Climate and Urban Fire Disaster in Mountain Environment of Aizawl Municipal Corporation Area, Mizoram, India

R. Lalrinchhana, R. Zonunsanga*[1],
Rintei Renthlei[1], Zothansanga Hmar[1] and, Ankita Mishra[1]

Abstract

Fire is known as the earliest element which roots human civilization. It serves as an excellent servant but also sometimes exhibits its characters as a terrible master. Fire-induced disasters are amongst the most destructive hazards in urban environment as they imposed massive threats to loss of properties and lives especially to the weaker sections in the society such as youngsters, old-aged and female. Fire disasters can be however mitigated through awareness and analysis of atmospheric weather condition to comprehend its risk and vulnerability. Mizoram is one of the most vulnerable states of fire hazards due to frequent delay in the onset of the monsoon and prevalence of long dry spell season. The urban environment having high density of buildings poses threats to occurrences of fire from house to house. This paper attempts to analyze the various climatic and weather elements with environmental scenarios and correlate the same with the occurrences of house fire within the jurisdiction of the Aizawl Municipal Corporation Area (AMC). Data procured from the Fire and Emergency Services Department, Government of Mizoram and the Meteorological Centre, Aizawl have been analyzed including other secondary data collected from reliable sources. The study reveals that low rainfall, low humidity and low temperature are the factors imposing threats to urban fire in the study area.

Keywords: *Climate, Hazards, Disasters, Environment, Urbanization, Season*

[1] Centre for Disaster Management, Mizoram University, Aizawl, Mizoram, INDIA
[*] Corresponding Author: ascassdir@gmail.com

1. Introduction

The history of humanity starts with the discovery of fire which is the earliest source of power. Fire is known as the earliest element which roots human civilization. The four fundamental and basic requirements of human civilization have been food, clothing, shelter, and security since the beginning of time. Perhaps man first came into contact with fire to fulfil his primal craving (Jain 2007).

Disasters caused by fire are extremely dangerous for people, property, and the environment. These terrible occurrences can happen anywhere, at any moment, and leave destruction and hopelessness in their wake. It is essential to comprehend the origins, effects, determinant factors, anthropogenic activities and mitigation strategies for fire disasters in order to lessen their negative social effects.

Fire hazard, either natural or man-made has dominated the field of disasters (Cavallini et al. 2007). Fire serves as an excellent servant, but also as a terrible master. Fire and fire-related accidents cause the biggest concern and carry the highest risk of all hazards. The presence of a well-equipped public fire service and their correct servicing and maintenance; proper in-build fire safety measures in the building/premises as per specifications lower the fire risk to a large extent. The majority of fire disasters are caused by human error, inadequate maintenance, or sabotage. Almost everywhere, including houses, offices, hospitals, or public spaces, one can expect to encounter fire disaster (Vidyadharan et al. 2018). Mitigating or eliminating the adverse effects of such fires on the service functions of urban ecosystems, while enhancing the resilience of urban greening systems in disaster prevention and risk reduction, has become a pivotal challenge in modern urban development and management (Zhang et al. 2025).

The number of fire accident has significantly increased, putting lives in danger and harming the economy and the environment (Felix et al. 2015). Uncontrolled fire is one of the main of building collapses, causing damage, probable injury and loss among other factors (Wong and Jan 2003). The subject of fire safety management has become a source of concern for the Indian situation because, on average, about 21 (33.5%) men and 42 (66.5%) women passed away each day from such fire and related reasons (Vidyadharan et al. 2018). According to the National Crime Records Bureau, fire causes the death of roughly 60 persons each day in India with approximately 25,000 people perishing annually as a result of fires and other associated cause. Urbanization and its consequent population pressure increase the number of high-rise buildings and hence the implementation fire safety has become significantly difficult (Kodur et al. 2019). Yao et al. (2024) mentioned that temperature variability is one of the primary factors of urban fire in China and that the fire-temperature relationship is seasonally and regionally explicit.

Apart from other disasters, Mizoram is one of the most vulnerable states of fire hazards in India. As per the record (2012 - 2021) of the Department of Fire and Emergency Services, Government of Mizoram, there were 728 house fire causing 30 fatalities and 71 injuries. In most cases, these recorded fire disasters were the resultants of malfunctioning and leakage of electricity and negligence and, hence the need of systematic and effective fire hazard management is crucial for the state. Many of these incidents are reported to have started from the places where foods are cooked at the basement of houses for domesticated animals which are reared for commercial purposes at the suburb of the city.

2. Background of the Study Area

The present study is mainly confined in the AMC area which is the capital of Mizoram, one of the northeastern states of India. It is located within the grids of 23^0 39’36” - 23^0 48’ 00” N latitude and 92^0 40’ 48” - $92^0$45’00” E longitude in the northern part of the state, covering 176 km^2 (Figure 1). The city is densely populated with several high-rise building constructed mostly along steep slopes and hill-top which makes the buildings highly vulnerable from catching fire from one building to the other. Further, its geographical features impose certain restrictions for traffic movement of concerned personnel during fire disaster and emergency.

Aizawl District has the highest district-wise population and highest urban population in Mizoram. The average sex ratio of Aizawl urban area (2011 Census) was 1,024 female per 1000 males showing the high vulnerability of casualties and fatalities arising from the dominant female population. Further, the city is prone to fire disaster due to lack of spatial planning. Due to rapid urbanization and population pressure, the organized areas with growing population are gradually converting into unorganized area causing greater problems (Sharma 2020).

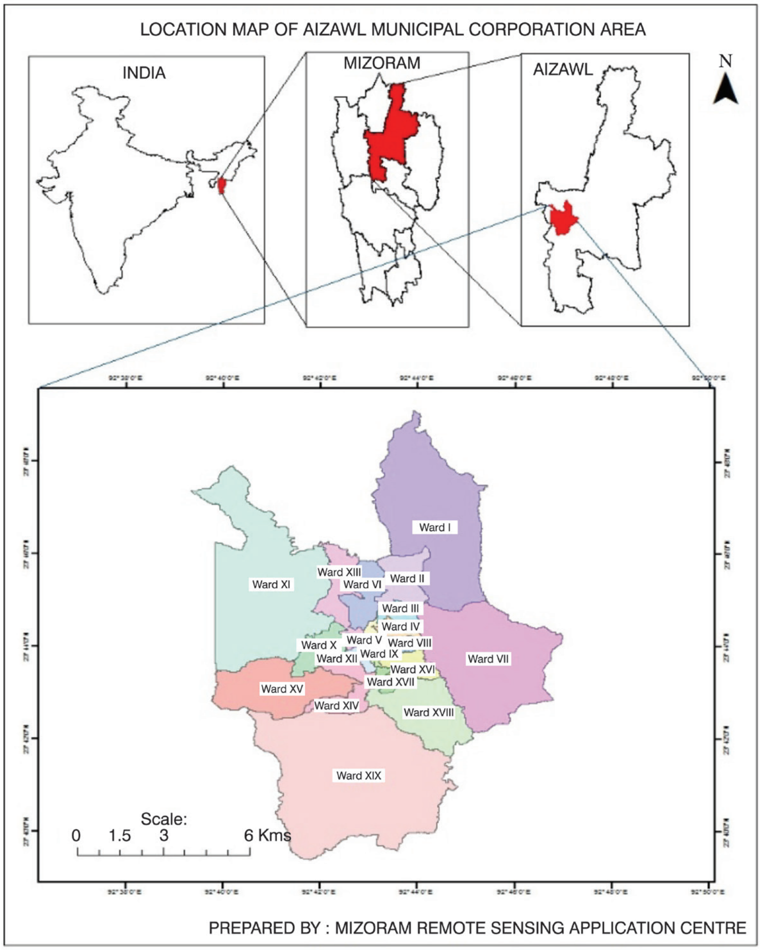

Figure 1 : Map of AMC Area

The AMC, formed in the year 2010, is divided into 19 Wards and represented by 19 elected members and others, officially appointed by the Governor of Mizoram. There are 85 Local Councils comprising of several elected members under these 19 Wards.

3. Data Collection and Methodology

This paper is based on a time-dimensional analysis of past fire disaster extracted and gathered from the official records of the Fire and Emergency Services Department, Mizoram and the daily weather data including temperature, humidity and rainfall were collected from the Meteorological Centre, Aizawl covering the period during 2012 – 2022.

The two main metrics used to assess the severity of a fire disaster during a certain time period were the quantity and value of property loss and the number of fire disaster incidents. The two primary climatic seasons classified as 'dry' and 'wet' seasons are used to determine the occurrences of fire in the area. The months of January to April and November to December are considered as Dry seasons and the other remaining six (06) months are classified as Wet season. Calculation of the average temperature is based on the lowest and highest daily temperatures to acquire the average temperature for a month and similarly for the course of the eleven (11) years. Descriptive statistics such as mean, percentage etc. are used in this research to simplify the analyzed data. Besides, a multiple regression is utilized to predict and explain the expected and actual data.

Multiple Regression Analysis (Factors Affecting House Fire Cases in AMC Area) In this study a multiple regression was employed to predict and explain the house fire cases in the AMC area. A regression equation is a statistical tool that helps to determine the value of the dependent variable using the independent variable.

$$y_i=\beta_O+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\mu_t$$

Where yi the dependent variable, $X_1, X_2 \ldots\ldots X_n$ are independent variables which help to predict the value of y_i, $\beta_1, \beta_2 \ldots\ldots\ldots\ldots \beta_n$ are coefficients.

In this study, the dependent variable is house fire cases and independent variables are humidity, temperature, and rainfall. The analysis of multiple regression are discussed as follows:

Dependent variable : House fire cases (yi)

Independent variables : X_1= Temperature (Degree Centigrade)

X_2= Humidity (Percentage)

X_3=Rainfall (mm)

$$\text{Fire Cases}=\beta_0+\beta_1\ (\text{Temperature})+\beta_2\ (\text{Humidity})+\beta_3\ (\text{Rainfall})+\mu_t$$

Table 1 : Coefficient of Determination

R	R Square[b]	Adjusted R Square	Sig.	Std. Error of the Estimate
.915[a]	0.837	0.776	.002[b]	5.289

a. Predictors: Temperature, Humidity, Rainfall.

c. Dependent Variable: House fire cases.

From the table above R^2 =0.837 which indicate that 83.7 percent changes or variation in house fire cases was explained by humidity, temperature, and rainfall, while the remaining 16.3 per cent were unexplained by Random error which may results from other factor not considered in this research.

Table 2 : Multiple Regression Analysis of Fire Cases in Relation to Humidity, Temperature, and Rainfall

Variable	Unstandardized Coefficients	SE of B	Standardized Coefficients	T value	P value
Temperature	-1.827	1.112	-0.369	-1.643	0.139
Humidity	-0.656	0.346	-0.472	-1.894	0.095
Rainfall	-0.456	0.753	-0.197	-0.605	0.562

Note: * denotes significant at 5 per cent level.

*One regression equations was found out to predict the value of dependent variable.

4. Results and Discussion

According to historical fire statistics, over 90% of the known fires are human-caused (Guo et al. 2016) and human activities are the main causes of fires especially where population density is high (Zong et al. 2021) that weather conditions alone have the least responsibility towards fire outbreak and weather factors are the only influencing factors and such environmental factors cannot be generalized. The research findings of Guo et al. (2023) however reveal that the hysteresis effect of temperature is very important in driving fire occurrence.

According to Table 1, the multiple regression coefficient of 0.915 reflects the strength of the association between the actual and expected fire cases. Since the projected values are generated as a linear combination of humidity, temperature, and rainfall, the coefficient value of 0.915 suggests a strong and positive association between house fire cases and the three independent variables. The R-square (R^2) that is Coefficient of Determination assesses the goodness of fit of the estimated Sample Regression Plane (SRP) in terms of the percentage of the variation of the response variables that is described by the sample regression equation. Hence, the value of R^2 is 0.837, which indicates that about 83.7 per cent of the variation in house fire cases is explained by the estimated SRP that employs humidity, temperature, and rainfall as independent variables, and the value of R^2 is significant at the 5 per cent level.

Holding all other variables fixed the coefficient temperature of -1.827 shows the partial influence on house fire. The calculated negative sign indicates that this impact is negative, with a -1.827 decrease in house fire for every increase in temperature, and the value of this coefficient is statistically insignificant. The coefficient of humidity is -0.656, which shows the partial influence of humidity on house fire when all other variables are held constant. The calculated negative sign indicates that the impact is positive, with the fire case decreasing by -0.656 for every unit increase in humidity and the coefficient value is significant. The coefficient of rainfall is -0.456, which shows the influence of rainfall on house fire, with other variables being held constant. The estimated negative sign indicates that this impact is negative, with house fire decreasing by -0.456 for every unit increase in rainfall, and the value of this coefficient is statistically significant at 5 percent level. In accordance with the standardized coefficient, rainfall (-0.197) is the most significant element in determining house fire, followed by temperature (-0.369) and humidity (-0.472).

5. Chronology of Fire Disaster

The frequency of house-fire occurrences in the study area during the 11 years (Table 3) shows that there were 212 registered cases with 234 numbers of actual houses on fire.

The highest recorded number of registered house-fire staggering to 26 incidents with actual number of 30 house-fire incidents took place in the year 2012 which was followed by the year 2013 and 2021 as the second and third highest respectively. The year 2022 recorded the lowest number of annual house-fire cases with 14 registered house-fire cases and actual 17 houses burnt and one (01) fatality. This decreased in the number of house fire incident is attributed to the increasing attention towards the concept of disaster resilience gained over the past years (Gernay et al. 2016).

Table 3 : Year-wise Fire Occurrence in the Study Area (2012 – 2022)

Sl. No	Year	Number of House Fire		Number of Casualty		Property Damage Value (INR)
		Case Registered	Actual Number	Loss of lives	Persons Injured	
1	2012	26	30	3	5	8,60,15,110. 00
2	2013	25	25	1	4	1,40,88,180. 00
3	2014	20	23	0	0	2,35,21,000. 00
4	2015	17	21	1	0	1,63,42,500. 00
5	2016	19	19	0	0	1,97,09,900. 00
6	2017	18	20	0	0	8,66,47,000. 00
7	2018	15	16	0	0	3,28,18,000. 00
8	2019	16	16	0	0	1,21,05,730. 00

9	2020	19	19	0	0	4,08,06,680. 00
10	2021	23	28	0	0	9,20,40,000. 00
11	2022	14	17	1	0	4,57,92,220. 00
TOTAL		**212**	**234**	**6**	**9**	**46,98,86,320. 00**

The second and third lowest of fire cases were recorded in the year 2018 and 2019 respectively. Throughout this (11) eleven years, the average number of house-fire was 19.27. It means that about 20 houses are burnt every year and the highest value of property damage and loss was witnessed in the year 2021.

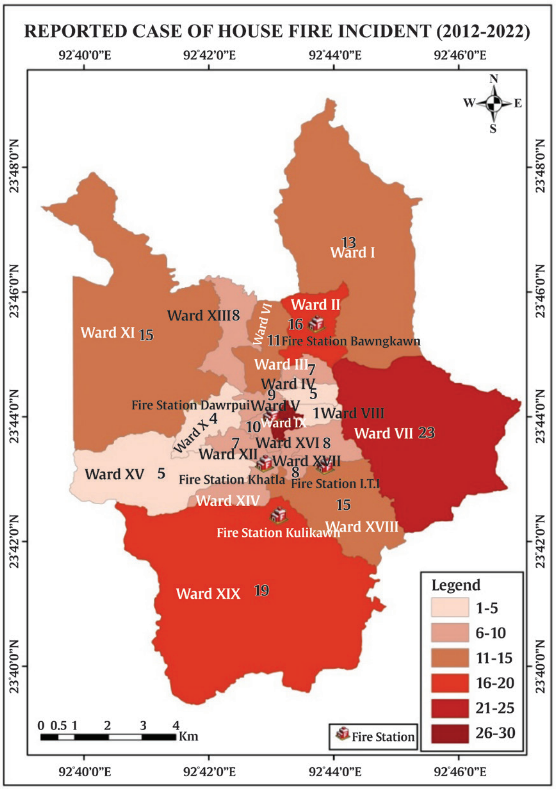

Figure 2 : Location of Fire Stations and No. of reported house fire incident

According to the Meteorological Department, the state of Mizoram typically receives sufficient amount of rainfall from the South-West Monsoon. Owing to its tropical-monsoon location, the region exhibits one of the World's most precipitous zones (Zonunsanga & Magner 2017). The summer monsoon, often known as the rainy season, officially begins in April and lasts until late October. From May through September witnesses heavy rainfall whereas November through February, known as the winter season is often dry and receives relatively low rainfall. Analysis of house-fire frequency reveals that majority of house-fire disaster in the course of the study period occurred during dry season from November to April with a record of 171 houses burnt accounting for almost three-fourth of the total house-fire, and 63 houses burnt during wet season between May to October.

Figure 2 and Table 4 represent the month-wise occurrences of house fire in AMC area during 2012 – 2022 by numbers as well as calculated average. The month of January is observed as having the highest frequency of house fire recorded as 38 houses burnt during the period, followed by March (35), December (32), February (28) and April (23) which all fall under the realms of dry season. The figures apparently show that fire flames spread easily to its other adjacent houses during the dry season. On the other hand, during the wet season the number of house fire incident and the actual number of house on fire were the same, clearly showing that during the wet season, despite the occurrences of fire incident, the flames do not spread to other buildings within its neighborhood. In this regard, not only the climatic conditions, i.e. the dry-rainless season but also the urban environment such as topography and density of houses also determine the risk and vulnerability. During dry season, a single fire incident often caused multiple number of houses on fire which implies that a house on fire imposes high vulnerability to the adjacent house at the higher ground to catch fire owing to both topographic and dryness conditions.

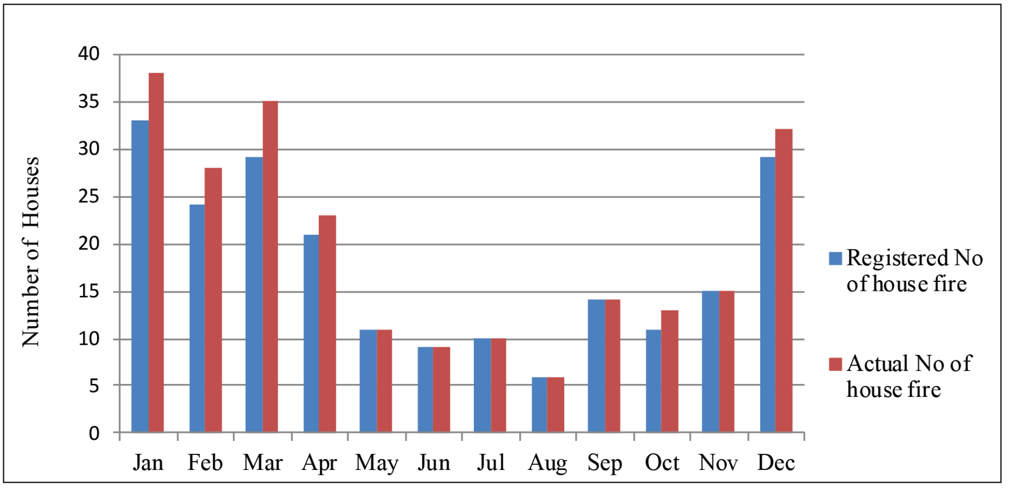

Figure 3 : Month-wise house-fire in the Study area

Table 4 shows that the average weather/climatic parameters of the AMC environment such as temperature, humidity and rainfall of every month during the years from 2012 to 2022 along with the average house fire case as well as the average number of house fire during each respective month. According to the table, during the dry season (January, February, March, April, November and December) the average rainfalls of each month were comparatively less and that the average number of house fire was greater than rest of the remaining wet months.

Additionally, a considerable direct variation was found between the average monthly rainfall and the numbers of monthly house fire case according to the earson correlation result.

Table 4 : Year-wise Fire Occurrence in the Study Area (2012 – 2022)

Month	Average Weather/Climatic Conditions (2012 – 2022)			Total Number of House Fire (2012 – 2022)		Average Number of House Fire (Monthly)		Property Loss and Damage Value (in INR)
	Temperature (ºC)	Humidity (%)	Rainfall (mm)	Cases Registered	Actual Number	Cases Registered	Actual Number	
Jan	17.00	71.20	0.34	33	38	3.00	3.45	9,96,35,100. 00
Feb	19.20	60.30	0.44	24	28	2.18	2.54	3,74,54,000. 00
Mar	21.89	62.98	1.41	29	35	2.63	3.18	3,79,83,720. 00
Apr	22.78	70.30	4.17	21	23	1.90	2.09	7,24,11,900. 00
May	22.76	76.81	8.05	11	11	1.00	1.00	65,38,000. 00
Jun	22.72	82.87	12.83	09	09	0.81	0.81	98,65,500. 00
Jul	22.72	84.50	11.39	10	10	0.90	0.90	1,39,07,000. 00
Aug	22.84	84.05	11.24	06	06	0.54	0.54	38,62,000. 00
Sep	22.71	75.42	9.14	14	14	1.27	1.27	52,87,180. 00
Oct	22.88	82.92	6.23	11	13	1.00	1.18	6,51,44,910. 00
Nov	20.51	75.36	1.23	15	15	1.36	1.36	1,41,15,710. 00
Dec	17.20	71.30	0.41	29	32	2.64	2.90	10,36,81,300. 00
Total Value of Property Loss and Damage (in Rs.)								**46,98,86,320. 00**
Dry Season			*2012 – 2022 Data Analysis Record*				**Wet Season**	

Considering the property damage, the estimated property loss by the concerned authorities during dry period reached more than three quarter, i.e. 78% of the total property loss during the years 2012 to 2022. The total value of property damage/loss during the wet season accounts for only about 22% of the total loss from house fire. To be more precise, the property damage value during the dry season was Rs. 36,52,81,730/- (INR) and during the wet season was Rs. 10,46,04,590/- (INR). This scenario of property loss clearly shows that seasonal variations i.e. either dry or wet seasons exert major influence on the extent of property loss and damage caused by fire where house fire during dry season is more devastating as the fire grows and burns more rapidly before arrival of professional fire fighters.

The monetary value of property damaged by house fire has been calculated by the concerned authority based on the type of houses which are classified as RCC building, Semi-RCC building, Assam type building and Kutcha houses.

Table 5 : AMC Ward-wise House Fire occurrences

AMC Ward No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No of Fire Incident	13	16	7	5	9	11	23	1	28	4	15	10	8	7	5	8	8	15	19
No of House Fire	13	16	7	5	10	15	26	1	28	4	16	10	10	7	10	9	8	19	20

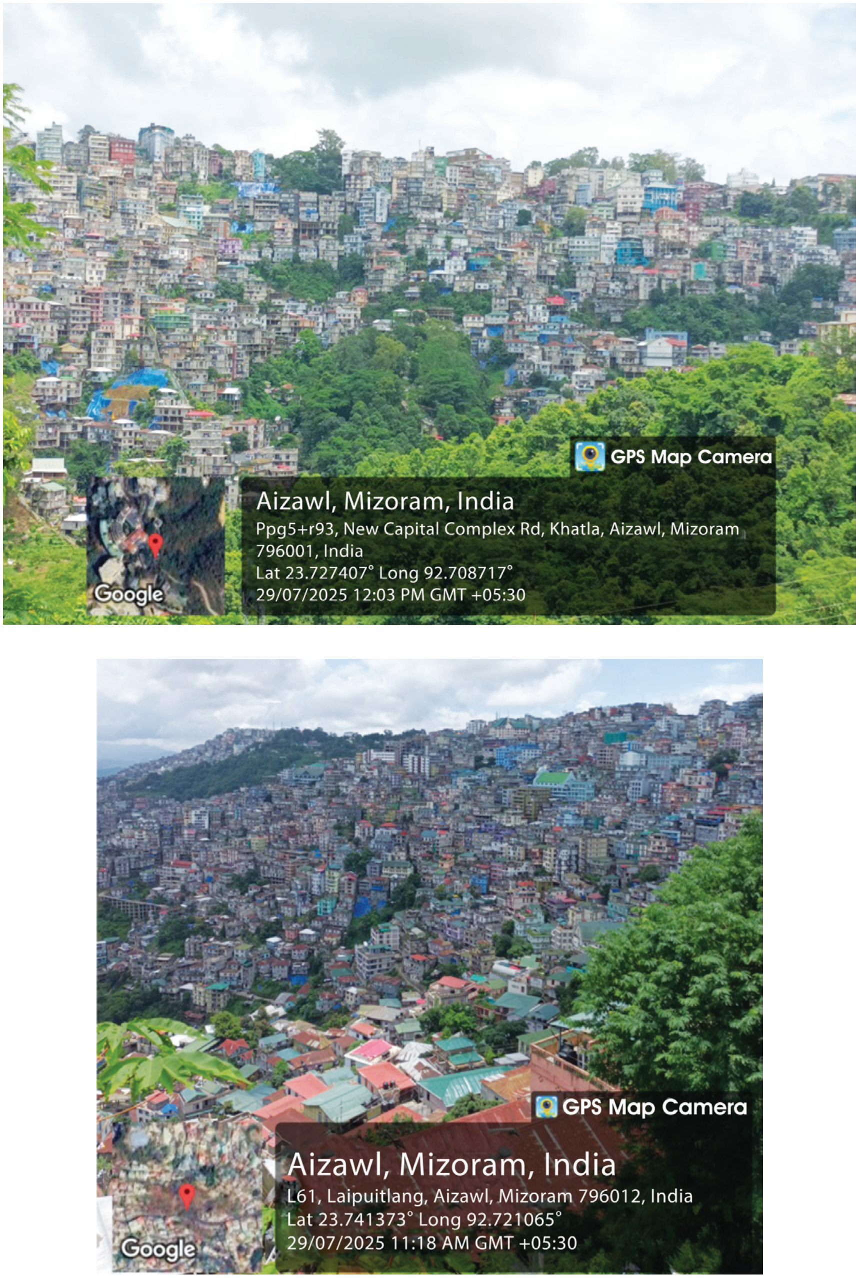

Figure 4 (Plate) : Location of Aizawl City on steep mountainous slope

4. Conclusion and Recommendation

The study revealed that house fire hazard can happen at any climatic seasons but variation in house fire cases is greatly influence by the humidity, temperature, and rainfall in the study area during the study period. Fire events occurred more frequently during the dry season when humidity and air temperature are low.

The results have implications for the Fire and Emergency Services Department, Mizoram and other relevant stakeholders in terms of preventing and reducing fire hazards during times of high fire risk. The services of fire fighters have been recently enhanced through modern equipment and also the installation of fire hydrants attached to domestic water supply pipelines at various stations which have been made in collaboration with the Public Health Engineering Department of the state Government.

Spatial planning of the AMC area is a must to combat fire disasters through augmentation of groundwater recharge by means of afforestation to enhance groundwater infiltration and interception by vegetative canopies. Water availability lowers the risk of fire disaster. House fire at the foothill can cause devastating impact to the adjacent building constructed at the higher slope as flames are subject to rise which could easily transfer the heat and flame upward.

The semi-slums and the marginal are generally residing at the outskirt foothill of the city. Owing to their low economy, burning of fuel-wood for domestic cooking is sometimes necessary, which are further kept unattended and neglected while cooking due to lack of awareness. Electricity supplies are often directly connected from the main lines mostly for use as heater during dry-cold winter season which often cause short circuit and leakages and resulted house fire. Such situations impose serious threats to loss of their lives and properties and also put their neighborhoods at high risks. Accessibility of houses on fire amidst the rugged and narrow terrain without proper roads also hinders the emergency services to quickly respond which can be tackled through induction of highly maneuver light motor vehicles as fire engines to ply through narrow-congested roads.

Figure 5 (Plate) : Panoramic view of the Eastern flank of middle hill ridge, Aizawl

5. Declaration and Statements

The author(s) declare that the research article entitled '*Climate and Urban Fire Disaster in Mountain Environment of Aizawl Municipal Corporation Area, Mizoram, India*' is neither published nor sent for publication elsewhere other than the NIDM's journal 'Disaster and Development'.

Further, the authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article and that the author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Cavallini, M., Papagni, M. F., Baruffaldi Preis, F. W. (2007). Fire Disasters in the Twentieth Century. Annals of Burns and Fire Disasters, 20(2): 101–103.
2. Gernay, T., Selamet, S., Tondini, N. and Khorasani N.E. (2016). Urban infrastructure resilience to fire disaster: An overview. Procedia Engineering, 161: 1801-1805. https://doi.org/10.1016/j.proeng.2016.08.782.
3. Guo, F., Su, Z., Wang, G., Sun, L., Tigabu, M., Yang, X. and Hu, H. (2017). Understanding fire drivers and relative impacts in different Chinese ecosystems. Science of the Total Environment, 605: 411- 425.
4. Guo, M., Yao, Q., Suo, H., Xu, X., Li, J., He, H., Yin, S. and Li, Jianuo. (2023). The importance degree of weather elements in driving fire occurrence in mainland China. Ecological Indicators, 148: 110152. http://doi:10.1016/j.ecolind.2023.110152.
5. Jain, V. K. (2007). Fire Safety in Buildings. Taylor & Francis.
6. Kodur, V., Kumar, P., & Rafi, M. M. (2019). Fire hazard in buildings: Review, assessment and strategies for improving fire safety. PSU Research Review, 4(1): 1-23. https://doi.org/10.1108/PRR-12-2018-0033.

7. Sharma, R.C. (2020). Urban fire risk mitigation. Webinar Report. National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India, New Delhi. Retrieved from https://Report_20November2020aak.pdf.
8. Vidyadharan, A., John, J., Thomas, C., &Yadav, B. P. (2018). Fire Safety Management in India: A Review. In N. A. Siddiqui, S. M. Tauseef, S. A. Abbasi, & A. S. Rangwala (Eds.), *Advances in Fire and Process Safety* pp. 171-181. https://doi.org/10.1007/978-981-10-7281-9_14
9. Wong, N. H., & Jan, W. L. S. (2003). Total building performance evaluation of academic institution in Singapore. Building and Environment, 38(1): 161-176. https://doi.org/10.1016/S0360-1323(02)00021-5.
10. Yao Q., Dabang J., Ben Z., Xiaochun W., Xiaolin Z., Keyan F., Lamei S., Zhou W., Yongli W., Linhao Z., Yanyan P., Amy H., Shuai X., Maowei B., Xinyan H. and Valerie T. (2024). Anthropogenic warming is a key climate indicator of rising urban fire activity in China. National Science Review 11 (5). https://doi.org/10.1093/nsr/nwae163.
11. Zhang, D., Manqing Yao, Yingying Chen and Yujia Liu (2025). The Role of Urban Vegetation in Mitigating Fire Risk Under Climate Change: A Review. Sustainability 17(6). https://doi.org/10.3390/su17062680.
12. Zong, X., Tian, X. and Liu, J. (2021). A fire regime zonation system for China. Frontier in Forests and Global Change, 4, Art. 717499.
13. Zonunsanga, R. and Magner, Joe. (2017). Hydrological engineering for sustainable agriculture in the eastern tropical Himalayas: A conceptual discussion. Science Vision 17 (2): 55-60. https://doi.org/10.33493/scivis.17.02.01.