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# Evaluating Rain Garden Efficacy for Sustainable Urban Stormwater Management

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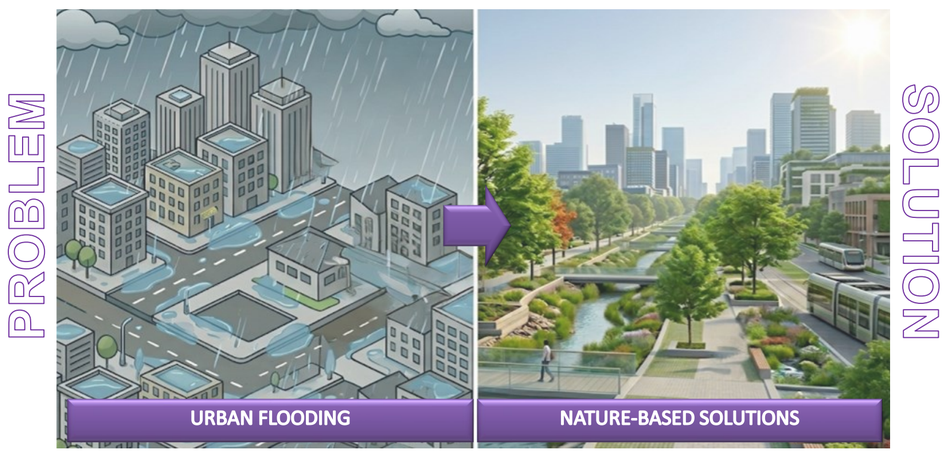
## INTRODUCTION & AIM

- **Ongoing urbanization** and **climate change** driving significant environmental impacts, most notably **urban flooding**.
- **Nature-based Solutions (NbS)** represent a key strategy for sustainable urban drainage. Among these, **Rain Gardens (RGs)** are bio-retention systems engineered to intercept, temporarily store, and treat stormwater runoff from adjacent impervious surfaces.




- **The aim** of this study is to evaluate the hydrological efficiency of specific RG configurations and investigate how various design parameters influence system performance.

## METHOD

### CASE STUDY

**Location:** In front of the main entrance of the Municipal Offices of Cerisano, a small town in the Calabria Region, in Southern Italy.

**Infiltration Area:** 20 $m^2$ (5% of the rooftop area to be drained).

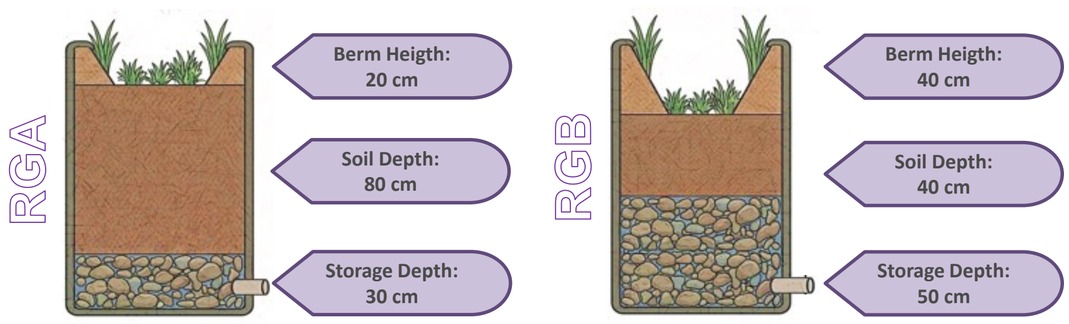
### MODEL DEVELOPMENT

A predictive hydrodynamic model was developed using EPA-SWMM 5.2, comparing scenarios with and without Nature-based Solutions (NbS).

**Model Setup**

- **Routing & Infiltration**: Dynamic Wave routing; SCS CN method.
- **LID Control**: Bioretention Cell unit to simulate specific lined RGs behavior.
- **Rainfall**: 1-hour synthetic Chicago hyetograph (T = 10 years; peak ratio 0.4).

**RG Configurations**




**Hydrological performance indexes**

System efficiency was assessed at the outlet node by evaluating:

- Maximum Total Inflow Reduction (%)
- Total Inflow Volume Reduction (%)

## RESULTS & DISCUSSION

To assess the hydrological effectiveness of the NBS, the **results obtained at the outlet node** for the reference condition (Scenario 0 – current scenario without rain garden) were compared with those obtained at the same node after the Rain Garden (RG) implementation (RGA and RGB).

The **hydrological efficiency of the specific RGs,** expressed in terms of the hydrological performance indexes, are displayed in the below Table.

| ID | Max Total Inflow Reduction (%) | Total Inflow Volume Reduction (%) |
|---|---|---|
| **RGA** | 48.5 | 51.9 |
| **RGB** | 94.5 | 92.5 |

- The findings demonstrate that the **implementation of the RG provides significant benefits** in terms of both Maximum Total Inflow Reduction and Total Inflow Volume Reduction.
- The LID control unit output suggested that specific **attention** must be paid to defining **berm height** and estimating **soil hydraulic conductivity.**
- A comparison between Scenario 0 and the RG implementation scenarios at the outlet node demonstrates that the **rain garden is an effective strategy for urban stormwater management**.

## CONCLUSION

- The **hydrological performance** of the Rain Garden is **highly dependent on specific design variables.**
- The demonstrated efficacy of this sustainable approach supports the widespread adoption of RGs as a **tool for addressing the environmental pressures of modern urbanization.**

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