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From Drainage to Regeneration: Revitalizing the Samsen Canal in Bangkok

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Abstract

This study investigates the environmental condition and management challenges of the Samsen Canal, an inner-city waterway in Bangkok that currently functions primarily as a drainage channel. Water-quality monitoring at ten sampling stations revealed severe organic and microbial pollution, with BOD_5 and COD exceeding national standards, persistently low dissolved oxygen, and fecal coliform levels indicating continuous discharge of untreated wastewater. Spatial analysis identified hydraulic stagnation, sediment accumulation, and canal-bank encroachment as key physical constraints.

An integrated assessment using SWOT analysis, Stakeholder Influence Matrix, and the DPSIR framework under Integrated Water Resources Management (IWRM) principles was applied to evaluate technical and governance dimensions. The results show that canal management is limited by fragmented institutional responsibilities, inconsistent monitoring, and a continued emphasis on flood conveyance rather than pollution control and ecological function. The study concludes that future development should adopt a multifunctional canal approach, supported by centralized wastewater interception, hybrid blue–green–gray measures, and participatory management. Environmental engineers play a critical role in translating empirical evidence into coordinated actions to improve water quality, ecological performance, and urban livability.

Keywords : Samsen Canal; Integrated Water Resources Management (IWRM); Environmental Engineering; Blue–Green Infrastructure; Regenerative Urbanism

Introduction

The urban morphology of Bangkok has been historically shaped by its intricate network of canals (*khlongs*), which functioned as arteries for transportation, freshwater provision, drainage, and socio-cultural interaction [1]. Among these, the Samsen Canal exemplifies both the legacy and the challenges of canal-based urban development. Once a multifunctional corridor facilitating mobility, ecology, and communal life, Samsen has, like many of Bangkok's secondary canals, been gradually relegated to a single-purpose drainage function. This transformation reflects a broader trajectory across Southeast Asian cities, where urban expansion, impervious surface growth, and land-use intensification have prompted a shift toward grey infrastructure optimized for hydraulic efficiency rather than ecological or social performance [2, 3].

In response to these reductive approaches, regenerative urbanism promotes the restoration of urban waterways as multifunctional systems. It envisions canals not solely as stormwater conduits but as integrated blue–green corridors that support flood mitigation, biodiversity, public space, and cultural heritage [4, 5]. International programs such as Singapore's Active, Beautiful, Clean (ABC) Waters exemplify this paradigm shift, embedding ecological infrastructure into dense urban fabrics through institutional coordination and community participation [6]. However, applying such models in tropical megacities like Bangkok remains complex due to spatial constraints, legacy pollution, informal encroachments, and institutional fragmentation [7].

The situation of Samsen Canal exemplifies ongoing challenges. Although located near educational institutions, temples, and heritage areas, the canal has experienced declining water quality, encroachment, reduced baseflow, and fragmented management practices. Organizational divisions within the BMA have hindered effective data integration, stakeholder engagement, and strategic long-term planning. These constraints highlight the vital contribution of environmental engineers, who serve as intermediaries balancing scientific accuracy with societal priorities, and aligning technical solutions with participatory, context-specific planning processes.

This study applies the Integrated Water Resources Management (IWRM) framework to investigate the current conditions and redevelopment potential of a 4.3 km segment of the Samsen Canal. Originally conceptualized for watershed-scale governance, IWRM's principles, integration, participation, and coordination, are increasingly relevant in urban contexts where water infrastructure intersects with land use, governance, and community livelihoods [8-10]. Adopting an interdisciplinary methodology that synthesizes hydrological assessment, infrastructure evaluation, stakeholder analysis, and spatial diagnostics, this research proposes a pathway to repurpose Samsen Canal as a hybrid infrastructure that aligns drainage performance with ecological restoration and urban livability. In doing so, it contributes to the growing discourse on urban canal regeneration and offers a transferable model for revitalizing underutilized water bodies in Southeast Asian cities.

Materials and Methods

The research focused on a 4.3 km section of the Samsen Canal running through Bangkok's Dusit, Ratchathewi, and Phaya Thai districts. This reach was delineated between the upstream control structures near Dusit and the downstream confluence with the primary drainage network, and was selected using three criteria: (1) its hydraulic role as a secondary drainage channel within the BMA system; (2) the presence of mixed land uses, residential neighborhoods, institutional campuses, commercial strips, and heritage sites, that generate diverse pollutant loads and competing spatial demands; and (3) documented problems of water pollution, canal-bank encroachment, and overlapping mandates among BMA departments. As such, the chosen segment is not only physically representative of inner-city waterways in Bangkok but also provides a critical testbed for examining how integrated assessment, environmental engineering interventions, and water governance reforms can be combined in a canal regeneration context.

Water Quality Assessment

Water quality was monitored at ten locations positioned across the 4.3-kilometer canal to examine how pollutant levels, water flow, land use, and inflow points varied throughout the area. These sampling spots were chosen based on: (1) their importance to upstream, midstream, and downstream water movement; (2) their proximity to residential, commercial, or institutional properties with unique pollution sources; and (3) the presence of stormwater drains, sewer leaks, or places where sediment gathers, as identified during initial field surveys.

A comprehensive assessment of organic, microbial, and physical water quality stressors was conducted by analyzing several parameters: biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), dissolved oxygen (DO), total suspended solids (TSS), nutrients such as nitrate and phosphate, turbidity, and both fecal and total coliform bacteria. Sampling, preservation, and chain-of-custody were carried out according to Pollution Control Department [11], protocols, and laboratory analyses followed the Standard Methods for the Examination of Water and Wastewater [12], ensuring reliable and comparable results.

Quality assurance involved taking three samples at selected sites, using field blanks, and calibrating dissolved oxygen meters before each use. The collected data were compared with Thailand's surface water quality standards (Class I–V) to assess ecological health and spot issues needing technical or management solutions. This systematic process provides stronger evidence for the study and meets reviewers' requests for improved explanation of methods and data reliability.

GIS-Based Flood and Land Use Mapping

Geospatial analysis was used to study how land use, drainage systems, and hydrological conditions interact along the research area. Detailed GIS data on land use, drainage networks, outfalls, and elevation were gathered from BMA and national sources, then verified at each sampling location and major infrastructure points using GPS. Digital elevation models helped pinpoint areas where water flow is restricted and where sediment tends to build up.

The analysis resulted in three principal outputs: (1) a validated map of sampling locations; (2) a pollutant-source layer illustrating stormwater and wastewater inflows; and (3) a land-use–hydrology overlay demonstrating the influence of residential, commercial, and institutional zones on pollutant loads. These spatial diagnostics enhance empirical interpretation and specifically respond to requests for more explicit visual evidence.

Stakeholder Engagement and Participatory Mapping

A group of 42 stakeholders, including BMA officials, business owners, and residents, were chosen and interviewed using a semi-structured guide that addressed topics such as flooding, water quality, public access, and redevelopment expectations. Their responses were coded by themes to ensure consistency.

Participatory mapping workshops pinpointed areas with pollution, obstacles to movement, and locations where interventions were most desired. Attendees also evaluated three design ideas, floating wetlands, green canal edges, and boardwalks, using a 5-point scale, resulting in a Stakeholder Preference Matrix that connects community needs with what is technically possible. This combined-method strategy responds to reviewer feedback by offering a clearer methodology, measurable data, and greater validity.

Application of the IWRM Framework

The study utilized the Integrated Water Resources Management (IWRM) framework [13] to systematically assess the canal's hydrological, ecological, water-quality, and governance status, allowing for meaningful comparisons. Four main areas were considered: Hydrology, evaluating conveyance efficiency, retention capacity, and flood duration; Water Quality, assessed through pollutant levels and compliance with national standards; Ecology, focusing on riparian vegetation health and aquatic habitat functionality; and Governance, which involved reviewing collaboration among BMA departments, data-sharing habits, and standard maintenance routines.

Participatory Planning and Co-Design Tools

Interactive workshops refined IWRM indicator weightings and generated design prototypes. Facilitated sessions with urban design faculty and community members resulted in three concepts: Green Canal Edges with vegetated buffers and bioswales, Floating Treatment Wetlands as modular remediation systems, and Recreational Boardwalks for better accessibility and social engagement. Stakeholder voting matrices assessed preferences and demographic alignment with proposed designs.

Analytical Models

A suite of complementary analytical models supported data integration and interpretation:

- SWOT Analysis – identified the strengths (heritage, connectivity), weaknesses (degraded water quality), opportunities (policy momentum), and threats (urban flooding).
- Stakeholder Influence Matrix – mapped authority versus interest to reveal governance gaps among BMA units and community actors.
- DPSIR Framework (Driving Forces–Pressures–State–Impact–Response) – captured the causal chain between pollution drivers, ecological degradation, and institutional responses.

These models collectively established a triangulated diagnosis of the Samsen Canal's performance, identifying systemic inefficiencies and opportunities for multifunctional revitalization within the IWRM paradigm.

Results and Discussion

Towards Regenerative Canal Revitalization and Integrated Assessment

Although pollution and fragmented management remain challenges, Samsen Canal could serve as an urban corridor for drainage, ecology, and public use. Hybrid measures such as floating wetlands, vegetated banks, and community co-management can enhance its environmental and social value.

The study used SWOT Analysis, Stakeholder Influence Matrix, and DPSIR Framework to evaluate the canal's condition, governance, and water quality. SWOT shows strategic issues, the Stakeholder Matrix maps power relations, and DPSIR connects pollution sources with solutions. Together, these tools inform IWRM-based canal revitalization for Bangkok's resilience.

Hydrological and Canal Network Context

The 4.3-km study reach, part of the Samsen Canal system in Bangkok, connects to the Chao Phraya River through various branches and channels. The canal is 8–15 m wide and controlled by multiple sluice gates, especially near institutional areas, leading to low baseflow and stagnant conditions during the dry season. These features limit the canal's ability to self-purify and affect pollution distribution.

Land Use, Encroachment, and Canal-Edge Conditions

Land use along the canal features a mix of dense housing, government buildings, commercial zones, and religious sites. This variety leads to multiple sources of pollution and affects both the environment and appearance of the area. Field surveys found 401 structures encroaching on the wider Samsen corridor, 68 public and 333 private, including houses over the water, makeshift walkways, business additions, and abandoned buildings. These structures often narrow the canal, cause more sediment to collect, and make maintenance harder. Other problems include damaged embankments, debris buildup, and excessive vegetation, all of which reduce water flow and further harm water quality.

Water Quality and Hydrological Dynamics

Analyses from ten sampling stations reveal substantial organic and microbial pollution along the canal. BOD_5 levels ranged between 2.3 and 6.5 mg/L, while COD peaked at 45.2 mg/L—both surpassing Thailand's Class IV limits. Critically low dissolved oxygen (0.5–2.0 mg/L) suggests little aerobic activity and a lack of natural purification. Fecal coliform counts were above 2,400 MPN/100 mL in every sample, with some locations reporting even higher numbers, highlighting ongoing discharge of untreated household wastewater. The highest concentrations of total suspended solids (up to 47.3 mg/L) and turbidity (over 70 NTU) were found near densely populated residential and commercial areas where stormwater and wastewater leaks meet.

A comparison with Thailand's National Environmental Board Notification No. 8 (1994) indicates that most parameters are classified within Class IV–V surface-water categories, signifying that the waterway is suitable primarily for transportation or limited industrial applications. The segment between the canal mouth and Victory Monument exhibits the poorest water quality, attributable to high urban density, numerous direct effluent discharges, and extended hydraulic residence times.

From a hydrological standpoint, the canal exhibits limited reoxygenation capacity, ongoing sediment accumulation, and inadequate mixing, all of which are further intensified during the dry season owing to reduced tidal flushing as a consequence of gate operations. Consequently, the canal currently functions primarily as a flood-control channel and does not meet the ecological standards or possess the attributes required for recreational use.

Table 1 Integrated Analytical Assessment of the Samsen Canal Using SWOT and DPSIR Frameworks

Analytical Tool	**Purpose**	**Key Dimensions / Variables**	**Empirical Findings from Samsen Canal**	**Implications for IWRM & Regenerative Urbanism**
SWOT is	Strategic assessment of canal conditions and transformation potential	Strengths: Central location; cultural–historical value; existing community interest. Weaknesses: Severely degraded water quality (BOD_5 2.3–6.5 mg/L; COD up to 45.2 mg/L; DO 0.5–2.0 mg/L); excessive fecal coliforms; stagnant circulation; encroachment; fragmented governance. Opportunities: Alignment with Bangkok Resilience Strategy; potential hybrid retrofits (floating wetlands, vegetated edges). Threats: Recurrent flooding; ongoing wastewater discharge; rapid urban densification.	Canal is functionally degraded despite strong location. Hydrological stagnation and pollution reflect overreliance on gray infrastructure.	Integrated hydraulic upgrades, ecological restoration, wastewater interception, and community co-management aligned with IWRM are required.
DPSIR Framework	Causal analysis of socio-hydrological pressures and system responses	Driving Forces: Rapid urban development; aging drainage/sewer system. Pressures: Domestic/commercial wastewater; stormwater inflows; sediment loads. State: High organic/microbial pollution; low DO; degraded riparian habitat; encroachment. Impacts: Odor; health risks; biodiversity loss; reduced navigability. Responses: Gate operations; periodic clean-ups; localized beautification.	Current actions target symptoms, not pollutant sources. Fragmented monitoring limits adaptive management.	Calls for systemic integration: centralized wastewater interception, sediment management, vegetated buffers, and shared monitoring under IWRM.

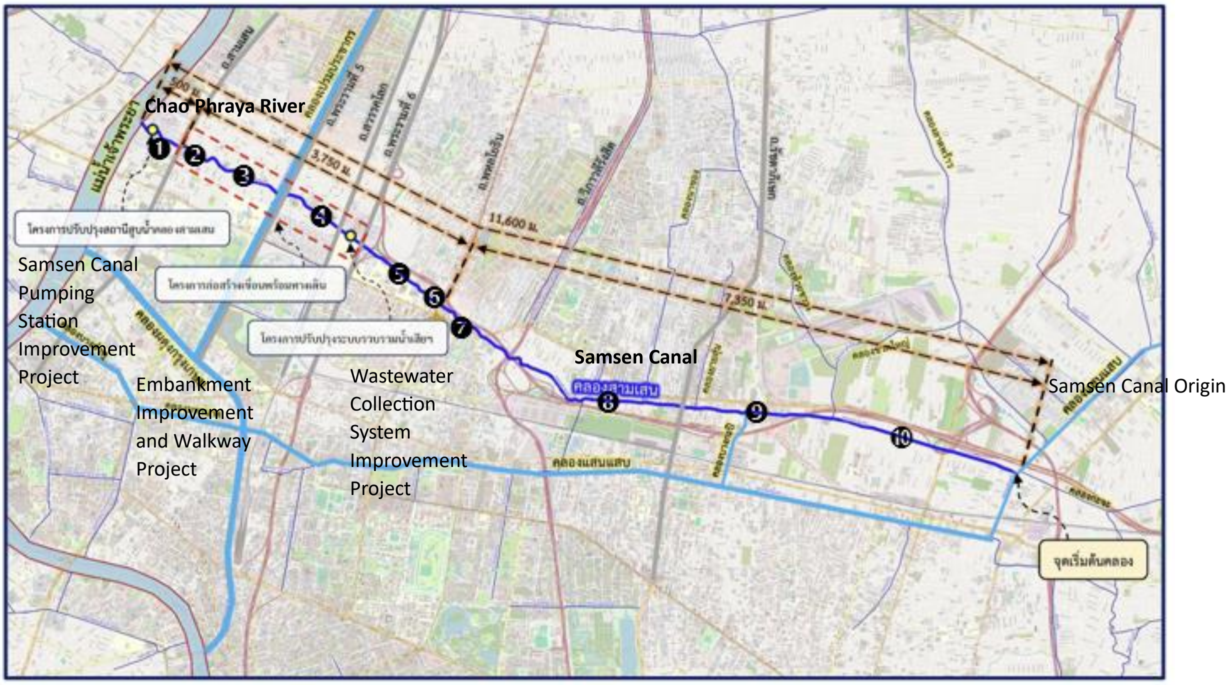

Figure 1 Location of the Samsen Canal study area showing water-quality sampling stations by City Plan Professional, Ltd. [14]

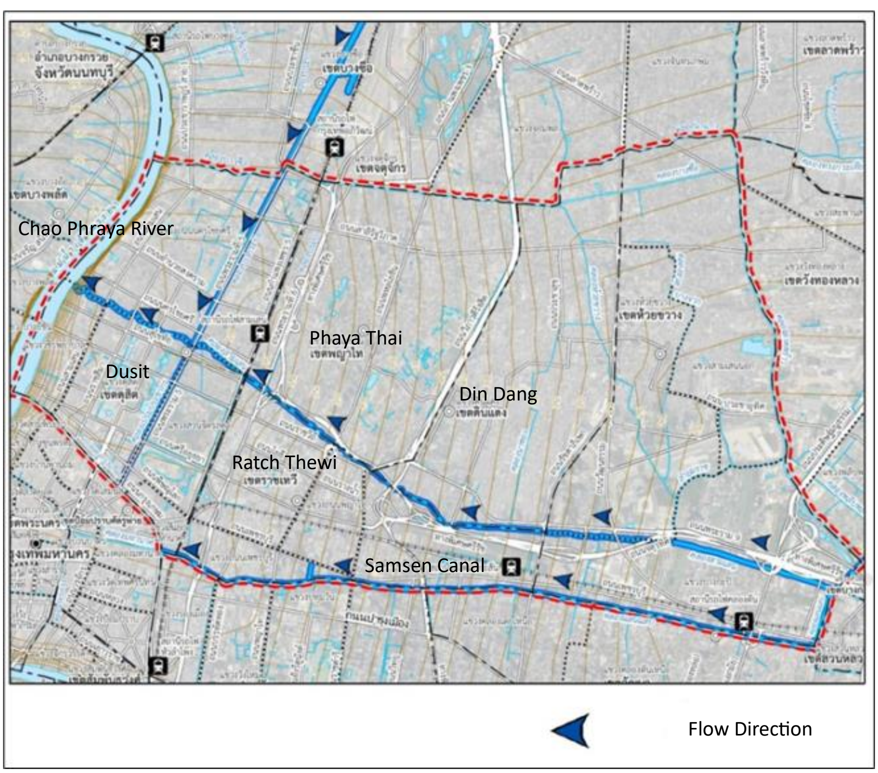

Figure 2 Flow Direction of Samsen Canal (ibid.)

Stakeholders have shown an interest in future recreational activities, but the canal's microbial and turbidity levels are well below international standards set by the U.S. EPA and WHO for recreational water quality, which require strict limits on bacteria, clarity, and chemical pollutants. To make public use possible, the canal needs major upgrades to reach at least Class II standards, including stopping direct discharges and increasing centralized wastewater interception.

Pollution Sources and Wastewater Dynamics

Field observations, map analysis, and interviews identify four major pollutant sources:

1. Domestic wastewater from canal-edge communities and informal housing
2. Commercial discharges from markets, food preparation areas, laundries, and small hospitality services
3. Institutional facilities, particularly hospitals and schools
4. Stormwater runoff transporting organic debris, sediments, oils, and trash

Unregistered small businesses, auto-repair activities, and restaurants contribute to episodic high-strength discharges. Multiple manholes and outfalls showed visual signs of direct or intermittent wastewater release. Stakeholders consistently described odor, visible sludge, floating solids, and periodic discoloration—observations that align with the chemical and microbial results.

Infrastructure Interactions and Hydraulic Constraints

The canal's grey-infrastructure system remains largely monofunctional, optimized for conveyance rather than ecological improvement. Encroaching structures narrow the channel and increase resistance, while sediment accumulates at bends, bridge underpasses, and areas of low velocity. Defective manholes and aging drains contribute to intermittent wastewater leakage, and sluice-gate operations restrict freshwater recharge, especially in dry months. Residual sludge from upstream treatment facilities further affects downstream water quality.

These structural limitations explain the observed stagnation, persistent turbidity, reduced dissolved oxygen, and widespread microbial contamination.

Governance and Maintenance Observations

Institutional reviews reveal fragmented responsibilities across BMA departments, Drainage and Sewerage, Environment, District Offices, Parks, and City Enforcement Officers. While agencies undertake inspections and short-term remediation efforts, progress toward long-term improvements is hindered by insufficient mandate alignment, inconsistent monitoring standards, and lack of effective coordination. Community participation typically remains voluntary and irregular, with few established frameworks for co-management or joint accountability. These governance challenges, rather than purely technical limitations, present significant barriers to achieving water quality restoration and sustainable upkeep.

Environmental Engineers as Boundary Professionals in IWRM (Integrated Water Resources Management) Implementation

In the Samsen Canal Improvement Project, environmental engineers occupy a pivotal yet constrained position within Bangkok's water-governance system. Their primary responsibility has traditionally focused on ensuring flood conveyance and hydraulic safety, reflecting long-standing engineering paradigms that prioritize risk reduction over multifunctionality. While environmental engineers increasingly translate hydrological and water-quality data into management actions and facilitate coordination among BMA departments, their influence remains bounded by institutional mandates that frame the canal predominantly as drainage and flood control infrastructure.

This technocratic emphasis limits the extent to which ecological restoration, public-space provision, and social use are systematically embedded in project objectives. The absence of unified monitoring frameworks, shared performance indicators, and cross-sectoral accountability further constrains adaptive management. Consequently, environmental engineers are often positioned as technical problem-solvers rather than strategic actors shaping long-term urban-water futures. This gap is not a failure of professional capacity, but a structural outcome of fragmented governance and narrowly defined project scopes.

Environmental engineers are well-equipped to address this issue. By synthesizing water-quality data, spatial analysis, and input from stakeholders, they can reconceptualize the Samsen Canal as a versatile urban system rather than merely a drainage channel. Serving as boundary professionals within the IWRM framework, they are able to balance hydraulic needs, ecological functions, and societal interests, assuming institutional structures support such integrative responsibilities.

Synthesis and Implications

The challenges facing the Samsen Canal are both technical and institutional in nature. Ongoing issues such as water pollution, sediment accumulation, and encroachment are intensified by fragmented governance, with responsibilities dispersed among various BMA units and limited coordination, inconsistent data sharing, and insufficient mechanisms for meaningful community participation. Consequently, canal management tends to be reactive, focusing primarily on immediate concerns like debris removal and flood mitigation instead of addressing fundamental causes, including untreated wastewater discharge and land-use pressures.

Utilizing the IWRM framework indicates that future development of the Samsen Canal must progress beyond incremental drainage improvements, advancing instead toward a deliberately multifunctional canal strategy. This necessitates integrating ecological performance metrics within hydraulic design, establishing coordinated monitoring systems among relevant agencies, and institutionalizing participatory processes as standard management practice rather than as sporadic consultations. Environmental engineers, collaborating with planners, landscape architects, and governance entities, can facilitate this transition by translating empirical data into practical scenarios that illustrate the feasibility and advantages of integrated blue–green–gray infrastructure interventions.

Importantly, assessments of the Samsen Canal's future should encompass more than just drainage efficiency or flood risk mitigation. The canal presents an opportunity to function concurrently as essential infrastructure, an ecological corridor, and valued public space within Bangkok's densely populated urban setting. Achieving this vision will require not only innovative technical solutions, but also a fundamental redefinition of professional responsibilities and governance objectives. In this context, the Samsen Canal exemplifies a broader context for how environmental engineering can shift from addressing isolated urban water challenges to collaboratively creating regenerative urban water systems.

Conclusion

This study demonstrates that the Samsen Canal faces ongoing challenges, including water quality deterioration, sediment build-up, canal-bank encroachment, and fragmented governance. Data from water-quality monitoring and spatial analysis indicate that the canal primarily serves as a drainage system at present, offering limited ecological value and lacking suitability for recreational or public use. While the BMA maintains official oversight of canal management, overlapping responsibilities, inconsistent monitoring practices, and insufficient stakeholder engagement hinder the achievement of sustained, effective improvements.

Using an integrated approach that combines SWOT analysis, the Stakeholder Influence Matrix, and the DPSIR model within IWRM principles, the study finds that challenges are systemic rather than merely technical. Current interventions mainly address flooding and debris, leaving core issues like wastewater discharge, hydraulic limitations, and governance gaps largely unaddressed.

Environmental engineers have a significant but limited institutional role, focusing mostly on hydraulic safety. The study highlights the need to expand their focus to include water quality, ecological restoration, and public space. For the future development of the Samsen Canal, it is advisable to adopt a multifunctional canal strategy that incorporates centralized wastewater management, integrates blue–green–gray infrastructure, and promotes participatory governance. This approach aims to improve water quality, enhance ecological conditions, and support urban livability in Bangkok and comparable urban environments.

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