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Assessment of Light Pollution from Billboards and Its Impact in Mumbai

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Abstract

The rapid urban development in cities has led to increased use of artificial lighting, like for safety, which is essential, but the ALAN used for commercial advertising and facet lighting leads to increased illumination in the dark, paving a way for light pollution. Thus, ALAN from the billboards represents an underlying source of urban light pollution with potential impacts on public health, traffic safety, and environmental sustainability. This study quantifies billboard illumination along the major commuting roads using ground-level lux measurements rather than satellite or skyglow data and evaluates the impacts on residents and drivers. The field measurement of 24 billboard sites showed the lux ranging from 6 to 250 lux. Furthermore, the survey from drivers and residents conveyed adverse effects on their health. Further, the drivers are experiencing glare problems. The study was carried out on two major commuter highways in Mumbai. There were notable geographic disparities between the eastern and western highways. These findings suggest that current billboards lighting practices in Mumbai show unsustainable urban practices.

Keywords: Light pollution, Artificial lighting, Billboards, cities

Introduction

Light sustains life on Earth by regulating biological cycles, enabling vision, and supporting photosynthesis. However, the proliferation of artificial light at night (ALAN) has dramatically altered natural light-dark cycles, creating widespread light pollution that extends beyond obscuring stars to become a significant anthropogenic pressure on ecosystems and human health. ALAN's intrusion into natural habitats and human dwellings disrupts ecological processes and endocrine systems, with consequences that are still unfolding. (Falchi et al., 2016; Gaston et al., 2015).

In densely populated Mumbai, light pollution is inescapable, with large-format illuminated billboards along major transportation corridors representing prominent sources. These structures, designed for maximum visibility, operate high-intensity digital displays throughout the night and emit light rich in blue wavelengths that effectively suppress melatonin, a hormone critical for regulating sleep-wake cycles, and ALAN's prolonged exposure leads to breast and prostate cancer. (Kuechly et al., 2012; Garcia-Saenz et al., 2018).

A significant research gap exists in systematic, ground-level assessment of billboard light pollution within the Indian urban context. While satellite studies document skyglow, they cannot quantify localised glare and light trespassing directly affecting residents and drivers. This study addresses and fills this gap through a targeted assessment of highway billboards in Mumbai.

Problem Statement: Unregulated artificial light emission from billboards along Mumbai's Western and Eastern Express Highways is an under-researched light pollution source, potentially threatening road safety through driver distraction and glare, compromising nearby residents sleep and well-being through light trespass, and contributing to ecological disruption all within a regulatory framework lacking specific, enforceable brightness limits (Min et al., 2018).

Objective: To assess light pollution levels from highway billboards and evaluate impacts on drivers and nearby residents through light intensity measurements and stakeholder perception surveys.

Hypothesis: The measured illuminance levels (in lux) in proximity to highway billboards will exceed the recommended thresholds for public lighting and pedestrian areas as per guidelines. A significant proportion of nearby residents will report negative impacts on sleep quality and well-being, which they attribute to billboard lighting. A majority of drivers will report instances of glare and distraction from billboards, perceiving them as a contributor to unsafe driving conditions.

Literature Review

Light pollution is defined as the alteration of natural light levels by anthropogenic sources, encompassing skyglow, glare, light trespass, clutter, and over-illumination. Billboards serve as a unique source, intended solely for commercial visibility. They often use high-intensity LED displays that are rich in blue-wavelength light, which can stop melatonin production and throw off circadian rhythms. Glare from such billboards impairs driver vision and increases distraction; eye-tracking studies indicate that digital billboards attract longer and more frequent fixations than static signs, potentially compromising road safety. Residents living near billboards frequently report sleep disturbance from light trespass and discomfort from glare (Longcore & Rich, 2004; Falchi et al., 2016; Hölker et al., 2010).

Beyond human health, artificial light at night (ALAN) affects ecosystems. Insects suffer mass attraction and mortality; birds experience disorientation and collision at lighted structures; marine organisms lose navigational cues; and predator-prey dynamics shift. A sustainability paradox exists: digital billboards consume substantial energy, and the frequent replacement of vinyl sheets generates non-biodegradable waste, creating a dual environmental burden (Aryan et al., 2021; Vinit Rane, personal communication, 2025; Gaston et al., 2013).

Despite growing awareness, research gaps remain, particularly in Indian cities. Most light pollution studies originate from North America or Europe, and Mumbai lacks systematic ground-level assessments of billboard illumination and stakeholder impacts. Billboard-specific investigations are scarce, with most literature focusing on street lighting or architectural illumination. This study addresses these gaps by combining on-ground lux measurements with driver and resident surveys along the Western and Eastern Express Highways.

Materials And Methods

Study Area and Site Selection

This research was conducted along Mumbai's Eastern Express Highway (EEH) and Western Express Highway (WEH) during September 2025. These arterial routes represent major commuting corridors serving Mumbai's eastern and western suburbs (Figure 1)

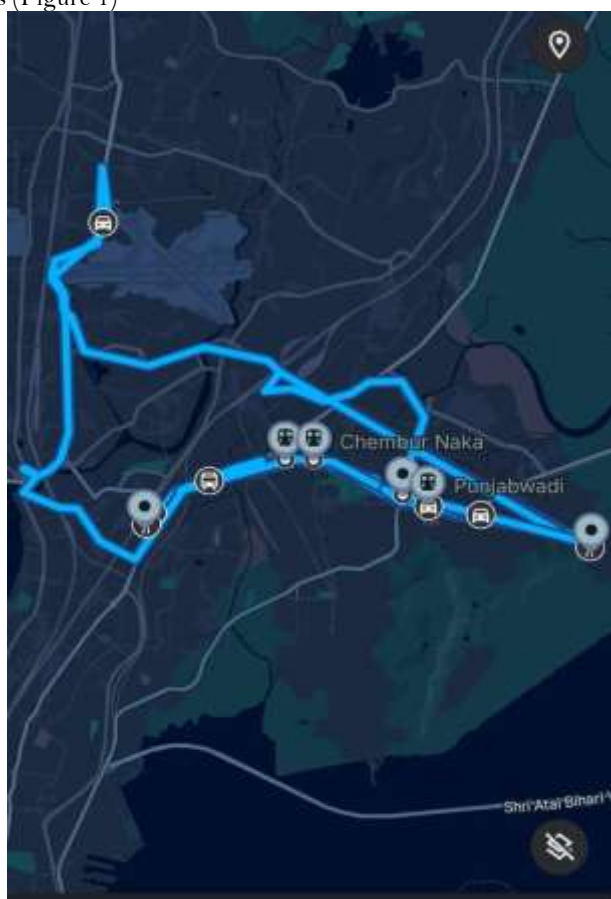


Figure 1: Map of study area for surveyed billboards along the WEH and EEH highways.

Billboard sampling sites were selected using purposive sampling to represent diversity in billboard type (traditional backlit, LED static, digital video), proximity to residential areas, and traffic density. Each site was documented with geotagged photographs that recorded location, billboard characteristics, and environmental context.

Light Intensity Measurement Protocol: The primary quantitative data for this study consisted of light intensity measurements in Lux (lx), the SI unit of illuminance.

Professional Lux Meter: A calibrated digital lux meter (Dr. Meter LX1330B Digital Illuminance Light Meter) was used for all primary luminance measurements.

Mobile Application: The "Lux Meter" app for Android was used as a secondary, corroborative tool to check for significant discrepancies and to facilitate measurements when the dedicated meter was unavailable. All app readings were cross referenced with the professional meter where possible. Measurements were taken between 8:00 PM and 11:00 PM during the period of September 2025.



Figure 2: Geotagged photograph of a digital billboard on the Western Express Highway, Mumbai (September 2025).

Drivers Survey: A structured 10-item questionnaire was given to drivers who regularly drive on Mumbai's highways during nighttime. The survey assessed demographic characteristics, driving frequency, experiences of glare or visual discomfort, perceived brightness levels, impacts on visibility of road signs and vehicles, and recommendations for mitigation measures.

Resident Survey: A 12-item questionnaire was given to residents living in proximity to highway billboards. The survey assessed demographic information, awareness of light pollution concepts, frequency of billboard light exposure, sleep quality impacts, health perceptions, and regulatory opinions.

Results & Discussion:

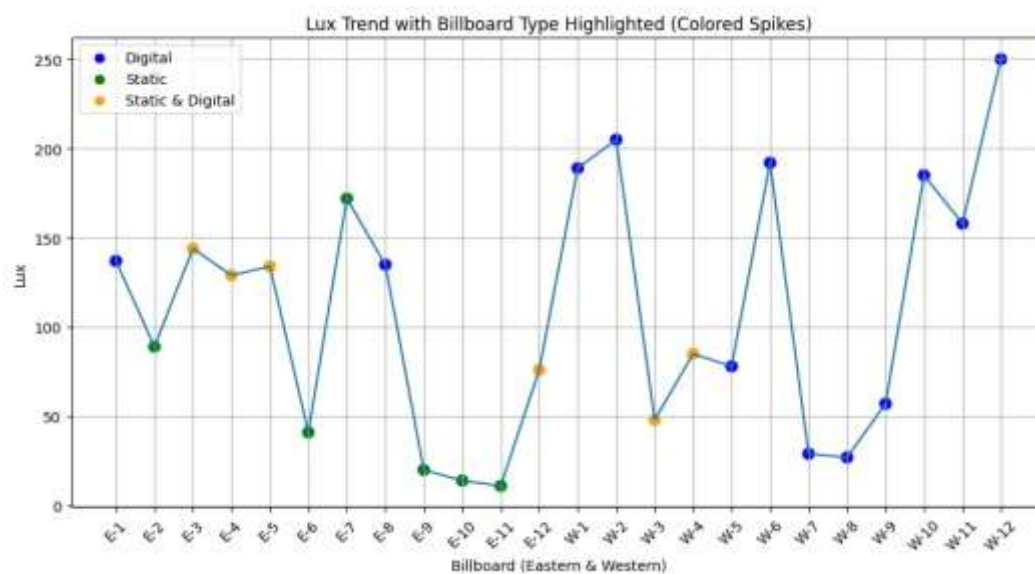


Figure 3: Illuminance measurements from 24 billboard sites revealed substantial variability.

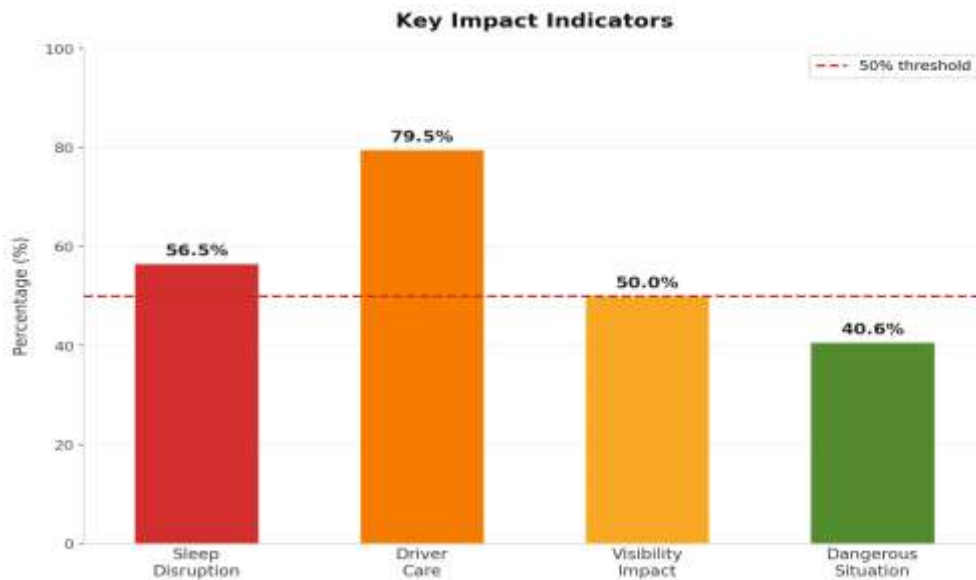


Figure 4: The key indicators of survey results for drivers and residents.

The finding of this study is the regulatory disparity between Mumbai's two major express highways. Billboards on the Western Express Highway (WEH) operated at full intensity for 24/7 with lux values reaching upto 250 lux, while the Eastern Express Highway (EEH) consistently switched off around 10.55 PM. This operational difference showed inconsistent enforcement. The placement of billboards were in front of slums. The hypothesis was partially supported: the lux- level exceeded the recommended limit, and drivers consistently reported glares and distraction, with only a subset attributing sleep disturbance to billboard lighting. As this study has the limitations of modest sample size, lack of seasonal variation,

Conclusion

This study assessed billboard light pollution along Mumbai's Western and Eastern Express Highways using ground-level lux measurements and stakeholder surveys. Illuminance ranged from 6 to 250 lx, with higher and sustained levels on the Western Express Highway (WEH) compared to the Eastern Express Highway (EEH), where a 10:55 PM curfew reduced illumination. Among 41 drivers, 80% reported glare or visual discomfort; among 61 residents, 60% reported sleep disturbance attributed to billboard lighting. Billboard placement adjacent to slum settlements raised environmental justice concerns. It provides the first systematic ground-level evidence of billboard light pollution in Mumbai, filling a critical research gap. Addressing this issue is essential for public health, road safety, and sustainable urban development.



Figure 5: On-Grounds assessment of digital billboard brightness using a lux meter.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper

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