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# Water Sensitive Urban Design: Storm Water Management Practices as an Opportunity

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***Abstract - Rapid urbanization, exhausted resources, imbalance in urban hydrological cycle, great pressure on ecological functions, unhygienic and unhealthy environment is the outline in almost all Indian cities. Tremendous pressure on land caused by increasing urban population has led to a significant increase in impermeable and paved surfaces which has reduced the infiltration rate. Under natural climatic parameters, water acts as a complete cycle of precipitation, evaporation, surface water runoff and infiltration. However, in cities this cycle is disrupted. Urban water is polluted and unable to percolate into the ground due to its paved surfaces, which results in rapid collection and drainage into public sewers which do not get the time to evaporate. Ultimately, it has negative effects on groundwater recharge. Mismanagement of surface water and urban runoff results in flooding, erosion, and water problems. All these issues clearly indicate the need for efficient solutions for urban stormwater management. This research aims to identify strategies that can potentially integrate water cycle loop, water supply, groundwater and storm water with effective spatial design considerations that are water-sensitive in nature through a literature review. The research recommends techniques at urban design level and then individual design level towards building water-sensitive sustainable cities in consideration with the Sustainable Development Goals 2030, that covers clean water, sanitation and sustainable cities, as well as community involvement, as significant priorities.***

***Keywords - Cities, Hydrological cycle, Infiltration rate, Storm water, Urbanisation and Water Sensitive Urban Design***

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## INTRODUCTION

**Cities have experienced tremendous expansion in** the 20th century. Oftentimes this expansion has been uncontrolled, which has resulted in the shifting of non-urban to urban land use. For the first time, 2011 census data showed significant increase in the urban population in India which was slightly higher than the increase in rural population. India's National Population Commission (NCP) predicts that over the next 15 years (that is, by 2036), about 38.6 percent (600 million) of Indians will live in urban areas (Census of India 2011, 2020). The United Nations also emphasized that India's urban population will nearly double from 461 million to 877 million between 2018 and 2050 (UNO, 2018). With the increase in urban population there is tremendous pressure on land. This spread of the built up areas has significantly increased impermeable and paved surfaces which has reduced the infiltration rate. Flooding, erosion, and other water-related issues come from poor storm water and urban runoff management. This in turn affects our urban cycle. Under natural conditions, water acts as closed loop of precipitation, infiltration, runoff and evaporation. However, in urban areas this loop is disturbed. Urban water is contaminated and unable to permeate the earth because of paved surfaces, which results in rapid collection and drainage into public sewers that do not get the time to evaporate. Ultimately, it has negative effects on urban climate. All these issues clearly indicate the need for efficient solutions for urban water management (Hoyer, 2011).

## CITIES AND WATER

Water emerges in cities as potable water, storm water and grey water managed by the municipality. Storm water must infiltrate the ground or paved surfaces (roofs, streets, etc.) to avoid flooding and keep side streets and buildings dry and safe (Hoyer, 2011). The findings states that around “4.0 billion

people, two-third of the world population experiences severe water scarcity during at least some part of the year, implying that the situation is worse than suggested by previous studies which estimated between 1.7 and 3.1 billion people" (NATIONS, 2021) . The existing water management practices are not helping cities in increasing the efficiency of water cycle and creating awareness of the importance of water resources.

## LITERATURE REVIEW CONVENTIONAL APPROACH

Storm water management practices are constantly evolving. In Ontario, urban storm water has been managed for flood control purposes since the 1970s. In the 1990s, storm water management was also recognized as an important tool for improving water quality and reducing pollution of lakes and rivers. Since then, this practice has focused primarily on centralized storm water storage. This is also known as storm water treatment at the end of the pipe(Goulden et al., 2018).

**Sewerage systems are divided into two categories:**

1. Combined sewerage systems collect both wastewater and storm water in a single pipe network. Mixed water is transported to a wastewater treatment plant, where it is cleaned before being released into the river.

2. Separate sewerage systems: Wastewater and storm water are collected in two different sewerage systems. The wastewater is transported to a wastewater treatment plant, whereas the storm water pipe either discharges directly to the receiving water (in the absence of pollutants) or is treated separately before being discharged into the river. (Hoyer, 2011)

## WATER SENSITIVE URBAN DESIGN (WSUD) AS SUSTAINABLE APPROACH

**WSUD (Water-Sensitive Urban Design) is an integrated method that combines the following components in planning and design to redesign water use and complete the water cycle.**

1. Protect local water sources (lakes, ponds and wetlands) to get additional water resources.

2. Landscape elements (e.g., vegetated ditches and buffer zones band, biological note system) are used to manage rainwater in public locations, especially open areas in cities.

3. Recycle and reuse wastewater naturally (low cost / low energy).

4. Enhance water conservation approaches at different scales (building / campus) - means by applying water- saving practices, landscaping and implementing water-saving practices—thus reducing the load on the city and groundwater supply systems sources. Rainwater harvesting and in situ conservation are also significant inmitigating water scarcity.

5. By cooperating with professionals from many fields to present different viewpoints and skills, the urban cycle will be connected.(*Water Management to Water Sensitive Planning-A Contemporary Approach for Sustainable Urban Development*, n.d.)

**Table 1: Comparison Between Conventional Practices And Wsudp (Source: Author)**

| Conventional Approach | WSUDP Approach |
|---|---|
| Fragmented approach: Water supply, wastewater andstorm water are managed separately. | Integrated approach: Water supply, wastewater, and storm water, as well as other aspects of urban development, are all linked through planning and design. |
| Linear water cycle: Through supply to single use, fromtreatment to environmental disposal, a straight path is followed. | Closed urban water cycle: Water moves in a cyclic manner used multiple times evaporation to filtration. |
| Increase demand: The increase in demand will be met by investment in resources and centralised infrastructure leading to leak losses. | Reduce demand: Storage, rainwater harvesting, and reuse are all options for reducing demand. Leaks canbe reduced with distributed systems. |
| Storm water as a nuisance: Storm water is drained asquickly as possible from the city. | Storm water as a resource: Rainwater is attenuated and maintained at the water source so that it can flow in the aquifer and eventually flow into the body of water. Storm water infrastructure aims to improve the cityscape and provide recreational opportunities. |
| Big/centralized-better: To collect water from a distant source and treat wastewater at a remote location, aswell as to expand the complete infrastructure. | Small/decentralized is possible: Promote ocal resource and dispose of wastewater near the sourceand promote sustainable approach. |


**Figure 1: Conventional Approach**


**Figure 2: WSUD Approach**

## WSUDP PRINCIPLES

There are four water sensitive design principles: (1) cater to potable water demand; (2) reduce wastewater production; (3) rainwater treatment; (4) use of natural water resources as a feature of the landscape. In terms of technical solutions, water sensitive design basically offers strategies for rainwater accumulation, rainwater filtration and ultimately release of water into nature, it also connects social and technological aspects. These

solutions can be achieved by natural components of the landscape (garden, swimming pool), by technological approaches (pipes, roofs, pumps), or by a combination of both two (reservoir, storage tank).(Walsh et al., n.d.)

**WATER SENSITIVE URBAN DESIGN TECHNIQUES**

1. **GRASSED SWALES:** The design of grassed swales or lawn gutters are designed to allow storm water to enter at more gradual and controlled rate, and acting act as a filter means to remove pollutants while allowing storm water to exit (Figure 3). Channels are a low-cost, low-maintenance option for removing scale, nutrients and contaminants. They increase the penetration of rainwater and visually add an aesthetic element to the site.(*Virginia Stormwater Management Program (VSMP)*, n.d.)

2. **RAIN GARDENS:** A rain garden is a garden in which flowering plants and grasses (both preferably) that can survive in moist soil after heavy rains grow. But these are not gardens with stagnant water (Figure 4). Rainwater gardens collect runoff from rainwater, slow it down and enhance its penetration into the earth. These attractive gardens assist homes and businesses in reducing rainfall runoff, as a result pollutants carried away from roofs and hard surfaces are not swept into streams and lakes (Rain Gardens, n.d.).

3. **INFILTRATION TRENCH:** A shallow digging ditch filled with gravel or rubble is known as an infiltration trench, designed to filter rainwater through permeable soil into an aquifer of groundwater (Figure 5). In locations with poor rainwater drainage, it is frequently utilised to transport wastewater from impermeable surfaces like sidewalks and parking lots. (Infiltration Trenches, n.d.).

4. **BIO-RETENTION SYSTEM:** The bio-retention system consists of a soil layer with suitable non-invasive plants (preferably native plants). Rainwater that flows into the bio-settlement system is filtered through the soil bed before being transported downstream through the underground drainage system or infiltrating the existing underground soil layer (Figure 6). Bed vegetation planted in the soil allows for the absorption of pollutants and runoff water, and helps to maintain voids and associated soil infiltration rates in the bed (Fallis, 2013).

5. **FLITER STRIPS IN PARKING LOTS:** Filter strips are planted areas near to impermeable surfaces that are gently sloping. They're supposed to assist improve storm water quality by reducing the effects of sheet flow and velocity (Figure 7). They're also called vegetated filter strips, grassed filter strips, grassed filters, or buffer strips, and they help remove sediments and other pollutants while boosting infiltration.(Stormwater Management - Filter Strips, n.d.).

**Figure 3: Grass Swales Source:(Virginia Stormwater Management Program (VSMP), n.d.)**


**Figure 4: Rain Garden Source: (Rain Gardens, n.d.)**

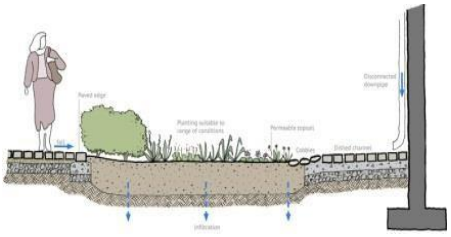

**Figure 5: Infiltration Trench Source: (Infiltration Trenches, n.d.)**

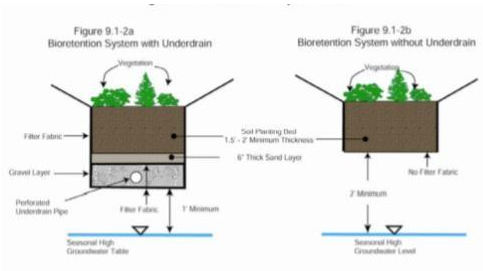


**Figure 6: Bioretention System Detail Source: (Fallis, 2013)**

**Figure 7: Parking lot Strips**

**Source: (Stormwater Management - Filter Strips, n.d.)**

## CONCLUSION

"We forget that the water cycle and the life cycle are one." — Jacques Yves Cousteau

The goal of long-term storm water management is to reduce runoff by treating storm water as close to the point of origin as possible, ideally on-site. "Treating" does not signify the collection and discharge of storm water in the public sewer system, rather it would be treated judicially to reduce the surface runoff and to increase the storm

water infiltration rate. Past experiences have proven the misconduct of water which results today in downfall of water table and climatic crisis. This is because, conventional approach of water management proceeds towards the quick collection of storm water and drain it which reduces the infiltration rate and simultaneously affects the hydrological cycle adversely.

This paper highlights the water sensitive techniques like infiltration trenches, swales and rain gardens at urban design level and then individual design level which can be adopted to make the cities sustainable, aiming for the Sustainable Development Goals-2030 which include clean water, sanitation, and sustainable cities, as well as community participation.

## RECOMMENDATIONS

Storm water management includes management of water at terraces, ground, roads and pavements which are the catchment points of surface water. This surface water flows towards the drain. For the sustainable water sensitive management this surface water should be promoted towards the pervious surface to increase the infiltration rate. Apart from the design techniques mentioned above, several design considerations can be adopted at urban as well as individual level to make the cities sustainable and increase the infiltration rate such as

1. Creating contours to allow surface water to infiltrate into the ground effectively.
2. Reducing the surface drain time of storm water and allowing the storm water to infiltrate into the ground through infiltration bed that filter rainwater through permeable soil into an aquifer of groundwater.
3. Using turf pavers on the pathways and on parking lots. It has high infiltration rates of storm water. This allows the paved area to work in tandem with Mother Nature, rather than against her.

Along with these initiatives at individual level, the development authorities and concerned government bodies should make it mandatory to incorporate WSUDP strategies and techniques in all architectural and planning projects to effectively restore the hydrological cycle in cities.

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