A Qualitative Review of Green Stormwater Infrastructure (GSI) Practices: Opportunities for Least Developing Countries

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Motivation

- While GSI is emerging largely in developed nations, its adoption in least developing countries (LDCs) faces significant challenges, making it essential to explore GSI as a solution for rapid urbanization and sustainable development.
- Lack of regulatory frameworks and institutions are leading barriers to the adoption of GSI LDC.
- SWOT analysis helps decision-makers in LDCs tailor GSI practices to local needs for both new developments and retrofitting projects.
- Our study aims to analyze SWOT analysis and provide an explanatory assessment of GSI retrofit and new development opportunities for Addis Ababa and Dhaka city.

Methodology

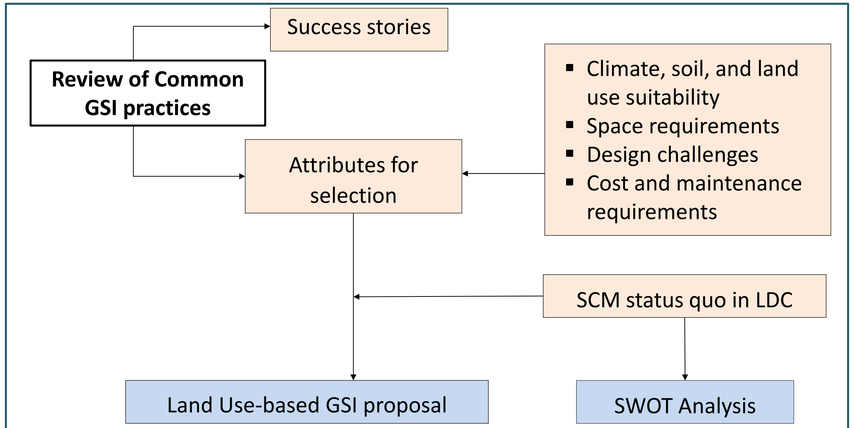


Figure 1: Conceptual Framework

Common GSIs (Success stories)

Bioretention/rain gardens: Manage 86% of rainfall, reduce runoff by 97%, peak flows by 45%, and remove up to 100% of TSS (McGauley et al., 2023; Shafiq & Kim, 2017)

Green Roofs: decrease runoff volume (69%) and peak flow rate(71%) (Li et al., 2019) and delay stormwater by up to 231 min.

Permeable Pavement: reduce runoff volume (25-93%), TSS (33-94%), and TP (10.9-33.6%) and delay stormwater (28-50 min) (Collins et al., 2008).

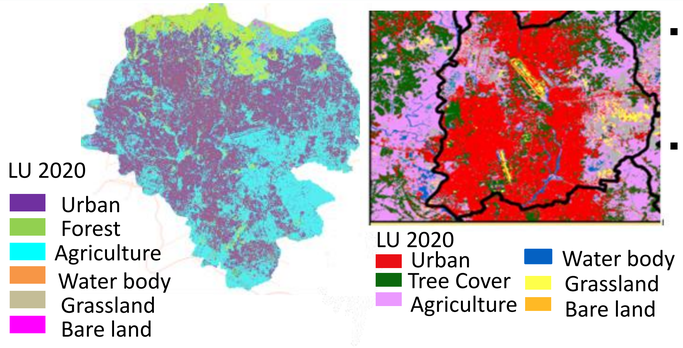
Water Harvesting Systems: Rain barrels and cisterns can reduce combined sewer overflow by up to 12% and 24% (Ghodsi et al., 2021).

Infiltration Trenches: reduce 29% of peak discharge and volume (Bhusal et al., 2024).

Attributes for Selection

GSI Type	Climate	Cost	Drawbacks	Maintenance Requirements	Design Challenges
Raingarden	Temperate and Humid	Low to Medium	Media Clogging and Sediment Contamination	Debris Removal, Post Storm Inspection	Overflow Management, Soil and Plant Selection
Infiltration Trenches	Temperate	High	Clogging Concerns and Pretreatment	Sediment Removal	Permeability Management, Compaction
Green Roofs	Temperate	High	Limited Stormwater Retention Capacity	Weeding, Vegetation Mgm't	Structural Considerations
Permeable Pavement	Temperate and Humid	High	High Maintenance , Clogging	Vacuuming, Pressure Washing	Clogging Risk, Load Bearing Capacity
WH Systems	Arid and Semi Arid	Low to Medium	Pretreatment, Routine Maintenance	Debris Removal and Cistern Cleaning	Water Treatment , Climate Variability

Stormwater Control Measures in LDCs



- Built-up area has increased by around 188% from 1990 to 2020 in Dhaka City.
- About 52% of urban green space was transformed into settlements between 2017 and 2020 in Addis Ababa city.

Figure 2: Land Use Map of Addis Ababa and Dhaka City

Land Use-based GSI Proposal

	Retrofitting			New Development		
	Buildings	Roads/ Streets	Open Space/ Bare Land	Buildings	Roads/ Streets	Open Space/ Bare Land
Rain Gardens						
Permeable Pavement						
Infiltration Trenches						
Green Roofs						
Water Harvesting						

Legend: green (highly recommended) , yellow (moderately recommended), red (not recommended), blue (conditional)

SWOT Analysis

Strengths (S) • Job creation • Fit with gray infrastructure • Cost-efficiency	**Opportunities (O)** • Employment opportunities • Sustainable Development Goals • Enhancing urban green space
Weakness (W) • Funding issues • Lack of policy and regulations • Socio-political factors	**Threats (T)** • Increased flooding • Water pollution and depletion • Erosion and sedimentation
O-S Strategies • Retrofit and integrate with existing gray infrastructure • Research low-cost local alternatives	**O-W Strategies** • Increase technical knowledge • Conduct seminars, workshops, roundtables, etc. • Develop policies/regulations
T-S Strategies • Enforce environment rules • Build awareness • Coordinate with relevant laws and regulations	**T-W Strategies** • Capacity building • Support local groups firms • Offer incentives to industry and individuals to support GSI

Figure 3. SWOT Analysis

Summary and Way Forward

- GSI practices should be prioritized for sustainable stormwater management amongst rapid urbanization and climate change.
- Adding computational models could provide data on GSI effectiveness, aiding decision-making.
- Community-based approaches, combined with governance frameworks, can enhance GSI implementation in developing countries.

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