Ministry of Housing and Urban Affairs
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Atal Mission for Rejuvenation and Urban Transformation
अमृत 2.0

Advisory on

PRE-MONSOON PREPAREDNESS and MITIGATION OF URBAN FLOODING



Central Public Health & Environmental Engineering Organisation (CPHEEO)

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FOREWORD

Monsoon-induced urban flooding is an increasingly pressing issue in Indian cities, often causing severe disruption to public life, damaging infrastructure, and posing significant public health risks. While cities are expanding rapidly, the associated increase in impervious surfaces, unplanned growth, and degradation of natural drainage channels have heightened flood vulnerability across urban settlements.

This Advisory on "Pre-Monsoon Preparedness & Mitigation of Urban Flooding" has been structured as an actionable guidance document to assist ULBs, Ward Level Officers, City Engineers, and other Stakeholders in anticipating and managing flood risks effectively. The objective of the Advisory is to support cities in transitioning from reactive to preventive flood management through structured planning, capacity building, and real-time coordination.

The advisory lays out a comprehensive checklist of preventive and emergency measures across various domains including drainage infrastructure maintenance, pump station preparedness, water body rejuvenation, rainwater harvesting integration, public engagement, etc during monsoon emergencies. Additional suggestive measures for flood mitigations like green drainage features, sponge parks, stormwater management and road tunnel (SMART), water sensitive urban design (WSUD), bioswale, permeable paving, and decentralized stormwater interventions are also elaborated. The Manual on Storm Water Drainage Systems, 2019, published by CPHEEO may also be referred to for engineering design and management of storm water drainage systems..

I would like to acknowledge the efforts made by Dr. Ramakant, Deputy Adviser (PHE) and his team member Mr. Naveen Daila, CPHEEO in framing the Advisory which may be very useful for drainage assessment and necessary measures to be taken by the cities/town for urban flood mitigation.

I believe this document shall be used as an important support tool for ULBs in ensuring citizen safety and maintaining critical infrastructure functionality pre, during and post monsoon. Let us together make our cities more flood resilient and prepare the cities to accept more challenges of the storm water drainage systems.

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1. Introduction

Urban flooding and waterlogging pose major challenges to cities across India during the monsoon season. These events result in public health risks, infrastructural damage, and disruption of essential services. To minimize such impacts, Urban Local Bodies (ULBs) must proactively plan and implement structured measures for drainage preparedness, emergency response, and public awareness. This document provides guidance on actions or initiatives to be taken by Cities/ULBs/ Parastatal bodies for preparedness before the onset of monsoon on water logging/flooding in urban areas due to the blockage of the storm water drain and/or overflow of the underground drainage system. This document also described innovative methods to be adopted for flood mitigation in consideration of climate resilience, integration of Rainwater harvesting systems with storm water drains and green drainage features to overcome water logging/flood in urban areas

Over the past two decades, urban flooding has emerged as one of the most critical climate-resilience challenges for Indian cities. Several instances—such as the floods in Mumbai (2005, 2008, 2009), Chennai (2004, 2015), Delhi (2002, 2003, 2009, 2010, 2011), Surat (2006), Jammu & Kashmir (2014), and Kerala (2018)-have caused devastating loss of life, infrastructure damage, and prolonged disruption of public services.

With rapid urbanization, increased impervious surface cover, and changing rainfall patterns, the frequency and severity of waterlogging and flash floods are expected to rise. Unplanned growth, encroachment on natural drains, and under-performing or outdated drainage systems have exacerbated the problem in many cities. It is imperative that stormwater drainage systems be planned and implemented in a structured and phased manner, taking into account aspects such as design, rainfall intensity, maintenance, and long-term resilience.

The drainage system is at its best when it is maintained properly as designed. For this purpose, it is necessary that the drains keep their shape and slope in the designed manner during their lifetime. It is also necessary to ensure that the drains retain their full cross section, particularly during monsoons.

The system of maintenance can be classified into the following three categories:

- **Regular Maintenance**: Routine inspections, silt removal, minor repair works, and upkeep of structural components throughout the year.
- **Periodical Maintenance** Seasonal or scheduled cleaning before and after monsoon, re-profiling of drain bed, RCC cover slab replacement, etc.
- **Special Maintenance/Emergency Repairs**: Structural damage, accident-prone conditions, or after unusually heavy rainfall events and damage of sewer manholes.

To ensure effective implementation, each ULB should prepare a ward-level pre-monsoon action plan, maintain a geo-tagged asset register of drains, conduct mock drills for emergency pumping, and establish a real-time monitoring system through inspection logs or public helplines. Engagement of the community and coordination with disaster management authorities will further enhance the preparedness outcomes.

2. Objective

The objective of the advisory is to:

- **Minimize Urban Flooding and Waterlogging:** Guide Urban Local Bodies (ULBs) in implementing preventive actions to reduce monsoon-related disruptions and damages.
- **Ensure Drainage System Readiness:** Establish protocols for inspection, desilting, and repair of stormwater drains and outfalls ahead of heavy rains.
- **Promote Public Health and Safety:** Reduce the risk of waterborne diseases, property loss, and traffic hazards through proactive maintenance and public awareness.
- **Strengthen Emergency Response and Community Engagement:** Enhance institutional preparedness, inter-departmental coordination, and citizen participation for rapid response during flooding events.
- **Mainstream Climate Resilience in Urban Planning:** Integrate climate-adaptive drainage designs and infrastructure to strengthen city preparedness and recovery from extreme rainfall, flooding, and environmental shocks.

3. Key Causes of Urban Flooding

- **Increased Impervious Surfaces**: Extensive concretization and paving in urban areas prevent rainwater from naturally infiltrating into the ground, increasing surface runoff and contributing to urban flooding.



Figure 1: Undersized and outdated drainage

- **Undersized and Outdated Drainage Systems**: Many cities rely on old or insufficiently sized drains that cannot handle the volume of runoff from intense rainfall events.

- **Blocked Drains Due to Solid Waste and C&D Dumping**: Uncollected garbage, construction debris, and sediment often clog stormwater drains.



Figure 2: Dumping of solid waste in storm water drains

- **Unplanned and Fragmented Drainage Development**: Stormwater drainage networks have grown in a piecemeal manner without integrated planning, leading to ineffective and disconnected drainage paths.

- **Encroachments on Drains and Natural Outfalls**[1]: Buildings, boundary walls, and other unauthorized structures block or narrow down the drainage channels, reducing capacity and causing backflow.
- **Lack of Proper Drain Mapping and Inventory**: Absence of updated GIS-based maps results in unmonitored drain segments and difficulty in scheduling maintenance.
- **Road Level Higher Than Building Plinths**[2]: Continuous re-carpeting raises road levels, making buildings vulnerable to water ingress during monsoons.
- **Poor Road Design and Lack of Camber**: Roads lacking side camber act as channels for water flow and stagnation, weakening the pavement and increasing flood risk.
- **Neglect of Water Body Integration**: Urban lakes, ponds, and wetlands are often disconnected from stormwater drains and poorly maintained, reducing their capacity to store and buffer runoff.



Figure 3: Encroachments on drains



Figure 4: Road level above then house plinth level

- **Insufficient Systems for Low-Lying Area Drainage**[3]: Absence of pumping systems and poorly designed outfalls in low-lying areas delay stormwater evacuation.



Figure 5: Water body in dry state



Figure 6: Water logging in low-laying area

[1] Figure 3 Source: Times of India -Encroachments on Drains
[2] Figure 4 Source: Times of India News (20 Aug 2022)- Road Level above than House plinth level
[3] Figure 5 Source: News 18 (28 June 2024)- low-Laying area water Logging

4. Pre-Monsoon Preparedness Action Plan

Is your city monsoon-ready?

The following checklist may be used to assess flood risks and implement timely measures for minimizing waterlogging and urban flood impacts[4]



Figure 7: Flooded road in Bengaluru

A. Short-Term Actions Checklist

S.No.	Activity	Status (✓/✗)	Remarks
1.	Conduct physical inspections of all drains (primary, secondary and Tertiary)		
2.	Remove all visible silt, plastic, polythene, and debris from roadside drains, culverts, and gully inlets to avoid immediate clogging		
3.	Install temporary trash nets or metal screens to prevent entering of floating debris in larger drains and choking		
4.	Check for opening of inlet of the drains for smooth entering of storm		
5.	Check for silt of road sweeping to disposed of appropriately to avoid silting		
6.	Check for repairing of potholes to avoid water holding on the road		
7.	Inspect and secure all storm drain covers, gully traps, and chamber lids to prevent accidents		

[4] Figure 7 Source: THE WEEK MAGAZINE- Flooded Road Bengaluru

8.	Inspect and check of manhole to avoid the back flow of the sewage and accidents		
9.	Check the operations of the pumps for dewatering in water logged areas and ready for emergency		
10.	Check for generator backup and fuel at all permanent pumping stations		
11.	Position mobile pumps in flood-prone zones based on mapped hotspot		
12.	Place barricades and sandbags around vulnerable institutions like hospitals, transformers, and subways		
13.	Activate 24x7 monsoon control room with dedicated telephone numbers and complaint response teams		
14.	Issue public advisory (via print media, digital media and social media) on drain usage, safety near manholes, and complaint info		
15.	Attention on IMD weather alerts and forecasts to field engineers and control room daily for planning operations		
16.	Finalize ward-level response team rosters with names, contact details, and duty shifts		
17.	Make provision of budget for emergency response measures		

B. Long-Term Flood Risk Reduction Measures Checklist

S. No.	Activity	Status (✓/✗)	Remarks
1.	Prepare/update GIS-based Drainage Master Plan		
2.	Identify and check storm drains with self-cleansing slope and RCC lining where ever needed		
3.	Identify and remove encroachments along drains, nallahs, and in waterbody catchment areas		
4.	Check for the design of drain outfall structure		
5.	Install or maintain rainwater harvesting and recharge pits in public buildings		
6.	Promote permeable surfaces in new and existing developments (e.g., paver blocks, green lanes)		
7.	Conduct annual sediment testing and desilting of all waterbodies to increase water holding capacity		
8.	Make the provision to channelize the flow of storm water on the road to the drain		
9.	Install sensors/CCTV at key water-logged areas to take necessary measures		
10.	Develop SOPs and task responsibilities for ward-level flood response teams		
11.	Build sanitation volunteer and RWA-based alert networks		
12.	Implement public awareness campaigns on stormwater and solid waste behavior		
13.	Ensure flood resilience features incorporated in Drainage Master Plan		
14.	Allocate annual pre-monsoon maintenance budget		

C. Tools and Equipment Checklist for Drain Maintenance

General Equipment	
▪ Shovels	▪ Lanterns
▪ Iron hooks	▪ Plunger rods
▪ Handcarts	▪ Observation rods
▪ Silt drums	▪ Manhole guards
Mechanical Equipment	
▪ Rodding machines with flexible conduit rods	
▪ Scrapers	
▪ Portable pumps (diesel/petrol-based)	
Safety Gears	
▪ PPE kits	▪ Tripod stands
▪ Danger flags	▪ Safety lamps
▪ Medical kit	▪ First-aid box
▪ Medical transport vehicle	▪ Cleansing material
▪ Gas detection instruments	

D. Citizens Responsibilities

Do's	Don'ts
Clean and maintain surroundings, rooftops, and nearby drains.	Do not dump plastic, kitchen waste, or debris into stormwater drains.
Report any flooding, broken covers, or drain blockages to ward offices.	Avoid covering storm inlets and gully traps with temporary ramps or slabs.
Cooperate with field teams during desilting, dewatering, and rescue operations.	Do not allow open defecation near drains, nallahs, or water bodies.
Participate in community clean-up campaigns and monsoon awareness drives.	Refrain from diverting sewage into stormwater drains.
Follow updates and alerts shared by ULBs via digital media	Do not build on natural water flow paths or encroach on drain easements.






E. Flowchart: Pre-Monsoon Preparedness Setup

A schematic flow of actions can simplify planning and monitoring at ULB level:

Pre-Monsoon Preparedness Flow - Step-by-Step Sequence



ULB-Level Planning and Advisory Dissemination

`



Identification of Vulnerable / Waterlogging-Prone Areas



Drainage Infrastructure Review and Desilting

- Desilting of open and covered stormwater drains
- Cleaning of culverts, catchpits, and gully traps
- Transport and dispose of silt within 24 hours



Structural and Conduit Inspections

- CCTV/robotic/machine-assisted methods for large drains
- Checking of blocked or damaged drain sections



Pumping Station & Mobile Pump Readiness

- Testing of pump stations and rising mains
- Fuel availability and backup generator checks



Manhole and Sewer System Inspection (where combined)

- Safety gear for workers
- Confined space safety and emergency planning



Rooftop Rainwater Harvesting System (RRHS) Checks

- Pre-positioning of sandbags, tools, gumboots, ropes



Community Outreach and Awareness Campaigns

- IEC/BCC activities using print, digital, street plays, school involvement



Setup of Control Room and Alert Mechanism

- Linkage with IMD/SDMA
- Digital/print media, speaker systems, citizen helpdesks

F. Immediate Steps During Monsoon Emergency

S. No.	Activity	Component	Status (✓/✗)
1.	**Deploy Dewatering Pumps**	Identify waterlogged hotspots and place pumps accordingly	
		Use proper suction and discharge pipes	
		Discharge into nearest functional drains, nallahs, or waterbodies	
2.	**Clear Choked Drains and Inlets**	Mobilize sanitation teams to clean gully traps, catch pits	
		Remove plastic, silt, and debris from grates	
		Use manual tools and safety gear	
3.	**Establish Emergency Shelters**	Open pre-identified schools/community halls	
		Ensure clean water, power backup, toilets facilities	
		Supply food, blankets, first aid kits and sanitation material	
4.	**Issue Public Alerts**	Share weather warnings and safety tips via digital media, loudspeakers, radio	
		Display emergency helpline numbers	
		Avoiding flooded routes	
5.	**Activate Ward-Level Teams**	Ensure coordination among the officials' staff, pump operators and volunteers	
		Designate contact persons and conduct daily situation briefings	
6.	**Distribute Emergency Kits**	Provide water bottles, first aid kit, packaged food, sanitary pads	
		Focus on slums, low-lying areas, and vulnerable groups	
7.	**Arrange Boats (as applicable)**	Deploy boats in flood-prone Zones	
		Ensure availability of life jackets and trained operators	

5. Design Aspects of Storm Water Drainage

Urban stormwater drainage systems are essential for managing rainwater to prevent urban flooding, waterlogging, and damage to infrastructure. A systematic engineering approach, guided by hydrologic data and catchment analysis, ensures that stormwater is efficiently collected, conveyed, and disposed.

The design process involves:

Rainfall Analysis

↓

Construction of IDF curve

↓

Translation of IDF curve into rainfall Hyetograph

↓

Runoff Estimation

↓

Design of Stormwater Drainage systems

Key design considerations are outlined below. For comprehensive technical guidelines and detailed methodologies, ***Manual on Storm Water Drainage Systems – Part A: Engineering Design,2019*** published by **CPHEEO**, May be referred to.

A. Rainfall Analysis

Rainfall analysis is carried out to identify and sort out various magnitudes (intensities) of rainfall events and their corresponding durations occurring at a station from a continuous series of historical rainfall records taken for a fairly long period viz. last 25 - 30 years or more. Self-Recording Rain Gauge (SRRG) charts used to analyzed rainfall data collected by IMD Intensity-Duration-Frequency (IDF) curves are not static as they are influenced by change in pattern of rainfall and therefore IDF curve should be updated at an interval of 5 – 10 years for accurate results which are used in estimation of runoff for design of storm water drains.

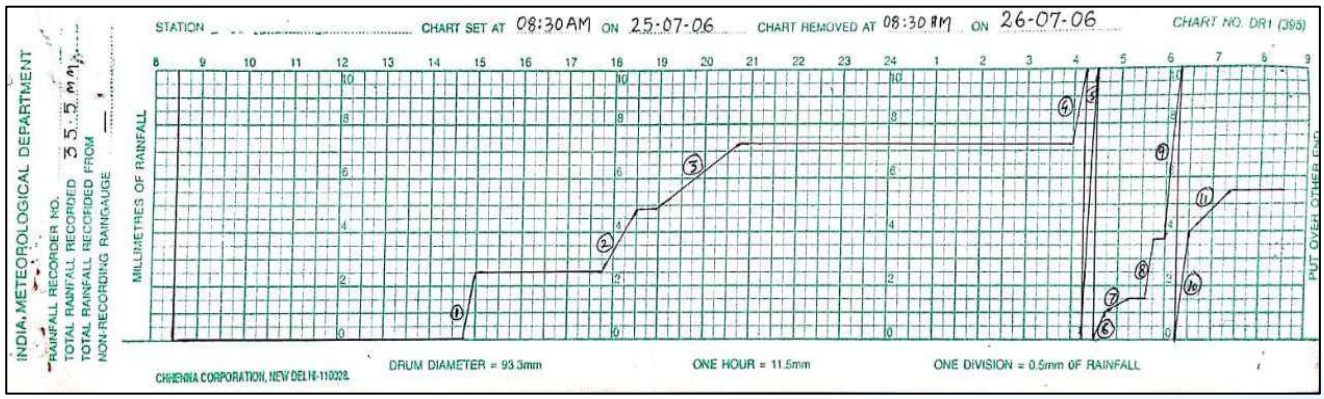


Figure 8: Self Recording Rain Gauge (SRRG) chart for 24 hrs

Design Return Period

The frequency or return period of a storm event may be defined as the average recurrence interval between events equal to or exceeding a specified magnitude. Thus, if it is stated that the return period of rainfall of 20 cm in 24 hours is 10 years at a certain station 'A', it implies that on an average rainfall magnitude equal to or greater than 20 cm in 24 hours occur once in 10 years.

The design return period of a storm is an integral part of IDF curve developed, based on analysis of past rainfall data, for designing of storm water drainage systems. The recommended design return period of storms is given below for estimation of storm runoff.

Table 1: Recommended Design Return Period for various types of urban catchments

S. No.	Urban Catchment	Return Period	
		Class - I Cities**	Other cities***
1.	Central Business and commercial	Once in 5 years	Once in 2 years
2.	Industrial	Once in 5 years	Once in 2 years
3.	Urban Residential	Once in 5 years	Once in 2 years
4.	Airports and other critical infrastructure*	Once in 100 years	Once in 50 years

*Critical infrastructure includes Railway Stations, Power stations, etc., **Class I Cities are cities having population 1 Lakh and above, ***Other cities are cities having population less than 1 lakh

B. IDF Curve (Intensity-Duration-Frequency Curve)

- Establishes the relationship between rainfall intensity, duration, and frequency.
- IDF curves are dynamic and must be updated every 5–10 years.
- Required for determining peak stormwater runoff.
- Used to select the design rainfall intensity for different parts of the city.

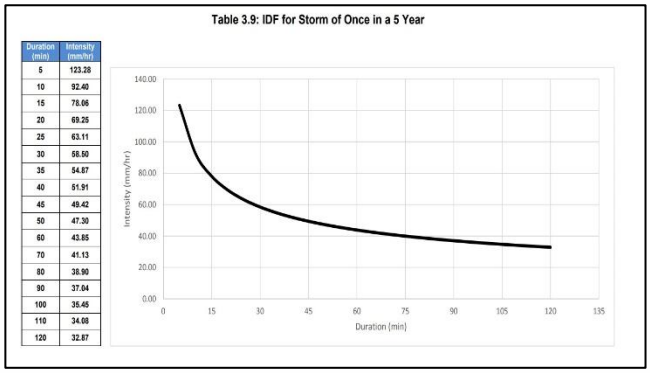


Figure 9: Representation of IDF curve

C. Runoff Estimation

Among the various methods available for runoff estimation in urban stormwater drainage design, the Rational Method is widely used. The planning and design of storm water drains should be seen in the ***Manual on Storm Water Drainage Systems – Part A: Engineering Design,*** 2019

6. Suggestive Measures for Flood and Waterlogging Prevention

6.1 Drainage Infrastructure Readiness

Stormwater drains form the first line of defense in flood prevention. Their maintenance and de-silting must be prioritised well before the onset of the monsoon.

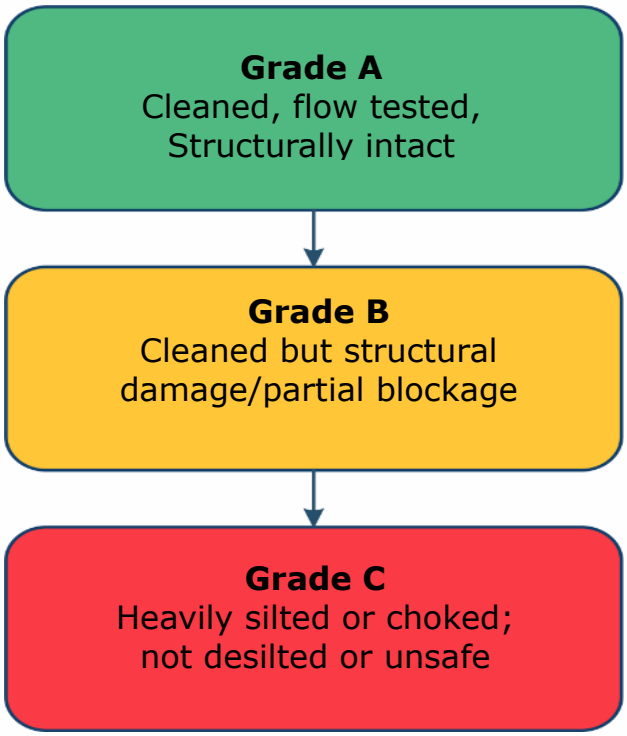
Key Actions:

- Undertake city-wide desilting of all primary, secondary, and tertiary drains.
- Clear catchpits, gully traps, and side inlets of all silt and debris.
- Ensure proper profiling of brick-lined or earthen drains to restore original slopes.
- Maintain a chainage-based inventory of drain segments for inspection and tracking.
- Carry out flow tests post-cleaning to verify free discharge.

Important Note: To assess the readiness of urban drainage networks before monsoon, cities may adopt a Drainage Health Grading System. This helps classify drain segments based on their functional condition, cleanliness, and flow performance. The grading supports targeted interventions and helps prioritize resource deployment before heavy rainfall.

The classification is as follows:

- **Grade A (Healthy):** Drains are clean, structurally intact, and allow free flow. No silt accumulation observed. Regular maintenance schedule is being followed. No immediate action required other than routine checks.
- **Grade B (Moderately Functional):** Minor siltation or debris observed. Partial damage to side walls or slab covers. Water flow is moderately impacted. Desilting and minor repairs should be scheduled before monsoon.
- **Grade C (Poor/Blocked):** Heavy siltation, flow completely or largely blocked. Structural failure or encroachment present. High risk of flooding. Immediate desilting, repairs, and enforcement action required.



Types of Drains and Typical Cross-Sections

Urban stormwater systems can be categorized as follows:

a. Primary Drains

- Large drains/natural nallahs that collect runoff from several zones and discharge into rivers, lakes, lands or terminal drains.
- Usually open RCC, brick, or earthen channels requiring machine or robotic cleaning.

b. Secondary Drains

- Mid-level collectors transferring runoff from multiple streets to primary drains.
- Often covered, U-shaped,Box-type,rectangular, trapezoidal RCC or brick masonry structures.

c. Tertiary Drains

- Local drains inside colonies and along lanes, carrying runoff.
- Mostly shallow, open brick or concrete-lined, cleaned manually.

Cross-Sections:



U-shaped RCC (covered/uncovered)



Box-type RCC (high load areas)



Trapezoidal section drains

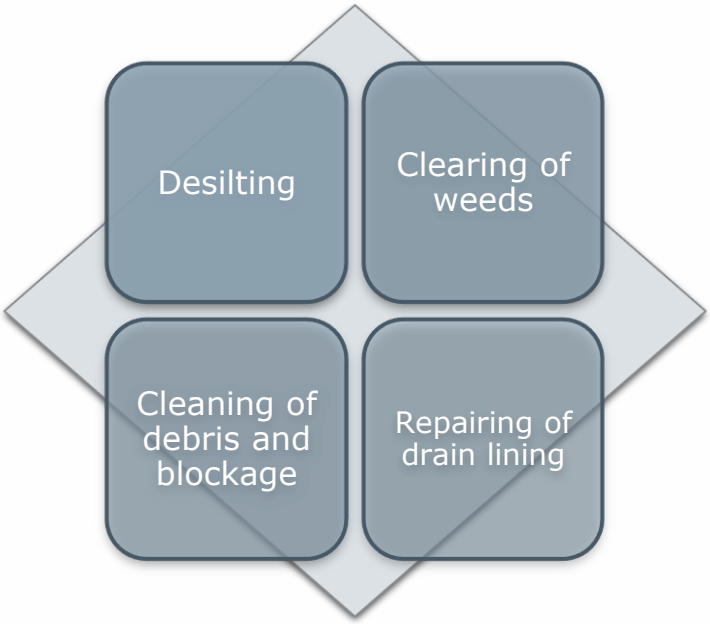


Rectangular Section drain

Figure 10: Different cross sections of drains

Maintenance Procedure

Periodical inspection and maintenance of drains is necessary, as failure of drains will occur due to deficiency in maintenance. The principal activities in maintenance are:



Regular maintenance is crucial for the effective functioning of drainage systems. Maintenance teams must have access to updated drain drawings with technical specifications, proper numbering, and chainage. All works should be carried out as per the post-construction inventory and verified through periodic inspections.

After proper inspection, following maintenance activities should be carried out:

I. All drains should be desilted thoroughly before onset of monsoon. It is also essential that all the drains are in a state of good condition and works regarding, reshaping or profile correction, wherever required is completed well before the onset of monsoon.

II. During the rains also, there is a need to monitor at the exit and entry point of water for the presence of undesirable collection of rubbish, polythene/paper bags blocking the passage of water and in everyway ensuring free unobstructed flow of rain water. Wherever feasible, at suitable intervals, solid waste arresting nets may also be provided in larger drains to avoid its choking / disposal in main receiving water bodies

III. The condition of road camber also needs to be watched. During rains, specially after heavy showers, all cross drainage structures should be inspected to observe any blockage due to debris, log of wood and other such materials. After that, the deficiencies in the drainage system should be assessed and problem locations identified and record kept updated. Necessary corrective measures should be implemented immediately after rains.

IV. The missing / corroded slabs of the covered drains are also required to be identified and replacement/repairs need to be carried out on priority to avoid accidents.

Coordination with Road/PHE/Water Boards Department

To ensure holistic drainage readiness before the monsoon, ULBs/Department must coordinate with Road/PHE/Water Boards departments. Certain interventions are required to prevent water logging are as under:

- Inspect and secure all sewer manhole covers to prevent backflow and contamination.
- Ensure all manholes are firmly closed and structurally intact before monsoon; open or damaged covers pose a major risk of accidents and fatalities, especially during flooding when they become invisible.
- Repair potholes and low spots on roads to prevent waterlogging and slow drainage near inlets.
- Maintain proper camber in road design so that runoff flows towards drain rather than pooling in the center.
- Ensure proper road re-carpeting to avoid blocking stormwater inlets and to avoid raising road levels above the plinths.
- Ensure simultaneous inspection of sewer and stormwater lines in common corridors to avoid cross-contamination or blockages.
- Synchronize flushing of drains and sewers before heavy rains, especially in mixed-use corridors.
- Clear obstructions like vendor encroachments, construction debris, or parked vehicles from around inlets and access chambers of drain.

Install reflective indicators or guardrails near known open chambers or depressions or accident prone locations to protect pedestrians in case of heavy rainfall.



Visual representation - Heavy Rainfall

6.2 Desilting of Drains and Outfall Cleaning

Desilting and cleaning of stormwater drains are essential pre-monsoon activities to ensure unobstructed flow and reduce the risk of urban flooding.

Desilting and Cleaning of Stormwater Conduits

- Post-inspection, if a section of the stormwater conduit is found to be heavily silted or clogged, immediate desilting should be undertaken using either manual or mechanical methods.
- After de-silting, a water flow test must be conducted through cleaned segments to confirm unobstructed discharge.
- If re-silting is observed, particularly due to improper disposal of solid waste, C&D materials, or encroachments, corrective actions should include both engineering interventions and public awareness measures.
- Identified hotspot locations must be geo-tagged using GIS tools for targeted interventions and regular monitoring.



Figure 11: Drain desilting process

Outfall Channel and Terminal Drain Cleaning

Efficient drainage relies heavily on the capacity of outfall and terminal channels to discharge stormwater into natural water bodies without obstruction.

Key Measures:

- Clean all outfalls, end-of-pipe terminals, and nallah discharge points from accumulated silt, debris, and solid waste.
- Remove encroachments, illegal ramps, or dumping activities in and around outfall areas.
- Use mechanical dredgers or earthmoving equipment for wide or inaccessible terminal channels where manual cleaning is feasible.



Figure 12: Outfall cleaning work

Deficiencies and remedies for storm water drains:

Deficiency	Cause	Remedy
Ponding	Inadequate cross-section, formation of depression or settlement in bed, bed erosion	Deepening the drain, re-filling eroded or depressed area.
Silting	Invert slope inadequate, excess soil entry into the system, less flow compared to design section	Improvement in slope if possible. Check entry points for silt rubbish etc. Provision of grating at entry points
Blockage due to debris vegetation etc.	Uneven drain bed, absence of maintenance, cleaning	Desilting and cleaning. Provision of grating at entry Points
Erosion of bed and cross section	Steep invert slope, caving in of sides because of lack of lateral support	Provide flatter slope with drops, if needed. Adequate side support, re-alignment, if required.

Source: IRC: SP :50-2013

Desilting Methods of Storm Water Drains

i. Manual Cleaning

- Suitable for tertiary drains, shallow roadside channels, and narrow stormwater paths.
- Workers use shovels, buckets, hooks, and handcarts to remove silt and debris.
- Requires adequate safety gear such as gloves, boots, helmets, gas detectors, and manhole guards.
- Best used in densely populated areas or confined spaces where machines cannot operate.



Figure 13: Shovels and spades

ii. Mechanical Cleaning

- Applied in primary and secondary drains where silt deposition is extensive and access is feasible
- Commonly used equipment includes:
- Excavators/JCBs for large open drains and culverts.
- Grab buckets and suction pumps for deep silt deposits.
- Conveyor belt systems in built-up areas for lifting and moving silt quickly.
- Enables faster and large-volume desilting, improving efficiency.



Figure 14: Cleaning of open drains by JCB

iii. Robotic Excavators

- Ideal for covered, deep, or inaccessible stormwater conduits in urban cores or high-traffic zones.
- Utilizes robotic arms, CCTV inspection, and high-pressure jetting equipment.
- Often used for box-type or enclosed RCC storm drains with minimal access.
- Increases safety, precision, and documentation.



Figure 15: Robotic excavator in Chennai

6.3 Pumping Station and Rising Main Readiness

Pump stations help evacuate water from low-lying areas like in underpasses, subways, or sunken roads and near closed drainage basins, especially where gravity-based drainage is inadequate. They serve as the primary infrastructure to ensure timely removal of accumulated water during heavy rainfall.

Their operational efficiency is critical during monsoons.

- **Routine Maintenance Protocols:**
  - **Daily:** Check pump cleanliness, voltage, gland pressure, and operating temperature.
  - **Monthly:** Replace worn parts and calibrate instruments, if required.
  - **Annually:** Inspect and repair impellers, motors, and electrical controls.
- **Standby Systems:**
  - Ensure availability of diesel generators and backup pumps.
  - Inspect rising mains for cracks, leaks, or drops in operating pressure.





Figure 16: Pump Setup for drain water evacuation

Dewatering Operation: How It's Done

- Use submersible or centrifugal dewatering pumps in waterlogged areas (stormwater chambers, roads, basements, or low-lying colonies).
- Connect suction pipe to flooded point and discharge pipe to identified outfall.
- Ensure hose is tightly clamped, filters are in place, and priming (if required) is done before operation.
- Operate pump in intervals based on inflow rate; monitor suction basket to avoid blockages.
- Always wear PPE (gloves, boots, mask) and use earthing for electrical safety.

Safe Discharge Points for Pumped Water

Discharged water must be routed in a controlled and non-obstructive manner:

a. **Nearest Functional Stormwater Drain**: Preferred if drain is not running with full capacity and has open flow.
b. **Natural Nallahs or Outfalls**: Use HDPE pipes or temporary bamboo channels to direct water toward nearby streams or terminal drains.
c. **Open Parks or Water Retention Zones**: Only if soil is permeable and flooding won't affect public access.
d. **Designated Water Bodies**: Retention tanks, ponds, or lakes already earmarked for stormwater diversion.



Figure 17: Dewatering of drain

e. **Temporary Storage Tanks or Trenches**: Used as buffer zones before water is slowly released or recharged.

6.4 Rooftop Rainwater Harvesting and Recharge System

Maintenance of Rooftop Rainwater Harvesting Systems (RRHS) not only reduce runoff but help households during water-scarcity.

Tips for Maintenance of the RRHS

a) Always keep the surroundings of the tank neat and clean and hygienic.

b) Remove dust, algae from the roof tiles and asbestos sheets before the monsoon.

c) Drain the tank completely and clean the inside of the tank thoroughly before the monsoon.

d) Clean the water channels (gutters) often during rainy season and definitely before the first monsoon rain.



Figure 18: Rain water harvesting

e) Avoid first 15 or 20 minutes of rainfall depending on the intensity of rain. Use the first flush arrangement to drain off this first rainwater.

f) Change the filter media every rainy season.

g) Cover all inlet and outlet pipes with closely knit nylon net or fine cloth or cap during non-rainy season to avoid entry of insects, worms and mosquitoes.

h) Check and clean mesh at the inlet and outlet of the water channel (gutter) to facilitate free flow of rain water.

i) Check the down take pipes for Cracks due to exposure to the sun, over pressure due to faulty selection (diameter) or rusting of pipes.

j) Withdraw water from the system at the rate of 5 litres/head/day. This will ensure availability of water throughout the water scarcity period.

k) Leakage or cracks in the storage tank should be immediately attended to. This will obviate the need for major repairs caused by propagation of cracks.

l) Heavy loads should not be applied on the lid.



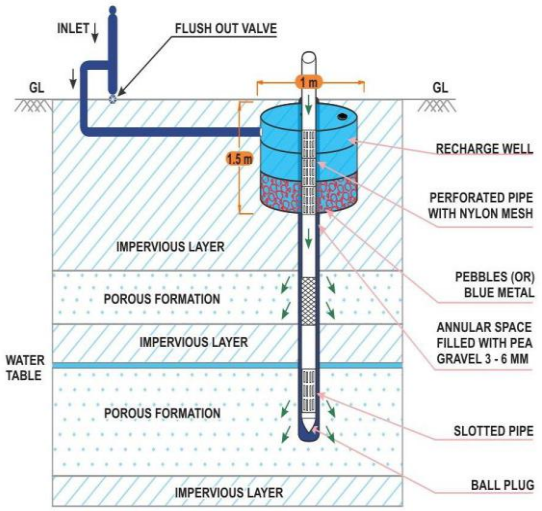
Figure 19: Representation of dug well recharge structure

a) Water should not be allowed to stagnate in the collection pit.

b) The tap should have lock system to prevent pilferage or wastage of water.

c) The filter material should be washed thoroughly before replacing in the filter bucket.

d) In coastal areas, the outer side of the tank may be painted with corrosion-resistant paint at least once in 3 years and in other areas lime (Calcium Carbonate) based whitewash may be applied regularly.



e) Link roof-top rainwater pipes to **abandoned borewells or dug wells** after filtration, to enhance recharge in space-constrained urban areas.

6.5 Integration of Rainwater Structures with Drains

Urban drainage planning must evolve to include source control through rainwater harvesting integration.

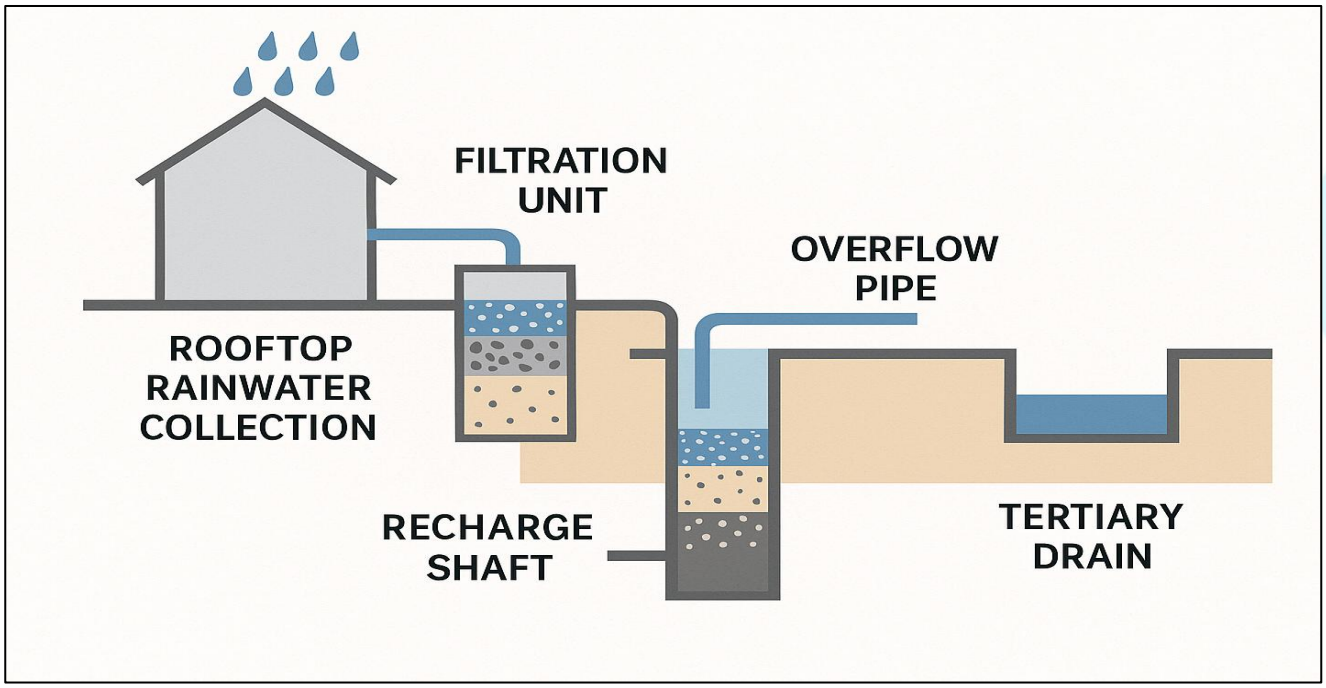


Figure 20: Schematic diagram rooftop-rainwater harvesting

Practical Interventions:

- Construct recharge pits or soak wells at downstream of local drains (especially in parks or campuses).
- Install infiltration trenches alongside roads and footpaths.
- Retrofit schools, market buildings, and community halls with rooftop harvesting linked to storm drains.
- Maintain **percolation pits** at bus stands, petrol stations, and at large public plots.
- Develop **infiltration swales** in institutional areas and recharge shallow aquifers
- Introduce filter strips at road margins or green buffers to reduce direct pollutant entry into drains



Figure 21: Representation of percolation pits



Figure 22: Representation of swales

Technical Consideration: Ensure there is no sewage mixing in such drains; harvesting must only be from stormwater-carrying drains or rooftops.

6.6 Rainwater Harvesting Parks in Urban Public Spaces

Rainwater Harvesting Parks offer dual benefits of water conservation and recreational facility. Designed with shallow depressions, these parks promote rainwater percolation, recharge aquifers, and act as stormwater buffers.

Components Include:

- **Catchment and transport area**: Hard paths or roof runoff from adjacent buildings.
- **Filtration and Storage zones**: Sand bed filters, leaf slides, wall-mounted filters, or check dams.
- **Cost-effective Innovations**:
  - Use of **discarded tyres** for temporary water holding or barriers



Figure 23: Filtration and Storage Zone in park

Recommended Sites: Public parks, school campuses, green buffers, and institutional premises.



Figure 24: Representation of tyres being reused in park

6.7 Water Body Cleaning and capacity enhancement



Urban water bodies (ponds, lakes, tanks) act as natural buffers during rainfall and can help to absorb stormwater if cleaned and maintained prior to monsoon.

Purpose: To increase water holding capacity and ensure smooth entry and exit of stormwater.

Figure 25: Desilting work to increase water holding capacity

Steps:

- Conduct a bathymetry check or visual inspection to assess silt levels.
- Prioritize spot desilting at inlets, outlets, and high-deposition zones.
- Use dry dredging where feasible before rains begin, especially in peri-urban or seasonal waterbodies.
- Avoid machinery compaction by using bunded paths and controlled excavation.

Recommended Measures:

- Desilt peripheries and inlets to increase holding capacity.
- Remove floating waste, plastic, and aquatic weeds.
- Strengthen embankments and bunds to prevent overflow or breaches.
- Ensure proper inlet/outlet connectivity between storm drains and water bodies where ever permitted.



Figure 26 : Strengthening of water body



Figure 28: Inlet connectivity inspection work



Figure 27: Fully developed water body

- Construct **terrain-modeled terraces** and **retention walls** with local materials to support stepwise infiltration and control erosion near urban ponds.
- Use **detention basins** as buffer spaces for excess stormwater during peak rains, which later percolate or are reused.



Figure 29 : Representation of detention basins

6.8 Removal of Encroachments and Roadside Obstructions

In every town and city, rampant illegal encroachment of natural and constructed drainage corridors, lead to serious obstruction and choking of storm runoff with consequent flooding.[5][6][7]

Action Points:

- Identify and remove temporary kiosks, debris piles, and construction waste blocking natural or engineered drains.
- Evict illegal structures built on or over drain alignments, especially near culverts and outfalls.
- Ensure footpaths are cleared of stored materials and the drain side is accessible to desilting teams.



Figure 32: Main drain encroachment clearance work-Delhi



Figure 31: Removing encroachments around stormwater drains at in Bengaluru



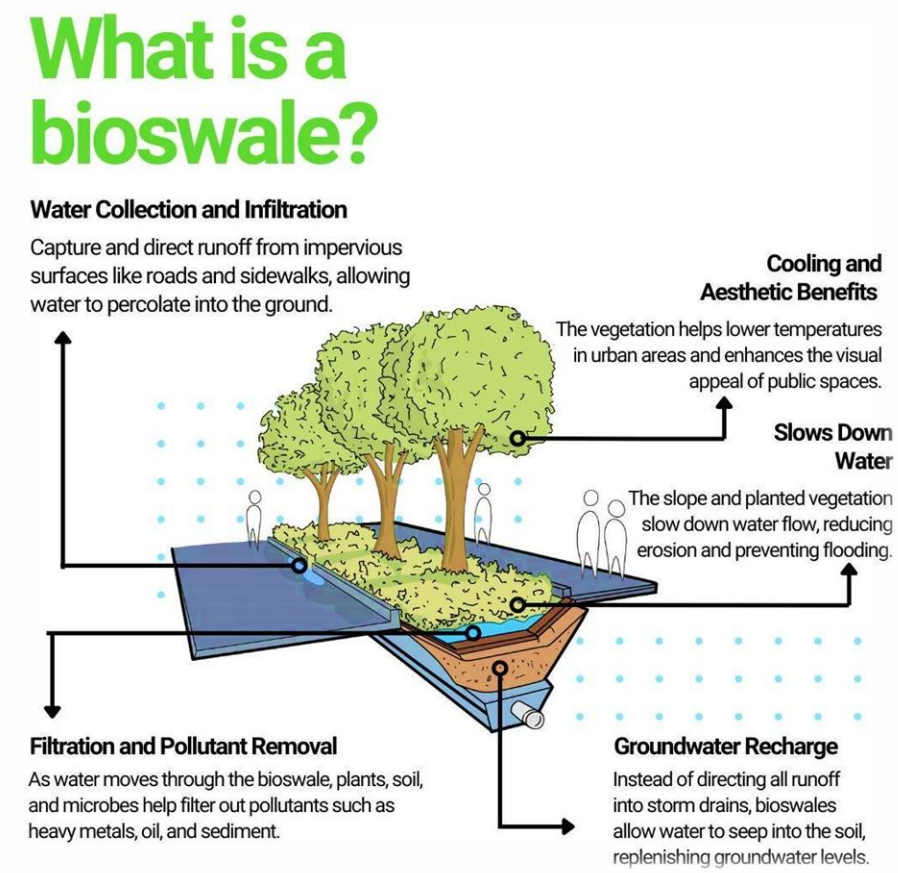
Figure 30: Demolishing of a portion of a house for encroaching a storm water

[5] Figure 30 Source: www.livehindustan.com (6 May 2025)- Demolishes a portion of a house for encroaching a storm water
[6] Figure 31 Source: The Hindu News (4 Sep 2022)- Removing encroachments around stormwater drains at in Bengaluru
[7] Figure 32 Source: The Hindu News (4 Sep 2022)- Main Drain encroachment clearance work-Delhi

6.9 Green Drainage Features: Nature-Based Urban Flood Prevention

ULBs are encouraged to integrate Green Drainage Features in both existing and new urban developments. These sustainable, low-impact designs reduce surface runoff, improve water quality, recharge groundwater, and enhance urban aesthetics

a. Bioswales[8]:



Where to Implement:

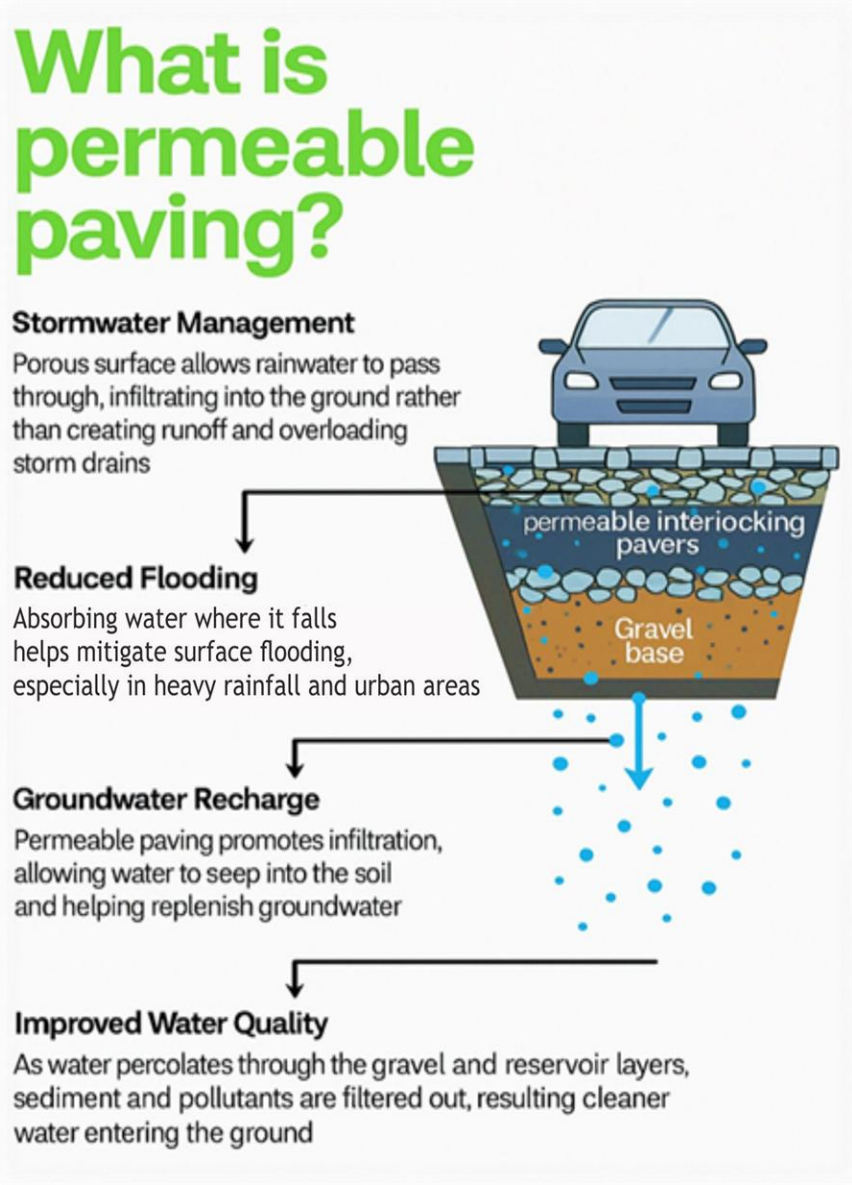
- Along footpaths, road medians, or boundary walls of institutional campuses.
- Near parking lots, bus depots, and linear road corridors.

Benefits:

- Slows runoff, filters debris and pollutants.
- Reduces volume and velocity of water entering storm drains.
- Enhances green cover and biodiversity in urban zones.

[8] *Source: UN-Habitat – Stormwater Infrastructure Education Material, www.unhabitat.org*

b. Permeable Paving:



Where to Implement:

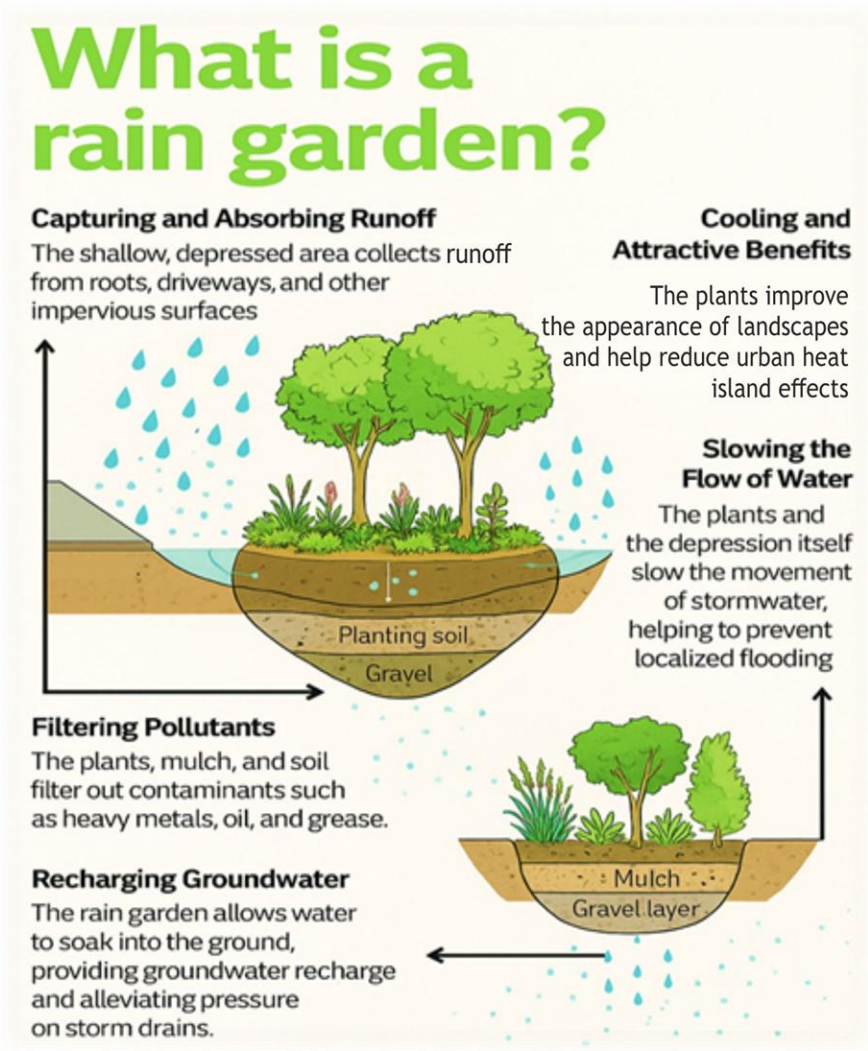
- Parking areas, sidewalks, internal roads of housing societies.
- Commercial complexes and park peripheries.

Benefits:

- Prevents flash runoff and water pooling.
- Reduces demand on drainage infrastructure.

c. **Rain Gardens:**

Engineered green depressions planted with native vegetation designed to capture and absorb runoff from rooftops, roads, and pavements



Where to Implement:

- Public parks, school grounds, community centers.
- Traffic islands and housing society courtyards.

Benefits:

- Filters the pollutants from surface water.
- Promotes groundwater recharge and reduces load on stormwater drains.
- Enhances local aesthetics and urban cooling.

6.10 Sponge Parks: Nature-Based Urban Flood Resilience Intervention[9]

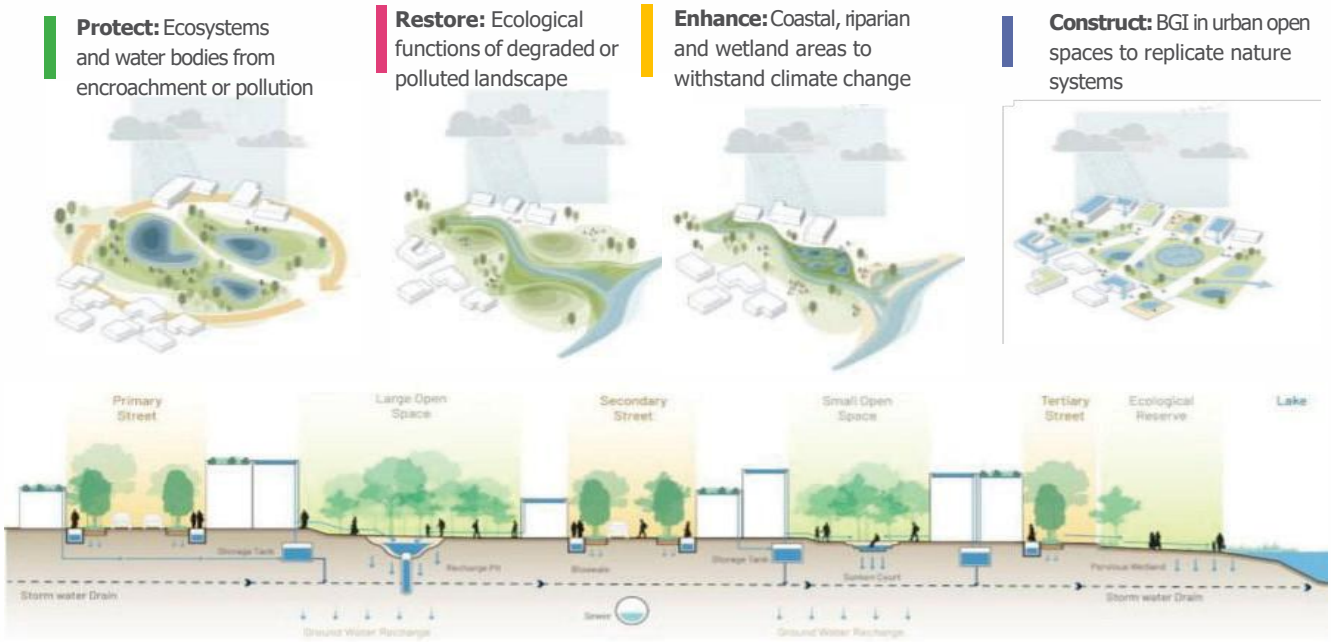
Sponge City" is an urban planning paradigm based on NbS principles that leverage regional landscapes and blue-green infrastructure (BGI) to manage storm water holistically and build resilience to multi-hazards. A Sponge City benefits from an integrated planning approach that leverages natural and constructed blue- green systems to reduce, delay, and store runoff from storm events to limit flooding and recharge the aquifer where conditions allow.

Constructed blue-green systems include Sponge Streets that improve streets and Sponge Parks that retrofit existing open spaces for disaster risk mitigation. A study by Sponge Collaborative in Chennai showed BGI can cost-effectively supplement stormwater infrastructure to mitigate flooding from extreme storms.



Sanya Dong'an Wetland Park by **TurĐnscapĐ / KonŪian Tu**
Source: The Cultural Landscape

Nature-based Solutions (NbS) principles for Sponge City



Integrating open spaces, streets, buildings, water bodies with blue-green infrastructure (BGI) and stormwater drainage to build a Sponge City.

[9] *Source: GIZ, – Training material: Sponge park manual Summary Booklet*

What are Sponge Parks

Sponge Parks are open spaces that are designed to temporarily hold rainwater, filter stormwater runoff, and recharge groundwater. Transforming open spaces into Sponge Parks require an integrated approach that brings together the four systems of soil, hydrology, vegetation, and social amenities. By following this manual, city leaders and engineers can implement socially vibrant Sponge Parks that built urban resilience to flooding, water scarcity, and extreme heat.

M.S Swaminathan Wetland Eco Park by **Sponge Collaborative**



Chulalongkorn University Park by **LANDPROCESS**
Source: World Landscape Architecture



Bishan-Ang Mo Kio Park by **Ramboll Studio Draisaitl**



Sponge Park Systems



S.1. SOIL & GRADING
Modifying soil composition, improving soil health, and contouring earthworks to create zones for intensive planting, programmed spaces, and hydrology



S.2. HYDROLOGY & BLUE-GREEN INFRASTRUCTURE
Ensuring the sequence, sizing, and detailing of BGI components strategically delays, stores, and stores runoff while recharging the aquifer



S.3. VEGETATION & PLANTING
Selecting native and adaptive species, optimizing planting density, and designing layered vegetation to improve biodiversity, soil stability, microclimate, and stormwater absorption.



S.4. AMENITIES & FACILITIES
Integrating functional and recreational elements—such as seating, lighting, walkways, and play zones—designed for user comfort, accessibility, and harmony with the landscape and water systems.

Sponge Park Functions



Delay
By incorporating features like swales, permeable surfaces, and vegetation buffers, Sponge Parks can delay the flow of water, allowing more time for infiltration and reducing peak flows during heavy rainfall events.



Filter
Through natural filtration processes facilitated by vegetation, soil, and engineered media, pollutants and sediments are removed from storm water runoff before it enters groundwater or surface water bodies.



Store
Sponge Parks are designed to temporarily store storm water runoff. Features such as rain gardens, retention ponds, and infiltration basins capture excess water, reducing pressure on drainage systems and preventing flooding downstream.



Recharge
By promoting infiltration and allowing water to percolate through soil layers, these parks replenish recharge wells and contribute to sustainable water management.

Prioritization

Prioritization refers to having a systematic way to determine which open spaces can be upgraded to have the most positive environmental and social impact on communities.

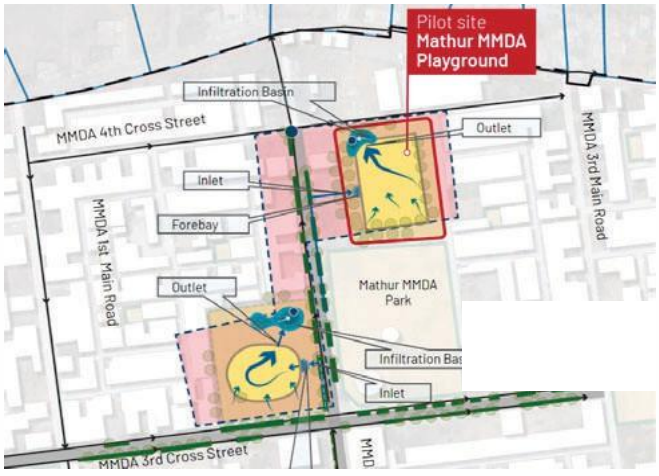
Prioritization uses environmental pre-screening mechanisms, multi-criteria decision criteria, and community engagement to decide which open spaces should be upgraded to Sponge Parks on a priority basis or which ones are most suitable for piloting Sponge Parks.

While Strategic Planning outlines a framework for selection of sites, Prioritization evaluates those sites for technical, political, and environmental feasibility that require on- ground investigations, meetings with zonal engineers, and community consultations.

In the prioritization phase, community inputs on perceived risks can provide more insights on flooding, water scarcity, and extreme heat stressors. The community will also be able to validate the impact of the lack of open spaces and the social facilities desired in the neighborhood. A quick social audit of existing facilities and the socio-economic profile of the neighborhood within the walking catchment area can help determine the provision of programs like playgrounds, outdoor gymnasiums, community gardens, or public toilets.

Prioritization Checklist

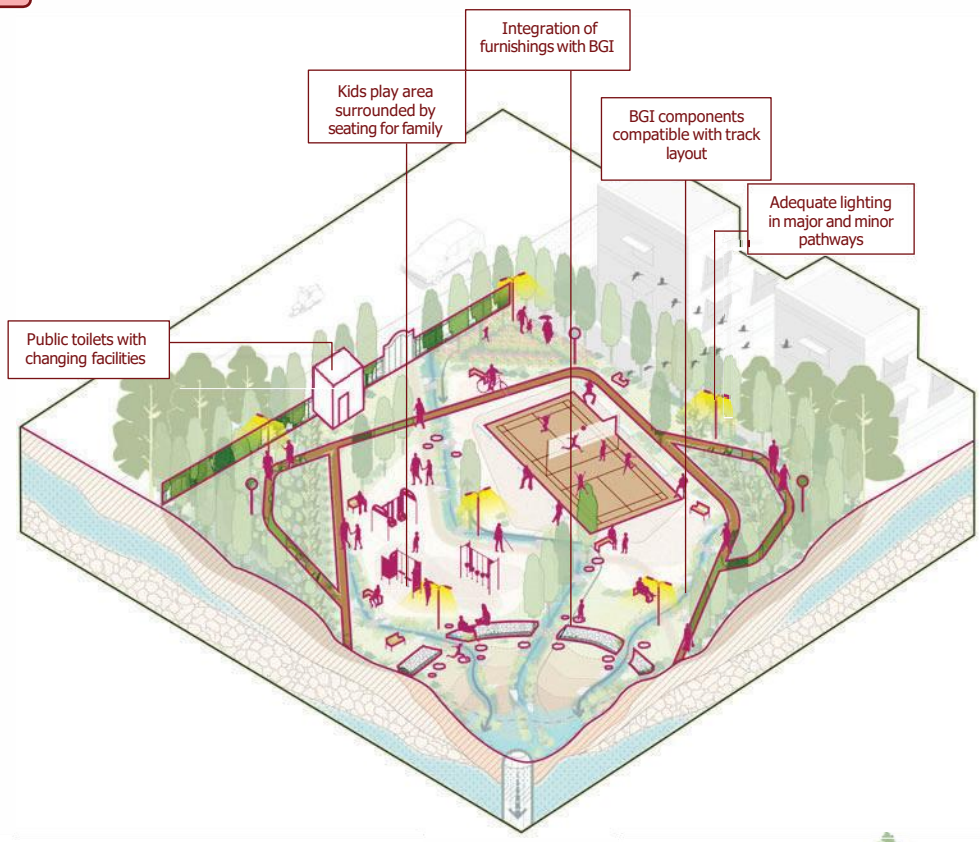
- ☑ **Aquifer Recharge and water Quality**
  - Assess soil infiltration rate and depth to groundwater table to estimate aquifer recharge benefits.
  - Ensure catchment area has no point pollution sources and OSR can support adequate filtration to prevent aquifer contamination as a Sponge Park
- ☑ **Flood Mitigation**
  - Calculate contributing catchment area and runoff volume for 5, 10, 25 year RP storms to determine if OSR site can mitigate flooding as a Sponge Park
- ☑ **Urban Greenery and Ecology**
  - Study ecological corridor, habitat Potential, and heat island effect
- ☑ **Community Needs**
  - Engage community to understand social and climate needs that can be fulfilled by the social facilities and landscape provided in the potential Sponge Park





Soil testing and infiltration rate analysis

Concept Design for Sponge Park System

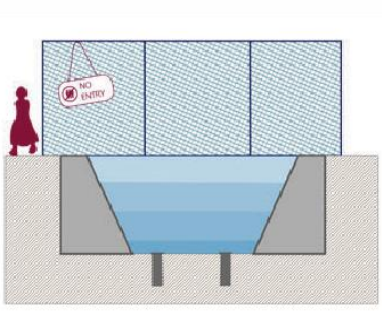




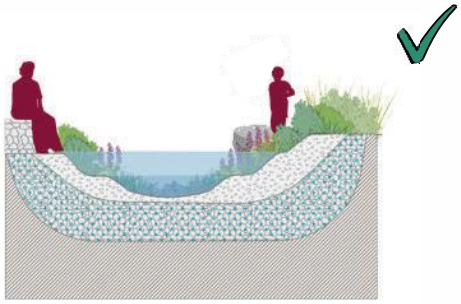
Don't separate BGI from social uses, furnishings, and program



Do integrated BGI with park functions as a social amenity



Don't design BGI with depths that are dangerous for children



Do provide gentle slopes and opportunities for nature play in BGI

6.11 Managing Road Elevation to Prevent Flood Intrusion into Buildings

In many urban areas, repetitive road re-carpeting and surface strengthening-without prior milling-have led to progressive elevation of road levels above the plinths of adjoining buildings. This imbalance becomes critical during heavy rainfall, as stormwater may enter homes, particularly when the drainage system is overloaded. In such cases, backflow may also lead to sewage mixing with rainwater, posing serious health and hygiene risks.

To address this, Urban Local Bodies should conduct a detailed survey to identify stretches where road levels have surpassed residential plinths and prioritize corrective actions.

Recommended Technological Interventions:

- **Hot In-Situ Recycling:** This method involves removing the top layer of bituminous road, remixing it with the required bitumen, and re-laying the material at the same elevation using a continuous chain of machines. It allows resurfacing with minimal elevation gain and disturbance.
- **Batch-Plant Recycling:** In this alternative, extracted bituminous layers are transported to a mixing plant for reprocessing and reapplication. While effective, it is more time-consuming and logistically intensive.
- **Micro-Surfacing Technology:** A thin layer of modified bitumen emulsion mixed with fine aggregates is applied to seal cracks and restore riding quality. This treatment extends road life by 2–3 years without raising surface height.
- **Cement Concrete (CC) Roads:** For new developments, CC roads offer a lifespan of 20–25 years with minimal maintenance. They are ideal for zones where service ducts are planned separately, minimizing surface disruption during utility repairs.

6.12 Flood-Resilient Design in Riverine and Low-Lying Areas

In towns or settlements where the ground level is significantly lower than nearby riverbanks or major outfall channels, preventive design modifications are essential to safeguard households and infrastructure from backflow flooding.

Key Interventions:

- Provision for barrier systems to avoid reverse flow to be made to protect the property at the entry level of the drain.
- Ensure all new buildings in these areas have raised plinth levels based on past flood records and drainage master plan contours.
- Promote elevated drain layouts and localized bunding or embankment protection around habitations that are repeatedly impacted.
- Integrate flood-resilient house design practices into local building by-laws, particularly in riverfront towns, delta zones, or depressions.

6.13 Integrating Climate Resilience in Urban Flood Management

Urban flooding is a growing concern in the face of climate change, with unpredictable precipitation patterns and rising sea levels impacting infrastructure performance. Therefore, embedding climate resilience in city-level monsoon preparedness is critical.

Many countries are coming out with innovative storm water practices, suiting to their socio-economic and geographical condition. Under these practices, the maximum utilization of water resources is targeted with minimum investment. The following models are prominent and can be integrated into the storm water drainage planning and designing. A brief of these models is presented below[10].

A. Climate-Resilient Stormwater Solutions:

1. Water Sensitive Urban Design (WSUD)

WSUD focuses on integrating the urban water cycle, including stormwater, groundwater, and wastewater, into urban design to reduce environmental degradation.

Water Sensitive Urban Design for urban storm water seeks to address, inter alia, the following important aspects:

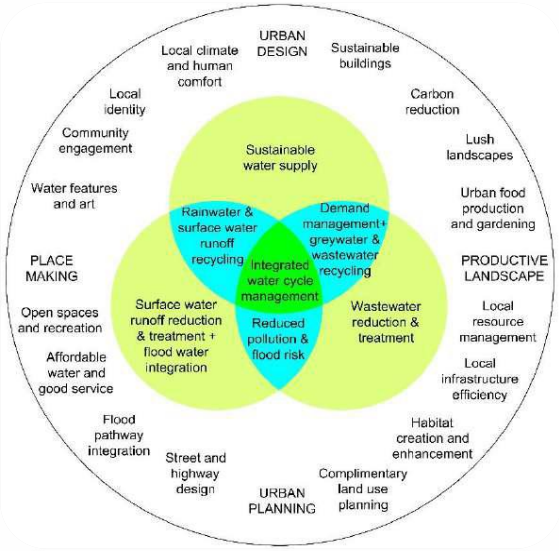


Figure 33: Aspects of Water Sensitive Urban Design

Minimizing runoff at or near its source, by directing runoff from impervious surface to pervious areas to reduce quantity and improve quality of runoff.

I. Preserve the existing topography and features of the natural drainage system including waterways and water bodies.
II. Integrate public open space with storm water drainage corridors to maximize public access, passive recreation activities and visual amenity, while preserving essential waterway habitats and wildlife movement corridors.
III. Preserve the natural water cycle including minimizing changes to the natural frequency, duration, volume, velocity, and peak discharge of urban storm water runoff.
IV. Protect surface water and groundwater quality.
V. Minimize the capital and maintenance costs of storm water infrastructure.

[10] These models Ref. to CHAPTER 10: Manual on Storm water Drainage systems PART-A Engineering Design,2019

2. Low Impact Development (LID)

LID is an innovative storm water management approach modeled after nature i.e manages rainfall runoff at the source using uniformly distributed decentralized micro-scale controls.

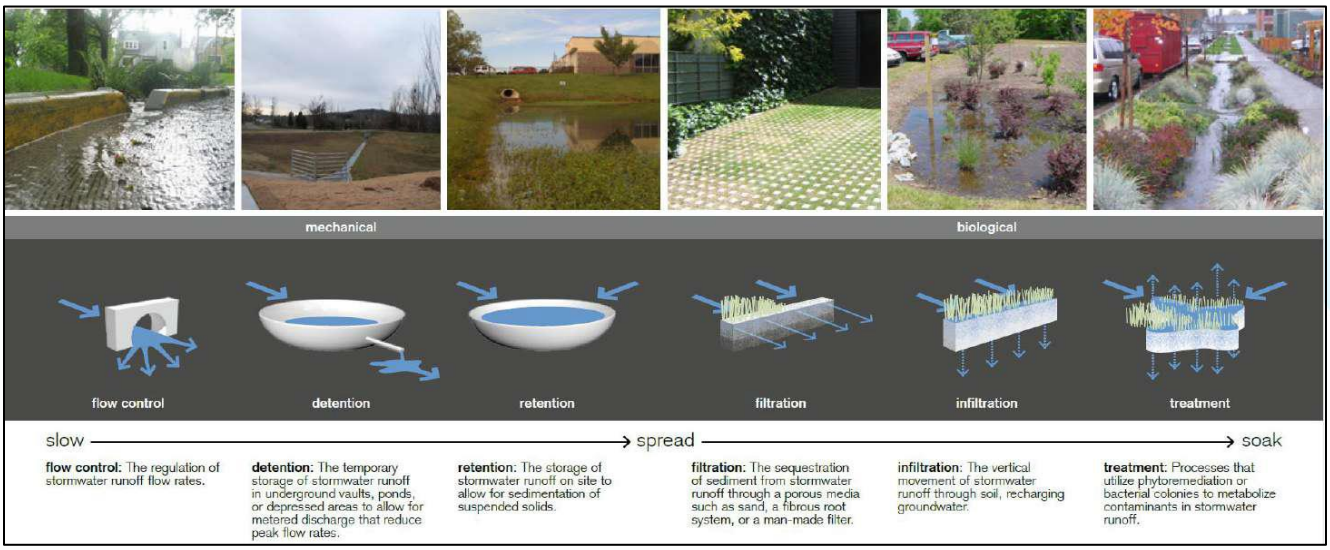


Figure 34: Basic LID strategy

3. Sustainable Urban Drainage Systems (SuDS)

Sustainable drainage systems aim towards maintaining or restoring a more natural hydrological regime, such that the impact of urbanization on downstream flooding and water quality is minimized.

Following two main objectives of SuDS are:

I. Minimize the impacts of urban runoff by capturing runoff as close to source as possible and then releasing it slowly
II. Reduces pollutants in the surface water by settling out suspended solids

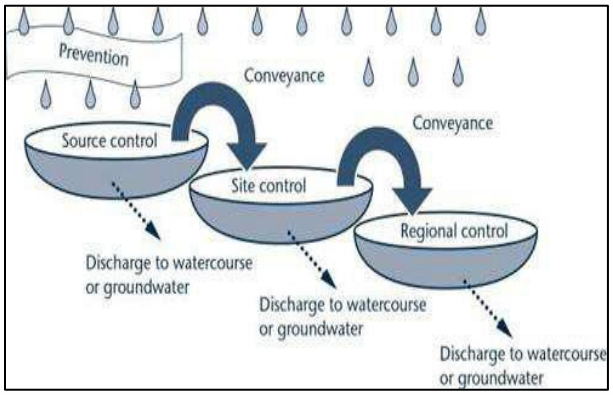


Figure 36: SuDS planning process

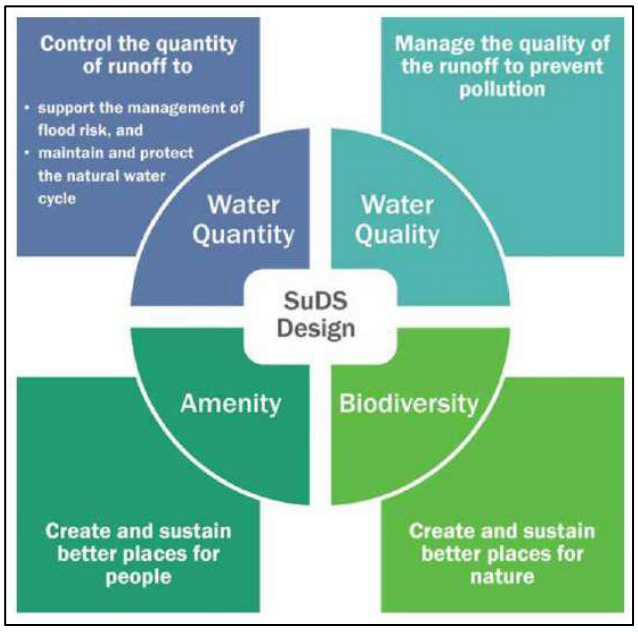


Figure 35: SuDS design principles

4. SMART (Stormwater Management and Road Tunnel)

SMART (Stormwater Management and Road Tunnel) is a multipurpose tunnel that doubles up as roadway for vehicles and a channel to get rid of storm water. The main objective of this tunnel is to solve the problem of flash floods and also to reduce traffic jams. There are two components of this tunnel, the storm water tunnel and motorway tunnel. The storm function of the SMART tunnel is to divert flood water caused by heavy rain into a bypass tunnel under the motorway tunnel. If the rains continue and flooding gets worse the motorway tunnel is closed to vehicles - allowing water to flow through both the traffic and bypass tunnels. The tunnel project is implemented in Kuala Lumpur, Malaysia, Japan, Dubai etc.

Case Study: Kuala Lumpur SMART Tunnel, Malaysia[11]

The SMART Tunnel in Kuala Lumpur is a globally recognized example of innovative urban infrastructure that combines traffic management with flood mitigation. Commissioned in 2007, it spans approximately 9.7 kilometers and integrates dual-use functionality—stormwater diversion and a double-deck motorway.

Key Features:

- **Dual-Functionality:** Designed to divert stormwater and alleviate flash flooding while also serving as a vehicular tunnel under normal conditions.
- **Four Operational Modes:** The tunnel operates under four progressively escalating modes based on rainfall intensity and flood severity—starting from no diversion to full closure for floodwater passage.

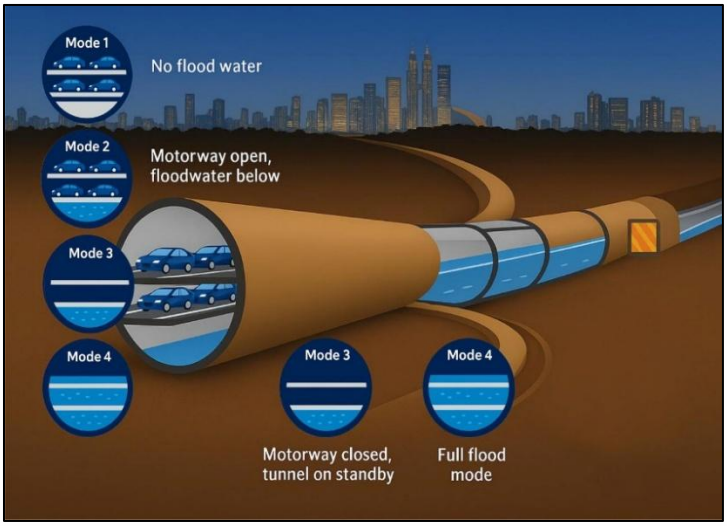


Figure 37: Animated cross-sectional view of SMART

- **Automation & Control:** A real-time monitoring system detects rainfall and triggers gate mechanisms to switch between traffic and stormwater modes efficiently.
- **Flood Management Impact:** The tunnel has successfully mitigated flooding in Kuala Lumpur's city center and has become a benchmark for resilient urban infrastructure.

[11] Study Source: https://smarttunnel.com.my/smart/what-is-smart/ , https://iahr.oss-accelerate.aliyuncs.com/upload/file/20200602/1591059165975059.pdf

Unique Features:

- Automated Flood Control Gates
- Cross Passage
- Ventilation/Escape Shafts
- Radio Re-Broadcasting Services
- Air Quality Monitoring Equipment (AQME)
- SCADA Monitoring & Surveillance
- Other Emergency Equipments
- First Responder Vehicle (FRV)
- Medical Response Vehicle (MRV)
- Alam Flora Road Sweeper

Operational Modes of The Smart Tunnel:



The SMART (Stormwater Management and Road Tunnel) was developed to mitigate urban flooding in Kuala Lumpur while simultaneously offering traffic decongestion solutions. The tunnel operates in **four distinct modes**, each triggered based on the severity of the rainfall and flood conditions:



No Flood water will divert into SMART System.



The SMART system will be activated and floor water will be diverted into bypass tunnel in the lower channel of the motorway. Up to this point, the motorway will still be opened to traffic.



The SMART system will be activated and the motorway will be cleared and closed to traffic; Sufficient time will be allocated to allow the last vehicle to exit the motorway. Tunnel is on standby mode for stormwater diversion into the motorway component. Tunnel prepares to divert stormwater into both levels.



The SMART system will be activated if heavy rain storm prolongs, and the motorway will be filled with stormwater after all the gates are opened, Motorway component will be used for passage of floor after traffic evacuation Completed. The motorway will be re-opened to traffic within 48 hours.

5. Decentralized Stormwater Interventions

Storm water runoff control at decentralized level is of immense use and not only meets the local requirement of water for domestic uses but also can recharge ground water and minimize investment in storm water drainage infrastructure. In addition, it can contribute immensely to prevent frequent flooding in low lying areas. Decentralized innovative interventions that may be integrated in design / incentivize to realize above mentioned benefits are given like Local recharge pits (RRHS), Rooftop harvesting linked to soak pits Permeable pavement, Rain Garden, Infiltration trench, Soakaway, Bioretention



Figure 38: Decentralized innovative intervention in storm water drainage

7. Important Technical Considerations

7.1 Electrical Safety and Infrastructure Inspection

The risk of electrocution, short circuits, and fire hazards is increased in monsoon season particularly during flooding. Pre-monsoon electrical inspections are therefore critical.

Key Measures:

- Adopt waterproofing transformer units, feeder pillars, streetlight poles, and junction boxes in low-lying areas.
- Elevate and secure electric panels and switchboards at pump houses and shelters.
- Coordinate with state electricity boards to prepare a disconnection protocol during urban flooding.
- Use insulated tools and PPE kits for all electrical staff working near waterlogged sites.

7.2 Sewer-Storm Drain Mapping and Separation

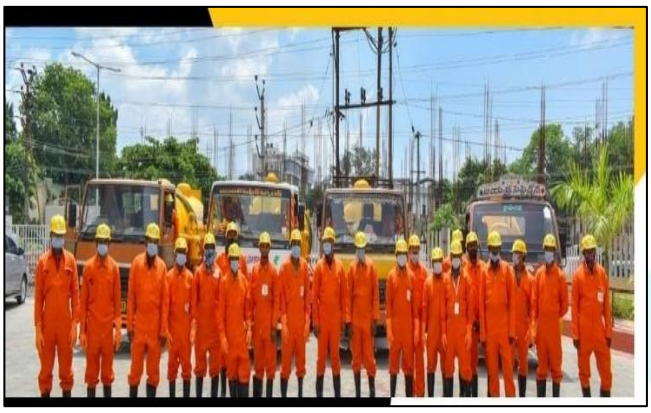
In many urban areas it has been observed that, the stormwater drains are connected to sewer lines, which leads to contamination, overflow, and foul odours during rains.

Required Actions:

- Conduct mapping and inspection of overlapping zones using GIS or ward-level surveys.
- Identify sewer connections discharging into storm drains and disconnect them.
- Plan for in-situ upgradation or reconstruction of combined systems in a phased manner.
- For areas with separate systems, ensure their independent monitoring and maintenance.
- Secure sewer manhole covers and intact to prevent sewage backflow during waterlogging or surcharged conditions.
- Repair potholes and road depressions to prevent localized water stagnation, especially at intersections and low camber points.

8. Safety of Maintenance Personnels

It is important to be well equipped prior to start of work, as per the guidelines of OSHA with special emphasis to the particular type of works. In the hierarchy of controls, personal protective equipment is considered first to avoid work-related injury or illness. Basic guidelines that should be followed before starting maintenance works.



I. Obtain proper training in principles of excavation safety and be thoroughly familiar with equipment to be used.
II. Make sure an updated first aid kit, emergency contact information and hand-held radios or cell phones are available at the site of work.
III. Operate equipment safely in accordance with manufacturers specifications
IV. Wear highly visible apparel while working at site
V. Do not enter a trench or excavation unless it is protected against caving.
VI. Identify where to dispose of removed sediments and wastes prior to cleaning the drains – record should be maintained and disposal should be at designated place assigned by ULB
VII. Use shovels, trowels or high suction vacuum to remove wastes and sediments.
VIII. Do not clean out sediments and wastes with bare hands.



Figure 39: Maintenance workers wearing PPE kits



Figure 40: Training on maintenance work

IX. During operation if road is open to traffic use traffic control devices such as flaggers, pavement markings etc. –
X. elaborate daytime, accidents,
XI. Remove all temporary traffic controls when no longer required.
XII. Repair identify and address

Personal Safety

Following personal safety equipment should be used by maintenance staff while maintaining the storm surface drains.

I. **Eye protection:** Spectacles/goggles, shields, visors etc.
II. **Hearing protection:** Ear muffs and plugs etc.
III. **Hand protection:** Gloves and barrier creams etc.
IV. **Foot protection:** Hard toed shoes/boots etc.
V. **Head protection:** Helmets, caps, hoods, hats
VI. **Working from heights:** Harness and fall arrest devices etc.
VII. **Skin protection:** Hats, long sleeved clothes etc.



Figure 41: Personal safety equipment (animated)

9. Emergency Preparedness

9.1 Setup of Control Rooms and Ward-Level Coordination

City-Wide Monsoon Control Room:

- Establish a 24×7 monsoon control room, managed by engineering, health, sanitation, and power utility officers.
- Integrate real-time rainfall alerts from IMD.
- Maintain updated maps of vulnerable zones
- Designate city-level representative and their contact numbers.
- **Display emergency helpline numbers** prominently at key public locations (e.g., bus stands, hospitals, ward offices, market areas), customized as per the City/ULB.



Figure 42: Monsoon Control Room view (animated)

Ward-Level War Rooms:

- Establish local teams of engineers, pump operators, sanitation workers, and community representatives in each ward.
- Designate ward-level representative and their contact numbers
- Daily coordination calls must be attended on high priorty during active rain periods.

9.2 Resource Mobilization and Team Deployment

Material Readiness:

- Dewatering pumps, diesel stock, suction hoses.
- Sandbags (100+ per waterlogging-prone location).
- Emergency tools: torches, ropes, gumboots, high-visibility jackets, raincoats.
- Mobile toilets and water tankers for relief sites.

Team Readiness:

- Roster of available ground staff (with shifts and phone numbers).
- Pump deployment map with pre-identified hotspots and contact points.
- Checklists to be maintained for daily readiness status and shared with the control room.

Water Boating Provision:

- Provision of inflatable boats or mechanized watercraft must be ensured for coastal areas, low-lying urban basins, or flood-prone wards.
- Boats should be equipped with life jackets, ropes, first-aid kits, and communication devices.
- Pre-identify safe docking and embarkation points, especially near slums, vulnerable settlements, and underpasses.
- Staff must be trained in basic rescue operations and coordinated with NDRF/SDRF if applicable.

9.3 Evacuation and Relief Centre Planning

Safe Shelter Sites:

- Pre-identify government schools, community halls, or temples or any other establishments located on high ground.
- Ensure accessibility, clean toilets, drinking water, and power backup.

Relief Logistics:

- Prepare stock of food packets, ORS sachets, chlorine tablets, and medicines.
- Create tie-ups with local NGOs, SHGs, and civil defense for support.
- Coordination with District Disaster Management Authority (DDMA) for protocol and support.

10. Community Awareness and Public Participation

10.1 Roles and Responsibilities of Citizens (Do's and Don'ts)

Active public participation helps in maintaining urban stormwater infrastructure and reducing avoidable blockages or flooding events.

Do's

- Clean and maintain surroundings, rooftops, and nearby drains.
- Report any flooding, broken covers, or drain blockages to ward offices.
- Cooperate with field teams during desilting, dewatering, and rescue operations.
- Participate in community clean-up campaigns and monsoon awareness drives.
- Follow updates and alerts shared by ULBs via digital media.

Don'ts

- Do not dump plastic, kitchen waste, or debris into stormwater drains.
- Avoid covering storm inlets and gully traps with temporary ramps or slabs.
- Do not allow open defecation near drains, nallahs, or water bodies.
- Refrain from diverting sewage into stormwater drains.
- Do not build on natural water flow paths or encroach on drain easements.

10.2 Modes of Communication and Awareness Strategies

a. **Print Media:** Booklets in simple language (Hindi, English, regional) should be distributed to inform citizens about storm drainage systems.

b. **Electronic Media:** 15–20 min audio-visual programmes should be telecast on Doordarshan and AIR via Prasar Bharati to ensure wide outreach.

c. **Social media:** Short instructional videos and messages can be circulated on platforms like Facebook, Twitter, and Instagram for rapid dissemination.



Figure 43: Street play for awareness

d. **Cinema Halls:** Promotional videos aired before movies can reinforce awareness using content common to television advertisements.

e. **Street Plays:** NGOs and student groups can perform skits on storm drainage at public places to connect with diverse audiences.

f. **Posters, Pamphlets & Hoardings:** Display visuals at key locations like stations and markets; distribute pamphlets door-to-door or via newspapers.

g. **Voluntary Organizations**: Educated volunteers can conduct seminars, street plays, and awareness drives to engage communities.

h. **Door-to-Door Campaigns:** Volunteers from various groups should personally reach households to explain civic responsibilities in simple terms.



Figure 44: Awareness drives by volunteers

i. **CSR Campaigns:** Industries can support campaigns financially and operationally as part of their Corporate Social Responsibility efforts.

j. **Mobile Phones:** Send short awareness messages or recorded calls with links to official sites for further public guidance.

k. **Sanitation Volunteers:** ULBs should form ward-wise WhatsApp groups of citizen volunteers to monitor and report local stormwater issues.

10.3 Role of Sanitation Volunteers and Community Monitors

To ensure continuous ground-level feedback and early issue identification, ULBs are advised to set up a network of **Sanitation Volunteers** at the ward-level.



Figure 45: Sanitation volunteers

Key Functions:

- Report clogged drains, open manholes, broken covers, and illegal dumping.
- Monitor RRHS installations and local soak pits.
- Act as citizen interface for ULBs via digital media or community notice boards.

- **Promote Safe Drinking Water Practices:** Sanitation volunteers should advise community members to consume only boiled or treated water during the monsoon season to prevent the spread of waterborne diseases such as cholera, typhoid, and diarrhea.
- **Facilitate Mobile Toilet Usage in Water logged Areas:** In areas affected by flooding or stagnant water, volunteers must coordinate with the ULB for the deployment of mobile toilet units and guide residents on their safe and hygienic use to avoid open defecation and related health hazards.

Management:

- Each ward officer shall maintain a list of active volunteers.
- Daily or weekly messages (photos, videos, reports) can be shared in the ward-level digital media groups.
- ULB must acknowledge and act promptly on verified alerts.



Figure 46: Representation of Active Volunteers with proper PPE kits

11. Additional Preventive Measures

11.1 Institutional Coordination and Mock Drills

Preparedness must be tested in real-time conditions. ULBs should conduct pre-monsoon drills simulating various flooding scenarios.

Coordination Needed:

- Disaster Management Authority (DDMA)
- Public Works Department
- Municipal corporation
- Water Boards
- Health Department
- Fire and Emergency Services
- Local police and traffic division

Mock Drill Focus Areas:

- Pumping equipment operation
- Emergency evacuation of flooded areas

11.2 Complaint Redressal and Real-Time Response System

Public complaint and redressal system must be operational. Some of the practices to be followed during flood emergency are as under:

Best Practices:

- Launch a dedicated helpline number with 24x7 availability.
- Set up a centralized dashboard for tracking complaints by location and status.
- Share ward-level contact numbers of engineers and sanitation staff on posters and social media.
- Resolve waterlogging complaints on top most priority basis during peak rain hours.

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