

Integration of Artificial Intelligence in inclusive urban design to enhance gender and disability safety: A design-based research in Surabaya

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ARTICLE INFO	ABSTRACT
<p><i>Article history:</i> Received September 19, 2025 Received in revised form Dec. 31, 2025 Accepted January 07, 2026 Available online March 01, 2026</p> <p><i>Keywords:</i> Artificial intelligence Disability Gender Inclusive city Urban design</p> <p>*Corresponding author: Ainin Bashiroh Civil Engineering, Faculty of Engineering, Universitas Islam Majapahit, Indonesia Email: aininbashiroh@unim.ac.id ORCID: https://orcid.org/0000-0002-4703-6815</p>	<p>Limited accessibility and safety for women and persons with disabilities remain critical issues in urban development in Indonesia, particularly in public spaces that are insufficiently responsive to vulnerable groups. This study aims to develop an inclusive urban design concept based on gender and disability perspectives through the integration of Artificial Intelligence (AI) and participatory approaches as an evidence-based design foundation. The research adopts a Design-Based Research (DBR) approach using mixed methods that combine AI-based quantitative analysis and participatory qualitative methods. Quantitative data were obtained through YouTube data crawling (853 entries, 729 valid datasets) and analyzed using Named Entity Recognition (NER) to identify potentially unsafe urban locations, then visualized through WebGIS. Qualitative data were collected through Focus Group Discussions (FGDs) involving disability organizations, women's groups, and policymakers. The results identified three vulnerable locations in Surabaya: Kedung Cowek Street, Wonorejo Timur Street, and Kupang Indah Street. The study formulates inclusive urban design elements, including standardized pedestrian pathways, guiding blocks, gentle ramps, lighting levels of at least 12 lux, accessible transit stops, signage, and gender-sensitive public facilities. The novelty lies in integrating AI-based social media analysis with participatory approaches within a DBR framework to support data-driven inclusive urban design.</p>

Introduction

The development of inclusive cities is a core pillar of the Sustainable Development Goals (SDGs), particularly Goal 11: Sustainable Cities and Communities (UN WOMEN 2025). Inclusive cities are defined not only by efficient infrastructure and services but also by their ability

to ensure safety, accessibility, and equality for all residents. However, many cities worldwide, including those in Indonesia, continue to face challenges in providing safe and accessible urban environments, especially for women and persons with disabilities. Women remain highly vulnerable to violence in public spaces, while persons with disabilities frequently encounter physical and social barriers to accessibility and



safety (WHO 2023). Data from the Ministry of Women's Empowerment and Child Protection show that one in three women experiences sexual harassment in urban public spaces, including public transportation systems (Kemen PPPA 2021).

In response to growing urban complexity, many Indonesian cities, including Surabaya, have adopted smart city initiatives over the past decade. These initiatives generally emphasize digital technologies to improve efficiency, connectivity, and urban management. However, rapid digitalization has not always been accompanied by inclusivity. In some cases, it has created new gaps in accessibility and safety for vulnerable groups (Macaya et al. 2021). Existing smart urban design policies tend to prioritize system performance and efficiency, while the perspectives of women and persons with disabilities remain insufficiently integrated into planning processes (Makkonen and Inkinen 2024). Conversely, cities that combine digital transformation with inclusion-oriented approaches have shown greater potential to reduce social disparities and improve urban quality of life (S. Zhou, Loiacono, and Kordzadeh 2024).

Within this context, Artificial Intelligence (AI) offers a strategic opportunity to connect smart city development with inclusive urban goals. AI enables the analysis of mobility patterns, identification of crime-prone areas, and large-scale data processing to support more responsive and risk-sensitive decision-making (Guedes 2024; Santos et al. 2024). Despite this potential, most existing studies on AI in urban planning focus primarily on technical performance and efficiency, with limited integration of gender and disability perspectives, particularly in developing countries (Makkonen and Inkinen 2024). Some studies examine women's experiences in creating safer public spaces without digital tools (Qian et al. 2023), while others explore IoT and Big Data for gender inclusion but lack participatory approaches (Ababneh et al. 2025). More recent research applies AI models to participatory urban planning (Z. Zhou et al. 2024; Qian et al. 2023), yet these approaches still emphasize efficiency over substantive inclusivity.

In Indonesia, research that explicitly integrates AI with gender- and disability inclusive urban design remains limited (Itriyati 2022). Therefore, the novelty of this study lies in its

holistic and interdisciplinary approach, combining AI-based spatial mapping with participatory design involving women and persons with disabilities. Building on previous work (Bashiroh and Bachriwindi 2024), this study aims to formulate inclusive urban design criteria and concepts that are responsive to gender and disability perspectives. It hypothesizes that integrating AI within a smart city framework, when combined with participatory approaches, enhances the identification of urban risk areas and produces safer, more accessible, and more inclusive urban design outcomes than efficiency oriented smart city approaches.

Methods

This study was designed in two interconnected stages using a Design-Based Research (DBR) framework, which enables the integration of Artificial Intelligence (AI)-based spatial analysis with community-based participatory approaches. Throughout the research process, careful attention was given to ethical considerations, particularly informed consent, data privacy, and the protection of vulnerable groups (Eriksson, Elif Baykal, and Torgersson 2025).

Research stages

The first stage, the AI-based research stage, aimed to identify spatial risk patterns related to the safety of women and persons with disabilities in urban public spaces (Irsyad 2023). Data were collected through metadata crawling of publicly available YouTube videos, specifically titles and descriptions, using the YouTube Data API v3. No personal user data were accessed or processed, ensuring privacy protection and compliance with the platform's terms of service. The collected data were preprocessed through text normalization to support further analysis.

Location identification was conducted using a combination of gazetteer matching to detect formal administrative place names and Named Entity Recognition (NER) using the bert-base-indonesian-NER model to capture informal or contextual spatial references (Irsyad 2023). Types of incidents were then classified using a keyword-based approach, including sexual harassment, gender-based violence, and discrimination. The analysis results were converted into GeoJSON format and visualized through interactive maps to

identify high-risk areas, with the emphasis placed on spatial patterns rather than individual cases.

The second stage, the community-based research stage, focused on validating and enriching the AI findings through the lived experiences of public space users. Fieldwork activities included surveys, semi-structured interviews, Focus Group Discussions (FGDs), and direct observations at the three study sites. A total of 50 participants women and persons with disabilities were purposively selected to ensure meaningful representation of vulnerable groups. Participation was voluntary and based on informed consent, and all participant identities were anonymized. The FGDs were conducted in an inclusive, gender-sensitive, and disability-friendly manner. Qualitative findings were subsequently used to refine and validate inclusive urban design concepts through further discussions with government agencies and community-based organizations.

Results and discussion

This section presents the study’s key findings by integrating AI-based spatial mapping, participatory design criteria from FGDs with women’s groups and persons with disabilities,

and their translation into design concepts. The results identify major barriers, design criteria, and expected outcomes, analyzed in relation to recent literature on inclusive urban design. AI-based spatial mapping analyzed 729 pre-processed video records from 853 crawled videos, identifying 48 relevant location entities using NER and classification, as summarized in [table 1](#).

Table 1. Dataset

Crawling data	Preprocessing	NER location analysis
853 data	729 data	48 data

These findings confirm that combining gazetteer matching and NER yields complementary and more comprehensive geospatial mapping. Gazetteer matching effectively identified formal administrative locations, while NER captured informal or contextual place references in video descriptions. The hybrid approach revealed spatial concentrations of cases, identifying three main vulnerable areas: Jl. Kedung Cowek, Jl. Wonorejo Timur, and Jl. Kupang Indah. The results were visualized through a Geographic Information Systems (GIS) based spatial map and a web GIS dashboard highlighting gender- and disability-related security risks.



Figure 1. Gender and disability security risk locations in Surabaya

The GIS map identifies incident clusters and priority areas, while the web GIS enables interactive data access. These findings align with

(Cáceres García de Marina et al. 2025) just city framework, demonstrating that AI and alternative data sources such as social media support

evidence based, transparent, and participatory urban planning for safer and more inclusive cities. Results of design criteria based on participatory analysis

Participatory design criteria were developed through FGDs with persons with disabilities and women’s groups, supported by in-depth interviews with DP3APPKB for validation. This approach captured lived experiences and ensured their integration into a comprehensive and contextual foundation for inclusive urban design, promoting safe, equitable, and accessible public spaces for all.

Table 2. Disability-based inclusive design criteria

FGD findings	Inclusive design criteria	Expected outcomes
Uneven sidewalks / blocked by vendors	Sidewalk ≥ 1.5 m, flat, unobstructed	Safe and accessible sidewalks
Lack of guiding blocks & ramps	Guiding blocks, slope $< 8^\circ$	Inclusive and disability-friendly pathways
Poor public lighting	Streetlights ≥ 12 lux at risk points	Safe mobility at night
Areas prone to harassment/crime	CCTV, panic button, security post	Improved public safety for vulnerable groups
Inaccessible public transport	Bus stops with ramps, audio-visual info, wheelchair space	Inclusive and accessible public transport
No disability parking	Dedicated parking with direct facility access	Safe and accessible parking
Unclear signage	Clear signage with symbols & audio	Accessible information for persons with disabilities

Based on [table 2](#), the FGD with the Indonesian Disability Association (PPDI) reveals a causal relationship between the lived experiences of persons with disabilities, the formulation of inclusive urban design criteria, and the proposed design interventions. Accessibility and safety barriers are understood not merely as technical issues, but as spatial factors that directly shape mobility patterns and perceptions of safety in urban public spaces.

The primary finding damaged, uneven, and obstructed sidewalks reflects a structural failure of urban space to support independent mobility for wheelchair users and persons with visual impairments. This condition necessitates pedestrian design criteria that emphasize

continuous routes, adequate width, and safe surface quality. The cause–effect relationship is evident: poor sidewalk conditions increase safety risks and mobility dependence, positioning accessible sidewalks as a primary design intervention rather than a supplementary feature. This finding aligns with ([Gupta, Yadav, and Nayak 2025](#); [Selanon, Dejnirattisai, and Naknawaphan 2025](#)), who emphasize responsiveness to local conditions and user experiences.

The absence of guiding blocks and ramps indicates systemic neglect of navigational needs for persons with visual and mobility impairments. This finding directly informs the inclusion of tactile guiding blocks and ramps with slopes below 8° as mandatory design criteria. Pathways lacking tactile guidance are shown to increase navigation errors and accident risks ([Cohen et al. 2024](#)), reinforcing international ramp slope standards as evidence-based corrective interventions ([Selanon and Chuangchai 2024](#)).

Poor lighting at bus stops, parks, and pedestrian routes was associated with heightened fear of crime, demonstrating that insecurity is spatially produced. Accordingly, a minimum illumination level of 12 lux is established as a design criterion to enhance psychological safety.

Concerns regarding crime further generate the need for visible safety mechanisms, operationalized through the integration of CCTV systems, panic buttons, and security posts as design interventions combining technological and natural surveillance ([Bashiroh and Bachriwindi 2024](#)).

Barriers in public transport and wayfinding such as the absence of ramps, audio-visual information, disability parking, and multisensory signage indicate exclusion along the entire mobility chain, informing integrated transport and wayfinding design concepts that support independent mobility ([Z. Zhou et al. 2024](#); [Li et al. 2025](#)).

Table 3. Gender-based inclusive design criteria

FGD findings	Inclusive design criteria	Expected outcomes
Inadequate public lighting (streets, parks, terminals)	Standardized street lighting, integrated surveillance system (CCTV, sensors)	Safer night mobility, reduced crime rates
Limited pedestrian accessibility	Barrier-free pedestrian pathways,	Safe and inclusive public spaces

FGD findings	Inclusive design criteria	Expected outcomes
(sidewalks, crossings, street vendors)	universally accessible design	
Lack of gender-sensitive facilities (toilets, lactation rooms, safe waiting areas)	Integration of women-oriented facilities into public infrastructure	Increased comfort and usability of public spaces
Poor safety and accessibility of public transport	Gender-sensitive transport modes, safe waiting areas	Improved accessibility to public transport
Social and cultural barriers restricting women's freedom	Gender-inclusive urban design principles to foster inclusivity	Greater participation of women in public activities
Minimal nighttime surveillance and activity	Enhanced surveillance through artificial and natural control	Improved safety with CCTV, panic buttons, and public monitoring
Non-standard open space and facility maintenance	Utilization of vacant land and systematic facility management	Improved quality and safety of public facilities
Unstructured landmarks and signage	Clear, visible landmarks and signage for orientation and wayfinding	Enhanced accessibility and user orientation
Disorganized vegetation creating unsafe blind spots	Structured vegetation planning to reduce blind spots	Reduced crime risk and enhanced psychological security

Based on table 3, the Focus Group Discussion (FGD) with women's groups shows that experiences of fear, discomfort, and restricted mobility directly informed gender-responsive urban design criteria and interventions. The findings confirm that women's safety and inclusion result from the interaction of physical, psychological, and socio-cultural factors that must be translated into concrete spatial responses.

Insufficient lighting in streets, parks, and transport areas emerged as a key contributor to fear of crime, particularly at night, establishing a direct link between lighting conditions and women's willingness to use public spaces. Accordingly, adequate illumination was adopted as a core design criterion, functioning not only as infrastructure but also as a safety intervention that enhances psychological comfort (Selanon, Dejnirattisai, and Nakanawaphan 2025; Bashiroh

and Bachriwindi 2024; Gupta, Yadav, and Nayak 2025).

Pedestrian barriers such as damaged sidewalks, illegal parking, and street vendors were identified as constraints on women's mobility and sense of control. These findings informed the requirement for continuous, unobstructed pedestrian networks prioritizing visibility and ease of movement. Similarly, the limited availability of gender-sensitive facilities, including public toilets, lactation rooms, and safe waiting areas, shaped interventions aimed at improving comfort, dignity, and everyday usability (Bashiroh and Bachriwindi 2024).

Concerns about unsafe public transport led to the inclusion of safe waiting zones, clear information systems, and gender-sensitive spatial layouts in line with inclusive transport principles (ADB 2022). Socio-cultural constraints further highlight the need for inclusive design to promote visibility and participation, supporting women's presence in public spaces (Gupta, Yadav, and Nayak 2025).

The FGD also emphasized surveillance measures such as CCTV, emergency buttons, and community-based monitoring which informed interventions combining technological and social surveillance consistent with safe city principles (Bashiroh and Bachriwindi 2024; Selanon and Chuangchai 2024). Clear landmarks and signage were translated into wayfinding strategies that reduce anxiety.

Overall, table 3 demonstrates that women lived experiences directly shaped gender-responsive design criteria. Integrated with disability-focused findings, the results reinforce that inclusive urban design must address both physical accessibility and socio-psychological comfort to create safer and more equitable cities.

The concept of gender and disability-based inclusive city design

The findings indicate that the design of an inclusive city is not solely focused on physical development but also encompasses social, cultural, and policy aspects. The macro design concept is applied to three locations in Surabaya, which were identified through AI-based spatial analysis. Furthermore, the proposed concept represents the implementation of the design criteria that have been discussed in the previous subsection. The following section presents the design concept generated in this study.



Figure 2. Key plan of vulnerable location in Surabaya: Jln. Kedung Cowek. Jl. Wonorejo Timur and Jl. Kupang Indah

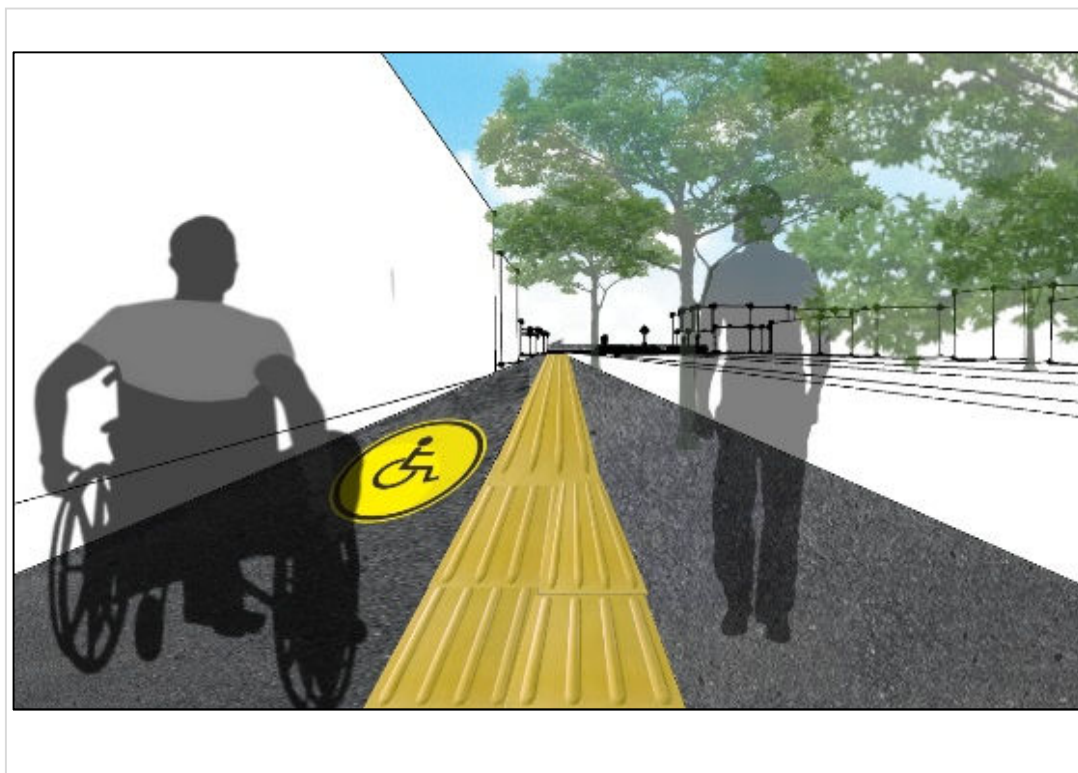


Figure 3. Pedestrian ways as an inclusive mobility strategy.

This figure represents the pedestrian way design derived from FGD and AI-based spatial analysis, which identified damaged sidewalks, discontinuity, and obstructions as major constraints to mobility and perceived safety for

women and persons with disabilities. The concept translates empirical findings into continuous, barrier-free pedestrian routes that enhance accessibility, visibility, and everyday safety in public spaces.

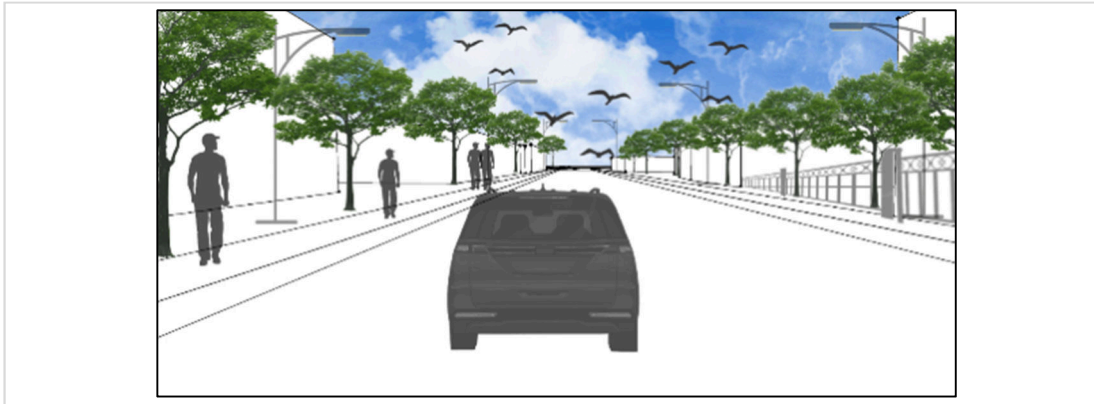


Figure 4. Vegetation as a safety and visibility strategy

This figure illustrates the strategic placement of vegetation derived from FGD and AI-based spatial analysis findings, which identified blind spots and poor visibility as key contributors to fear and perceived insecurity, particularly for

women. The vegetation design supports clear sightlines, reduces hidden areas, and enhances environmental comfort, translating empirical safety and visibility concerns into landscape-based design interventions.



Figure 5. Bus stop as a Gender and Disability sensitive transport node.

This figure illustrates the bus stop design informed by FGD and AI-based spatial analysis, which identified poor lighting, unsafe waiting areas, and limited accessibility as key sources of

fear and exclusion for women and persons with disabilities. The concept translates these empirical findings into design interventions that enhance

visibility, comfort, accessibility, and perceived safety in public transport environments.



Figure 6. Surveillance as an integrated safety strategy

This figure depicts the surveillance concept derived from FGD and AI-based spatial analysis, which identified blind spots, low activity levels, and limited social control as factors increasing fear and crime risk, particularly for women. The

design integrates technological surveillance (CCTV, sensors) with activity-based and natural surveillance to enhance visibility, perceived safety, and inclusive use of public spaces.

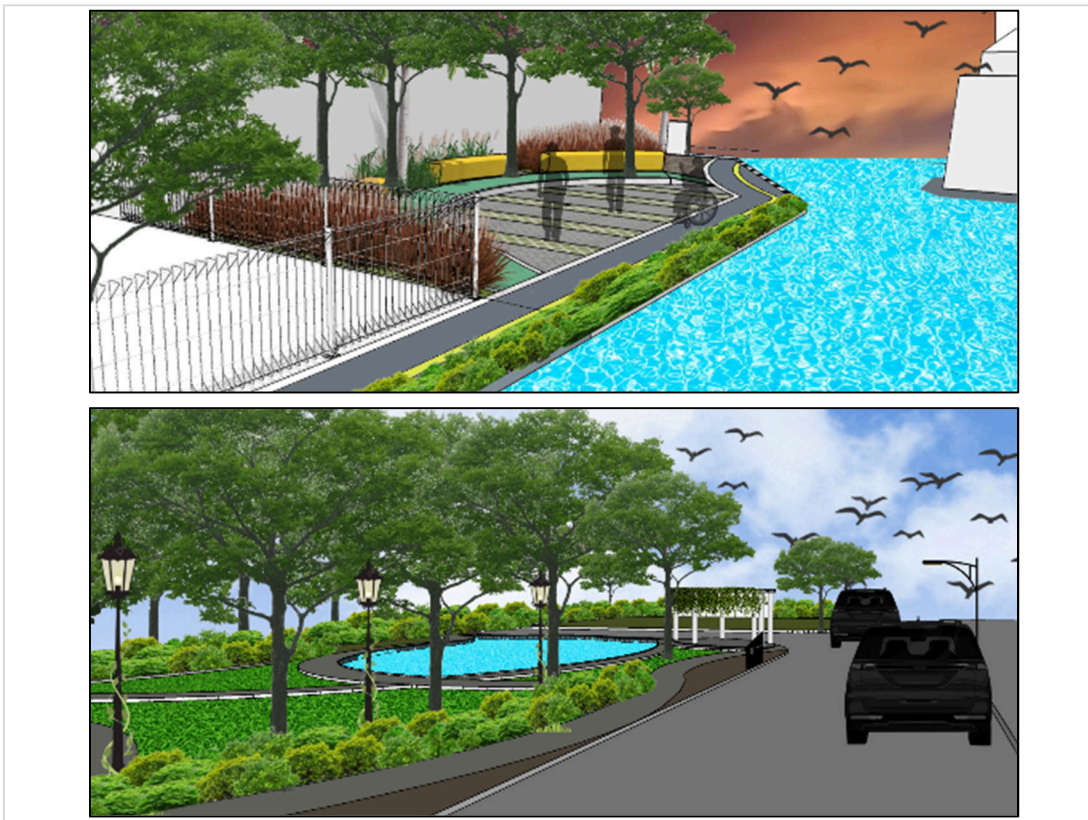


Figure 7. Open space as an inclusive and safe public realm

This figure illustrates the open space design informed by FGD and AI-based spatial analysis,

which identified neglected land and underutilized parks as sources of fear, exclusion, and limited

social interaction, particularly for women and persons with disabilities. The concept translates these empirical findings into inclusive, active, and

well-managed open spaces that enhance safety, accessibility, environmental quality, and community use.



Figure 8. Bus station as a safe and inclusive mobility hub

This figure presents the bus station design derived from FGD and AI-based spatial analysis, which identified inadequate lighting, poor accessibility, and enclosed waiting areas as contributors to fear and exclusion for women and

persons with disabilities. The concept translates these empirical findings into an open, well-lit, and universally accessible station that enhances safety, comfort, and equitable access to public transport.

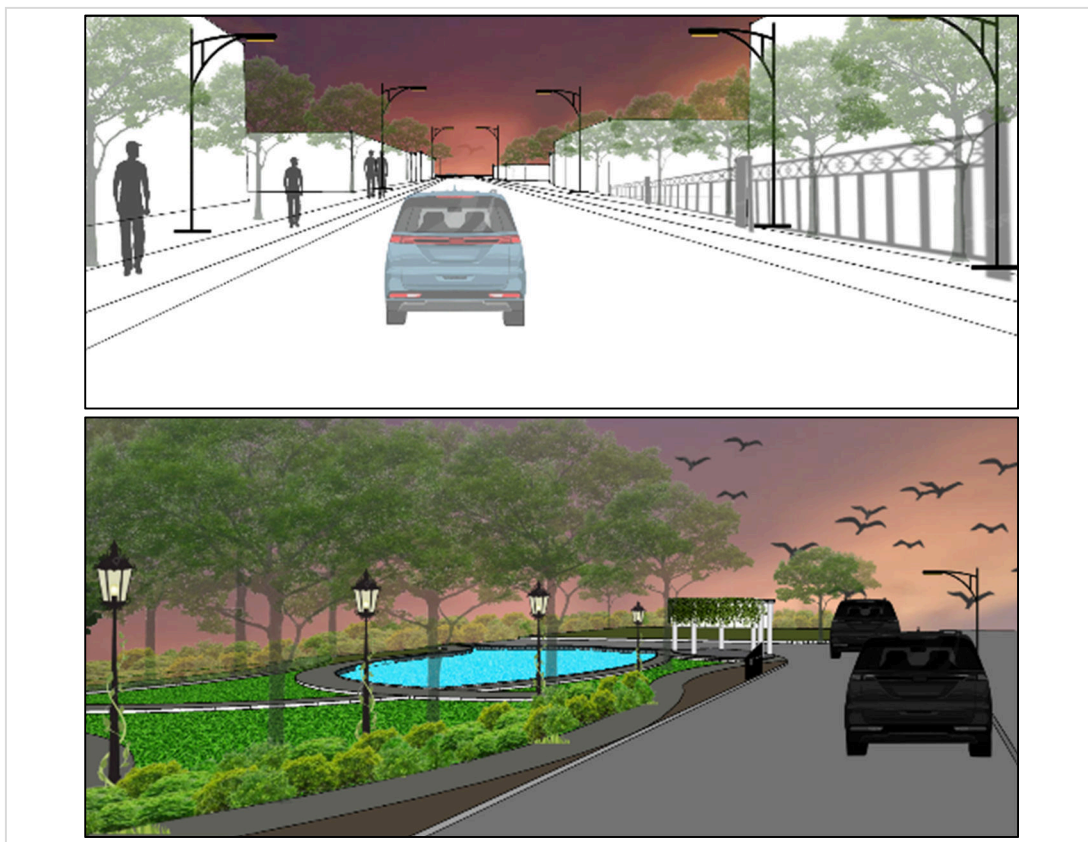


Figure 9. Lighting, sensors, and CCTV as a preventive safety system

This figure illustrates the integrated lighting, sensor, and CCTV strategy informed by FGD and AI-based spatial analysis, which identified poorly lit areas and limited surveillance as major contributors to fear and crime risk, particularly for women. The design translates these empirical findings into standardized lighting and intelligent monitoring systems that enhance visibility, deterrence, and inclusive safety in public spaces.

Conclusions

This study demonstrates the potential of integrating Artificial Intelligence (AI), Natural Language Processing (NLP), and Geographic Information Systems (GIS) to address urban safety and inclusivity for women and persons with disabilities. Spatial analysis of 729 pre-processed digital media records identified 48 vulnerable location entities, while a hybrid gazetteer–NER approach proved effective in producing comprehensive geospatial insights for evidence-based planning. Participatory FGDs with

women's forums and disability associations reinforced these findings by translating lived experiences into inclusive design criteria, highlighting the need for accessible pedestrian infrastructure, adequate lighting, gender-sensitive facilities, inclusive transport, and integrated surveillance systems.

Beyond Surabaya, the methodological framework is transferable to other urban contexts facing similar challenges, offering a scalable model for inclusive urban planning. A key direction for future research is the development of the proposed design concepts into a digital twin framework by integrating AI, GIS, and real-time urban data. This approach would enable dynamic simulation, scenario-based planning, and policy evaluation, supporting the application of gender-responsive and inclusive urban design across cities in Indonesia. Despite limitations related to data quality and ground-truth validation, this study underscores the value of alternative data sources and community engagement in advancing equitable, safe, and accessible urban environments.

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Ahmad Syaifuddin contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

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Komang Ayu Laksmi Harshinta Sari contribute to methodology, supervision, and validation.

Ade Fitriyanti Ulul Azmi contribute to methodology, supervision, and validation.

Ionocki Prasetyo contribute to methodology, supervision, and validation.