

## Supplement File S2

**Table S1.** Review of literature on identifying the potential urban fire incidence

<i>Author</i>	<i>Objective</i>	<i>Area</i>	<i>Criteria</i>	<i>Results</i>
[1]	Exploring the effectiveness of social preventative strategies in preventing residential fires	Sweden	Complexes, smokers, elderly, disabled, age of the building, households' alcoholism, population density, income, fire alarm system and warning	The impact of various fire protection techniques varies greatly depending on sociodemographic factors such as age, gender, and living standards.
[2]	Identifying the fire risk in cities near high-risk land uses.	Khulna, Bangladesh	Distance from warehouse and power station, hospital and fire station, population density, the ratio of children, elderly and women, surrounding land uses, condition of electrical appliances connections	Due to the proximity to three oil depots and two power plants, as well as high population density and terrible economic conditions, 25% of the buildings were at low danger, 55% were at medium risk, and 20% were at high risk.
[3]	Studying the fire dynamics and their relevance to urban development	Nanjing, China	Increased population and expanded urbanization	The fire's hot spots have taken on a central-periphery pattern due to the concentration of commercial business activity in the core section and the large population density in the outskirts.
[4]	Modelling the residential fire risk	Helsinki, Finland	Population density, low rate of literacy, unemployment rate, middle income, homeownership, building density, building age, family structure, children and adult rates	Residential fires are spatially unstable, with higher densities in the city centre and lower densities in the eastern part of Helsinki. The fire risk is influenced by community structural elements, socioeconomic level, and housing conditions.
[5]	Recognizing the spatial patterns of fires and the various methods for detecting high-risk areas	Nanjing, China	Urban land uses	The utilization of land has a substantial correlation with the occurrence of fires. Residential structures, business facilities, administrative buildings, recreational and industrial facilities, and other heavily

---

				inhabited locations are also vulnerable to fires.
[6]	Identifying the patterns and features of urban fires	Iasi, Romania	Inadequate housing or building materials, population density, Existing or non-existing a caregiver in the household, lack of access routes, low income, limited access to utility grids)	Fires follow the pattern of the peripheral centre in terms of geographical distribution; neighbourhoods in the surrounding environment are more vulnerable to fire. More fires are concentrated in residential, administrative, cultural, and industrial land uses; these places are frequented by the homeless population, who use rubbish as a raw material.
[7]	Fire risk modelling and analysis	Zanjan, Iran	Location of urban infrastructures such as oil and gas pipelines and power lines, gas station, power substations, fire stations, hydrant valve, industrial uses, department stores, narrow streets, building's technical specifications, availability of firefighting, social education of residents and features of high-rise buildings and their position in creating a fire hazard	When compared to the risk of building features, the risk of urban infrastructure is relatively low, and most high-rise buildings have a medium or high-risk rating. They also found that the distance between the components impacts how high-risk locations are assessed. The findings of the Sensitivity Analysis (SA) also suggest that the most influential element in reducing the danger of fire is inhabitants' social education.
[8]	Studying the relationship between socioeconomic features and urban fire risk in 283 Chinses cities	283 City of China	Population level, population growth, population density, unemployment rate, income level, economic development, education level, regional GDP growth rate, regional GDP per capita, number of industrial enterprises, electricity consumption per capita, gas consumption per capita	Urban fire risk is a complex phenomenon, and it is linked to a variety of socioeconomic factors. While fire incidence is adversely connected to education and income, population density and unemployment rate positively correlate to fire incidence.
[9]	Exploring the relationship between residential fires and	Queensland, Australia	High construction density, population growth, fire stations	The rate of residential fires is higher in the metropolis and poorer neighbourhoods. The high density of building coefficient,

---

	socioeconomic conditions			population expansion, and the number of fire stations might all be the related factors.
[10]	Identifying the buildings' vulnerability located in the old centres of the city related to the fire risk	Seixal, Portugal	Type of land use	The fire risk in commercial, services and industrial buildings tends to be particularly significant.
[11]	Studying the relationship between socioeconomic and demographic characteristics and the rate of fire incidence in residential areas	Midland, England	Population, number of households, population density, single-parent households, unemployment rate, bilingual households, education level, number of children and elderly, crowded households, disabled people, ethnic composition, deprivation	Urban fire risk is highly linked to socioeconomic factors, including population density, unemployment rate, and poverty.
[12]	Studying the fire risk in high-density cities	Surabaya, Indonesia	Population density, gender and poverty ratios, disabled people and age group ratios, GDP, building density, and vital and safety facilities	Building density and population have a positive and significant relationship with fire risk incidence.
[13]	Modelling the probable urban residential fires	Melbourne, Australia	Housing density, real estate, private rental housing, public rental housing, displaced / immigrant residents' percentages during the last five years, and the percentage of residents in the last year	Buildings in the city downtown are more vulnerable, and this is due to economic factors and ownership.
[14]	Discovering the temporal and spatial dynamics of the response time to a residential fire incident	Brisbane, Australia	Response time and number of fire incidents	In heavily inhabited places, the rate of fire is more significant. In less populated locations, emergency response times are also slower.

**Table S2.** The criteria used to identify vulnerable areas in terms of potential fire risk in the study area

<i>Symbol</i>	<i>Criteria</i>	<i>Sub-criteria</i>	<i>Definition and measure unit/ source</i>	<i>Reference</i>	<i>Data source</i>
C1	<b>Socioeconomic</b>	Population density	The number of people per km <sup>2</sup> (or acre) of land.	[1,2,6]	Statistical Center of Iran (SCI)
C2		Household size	Splitting the population by the number of households to get the average number of persons in each household (individuals).	[4]	Statistical Center of Iran (SCI)
C3		Old age ratio	The disabled people to the total population ratio per block multiplied by 100	[11]	Statistical Center of Iran (SCI)
C4		The ratio of the 14-year-old group and lower	14-year-old group ratio and lower	[1,2,4,6,11]	Statistical Center of Iran (SCI)
C5		Disability ratio	65-year-old people and over to the total population ratio per block multiplied by 100	[15]	Statistical Center of Iran (SCI)
C6		Illiteracy rate	The number of illiterate people ratio divided by the total population over six years multiplied by 100	[16]	Statistical Center of Iran (SCI)
C7		Unemployment rate	Unemployed population ratio divided by 15-65-year-old age group multiplied by 100	[17,18]	Statistical Center of Iran (SCI)
C8		Residential units' density	The total area of building units located in a block divided by the area of the census blocks	[4,9]	Municipality of Ardabil City
C9	<b>Built-environment</b>	The ratio of buildings made of non-durable materials	The ratio of the buildings with low-durability materials (such as clay, mud, brick and iron) to total residential units multiplied by 100	[19]	Municipality of Ardabil City
C10		The ratio of older buildings older than 30 years	The actual age of a building is defined as the number of years after it was completed (typically in years). In the current research, this variable represents the ratio of buildings over 30 years old to total building units per block multiplied by 100.	[20]	Municipality of Ardabil City
C11		The ratio of worn-out and demolishing buildings	The ratio of worn-out and demolishing buildings to total buildings multiplied by 100	[6]	Municipality of Ardabil City
C12		Mixed land-use	The ratio of 14-year-old children and lower to the total population multiplied by 100	[10]s	Municipality of Ardabil City
C13		High-rise buildings ratio	The number of six-floor buildings and more to the total buildings located in the blocks multiplied by 100	[21]	Municipality of Ardabil City

C14	Urban infrastructures and facilities	Buildings density with high fire incidence potential	It consists of one refueling centre, buildings next to high voltage power plants and gas supply networks, large industrial centres and wood and mechanics workshops, large warehouses for chemical and combustible products	[7,22]	Municipality of Ardabil City
C15		The ratio of small-sized property units	The ratio of the number of property land parcels less than 120 m <sup>2</sup> to total land parcels per block multiplied by 100	[10]	Municipality of Ardabil City
C16		Distance from the hydrant valves	The distance of the blocks from the hydrant valves per meter (the risk of vulnerability increases as the distance increases)	[23]	Municipality of Ardabil City
C17		Distance from fire stations	The distance of the blocks from the fire stations per meter (the risk of vulnerability increases as the distance increases)	[6]	Municipality of Ardabil City
C18		The degree of permeability of the urban texture	The number of blocks facing streets with less than 6 m of free width.	[6,7]	Municipality of Ardabil City
C19	Previous fire incidences rates	Previous fires rate	The number of fires in each block per 10,000 population is calculated by the Experimental Bayesian Smoothing (EBS) method.	[24]	Municipality of Ardabil City

### Selected References

1. Runefors M, Nilson F. The Influence of Sociodemographic Factors on the Theoretical Effectiveness of Fire Prevention Interventions on Fatal Residential Fires. *Fire Technol.* Published online 2021:2433-2450. <https://doi.org/10.1007/s10694-021-01125-x>.
2. Shama S, Shurid AS, Haque MN. Risk Assessment of Accidental Fire Breakdown in a Residential Area of Khulna City, Bangladesh. *J Eng Sci.* 2021;12(2):109-118. <https://doi.org/10.3329/jes.v12i2.54636>.
3. Zhang, X.; Yao, J.; Sila-Nowicka, K.; Jin, Y. Urban Fire Dynamics and Its Association with Urban Growth: Evidence from Nanjing, China. *ISPRS Int. J. Geo-Inf.* 2020, 9, 218. <https://doi.org/10.3390/ijgi9040218>.
4. Todorovic S. Modelling risk factors in urban residential fires in Helsinki. Published online 2020. Available from: <https://eprints.gla.ac.uk/210971/>. (accessed on 07 March 2023).
5. Xia Z, Li H, Chen Y, Yu W. Detecting urban fire high-risk regions using colocation pattern measures. *Sustain cities Soc.* 2019;49:101607.

<https://doi.org/10.1016/j.scs.2019.101607>.

6. Bulai AT, Roşu L, Bănică A. Patterns of urban fire occurrence in Iasi City (Romania). *Present Environ Sustain Dev*. 2019;(2):87-102. <https://doi.org/10.15551/pesd2019132006>.
7. Masoumi, Z.; van L.Genderen, J.; Maleki, J. Fire Risk Assessment in Dense Urban Areas Using Information Fusion Techniques. *ISPRS Int. J. Geo-Inf*. 2019, 8, 579. <https://doi.org/10.3390/ijgi8120579>.
8. Hu J, Shu X, Xie S, Tang S, Wu J, Deng B. Socioeconomic determinants of urban fire risk: A city-wide analysis of 283 Chinese cities from 2013 to 2016. *Fire Saf J*. 2019;110:e102890-e102890.
9. Chhetri P, Corcoran J, Ahmad S, Kiran KC. Examining spatio-temporal patterns, drivers and trends of residential fires in South East Queensland, Australia. *Disaster Prev Manag An Int J*. 2018, 27(5): 586-603. <https://doi.org/10.1108/DPM-09-2017-0213>.
10. Ferreira TM, Vicente R, da Silva JARM, Varum H, Costa A, Maio R. Urban fire risk: Evaluation and emergency planning. *J Cult Herit*. 2016;20:739-745. <https://doi.org/10.1016/j.culher.2016.01.011>.
11. Hastie C, Searle R. Socio-economic and demographic predictors of accidental dwelling fire rates. *Fire Saf J*. 2016;84:50-56. <https://doi.org/10.1016/j.firesaf.2016.07.002>.
12. Rahmawati D, Pamungkas A, Aulia BU, Larasati KD, Rahadyan GA, Dito AH. Participatory mapping for urban fire risk reduction in high-density urban settlement. *Procedia-Social Behav Sci*. 2016;227:395-401. <https://doi.org/10.1016/j.sbspro.2016.06.091>.
13. Ardiantoa R, Chhetria P, Dunstallb S. Modelling the Likelihood of Urban Residential Fires Considering Fire History and the Built Environment: A Markov Chain Approach. 2015, In: *21st International Congress on Modelling and Simulation, Gold Coast, Australia, 29 Nov to 4 Dec 2015, Available from: https://www.mssanz.org.au/modsim2015/M4/ardianto.pdf. (accessed on 01March 2023)*.
14. Kiran KC. Temporal and spatial patterns of fire incident response time: a case study of residential fires in Brisbane. In: 7th State of Australian Cities Conference, 9-11 December 2015, Gold Coast, Australia, 9-11 December 2015. State of Australian Cities Research Network. Available online: <https://espace.library.uq.edu.au/view/UQ:383963>. (accessed on 02 March 2023).
15. Kuran CHA, Morsut C, Kruke BI, et al. Vulnerability and vulnerable groups from an intersectionality perspective. *Int J Disaster Risk Reduct*. 2020;50:101826. doi:10.1016/j.ijdrr.2020.101826
16. Al-Yasiri HQM. Trends in the illiteracy rate in Iraq and its regional neighborhood for the period 2010-2020. *Misan J Acad Stud*. 2021;20 (40). Available online: <https://www.iasj.net/iasj/article/215027>. (accessed on 20 February 2023).
17. Young AO. Cohort Size and Unemployment Rate: New Insights from Nigeria. *Glob J Emerg Mark Econ*. 2021;13(1):122-151. <https://doi:10.1177/0974910121989461>
18. Guldåker N, Hallin PO. Spatio-temporal patterns of intentional fires, social stress and socio-economic determinants: A case study of Malmö, Sweden. *Fire Safety Journal*. 2014 Nov 1; 70:71-80. <https://doi.org/10.1016/j.firesaf.2014.08.015>.
19. Ni S, Gernay T. A framework for probabilistic fire loss estimation in concrete building structures. *Struct Saf*. 2021;88. <https://doi:10.1016/j.strusafe.2020.102029>.

20. Dadzie J, Ding G, Runeson G. Relationship between sustainable technology and building age: evidence from Australia. *Procedia Eng.* 2017;180:1131-1138. <https://doi.org/10.1016/j.proeng.2017.04.273>.
21. Lago A, Faridani HM, Trabucco D. Damping Technologies for Tall Buildings. 2018, *Butterworth-Heinemann*, 1st edition, Massachusetts , USA. eBook ISBN: 9780128159644.
22. Winandari MIR, Wijayanto P, Faradila. Fire risk based on building density in dense settlement. In: *IOP Conference Series: Earth and Environmental Science*. Vol 780. IOP Publishing; 2021:12053. doi:10.1088/1755-1315/780/1/012053.
23. Raškauskaitė, R.; Grigonis, V. An Approach for the Analysis of the Accessibility of Fire Hydrants in Urban Territories. *ISPRS Int. J. Geo-Inf.* 2019, 8, 587. <https://doi.org/10.3390/ijgi8120587>
24. Cruz MG, Hurley RJ, Bessell R, Sullivan AL. Fire behaviour in wheat crops-effect of fuel structure on rate of fire spread. *Int J Wildl Fire.* 2020;29(3):258-271. doi:10.1071/WF19139.