Introduction

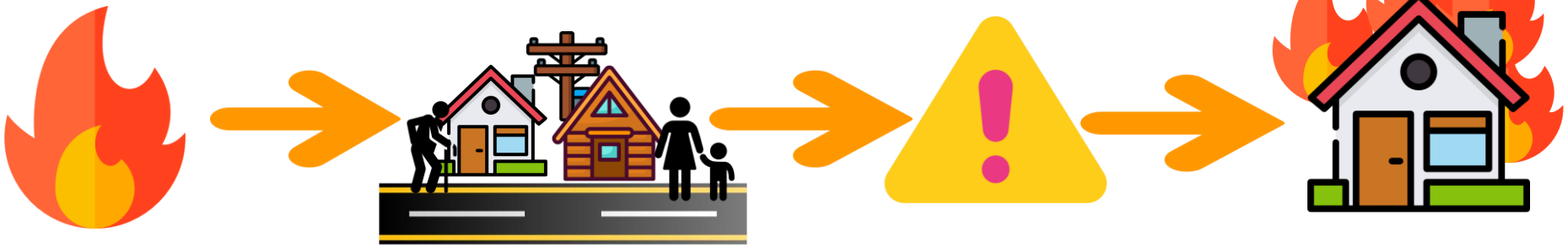
What is the project about?

Identifying fire-prone zones in Bhaktapur Municipality

Strategic interventions for emergency response

Disaster prevention and mitigation

Concept of the project:



Motivation

Why we chose this project?

1. Frequent Fire Incidents
2. High Fire Vulnerability
3. Lack of Fire Zoning and Emergency Infrastructure

What Inspired Us?

1. Community Resilience
2. Application of Civil Engineering in Disaster Response Planning

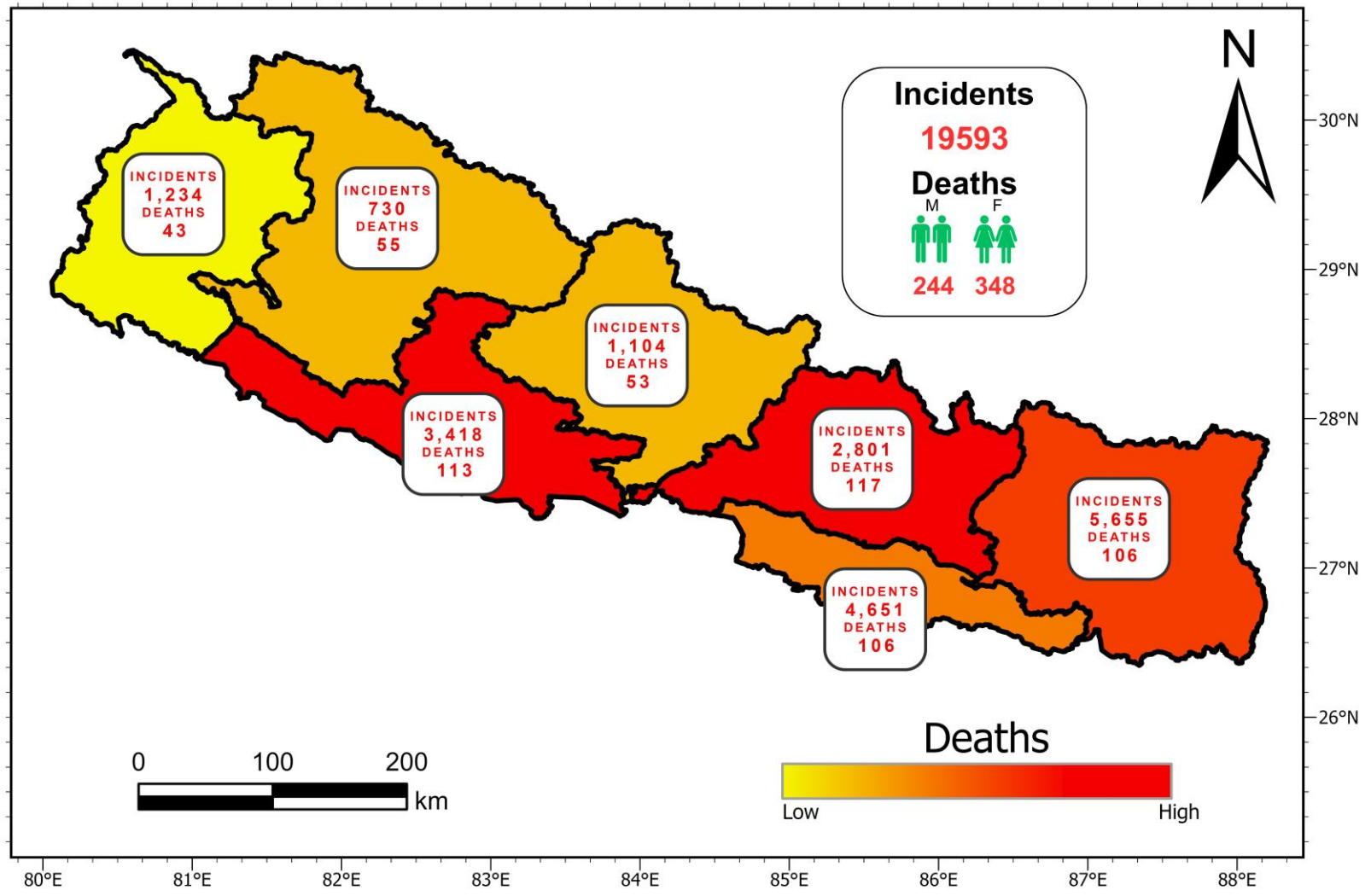


Figure 1: Province-wise distribution of **fire incident and deaths (excluding wildfire)** across Nepal from **2018-2024 AD**; (Data Source: Ministry of Home Affairs)

STUDY AREA

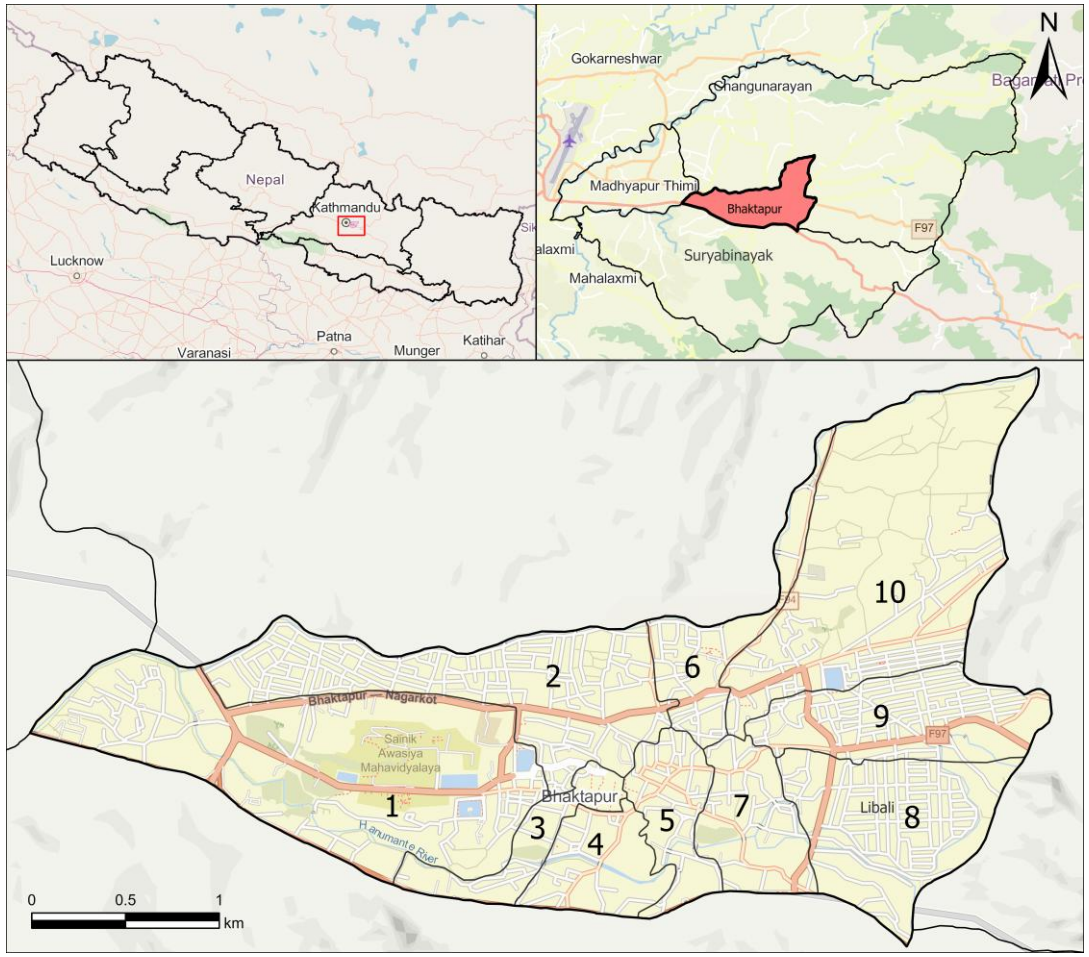


Figure 2: Study area map of Bhaktapur Municipality illustrating the administrative unit boundaries.

Research Question

- Which areas of the Bhaktapur Municipality are most susceptible to fire?
- How are those area at risk?
- Current scenario of public on fire safety, emergency response and preparedness?

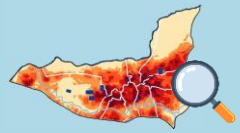
1. Parking Congestion

2. Old House Structure

3. Narrow Alley

4. Cultural Heritage

Objectives



1. Developing Fire Susceptible Map

2. Analyzing Preparedness

3. Proposing Civil Engineering Interventions

4. Response Optimization

Detailed Methodology

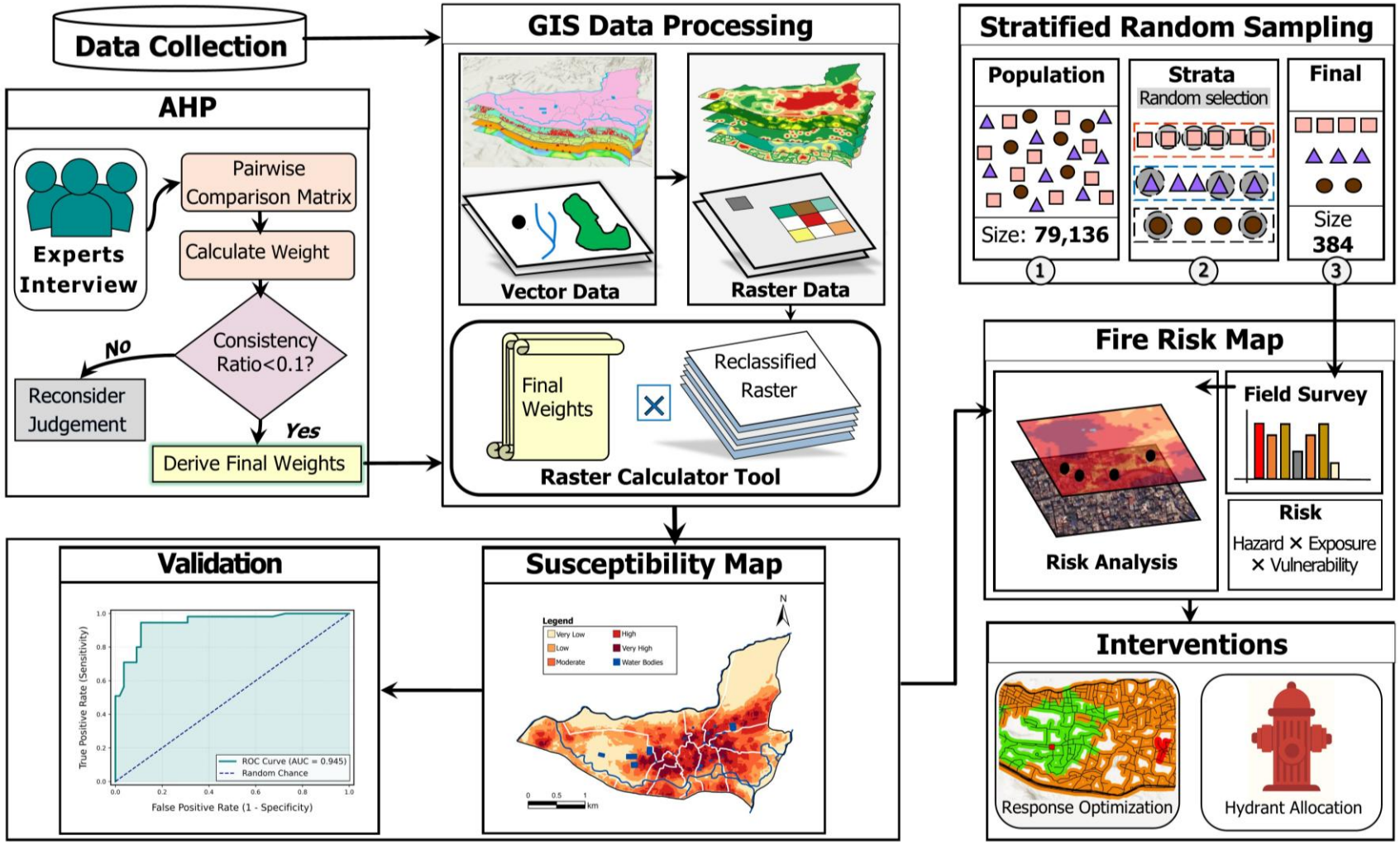


Figure 3: Detailed Methodology

Summarized Methodology

- AHP
- Mapping
- Validation
- Risk
- Interventions

AHP Parameters

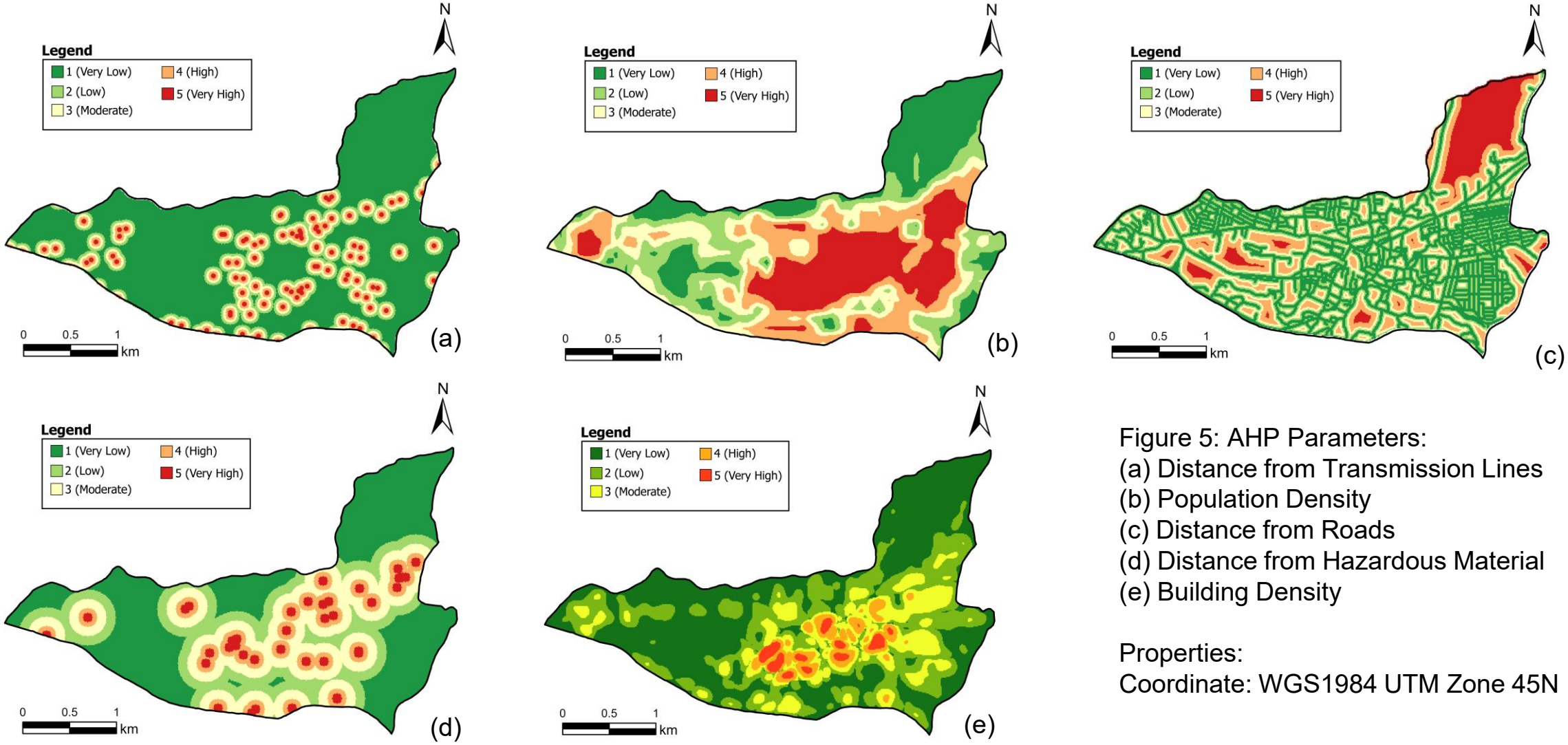


Figure 5: AHP Parameters:
(a) Distance from Transmission Lines
(b) Population Density
(c) Distance from Roads
(d) Distance from Hazardous Material
(e) Building Density

Properties:
Coordinate: WGS1984 UTM Zone 45N

Response Optimization

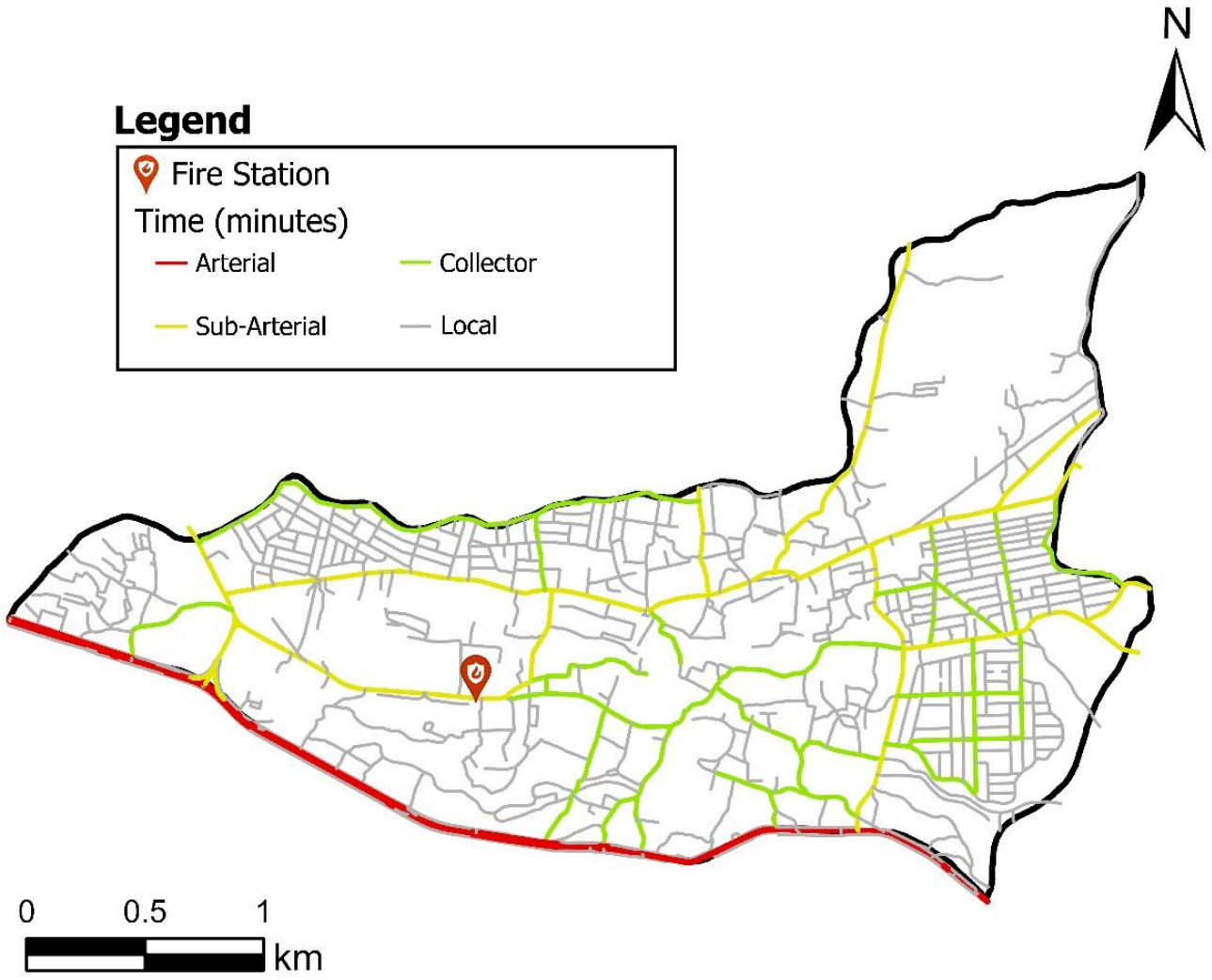


Figure 6: Classification of Road as per Urban Road Standards (2076)

Table 1: Average Speed Assignment

Road class	Surface type	Average speed (km/hr)	
		Peak time	Off-peak time
Arterial road	Blacktopped	50	70
Sub-Arterial road	Blacktopped	25	30
Collector road	Blacktopped	15	25
	Brick-paved	10	15
	Stonepaved	10	15
	Earthen	8	12
Local road	Blacktopped	15	20
	Brick-paved	10	15
	Stonepaved	7	12
	Earthen	5	10

Results and Observations

Table 2: Final weightage of criteria through AHP

Factor	PD	TL	DHM	DR	BD	Weight
PD	1	2	2	4	1	0.297
TL	0.5	1	1	3	0.5	0.162
DHM	0.5	1	3	3	0.333	0.151
DR	0.25	0.333	0.333	1	0.25	0.064
BD	1	2	3	4	1	0.325
					Consistency Ratio (CR) =	0.013

PD	Population Density
TL	Distance from Transmission Line
DHM	Distance from Hazardous Material
DR	Distance from Road
BD	Building Density

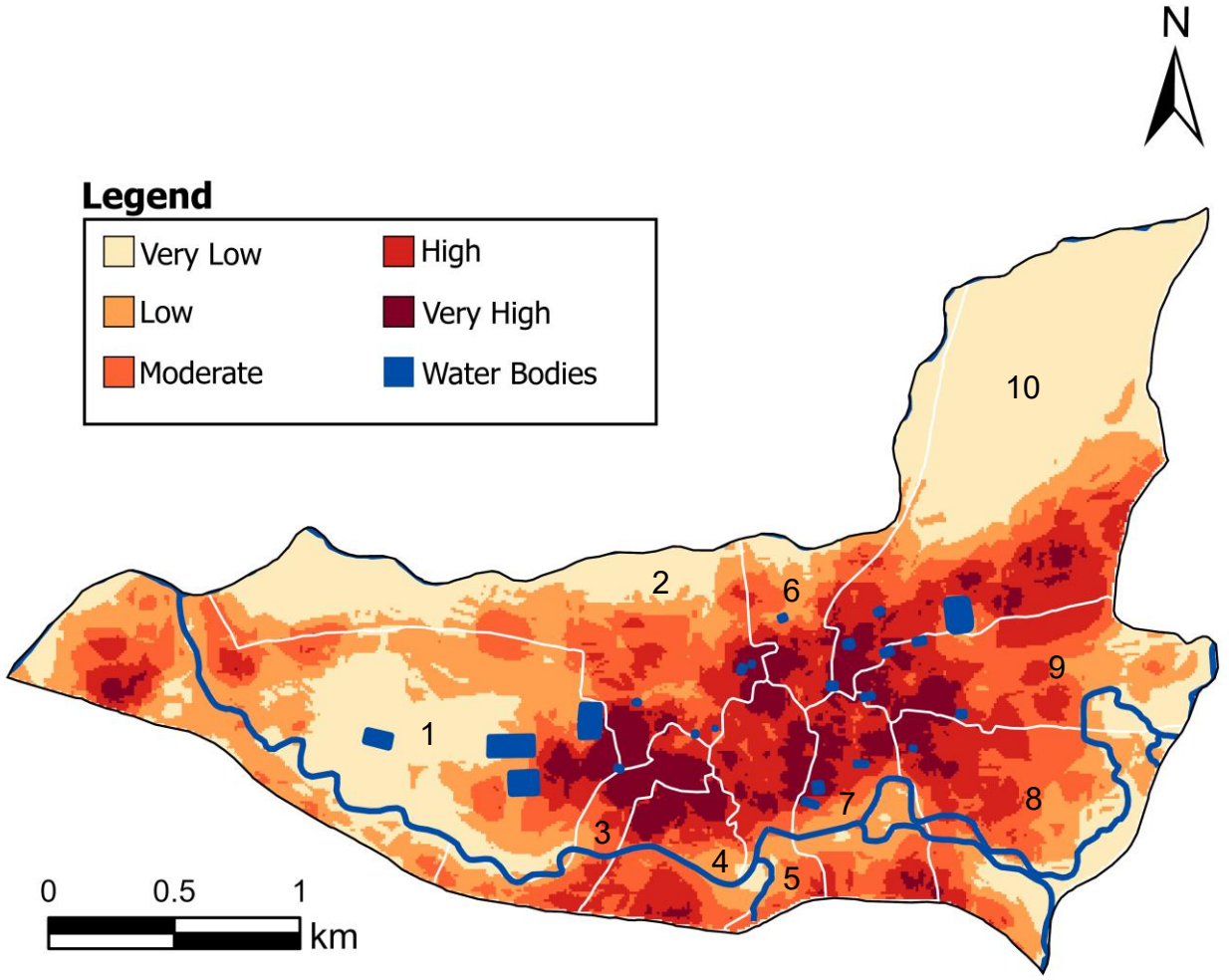


Figure 7: Fire susceptibility map of Bhaktapur Municipality; light colored areas indicate very low fire susceptibility zones while darker colored areas indicate very high susceptibility zones; white represent ward boundary

Validation

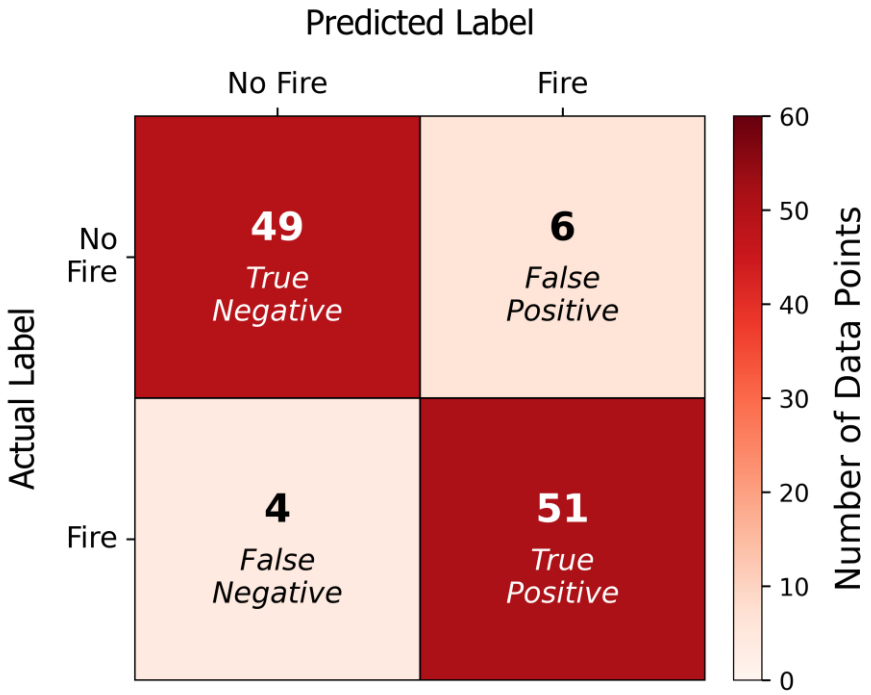


Figure 8: Confusion matrix

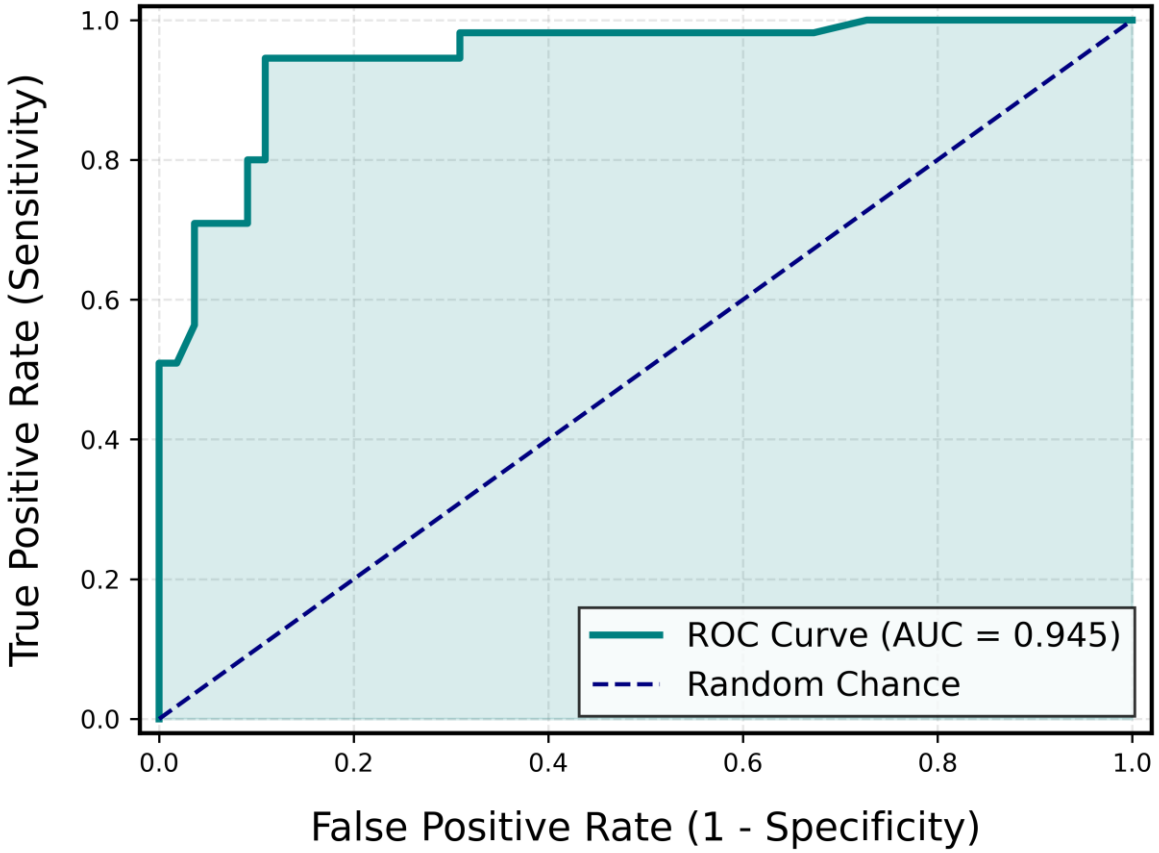


Figure 9: Receiving Operating Characteristics (ROC) Curve

Accuracy : 0.909, Precision : 0.894, F1 Score : 0.91, Kappa Score : 0.81, Recall : 0.927

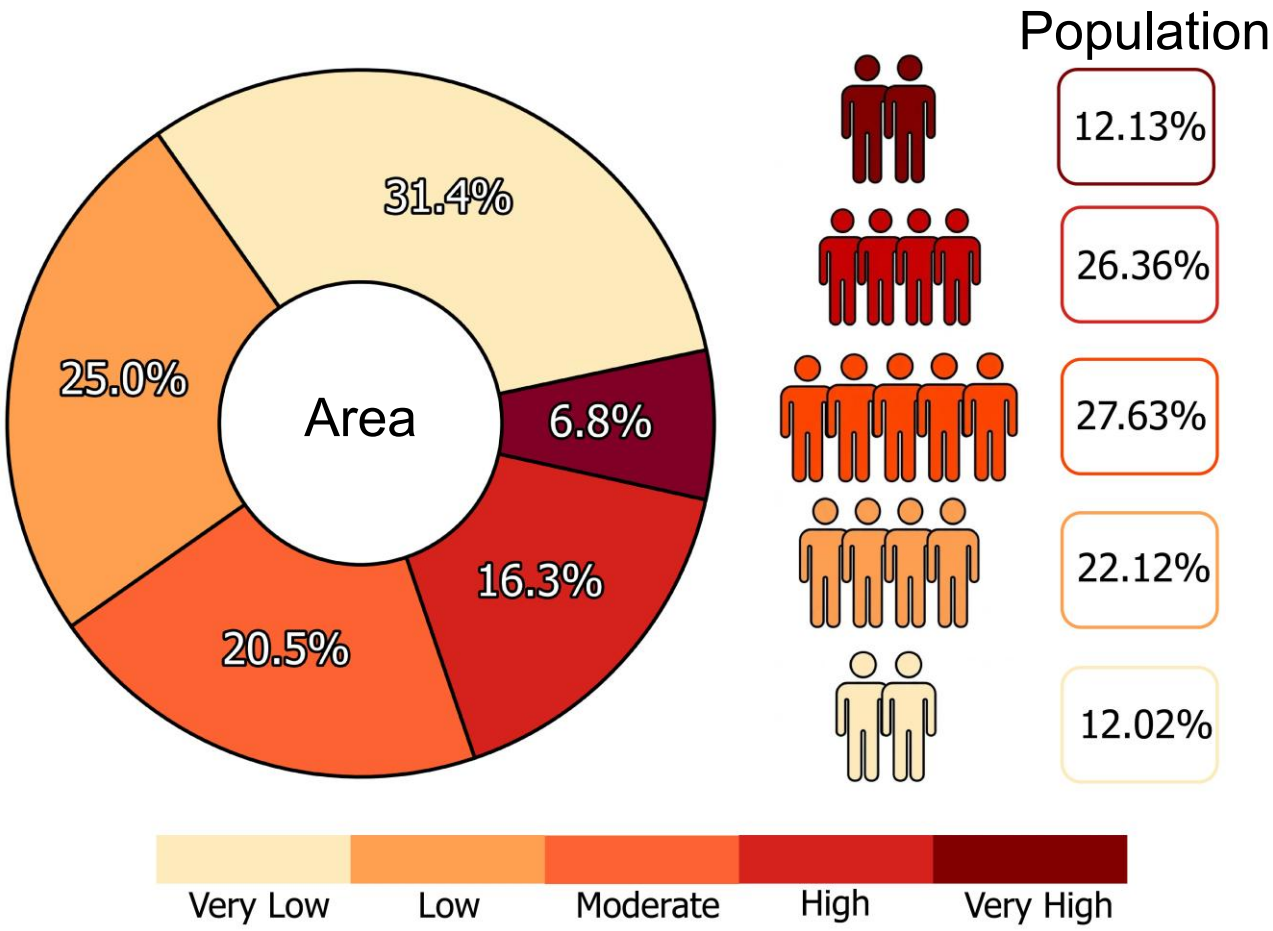


Figure 10: Comparison of land area and population distribution across the susceptible zones.

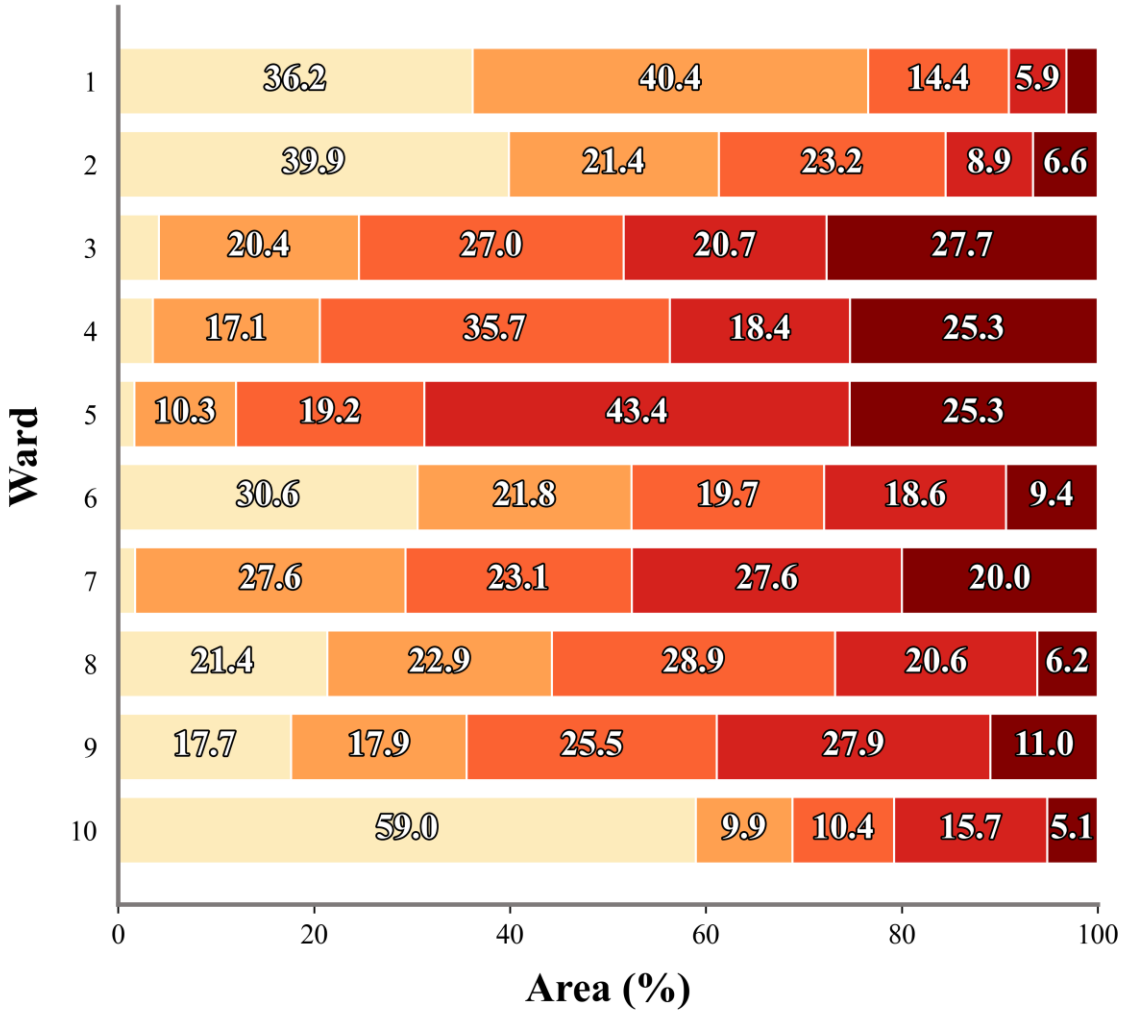


Figure 11: Area covered by fire susceptibility classes in individual wards (in terms of %)

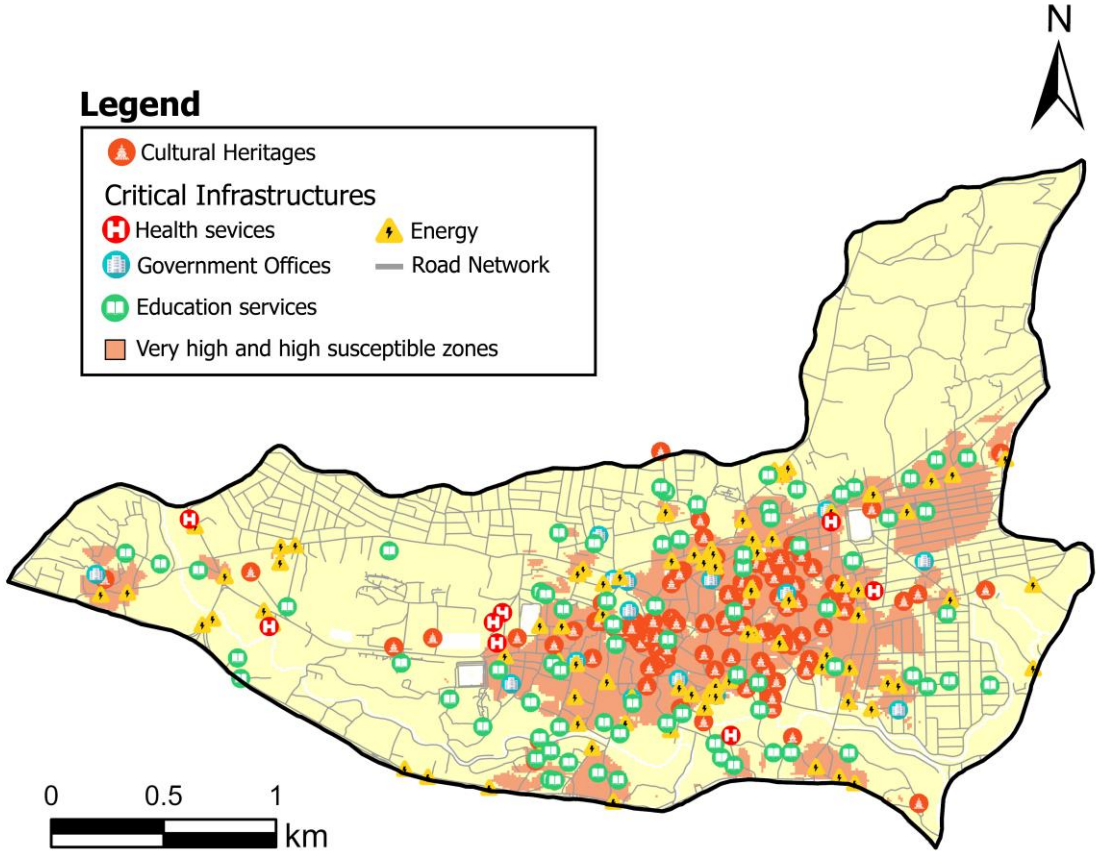


Figure 12: Locations of infrastructures lying along the susceptible zones

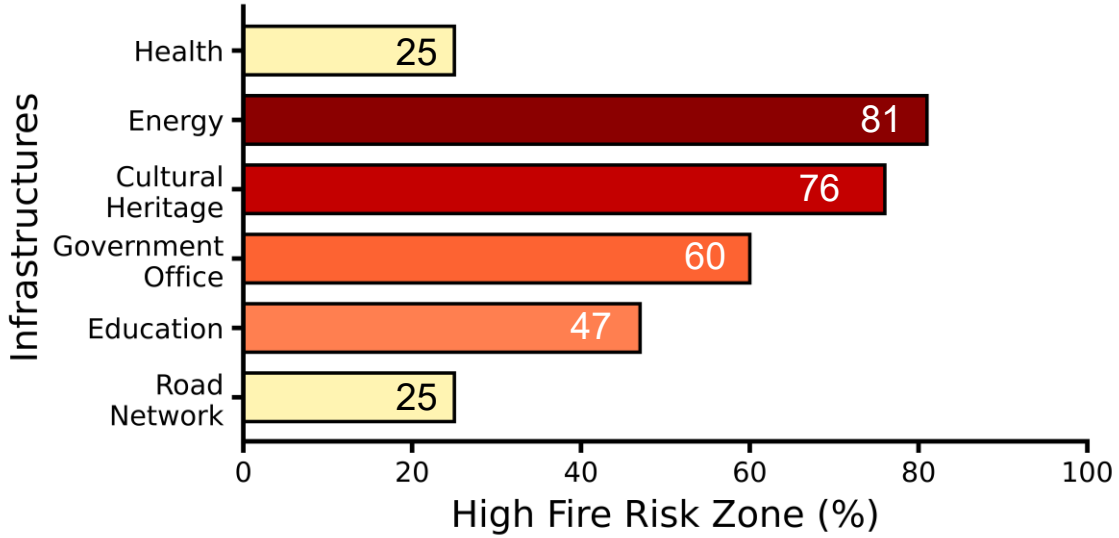


Figure 13: Percentage of infrastructures that falls within a high and very high fire susceptible zone.

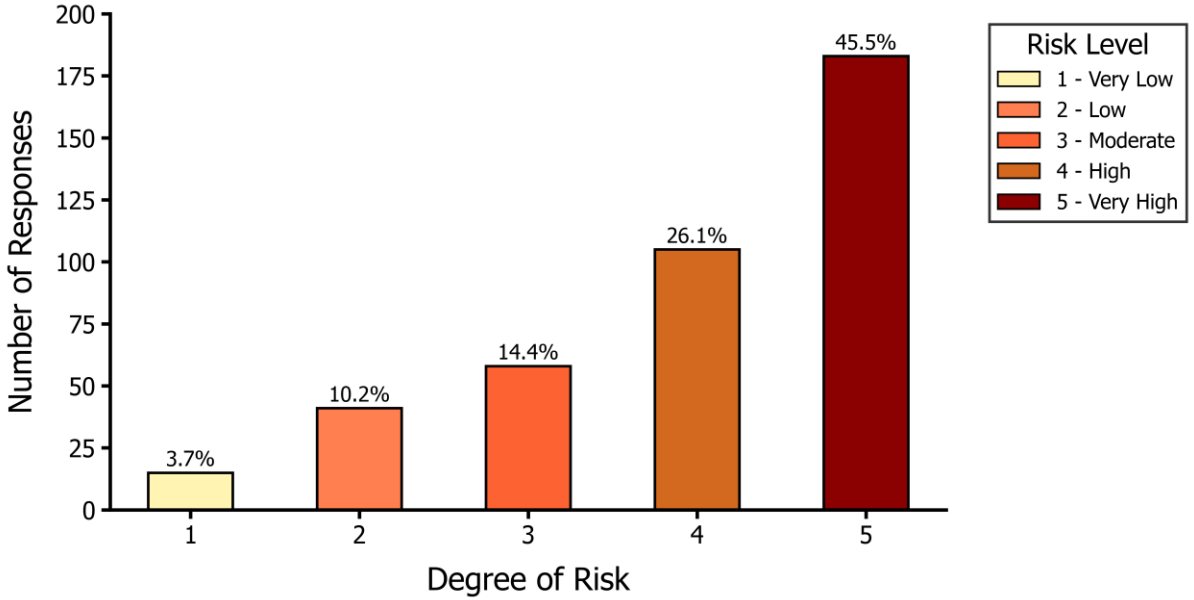


Figure 14: Perceived fire risk due to **unmanaged electric cables** and overhanging wires on utility poles

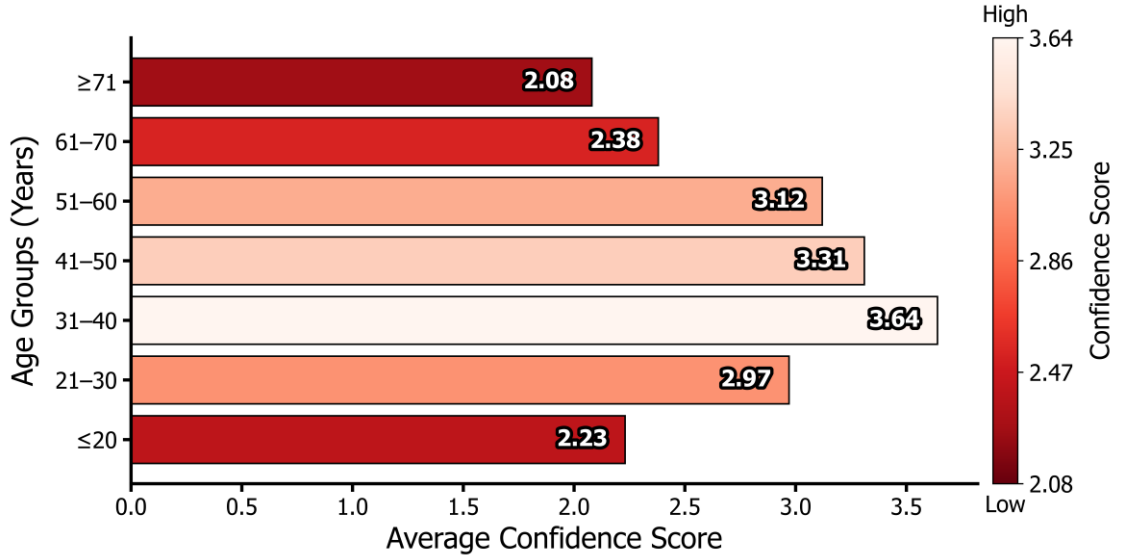


Figure 15: Perceived **confidence to handle small fire outbreaks** while maintaining safety among respondents by their **age groups**

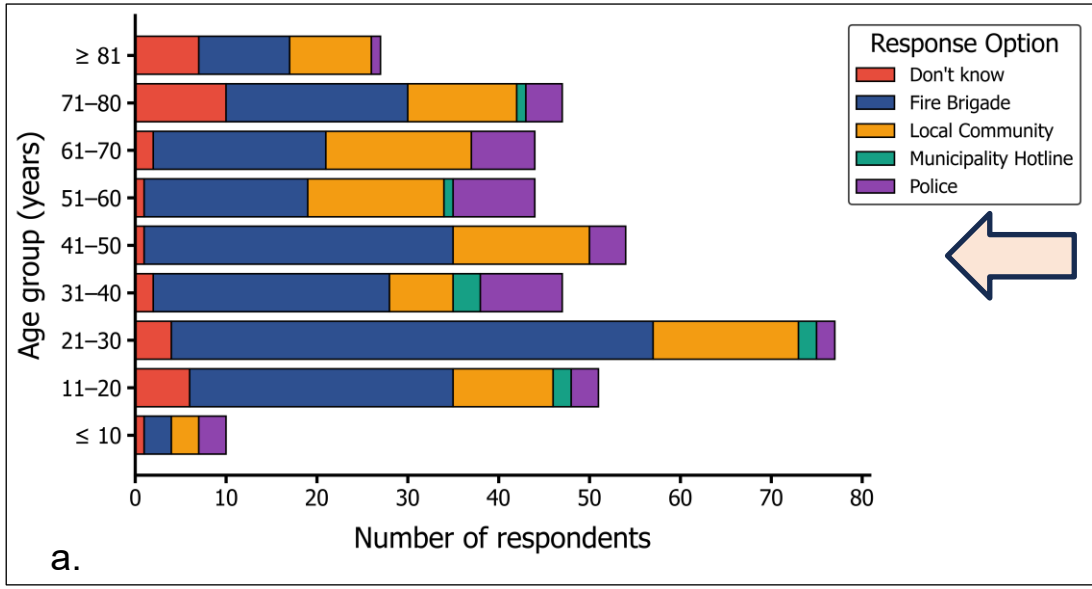
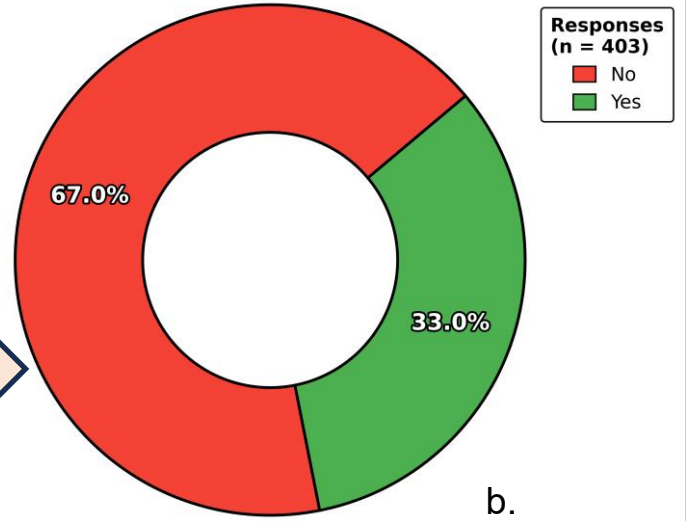


Figure 16 a : First contacted emergency number when questioned who the respondents **would contact first in case of fire emergency**

Figure 16 b: Awareness on **emergency contact number** of fire brigade



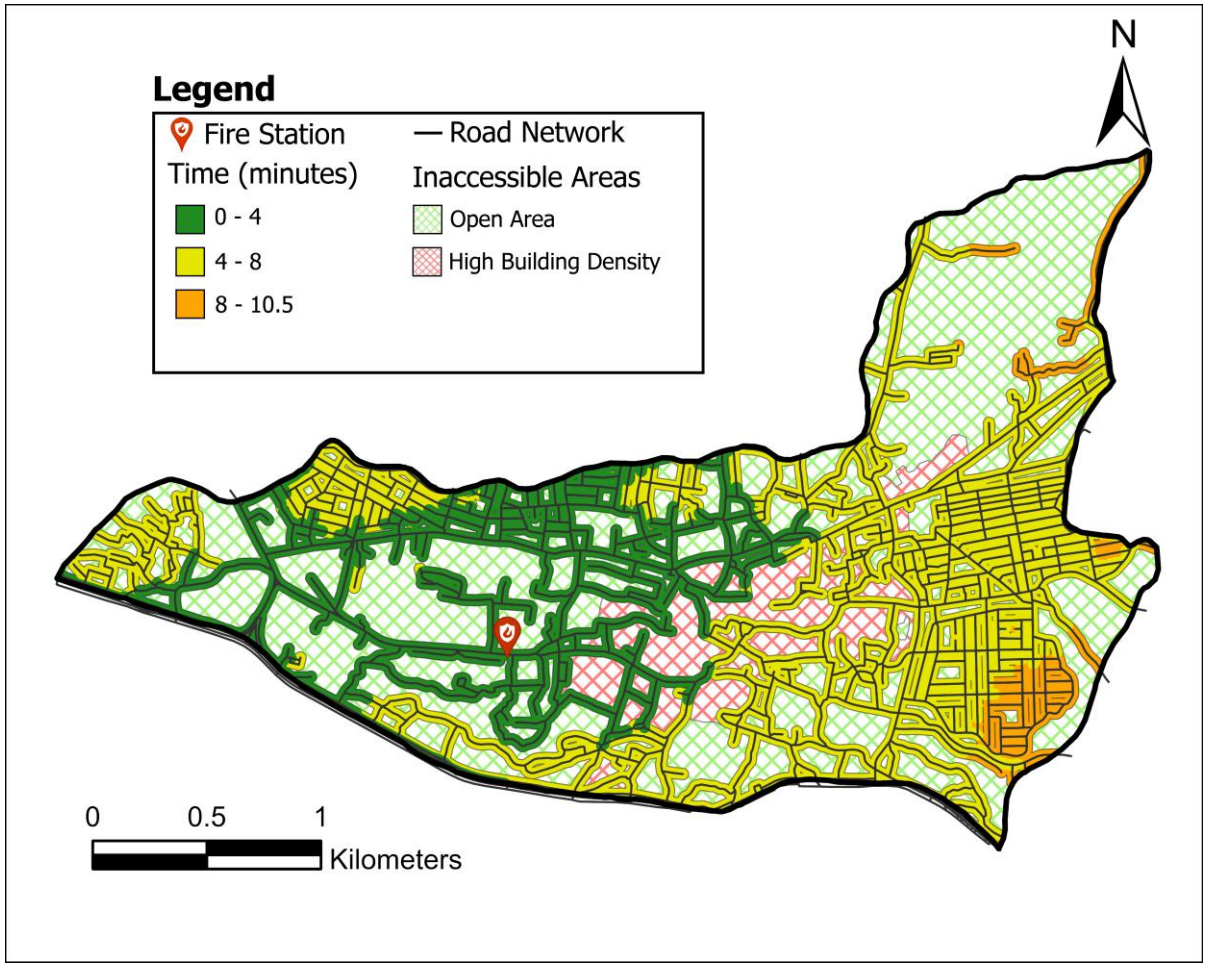


Figure 17: Service area coverage by fire station during normal traffic flow condition

Classification as per NFPA (2020)

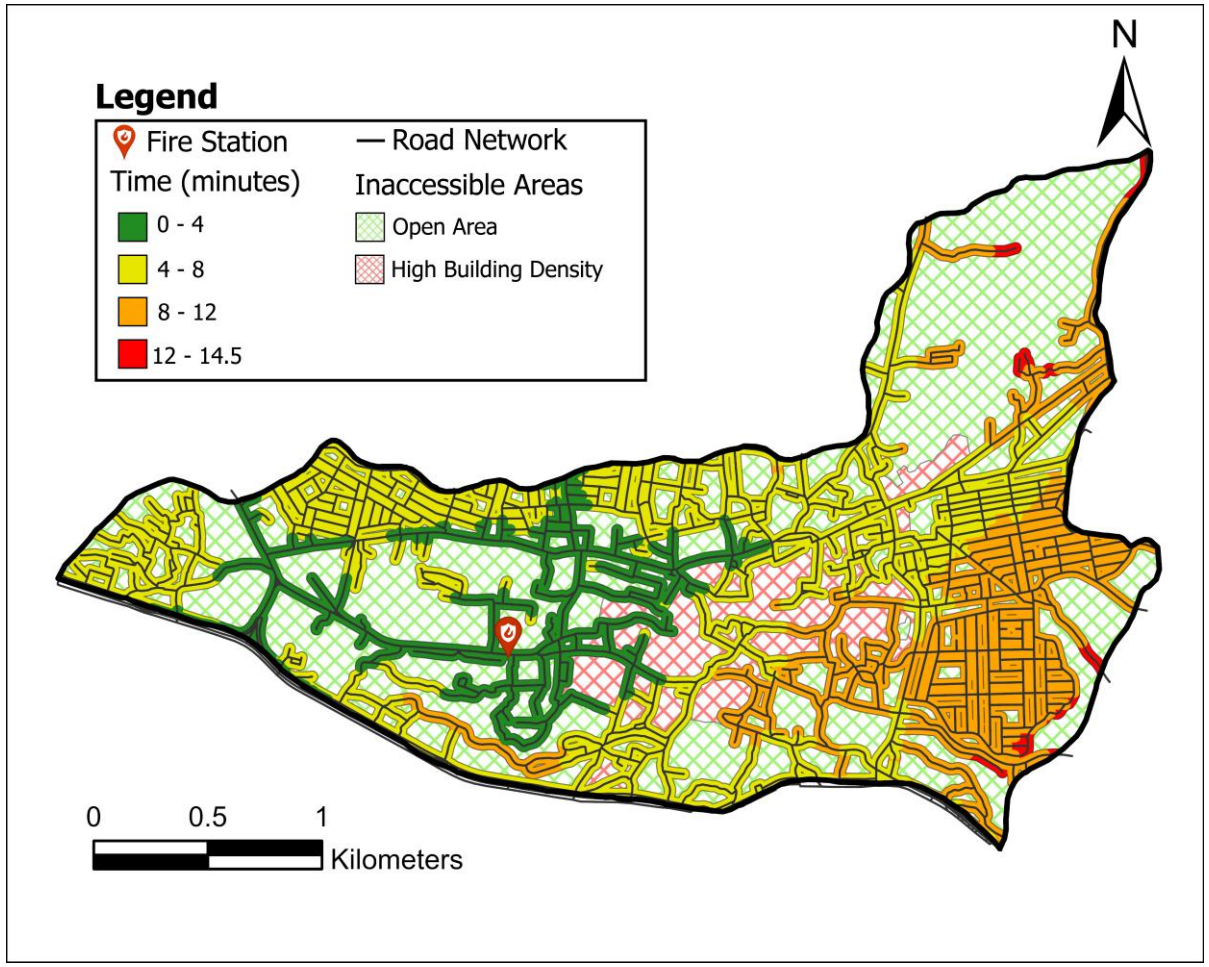
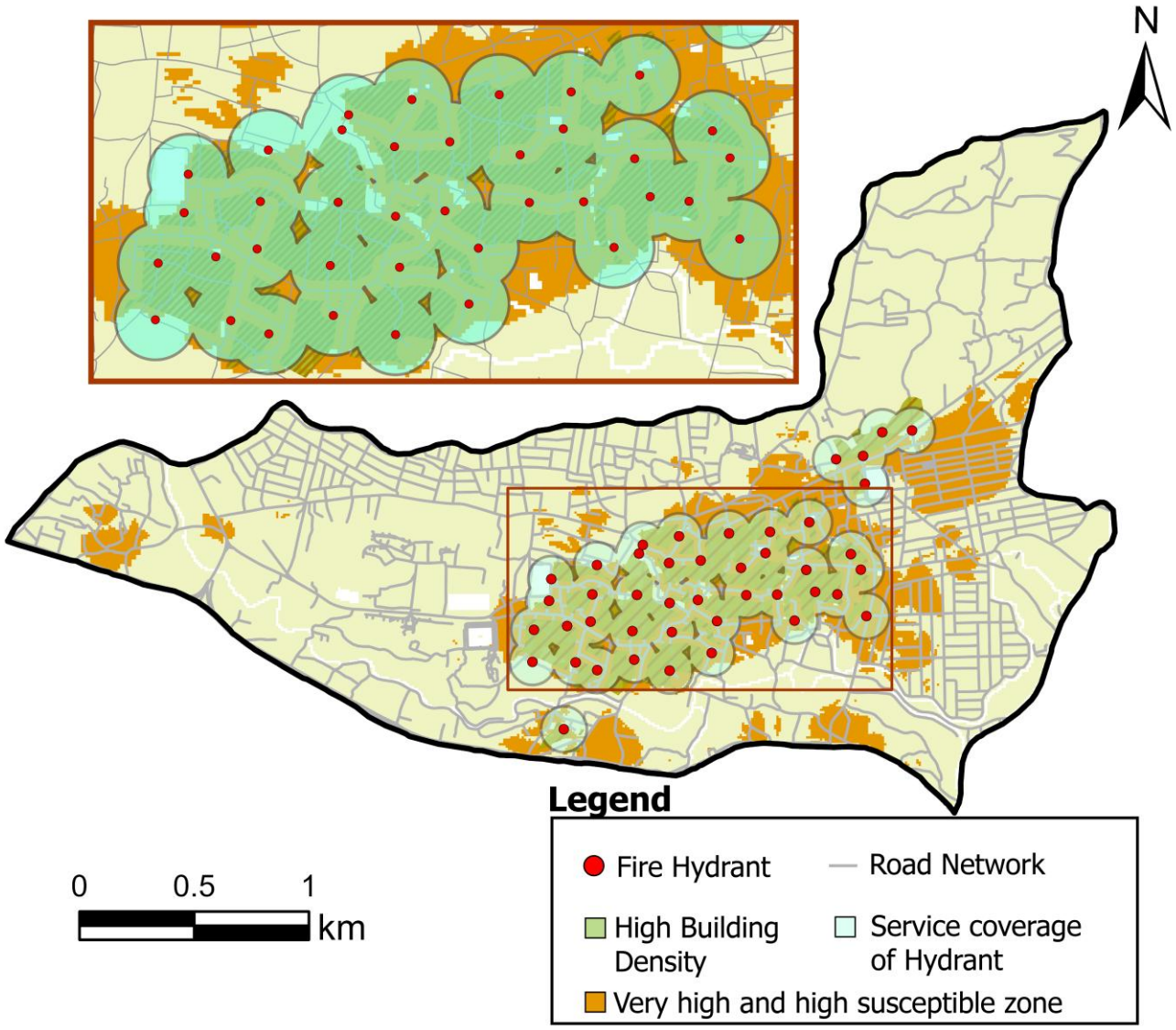


Figure 18: Service area coverage by fire station during peak traffic flow condition

Classification as per NFPA (2020)



Location Strategies:

1. Placement of Hydrants following NFPA (1995) and ICC (2011) guidelines for distribution in urban areas.
2. Hydrants proposed on the road intersection and public spaces.
3. 100 meters buffered applied as per Lee et al. (2020) to ensure reach within inaccessible areas.
4. 44 number of total fire hydrants proposed.

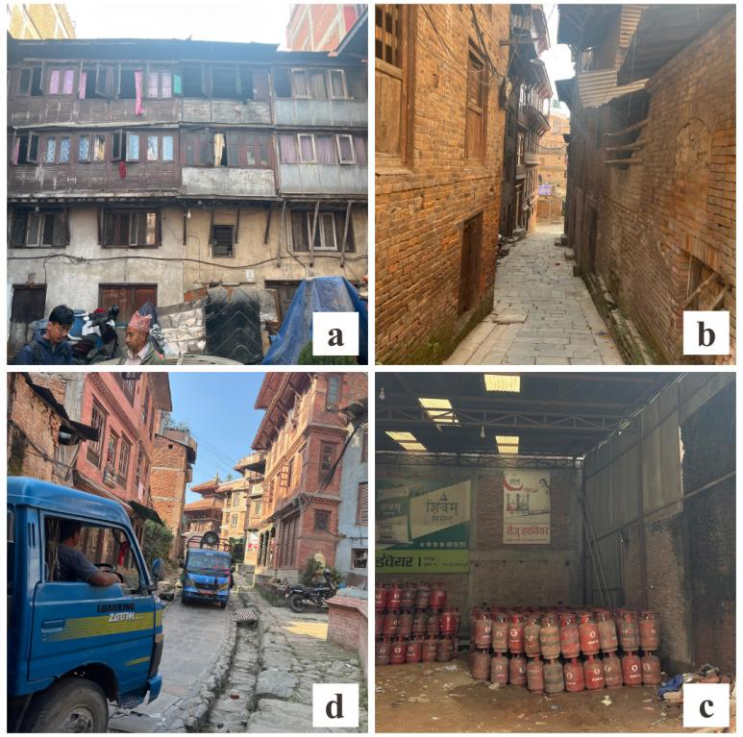
Figure 19: Spatial distribution and area coverage by proposed fire hydrants over inaccessible structural area The proposed fire hydrants (red) show the service coverage (blue) across the structural inaccessible areas (hatched in yellow). The hydrant are buffered up to 100 meters.

Summary

1. Fire Hazard: (Ignition Sources)

a. Faulty Wiring
b. Unsafe LPG Storage
c. Commercial Gas Store
d. Overload Wiring

2. Exposure x Vulnerability



a. Densely Packed Structure
b. Dense Building with Narrow Alley
c. Lack of Fire Safety
d. Single lane access

3. Fire Risk (Potential for Disaster)

- Property Damage
- High Potential for casualties
  (Source: Juddha Barun Yantra)

Conclusion

- Around 39% of total residents live in high or very high fire risk zones, despite these zones covering only 23% of the total area.
- Emergency contact choices with large number of respondents favored to contact Fire Brigade. However, above 67% of respondents doesn’t know the fire brigade number.
- Urgency of intervention, with 76% of cultural heritage sites and 81% of energy infrastructure located within high-risk zones.
- The increase in 39% of travel time was seen (i.e., 4 minutes) between off peak and peak traffic condition.
- 44 location of the hydrants were proposed.
- This study can be used for the policy level planning and development.

References

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