

Urban Green Renaissance in Malang: Trunojoyo Park and the Path to Sustainable Urban Futures

Nadia Trikarlina Laraswati¹; Igo Maulana Basri²; Rafael Miku P. Sogen³; Cut Puan Galuh Angelina⁴; Titik Poerwati⁵; Kevie Desderius^{5,6*};

^{1,2,3,4}Department of Regional and Urban Planning Engineering, Faculty of Civil Engineering and Planning, National Institute of Technology, Malang

⁵ Master of Disaster Management, Graduate School, Universitas Airlangga

⁶ Engineering Professional Study Programme, Faculty of Engineering, Widya Mandala Catholic University Surabaya

Abstract

Urban green spaces play a crucial role in promoting ecological resilience, social inclusion, and sustainable city development. This study examines Trunojoyo Park in Malang as a representative case of mid-sized Indonesian urban parks, analyzing its ecological functions, infrastructure conditions, accessibility features, and patterns of visitor utilization. The research applies a descriptive qualitative approach using a case study design, supported by field observation, document review, and spatial analysis. The analytical approach employs interactive analysis techniques consisting of data reduction, data display, and conclusion drawing, combined with spatial interpretation to assess ecological and functional performance of the park. Findings reveal that the park provides important ecosystem services, including air quality improvement, carbon sequestration, stormwater regulation, and urban heat island mitigation. It also accommodates diverse recreational, cultural, and educational activities, serving as a vital community hub. However, several limitations remain evident, such as deteriorating infrastructure, inadequate drainage systems, limited vegetation diversity, and insufficient universal accessibility. These issues restrict the park's overall performance and reduce inclusivity for vulnerable groups. The discussion highlights the urgency of revitalizing Trunojoyo Park to enhance ecological design, strengthen accessibility, and modernize management systems through smart technologies and participatory governance. By addressing these priorities, Trunojoyo Park can evolve into a resilient and inclusive green space that not only supports environmental services but also fosters social equity and cultural vitality. This case study underscores the importance of integrating ecological principles and community-centered approaches in urban park planning to advance sustainable urban futures.

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Corresponding Author:

Kevie Desderius
(kevie.desderius-2023@pasca.unair.ac.id)

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1. Introduction

Rapid urbanization in Indonesian cities continues to pose significant challenges in maintaining adequate green open spaces, known locally as Ruang Terbuka Hijau (RTH) (Pakaya et.al., 2024). These green spaces are essential not only for ecological balance but also for the social and recreational well-being of urban communities (Widati, 2024). National policy, stipulated in Law No. 26 of 2007 on Spatial Planning, mandates a minimum of 30% urban land area to be dedicated as green open space, with 20% public and 10% private (Salsabila, 2025). Despite this, many Indonesian cities including Malang fall short both in quantity and quality of green spaces due to intense land use pressures (Pambudi et.al., 2024).

Trunojoyo Park, centrally located in Malang near the city's main railway station,

exemplifies an urban green space with multifaceted roles (Setyabudi et.al., 2021). Established in 2014 as part of the city's initiative toward child-friendly and sustainable urban environments, the park spans 5,840 square meters (Setyabudi & Agus, 2020). It uniquely integrates recreational, educational, and environmental functions within a strategic transportation and commercial hub (Seran et.al., 2024). This location underscores its importance as a critical node within Malang's green infrastructure network.

The role of urban parks exceeds simple leisure; research affirms their contribution to improving urban air quality, mitigating urban heat islands, managing stormwater runoff, and enhancing public health outcomes (Agustin et.al., 2023 ; Efendi & Kristiana, 2024). Urban green spaces provide vital ecosystem services such as carbon sequestration, habitat for biodiversity, and microclimate regulation, which are particularly needed in densely built environments (Aristo, 2023 ; Kusmana, 2015). Furthermore, these spaces foster social cohesion by serving as meeting venues, spaces for physical activities, and cultural expression points (Pramesti et.al., 2019).

Despite their benefits, urban parks in Indonesia encounter several challenges including inadequate maintenance budgets, accelerated deterioration of infrastructure, and lack of universal accessibility (Agustina & Purwanto, 2025 ; Budiyaniti, 2018). Many parks in high-traffic urban areas suffer from the strain of intensive usage, leading to rapid wear and increased upkeep requirements (Juwono & Subagyo, 2017). Moreover, their integration into broader urban planning frameworks remains insufficiently developed, hampering their potential in sustainable urban development (Ardillah et.al., 2024).

Addressing these issues necessitates comprehensive urban planning approaches that harmonize ecological integrity, social needs, and economic feasibility (Akibu, 2025). This study focuses on Trunojoyo Park as a representative case to formulate actionable strategies aimed at sustainable urban green space revitalization. These strategies envision enhancing the park's ecological functions, improving visitor experience, and securing its long-term viability.

While previous studies have extensively discussed the ecological and social functions of urban green spaces, most have focused on general assessments without integrating spatial, ecological, and user-based analyses into a unified evaluation framework. This study offers novelty by combining ecological performance assessment, infrastructure evaluation, and accessibility analysis within a single case study approach, specifically applied to a strategically located urban park. Furthermore, this research introduces an integrative development framework that links ecological city concepts and healing environment principles with practical urban park management strategies. This integrated perspective provides a more comprehensive and context-specific model for urban green space revitalization, particularly in mid-sized Indonesian cities such as Malang.

The primary aim of this research is to critically evaluate the existing conditions of Trunojoyo Park, identifying deficiencies in facilities, utilities, and accessibility features. It further seeks to develop an integrated urban park development framework that incorporates contemporary sustainability concepts such as ecological city models and healing environment principles. The framework aims to guide future redevelopment efforts not only for Trunojoyo Park but also for similar urban green spaces across Indonesia.

Core research questions include identifying current infrastructural and operational gaps, assessing the applicability of advanced urban ecological theories, and determining optimal development and financing strategies. Additional inquiry centers on how an enhanced Trunojoyo Park can further contribute to broader sustainable urban futures in Malang. The study prioritizes evidence-based recommendations that address both practical management and policy perspectives.

Malang City's growing population and urban density intensify the demand for well-functioning green spaces capable of mitigating adverse urban environmental impacts (Rahmawati et.al., 2024). Existing green space shortages amplify environmental injustices by limiting equitable access to park amenities, disproportionately affecting vulnerable groups (Kurniawan & Muta'ali, 2025). This underscores the need for strategic planning that ensures green spaces remain inclusive and accessible to all residents (Ghafur, 2025).

Implementing sustainable urban green space development aligns with global urban sustainability goals and Indonesia's national urban planning directives (Nurfatiha et.al., 2024). By focusing on Trunojoyo Park, this study provides a tailored yet scalable model for integrating

ecological, social, and economic dimensions into urban park management. This urban green renaissance is critical for enhancing liveability and resilience in Malang's rapidly evolving urban landscape (Kusdiwanggo & Yusran, 2024 ; Pambudi et.al., 2024).

In sum, this research addresses an urgent urban challenge: bridging the gap between policy mandates for green space provision and realities of urban growth and infrastructural limitations. It advances scholarly understanding of urban park sustainability while offering Malang City actionable insights for nurturing its green heritage. Ultimately, the study contributes to a vision of vibrant, healthy, and sustainable Indonesian cities where public green spaces are vital urban commons.

2. Methods

Research methods

This study employs a qualitative descriptive research methodology to comprehensively evaluate the current conditions and potentials of Trunojoyo Park, with a focus on ecological, social, and infrastructural dimensions. The qualitative approach facilitates an in-depth understanding of existing challenges and opportunities through direct field observations, spatial analysis, and literature review. This methodology allows researchers to capture both objective facility conditions and subjective user experiences, which are essential for formulating sustainable urban park development strategies.

Study Area

The research was conducted at Trunojoyo Park, located on Jalan Trunojoyo, in the Klojen District of Malang City, East Java, Indonesia. The park covers approximately 5,840 square meters and serves as a critical urban green space adjacent to Malang's central railway station. The strategic location places the park at the crossroads of transportation, commercial, and residential activities, making it a vital node for urban recreation and environmental quality improvement.



Figure 1: Location of Trunojoyo Park, Malang City

Source: Author's Preparation (2025)

Data Collection

Primary data were collected through systematic field observations conducted over six months from February to July 2025. Researchers documented the condition of park infrastructure, including seating, playground equipment, lighting systems, water features, landscaping elements, and accessibility facilities. Visitor activities and usage patterns were observed at different times and days to identify periods of high traffic and diverse user groups. Photographic documentation complemented observational data to provide visual evidence of infrastructure status and park use.

Secondary data collection comprised a review of policy and planning documents, including the original design plan of Trunojoyo Park, maintenance records from the Malang City government, relevant city spatial planning regulations, and literature on sustainable urban park planning and ecological city concepts. Academic articles and case studies informed the theoretical framework and development strategies proposed in this research.

Data collection & instruments

Data were collected through triangulation techniques: (1) semi-structured interviews (recorded with permission, transcribed verbatim) using guidance that included business history, production processes, product changes, marketing strategies, revenue, and workforce regeneration; (2) participatory/non-participatory observation at production sites, workshop activities, and tourism village facilities with observation checklists; (3) documentation in the form of photographs, brochures, minutes of the association, and related local documents; and (4) a short questionnaire to visitors when available to complete the basic quantitative data. All instruments were tested on 2–3 pilot informants and revised prior to the main collection. All qualitative data from interviews and observations were transcribed and processed using manual coding techniques. Field notes and documentation were systematically archived and labeled based on date, location, and data type to ensure traceability and ease of analysis.

Analytical Procedures

The analysis was structured around four key dimensions. First, physical infrastructure conditions were assessed using standardized evaluation criteria to rate the functional and structural integrity of park facilities. Second, spatial analysis utilizing Geographic Information Systems (GIS) was performed to evaluate circulation patterns, area utilization, and the relationship of park zones. Third, ecological function was assessed based on vegetation coverage, air purification capacity, carbon sequestration estimates, and water management effectiveness using established ecological metrics. Fourth, social and economic functions were analyzed by interpreting visitor demographic data, activity diversity, and the potential for economic benefits to adjacent commercial sectors.

Theoretical Framework

The study integrates two complementary concepts guiding sustainable urban park enhancement. The Ecological City framework emphasizes designing urban environments that harmonize with natural ecosystems to maximize resiliency and resource efficiency. The Healing Environment concept underlines designing spaces to promote psychological and physical well-being by engaging sensory experiences and providing restorative natural settings. Together, these frameworks justify the recommendations for design, management, and financing strategies.

Validation and Quality Assurance

Data triangulation was employed by comparing field observations, spatial data, and documentary reviews to ensure reliability. Peer discussions and consultations with park management and urban planning experts validated findings and interpretations. All quantitative ecological estimates were crosschecked against trusted scientific models, and data collection protocols followed ethical and professional standards.

Data validity was ensured through multiple qualitative validation criteria. Credibility was achieved through data triangulation (observations, interviews, and documents), prolonged engagement in the field over six months, and member checking with selected informants. Transferability was ensured by providing detailed descriptions of the study context, enabling applicability to similar urban park settings. Dependability was maintained through an audit trail documenting all research procedures, data collection processes, and analytical steps. Confirmability was strengthened by cross-checking findings with theoretical frameworks and minimizing researcher bias through peer debriefing and expert consultation. Additionally, spatial and ecological data were validated by comparing field measurements with established environmental indicators and relevant scientific references.

3. Results and Discussion

3.1. Current Condition Assessment

The comprehensive evaluation of Trunojoyo Park revealed significant deficiencies across multiple infrastructure categories that impact both visitor experience and ecological functionality. The assessment identified critical maintenance needs, safety concerns, and accessibility limitations that require immediate attention.

Facility Infrastructure Conditions

The park's seating infrastructure shows extensive deterioration with approximately 70% of benches exhibiting moss growth, surface damage, and structural instability. This deterioration is attributed to inadequate maintenance schedules and the use of materials unsuitable for tropical climate conditions. Additionally, frequent exposure to heavy rainfall and humidity accelerates the decay process, making the benches uncomfortable and unsafe for users. Immediate restoration and replacement with weather-resistant materials are necessary to improve visitor experience and safety.

The playground equipment, while structurally sound, suffers from compromised safety due to unstable foundation systems caused by poor drainage management around equipment bases. Water accumulation during rainy seasons leads to soil erosion and uneven surfaces, increasing the risk of accidents. Lack of regular inspections further exacerbates these issues, putting children at potential harm. Improving drainage and conducting periodic safety assessments are critical steps to ensure a safe play environment.

The park's single shelter structure demonstrates critical deficiencies including roof leakage during rain events, compromised structural integrity in several areas, and inadequate capacity for the park's typical visitor volume. These conditions create safety hazards and limit the park's usability during adverse weather conditions. Meanwhile, the reading room facility, one of the park's unique features, remains underutilized due to unclear operational schedules, absence of staffing, and lack of visitor information systems. Despite its physical condition being relatively good, the facility's potential as an educational resource remains largely unrealized and requires better management and promotion to maximize its benefit to visitors.

Table 1. Existing Condition of Facility Components in Trunojoyo Park, Malang City

Facility Components	Existing Conditions	Potential/Problems
Seating (bench)	Many of the benches are mossy, some are damaged or wobbly	Limited use in rain/heat; visitor comfort decreases; Aesthetics of the space are disturbed
Toilets & laundry (sanitation)	Facilities are available but cleanliness, ventilation, and function are much diminished	Health risks & security perceptions; Reduce the duration of visitor visits
Description (trails & parks)	Some dark spots; lights off or uneven	Night security is reduced; limited nighttime use; Prone to vandalism
Trash can	The units are present but some are broken/closed missing; inconsistent emptying	Scattered garbage, odors, aesthetic and sanitation problems
Children's play area	The equipment is there but the rubber/softfall surface is peeled or worn	Child safety risks; Parents are hesitant to use the facilities
Pergola / shady structure	The structure is present but many parts lack maintenance (moss, porous)	Reduced shade function; Potential for long-term structural damage
Mini-amphitheater / performance hall	Small capacity; Event utilization is not routine	Potential underutilization; economic-cultural opportunities have not been exploited
Reading room / mini library	Basic facilities are available but maintenance & programs are lacking	Low educational potential; Minimal Community Utilization Margin
Surveillance & reporting system (CCTV, app)	Limited supervision; No Integrated Reporting System	Slow response to damage/incidents; Weak management coordination
Water drainage & diffusion	The channel is there but it is flooded/blocked at some points	Local flood risk, inundation reduces comfort and damages facilities
Walkways & accessibility	Some paths are uneven/obstructed; Unclear access	Pedestrian mobility barriers; Reduce connectivity with stations
Signage & information	Limited or faded direction/rule pointer	Visitor confusion; Communication of rules and activities is less effective
MSME & kiosk area	Space for MSMEs is limited and unstructured	The local economic potential is not optimal; Conflict of use of space during events
Countryside / Vegetasia	Large trees are present, but the distribution of shade and groundcover plants is uneven	Hot spots (thermal discomfort), water absorption capacity is not optimal

Source: Researcher Identification Results, 2024

Utilities and Infrastructure Systems

The park's lighting system presents significant safety and security concerns with approximately 40% of fixtures non-functional or operating at reduced capacity. This shortfall is especially problematic during evening and early morning hours when many visitors use the park, increasing the risk of accidents and crime. Dependence on commercial lighting from nearby street vendors underscores the park's inadequate lighting infrastructure. To address this, a comprehensive repair and upgrade plan is necessary to restore full functionality and enhance visitor safety.

Waste management infrastructure demonstrates both strengths and weaknesses. The park features well-designed waste separation systems with color-coded containers that encourage proper disposal. However, several containers are damaged, with holes and missing lids reducing their effectiveness and leading to litter and contamination risks. Although waste container placement generally follows accessibility principles, some park areas lack sufficient coverage, which may contribute to improper waste disposal. Maintenance and strategic expansion of waste facilities will improve cleanliness and environmental sustainability.

The park's water management systems, including the central fountain and drainage infrastructure, show mixed performance. While the fountain functions well and serves as a popular recreational feature, the surrounding drainage systems suffer from poor maintenance. This negligence causes water stagnation issues, which may create breeding grounds for mosquitoes and pose health risks to visitors. Improved routine maintenance and possible redesign of drainage pathways are essential to enhance water flow and reduce potential hazards.

Table 2. Existing Condition of Utilities and Infrastructure Systems in Trunojoyo Park, Malang City

Utilities & Infrastructure Component	Existing Condition	Potential / Issues
Electricity supply (grid)	Available for basic needs, but there are points with intermittent faults or uneven connections.	Reliance on a single source; outages disrupt lighting and events.
Lighting (park paths & fixtures)	Several lights are non-functional or provide uneven illumination.	Dark spots at night → reduced safety and limited after-dark use.
Potable water supply	Connections exist for toilets and taps, but flow/pressure is not always consistent.	Low pressure or interruptions affect sanitation and cleaning.
Stormwater drainage & infiltration	Drainage channels and soakaways exist but are clogged or poorly maintained in spots.	Ponding and reduced infiltration → local flooding risk and facility damage.
Irrigation system	Watering is mostly manual (hoses, watering cans).	Dependence on manual labor → irregular watering and plant stress in dry periods.
Waste collection & solid waste disposal	Routine collection in place, but some bins are damaged.	Littering, inconsistent separation → aesthetic and sanitation concerns.
Sanitation system (toilets & waste treatment)	Toilets are present but functionality and cleanliness have declined.	Health risks; uncertainty about effluent treatment or connection to sewer/septic.
Telecom & connectivity (cellular / Wi-Fi)	Cellular coverage varies; public Wi-Fi is generally unavailable.	Limited digital support for reporting, event information, or cashless transactions.
Security & monitoring (CCTV, alarms)	Electronic surveillance is limited or not integrated.	Slow incident response; vulnerability to vandalism/crime.
Power outlets & event support infrastructure	Permanent power outlets are limited for staging/events.	Constraints for small/medium events; risky use of extension cables.
Transport access / drop-off & parking	Highly strategic location in front of the station, but drop-off/parking space is limited.	Conflicts between pedestrians, vehicles, and vendors; reduced event accessibility.
Information systems & PA (announcements, digital signage)	Basic signage exists; no public announcement or digital signage system.	Difficulty in quickly communicating event updates or emergency information.

Source: Researcher Identification Results, 2024

Accessibility and Universal Design

The assessment revealed significant deficiencies in accessibility provisions for disabled users. The park lacks proper wheelchair-accessible pathways, with existing walkways featuring barriers, uneven surfaces, and inadequate width specifications that make navigation difficult or impossible for many visitors with mobility impairments. Additionally, restroom facilities do not meet universal design standards, limiting access for disabled visitors as well as families with young children who require accessible changing areas or support features. These shortcomings reduce the overall inclusivity of the park and restrict usage by a diverse range of visitors.

Wayfinding and information systems are virtually absent throughout the park, creating serious navigation challenges, especially for first-time visitors and individuals with visual

impairments who rely on clear, accessible cues. The absence of tactile or audio guidance features further exacerbates the difficulties in orientation within the park's spaces. Moreover, the lack of multilingual signage limits accessibility for international tourists, despite the park's strategic location near major transportation infrastructure, which attracts diverse visitors. Enhancing wayfinding tools and adding language options would significantly improve user experience for all.

To address these issues, the park should prioritize the retrofit of its pathways to meet wheelchair accessibility standards and upgrade restroom facilities to universal design criteria. Implementing comprehensive wayfinding systems, including tactile maps, audio guides, and multilingual signage, will support better navigation and inclusiveness. These improvements are essential to making the park welcoming and usable for visitors of all abilities and backgrounds.

Table 3. Existing Condition of Accessibility and Universal Design in Trunojoyo Park, Malang City

Component	Existing Condition	Potential / Issues
Entrances & main access points	Main entrance faces the station; some access points are unclear or narrow at certain locations	Confusion for first-time visitors; barriers for wheelchair users or strollers during peak times
Pathways & circulation	Primary paths exist but some sections are uneven, obstructed by vegetation, or have damaged paving	Trip hazards; difficulty maneuvering wheelchairs; reduced comfort for older adults
Ramps & slope gradients	Ramps present in some areas but several are steep or lack handrails	Unsafe for wheelchair users, people with limited mobility, and children
Surface materials	Mixed surfaces (concrete, pavers, turf)	Slippery when wet; surfaces are not consistently non-slip or even for accessible movement
Signage & wayfinding (including tactile/Braille)	Basic signage exists but is small and lacks tactile/Braille indicators	People with visual impairments struggle to navigate; visitors unfamiliar with the park may be disoriented
Seating & rest areas	Benches are scattered; some are low, lack armrests, or do not allow wheelchair space	Insufficient rest points suited to older adults or people with disabilities
Accessible toilets & changing facilities	Toilets are available but accessible features (wide doors, grab bars) are limited	May be unusable for wheelchair users or visitors requiring assistive fixtures
Drinking fountains & amenities	Water points are limited and mounted at a uniform height	Not friendly for children, wheelchair users, or people of different heights
Lighting & visibility	Lighting is uneven, especially along secondary paths	Reduced visibility at night → hazards for people with low vision
Tactile cues & audible information	Little to no tactile paving or audio information	Navigation barriers for blind/partially sighted users; emergency/event info not effectively communicated
Inclusive play areas	Play areas exist but are not designed inclusively (height and access limitations)	Children with disabilities may not be able to use play equipment
Parking & drop-off for people with disabilities	Drop-off/parking space is limited; designated accessible slots are unclear or inadequate	Difficulty for vehicle users who need quick, close access
Public transport linkage (station access)	Park is strategically located in front of the station, but transition routes are not fully universal	Modal transfers (walk → train) are challenging for users with special needs
Emergency access & evacuation routes	General evacuation routes exist but signage and dedicated access for emergencies are limited	Evacuation may be inefficient for people with limited mobility
Maintenance & obstacle management	Vegetation, vendors, or stored items occasionally block routes	Obstructed routes reduce consistent accessibility and safety

Source: Researcher Identification Results, 2024

3.2. Visitor Utilization Patterns

Visitor utilization patterns at Trunojoyo Park reveal a hybrid use profile driven by its gateway location: during weekday mornings and evenings the park functions largely as a transit-adjacent pass-through for commuters and station users, while afternoons and weekends show higher dwell times by families, students, and older adults who use the playground, reading corner, and seating areas for socializing and informal learning. Peak weekend activity concentrates around the amphitheater and potential UMKM zones during cultural or market events, yet nighttime utilization remains low due to uneven lighting and perceived safety concerns. Usage is spatially heterogeneous—some pockets (plaza, amphitheater) attract programmed activity, whereas other green patches suffer underuse due to limited seating and shade. These patterns suggest the need for time-sensitive programming, improved lighting and seating, clearer wayfinding, and targeted maintenance to convert transient flows into sustained, diverse park engagement.

Demographic Distribution and Activity Patterns

Observational data reveals distinct patterns in park utilization across different user groups and time periods. On weekdays, local residents make up the largest group of park users at 45%, followed by students and university attendees at 35%, and office workers at 20%. The peak usage times during weekdays are early morning hours from 05:00 to 08:00, predominantly for exercise activities, and late afternoon hours from 16:00 to 18:00, when visitors engage in relaxation and social interactions. These patterns reflect the park’s role as a vital recreational and social space for the surrounding community.

Weekend patterns display a substantial shift in visitor composition and activity. Family groups constitute the majority at 55%, highlighting the park’s appeal as a family-friendly destination during leisure time. Teenage gatherings account for 30%, and tourists make up 15% of weekend visitors. Activity peaks occur later in the day, from 16:00 to 21:00, aligning with informal entertainment events and the presence of food vendors in nearby areas. This increased diversity in users and activities reflects the park’s multifunctional role during weekends and holidays.

The playground area primarily serves children aged 3 to 12 years, with peak usage during weekends and school holidays when families frequent the park. However, safety concerns rooted in foundation instability have limited the playground’s full potential usage, causing anxiety among supervising parents. Addressing these safety issues is critical to enhancing the playground’s appeal and ensuring a secure environment for young visitors, which will support higher engagement and satisfaction with the park’s facilities.

Activity Diversity and Space Utilization

Trunojoyo Park demonstrates strong versatility in accommodating a wide range of activities, from passive recreation such as reading and socializing, to active recreation including playground use and informal sports. Educational activities like library visits and outdoor learning also coexist with cultural expressions in the form of informal performances and community gatherings. This diversity underscores the park’s potential as a multifunctional green space, yet spatial design constraints often hinder harmonious integration of these activities, creating overlaps and occasional conflicts between different user groups, particularly during weekends and holidays.

The central fountain area functions as the park’s most prominent social focal point, drawing visitors across age groups and enabling intergenerational encounters. Its role extends beyond aesthetics, as the water feature provides cooling effects in Malang’s tropical climate, improving comfort levels for users during hot periods. The fountain space illustrates how a well-designed landscape element can enhance both environmental quality and social vitality, making it one of the park’s most successful assets in shaping patterns of use and interaction.

Despite these strengths, activity distribution across the park remains uneven. Certain spaces, such as the plaza and fountain, experience heavy crowding, while peripheral green areas are underutilized due to limited shade, insufficient seating, or unclear functional designation. This imbalance indicates the need for more deliberate spatial zoning and supportive infrastructure to balance footfall, minimize user conflicts, and ensure that the full extent of the park contributes to recreational, educational, and cultural engagement. Enhancing spatial legibility and diversifying facilities across different nodes would help transform underused areas into active, inclusive spaces that complement the park’s role as a vibrant urban green hub.

Table 4. Activity–Space Matrix of Visitor Utilization in Trunojoyo Park

Activity Type	Main Spaces Utilized	User Groups	Current Issues / Gaps
Passive recreation (reading, chatting, resting)	Reading corner, benches near fountain, shaded seating areas	Students, older adults, commuters waiting for trains	Limited shaded seating; some benches damaged or uncomfortable
Active recreation (playground, informal sports)	Playground zone, open lawn areas	Children, teenagers, young families	Safety concerns due to worn-out surfaces; lack of buffer zones with other activities
Educational activities (library, informal learning)	Mini library, shaded corners used for study	School groups, students, families with children	Library underutilized; programs/events irregular; seating capacity limited
Cultural activities (performances, community gatherings)	Amphitheater/plaza near fountain	Local artists, community groups, families	Limited stage capacity; lack of regular programming; overlap with passive users
Transit-related use (waiting, short-stay, meeting point)	Fountain plaza, entrances near station	Commuters, travelers, short-term visitors	Overcrowding at peak hours; noise and pedestrian congestion
Commercial/UMKM activities (food stalls, informal vending)	Periphery near entrances, some open spaces	Vendors, visitors buying snacks	Unstructured layout; conflicts with pedestrian flows; waste management issues
Leisure & photography (casual strolls, photo spots)	Fountain plaza, pergola, landscaped paths	Teenagers, tourists, young adults	Concentrated at iconic spots; underuse of peripheral green areas

Source: Researcher Identification Results, 2024

The ecological function of Trunojoyo Park is strongly shaped by its vegetation, which consists of mature tropical tree species such as trembesi, mahogany, and bungur. These trees contribute to essential ecosystem services in the form of air pollutant removal and carbon sequestration, which directly enhance the livability of Malang’s dense urban core. Within an area of 5,840 m², the existing canopy not only provides shade and microclimate regulation, but also captures air pollutants and stores atmospheric carbon, thereby reinforcing the role of the park as a green infrastructure asset.

Assessment of air quality regulation indicates that tree cover in the park removes approximately 90–420 kg of air pollutants per year, depending on species density and canopy coverage. This pollutant capture capacity translates into tangible public health benefits, including reduced respiratory risks and improved urban air quality, although the precise economic valuation requires integration with local health cost data. Nonetheless, the service represents a significant contribution considering the limited spatial extent of the park.

Table 5. Estimated Air Pollutant Removal and Carbon Sequestration in Trunojoyo Park

Scenario (Tree Density)	Pollutant Removal (kg/year)	Carbon Sequestration (kg C/year)	CO ₂ Equivalent (Mg/year)	Economic Value of Carbon (IDR/year, 50k- 400k/tCO ₂)
Low (30 trees)	90 – 210	300 – 750	1.1 – 2.8	55,000 – 1,100,000
Medium (60 trees)	180 – 420	600 – 1,500	2.2 – 5.5	110,000 – 2,200,000
High (90 trees)	270 – 630	900 – 2,250	3.3 – 8.3	165,000 – 3,300,000

Source: Results of Researcher Estimate Analysis, 2025

Carbon sequestration analysis further highlights the park’s role in climate regulation. Based on conservative tropical urban forest coefficients (10–25 kg C/tree/year), the park’s vegetation is estimated to sequester 600–1,500 kg of carbon annually, equivalent to 2.2–5.5 Mg CO₂ per year under a medium-density scenario of 60 mature trees. This range aligns with prior estimates suggesting approximately 1.76 Mg C/year (≈6.45 Mg CO₂) when canopy maturity and growth rates are optimized. Thus, Trunojoyo Park provides a modest but measurable contribution to Malang’s urban carbon balance.

Economic valuation of these services, using indicative carbon pricing mechanisms (IDR

50,000–400,000 per ton of CO₂), suggests an annual carbon service value of IDR 110,000–2,200,000 for the medium-density scenario. While relatively small in monetary terms, the symbolic and ecological significance is far greater, underscoring the importance of maintaining and expanding tree cover. Strategic enrichment planting and structured vegetation layering would likely double these values over the next decade, positioning the park as both a local climate regulator and a model of sustainable urban green infrastructure.

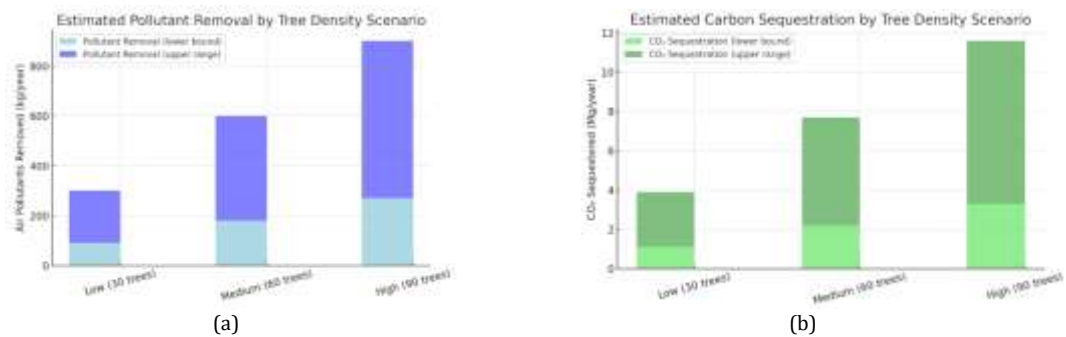


Figure 2: Estimated Air Pollutant Removal and Carbon Sequestration in Trunojoyo Park
Source: Visualization of Analysis Results, 2025

Stormwater Management and Urban Heat Island Mitigation

Stormwater management is an essential ecological service provided by urban parks, reducing runoff volumes and mitigating localized flooding. With a total area of 5,840 m², Trunojoyo Park contributes significantly to water infiltration compared to surrounding impervious surfaces. Using conservative infiltration coefficients for urban green spaces (0.035 m water depth annually), the park’s stormwater retention and infiltration capacity is estimated at ≈204 m³/year. This service aligns closely with earlier estimates and represents an important flood risk reduction mechanism in the station’s high-traffic catchment area.

Despite this potential, the park’s drainage system shows evidence of clogging, uneven maintenance, and limited bioswale or soakaway integration. These deficiencies mean that the theoretical maximum infiltration capacity is not fully realized, with actual effectiveness potentially 20–30% lower than calculated. Addressing these gaps through rain gardens, permeable paving, and additional soak pits could significantly increase stormwater regulation, while simultaneously enhancing groundwater recharge and soil moisture balance. The economic value of this service, based on avoided flood damage and drainage costs, is estimated at IDR 6.8–7.2 million per year under current conditions.

Table 6. Estimated Stormwater Management and Cooling Services of Trunojoyo Park

Ecosystem Service	Estimation Method	Capacity (Annual / Peak)	Economic Value (IDR/year)	Notes
Stormwater infiltration	Area (5,840 m ²) × Infiltration coeff. (0.035 m)	≈204 m ³ /year	6.8 – 7.2 million	Value based on avoided flood/damage costs
Cooling (UHI mitigation)	Temperature differential between vegetated & built-up areas	2–3°C reduction	Not directly monetized; indirect benefits via energy savings, health gains	Localized to park & adjacent commercial/transport nodes

Source: Results of Researcher Estimate Analysis, 2025

In terms of urban climate regulation, Trunojoyo Park contributes to urban heat island (UHI) mitigation by providing shaded areas and evapotranspirative cooling. Microclimate observations in comparable tropical city parks indicate average temperature reductions of 2–3°C within and adjacent to tree canopies compared to nearby built-up areas. In Malang’s dense commercial and transport hub, this service is particularly valuable: it lowers heat stress for commuters, reduces energy demand in adjacent buildings, and improves thermal comfort for

outdoor activities.

The combined stormwater and cooling services underscore the multifunctional role of relatively small urban parks. While the absolute volumes and valuations may appear modest, the co-benefits—such as improved commuter experience, reduced infrastructure strain, and enhanced resilience to climate extremes—justify continued investment. Strategic retrofitting of drainage infrastructure and expansion of canopy coverage would both double stormwater absorption and increase cooling intensity, positioning Trunojoyo Park as a key node in Malang's urban climate adaptation strategy.

3.3. Discussion

Ecological Performance and Climate Adaptation Role

The ecological assessment of Trunojoyo Park highlights its vital contribution to urban environmental regulation. Mature tree cover contributes to measurable pollutant removal and carbon sequestration, complementing the city's broader climate change mitigation strategies. The park's estimated 2–5 Mg CO₂ sequestration annually may appear modest, yet it represents a critical carbon sink within Malang's dense urban fabric. Moreover, its stormwater infiltration capacity of more than 200 m³ per year provides essential flood-risk reduction in an area characterized by high imperviousness. These findings align with studies in other tropical urban contexts showing that even small urban green patches deliver significant co-benefits for climate adaptation when strategically located near transport hubs and commercial corridors.

Visitor Experience, Accessibility, and Inclusivity

Findings on utilization patterns show that Trunojoyo Park accommodates diverse functions—from passive leisure and educational use to cultural activities and commercial interactions. However, spatial conflicts emerge during peak hours due to uneven infrastructure distribution and accessibility gaps. The limited provision of shaded seating, inadequate universal design features, and underutilized peripheral areas reduce the park's inclusivity. Similar challenges have been reported in Southeast Asian cities where rapid urbanization often sidelines universal design in public space planning. Addressing these gaps would allow the park to evolve beyond a transit-adjacent space into a genuinely inclusive green hub that fosters intergenerational and cross-community interactions.

Governance and Policy Integration

While the park demonstrates ecological and social benefits, its management is constrained by fragmented governance and insufficient maintenance. Drainage deficiencies, inconsistent waste management, and limited cultural programming point to the absence of integrated planning and monitoring systems. Embedding the park within Malang's broader sustainability and resilience frameworks—such as climate action plans, health promotion strategies, and urban biodiversity policies—would enhance institutional accountability. Comparative studies suggest that successful urban green space governance requires multi-actor collaboration, involving municipal agencies, local businesses, and community groups to ensure long-term sustainability and adaptive management.

Pathways Toward Sustainable Urban Futures

The challenges and potentials identified in Trunojoyo Park provide important lessons for Malang's pursuit of sustainable urban futures. By improving ecological infrastructure, enhancing accessibility, and embedding participatory governance, the park can serve as a microcosm of urban resilience strategies. Investments in vegetation enrichment, inclusive play areas, and smart utilities would not only maximize ecosystem services but also position the park as a model of green innovation in a transit-oriented urban district. Ultimately, the integration of ecological functions, cultural vitality, and equitable access in spaces like Trunojoyo Park embodies the essence of an Urban Green Renaissance, aligning local initiatives with global agendas such as the SDGs and New Urban Agenda.

Development Strategy Framework

The development of Trunojoyo Park requires a comprehensive strategy that integrates ecological, social, and infrastructural dimensions. The proposed framework draws upon the

principles of the ecological city, healing environment design, and infrastructure modernization, ensuring that the park evolves into a resilient and inclusive green space. By aligning environmental performance with user experience and governance capacity, the framework highlights pathways to transform the park into a model for sustainable urban futures in Malang.

Ecological city integration is central to this framework, emphasizing the role of urban nature as a climate adaptation asset. Strategic interventions include the enrichment of biodiversity through the introduction of native plant species, the establishment of pollinator gardens, and the creation of bird habitats through layered tree planting. In addition, sustainable water management can be achieved through the application of bioswales, rain gardens, and other nature-based solutions that enhance infiltration and groundwater recharge. These interventions may be complemented by renewable energy systems, such as solar-powered lighting and smart monitoring, positioning the park within a low-carbon development pathway.

Complementary to ecological functions, the healing environment approach underscores the park's potential to foster psychological well-being and inclusive recreation. Sensory-oriented design interventions—such as vegetation placement for acoustic buffering, therapeutic planting schemes, and improved lighting design aligned with circadian rhythms—would enhance the restorative qualities of the park. Quiet zones for meditation, sensory gardens for visitors with disabilities, and universally accessible pathways reinforce the inclusivity of the space. Enhanced wayfinding systems, equipped with tactile and auditory elements, further ensure equitable access for diverse user groups, including the elderly and persons with disabilities.

Finally, the infrastructure modernization plan addresses the pressing need to balance routine maintenance with forward-looking upgrades. Priority measures include the replacement of outdated lighting with energy-efficient LED systems equipped with smart controls, the installation of safe and inclusive playground equipment, and the rehabilitation of shelters and restrooms to meet universal design standards. Secondary enhancements such as WiFi provision, digital information systems, charging stations, and sensor-based maintenance monitoring would support the evolution of Trunojoyo Park into a “smart park.” Together, these measures position the park not only as a node of ecological resilience and social inclusion, but also as a living laboratory of sustainable urban innovation in Malang.

Urgency of Revitalizing Trunojoyo Park

The assessment of Trunojoyo Park reveals several urgent dimensions that justify immediate revitalization efforts. First, infrastructure deterioration is a critical issue. Facilities such as benches, toilets, playground equipment, and shelters exhibit signs of wear and reduced safety standards. Drainage systems show clogging and inadequate infiltration, which limit the park's stormwater management capacity and increase the risk of localized flooding. Without prompt intervention, these deficiencies not only reduce visitor comfort but also threaten public safety and environmental resilience.

Second, ecological functions require reinforcement. Although existing tree cover provides measurable ecosystem services in terms of carbon sequestration, pollutant removal, and microclimate regulation, these benefits are constrained by limited vegetation diversity and underutilized green patches. The absence of pollinator-friendly plants, insufficient groundcover, and uneven canopy distribution reduce the park's capacity to mitigate urban heat island effects and support biodiversity. Strategic ecological enrichment is therefore urgent to optimize both environmental services and long-term climate adaptation.

Third, accessibility and inclusivity remain inadequate. Pathways are uneven, ramps are either absent or too steep, and signage lacks tactile and auditory elements. Rest areas do not yet accommodate users with disabilities or elderly visitors, while playground facilities are not designed inclusively. These shortcomings create barriers for equitable use and contradict the principle of universal design. Revitalization is thus essential to transform the park into a genuinely inclusive space that meets the needs of diverse urban communities.

Finally, management and technological modernization lag behind contemporary urban park standards. Lighting is uneven, security surveillance is limited, and digital infrastructure is minimal. These gaps reduce nighttime usability, heighten safety concerns, and constrain

efficient park management. Integrating smart technologies—such as WiFi, CCTV, sensor-based monitoring, and digital information systems—has become urgent to enhance visitor experience and enable proactive maintenance. Combined with improved governance mechanisms, these upgrades would reposition Trunojoyo Park not only as a recreational space but as a model of sustainable, resilient, and smart urban green infrastructure for Malang.

Table 7. Urgency Matrix for Revitalizing Trunojoyo Park

Issue Area	Urgency Level	Key Problems Identified	Potential Impact if Unaddressed
Infrastructure & Facilities	Very High	Damaged benches, unsafe playground, poor toilet condition, drainage clogging	Safety hazards, reduced visitor comfort, increased flood risk
Ecological Functions	High	Limited vegetation diversity, uneven canopy, lack of pollinator habitats	Declining air quality, reduced carbon sequestration, weaker UHI mitigation
Accessibility & Inclusivity	Very High	Uneven pathways, steep/absent ramps, non-inclusive playground, lack of tactile signage	Exclusion of elderly & disabled users, inequitable public space access
Safety & Security	High	Insufficient lighting, limited CCTV coverage, unmanaged dark spots	Increased crime/vandalism risk, low nighttime usage
Technology & Management	Medium–High	Minimal digital systems, no smart monitoring, weak wayfinding	Inefficient maintenance, limited engagement, reduced visitor trust
Cultural & Social Activation	Medium	Amphitheater underutilized, irregular programming, unstructured UMKM stalls	Lost opportunities for community engagement & local economy

Source: Results of Researcher Analysis, 2025

Sustainability and Long-term Management

1. Maintenance Strategy

Ensuring the sustainability of Trunojoyo Park extends beyond physical revitalization and requires robust long-term management systems. Sustainable operations should be supported by systematic maintenance protocols that prevent recurring deterioration of infrastructure and ecological assets. Regular cleaning, preventive maintenance of lighting and drainage systems, and structured landscaping care must be institutionalized within municipal routines. To strengthen local ownership, the establishment of friends-of-the-park volunteer groups can provide supplementary support while fostering community stewardship. Digital maintenance tracking systems are also recommended, enabling real-time reporting of facility conditions and faster response to damages. Furthermore, the integration of revenue-generating activities—such as structured UMKM kiosks, event rentals, or eco-tourism programs—can provide additional financial streams to sustain ongoing operations without over-reliance on municipal budgets.

2. Monitoring and Evaluation Framework

Long-term park sustainability relies on consistent monitoring and adaptive evaluation to ensure that ecological, social, and economic goals are achieved. Ecological monitoring should include annual assessments of ecosystem services, such as carbon sequestration, stormwater infiltration, and biodiversity indicators. Social monitoring requires quarterly visitor satisfaction surveys and inclusivity audits to evaluate accessibility and user equity. Infrastructure monitoring can be carried out through monthly inspections of playground safety, lighting, sanitation, and accessibility features. Finally, continuous digital safety monitoring via CCTV and sensor systems is essential to maintain visitor trust and encourage nighttime use.

3. Integrative and Adaptive Management

The integration of maintenance and monitoring must be embedded in an adaptive management framework that allows for iterative adjustments based on data and feedback. By linking ecological performance indicators with user experience and economic outcomes, decision-makers can prioritize interventions that deliver the greatest co-benefits. This approach aligns with sustainable urban governance principles, where flexibility and stakeholder participation ensure that revitalized parks do not regress into underutilized or deteriorated spaces. In the case of Trunojoyo Park, embedding sustainability planning

within Malang's broader resilience and climate adaptation strategies will ensure that investments in infrastructure, ecology, and accessibility continue to yield long-term dividends for the city and its residents.

4. Conclusion

This study demonstrates the strategic importance of Trunojoyo Park as an urban green space that contributes to ecological resilience, social cohesion, and cultural vitality in Malang. The park delivers valuable ecosystem services, including air purification, carbon sequestration, stormwater regulation, and mitigation of urban heat island effects. It also functions as a community node, accommodating diverse activities across generations and supporting informal cultural and educational interactions.

Despite these contributions, the findings reveal that several challenges limit the park's capacity to serve as a model of sustainable urban space. Infrastructure deterioration, inadequate drainage, insufficient ecological diversity, and limited accessibility undermine its functionality and inclusivity. Technological systems and management mechanisms are also lagging, reducing the park's efficiency and visitor safety, particularly during peak periods and nighttime use.

In conclusion, the revitalization of Trunojoyo Park is urgently needed to safeguard and enhance its ecological functions, ensure equitable access for all user groups, and modernize its facilities in line with contemporary sustainability principles. Strengthening ecological design, implementing universal accessibility, and integrating smart management systems will enable the park to evolve into a resilient, inclusive, and adaptive urban green space. Trunojoyo Park thus holds the potential to exemplify Malang's commitment to sustainable urban futures.

However, this study has several limitations. First, the research is based on a single case study, which may limit the generalizability of findings to other urban contexts. Second, the ecological assessment relies on simplified estimation techniques rather than advanced environmental modeling, which may affect the precision of ecological performance measurements. Third, data collection was conducted within a specific time frame, potentially limiting the ability to capture long-term seasonal variations in park usage and environmental conditions. Future research is recommended to expand the scope by incorporating comparative studies across multiple urban parks in different cities, applying more advanced quantitative ecological modeling, and integrating longitudinal data to better understand temporal dynamics. Additionally, further studies could explore the role of digital technologies and smart governance systems in enhancing urban park management and user experience.

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Conflict Of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. There are no financial or personal relationships that could have influenced the results or interpretation of this study

Data Availability

The data supporting the findings of this study were obtained through field observations conducted over a six-month period, spatial analysis, and document reviews related to Trunojoyo Park. Due to the nature of qualitative and location-based data, some datasets are not publicly available. However, data may be provided by the corresponding author upon reasonable request and with appropriate consideration of research ethics and data use limitations.

Author Contributions

The contributions of each author are as follows:

- **Conceptualization and research design:** all authors
- **Field data collection (observations, spatial documentation, and data recording):** first, second, third, and fourth authors
- **Data analysis (qualitative analysis and spatial interpretation):** all authors
- **Manuscript drafting:** first author and corresponding author
- **Reviewing, editing, and final approval:** all authors

All authors have read and approved the final version of the manuscript.

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