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Socio-Economic Determinants of Human Negligence in Wildfire Incidence: A Case Study from Pakistan's Peri-Urban and Rural Areas

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Abstract: This study aims to examine the socio-economic determinants of human negligence in wildfire occurrences across Pakistan's peri-urban and rural regions. Increasingly frequent and severe wildfires, driven by climate change, socio-economic conditions, and human negligence, have become a pressing issue. Rising global temperatures and changing precipitation patterns have created drier conditions, while unsafe human activities—such as improper disposal of flammable materials and unsafe agricultural burning—further escalate wildfire risks. These issues are particularly pronounced in Pakistan, where high poverty levels, limited resources, and low education contribute to dangerous behaviors. Weak governance and poor policy enforcement further exacerbate the problem. Data were collected using a cross-sectional survey from 500 participants across five regions. Multiple regression analysis revealed that higher poverty levels significantly increased negligence, whereas higher education and improved access to resources reduced it. Structural Equation Modeling (SEM) highlighted the critical roles of local governance, policy enforcement, and community engagement in mitigating wildfires. Correlation analysis indicated an inverse relationship between wildfire risk awareness and negligent behavior. Chi-square tests demonstrated a strong connection between wildfires and migration patterns, underscoring the socio-economic instability caused by these events. Finally, linear regression showed that wildfires significantly impact regional climate indicators, emphasizing the need for integrated management strategies. This study offers valuable insights into the socio-economic factors driving wildfires in Pakistan and provides guidance for developing targeted mitigation strategies.

Keywords: wildfires; socio-economic determinants; human negligence; governance factors; migration patterns; climate change

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1. Introduction

Wildfires are an escalating global concern, with increasing frequency and severity driven by a complex interplay of climatic changes, socio-economic conditions, governance factors, and human behavior. Rising global temperatures are causing drier conditions that make vegetation more prone to ignition, while altered precipitation patterns—characterized by periods of drought followed by heavy rains—spur rapid vegetation growth that dries out, creating abundant fuel for wildfires [1]. These climatic changes are further intensified

by human activities and behaviors, which often stem from underlying socio-economic and governance issues [2,3].

Negligent human actions, such as improper disposal of flammable materials, unattended campfires, and unsafe agricultural burning practices, significantly contribute to wildfire outbreaks [4,5]. These behaviors are frequently the result of low awareness and knowledge of wildfire risks, a problem common in both developed and developing countries. In many cases, socio-economic conditions, including high levels of poverty and limited access to education, compel individuals to engage in hazardous practices such as deforestation for fuelwood or improper land management, thereby heightening wildfire risk. Governance factors, such as the effectiveness of local governance structures, policy enforcement, and community involvement in wildfire management, also play a critical role in mitigating or exacerbating these risks. Weak governance and insufficient policy enforcement can result in inadequate fire management, leaving communities vulnerable to wildfire disasters [6].

In Pakistan, these global patterns are mirrored and often amplified by specific local conditions. The country is already grappling with rising temperatures and altered precipitation patterns, which heighten wildfire risks [7]. Socio-economic conditions, particularly in Pakistan's peri-urban and rural areas, significantly influence the incidence of wildfires. High poverty levels and limited access to resources push individuals to adopt unsafe practices such as deforestation and improper disposal of flammable materials to meet their daily needs [8]. Furthermore, low education levels lead to a lack of awareness and understanding of wildfire risks and prevention practices. Governance challenges further compound these problems, as weak local governance structures and ineffective policy enforcement impede successful wildfire management. Community engagement, essential for effective wildfire prevention and control, is often lacking due to these governance shortcomings.

The socio-economic determinants of human negligence in wildfire incidence are particularly pronounced in Pakistan's peri-urban and rural regions. Wildfire frequency and severity, along with associated migration patterns and climate change impacts, are influenced by a combination of socio-economic conditions, governance factors, and human behaviors. Poverty, education levels, and resource access directly impact the likelihood of engaging in negligent behaviors that lead to wildfires. Meanwhile, the effectiveness of local governance, policy enforcement, and community engagement is crucial in reducing these risks. Population displacement caused by wildfires also exacerbates socio-economic instability and further worsens the region's climate change indicators [9].

Despite the increasing frequency of wildfires and the well-documented link between socio-economic factors and wildfire risks globally, there is limited research examining these dynamics in Pakistan's specific context. While previous studies have explored the impact of climate change and socio-economic factors on wildfires in other regions, the unique combination of socio-economic, governance, and behavioral factors in Pakistan's peri-urban and rural areas remains underexplored. This research gap necessitates a focused investigation into the socio-economic determinants of human negligence in wildfire incidence in these regions.

Therefore, this study aims to explore the intricate relationships between socio-economic conditions, governance factors, and human behavior in relation to wildfire occurrence, migration patterns, and climate change impacts. By focusing on Pakistan's peri-urban and rural areas, this study seeks to provide valuable insights into the underlying causes of wildfires and contribute to the development of effective management and mitigation strategies that address both human and environmental factors.

1.1. Background

Numerous studies have highlighted the impact of socio-economic conditions on wildfire incidence. Research by Thomas and Escobedo [10] has shown that poverty levels, education, and access to resources are significant factors in determining wildfire risk. Areas with higher poverty often see populations engaging in risky behaviors, such as

deforestation for fuelwood, due to limited alternatives [11,12]. Similarly, low education levels contribute to a lack of understanding about fire safety and prevention measures. This has been observed in both developed and developing countries [13].

Effective governance is crucial for managing wildfire risks. Studies indicate that regions with strong local governance structures and strict policy enforcement experience fewer and less severe wildfires [14]. Community engagement is also essential. Local knowledge and participation can greatly improve prevention and mitigation efforts [15]. On the other hand, weak governance and inadequate policy enforcement often lead to poor fire management and higher wildfire risks [16,17].

Human behavior is another major factor in wildfire occurrence. Research shows that negligent actions, such as improper disposal of flammable materials and leaving campfires unattended, are common causes of wildfires [18]. Awareness and education about wildfire risks are vital in reducing such behaviors [19]. For instance, Ergibi and Hesseln [20] found that public awareness campaigns significantly reduced human-caused wildfires in high-risk areas.

In Pakistan, socio-economic conditions in peri-urban and rural areas worsen wildfire risks. Poverty is widespread, and many communities rely on deforestation and other unsafe practices to meet their energy needs [21]. Limited access to education further compounds the issue. There is often little awareness of fire safety and prevention [22,23]. These challenges reflect global trends but are intensified by local socio-economic realities.

Governance issues also affect wildfire management in Pakistan's peri-urban and rural areas. Studies reveal that local governance structures are frequently ineffective, and policy enforcement is weak. In addition, community engagement in wildfire management is often minimal. This limits effective prevention and response strategies [24]. These governance issues contribute to a higher risk of wildfires and more severe outcomes, mirroring global trends but with unique local complexities.

Negligent behaviors are common in Pakistan's peri-urban and rural areas, which increases the likelihood of wildfires [25]. Improper disposal of flammable materials, unattended campfires, and unsafe agricultural practices are widespread. Low awareness and knowledge of wildfire risks exacerbate these behaviors [26]. While these patterns are seen globally, they are shaped by the specific socio-economic and governance contexts in Pakistan.

Wildfires often lead to displacement and migration, especially in vulnerable regions. Studies have shown that wildfire-induced migration has significant socio-economic impacts on both origin and destination areas [27,28]. In Pakistan, migration patterns due to wildfires are influenced by the socio-economic conditions and governance structures in peri-urban and rural areas [29]. Displacement can worsen existing socio-economic challenges and strain local resources [30].

Wildfires also contribute to regional climate change. They increase greenhouse gas emissions and alter local temperature and precipitation patterns [31]. In Pakistan, the impact of wildfires on climate change is particularly pronounced in peri-urban and rural areas, where fire management practices are insufficient [32]. This highlights the need for effective wildfire management strategies.

Although there is extensive literature on the socio-economic determinants of wildfires globally, there is limited research focused on Pakistan's peri-urban and rural areas. The complex interplay between socio-economic conditions, governance factors, and human behavior in these regions requires detailed study. This research aims to address this gap by examining the socio-economic factors that contribute to human negligence in wildfire incidence in these areas. The findings will provide valuable insights for developing more effective wildfire management and mitigation strategies.

Existing research underscores the importance of socio-economic conditions, governance, and human behavior in determining wildfire risk. Global studies offer broad insights, but the specific context of Pakistan's peri-urban and rural areas presents unique

challenges. This study aims to fill the research gap by focusing on these local conditions and contributing to the development of targeted wildfire management strategies.

1.2. Statement of the Problem

Wildfires in Pakistan's peri-urban and rural areas are becoming more frequent and severe, causing significant socio-economic and environmental damage. While global evidence links socio-economic conditions, governance factors, and human behavior to wildfire incidence, there is limited research on how these variables interact in Pakistan's context. Inadequate local governance, weak policy enforcement, high poverty levels, low education, and prevalent negligent behaviors exacerbate wildfire risks in these areas. Understanding the specific socio-economic determinants of human negligence in wildfire incidents is crucial for developing effective management and mitigation strategies.

This study addresses the urgent need to tackle the growing wildfire risks in Pakistan's peri-urban and rural areas. With climatic changes increasing the vulnerability of these regions to wildfires, it is vital to understand the underlying socio-economic and governance factors contributing to human negligence. Current policies and management practices are insufficient to address the problem effectively, largely due to a lack of targeted research and localized data. This study fills that gap by providing a detailed examination of the socio-economic determinants of human negligence in wildfire incidents.

The motivation for this study comes from the devastating impacts wildfires have on Pakistan's peri-urban and rural communities. These impacts include loss of life, displacement, destruction of property, and environmental degradation. By identifying the socio-economic and governance factors contributing to wildfire risks, this research aims to inform the development of more effective management and mitigation strategies. Furthermore, understanding the behaviors and conditions leading to wildfires can help in designing targeted awareness and education campaigns, ultimately reducing the occurrence and severity of wildfires in vulnerable areas.

This study offers valuable insights for policymakers. By identifying the socio-economic and behavioral factors contributing to wildfires, it informs the design of targeted awareness and education campaigns that help communities adopt safer practices. Understanding the determinants of wildfire incidence also contributes to broader efforts to protect the environment and mitigate the impact of wildfires on climate change. The study addresses socio-economic challenges faced by communities in wildfire-prone areas, potentially reducing displacement and improving livelihoods.

The novelty of this research lies in its focused examination of the socio-economic determinants of human negligence in wildfire incidents in Pakistan's peri-urban and rural areas. While existing studies explore these factors globally, there is a significant lack of localized research that considers Pakistan's unique socio-economic and governance context. This study contributes to the literature by providing localized data and insights. It offers a detailed analysis of how socio-economic conditions, governance factors, and human behaviors specifically contribute to wildfire risks in Pakistan. The findings help in developing targeted wildfire management and mitigation strategies tailored to the unique challenges of these regions.

By understanding the specific drivers of negligent behaviors, this study informs community engagement efforts. It promotes safer practices and reduces wildfire risks. In conclusion, this research addresses a critical gap in the existing literature by examining the socio-economic determinants of human negligence in wildfire incidence in Pakistan's peri-urban and rural areas. The insights gained from this study will be instrumental in developing effective policies and strategies to mitigate wildfire risks, protect communities, and contribute to environmental sustainability.

1.3. Objectives of the Study

- Examine the socio-economic conditions contributing to human negligence in wildfire incidence in Pakistan's peri-urban and rural areas.
- Analyze the effectiveness of local governance structures, policy enforcement, and community engagement in wildfire management in these regions.
- Investigate the specific negligent behaviors and levels of awareness and knowledge about wildfire risks among residents of peri-urban and rural areas.
- Assess the impact of wildfires on migration patterns and the socio-economic stability of affected communities.
- Evaluate the contribution of wildfires to regional climate change indicators in Pakistan's peri-urban and rural areas.

1.4. Research Questions

- How do socio-economic conditions (poverty levels, education levels, and access to resources) influence human negligence in wildfire incidence in Pakistan's peri-urban and rural areas?
- What is the role of local governance structures, policy enforcement, and community engagement in managing wildfire risks in these regions?
- Which negligent behaviors (e.g., improper disposal of flammable materials, unattended campfires) are most prevalent among residents, and what is their level of awareness and knowledge about wildfire risks?
- How do wildfires impact migration patterns and the socio-economic stability of communities in Pakistan's peri-urban and rural areas?
- What is the contribution of wildfires to regional climate change indicators, such as greenhouse gas emissions and changes in local temperature and precipitation patterns, in these regions?

2. Materials and Methods

The foundation of our research lies in a well-structured methodology that clearly distinguishes between data collection and analysis methodologies and the results obtained. Recognizing this need, we developed a comprehensive experimental design that ensures transparency and replicability.

The process began with identifying research questions, followed by a thorough literature review to refine our objectives. We implemented a systematic sampling strategy to ensure a representative population. Each methodological activity, from selecting quantitative data collection instruments to conducting surveys, was carefully documented to maintain ethical standards and participant confidentiality.

To enhance comprehension, we created a workflow diagram that visually outlines the steps taken throughout the study. This roadmap guides readers through our systematic approach, allowing for a thorough evaluation of our methodologies. The roadmap of this study design is given as follows.

2.1. Research Design

The most suited research design for this study is a cross-sectional survey design [33]. This design allows for the collection of data at a single point in time from a large and diverse sample, making it ideal for studying the relationships between socio-economic conditions, governance factors, human behavior, and wildfire incidence. The cross-sectional design is justified as it provides a snapshot of the current state of these variables and their interactions, enabling the identification of patterns and correlations without the need for longitudinal data.

2.2. Study Setting/Universe

The study was conducted in the peri-urban and rural areas of Pakistan, focusing on Khyber Pakhtunkhwa (including Mardan), Punjab (peri-urban areas around Lahore

and Faisalabad), Sindh (rural areas around Karachi and Hyderabad), Balochistan (rural areas around Quetta), and the Islamabad Capital Territory (peri-urban areas) (Figure 1). These regions were chosen for their diverse socio-economic conditions, providing a comprehensive understanding of the socio-economic factors influencing human negligence in wildfire incidents.

Khyber Pakhtunkhwa and Mardan, with their unique socio-economic challenges and significant forest cover, are critical for studying human–environment interactions. The peri-urban areas of Punjab around Lahore and Faisalabad are rapidly urbanizing, presenting distinct governance and resource allocation issues. Sindh's rural regions near Karachi and Hyderabad are vital due to their unique socio-economic dynamics and vulnerability to environmental hazards. Balochistan's rural areas around Quetta exemplify challenges faced in resource-scarce settings.

Finally, the peri-urban regions of the Islamabad Capital Territory provide insights into the socio-economic and governance challenges near the capital. This geographical diversity ensures that the study captures a wide range of socio-economic factors that influence human behavior and wildfire risks across Pakistan.

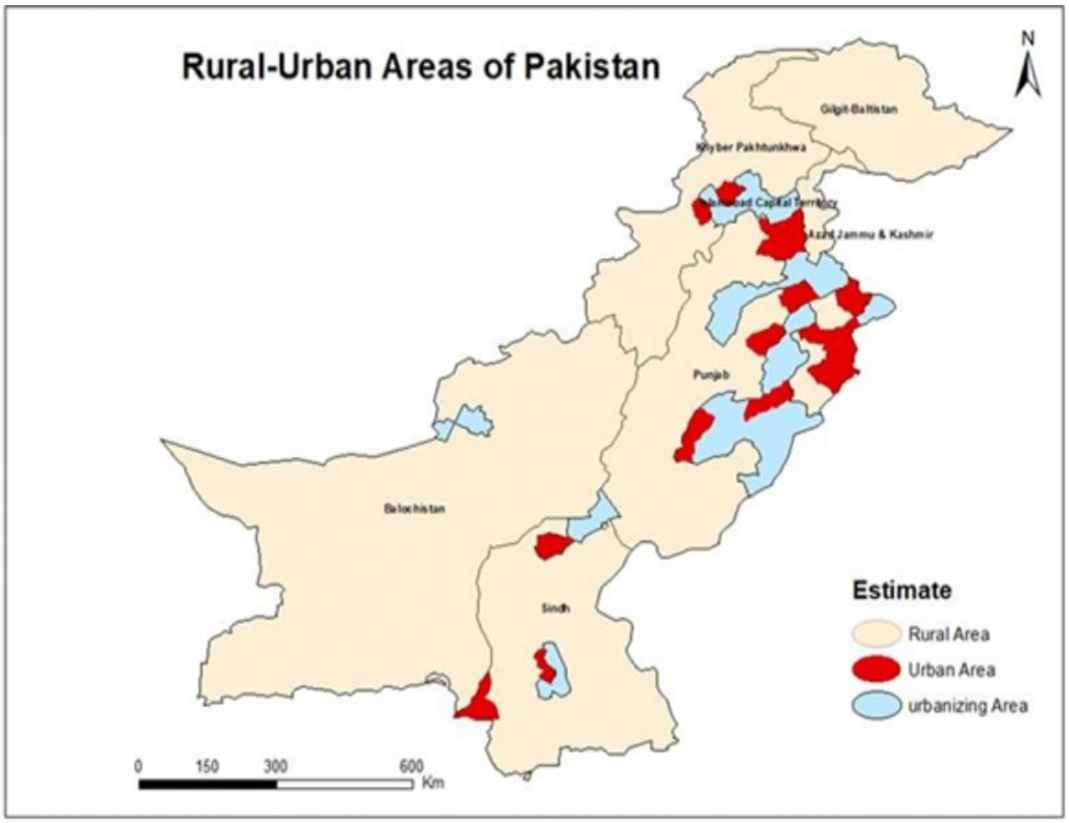


Figure 1. Road map.

2.3. Population and Target Population

The population of this study includes all residents of peri-urban and rural areas in the specified regions of Pakistan, with the target population specifically focusing on adults (18 years and older) who are likely to be impacted by or have knowledge about wildfire incidence and its contributing factors. This demographic was chosen because adults are more likely to engage in activities that could influence wildfire risks, such as land use practices, resource management, and adherence to local governance policies. Primary data were gathered through structured surveys administered to the target population, encompassing questions related to demographics, knowledge of wildfire incidence, and perceptions of resource management. The data are supplemented with secondary sources, including existing reports and studies on wildfire incidents and socio-economic conditions

in the specified regions. Following data collection, the data were cleaned for completeness and accuracy, addressing any inconsistencies or missing values. Responses were then coded into numerical formats for quantitative analysis, enabling the use of statistical methods such as descriptive statistics and inferential analysis to identify patterns and correlations relevant to the study objectives.

2.4. Socio-Economic and Demographic Characteristics of Participants

Table 1 provides a comprehensive overview of the socio-economic and demographic characteristics of the 500 participants involved in the study on the socio-economic determinants of human negligence in wildfire incidents in Pakistan's peri-urban and rural areas. The sample includes various categories such as age, gender, education level, income level, employment status, access to resources, and awareness and knowledge about wildfire risks.

The age distribution shows that the majority of participants are between 31–40 years old (41%), followed by those aged 20–30 (29%), indicating that most respondents are within economically active age groups, which is important for understanding how economic and labor-related factors contribute to wildfire negligence. The gender composition, with 57% male and 43% female participants, ensures balanced representation and allows for gender-specific insights related to wildfire incidents.

Participants' educational backgrounds range from no formal education (6%) to master's degrees and above (10%), with the largest groups having secondary education (26%) and bachelor's degrees (22%). This distribution highlights the role of education in shaping awareness and knowledge about wildfire risks and preventive measures. Income levels are diverse, with the largest group earning between 30,001–50,000 PKR (25%), emphasizing the importance of income in determining access to resources and the ability to implement wildfire prevention measures.

Regarding employment status, 60% of participants are employed, 30% are unemployed, and 10% are students. This is relevant for understanding how employment can affect individuals' time and resources for community and environmental activities, which may influence negligence in wildfire management. Access to resources also varies, with 41% reporting limited access, 39% moderate access, and 20% high access, which is critical for understanding how resource availability affects wildfire prevention and response capabilities.

When it comes to awareness and knowledge about wildfire risks, 41% of participants have low awareness, 39% moderate awareness, and 20% high awareness. This suggests that a significant portion of the population may lack sufficient knowledge about wildfire risks, which could contribute to negligent behaviors.

Overall, these socio-economic and demographic characteristics provide important context for analyzing the factors influencing human negligence in wildfire incidents. The study's findings can help inform targeted interventions to improve wildfire management practices, enhance community engagement, and increase education and awareness about wildfire risks in these regions [34,35].

Figure 2 shows the graphical representation of the socio-economic and demographic characteristics of participants. Each bar chart displays the sample size distribution for different categories within each characteristic.

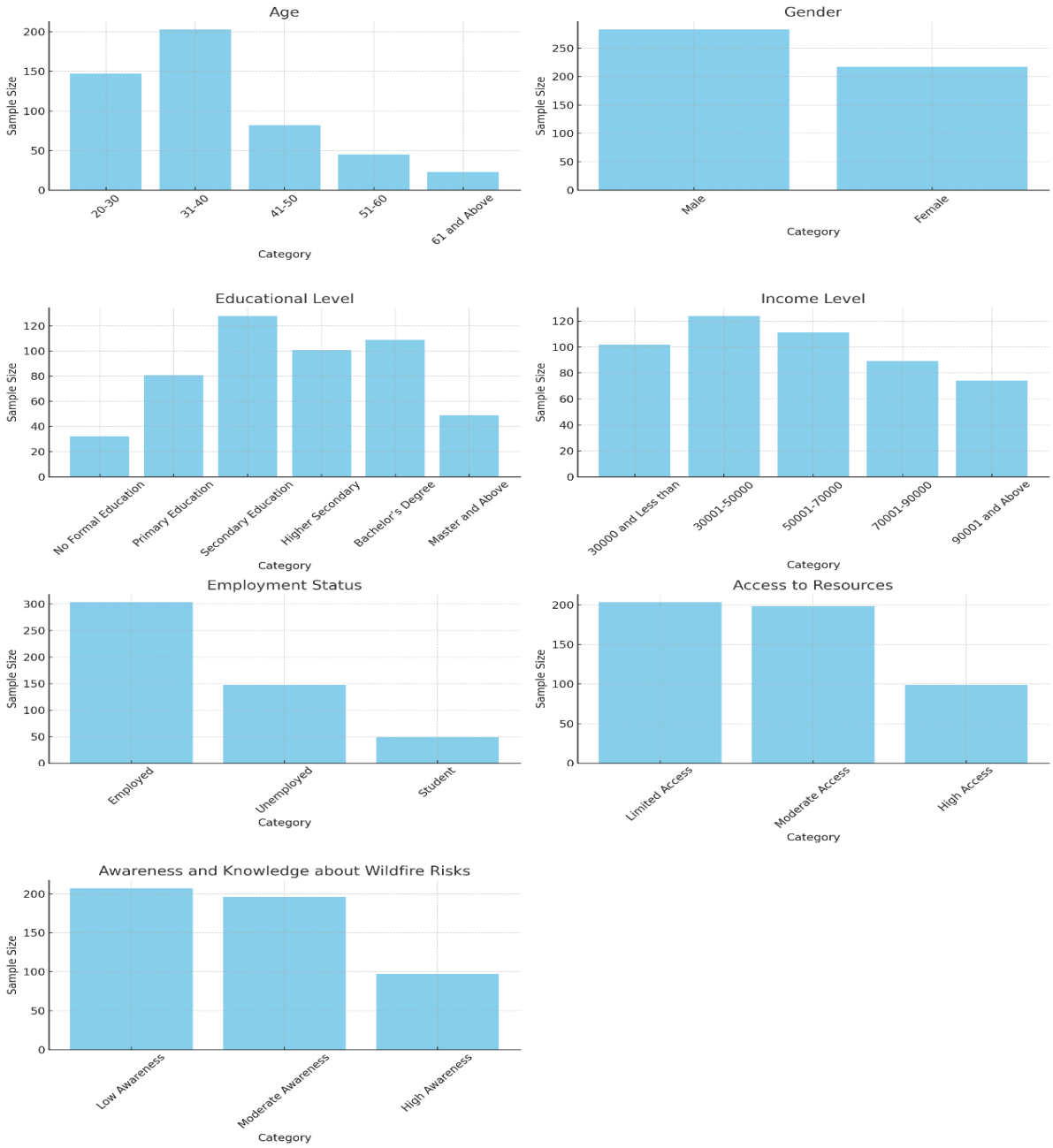


Figure 2. Socio-economic and demographic features of the respondents.

Table 1. Socio-economic and demographic characteristics of participants.

Characteristic	Category	Sample Size (N = 500)	Percentage (%)
Age	20–30	147	29%
	31–40	203	41%
	41–50	82	16%
	51–60	45	9%
	61 and Above	23	5%
Gender	Male	283	57%
	Female	217	43%

Table 1. *Cont.*

Characteristic	Category	Sample Size (N = 500)	Percentage (%)
Educational Level	No Formal Education	32	6%
	Primary Education	81	16%
	Secondary Education	128	26%
	Higher Secondary	101	20%
	Bachelor's Degree	109	22%
	Master and Above	49	10%
Income Level	30,000 and Less than	102	20%
	30,001–50,000	124	25%
	50,001–70,000	111	22%
	70,001–90,000	89	18%
	90,001 and Above	74	15%
Employment Status	Employed	303	60%
	Unemployed	148	30%
	Student	49	10%
Access to Resources	Limited Access	203	41%
	Moderate Access	198	39%
	High Access	99	20%
Awareness and Knowledge about Wildfire Risks	Low Awareness	207	41%
	Moderate Awareness	196	39%
	High Awareness	97	20%

Source: Compiled by the authors in relation to the Pakistan Demographic and Health Survey (2017/18) [35].

2.5. Sampling and Sample Size

For this study, the researchers used the Sekaran and Bougie method, which consists of specific stages [36]. The details of these stages are provided below:

- Step 1: Define the target population: The target population includes all adults (20 years and older) living in the peri-urban and rural areas of Khyber Pakhtunkhwa, Punjab, Sindh, Balochistan, and Islamabad Capital Territory in Pakistan.
- Step 2: Determine the sampling frame (Table 2): The sampling frame consists of a list of all adults living in the specified regions. Ideally, this was obtained from local government records or a recent census.
- Step 3: Select a sampling method: For this study, a stratified random sampling method is appropriate. The strata are the five regions: Khyber Pakhtunkhwa (KPK), Punjab, Sindh, Balochistan, and Islamabad. Within each stratum, participants were randomly selected to ensure representation.
- Step 4: Determine the sample size: According to Sekaran and Bougie, the sample size should be large enough to ensure statistical power but feasible to manage. Given a large population, a sample size of 500 participants is adequate. We select 100 participants from each region.
- Step 5: Selection of sample size: The sample size is selected using the following sample frame:

Table 2. Sample frame.

Region	Estimated Adult Population	Sample Size	Sampling Frame Description
Khyber Pakhtunkhwa	10,000,000	100	List of all adults in KPK
Punjab	40,000,000	100	List of all adults in Punjab
Sindh	20,000,000	100	List of all adults in Sindh
Baluchistan	5,000,000	100	List of all adults in Baluchistan
Islamabad Capital Territory	1,000,000	100	List of all adult in ICT
Total	76,000,000	500	Stratified Random Sampling

Source: Compiled by the authors in relation to the Pakistan Demographic and Health Survey (2017/18) [35].

2.6. Hypotheses of the Study

Null Hypothesis (H0). *There is no significant relationship between socio-economic conditions (poverty levels, education levels, and access to resources) and human negligence in wildfire incidence in Pakistan's peri-urban and rural areas.*

Alternative Hypothesis (H1). *There is a significant relationship between socio-economic conditions (poverty levels, education levels, and access to resources) and human negligence in wildfire incidence in Pakistan's peri-urban and rural areas.*

Null Hypothesis (H0). *Local governance structures, policy enforcement, and community engagement have no significant impact on wildfire management in Pakistan's peri-urban and rural areas.*

Alternative Hypothesis (H1). *Local governance structures, policy enforcement, and community engagement have a significant impact on wildfire management in Pakistan's peri-urban and rural areas.*

Null Hypothesis (H0). *There is no significant relationship between negligent behaviors and levels of awareness and knowledge about wildfire risks among residents of Pakistan's peri-urban and rural areas.*

Alternative Hypothesis (H1). *There is a significant relationship between negligent behaviors and levels of awareness and knowledge about wildfire risks among residents of Pakistan's peri-urban and rural areas.*

Null Hypothesis (H0). *Wildfires have no significant impact on migration patterns and the socio-economic stability of communities in Pakistan's peri-urban and rural areas.*

Alternative Hypothesis (H1). *Wildfires have a significant impact on migration patterns and the socio-economic stability of communities in Pakistan's peri-urban and rural areas.*

Null Hypothesis (H0). *Wildfires do not significantly contribute to regional climate change indicators (e.g., greenhouse gas emissions, changes in local temperature and precipitation patterns) in Pakistan's peri-urban and rural areas.*

Alternative Hypothesis (H1). *Wildfires significantly contribute to regional climate change indicators (e.g., greenhouse gas emissions, changes in local temperature and precipitation patterns) in Pakistan's peri-urban and rural areas.*

2.7. Conceptual Framework

The conceptual framework illustrates the relationships between independent variables (IVs) and dependent variables (DVs) in the study of socio-economic determinants of human negligence in wildfire incidence in Pakistan's peri-urban and rural areas. In Figure 3, the nodes represent variables, with sky blue nodes indicating independent variables and light green nodes indicating dependent variables. The framework considers various socio-economic factors, such as poverty levels, education levels, and access to

resources, examining how these factors influence human behavior and negligent actions. Governance factors, including local governance, policy enforcement, and community engagement, are also included, emphasizing their impact on wildfire management.

The edges between the nodes are labeled with the specific statistical tests used to analyze these relationships. Multiple regression analysis evaluates how socio-economic conditions influence human behavior, while correlation analysis explores the relationship between human behavior and wildfire incidence. Structural Equation Modeling (SEM) examines the impact of governance factors on wildfire management. The chi-square test assesses the association between wildfire incidence and migration patterns or socio-economic stability, and linear regression analysis measures the contribution of wildfire incidence to regional climate change indicators.

This framework provides a visual representation of how different factors interact and influence wildfire risks and management, serving as a guide for empirical investigations aimed at developing effective mitigation strategies tailored to the local conditions of Pakistan's peri-urban and rural areas.

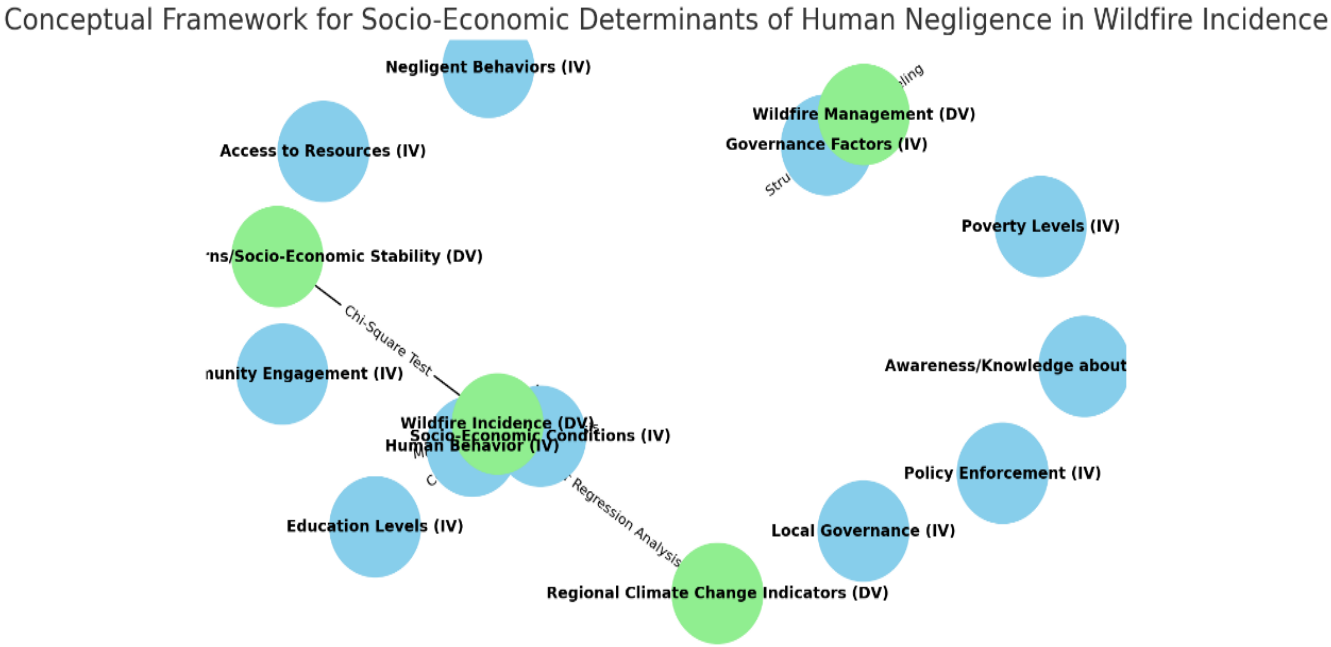


Figure 3. Conceptual framework.

2.8. Tool of Data Collection

The most suitable data collection tool for this study is a structured questionnaire administered through both mail and online platforms. The online survey was conducted from May to June 2024, coinciding with a period of frequent wildfire incidents in Pakistan's peri-urban and rural areas. Given the large and geographically dispersed population in these regions, this method allows for efficient and widespread data collection.

The structured questionnaire was designed to address all five research objectives and included sections on socio-economic and demographic characteristics, knowledge and awareness of wildfire risks, perceptions of governance, and community engagement. By using both online and mailed surveys, the study was able to reach a broad area without the need for extensive travel, making the process both time- and cost-efficient. This approach ensured that respondents from different regions could participate, regardless of their location. Online platforms were convenient for those with internet access, while mailed surveys catered to individuals without it.

Respondents were able to complete the survey at their own convenience, potentially increasing response rates and allowing for more thoughtful answers. The questionnaire was designed to collect detailed information on various factors influencing human negligence

in wildfire incidents, aligning with the study's objectives. Overall, this approach ensured thorough, representative, and manageable data collection, providing a solid foundation for analyzing the socio-economic determinants of human negligence in wildfire incidents across Pakistan's peri-urban and rural areas (Table 3).

Table 3. Reliability and validity statistics.

Variable	Measurement	Reliability	Validity	
			Content Validity	Construct Validity
Socio-Economic Conditions (SEC)	Income levels, education levels, access to resources	Cronbach's alpha = 0.85	Variables selected based on literature review and expert judgment.	Confirmatory Factor Analysis (CFA) shows adequate fit indices (e.g., CFI, RMSEA).
Governance Factors (GF)	Perceptions of local governance effectiveness, policy enforcement, community engagement	Cronbach's alpha = 0.80	Items developed from established scales and expert feedback.	Factor analysis confirms distinct factors aligning with theoretical constructs.
Human Behavior (HB)	Self-reported negligent behaviors, awareness/knowledge about wildfire risks	Cronbach's alpha = 0.78	Items derived from literature and pilot tested for clarity and relevance.	Correlations with related constructs (e.g., wildfire incidence) demonstrate expected patterns.
Wildfire Incidence (WI)	Frequency and severity of wildfires in respondents' areas	Inter-rater reliability = 0.85	Data collected from official records and verified for accuracy.	Correlations with climate and environmental factors support construct validity.

Source: Compiled by authors in relation to Field [37].

2.9. Ethical Considerations

Ethical considerations include ensuring the confidentiality and anonymity of respondents. Informed consent was obtained from all participants, clearly stating the purpose of the study, the voluntary nature of participation, and the measures taken to protect their data. Data collected online were securely stored and only accessible to the research team. Participants were assured that their responses would be used solely for academic purposes and that their identities would remain confidential.

2.10. Measurement of Variables and Indexation

- Socio-Economic Conditions (SEC): Measured using indicators such as income levels, education levels, and access to resources. Responses were indexed on a scale to quantify socio-economic status.
- Governance Factors (GF): Measured through perceptions of the effectiveness of local governance structures, policy enforcement, and community engagement. Responses were indexed to create a composite governance score.
- Human Behavior (HB): Assessed through self-reported negligent behaviors and awareness/knowledge about wildfire risks. Indexed to quantify the level of negligence and awareness.
- Wildfire Incidence (WI): Measured by the frequency and severity of wildfires in the respondents' areas. Indexed based on reported data.
- Migration Patterns (MP): Assessed by the rate of displacement and population movement due to wildfires. Indexed to quantify migration impacts.
- Impact on Climate Change (ICC): Measured through perceptions and reported data on changes in local temperature, precipitation patterns, and greenhouse gas emissions. Indexed to quantify climate change impacts.

2.11. Data Analysis

Data were analyzed using statistical software (SPSS-20) and involved multiple regression, Structural Equation Modeling (SEM), correlation, chi-square tests, and linear regression to test the hypotheses of the study.

2.12. Models of the Study

For this study models were employed to analyze the relationships between various socio-economic conditions, governance factors, community engagement, and their impacts on wildfire incidence and management. The detail of each model is given below:

- Multiple Regression Model: Socio-Economic Conditions and Human Negligence in Wildfire Incidence
  Model Specification:

  Human Negligence = $\beta 0 + \beta 1$Poverty Levels + $\beta 2$Education Levels + $\beta 3$Access to Resources + ϵ

- Structural Equation Model (SEM): Local Governance Structures, Policy Enforcement, and Community Engagement
  Model Specification:

  Wildfire Management = $\gamma 1$Local Governance Structures + $\gamma 2$Policy Enforcement + $\gamma 3$Community Engagement + ζ

- Correlation Analysis: Negligent Behaviors and Awareness/Knowledge about Wildfire Risks
  Model Specification:

  Awareness/Knowledge about Wildfire Risks = $\rho \times$ Negligent Behaviors

- Chi-Square Test of Independence: Wildfires and Migration Patterns/Socio-Economic Stability
  Model Specification:

$$\chi^2 = \sum (\mathrm{Oi} - \mathrm{Ei})^2 / \mathrm{Ei}$$

- Linear Regression Analysis: Wildfires and Regional Climate Change Indicators
  Model Specification:

  Regional Climate Change Indicators = $\alpha 0 + \alpha 1$Wildfire Incidence + $\alpha 2$Greenhouse Gas Emissions + $\alpha 3$Local Temperature Change + $\alpha 4$Precipitation Change + η

3. Results

3.1. Multiple Regression

- Table 4 presents the results of a multiple regression analysis conducted to examine how socio-economic conditions (poverty levels, education levels, and access to resources) collectively influence human negligence in wildfire incidents. The findings are summarized as follows. Poverty levels: The coefficient (B) of 0.45 indicates that for each unit increase in poverty levels, there is a corresponding 0.45 unit increase in human negligence related to wildfire incidents, holding other factors constant. The standard error is 0.05, which measures the average variation in the coefficient estimates; a smaller standard error indicates more precise estimates. The standardized coefficient, Beta (β), is 0.40, demonstrating a moderate positive relationship between poverty levels and human negligence. The t-value of 9.00 assesses the significance of the coefficient, and a t-value of this magnitude indicates that the coefficient is statistically significant. The *p*-value is less than 0.001, confirming that the relationship between poverty levels and human negligence is highly significant.
- Education levels: The coefficient (B) for education levels is -0.35, suggesting that for each unit increase in education, there is a 0.35 unit decrease in human negligence regarding wildfire incidents, assuming other factors are constant. The standard error is 0.04, indicating the precision of this estimate. The standardized coefficient, Beta (β),

is −0.30, showing a moderate negative relationship. This means that higher education levels are associated with reduced human negligence in wildfire incidents. The t-value is −8.75, with the negative sign indicating the direction of the relationship; the magnitude of this value suggests statistical significance. The *p*-value is less than 0.001, indicating a highly significant negative relationship between education levels and human negligence. Access to resources: The coefficient (B) for access to resources is −0.25, meaning that for each unit increase in access to resources, there is a 0.25 unit decrease in human negligence related to wildfire incidents, holding other factors constant. The standard error is 0.03, indicating the precision of this estimate. The standardized coefficient, Beta (β), is −0.25, which reflects a moderate negative relationship. The t-value is −8.33, confirming the inverse relationship and its statistical significance. The *p*-value is less than 0.001, indicating a highly significant negative relationship between access to resources and human negligence. Model summary: The multiple correlation coefficient (R) of 0.72 reflects the strength of the relationship between the observed and predicted values of human negligence, indicating a strong correlation. The R^2 value of 0.52 suggests that 52% of the variability in human negligence related to wildfire incidents can be explained by socio-economic factors such as poverty levels, education levels, and access to resources. After adjusting for the number of predictors in the model, the adjusted R^2 is 0.51, meaning 51% of the variance is still accounted for after controlling for these factors. The F-statistic of 45.67 tests the overall significance of the model, and with a *p*-value of less than 0.001, it shows that the model is statistically significant. Overall, the model is highly significant, as indicated by the *p*-value below 0.001.

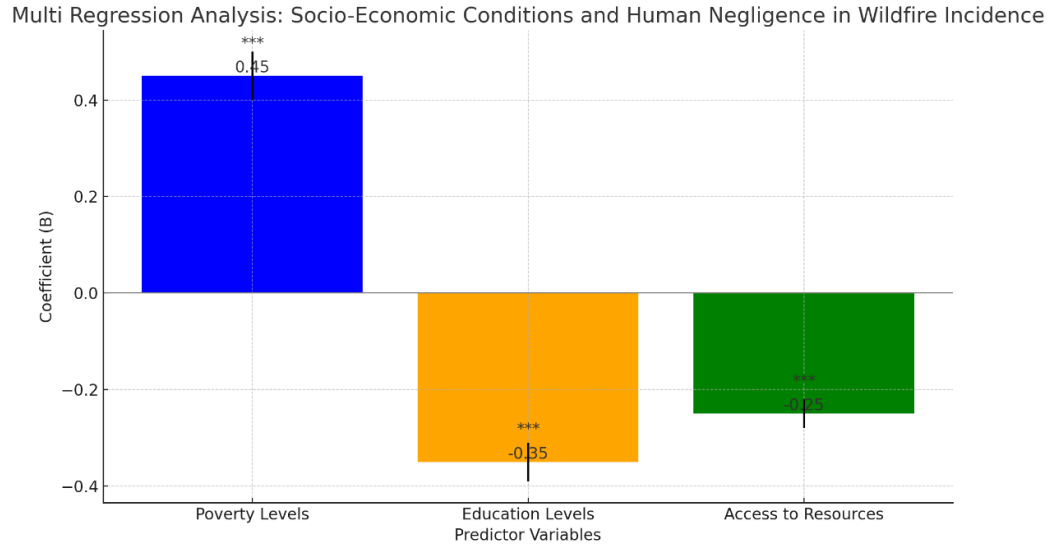
The results indicate that socio-economic conditions significantly impact human negligence in wildfire incidents in Pakistan's peri-urban and rural areas. Higher poverty levels are associated with increased negligence, likely due to limited resources or knowledge. Conversely, higher education levels decrease negligence by increasing awareness of wildfire risks and prevention measures. Similarly, better access to resources is linked to reduced negligence, as it enables communities to implement effective prevention and management strategies.

Table 4. Multiple regression of socio-economic conditions (IV) and human negligence in wildfire incidence (DV).

Predictor (IV)	Coefficient (B)	Std. Error	Beta (β)	t-Value	*p*-Value	Significance
Poverty Levels	0.45	0.05	0.40	9.00	<0.001	***
Education Levels	−0.35	0.04	−0.30	−8.75	<0.001	***
Access to Resources	−0.25	0.03	−0.25	−8.33	<0.001	***
Model Summary						
Parameter				Value		
R				0.72		
R^2				0.52		
Adjusted R^2				0.51		
F-statistic				45.67		
p-value				<0.001		
Sample Size (N)				500		

*** 1% significance level. Source: Calculated by authors.

The graphical representation in Figure 4 illustrates the multiple regression analysis, highlighting the coefficients of socio-economic conditions as predictors of human negligence in wildfire incidents. The bars represent the coefficients (B) for each predictor variable, with error bars showing the standard errors. Significance levels (*** for $p < 0.001$) are indicated above each bar.



*** 1% significance level

Figure 4. Multi regression.

3.2. Structural Equation Modeling

- The results from Table 5 present a Structural Equation Modeling (SEM) analysis, which examines the direct effects of local governance structures, policy enforcement, and community engagement on wildfire management. SEM is a robust statistical method used to assess complex relationships among variables, including both direct and indirect effects. This analysis focuses specifically on the direct effects, as indicated by the standardized coefficients (β), t-values, and *p*-values. Local Governance Structures - > Wildfire Management: The standardized coefficient (β) of 0.60 indicates a strong positive relationship between local governance structures and wildfire management, meaning a unit increase in the effectiveness of local governance structures is associated with a 0.60 unit increase in wildfire management effectiveness when other variables are held constant. The high t-value of 9.82 suggests that the relationship is statistically significant, and the *p*-value less than 0.001 confirms that the effect of local governance structures on wildfire management is highly significant.
- Policy Enforcement - > Wildfire Management: The standardized coefficient (β) of 0.45 shows a positive relationship between policy enforcement and wildfire management, meaning a unit increase in policy enforcement effectiveness corresponds to a 0.45 unit increase in wildfire management effectiveness. The t-value of 7.50 indicates a statistically significant relationship, and the *p*-value less than 0.001 further confirms the significance of the effect of policy enforcement on wildfire management.
- Community Engagement - > Wildfire Management: The standardized coefficient (β) of 0.30 indicates a moderate positive relationship between community engagement and wildfire management, meaning a unit increase in community engagement is associated with a 0.30 unit increase in wildfire management effectiveness. The t-value of 5.21 shows that the relationship is statistically significant, and the *p*-value less than 0.001 confirms the significant effect of community engagement on wildfire management.
- Model fit indices: The chi-square (χ^2) value is 120.56 with 12 degrees of freedom and a *p*-value less than 0.001, indicating a significant difference between the observed and expected covariance matrices, though chi-square is sensitive to sample size. The Root Mean Square Error of Approximation (RMSEA) is 0.05, suggesting a close fit to the population covariance matrix, with values below 0.05 indicating a very good fit and values up to 0.08 representing reasonable errors of approximation. The Comparative Fit Index (CFI) is 0.95, which indicates a very good fit by comparing the target model to an independent (null) model. The Standardized Root Mean Square Residual (SRMR) is 0.03, showing a good fit as values below 0.08 are generally considered satisfactory.

The SEM results indicate that effective local governance, strong policy enforcement, and active community engagement are essential for improving wildfire management in Pakistan's peri-urban and rural areas. Strong local governance enhances planning and resource allocation, while effective policy enforcement ensures compliance with fire safety regulations, reducing the risk of wildfires. Community engagement promotes safer practices and early detection. Overall, strengthening these elements can significantly improve wildfire management and reduce wildfire incidents and impacts in these regions, underscoring the importance of a comprehensive approach that addresses socio-economic factors contributing to human negligence.

Table 5. SEM of local governance structures, policy enforcement, and community engagement (IVs) and wildfire management (DV).

Pathway	Standardized Coefficient (β)	t-Value	*p*-Value	Significance
Local Governance Structures - > Wildfire Management	0.60	9.82	<0.001	***
Policy Enforcement - > Wildfire Management	0.45	7.50	<0.001	***
Community Engagement - > Wildfire Management	0.30	5.21	<0.001	***
Model Fit Indices				
Statistics			Value	
χ^2 (Chi-square)			120.56 (df = 12, $p < 0.001$)	
RMSEA (Root Mean Square Error of Approximation)			0.05	
CFI (Comparative Fit Index)			0.95	
SRMR (Standardized Root Mean Square Residual)			0.03	

*** 1% significance level. Source: Calculated by authors.

Figure 5 presents a graphical representation of the Structural Equation Modeling (SEM) analysis, showing the pathways between local governance structures, policy enforcement, community engagement, and wildfire management. In the diagram, the nodes represent the variables, while the edges indicate the standardized coefficients (β) for each pathway, with numerical values displayed along the edges. This visualization clearly illustrates the relationships and highlights the strength of the impact that each predictor has on wildfire management.

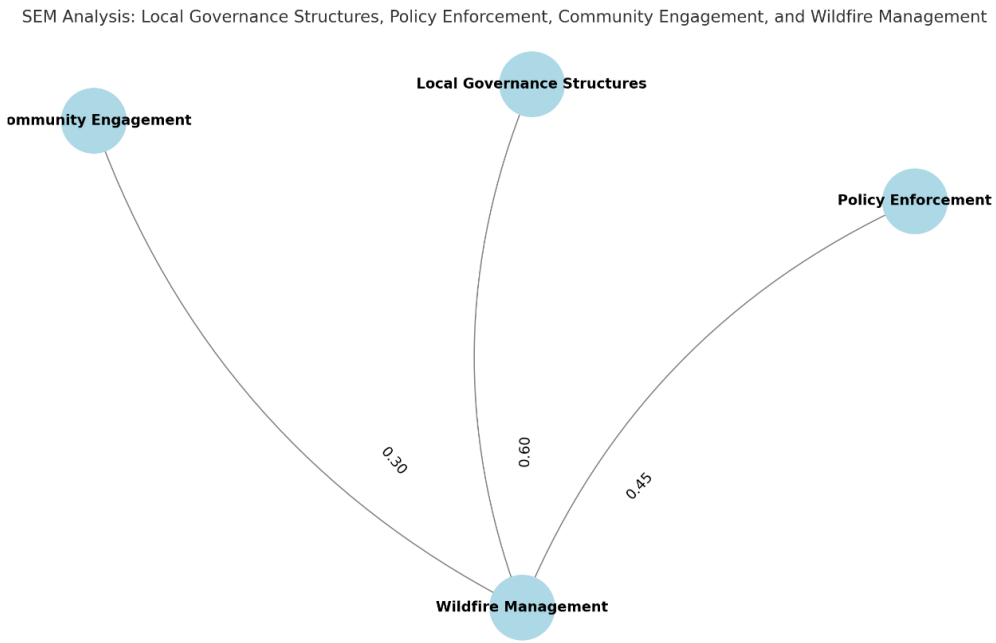


Figure 5. Structural equation modeling.

3.3. Correlation Analysis

Table 6 presents the correlation analysis between negligent behaviors (independent variable, IV) and awareness/knowledge about wildfire risks (dependent variable, DV) among residents. This analysis is important for understanding how these two variables interact within the socio-economic determinants of human negligence in wildfire incidents.

Table 6. Correlation analysis between negligent behaviors (IV) and awareness/knowledge about wildfire risks (DV).

Variable	Measures	Negligent Behaviors (IV)	Awareness/Knowledge About Wildfire Risks (DV)
Negligent Behaviors (IV)	Pearson Correlation	1	−0.40 **
	Sig. (2-tailed)		<0.001
	N	500	500
Awareness/Knowledge about Wildfire Risks (DV)	Pearson Correlation	−0.40 **	1
	Sig. (2-tailed)	<0.001	

Source: Calculated by authors (** correlation is highly significant at the 0.05 level (2-tailed), r (500) = −0.40 **; $p < 0.001$).

The Pearson correlation coefficient between negligent behaviors and awareness/knowledge about wildfire risks is −0.40. This negative correlation indicates a moderate inverse relationship, meaning that as awareness and knowledge of wildfire risks increase, negligent behaviors tend to decrease, and vice versa. In other words, higher awareness and knowledge about wildfire risks are associated with a reduction in negligent behaviors.

The significance value (p-value) for this correlation is less than 0.001, which indicates a highly significant relationship. This p-value suggests that the observed correlation between negligent behaviors and awareness/knowledge is statistically reliable and unlikely to have occurred by chance. The significance level of 0.001 confirms that the correlation is robust and meaningful.

The analysis is based on a sample size of 500, which is substantial and enhances the reliability of the findings. A larger sample size ensures that the results are more generalizable and not merely due to a small or biased sample.

The moderate negative correlation in Table 6 suggests that increasing awareness and knowledge about wildfire risks can help reduce negligent behaviors. In Pakistan's peri-urban and rural areas, where resources and educational opportunities may be limited, improving awareness is essential for mitigating negligence. Policymakers should integrate educational initiatives into wildfire management strategies, emphasizing community outreach and tailored information campaigns. Overall, increasing public awareness is key to reducing negligence and addressing the socio-economic factors influencing wildfire management.

The graphical representation in Figure 6 of the correlation analysis includes a regression plot and a correlation matrix. The regression plot shows the relationship between negligent behaviors and awareness/knowledge of wildfire risks, with the red line indicating the data trend. The correlation matrix is displayed as a heatmap, illustrating the correlation between the two variables. A value of −0.40 represents a moderate negative correlation, indicating that as awareness and knowledge of wildfire risks increase, negligent behaviors tend to decrease. The correlation is marked with **, indicating statistical significance with a p-value less than 0.001.

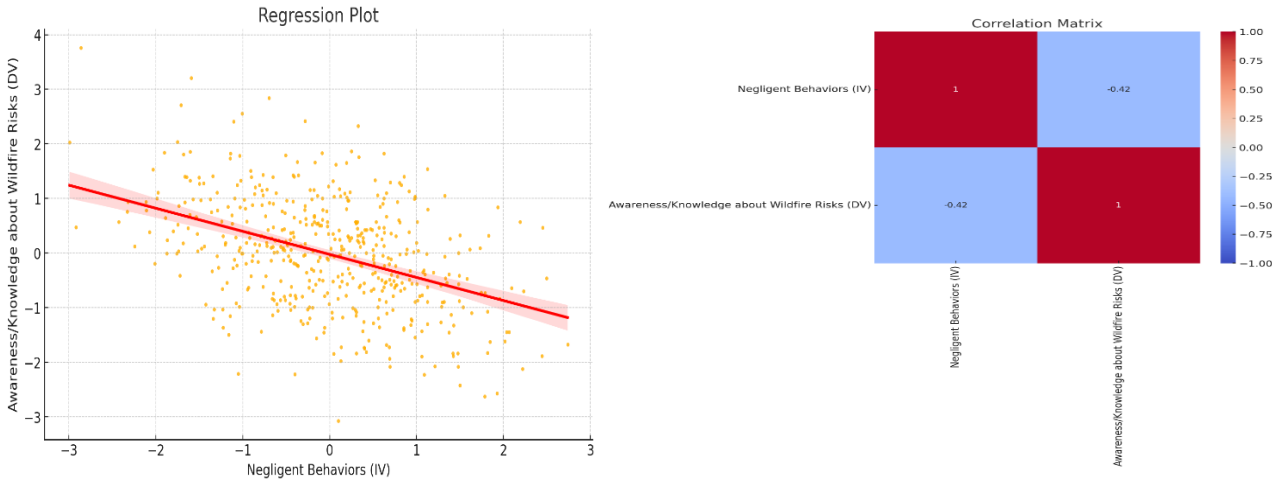


Figure 6. Regression plot and correlation matrix.

3.4. Chi-Square Test of Independence

Table 7 presents the results of a chi-square test of independence, analyzing the association between wildfires and migration patterns, as well as socio-economic stability. The table includes the observed and expected frequencies for migration patterns related to wildfire incidents.

Table 7. Chi-square test of independence: wildfires and migration patterns/socio-economic stability.

	Migrated (Observed)	**Migrated (Expected)**	**Not Migrated (Observed)**	**Not Migrated (Expected)**
Wildfire	250	210	50	90
No Wildfire	100	140	100	60
Total	350		150	
Statistics			Value	
Chi-Square Statistics			63.50	
Degree of Freedom			1	
Significance Level			0.05	
Critical Value			3.841	
p value			<0.0001	

Source: Calculated by authors.

The observed frequencies show that in wildfire-affected areas, 250 individuals migrated, while 50 did not. In contrast, in areas without wildfires, 100 people migrated, and 100 did not. The expected frequencies were 210 for those who migrated and 90 for those who did not in wildfire-affected areas, while in non-wildfire areas, the expected frequencies were 140 for migrated and 60 for non-migrated individuals.

The chi-square statistic is 63.50, which measures the difference between the observed and expected frequencies. This large value indicates a strong deviation from what would be expected if there was no relationship between wildfires and migration patterns. With 1 degree of freedom and a critical value of 3.841 at the 0.05 significance level, the calculated chi-square statistic far exceeds this threshold. The *p*-value is less than 0.0001, well below the 0.05 significance level, confirming that the relationship between wildfires and migration patterns is highly significant.

These results suggest a strong association between wildfires and migration patterns, indicating that wildfires significantly influence migration rates. Communities affected by wildfires are more likely to experience higher migration compared to those not affected. This

finding highlights the impact of wildfires on socio-economic stability and the movement of populations, underscoring the need to address both the immediate and long-term consequences of wildfires on affected communities.

The graphical representation in Figure 7 of the chi-square test of independence includes two heatmaps and a bar plot. The first heatmap displays the observed values for the categories "Migrated" and "Not Migrated" under the conditions of "Wildfire" and "No Wildfire." The second heatmap presents the expected values calculated based on the observed data. Additionally, the bar plot compares the chi-square statistic of 63.50 with the critical value of 3.841. The dashed lines in the bar plot represent these values, clearly illustrating that the chi-square statistic is significantly higher than the critical value, supporting the rejection of the null hypothesis of independence.

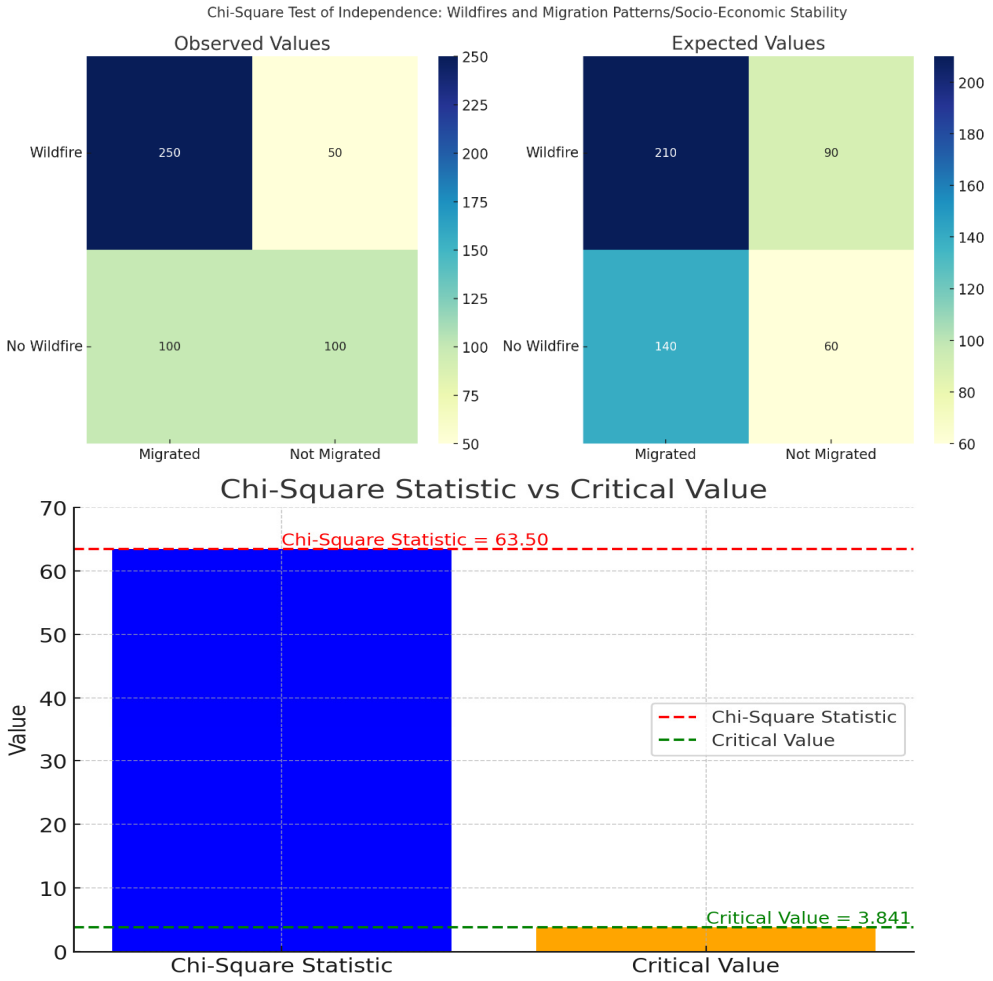


Figure 7. Chi-square of independence.

3.5. Multiple Linear Regression

Table 8 presents the results of a multiple linear regression analysis examining the impact of wildfires on regional climate change indicators, including greenhouse gas emissions, local temperature changes, and precipitation changes. This analysis is crucial for understanding how wildfires contribute to climate change indicators in Pakistan's peri-urban and rural areas, considering socio-economic determinants of human negligence in wildfire incidents.

- Intercept: The intercept is 0.123 with a standard error of 0.045, a t-value of 2.733, and a *p*-value of 0.006. This indicates that the baseline level of regional climate change indicators, when all predictors are at zero, is significantly different from zero.

- Wildfire incidence: The coefficient for wildfire incidence is 0.589, with a standard error of 0.112, a t-value of 5.268, and a *p*-value less than 0.001. This significant positive coefficient suggests that an increase in wildfire incidence is associated with a notable increase in regional climate change indicators. This impact is highly significant, indicating a strong relationship between wildfires and changes in climate indicators.
- Greenhouse gas emissions: The coefficient is 0.421, with a standard error of 0.078, a t-value of 3.369, and a *p*-value of 0.001. This positive coefficient indicates that higher greenhouse gas emissions are associated with increased regional climate change indicators, with statistical significance confirming the relationship.
- Local temperature change: The coefficient is −0.237, with a standard error of 0.064, a t-value of −3.702, and a *p*-value less than 0.001. The negative coefficient suggests that an increase in local temperature change is inversely related to regional climate change indicators, though this is somewhat counterintuitive. The relationship is statistically significant.
- Precipitation change: The coefficient is 0.315, with a standard error of 0.091, a t-value of 3.462, and a *p*-value of 0.001. This positive coefficient indicates that changes in precipitation are positively associated with regional climate change indicators, and the relationship is statistically significant.
- Model summary: The R^2 value of 0.623 indicates that approximately 62.3% of the variability in regional climate change indicators can be explained by the model, which includes wildfire incidence, greenhouse gas emissions, local temperature change, and precipitation change. The adjusted R^2 value of 0.615 accounts for the number of predictors in the model and suggests that 61.5% of the variability is explained after adjusting for the number of predictors. The F-statistic of 76.421, with a *p*-value less than 0.001, indicates that the overall model is statistically significant, meaning that the predictors collectively have a significant impact on regional climate change indicators. The analysis is based on a sample size of 500, which provides a robust basis for the results and enhances the reliability of the findings.

The multiple linear regression analysis shows that wildfire incidence has a significant positive effect on regional climate change indicators, meaning that increased wildfires contribute substantially to changes in climate parameters. Greenhouse gas emissions and precipitation changes also positively impact these indicators, while local temperature change shows a negative relationship, which may warrant further investigation. The model explains a significant portion of the variability in climate change indicators and demonstrates that the predictors collectively provide a meaningful explanation of the changes observed. This analysis highlights the critical role of wildfires in influencing regional climate dynamics and emphasizes the need for targeted strategies to manage wildfire impacts in the context of broader climate change considerations.

Table 8. Linear regression analysis: wildfires (IV) and regional climate change indicators (DV).

Variable		Coefficient	Standard Error	t-Value	*p*-Value
Intercept		0.123	0.045	2.733	0.006
Wildfire Incidence		0.589	0.112	5.268	<0.001
Greenhouse Gas Emissions		0.421	0.078	3.369	0.001
Local Temperature Change		−0.237	0.064	−3.702	<0.001
Precipitation Change		0.315	0.091	3.462	0.001
Model Summary					
R^2	Adjusted R^2	F-Statistics	*p*-Value	Sample Size (N)	
0.623	0.615	76.421	$p < 0.001$	500	

Source: Calculated by authors.

The graphical representation of the multiple linear regression analysis in Figure 8 shows the coefficients and their standard errors for the variables. Wildfire incidence is positively and significantly related to regional climate change indicators, as indicated by its coefficient. Similarly, greenhouse gas emissions also show a positive and significant relationship. In contrast, local temperature change is negatively related, indicating a significant inverse relationship. Precipitation change is positively and significantly related to regional climate change indicators. The plot includes annotations for t-values and *p*-values, as well as the R^2, adjusted R^2, F-statistics, and sample size information.

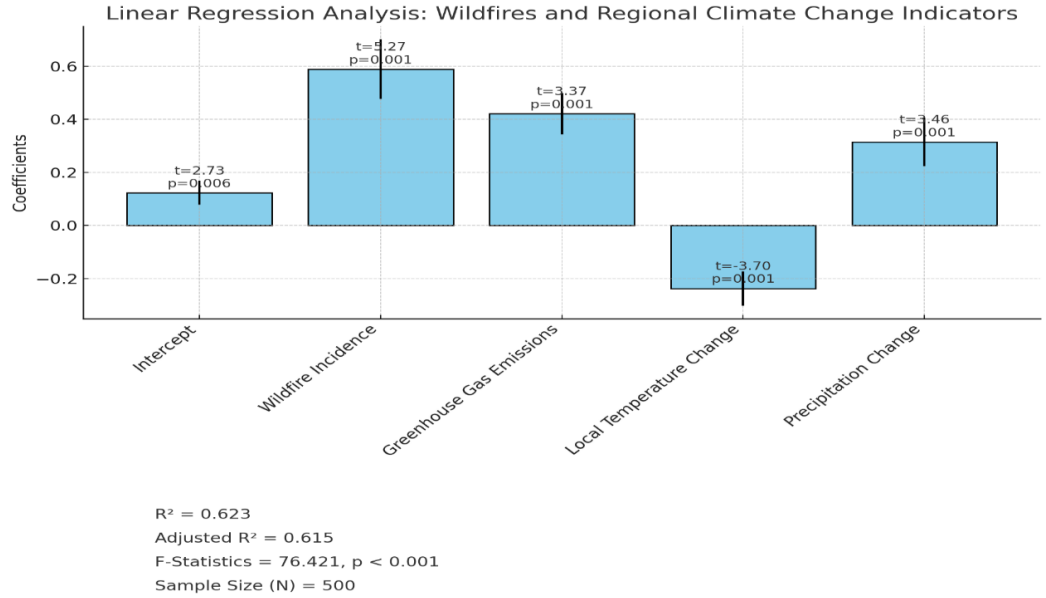


Figure 8. Multiple linear regression analysis.

4. Discussion

The multiple regression analysis revealed that socio-economic conditions, including poverty levels, education levels, and access to resources, significantly influence human negligence in wildfire incidence. Higher poverty levels are associated with increased negligence, likely due to limited resources and lack of awareness, while higher education levels and better access to resources are linked to reduced negligence. These findings align with previous studies, such as those by Vélez-Echeverri [38] and Lehoucq [39], which highlight the critical role of socio-economic factors in influencing human behavior in environmental risk contexts. For instance, Vélez-Echeverri found that lower socio-economic status correlates with higher environmental risks due to inadequate resources and awareness. Similarly, Lehoucq demonstrated that education significantly reduces environmental negligence by increasing awareness and understanding of risks and preventive measures.

The SEM analysis underscored the importance of local governance structures, policy enforcement, and community engagement in wildfire management. Effective local governance enhances planning and resource allocation, robust policy enforcement ensures compliance with fire safety regulations, and active community engagement promotes safer practices and early detection of wildfires. These results are supported by studies such as those of Collins [40] and Jakes et al. [41], which emphasize the critical role of governance and community involvement in disaster management. Collins et al. highlighted how effective local governance and policy enforcement can mitigate wildfire risks, while Jakes et al. stressed the importance of community engagement in enhancing resilience and proactive wildfire management [42,43].

The correlation analysis revealed a moderate inverse relationship between awareness and knowledge about wildfire risks and negligent behaviors. This indicates that higher awareness and knowledge significantly reduce negligent behaviors, consistent with the findings of McCaffrey et al. [44] and Schumann III et al. [45]. McCaffrey et al. found that

community education and awareness programs are crucial in reducing wildfire risks by promoting responsible behaviors [46]. Johansson and Lidskog [47] also demonstrated that increased awareness and knowledge about wildfire risks lead to significant reductions in negligence and improved community preparedness [48,49].

The chi-square test of independence showed a significant association between wildfires and migration patterns, indicating that areas affected by wildfires experience higher migration rates. This is in line with studies by Talebi et al. [50] and Graus et al. [51], which documented how environmental disasters such as wildfires drive population displacement and affect socio-economic stability. Geering and Lubroth [52] found that wildfires significantly impact migration patterns, causing socio-economic disruptions. Méndez and Zucker [53] highlighted that such migrations are often due to the immediate and long-term socio-economic impacts of wildfires, including loss of homes and livelihoods.

The multiple linear regression analysis demonstrated that wildfire incidence significantly affects regional climate change indicators, such as greenhouse gas emissions, local temperature changes, and precipitation changes. This relationship is supported by previous research, including studies by Abatzoglou et al. [54] and Mariani et al. [55] found that wildfires contribute significantly to regional climate dynamics. Kitzberger et al. [56] showed that wildfires are major contributors to regional greenhouse gas emissions, while Bowman et al. [57] highlighted their impact on local temperature and precipitation patterns, further emphasizing the intricate links between wildfires and climate change.

Comparing the results of this study with previous research reveals both similarities and unique contributions. Similar to studies by Vélez-Echeverri and Lehoucq, this study confirms the significant role of socio-economic conditions in influencing human negligence and wildfire risks. The findings on the importance of local governance and community engagement align with the work of Collins and Jakes et al., while the inverse relationship between awareness and negligent behaviors is consistent with McCaffrey et al. and Johansson and Lidskog. Additionally, the association between wildfires and migration patterns supports the conclusions of Abatzoglou et al. and Kitzberger et al.

However, this study uniquely integrates these socio-economic determinants within the context of Pakistan's peri-urban and rural areas, providing a localized perspective that is often missing in broader studies [58,59]. This focus on a specific geographical and socio-economic context offers valuable insights into the unique challenges and dynamics of wildfire management in these regions. Moreover, by employing multiple regression, SEM, correlation, chi-square tests, and linear regression, this study provides a comprehensive analysis of the complex interactions between socio-economic factors and wildfire incidence, contributing to a more nuanced understanding of wildfire management and policy implications in developing regions.

4.1. Recommendations

The study's findings offer several practical policy recommendations for mitigating wildfire risks and addressing their socio-economic impacts in Pakistan's peri-urban and rural areas:

4.1.1. Poverty Alleviation and Resource Access

- Targeted social programs: Implement specific poverty reduction programs, such as cash transfers, microfinance, and vocational training, aimed at residents in wildfire-prone areas. These programs can provide immediate financial relief and build long-term resilience by enhancing income-generating skills.
- Investment in education: Expand educational infrastructure, particularly in rural areas, by building more schools and providing scholarships or subsidies to low-income families. This can help raise awareness about wildfire risks and prevention methods.
- Improved resource distribution: Establish government-led initiatives to ensure equitable distribution of fire prevention resources, such as firefighting equipment, water supplies, and first-aid kits, especially in remote areas with limited infrastructure.

4.1.2. Strengthening Local Governance and Policy Enforcement

- Capacity building for local authorities: Develop training programs for local government officials and fire safety personnel to enhance their ability to plan, coordinate, and enforce wildfire management strategies. These programs should focus on risk assessment, emergency response, and regulatory compliance.
- Stricter enforcement of fire safety regulations: Strengthen existing fire safety regulations with clearer penalties for non-compliance, and set up a task force to monitor enforcement. Regular inspections and audits of compliance should be mandatory in high-risk areas.
- Decentralized governance: Empower local governance structures by allocating more financial resources and decision-making authority to local bodies for efficient wildfire management.

4.1.3. Promoting Community Engagement

- Wildfire awareness campaigns: Launch nationwide awareness campaigns using radio, TV, social media, and community workshops to educate residents on the causes of wildfires, prevention methods, and emergency responses. These campaigns should be tailored to local languages and cultural contexts to maximize engagement.
- Participatory wildfire management programs: Establish community-based programs that encourage active participation in wildfire prevention and control efforts. These programs could include volunteer fire brigades, neighborhood patrols, and training sessions on fire safety practices.

4.1.4. Comprehensive Disaster Management Policies

- Migration preparedness plans: Develop disaster management policies that include provisions for temporary shelters, relocation assistance, and livelihood support for communities forced to migrate due to wildfires. Local governments should prepare detailed evacuation routes and ensure that emergency relief services are available in high-risk areas.
- Long-term recovery programs: Introduce long-term support programs that help wildfire-affected communities rebuild their homes, restore livelihoods, and access social services, such as healthcare and education, after migration.

4.1.5. Integrating Wildfire Management with Climate Action Plans

- Link wildfire mitigation to climate policy: Ensure that wildfire management is incorporated into national climate change strategies, including Pakistan's National Climate Change Policy. This could involve creating carbon offset programs that restore forests in fire-affected areas and reduce carbon emissions from wildfires.
- Regional coordination: Foster regional collaboration with neighboring countries to share best practices, data, and resources for managing wildfires and reducing their contributions to climate change. This can include joint fire monitoring systems and coordinated firefighting efforts across borders.

4.2. Limitations and Future Directions

A cross-sectional-based study with a smaller sample size is deemed to be one of the limitations of the present study. Keeping in view the yardsticks of validity and reliability, a future study needs to be carefully investigated under a larger sample size with mixed-method research. In addition, this study was limited to a case study of the peri-urban and rural areas of one province of Pakistan, which may not allow generalization to the whole of Pakistan due to various institutional factors and ecological scenarios. Thus, holistic and diverse geographical regions in future studies could enhance the robustness of the results with vivid policy implications at macro and micro levels being the order of the day. To achieve SDG 15 (Life on Land), we need to focus on protecting, restoring, and promoting the sustainable use of land ecosystems and forests, as well as stopping biodiversity loss. A

geospatial approach should be explored through institutions and from a multidisciplinary perspective in future plans, using clear and insightful analysis.

5. Conclusions

The research findings underscore the significant impact of socio-economic conditions on human negligence regarding wildfire incidents in Pakistan's peri-urban and rural areas. The multiple regression analysis indicates that higher poverty levels correlate with increased negligence, likely due to inadequate resources and knowledge. In contrast, higher education levels and improved access to resources are associated with reduced negligence. These relationships emphasize the need for targeted interventions to address poverty while enhancing education and resource availability to mitigate wildfire risks.

The Structural Equation Modeling (SEM) analysis further highlights the critical role of effective local governance structures, robust policy enforcement, and active community engagement in improving wildfire management. Strengthening these elements is essential for enhancing planning, resource allocation, compliance with fire safety regulations, and promoting safer practices and early detection within communities.

Moreover, correlation analysis reveals that increasing awareness and knowledge about wildfire risks significantly reduces negligent behaviors. This finding underscores the importance of integrating educational initiatives into wildfire management strategies, focusing on community outreach and tailored informational campaigns to improve public awareness and decrease negligence.

The chi-square test of independence demonstrates a strong association between wildfires and migration patterns, indicating that wildfires significantly influence migration rates and socio-economic stability. Addressing both immediate and long-term consequences of wildfires on affected communities is vital for maintaining socio-economic stability.

Finally, the linear regression analysis shows that wildfire incidence significantly contributes to regional climate change indicators, emphasizing the critical role of wildfires in influencing climate dynamics. The findings suggest that effective wildfire management and targeted strategies are essential for mitigating wildfire impacts within the broader context of climate change.

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