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IISc Sustainable Transportation Lab (IST Lab)

Celebrating 15 Years of Contribution to Sustainable Development

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Identification of VRU Fatality Hotspots in Traffic Analysis Zones using Point Kernel Density Estimation Method

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Introduction

Road fatalities are among the top 10 leading causes of death, with 1.19 million fatalities globally (WHO 2023).

Low and middle-income countries account for 93% of world traffic crashes.

India accounts for 11% of total world traffic fatalities despite having 2% of global vehicular traffic (Morth 2018).

In the calendar year 2022, India reported 1.68 lakh fatalities, a rise of 9.4% compared to the previous year.

Bad roads, insufficient traffic routing, as well as the lack of training of the road users still account for a large number and kinds of accident causes.

Road crashes not only claim lives and inflict injuries but also create an economic burden to society due to loss of productivity.

Increased motorized traffic poses a great threat to VRUs.

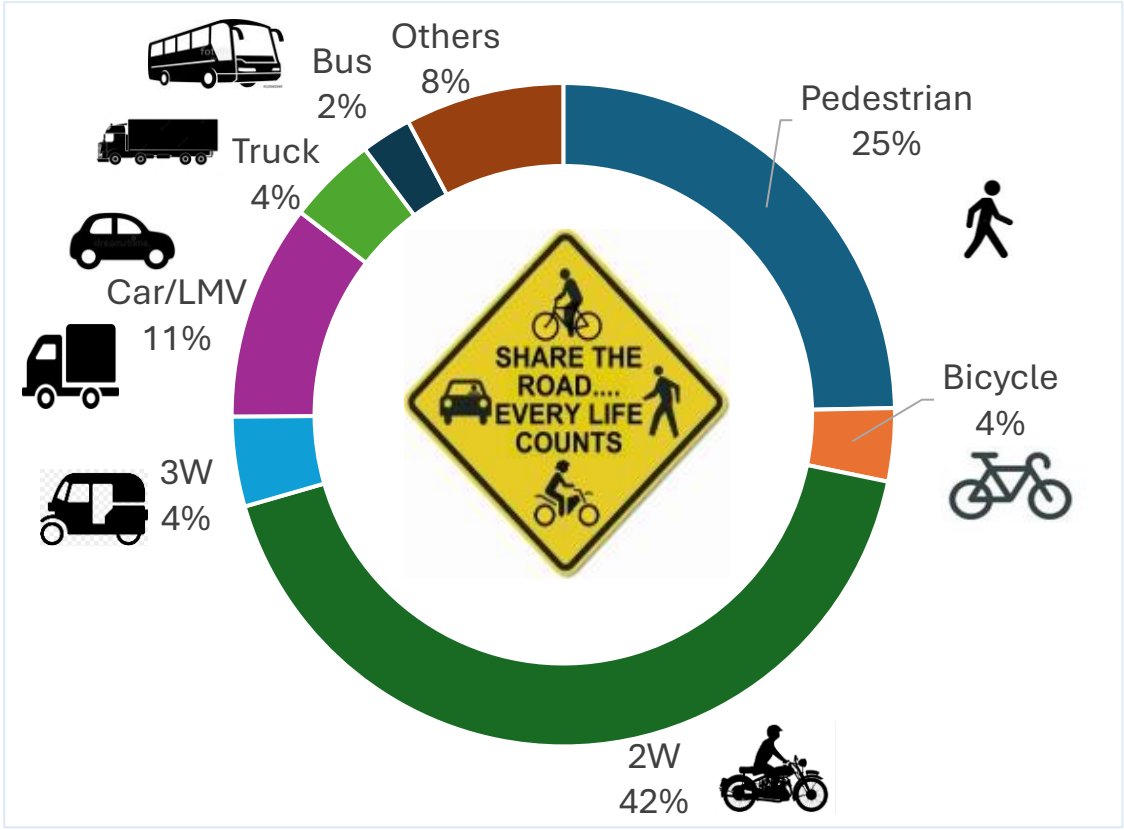
Vulnerable Road Users?

- Road users are at the highest risk in the traffic stream.
- Unprotected by outside shield/Traffic participants without outer protective cells are called Vulnerable Road Users (VRU).

Pedestrians

Bicyclists

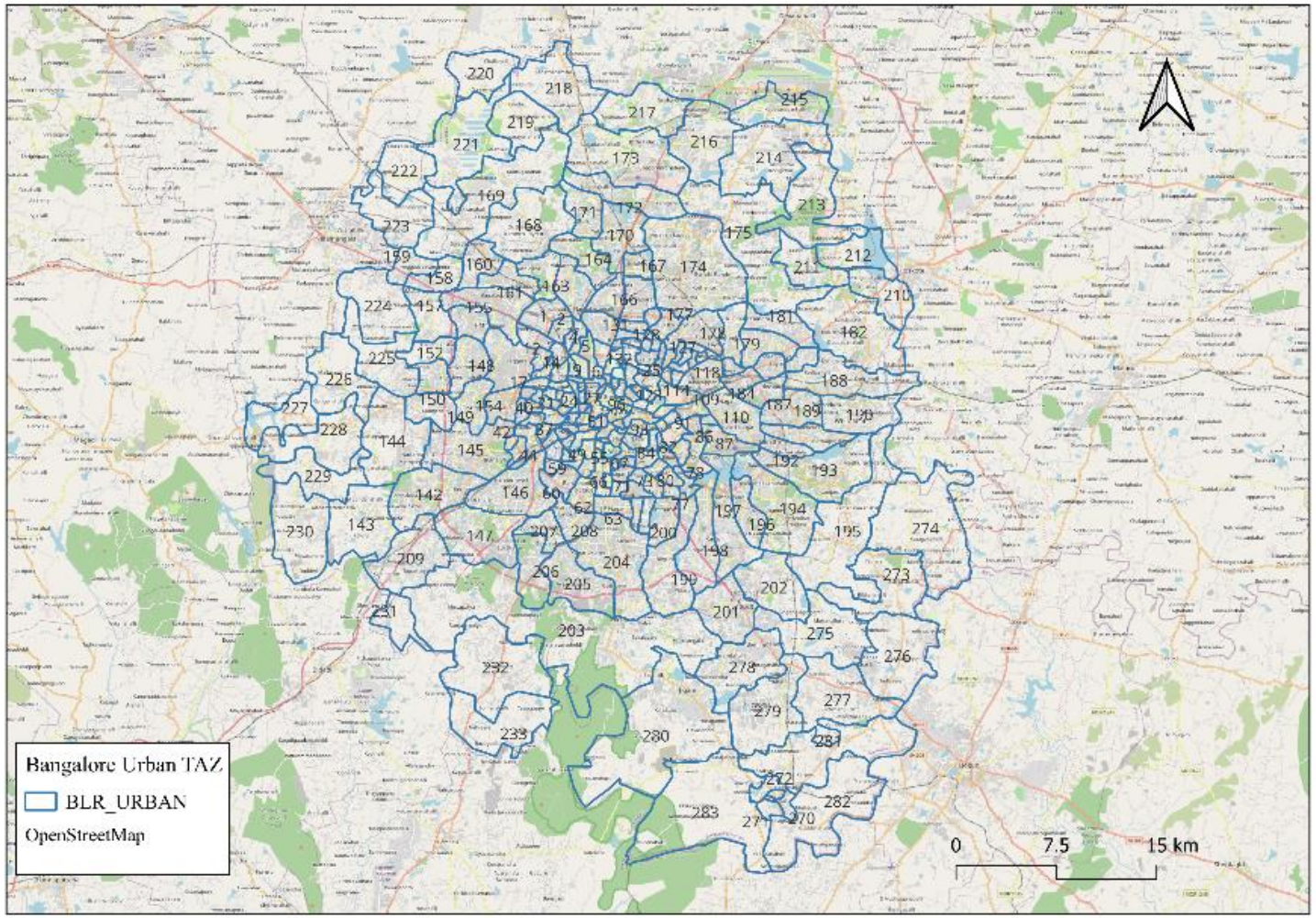
- VRU users are mainly struck by motorized vehicles and have a 29% share of fatalities in India.
- Lack of fatality-based macroscopic studies.



Literature Review

Authors & Study Location	Context	Method	Limitations
Xie et al.,2008 (Florida, USA) and Le et al.,2022 (Taichung, Taiwan)	• The studies discus the use of kernel density estimation (KDE) to produce a smooth density surface of traffic accidents in 2D and 1D space.	Point KDE and line KDE	• Only talks about the traffic Accidents.
Khanh Giang Le 2022 (Hanoi, Vietnam). Sandhu et al., 2016 (Gurgaon, India)	• Traffic accident hotspot identification by integrating kernel density estimation. • Determine traffic accident hotspot locations and simultaneously evaluate the statistical significance of the hotspot clusters.	Kernel density estimation and Gi* statistics method to validate the clusters.	• The limitation of this study is that several variables such as traffic exposures, environment, land use, geometric conditions of roads, and weather conditions were not considered in this analysis
Seiji Hashimoto et al.,2016 (Okayama, Japan)	• This study examined the relations between traffic accidents and city characteristics, such as population, road factors, and spatial factors. • Study presents the number of accident per square kilometer	Kernel density estimation (KDE) techniques were used to assess ranking and the relations efficiently.	• Network KDE can be used for more specific hazardous as an explained Variables.

Study Area

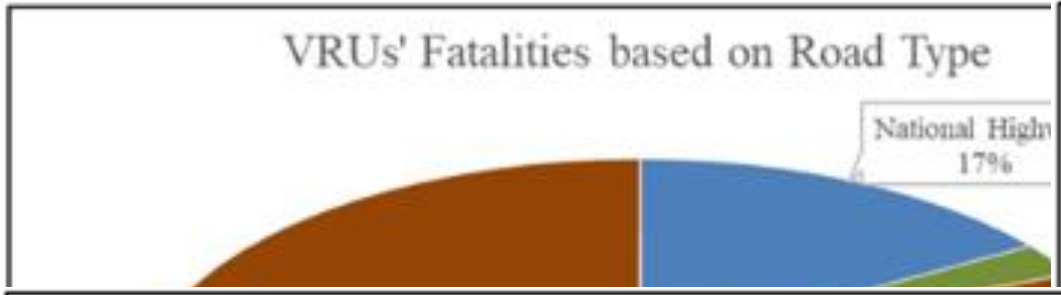


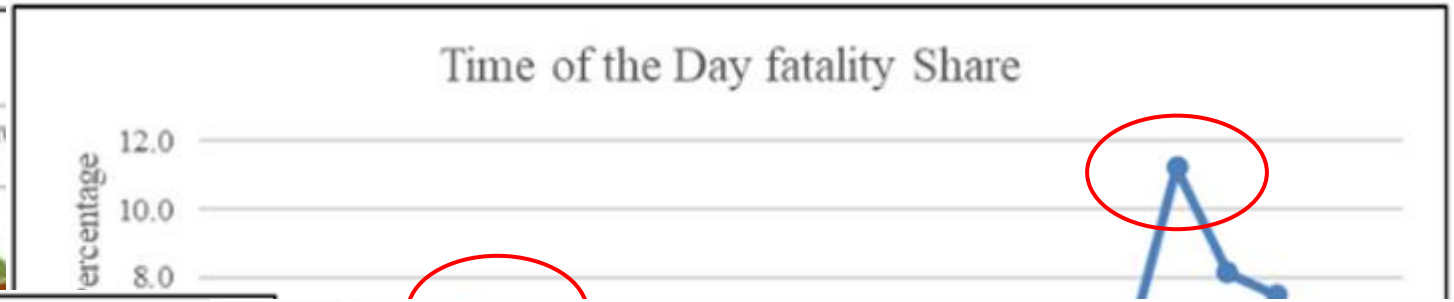
Bangalore Urban - 249 TAZs

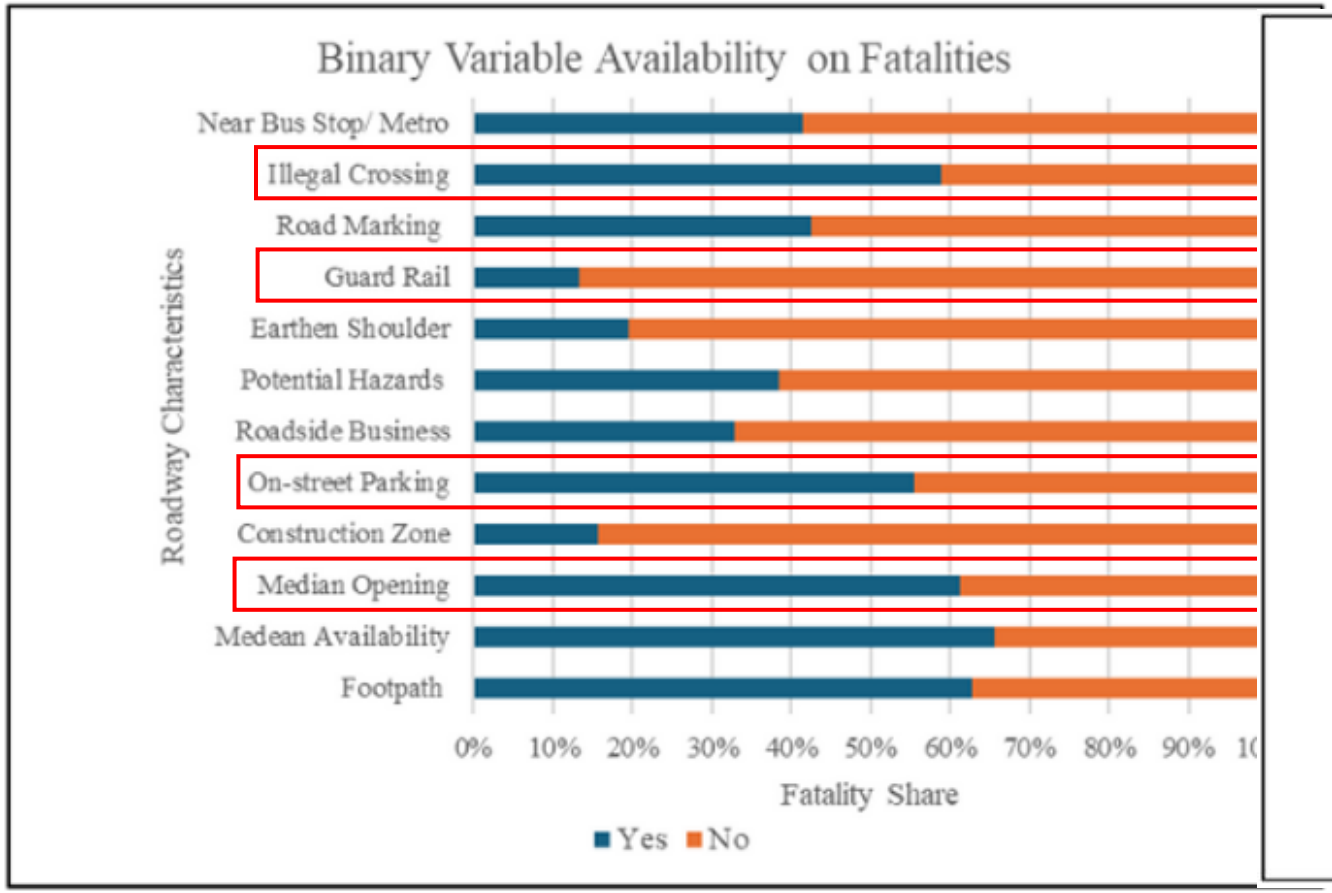
VRUs Fatalities- 296

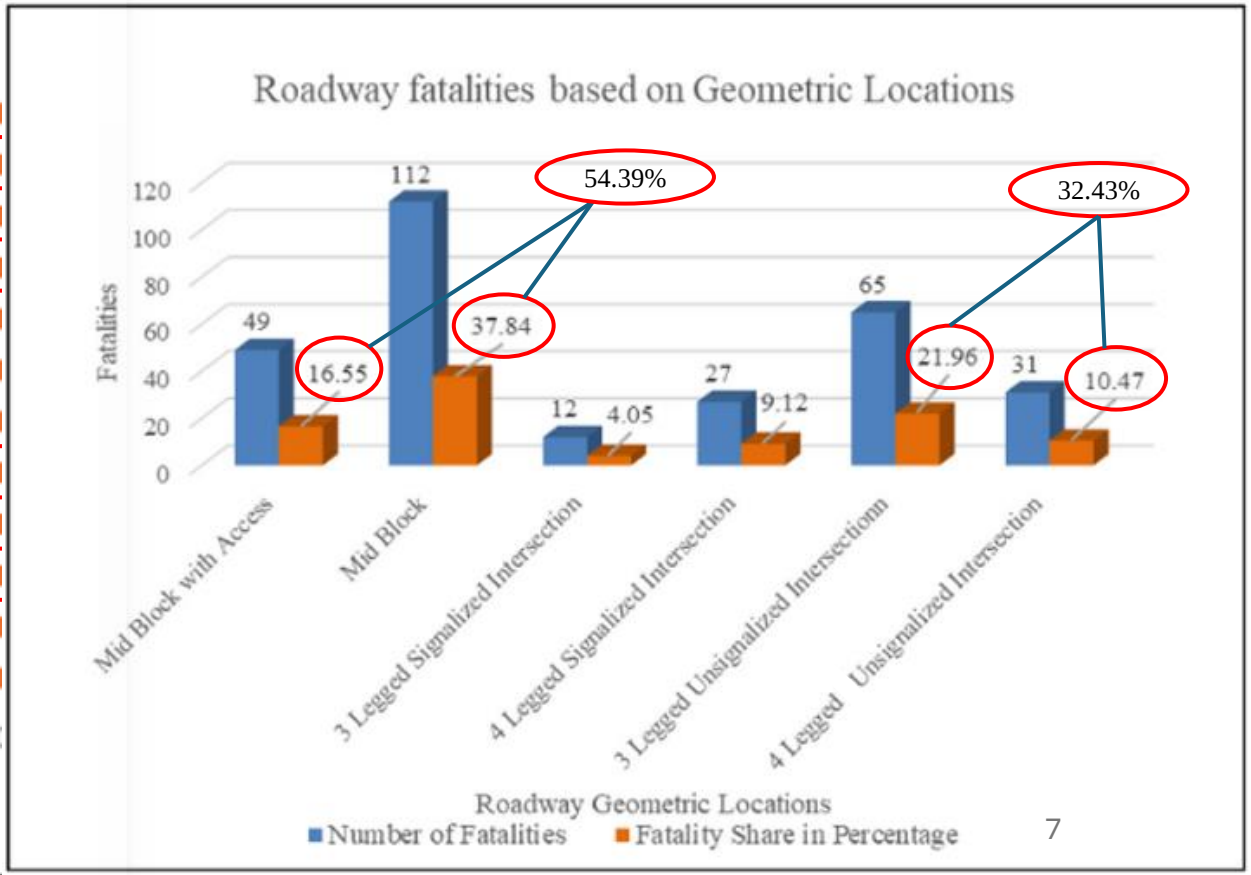
Fatality Reported in – 115 TAZs

Data Description







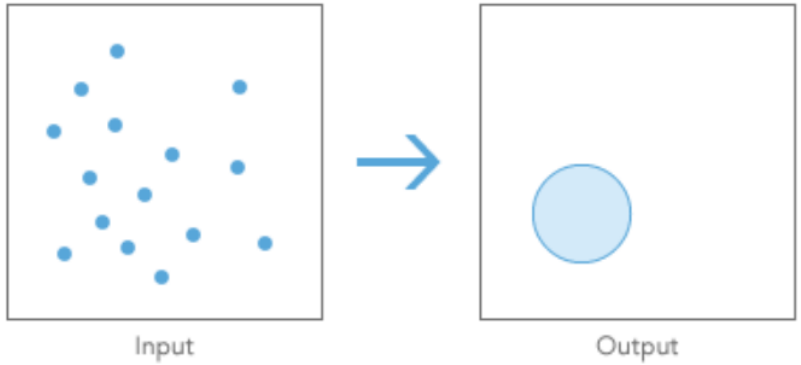


Methodology

Point Kernel Density Estimation

$$PKDE = \frac{1}{(radius)^2} \sum_{i=1}^{n} \left[\frac{3}{\pi} \times pop_i \left(1 - \left(\frac{dist}{radius} \right)^2 \right)^2 \right]$$

$$Search\ Radius = 0.9 \times \min \left(SD, \sqrt{\frac{1}{ln(2)}} * D_m \right) * n^{-0.2}$$



Standard Distance for 2D space

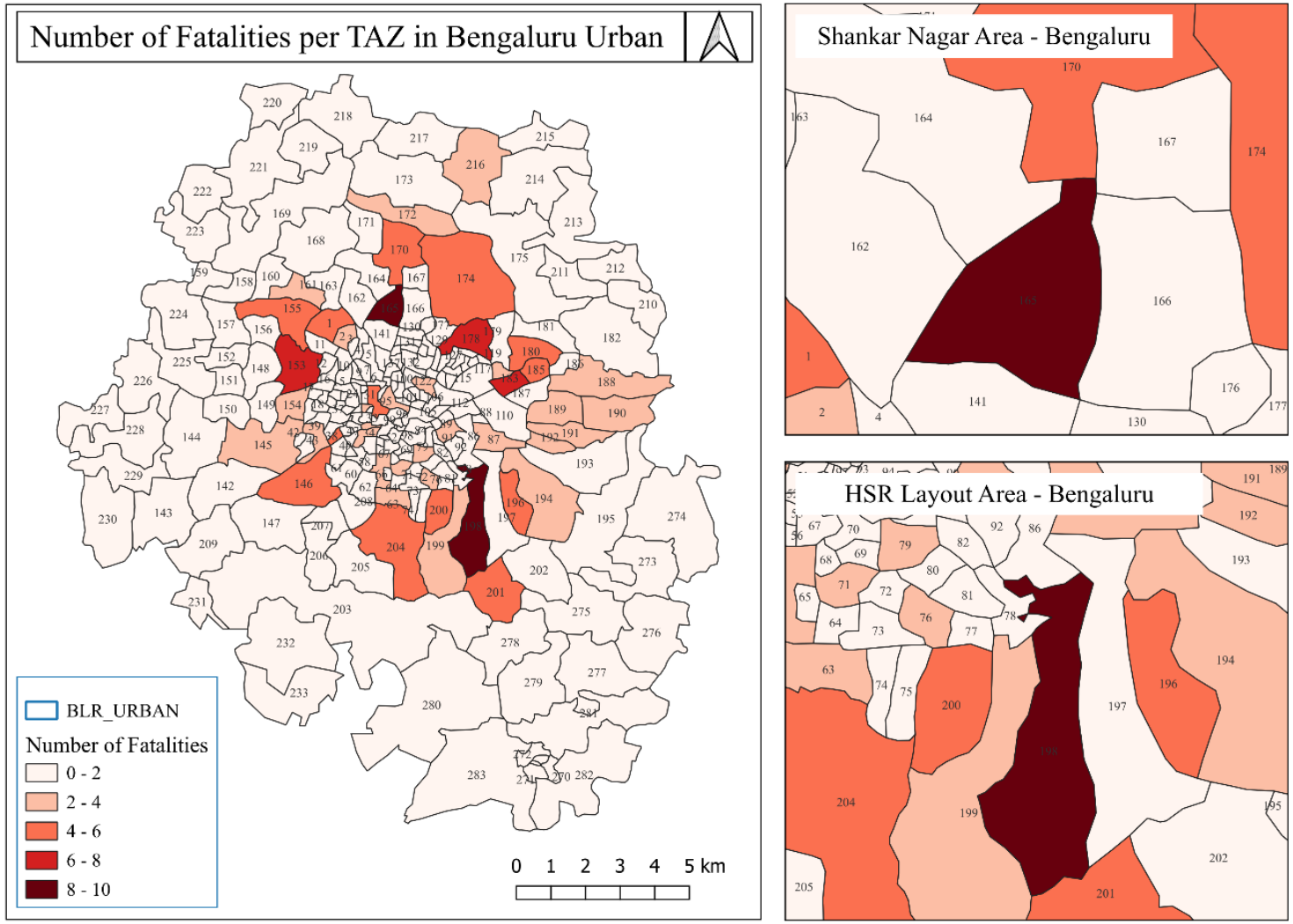
$$SD_w = \sqrt{\frac{\sum_{i=1}^{n} w_i (x_i - \bar{X}_w)^2}{\sum_{i=1}^{n} w_i} + \frac{\sum_{i=1}^{n} w_i (y_i - \bar{Y}_w)^2}{\sum_{i=1}^{n} w_i}}$$

$$SD = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{X})^2}{n} + \frac{\sum_{i=1}^{n} (y_i - \bar{Y})^2}{n}}$$

Whare, $w_i = 1$

Identification of Hotspot Zones

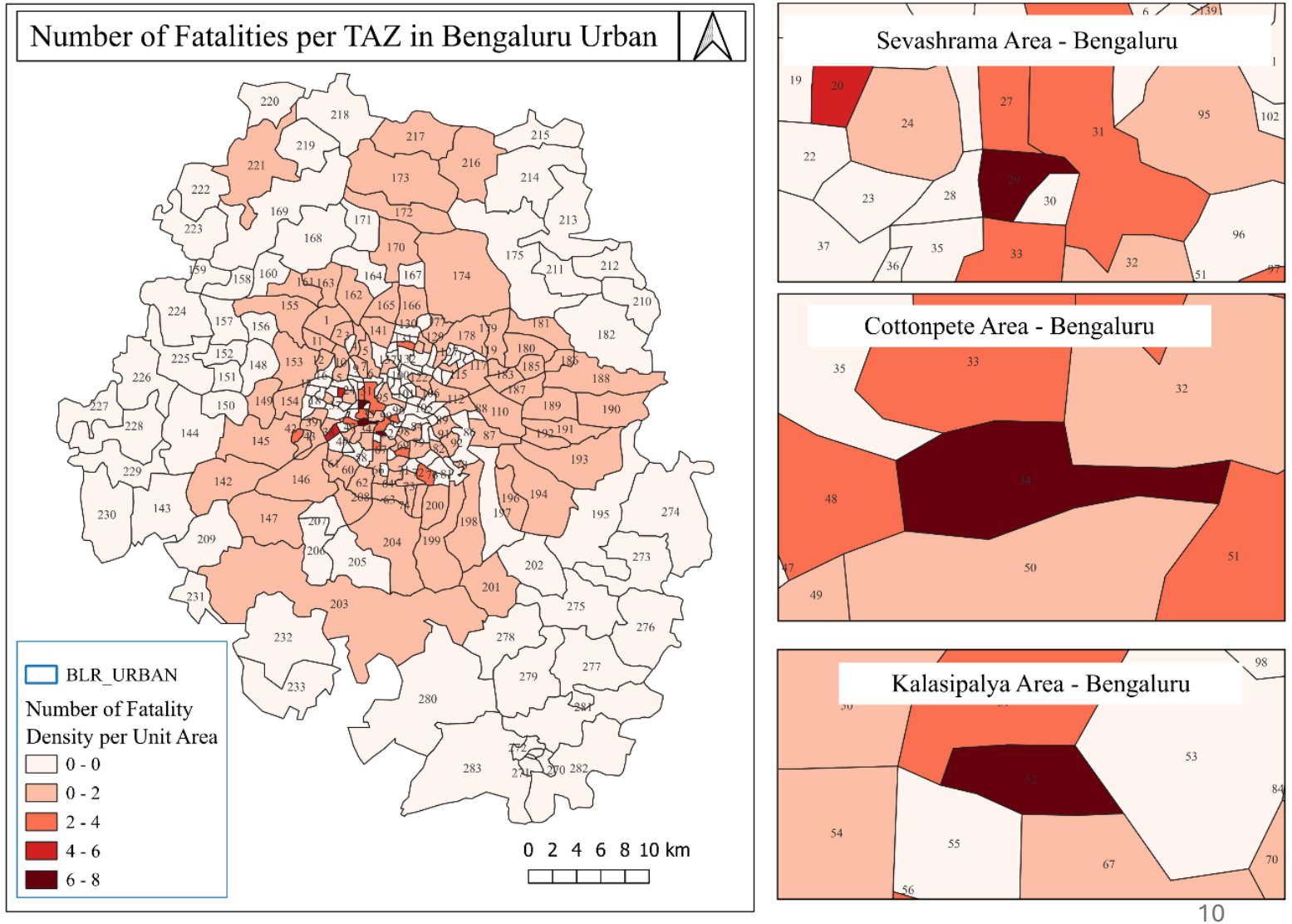
- Delineation of Fatalities based on the Traffic Analysis Zone (TAZ).
- Hotspot Zones are 165 (Shankar Nagar- Bengaluru and 198 (HSR Layout).
- Grey-spot Zones are 178, 183,153,170,174,180,185,155,1,3, 146, 204, 200, 196, and 201.
- Cold-spot Zones
- Limitation: Fatalities are not uniform because of different TAZ areas.



Number of VRU Fatalities per TAZ in Bengaluru Urban

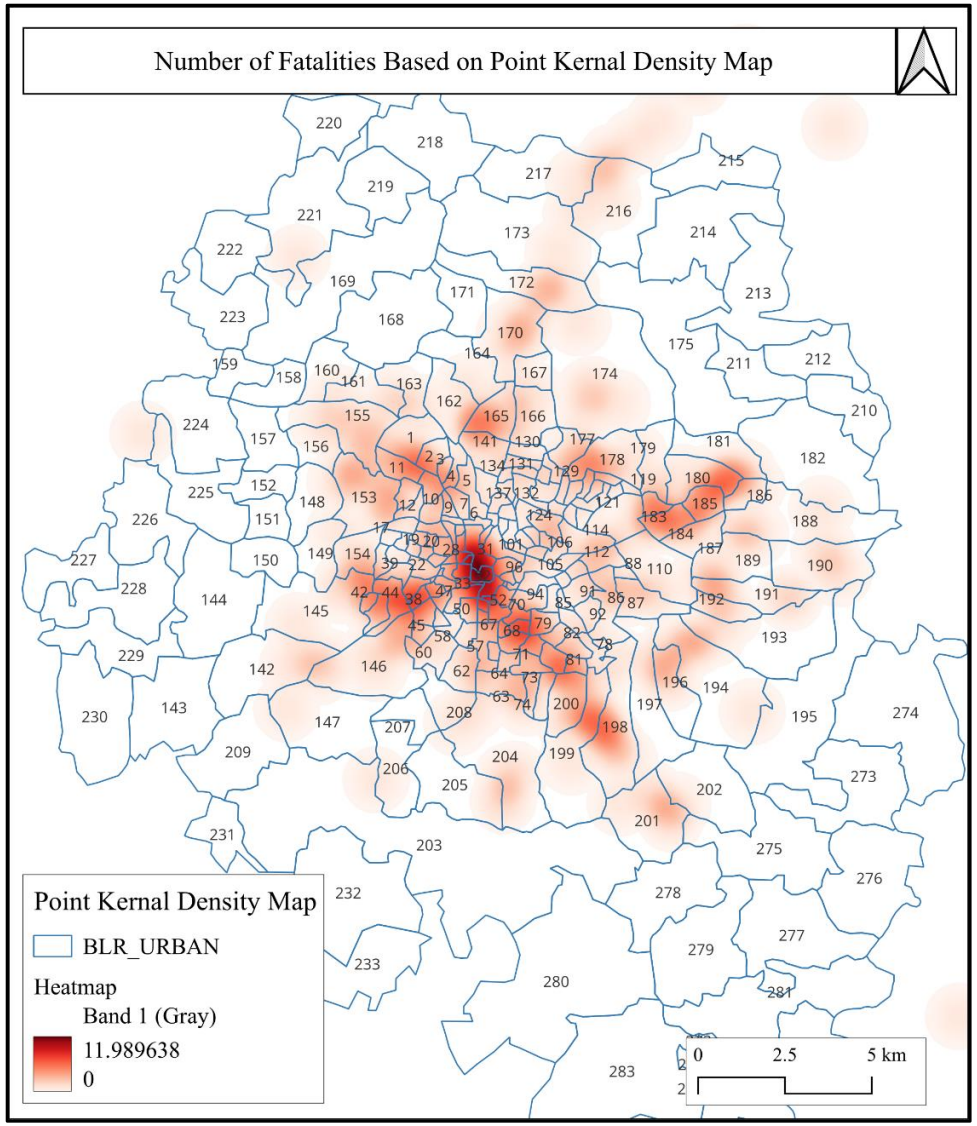
Identification of Hotspot Zones/ Area of TAZ

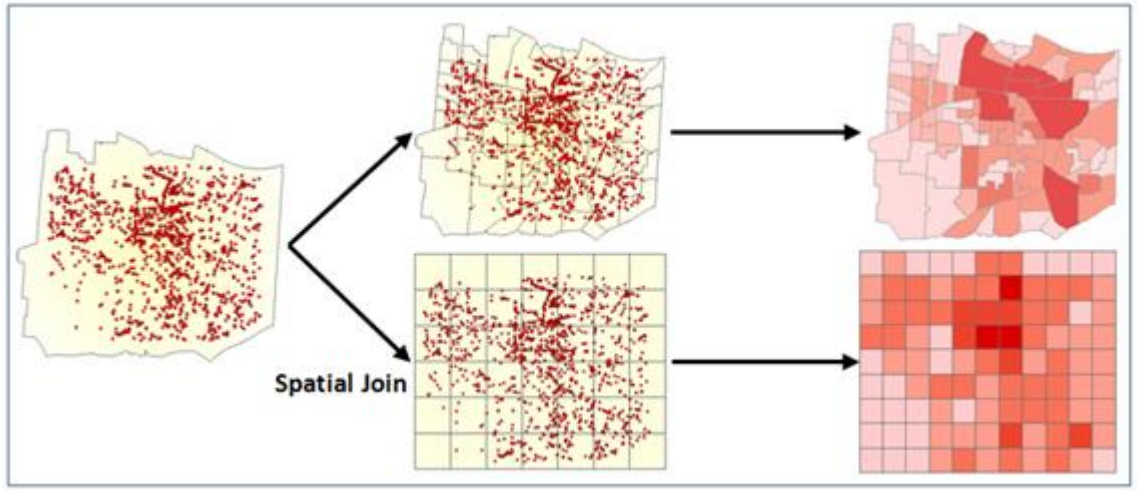
- Number of Fatalities per unit area of respected TAZ to identify Hotspot Zones.
- Sevashrama Area (Zone 29, Top right corner), Cottonpete Area (Zone 34, Right middle), and Kalasipalya Area (Zone 52, bottom right corner), which are classified as the fatality hotspots.
- Zones,24,38,99,96,31,33,42,47,67, 69,76, and 131 are depicted as grey spots.
- Method does not work when fatalities are happening near boundary of zones.



Number of VRU Fatality Density/Area of TAZ

Hotspots using Kernel Density Estimation Method





Source: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/h-how-hot-spot-analysis-getis-ord-gi-spatial-stati.htm

- Search Radius: 1 Km (Weights are highest close to the center and zero at the periphery of the circle.
- TAZs 32, 31, and 52, which comprise the central business district (CBD) of Bengaluru Urban.

Conclusion

- The paper discusses pedestrian and bicyclist fatalities and their spatial patterns.
- Lack of proper road marking (58%), unavailability of guard rails (87%), on-street parking (55%), and median openings (61%). These are identified as major contributors to fatalities.
- Hotspot Zones are 165 (Shankar Nagar- Bengaluru and 198 (HSR Layout).
- Sevashrama Area (Zone 29, Top right corner), Cottonpete Area (Zone 34, Right middle), and Kalasipalya Area (Zone 52, bottom right corner), which are classified as the fatality hotspots.
- TAZs 32, 31, and 52, which comprise the central business district (CBD) of Bengaluru Urban.
- This study can enable the determination of dangerous regions and locations where indicating area-wide traffic calming can be implemented preferentially.

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Thank you

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