics were used for the initial processing of the data and it was transformed to ascertain the annual, monthly and daily occurrence of fire events using Panda and Numpy libraries in Python (version 3.11.0).

To analyze the fire's destructive power, the active fires were classified into 4 categories based on their radiative power: very low (FRP $<$ 15 MW), low (FRP: 15 MW – 40 MW), moderate (FRP: 40 MW-80 MW), high (FRP: 80MW – 600 MW).

After the initial processing of the data, it was analyzed using G statistics of Getis-Ord which is an inferential statistic tool used for spatial autocorrelation that enables us to identify and understand the hot spot and the cold spot areas indicating where there are statistically significant points. It displayed the clustering of fire points. Hot and cold spots are determined using statistical analysis, specifically through the examination of standard deviations (Z scores) and probability values (p-values). When there are high Z scores accompanied by low p-values, it indicates the presence of a cluster zone or hotspot. The G statistics was applied with the Hotspot Analysis Tool and Optimize Hotspot Analysis Tool of ArcGIS (version 10.8).

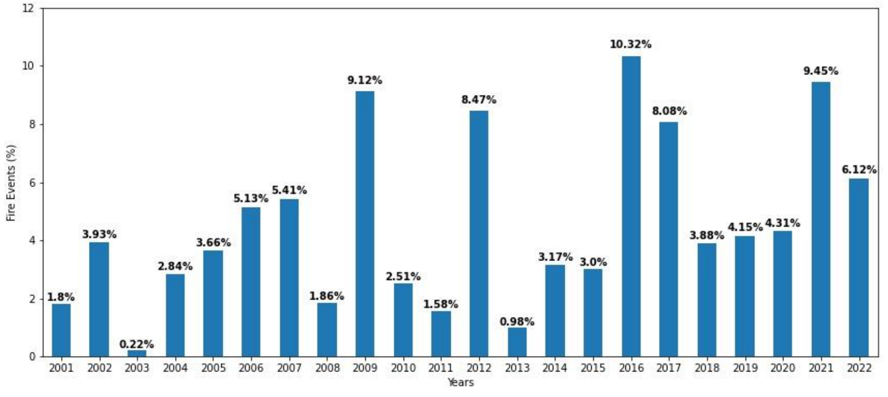
The fire density maps of fire occurrence from 2001 to 2022 were used to derive the spatiotemporal clustering of fire points. The maps help identify the hotspots (high fire occurrence density) and coldspots (low fire occurrence density) per unit area. Kernel density estimation is a non-parametric method employed to estimate the probability density function of unknown variables. In this study, a fixed bandwidth of 2 km was applied to perform KDE, which enabled the creation of continuous fire intensity maps using the available fire occurrence points. The maps for environmental variables were generated using ArcGIS version 10.8.

3. Results and Discussion

3.1 Temporal organization of fire events

The temporal trend of forest fire events in the study region were studied on yearly, monthly and daily basis from 2001-2022. The monthly changes in fire events were analyzed for each year. A total of 1,830 fire events were recorded with a confidence greater than 30% for the selected time period. The spread of fire events over different years varied (figure 3). The KPK region exhibits significant variations in altitude, resulting in considerable diversity in rainfall patterns recorded over the years that has triggered drought in all meteorological stations of KPK. The year 2003 had the least number of active fires (0.22%) followed by 2013 (0.98%). In 2016 the highest number of fire events representing 10.32% were recorded followed by 2021 with 9.45% and 2009 with 9.12%. An abrupt decrease in rainfall was recorded after 2015 leading to drought (Rahman et al., 2021) which could be a leading cause for increased fire events in the year 2016. A hot and dry spell was observed in the KPK region in the year 2021, which raised the danger of forest fires.

Figure 3 Yearly distribution of fire events in KPK



As seen in figure 4. there is a huge variation in average monthly patterns of fire events. The most significant being in June, which had the highest number of fire counts 36.48% followed by May (14.2%) and November (11.36%). Over the past twenty-two years, a total of 68% of fire occurred in the summer time and 32% fire events took place in the winter and spring months. Dry season subjects to warmer and drier conditions. Precipitation becomes limited, leading to the drying out of vegetation and soils. This, combined with shifts in wind patterns, creates favorable conditions for the initiation and propagation of fires. The occurrence of fires in the past three months can be attributed to cultural practices involving the clearance of land through controlled burning (FAO, 2019). These practices involve cultivating fallow land and clearing new areas, where fire is intentionally used to support agricultural activities.

Figure 4 Monthly distribution of fire events in KPK

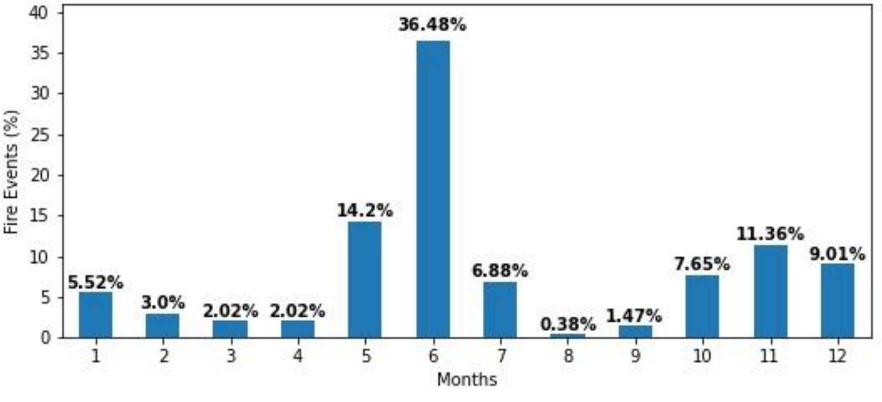
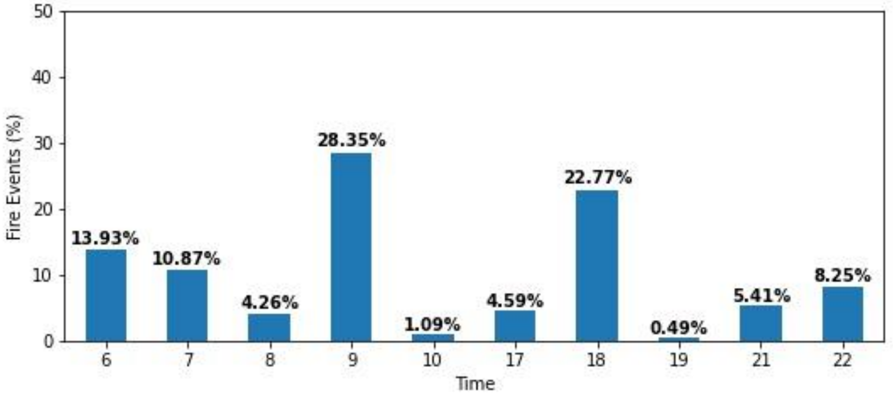


Figure 5 Time distribution of fire events



3.2 Fire Radiative Power (FRP)

The values of FRP vary from very low (< 15 MW) to high (80-600 MW). The FRP distribution in northern KPK is somewhat unifrom (figure 6). About 57.13% of the fires have very low FRP, followerd by low (40.14%) and medium (2.89%). The mean value of fire radiative power is 21.55 (MW). A low fire radiative power (FRP) value indicates that the fire is relatively small or weak.

This could be due to a variety of factors such as:

- early stage fire
- burning in an area with less available fuel
- weather conditions (high humidity or low wind speed)

Figure 6 Fire radiative power (FRP) classes

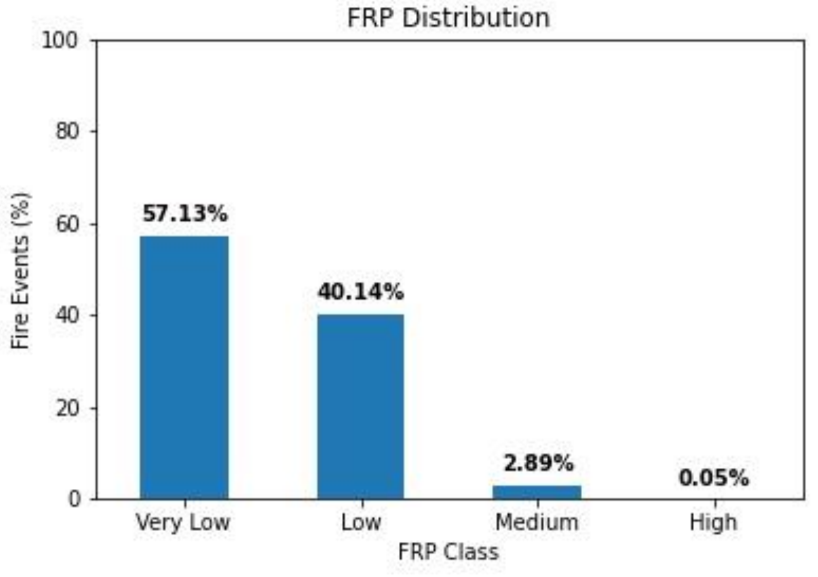
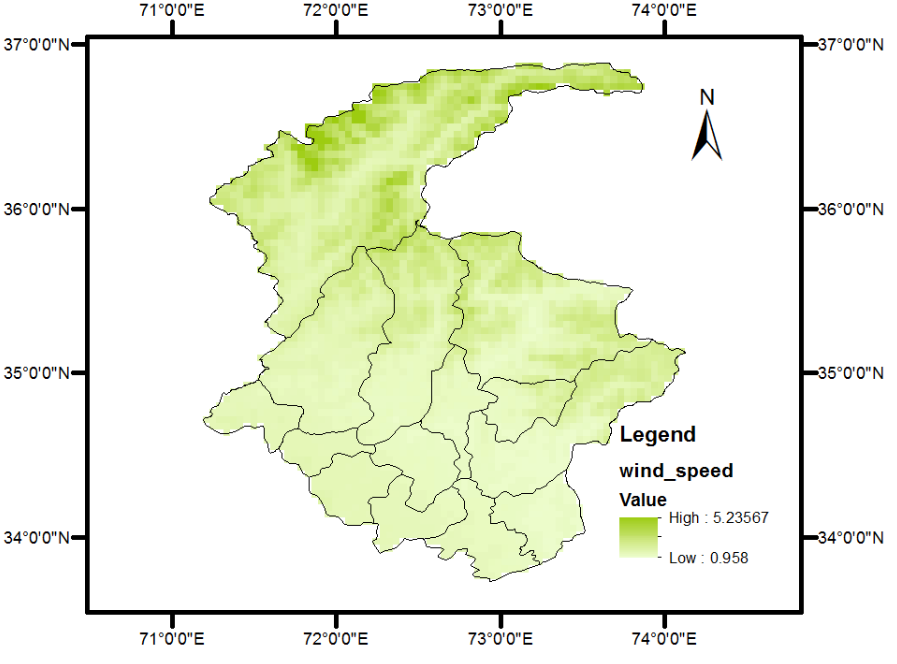


Figure 7 Wind speed in the study area (ms-1)



3.3 Kernel Density Analysis

The firt step for performing spatial analysis involved conducting data analysis to visually examine the fire occurrence points (figure 8). The outcomes of this analysis facilitated the creation of a Kernel Density Map (figure 10). Kernel Desnsity calculates the density of features in a given region. It can be used for point and line features and the time effect is not taken into account for its assessment. Kernel Density Analysis was performed in ArcGIS. The results indicate that most of the fires were concentrated in the souteast region of the study area which includes Buner, Mansehra, Haripur and Abbottabad.. The northwest region had fewer fire events and appeared to be least affacted by the fires. Deodar (*Cedrus deodara*), Blue Pine (P*inus wallichiana*), and Chir Pine (P*inus roxburghii*) are the most widespread tress in the study area which can be a contributing factor in the increased events of forest fires. These trees are highly flammable and can easily catch fire, especially during hot and dry weather conditions (Ahmed et al., 2020)

Figure 8 Fire distribution points

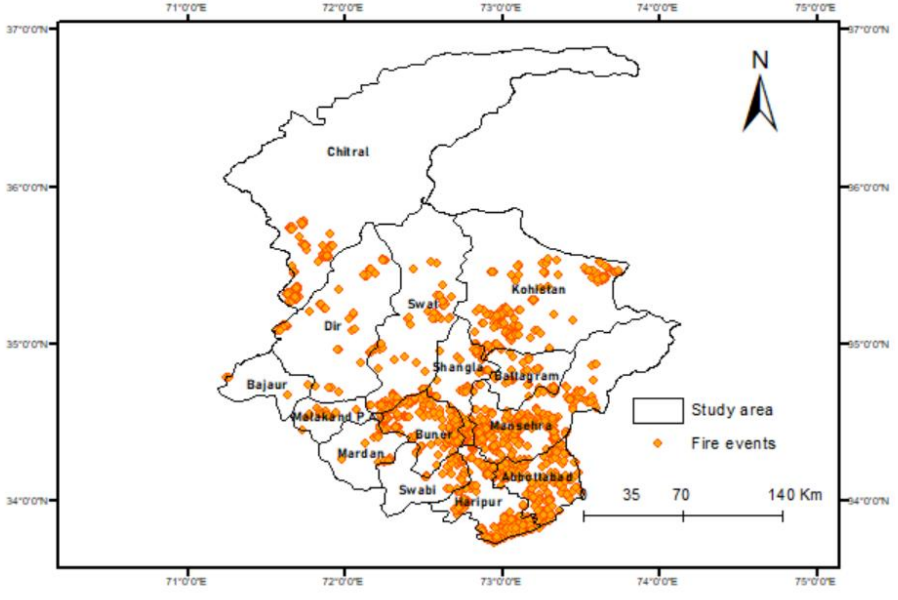


Figure 9 Mean Temperature in the study area

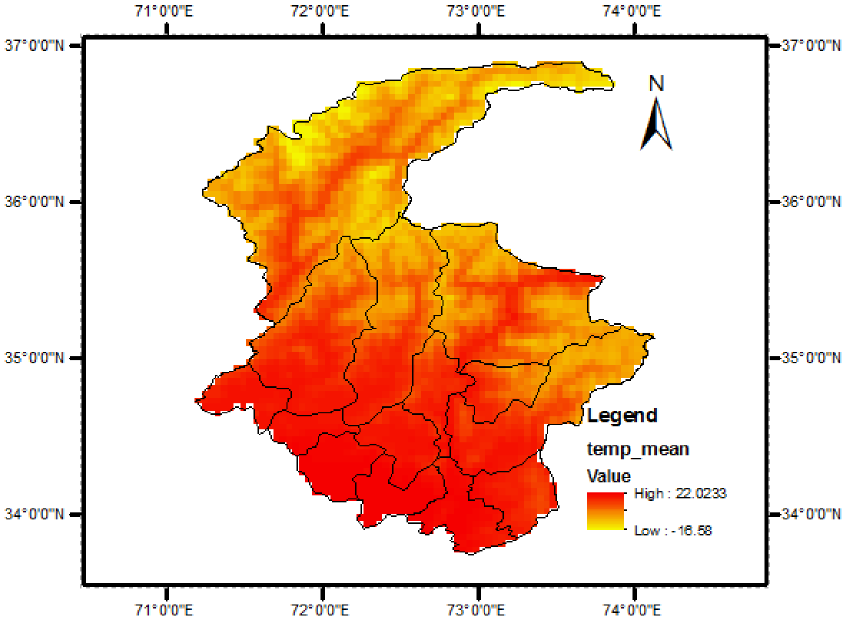
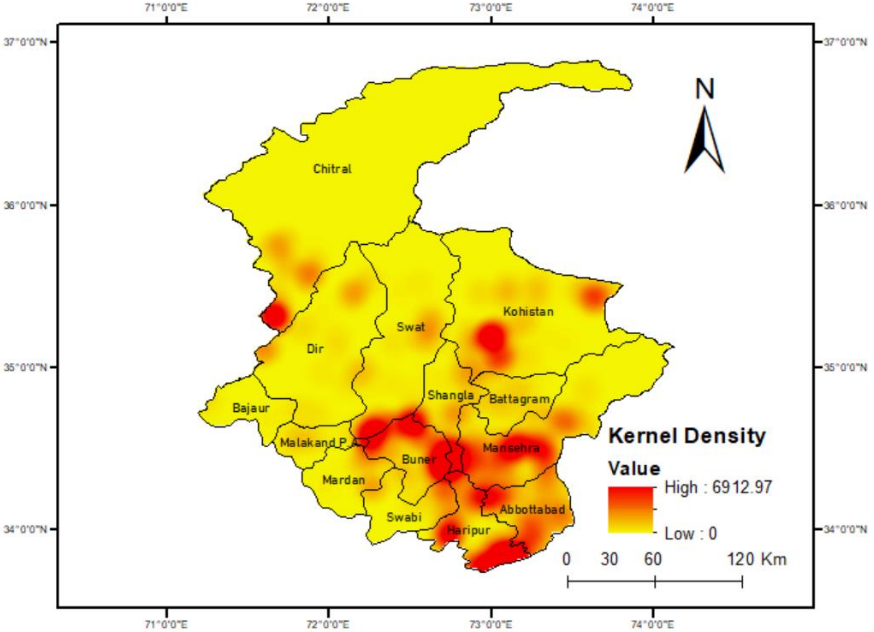


Figure 10 Kernel Density of fire events



3.4 Hotspot Analysis

After performing the initial temporal characterization of fire events, G Getis-Ord statistics was employed to determine the spatial patterns of fire points (figure 11). Hotspot analysis requires weighted points rather than individual incidents. The collective events (CE) were clustered using 2 km radius, which displayed hot and cold spots with 90, 95 and 99 percent confidence (figure 11). The results obtained from inverse distance weighted (IDW) interpolation show that the southeast part of the region has the hotspot regions and the northwest part has the coldspot regions. The hotspot results also correlate with KDE that most of the fires were concentrated in the southeast part of the study area which includes Buner, Mansehra, Haripur, Swabi and Abbottabad. The northwest region had fewer fire events and appeared to experience the least impact from the fires (figure12).

Figure 11 Collective Events (CE) hot and cold spots

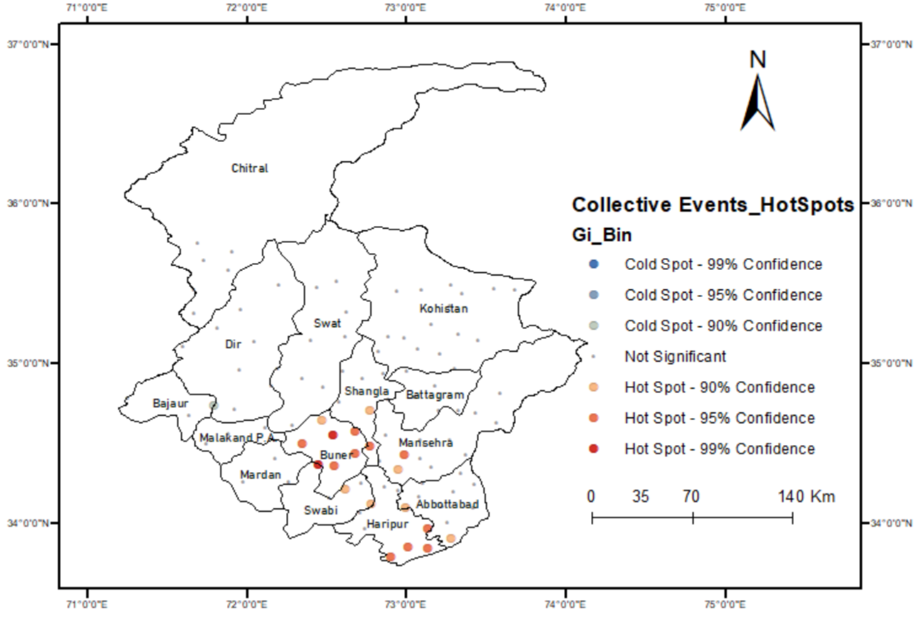
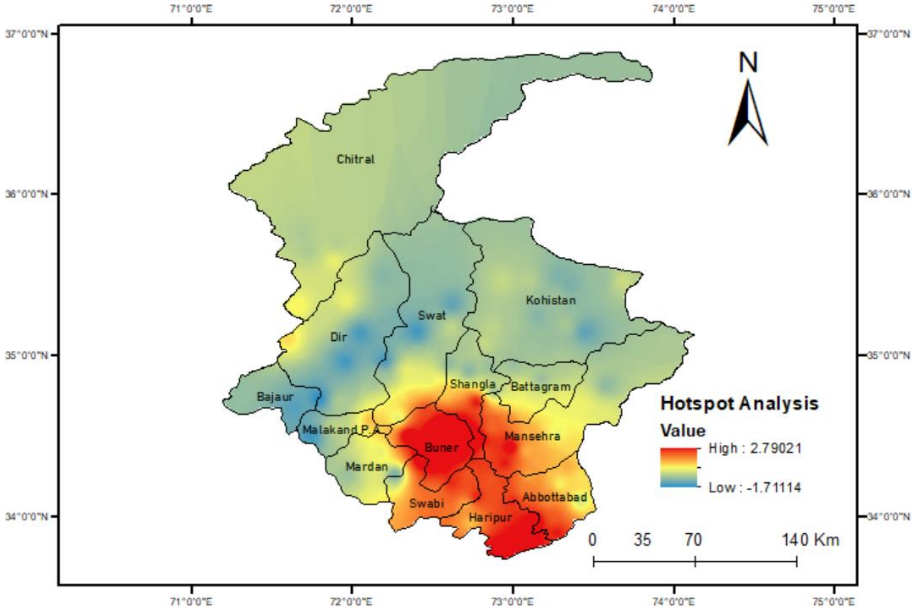


Figure 12 G Getis-Ord statistic of fire occurrence (Hotspot Analysis)



4. Conclusion

Hotspot analysis of forest fires is a critical tool for predicting, preventing, and managing forest fires. Identification of areas at high risk of fire and assessing the severity of the fire can help predict the spread of fires when studied in relation to the topographic and climatic variables of the hotspot regions. A total of 1,831 fire events were recorded from the year 2001 to 2022. The peak of fire events was observed in the months of May, June and July with a mean FRP of 21.55 MW. The climatic and topographic features indicate dry conditions present at lower elevation with less humidity. In correspondence to lower elevation the wind speed in the hotspot regions is less which indicates the high frequency (57%) of fires with low FRP. Abbottabad, Buner, Haripur, Mansehra and Swabi were identified as the hotspot areas with increased likelihood of forest fires. This study will help the policy makers and forest management authorities to make informed decisions about land-use planning and design an efficient contingency plan for dealing with forest fires.

References

Banerjee, P. (2021). Maximum entropy-based forest fire likelihood mapping: Analysing the trends, distribution, and drivers of forest fires in Sikkim Himalaya. *Scandinavian Journal of Forest Research*, *36*(4), 275–288. https://doi.org/10.1080/02827581.2021.1918239

Chandra, K., & Bhardwaj, A. (2015). *Incidence of Forest Fire in India and Its Effect on Terrestrial Ecosystem Dynamics, Nutrient and Microbial Status of Soil*. *5*, 69–78. https://doi.org/10.5923/j.ijaf.20150502.01

Chaparro, D., Vall-llossera, M., Piles, M., Camps, A., Rüdiger, C., & Riera-Tatché, R. (2016). Predicting the Extent of Wildfires Using Remotely Sensed Soil Moisture and Temperature Trends. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *9*(6), 2818–2829. https://doi.org/10.1109/JSTARS.2016.2571838

Cizungu, N. C., Tshibasu, E., Lutete, E., Mushagalusa, C. A., Mugumaarhahama, Y., Ganza, D., Karume, K., Michel, B., Lumbuenamo, R., & Bogaert, J. (2021). Fire risk assessment, spatiotemporal clustering and hotspot analysis in the Luki biosphere reserve region, western DR Congo. *Trees, Forests and People*, *5*, 100104. https://doi.org/10.1016/j.tfp.2021.100104

Coogan, S. C. P., Robinne, F.-N., Jain, P., & Flannigan, M. D. (2019). Scientists' warning on wildfire—A Canadian perspective. *Canadian Journal of Forest Research*, *49*(9), 1015–1023. https://doi.org/10.1139/cjfr-2019-0094

Elia, M., D'Este, M., Ascoli, D., Giannico, V., Spano, G., Ganga, A., Colangelo, G., Lafortezza, R., & Sanesi, G. (2020). Estimating the probability of wildfire occurrence in Mediterranean landscapes using Artificial Neural Networks. *Environmental Impact Assessment Review*, *85*, 106474. https://doi.org/10.1016/j.eiar.2020.106474

Flannigan, M. D., Stocks, B. J., & Wotton, B. M. (2000). Climate change and forest fires. *Science of The Total Environment*, *262*(3), 221–229. https://doi.org/10.1016/S0048-9697(00)00524-6

Giglio, L., Descloitres, J., Justice, C. O., & Kaufman, Y. J. (2003). An Enhanced Contextual Fire Detection Algorithm for MODIS. *Remote Sensing of Environment*, *87*(2), 273–282. https://doi.org/10.1016/S0034-4257(03)00184-6

Giglio, L., van der Werf, G. R., Randerson, J. T., Collatz, G. J., & Kasibhatla, P. (2006). Global estimation of burned area using MODIS active fire observations. *Atmospheric Chemistry and Physics*, *6*(4), 957–974. https://doi.org/10.5194/acp-6-957-2006

Jehan, I., Atta-ur-Rahman, & Waqas, T. (2020). Assessment of meteorological drought and trend detection in Khyber Pakhtunkhwa, Pakistan. *Arabian Journal of Geosciences*, *13*(16), 765. https://doi.org/10.1007/s12517-020-05747-3

Joshi, P. K., Chakraborty, A., & Shukla, R. (2018). Building a Resilient Community Against Forest Fire Disasters in the Northeast India. In A. Singh, M. Punia, N. P. Haran, & T. B. Singh (Eds.), *Development and Disaster Management: A Study of the Northeastern States of India* (pp. 187–200). Springer. https://doi.org/10.1007/978-981-10-8485-0_13

Kim, S. J., Lim, C.-H., Kim, G. S., Lee, J., Geiger, T., Rahmati, O., Son, Y., & Lee, W.-K. (2019). Multi-Temporal Analysis of Forest Fire Probability Using Socio-Economic and Environmental Variables. *Remote Sensing*, *11*(1), Article 1. https://doi.org/10.3390/rs11010086

Kwak, H., Lee, W.-K., Saborowski, J., Lee, S.-Y., Won, M.-S., Koo, K.-S., Lee, M.-B., & Kim, S.-N. (2012). Estimating the spatial pattern of human-caused forest fires using a generalized linear mixed model with spatial autocorrelation in South Korea. *International Journal of Geographical Information Science*, *26*(9), 1589–1602. https://doi.org/10.1080/13658816.2011.642799

Littell, J. S., Peterson, D. L., Riley, K. L., Liu, Y., & Luce, C. H. (2016). A review of the relationships between drought and forest fire in the United States. *Global Change Biology*, *22*(7), 2353–2369. https://doi.org/10.1111/gcb.13275

Mannan, A., Liu, J., Zhongke, F., Khan, T. U., Saeed, S., Mukete, B., ChaoYong, S., Yongxiang, F., Ahmad, A., Amir, M., Ahmad, S., & Shah, S. (2019). Application of land-use/land cover changes in monitoring and projecting forest biomass carbon loss in Pakistan. *Global Ecology and Conservation*, *17*, e00535. https://doi.org/10.1016/j.gecco.2019.e00535

Nazir, N., & Ahmad, S. (2018). Forest land conversion dynamics: A case of Pakistan. *Environment, Development and Sustainability*, *20*(1), 389–405. https://doi.org/10.1007/s10668-016-9887-3

Petropoulos, G. P., Griffiths, H. M., & Kalivas, D. P. (2014). Quantifying spatial and temporal vegetation recovery dynamics following a wildfire event in a Mediterranean landscape using EO data and GIS. *Applied Geography*, *50*, 120–131. https://doi.org/10.1016/j.apgeog.2014.02.006

Pivello, V. R. (2006). Fire Management for Biological Conservation in the Brazilian Cerrado. In *Savannas and Dry Forests*. Routledge.

Rahman, G., Rahman, A., Ullah, S., Dawood, M., Moazzam, M. F. U., & Lee, B. G. (2021). Spatio-temporal characteristics of meteorological drought in Khyber Pakhtunkhwa, Pakistan. *PLOS ONE*, *16*(4), e0249718. https://doi.org/10.1371/journal.pone.0249718

Rasheed, F., Yaqoob, S., & Ahmad, H. (2017). *Forest types of Pakistan* (p. 330).

Riebau, A. R., & Qu, J. J. (2005). Application of Remote Sensing and GIS for Analysis of Forest Fire Risk and Assessment of Forest Degradation. In M. V. K. Sivakumar, R. P. Motha, & H. P. Das (Eds.), *Natural Disasters and Extreme Events in Agriculture: Impacts and Mitigation* (pp. 335–350). Springer. https://doi.org/10.1007/3-540-28307-2_19

Tariq, A., Shu, H., Siddiqui, S., Munir, I., Sharifi, A., Li, Q., & Lu, L. (2022). Spatio-temporal analysis of forest fire events in the Margalla Hills, Islamabad, Pakistan using socio-economic and environmental variable data with machine learning methods. *Journal of Forestry Research*, *33*(1), 183–194. https://doi.org/10.1007/s11676-021-01354-4

Ullah, S., Gang, T., Rauf, T., Sikandar, F., Liu, J. Q., & Noor, R. S. (2022). Identifying the socio-economic factors of deforestation and degradation: A case study in Gilgit Baltistan, Pakistan. *GeoJournal*, *87*(3), 1657–1670. https://doi.org/10.1007/s10708-020-10332-y

Venkatesh, K., Preethi, K., & Ramesh, H. (2020). Evaluating the effects of forest fire on water balance using fire susceptibility maps. *Ecological Indicators*, *110*, 105856. https://doi.org/10.1016/j.ecolind.2019.105856

Yuan, C., Zhang, Y., & Liu, Z. (2015). A survey on technologies for automatic forest fire monitoring, detection, and fighting using unmanned aerial vehicles and remote sensing techniques. *Canadian Journal of Forest Research*, *45*(7), 783–792. https://doi.org/10.1139/cjfr-2014-0347

The Lahore School of Economics was established in 1993 as a private, non-profit university with the goal of developing world class teaching and research in Pakistan. The objectives of the LSE are to prepare young Pakistanis to undertake research in economics, finance, banking, business management, industry, and development, in order to deepen their understanding of, and be able to productively contribute to, the major issues and policies that impact Pakistan and Asia at large.

The Innovation and Technology Centre (ITC) was established in April 2015 at the Lahore School of Economics with an aim to promote innovation, a key to growth in Pakistan. The ITC is a platform for academics, the business community and the public sector to collaborate in areas of economic and social importance including innovation and technology, macroeconomic and microeconomic constraints facing firms, productivity growth, manufacturing, export promotion, and environment sustainability. In addition to the internationally recognized academic output it produces every year, the ITC conducts annual surveys of manufacturers, exporters and policymakers on business confidence, technology adoption, innovation, and export competitiveness. The Centre enjoys a wide range of connections with top-level policymakers, the Chambers of Commerce of various major cities of Pakistan and manufacturers.

The ITC produces consumer reports, working papers and other outputs as part of the LSE's overall publication programme, which also comprises of the Lahore Journal of Economics, Lahore Journal of Policy Studies, Lahore Journal of Business, a textbook series, Lahore School Case Study Journal, the CREB Working Paper Series, and CREB Policy Paper Series. The LSE strongly encourages both in-house and external contributors.

Innovation and Technology Centre,
The Lahore School of Economics,
Intersection of Main Boulevard, Burki Road,
Phase VI, DHA, Lahore 53200, Pakistan
Tel: +92-(0)42-3656-0969
URL: https://itc.lahoreschool.edu.pk
Email: ayeshakh@lahoreschool.edu.pk