Urban Drainage Flood Management

An Approach Paper for Building Awareness about Urban Flooding

Prepared by:

India Water Partnership

December, 2020

December 2020

Urban Drainage Flood Management

An Approach Paper for Building Awareness about Urban Flooding

Table of Contents

Urban Drainage Flood Management

An Approach Paper for Building Awareness about Urban Flooding

EXECUTIVE SUMMARY

With the increase in the number of frequent flooding and consequent disruption of economic activities, damages of life and property have posed a difficult challenge before city managers. Besides, flooding due to overflow of urban stormwater drainage is responsible for the degradation of the urban built environment and interferes with various other urban systems. Every monsoon increasing number of Indian cities confront the embarrassing breakdown of economic activities for two to three days. During the last twenty years as many major urban flooding have had a devastating impact on the population. At least one of the megacities and many state capitals are affected by floods each year, causing direct and indirect economic losses sometimes running into hundreds of billion rupees. They not only cause damages to structures and urban equipment but also devaluate areas subjected to inundation, induce losses associated with paralyzed businesses and services, interrupt the IT services and transport systems.

While more frequent and intense rainfall due to climate change has been the leading cause of frequent urban flooding, largely unplanned urbanization, with complete disregard to its impact on the hydrology of the area, have aggravated the situation. Further, in the absence of proper solid waste management, the urban water bodies: lakes, rivers and drains have become dumping grounds of city garbage and construction waste.

Urban stormwater drainage infrastructure that is expected to evacuate the excess stormwater runoff of the city is one of the most neglected urban infrastructures in almost all Indian cities. The old philosophy of design of urban stormwater drainage systems, which is based on the principle of the fast evacuation of stormwater has failed to keep pace with the expansive and intensive urbanization. Instead, with the progressively intensive urbanization, the space for drains has shrunk. The flooding due to rainfall events beyond the design rainfall also creates flood risks, also known as residual flood risks. Since cities have become the engines of national development, we cannot afford to get our urban flood management strategy wrong.

New trends of sustainable urban drainage based on the philosophy of replicating the natural hydrologic cycle, are getting popular world over. They are not only incremental but also provide multi-benefits of runoff becoming a resource and enhancing the environment. These new design trends, bundles as Sustainable Urban Drainage Systems (SUDS) approach in this paper, improve the quality and health of the social environment in the city and benefit the ecological health of physical space by enhancing biodiversity. SUDS approach attempts to arrest the water where it falls through a variety of features that help rainwater harvesting, recharge groundwater and rejuvenate water bodies. SUDS offer a sustainable and green solution to reducing the flood peak flows and thus mitigating the flood risks and also serve to rejuvenate the depleted water resources of the city within the framework of Integrated Water Resources Management.

Implementation of SUDS approach requires extensive coordination between various disciplines, departments such as landscape architecture, urban planning, road transport, public health engineering.It also requires engagement withmultiplestakeholder groups such as social scientists, ecologists, civil society, and city residents. At the same time to cope with the residual risks of urban flooding when the rainfall exceeds the design capacity of the stormwater drainage systems, the effective implementation of flood emergency management plans that include preparedness, response and recovery becomes inevitable. The ordinary citizen, who is the first respondent in a flooding situation, should be enabled to participate in such disaster management plans. Therefore, active participation of policymakers, urban planners, developers, water managers, self-governing entities, civil society actors, and citizens – practically every citizen - is essential for mitigating urban flood risks and making our cities more liveable. Sustainable stormwater management is indeed an issue for everyone.

Building Awareness about Urban Flooding

No single organization is charged with urban flood risk management. SUDS approach and disaster management require extensive coordination between various agencies of Urban Local Bodies (ULBs) as they have the principal constitutional responsibility for urban water supply, stormwater management and flood risk management.The High-Powered Expert Committee Report (2011) on the Urban Infrastructure and Services brought out the lack of the capacity in ULBs since most of them are inadequately staffed with outdated knowledge. There exist wide gaps in the knowledge about the nature and magnitude of the inter-linkages between various urban development activities on the urban flood risks. Ignorance of the impacts of urbanization on drainage is prevalent, among both technical specialists and the general public. Skilling and up-skilling, in hard, as well as soft skills,are required for professionals involved in the urban drainage, flood risk management and professionals working on water issues in allied sectors and stakeholders at various levels.

It has been realized at the highest political level (Prime Minister in his Independence Day Speech, 2019) that "water conservation campaigns should be launched, creating awareness in the common citizens about water". There is a need for children and youth to be ingrained with water consciousness. There is a need to change the mindset of the people so that they stop considering the water bodies as dumping grounds for all the refuge. User communities through Resident Welfare Associations (RWAs), civil society need to be engaged in building water sensitization and awareness program.

It is proposed to develop water e-learning (**WE-learning**) program dealing with various facets of the water sector, initially starting with urban flooding, stormwater drainage management and water-related disaster management. The program goal is to produce the skill development materials for technical skills, soft skills, water education and water awareness with the long-term objective to establish a professional certification for urban stormwater management. The contents of the modules will be tailored to the needs of urban planners, PHE professionals, PWD professionals engaged in road construction and maintenance; technicians involved in rainwater harvesting, plumbers, solid waste management, Resident Welfare Associations (RWAs), NGO volunteers, self-help groups and people involved in disaster preparedness and planning. As such, the target group for skill development in the water sector consists of every citizen of the country.

The WE-Learning is proposed to be implemented through a consortium of various institutions both government and non-government, engaged in multiple facets of urban flooding, urban planning, stormwater drainage management and disaster management duly supported by educational institutions.

Urban Drainage Flood Management

An Approach Paper for Building Awareness about Urban Flooding

1. Introduction

With rapid urbanization of the country, today there are more than 53 cities with a population above one million. In most of the Indian cities, urban growth has been mostly informal, unplanned,uncontrolled, and urban occupation sprawled. In order to meet rapid urbanization with limited expansion on agricultural land, densification of existing urban areas has become the dominating urban planning strategy.Impermeabilization of the soil and removal of plant cover for urbanization is responsible for recurrent flooding, landslides in hilly areas, and insufficient recharging of aquifers. The urbanization process which strongly alters the natural hydrologic cycle and the responses of the fluvial systems on the built environment modifiesthe natural drainage system within an urban area.

Due to mostly unplanned development of most of the cities and the dynamics of the population, the stormwater drainage systems, wherever they exist, are functioning far short of satisfaction. As a consequence, the frequency of urban flooding has increased in recent years, leaving its adverse impacts on socio-economic activities. Apart from the fast pace of urbanization, absence of properly engineered stormwater drainage infrastructuresis responsible for this deteriorating situation.Little maintenance of the existing drainage systems and the dilapidated condition of the drainage infrastructure in big megapolises further complicates the situation.Additionally, lack of social awareness among citizensresulting in the encroachment of the natural drainage systemsand dumping of garbage into the drainage systems has rendered the situation hopeless. Even normal rainfall events often lead to traffic snarls and disruption in urban life (Delhi 2020, Gurugram 2018) and cause substantial economic losses. Many cities are striving to reduce their negative, environmental impact.

Although drainage has been part of the urban planning process since ancient times, it got impetus after the industrial revolution, particularly in India, during the British period in the early twentieth century. In independent India, the urban planning process has not given stormwater drainage due to importance that has led us to the present situation, where the frequency of urban flooding is getting more critical due to its enormous economic, social and environmental impacts. While riverine flooding has got due attention from policymakers, urban flooding has been left to the discretion of urban local bodies and planners. Despite facing numerous urban floods, significantly more frequent during the current millennium, urban flood risk management had drawn little attention till recently.

Too often, urban flood management is marked by a narrow view of floods, concentrating on hydraulic and engineering solutions while ignoring spatial and ecological, and socio-economic aspects and risks. Usually,the attempt to avoid or to absolutely control flooding is unrealistic.Effectiveness of flood risk management strategies, to reduce vulnerabilities and build disaster-resilient communities, can be ensured by identifying and understanding the underlying factors contributing to the urban flood risks.

A green infrastructure approach towards sustainable urban drainage system(SUDS) is being advocated and adopted in many countries, which is based on the principle of developing a culture of prevention and preparedness and reducing vulnerability. SUDS approach which also helps minimize

existing flooding disaster risks in the spirit of Sendai Framework for Disaster Risk Reduction[1] (2015-2030) underlines the need to investing in resilient infrastructure adopting the "built back better" approach in rehabilitation and reconstruction.

Recent guidelines issued by the Government of India for urban drainage systems also recommend adoption of the sustainable urban drainage systems approach. However, it is also recognized that there is a general lack of awareness of such practices among the planners, policymakers, professionals working in the Urban Local Bodies and the public at large.

1.2 Scope and objective of the paper

Since development decisions and everyday activities of citizenshave a large impact on the quantity of surface runoff generated (magnitude of flooding) and the quality of stormwater runoff, it is the citizens themselves who need to understand repercussions of these actions and work together to mitigate these causes. Further, urban planning is a multi-disciplinary, multi-sectoral and multi-stakeholder process that involves negotiations, compromises and mutual concessions, a clear understanding of the risks, including flood risks, the society faces, need to be fully understood.

There are specific prerequisites for ensuring the successful and sustainable involvement of stakeholders.Awareness of stakeholders, and the way their actions or inactions influence the environment of the city and the overall well-being of its citizens, help in meeting desired objectives. This approach paper explores the ways and means of exploring these prerequisites, build awareness about urban flooding among all the stakeholders and involve them in flood risk reduction and management. The focus will be on urban flooding due to pluvial processes.

Build awareness of policymakers to the need for adopting the SUDS approach to make the infrastructure green, sustainable and climate-resilient, both while constructing new urban drainage systems or while rehabilitating and retrofitting the old systems. Help the ULB professionals, not only the water utility managers, but also the public health engineering professionals, and road transport engineers, in up-grading their skills in implementing this multi-disciplinary approach. Skill development of level III and level IV personnel to enable them to render better services to the citizens. Provide skills to the civil society organizations and NGOs in rainwater harvesting to enable them to act as catalytic agents and bring awareness among all citizens on their role in making the drainage systems as green assets.

The scope of this exploration is limited in the context of risk reduction due to pluvial flooding. However, the proposed action plan, when implemented, will lay the foundation for furthering the cause of integrated water resources management and attaining the Sustainable Development Goal[2] 6 and 11.

[1] UNISDR, 2015, “Sendai Framework for Disaster Risk Reduction, 2015 – 2030”, Geneva
[2]UN, 2015, A/Res/70/1, “Transforming Our World: The 2030 Agenda for Sustainable Development”

2. Understanding urban flooding

"Flooding", signifying the effects of a flood as distinct from the flood itself, is defined[3] as Overflowing by the water of the usual confines of a stream or other body of water, or accumulation of water by drainage over areas that are not usually submerged.Urban flooding occurs when intense rainfall within towns and cities creates rapid runoff from paved and built-up areas, exceeding the capacity of storm drainage systems.

The urbanization process strongly alters the natural hydrologic cycle and the responses of the fluvial systems on the built environment. The natural drainage system within an urban area gets highly modified, and its hydraulic characteristics are affected by day-to-day activities. It is essential to appreciate the characters and sources of urban flooding, which can be due to overflow of the stormwater drainage systems, drainage congestion, overflow of the river, storm surges and high tides.To understand the risks of urban flooding linkages between urban hydrology and various urban developments and activities such as urban infrastructure including urban water services,need to be understood.

2.1 Urban Hydrology

The hydrologic cycle consists of a continuous process of transport of water masses from the ocean to the atmosphere, and from it once more to the sea through precipitation, surface runoff and underground flow. Urban hydrology is the interdisciplinary science of water and its interrelationships of the hydrologic cycle with the urban development process, water regime, and quality of water in urbanized areas. On a local scale, the quantity of water and the speed at which it circulates through the different phases of the hydrologic cycle are directly influenced by factors such as altitude, temperature, topography, type of the soil, land use and the geology.

Water falling as precipitation (that includes rainfall and snowfall), upon arriving at the surface, may take various routes; some of it will evaporate and return to the atmosphere while the others part will **infiltrate the ground**. But if the intensity of rain goes beyond the infiltration and evaporation capacity, small accumulations of water called depression storage is formed. When these depressions fill and overflow, water begins to move along the surface. Upon forming a layer of water that covers the trajectory of movement, the **surface runoff** begins moving towards a body of water – lake, river or sea. If this runoff is stored during its course, this phase comes to be called **detention storage**. Various processes in other stages continue occurring concurrently. Therefore, part of the flow may infiltrate the soil, or it may evaporate, returning to the atmosphere before reaching a body of water.

The water that infiltrates the soil enters first in the soil zone containing plant roots. This upper part of the ground may retain a limited quantity of water, and this quantity is known as **field capacity**. Another route for the water that infiltrates the soil is direct evaporation to the atmosphere, which, through transpiration of the plant that took it up, returns it to the atmosphere. This process is called **evapotranspiration** and occurs at the top of the non-saturated zone, that is, in the zone where spaces between the soil particles contain both air and water.

When the water that passed through the previous phases continues to infiltrate into soils and rocks through their pores, fissures, and cracks, creating underground water flow, it reaches the saturated zone, enters in underground circulation, and contributes to increasing stored water, thereby**recharging the aquifers**. In the saturated zone or aquifer, the soil pores or fractures in rock formations are entirely filled by water and are therefore saturated.

[3] WMO, 1992,International Glossary of Hydrology (WMO No. 385, 1992)

2.2 Types of flooding

Urban settlements often experience pluvial flooding or a combination of pluvial flooding with riverine (fluvial)or coastal flooding. In certain coastal cities such as Mumbai and Chennai, all the three, pluvial, riverine, as well as coastal flooding, does occur, often in combination. Although the scope of this paper is restricted to pluvial flooding, it is essential to understand the various forms of flooding that urban centres can experience.

2.2.1 Pluvial flooding

Pluvial flooding refers to flooding events that are generated locally by the overload of the urban stormwater drainage system by extreme rainfall. Such floods occur when the ground cannot absorb rainwater effectively, or stormwater drainage systems are overwhelmed by excessive runoff. Cities have a large percentage of impervious areas that prevent significant infiltration of rainfall into soil. Increasingly dense urban developments, intensify the incidents of pluvial flooding. Pluvial flooding also occurs when the ground is saturated by melting snow, and consequent has low permeability.

2.1.2 Fluvial and riverine flooding

Fluvial floods are usually generated at a much larger rural catchment scale draining into a river, lake or wetland and are generallyslow-rising floods. Riverine flooding, the most common fluvial flooding, occur in large rivers with large catchment areas. In riverine flooding, relatively high-water levels overtop the natural or artificial banks of a stream or river. Rapid flooding due to flash floods, more often occur on smaller rivers, rivers with steep valleys, rivers that flow for much of their length over impervious terrain, or normally-dry channels. The nature of riverine flooding can vary significantly in terms of cause, timing and depth between different locations.Floods due to river overbank flow occur when the river level rises above river banks. Excessive river levels are typically the result of high runoff from upstream and backwater effect of high tides at the river mouth.Embankments, protecting cities may sometime breach due to increased flood levels and cause severe flooding of hitherto protected areas.

2.1.3 Coastal flooding

In general, coastal flooding is different from riverine (from the river) and pluvial (from intense rainfall) flooding. Cities in coastal areas, generally located in low lying areas where high tides or storm surges can hamper flood drainage to the sea and cause prolonged flooding.As climate change continues and the sea level rises, concerns regarding coastal flooding will continue to grow. Estuarine floods are caused by the interaction between the seaward flow of river water and landward flow of seawater during high tides leading to a build-up of water. Frequently, the funnel shape characteristic of many estuaries causes an increase in high water levels in the upper, narrowing reaches of the associated river.

2.3 Stormwaterdrainage

A stormwater drainage system is an infrastructure designed to drain theexcess rainwater from paved streets, parking lots, footpaths, sidewalks, and rooftops. It receives water through inlets and conveys it to a safe disposal point called the outfall which can be a water body - river or the sea.Stormwater pollution reduces the assimilative capacity of water bodies. Since everyday activities of citizens cause polluted stormwater runoff, it is the citizens themselves who need to understand the repercussions of their actions and work together to prevent it.

2.3.1 Stormwater hydraulics

Surface runoff drains to the lowest point and in moving across the road surface forms a layer of water of varying thickness as sheet flow that slowly gathers into rivulets. On reaching the lowest point, runoff is channelled along the pavement edge via kerbing/kerb and channelling or discharged over the shoulders to a suitable collection system such as a natural watercourse, drain or piped drainage system, finally out falling into a river or the sea.A stormwater drainage system is a network of surface drains, termed as tertiary, secondary and primary drains which are constructed as open or covered drains with a suitable gradient. Storm drains vary in design from small tertiary drains in residential areas to the large municipal primary drains and can be open or piped. For ordinary conditions, storm drains are sized to flow practically full under design discharge but not under pressure. The stormwater drains may overflow if it receives more than its design discharge or high water levels obstruct its outlet in the river or the sea.

Many stormwater drainage systems are gravity drains. However, the drainage system may encounter situations where gravity flow conditions may not be feasible either due to topographical configuration of low lying or tidal areas and also where the water level of receiving water bodies is higher than the water level of the outfall. In coastal cities where the surrounding sea and estuaries influence outfalls, tidal gates are provided at the outfall to seal the channel to prevent the backflow of seawater during high tide, sea-level rise and storm surges. Under such situations, it is imperative to resort to the pumping of stormwater to avoid flooding and waterlogging of the area.

2.3.2 Polluted runoff

Stormwater can carry various pollutants including litter, soil, organic matter, grease, oil and metals collected from roads and properties; fertilizers and pesticides from gardensand faecal material,bacteria from pet wastes and failing septic systems among other pollutants. Besides, the precipitation in urban areas may itself be contaminated while still in the atmosphere. Precipitation or the surface runoff over the undeveloped or grassy areas, such as parks and lawns get filtered and ultimately replenishes aquifers or flows into streams and rivers.

On steeper slopes, the increased flow velocity aided by the lack of significant vegetative cover results in transportation of a large quantity of sediment. Further, construction sites with loose soil produce 50 to 200 times the quantity of sediment and particulate pollution produced by completed urban areas. Deposition of such eroded sediments inflicts severe problems in the drainage channels in the areas located downstream of it resulting in frequent flooding.

Further, urban drainage aims at the removal of all unwanted water that includesgreywater (sullage), is domestic wastewater predominately from baths, basins and washing machines, and theblack water (sewerage)and the stormwater.Stormwater drains are expected to be separate and distinct from sanitary sewer systemsto avoid discharging of untreated sewage into the water bodiesand to prevent sewage treatment plants from becoming overwhelmed during a rainstorm and increase treatment costs. In most Indian cities the two systems often interfere with each other.

2.4 Understanding linkages

Urbanization changes land use from forest or agricultural uses to urban areas. Creation of impervious surfaces in the process of urbanization profoundly affects how water moves both above and below ground during and following storm events. The impacts of land-use change and construction of roads, cutting across natural drainage systems, has a significanteffect on the hydrologic response of the urban catchment. At the same time,flooding due to the overflow of stormwater systems has enormous impacts on the necessaryurban infrastructure for urban water management and the economic activities. These linkages are discussed in brief.

2.4.1 Hydrologic cycle

Alterations in the variables involved in the hydrologic cycle – slopes, the geology of the terrain, infiltration rates of the soil, vegetation cover, can modify the local hydrologic characteristics. Urbanization tends to remove existing vegetation in watersheds that are replaced by impermeable areas (asphalt roads, concrete sidewalks, roofs, parking lots, etc.). The removal of vegetation and the increasing imperviousness that follows the urbanization process, and the introduction of an artificial drainage system modify the hydrology significantly, producing larger flow volumes and peak flows, reducing the base flow discharges and the time of the concentration of the basin.

With the construction of roads and buildings, the natural channels and water-bodies that have controlled outflows in the basin/ sub-basin for centuries are obstructed or diverted through manmade pathways. At the time of unprecedented rainfall events, the water overflows these manmade watercourses and flood large areas.

2.4.2 Urban planning

The policymakers fully recognize the importance of cities as vehicles of economic growth and development. Still,in most of the Indian cities, post-independence, urban growth has been mostly informal, not controlled, urban occupation is sprawled andhas inadequate infrastructure.The scarcity of affordable housing drives the poor and some lower middle class to informal settlements[4] - with modalities ranging from squatting to informal rental housing. Besides, informal settlements can be a form of real estate speculation for all income levels of urban residents, affluent and poor. These settlements,often situated in geographically and environmentally hazardous areas,usually do not comply with planning and building regulationsandare generally deprived ofessential services.

Town and Country Planning Organization of India (TCPO), drafted the Model Town and Country Planning Act, in 1962,for the guidance of states. According to the TCPO guidelines, cities were expected to integrate open spaces in their Master Plans, duly linking them with natural drainage and wetlands.Reclaiming large tracts of land for the roads and buildings has left many cities bereft of wetlands and water bodies that could absorb urban outflows during the monsoon.As a result, there is a degradation of the urban environment inlarge parts of the cities almost everywhere.

The process of urbanization demands continued efforts to satisfy the growing demand for housing and a variety of infrastructure, requires revisiting the master plans.Presently, most of the Master Plans, wherever they exist, are often outdated and are more frequently bypassed than followed due to political pressure from different stakeholder groups.There is an urgent need to integrate water management with a broader planning systemthat calls for closer integration of flood management plans and land use plans by factoring flood risks intoland-use planning regulations and by-laws.

2.4.3 Urban water management

Stormwater drainage is intricately linked with urban water management, that includes, drinking water supply, wastewater disposal and stormwater removal in urban areas are managed. For economical as well as environmental reasons, there is a need to deal more explicitly with these overlapping parts between the three primary fields of urban water management in totality since they are interdependent.For example, many large Indian cities have to source water from long distances ranging from 50 to 200 km due to exhaustion or pollution of nearby sources. New challenges of climate change, growing populations, and over-tapped rivers and aquifers constrain traditional water supplies. Groundwater levels are declining in many parts of the nation, reaching in some instances 100-200 feet below historic levels in some cities. Wells and streambeds are running

[4] UN-Habitat (2015), “Informal Settlements “Habitat-III, Informal Papers, 22, New York
http://uploads.habitat3.org/hb3/Habitat-III-Issue-Paper-22_Informal-Settlements-2.0.pdf

dry, and water quality is decreasing, putting a strain on the drinking water sources.At the same time stormwater, if harvested and stored, can adequately meet many of the city demands for water.

Total Water Cycle Management[5] (TWCM) calls for all elements of the water cycle, infrastructure, land use planning, and social, environmental and economic issues, to be considered in an integrated manner (Fig. 2).

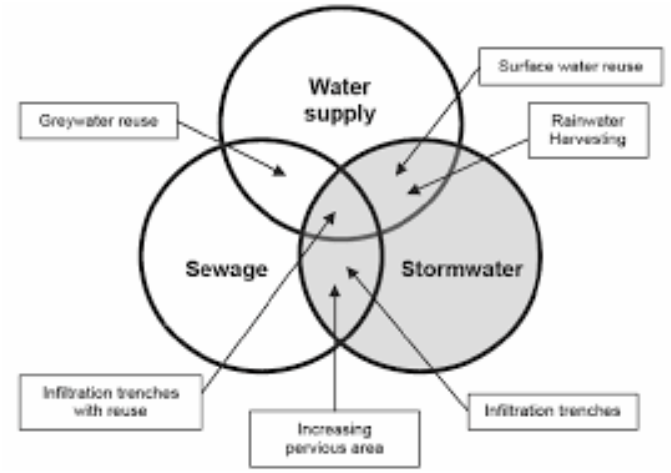

Fig. 2 Total Water Cycle Management {To be redrawn}

The TWCM approach is necessary to sustainably, effectively and efficiently plan and manage urban water and wastewater system. It decreases water demand, reduces stormwater runoff and improves pollutant wash-off from urban catchments by adopting sustainable water management practices.

2.4.4 Urban Infrastructure

Failure of drainage system often occurs due to deficiency in maintenance as well as a defect in design or construction of inlets to drains. Due to inadequate camber provision at the time of road construction or at the time of carrying repairs of the utilities crossing the roads, pools of water are formed resulting in the weakening and undermining of the pavement strength leading to formations of potholes in the streets. They cause skidding of vehicles, or plain splashing of water which create a nuisance for other vehicles and road-users resulting in snarling traffics, often causing jumbo traffic jams and disruption in urban life in general.

Inadequate provision of footpaths and stormwater drain or their subsequent encroachment by commercial establishments, street vendors, and on-street parking due to poor enforcement of the existing regulations restricts the stormwater flow from entering into the drainage system. The open tertiary drains provided are also encroached and illegally covered, making it inconvenient/impossible to be desilted and cleaned.

Most of the cities, including megacities, face acute problems related to solid waste management. Poor solid waste management is a significant factor contributing to unsanitary conditions in all water bodies, including lakes and drains.Disposal of solid waste, building debris and casual litter into drainage leads to the large and rapid accumulation of sediment in the drains. It causes blockage reducing their carrying capacity, frequent flooding of drainage systems and pollution.

[5]Chanan, A. and Woods, P., 2005. Managing the Water Cycle in Sydney Metropolitan: Local Governments Do Matter! In: Khan, S.J., Schäfer, A.I. and Muston, M.H. [Eds.]. Integrated Concepts in Water Recycling, http://www.uow.edu.au/science/chem/aquarec/icwr/x/Chanan.pdf

Lack of accepted standard design procedure of culverts acrossthe existing watercourses results in over-design, which raises costs, or under design, which causes flooding.Dumping of solid waste and construction waste into drains chokes the culverts and creates an obstacle for the stormwater flow in natural drainsresulting in consequent flooding.Faulty design of underpass drainage and inadequately provisioned pumping systems, regularly seen in almost all cities, disrupt traffic and other economic activities.

2.5 Understanding urban flood risks

Urban flooding is the result of the extent and intensity of rainfall, the topography of the city, type and efficiency of the drainage system, and sometimes possibletechnical breakdowns.During extreme rain events, only a limited portion of the generated surface runoff is gathered by the existing stormwater drainage system.In a majority of Indian cities, water is unable to find its way into the drainage system due to the clogging or inadequacy of the inlets into the drains, andit moves along roads to the lower elevation portions of the streets (such as underpass) or the other low-lying areas. As a consequence, the roads virtually become drains and are inundated with two to three feet deep water in certain areas resulting in traffic snarls. Such water flowing along the roads in steep terrain attain dangerous speed and cause fatalities. After entering the drainage system, the runoff, beyond the carrying capacity of the drainage system, flows over the roads and streets and ends up entering residential and commercial buildings and other public facilities.

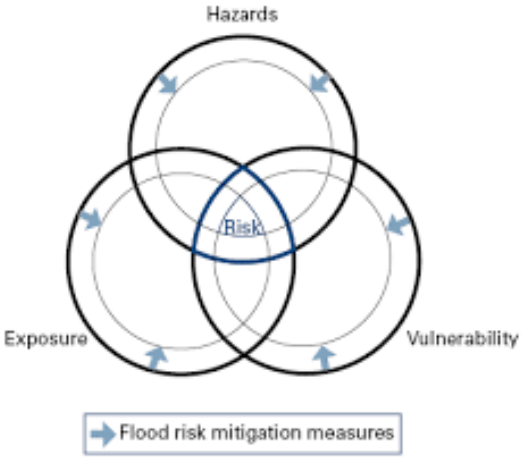

Fig.3 Construct of Flood Risk[6]{To be redrawn}

Risks due to urban floodings, like any other flooding, is a construct of three elements: the magnitude of **hazard**, extent and duration of **exposure** to flooding, and **vulnerability** of the exposed activity (Fig. 3). When people, infrastructureand economic activities are exposed to floodwaters, their vulnerability becomesthe decisive factor that governs the degree of harm and damage.

The impacts of urban floods can be physical, economic, social and environmental. Such flood impacts can cause**direct losses** - resulting from direct contact of buildings and infrastructure, human and animal lives, with floodwater, or **indirect losses**- resulting from the flood incident but not from its direct exposure to flooding. Apart from economic losses, flooding results in risks to the environment, people's health and quality of life (refer to Box 1).

Due to the high density of population and high economic value of properties and infrastructures exposed, financial losses due to urban floods are increasing exponentially (ref). Large quantities of

[6] APFM/WMO, 2009, "Risk Sharing in Flood Management – A Tool for Integrated Flood Management", APFM Technical Document 12, Flood Management Tools Series, Geneva.

water may flood buildings and cut off transport systems. Flooding of major roads and streets leads to change in the capacity of roads, delay of movement, volume and speed of vehicles and driver's behaviour on the road. Excessive water on the pavement, whether ponded or flowing, can represent a real risk of skidding of the vehicles.

Flooded buildings with sensitive equipment such as electrical and IT systems may have overwhelming societal effects. Moreover, since sensitive infrastructure systems usually are connected and interdependent, effects may cascade to other systems and over a much larger area than the one directly exposed. The infrastructure is often critical for society's function to work correctly and deliver basic services and supplies,such as freshwater and electricity to its inhabitants. Moreover, vital societal functions, such as hospitals, may not be able to tolerate interruptions in water supply and electricity.

At the same time, since urban areas are becoming increasingly complex and high-tech with sensitive infrastructures influencing economic activities in greaterregions other than the area directly exposed to flooding, the indirect financial losses can be substantial.Additionally, some of the adverse impacts may occur during the flooding. In contrast, othersmay materialize later, making it difficult to assess

BOX 2 Types of Flood Losses

- **Direct losses**
  - Economic - Damage due to flooding of public and private goods and property;
  - Safety of life - Drownings in floodwaters;
  - Social - Danger to public health due to contamination of drinking water, impaired health services;
  - Environmental - Eroded streambanks and channels result in loss of land and valuable property, clogging of waterways, sedimentation in lakes thereby killing aquatic animals;
  - Aesthetics – Spread of silt-laden dirty water, trash and debris causing foul odours;
- **Indirect losses**
  - Social - Impaired recreational activities such as swimming, fishing, boating; and
  - Economic - Thwarting of the free flow of traffic that hinders various services and economic activitie

the overall impacts that a flood event may have on society as a whole.Four out of seven targets under Sendai Framework[7]: reducing global disaster mortality, reducing the number of affected people, reducing disaster economic loss to GDP, reducing damage to critical infrastructure, and disruption of essential health and educational services have a direct bearing on how we manage our urban flood risks.

There are known and tested measures for urban flood risk management, typically classified as structural or engineered measures, and non-structural, management techniques. The traditional approach to protect urban areas against flooding includes the construction of protection embankments and stormwater drainage systems to evacuate the excess water as fast as possible. This approach tends to increase the downstream flood risks and harm the riverine ecosystems.

Integrated Flood Management[8](IFM) approach under the broader umbrellaof Integrated Water Resources Management[9] (IWRM)is accepted worldwide to be most successful in reducing flood

[7] UNISDR, 2015, “Sendai Framework for Disaster Risk Reduction, 2015 – 2030”, Genevahttps://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030
[8] WMO/APFM, 2009, “Integrated Flood Management - Concept paper”, WMO No. 1047, Geneva

risks.The IFM approach adopts a mix of strategies based on risk management principles andintegrating land and water management. It uses basin as a planning unit andtreats floods as part of the water cycle, duly recognizing that floods do serve as an essential natural resource. While the urban catchment is the basis for the purpose of designing a stormwater drainage system, planning for effective urban flood risk management has to take into consideration the flood risks in the entire catchment.

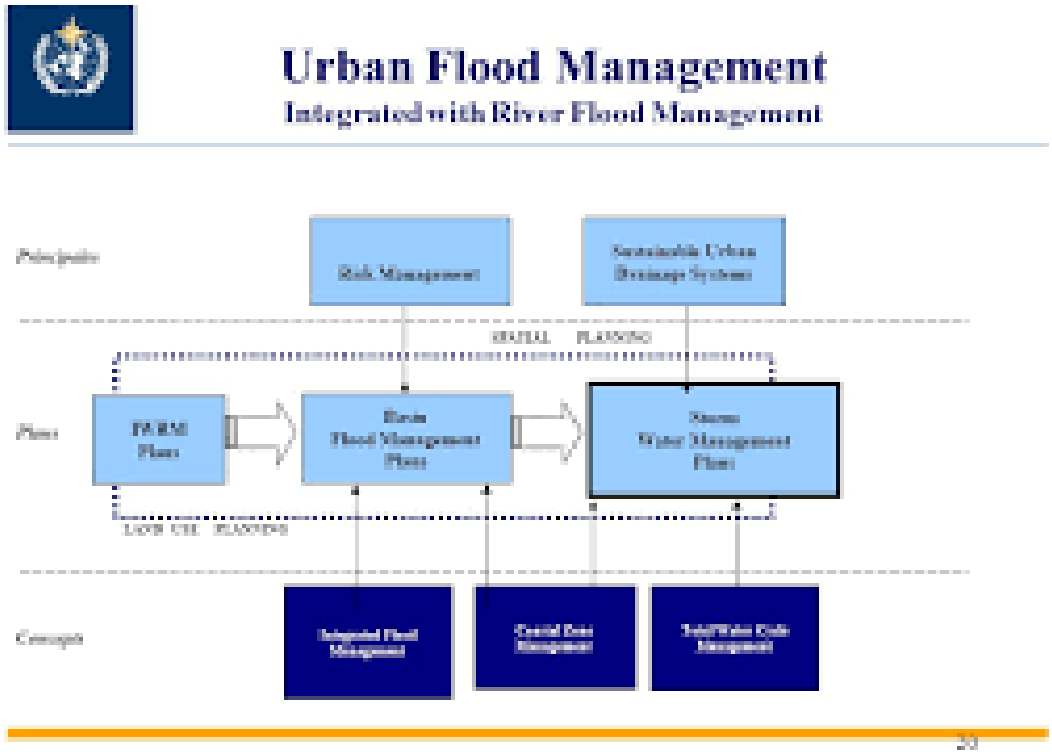

Fig. 4Integrated urban flood risk management framework {To be redrawn}

Urban flood risk management aims at mitigating flood riskby lowering any one or more of the risk elements: hazard, exposure or vulnerability. It has to be undertaken within a well-defined framework[10] that recognizes and makes use of the potential synergies that could be achieved through coordinated actions and addresses the conflicting requirements that arise often. Three general concepts that provide the basic framework for urban flood risk management (Fig. 4) are Integrated Flood Management (IFM); Total Water Cycle Management (TWCM); and Land-use Planning. IFM embraces all its principles and incorporates risk management principles.

Based on a comprehensive risk assessment and analysis, three strategies are adopted for flood risk management: risk reduction, risk retention, and as a last resort, risk transfer or risk-sharing.As part of the risk reduction strategy, the peak urban stormwater runoff can be modulated and delayed if the runoff is arrested at the source. If stored appropriately, andsubjected to minimal treatment according to the use, it can serve as a vital source of water during the non-monsoon season. Water can also be retained in the landscape in detention/ retention ponds, stored in surface storages or deposited underground through groundwater recharge.Better land-use planning can mitigate both direct and indirect potential primary losses and, can also mitigate the potential secondary losses.

[9] Global Water Partnership, 2000, “Integrated Water Resources Management”, Technical Advisory Committee TEC Paper No. 4, Stockholm

[10] WMO/APFM, 2008, “Urban Flood Risk Management – A tool for Integrated Flood Management”, Geneva.

It is evident for economic reasons that absolute protection against all floods is a myth. One of the best means of reducing these residual flood risks is to avoid exposure to flooding during rainfall eventsof magnitude higher than the design rainfall is by the effective implementation of flood emergency management plans consisting of a sequence of preparedness, response and recovery. Flood risk maps enable users to identify the most endangered areas and neighbourhoods (WMO, 2008). Risk maps provide information on the flood probability, the water level, flow velocity, sediment transport etc. They provide essential input to the disaster managersto prepare disaster management plans: the location of rescue shelters, rescue routes and the most vulnerable sections of the society.

Detailed guidance on the preparedness and response is provided in the NDMA guidelines on Urban Flooding[11] (2010). These guidelines call for a proactive, participatory, well-structured, failsafe, multi-disciplinary and multi-sector approach at various levels.

[1111] NDMA, 2010, “Management of Urban Flooding”, National Disaster Management Guidelines, New Delhi.

3 Urban drainage planning and design

3.1 Brief historical perspective

3.1.1 Urban flood management

In recent years, the frequency of urban flooding has increased, and the issue is getting more severeday-by-day due to its enormous economic,social and environmental impacts. While riverine flooding has been adversely impacting rural areas since independence,urban areas started getting noticeably affected by floodingduring the 70s as manifested through flooding,e.g., in Patna 1975, Delhi 1977 and 1978, Kolkata 1978. Markedly, most of these floods were essentially riverine floods.

Since late 80s pluvial flooding has been consistently impacting urban life, some of these events recalled from the present millennium are floods of Hyderabad (2000, 2001, 2012 and 2020), Ahmedabad in 2001, Delhi (2002, 2003, 2009, 2010 and 2011), Chennai (2004 and 2015), Mumbai (2005, 2008, 2009 and 2020), Surat (2006), Kolkata (2007), Jamshedpur (2008), Guwahati (2010), Jaipur (2012), Srinagar (2014) etc.During the very active monsoon of 2020,almost all states in the country suffered extensive flooding of rural as well as urban areas andlife in many urban centres such as Bangalore, Hyderabad, Mumbai, Nagpur, and many other Class II cities, came to a standstill.

Beginning with the National Program of Flood Management in 1954, the Central government has taken various initiatives for flood management. *RashtriyaBarhAyog (RBA) or* the National Flood Commission (1980),reviewed the effectiveness of various structural measures of flood control such as dams, embankments, and drainage channelsand non-structural methods like flood forecasting and flood hazard mapping.The main focus of RBA was on riverine floods. The Task Force on Flood Management/Erosion control set up in 2004 was no exception.

After 2005 Mumbai floods the National Disaster Management Authority (NDMA) focussed on urban floodsandissued guidelines[12] for their management.The guidelines identify the institutional framework required to tackle urban flooding and make recommendations for enhancing urban flood management capabilities, improving the urban stormwater drainage systems including sustainable drainage practices, as well as improving the techno-legal regime, response actions, capacity development and implementation strategies.Later, following the Chennai floods of 2015, the Ministry of Housing and Urban Affairs has issued standard operating procedure[13] (SOP) outlining the mitigation strategies for urban flood risks. These SOPs identifynodal agencies for early warning, sets a framework for city-level action plans, including the establishment of the emergency operations centre and other related measures.

3.1.2 Design practices of stormwater drainage

The sanitary hygiene concept foresees rapid expulsion of waters from the city to preserve the health of the population and eliminate any discomfort the water could cause. As such, urban drainage planning traditionally aims 'to transport the stormwater as rapidly as possible from our urban areas to the nearest waterways'. Nevertheless, what was not foreseen in this effort for channelling is the impact it causes downstream.

There are be two components of the stormwater design. The first component comprises of calculation of the total discharge that the system will require to drain off and the second entails

[12] NDMA, 2010, “Management of Urban Flooding”, National Disaster Management Guidelines, New Delhi.
[13] Min of Urban Development, 2010, “Urban Flooding – Standard Operating Procedure”, New Delhi.

fixing the dimensions of the drain to have adequate capacity to carry the discharge. Intensity, duration and frequency of rainfall, together with the size and type of area contributing the runoff, determines the quantity of runoff. Design is usually based on the rainfall intensity of short and intense storms occurring during the south-west monsoon, which generally overload the drainage system more than the steady but low rainfall which occurs during the north-east monsoon.[14]

Urban stormwater drainage infrastructure gets priority behind drinking water supply and sewerage projects in the majority of theIndian cities. No Indian cityhas a drainage system that can effectively deal with intense south-west monsoon rainfalls.In most of the cities, rainfall ofeven light or medium intensity causes urban flooding.The megacities in their central core zoneshave underground drainage facilities that are usually century old and consist of brick masonry ducts. In many cities, the drains are either non-existent or are undersized mainly because of lack of funds allocated to the stormwater drainage.

Until recently, the storm drains were designed for a rainfall intensity of 12–20 mm hr^{-1} as recommended in theManual on Sewerage and Sewage Treatment Systems[15], 1993 (revised in 2013). This has been one of the main reasons why the stormwater drains in many Indian cities are undersized.Further, due to the non-availability of space for road widening, many of the existing drains have been encroached upon, reduced in size and have had piers of bridges and metro lines constructed in them.

Recently, CPHEEO has issuedthe first dedicatedManual on Stormwater Drainage System[16] in 2019, whichcovers the Engineering aspects in Part Aand Operations and Maintenance aspects in Part B.Management of the stormwater drainage systems that include public awareness, capacity development, institutional arrangement and financial sustainability are dealt with in Part C of the manual. Themanual recommends that the drainage of urban catchments need not be designed for rare storm events of 25 or 50 years or higher recurrence period;instead, it is necessary to provide adequate protection against frequent flooding.

Absolute protection from flooding is technically infeasible and economically and environmentally unviable[17]. Based on techno-economic and risk considerations and to avoid vast dimensions of underground drains, the system is typically designed for a design storm of 10 years recurrence period or less. More extreme events are deliberately allowed to generate inundation of selected areas such as streets, infrastructure, and building basements,which has to be accepted as once in a while inconvenience. However, in such situations, the disaster preparatory measures as specified by 'National Disaster Management Guidelines, published in September 2010.

3.2 Sustainable development and adaptation to climate change

3.2.1 Sustainable development

The United Nations-sponsored World Commission on Environment and Development in*Our Common Future*(1987), identified *sustainability a*s a major concern. Planners havetheir task cut out to balance the conflicting demands of socialequity,economic growth, environmental sensitivity, andaestheticappeal. Water is central to economic, social and cultural development and well-being,

[14]Kadave, P T, et al, 2016, “Mumbai Floods, Reasons and Solutions”, in International Journal of Scientific and Research Publications, Volume 6, Issue 3.
[15]CPHEEO, 2013, “Manual on Sewerage and Sewage Treatment Systems”, Part A Engineering, Chapter 3 Design and Construction of Sewers, New Delhi
[16] CPHEEO, 2019, "Manual on Storm Water Drainage System", Vol. I, Part A – Engineering Design, New Delhi
[17] WMO/APFM 2006, “Integrated Flood Management – Concept Paper”.

and urban development recognized as the driver of the economic growth and development, the urban water managementoccupies a crucial role in realizing the Sustainable Development Goals[18].

It is recognized that achieving the 2030 Agenda for Sustainable Development will only be possible through an integrated approach, working across sectors, ministries and different administrative levels and geographical scales. All the stakeholders need to understand the interlinkages between various goals and maximize synergies and minimize trade-offs by working across traditional institutional structures.

Almost all the SDGs are impacted by the way we manage our water.Goal 6: Ensure availability of water and sanitation for all, is closely linked to Goal 1: End poverty; Goal 2: End hunger and achieve food security; Goal 3: Ensure healthy lives and promote well-being; Goal 11: Sustainable cities and communities; and Goal 15: Protect and restore terrestrial ecosystems.Under Goal 11,Make cities and human settlements safe, resilient and sustainable– three out of seven targets set are very closely linked to the Urban Flood Management. Target 11.4, reduce the adverse effects of natural disasters[19] - sets to significantly reduce the number of deaths and substantially decrease the direct economic losses caused by disasters; Target 11.5, reduce the environmental impact of cities - aims at reducing the adverse environmental impact of cities, including waste management; and Target 11.6, provision of access to safe and inclusive green and public spaces.

3.2.2 Adaptation to climate change[20]

Global warming has intensifiedthe global water cycle, making weather less predictable, rains more uncertain and heavy storm rainfalls more likely. Changes in much extreme weather and climate events, an excessive increase in high sea levels and an increase in the number of heavy precipitation events in several regions have been observed over the last seventy years. Increased episodes of high-intensity rainfall events are being experienced in shorter periods.Heavy thunderstormsappear to have increased in frequency. Further, growing urban areas, due totheir' urban heat island' effect may increase thunderstorm activity.The latest IPCC Special Report on Oceans and Cryosphere[21] has indicated that the sea-level is rising at a much faster level than estimated earlier, exposing the coastal cities to increased risk from flooding.

Climate change will amplify existing risks and create new risks for natural and human systems. However, adaptation can reduce the risks of climate change impacts. Taking a longer-term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness.

While mitigation – that involves reducing the greenhouse gases, adaptation involves adjusting to expected future climate. Effective institutions and governance underpin adaptation and mitigation responses, investments in environmentally sound infrastructure, and behavioural and lifestyle, among others. Our commitment to SDGs makes it imperative that we seek opportunities to link mitigation, adaptation and other societal objectives through integrated responses. Successful implementation will, however, rely on relevant tools, suitable governance structures and enhanced capacity of all stakeholders to respond.

Of late, **green infrastructure** has been viewed as a development imperative, especially with respect to the creation of liveable, environmentally sustainable and efficient cities. Green

[18]UN, 2015, A/Res/70/1, "Transforming Our World: The 2030 Agenda for Sustainable Development"www.Sustainabledevelopment.Un.Org

[20]IPCC, 2014: "Climate Change 2014: Synthesis Report". Contribution of WGs I, II and III to 5th AR of IPCC,
[21]IPCC, 2019: "IPCC Special Report on the Ocean and Cryosphere in a Changing Climate", Geneva.

infrastructure[22](GI) refers to natural or semi-natural ecosystems that provide water resource management by introducing the natural water cycle into urban environments. It offers practical measures to manage urban flooding, water supply and quantity regulation, at the same time generating multiple environmental benefits.When appropriately planned, designed and managed, GI has the potential to mitigate and adapt the effects of climate change.

3.3 New urban drainage design trends

Following the 1992 Earth Summit, where the international community adopted sustainable development as the means to address pressing problems of the world, the management of the urban stormwater system, and the urban water cycle more broadly, has seen significant new trends. Theemphasis is shifting from mostly focussed approaches of reducing flooding to an integrated approach with multiple objectiveswith distributed actions over the basin, trying to recover flow patterns similar to those that occurredbeforethe urbanization.

This broad approach has been attempted under various names[23].**Low Impact Development** (LID) used in the USA and Canadaand Low Impact Urban Design and Development (LIUDD), in New Zealand.The original intent of LID was to achieve 'natural' hydrology,i.e., the balance of pre-development runoff, infiltration, and evapotranspiration volumes, through a "functionally equivalent hydrologic landscape" using site layout and integrated control measures. Similarly, Sustainable Urban Drainage Systems (SUDS) or the Sustainable Drainage System (SuDS) in the United Kingdom; Water Sensitive Urban Design (WSUD), in Australia have developed a holistic approach to urban stormwater drainage design. Subtle distinctions between different approaches are presented by Tim Fletcher et al[24].Regardless of the name, these new trends in stormwater design attempt to balance diverse variables of the hydrologic cycle and their effects on the watersheds.

Besides, these new trends in the management of urban stormwater drainage systems, not only address the concerns of water quality but alsoestablish rainwater as a resource to be harnessed for supplementing the urban water supply needs.Droughts areincreasingly threatening large cities. In the recent past cities like Cape Town, Mexico City, California, Jakarta, Chennai and Mumbai, have faced drought conditions leading to the unprecedented water crisis.Due to urbanization, the imbalance in the water cycle has become so great that we are no longer replenishing the groundwater supplies, depleting thegroundwater table at alarming rates in many cities and our green spaces are increasingly moisture depleted.To rejuvenate groundwater, so that it serves as a dependable fallback option in years of drought and to sustain green spaces in our cities, we have to allow more infiltration in our cities.

3.4 Sustainable Urban Drainage System

In response to increasing extreme rainfall events due to climate change,Sustainable Urban Drainage System (SUDS) providesan alternative approach to the urban drainage problems, which is sustainable, adaptive and incremental. It is the green infrastructure for the stormwater drainage which reintroduces the natural water cycle into the urban environment and provides practical measures to manage pluvial (urban runoff or surface water) flooding.Green infrastructure is a cost-effective, resilient approach to addressing extreme weather impacts that provide many community benefits. While conventional piped drainage and water treatment systemsmove urban stormwater

[22]Suresh Kumar Rohilla et al., 2017, “Green Infrastructure: A Practitioner’s Guide”, Centre for Science and Environment, New Delhi

[23] Tim D Fletcher et al, 2015, “SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage”,Urban Water Journal, 2015 Vol. 12, No. 7, 525–542, http://dx.doi.org/10.1080/1573062X.2014.916314

away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits.

The SUDS triangle consists of water quantity, water quality and biodiversity, as shown in Fig 5. For a detailed treatment of SUDS approach, National Disaster Management Guidelines to Urban Flooding, and CPHEEO manual, may be referred.

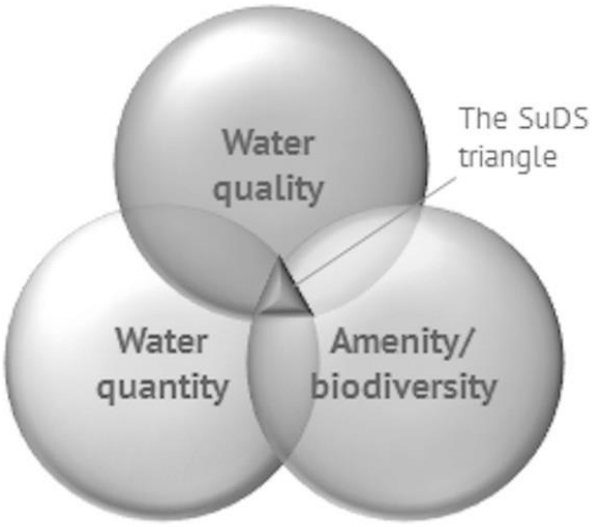

Fig 5. SUDS Triangle{To be redrawn}

The goals of SUDS are:

- Quantitative control of surface runoff;
- Improvement in the quality of water from surface runoff;
- Conservation of natural characteristics of water bodies; and
- Balance of hydrological variables in watersheds.

SUDS is implemented through features that mimic natural ecosystem's ways of handling stormwater runoff. To reduce the quantity of storm runoff reaching the stormwater drains, a portion of the stormwater, can be stored/percolated by introducing suitable techniques such as:

- In-situ storage/percolation within or around premises
- Storage of runoff in nearby pond/water tank
- Percolation of stormwater inside/outside the drains along its stretch
- Spreading water for recharge in low lying areas and park/gardens etc.
- Disposal to reservoir/water body

Examples of SUDS features:SUDS have a general design approach thatworks explicitly across all scales and is characterized by features that control the runoff right at the source, recharge the groundwater. In contrast, the runoff flows towards the drainage system and retain or detain it in natural or artificial depressions/storages.

- **Source control and prevention features:**
  - Green roofs, permeable and semipermeable pavements, rainwater harvesting, and infiltration trenches,rooftop reservoirs,micro reservoirs, andunderground reservoirs;

- **Permeable conveyance features:**
  - Filter drains,infiltration gullies; infiltration trenches;and swales
- **Passive treatment features:**
  - Detention basins, retention ponds and wetlands etc

A combination of SUDS features can improve the quality and health of the social environment in the city. They benefit the ecological health, enhance the biodiversity and vegetation within the cityscape and, improve the quality of local microclimate by delivering ecosystem services such as microclimate regulation, air purifying and filtration etc. In some areas, managed aquifer recharge for storage can be an alternative to other storage options.

On a new site, there are choices,and the planner can make generous provision for green areas and open public spaces, wherehe can appropriately provide green features of SUDS.In dense built-up environments,the emphasis is on the integration of rooftop rainwater harvesting and recharge systems to augment the existing stormwater drainage system. Existing open spaces can be retrofitted with some of the SUDS elements

Like all stormwater infrastructure, these green infrastructures require regular inspections and maintenance to assure proper function. Theyneed more labour and less heavy equipment than the upkeep of covered drainage infrastructure.For example, maintenance of swales and detention basins require a monthly site visit to undertake grass cutting, litter picking and inlet/outlet inspections. The permeable paving requires biannual suction sweeping.

3.5 Challenges of adopting SUDS in India

SUDS approach requires extensive coordination between various disciplines such as architects, planners, social scientists and ecologists and requires engagingdifferent stakeholder groups.Lack of coordination among multiple stakeholders and departments on the one hand and the lack of capacity to deal with multi-disciplinary activities, as discussed in the following paragraphs, pose challenges in the implementation of SUDS approach, that have to be overcome.

3.5.1 Unorganized city development

The main challenges to urban drainage in developing countries have to do with the inability of local government to provide appropriately serviced sites for the multitudes steaming into the towns and cities. Poor and even lower-middle-income migrants to the cities in urban and semi-urban settlementsseek space where they can construct a hut or a semi pucca room from their limited financial resources and land up in informal settlements. Such settlements generally come about almost invariably without permission of the city authorities.There is no town planning and no provision of services.The upgrading of drainage in informal settlements takes considerable skill as it usually requires the shifting of shacks/built-up areas to open up drainage routes. Such an effort, in turn, requires practical negotiating skills.

In the absence of proper services, the (informal) drainage system quickly becomes the recipient of waste of all kinds including water, faeces and solid waste.Even when the local authority accepts the existence of an informal settlement, the fact that it is usually illegal – at least to start with – means that they are reluctant to provide much apart from some "basic" services.

In formal new settlements, the local government generally focus on the delivery of houses rather than essential services such as water, sewerage, stormwater drainage, roads, electricity, solid waste removal, etc. Even in legally developed and developing colonies, the challenge is to ensure service delivery at the minimum necessary standards.

3.5.2 Institutional shortcomings

The High-Powered Expert Committee (2011) on the Urban Infrastructure and ServicesCommittee[25] believes that governance is the weakest and most crucial link which needs to be repaired to bring about the urban transformation so urgently needed in India. Urban local bodies suffer from fragmented management structure and financial resources. Even in better-resourced municipalities, provision of services to informal settlements is often frustrated by the fragmentation of those responsible for service delivery into several departments that do not always work together or even communicate well.

The ULBs are mostly understaffed and with out-of-date knowledge. They generally outsource significant activities to contractors who do not have adequately trained technical staff. Upgrading the skills of existing personnel in the urban sector by providing short and focused courses in urban management/finance/planning as well as skills of technicians working under them is essential to be able to use new technology tools, e.g. IT software, mobile phones, GPS, GIS etc. ULBs should train their employees on these and other skills continuously.

It is clear from the preceding that the main reasons for the failure to provide sustainable urban drainage to its citizens are primarily one of the resource constraints,both financial as well as human, at the local government level. Financial resources, which is beyond the scope of the discussion of this paper, by itself, will not solve the problem if there are insufficient numbers of skilled personnel who canspend the additional money usefully.

It is also worth mentioning that there is a need for introducing appropriate incentives to the staff for acquiring new skills or upgrading their existing skills.For example, the JNNURM provided for capacity building of ULBs on-demand but found that there were few takers. The state governments and ULBs need to rebuild the basic structure of the local government institutions by putting the staff in place at ULB level and prepare the groundwork for training.

3.5.3 Lack of capacity among local stakeholders

SUDS are implemented within the overall urban flood risk management framework, which consists of IWRM, IFM, TCWM approaches, which emphasize active stakeholder participation. The active, or otherwise, participation of citizens, who interact with,and are benefitted from various elements of SUDS on day to day basis will determine the success of the approach.

General creation of awareness among citizens is now recognized as an essential input to infrastructure projects, wherein actions of citizens could enhance or hamper the functioning of the green infrastructure.Stormwater drains which are prone to be used as dumping ground for all sorts of garbage need to be prevented to ensure the proper functioning of stormwater drains through awareness building. Similarly, the water recharge structures need due care and regular maintenance to function appropriately and efficiently. There isa need to increase stakeholders' knowledge and understanding of rainwater harvesting and flooding as phenomena as well as about the flood risks.

[25] HLCEP 2011

4 Capacity development for urban drainage and flood risks

The capacity development is mostly referred to at three levels[26] - individual, organization or community, and institution or system. The capacity development at the individual level is the most fundamental factor because it also includes knowledge, skills, value, attitude, health, awareness, and motivation. The capacity development on an individual level requires the development of conditions that allow an individual to participate. Capacity development should go beyond raising stakeholder awareness and aim at developing the capability of stakeholder groups to understand all facets of the issues. We need to acknowledge that different levels for different stakeholder groups depending on the roles they are expected to play needdifferent skill sets.

The capacity development at the **organization level**refers to means that will influence an organization's performance. It includes human resources (capacities of individuals in the organization), physical resources (facilities, equipment, materials), intellectual resources (organization strategy, strategic planning, management, business know-how, production technology, program management, process management), inter-institutional linkage (network, partnership), incentive and reward systems, and organizational culture and leadership of managers. The capacity development at the organization level will determine how individual capacities are utilized and strengthened. The capacity development at the institution level refers to the environment and conditions necessary for proving capacity at the individual and organizational levels.Community capacity-building starts with identifying a community's level of knowledge, their attitudinal behaviour and understanding of risk perceptions. It focuses on building awareness of flood risks in a catchment community, floodplain management activities to mitigate flood hazards and local environmental issues aimed at improving natural resources.

Institutional capacity-building aims at introducing a fundamental change in the ways the institutions are accustomed to functioning. It requires putting people first. At all stages–regional, national and local–it is critical to building up capacity to manage the organizational aspects of stakeholder's participation and to form partnerships with other groups with experience in participatory processes.

Most of the ULBs are inadequately staffed, overwhelmed by additional tasks and possess outdated knowledge. Changing technology presents a significant challenge and opportunity for the utility managers in the ULBs. Requirements for capacity development in terms of the demand-supply gap are high.Not only on account of the number of people to be trained but also in terms of competencies of personnel required to ensure service delivery standards, the task is enormous. We need to emphasize training and capacity development through re-skilling and up-skilling of technician level staff.

Individual capacity-building focuses on creating opportunities for those individuals already playing a pivotal role in government departments, RBOs, CBOs and NGOs and enables them to develop their understanding, knowledge base and leadership skills. Formal training programmes, study tours, attachments to and internships in other similar organizationscan achieve this objective. We should treat the capacity-building of individuals as a collective skill enhancement toward organizational development.

4.1 Urban planners

Urban planners develop spatial plans for the physical environment of their jurisdiction. Spatial planning by itself cannot adequately deal with problems in the physical, social, and environmental

[26] Ibid

systems of urban areas. Of all human activities, urbanization produces the most significant local changes in the processes of the Earth's hydrologic cycle.

As the primary function, ULBs prepare development plans and act as an apex body for coordination and execution of various projects or schemes,including the stormwater drainage schemes, for the planned development of the city. Among these works are water engineering works which act on rivers, lakes, and oceans, modifying their natural routes. Besides, practically all activities that carry out deforestation, or even for cleaning the area for new construction work, act negatively on the behaviour of the watershed. Locally, engineering works in general cause changes in water cycle variables such as infiltration, evaporation, and runoff. Town and Country Planning, engineering, sanitation, besides water supply and sewerage, have a definite role in UFDM.

Smart Cities, with urban water management identified as distinct features, have to be water-sensitive cities.Housing and other infrastructure have encroached many urban water bodies and their catchment. There is a need to integrate drainage management into the different sectors such as housing, transport, recreation or economic development; and committing that water is part of the ecosystem, and its uses are interdependent.

We need to take a review of the educational qualifications and on-job training requirements for urban planners, managers, including technicians,to develop the required human capacity in the framework. New skills on integrated green infrastructures, would be needed to be developed at a much larger scale.

4.2 Disaster managers

The Concise Guide on Strategic Approach[27] to Capacity Development for Disaster Risk Reduction observes that there is much room for the enhancement of individuals' knowledge and skills.It also emphasizes the strengthening of organizational and institutional structures, the fostering of a more conducive risk reduction environment, and the improvement in both mindsets and modalities of disaster risk reduction, through capacity development efforts.

There exist insufficient understanding and appreciation of the capacities required to bring about risk reduction and the methods that exist to build them. Training and education are a critical component of capacity development efforts in that they can help to raise awareness of critical issues, impart the knowledge required to act appropriately and effectively, and enable appropriate technical and administrative skills.

Since management of urban flooding is the responsibility of the ULB at the local level, they also are responsible for all disaster management effortsespecially in terms of early warning, preparedness, mitigation, rescue, relief and restoration. They need to prepare City Disaster Management Plans in accordance with the Guidelines of NDMA[28]. For example, ULBis responsible for developing step by step procedures and actions to be taken under each flood management strategy. Once the flood event materializes, the associated flood SOP[29]s has to be immediately initiated under the overall charge of ULB.

ULBs will be responsible for converting the historical flooding information supported by appropriate models into flood hazard maps. Determination of the likely flood-prone areas due to localized flooding has to be undertaken with a greater understanding of various flooding processes affecting

[27] UN ISDR, 2019, “Strategic Approach to Capacity Development for Implementation of the Sendai Framework for Disaster Risk Reduction – Concise Guide”
[28] NDMA Guidelines
[29] SOP

the drainage systems. This requires engagingexperts with whom the disaster managers in ULBs should be able to interact.

Early warning systems are expected to generate time-sensitive information about flood risk, which needs to be communicated to the emergency responders and other stakeholders about communities at riskby setting up workable systems of warning dissemination. The success of such a system is closely related to people's knowledge of flood risk and their familiarity with emergency response procedures.

4.3 Public works functionaries

Adequate drainage is a primary requirement for maintaining the structural soundness and functional efficiency of a road.Because of inadequate surface and subgrade drainage, the structural stability of pavement is undermined. In most of our cities, as part of recarpeting of roads surface profile is not maintained correctly hampering its quick drainage. Pools of water may form resulting in pothole formation, undermining the pavement course strength, and leading to skidding, or splashing of water which is a nuisance to other vehicles and road-users. Public Works Department personnel have to be sensitized to the need to maintain designed slopes and camber on roads so that the averagesurface runoff does not accumulate on roads.

4.4 Maintenance agencies

Failure of drains occurs both due to defect in design or due to deficiency in maintenance by desilting, cutting of weeds, clearing of obstruction, debris and blockage. It is, therefore, necessary to ensure that the drains keep their shape and slope and retain their full cross-section, particularly for the monsoons. It is also essential to ensure that the drains retain their entire cross-sectionand timely repairing of lining carried out immediately at the commencement of damage or deterioration. Before the onset of monsoon, all the drains shall be thoroughly desilted manually or suitable mechanical devices. The wet waste collected from desilting of drains remains by the side of the drainage to find its way back into the drains with first monsoon shower. Personnel in these maintenance activities need to be skilled to use modern equipment.

Generally, a city is divided into administrative wards, and further divided into health wards for solid waste management. In some cities, a majority of health wards are under private contract system, and other wards are managed through municipal workers. Workers tend to dispose of the collected litter into the nearby drain. Disposal of solid waste into drainage leads to the large and rapid accumulation of sediments in the drains. Dumping of solid waste and construction waste into drains also reduce the capacity of culverts which creates a hurdle for the stormwater flow. There is a lack of supervision and oversight in such activities. Difficulty in maintenance is also caused by a lesser degree of consciousness/civic sense. All users, roadside business establishments, street vendors, pedestrians need to be made aware of their civic responsibilities through awareness building programs.

4.5 Property owners

In urban areas, rainwater available from rooftops of buildings, paved and unpaved areas goes waste. Many techniques of rooftop rainwater harvesting in urban areas are described[30] below. Stormwater harvesting combined with filtration, infiltration and irrigation can reduce runoff volumes for the vast majority of storm events to close to pre-development levels.Whilst also helping to restore baseflows, return natural soil moisture levels and increases the amount of time that it takes for stormwater to reach stream channels, thereby reducing the flood peaks.

[30] CPWD, 2002, Rainwater harvesting and conservation – Manual", CSO, CPWD, New Delhi.

The rainwater harvesting system needs to be appropriately designed, keeping in view its ultimate use of the water collected. It needs to be constructed in a way that it does not occupy large space for the collection and the retaining rainwater for later use in less refined activities (watering gardens, flushing toilets in bathrooms, washing sidewalks, etc.).Nevertheless, the challenges that must be overcome for the efficient performance of RWH systems is their regular maintenance and upkeep, which needs to be carried out every year. All property owners need to be made conscious of the needs of rainwater harvesting.

Challenges such as utilizing stored stormwater thatrequirestreatment to remove the pollutants that are harmful to human health, lack of space to store the capturedstormwater during a storm; and the infrequent use of infrastructure required for water storage to be used only intermittently, thus increasing the per unit capital cost shall have to be overcome. As Roof-top RWH is essentially carried out at individual household level or community level, the availability of qualified technicians to undertake construction and regular maintenance of these systems pose a recurring challenge. Regulatory provisions should be made to ensure that only certified RWH technicians undertake these works. As RWH is increasingly being made compulsory by almost all major cities, there is a need for a large number of RWH technicians to be trained and skilled.

4.6 Public at large

Stakeholders need to increase their understanding as to how flooding may affect the public infrastructure in these places, and how the effects spread from one system to another.To facilitate multi-stakeholder planning, We must first identify all relevant stakeholders in a given area and create forums in which they can communicate their specific interests and needs to each other.

Every city dweller is a drainage service user and is likely to suffer due to flood hazard. To reduce his vulnerability to flooding, he has to support SUDS and increase his preparedness towards flood emergencies likely to be presented in case the rainfall intensity is beyond the design rainfall intensity. Every citizen needs to be aware of the water resource one uses, increased drainage runoff due to construction of his house and business, measures to conserve water, and flood risks around the city. Multi-stakeholder engagement is key to the success of urban drainage flood risk management as it ensures strong stakeholder support and is a catalyst for their proactive engagement.Capacity-building is an integral part of flood risk management.

Communities that have a good understanding of the risks to which they are exposed, often join together to influence decisions relating to disaster management and mitigation. They seek ways to continually improve their knowledge and participation skills by forming Community Flood Management Committees (CFMCs) in the flood-affected areas and play an essential role in flood emergency management activities. CFMCs use flood forecasts, together with flood hazard maps, to plan and execute flood emergency plans. Flood managers and disaster management functionaries have to motivate CFMCs and provide them with the necessary technical support and should be equipped with the required skills to interact and communicate with them.

5 The proposed plan of action

Urban Local Bodies (ULB) have the principal constitutional responsibility for the provision of urban water supply services, urban flood risk management, and managing urban drainage infrastructure. Most of the ULBs in the country lack the knowledge and tools required for providing efficient civic services including stormwater management despite the 74th Constitutional Amendment Act of 1992, which envisaged the creation of vibrant urban local bodies equipped with funds, functions and functionaries.

Ignorance of the impacts of urbanization on drainage is pervasive, among both technical specialists and the general public. IWRM and IFM approaches essentially require ensuring the effective participation of stakeholders.Different stakeholder groups have different needs and requirements, based on their areas of interests, respective roles and responsibilities. For effective participation of the stakeholders inurban flood risk management, they must be well conversant about various drainage and floodingissues so that they can make informed decisions.

5.1 Skill development

Realizing the skill gap in the country,vital to improving productivity and living standards of the people, National Skills Development Corporation (NSDC) established under Pradhan Mantri Kaushal Vikas Yojana (PMKVY)[31], has established Skill Development Councils for various sectors/industries. The need for Skill Development Council for Water has been felt, and the proposal is in the consultation phase.The skill development program for water domain must be comprehensive to develop awareness, understanding and proficiencythrough hard as well as soft skills**.**

Noticing the rapid and increasing change in technologies for the provision of water services and the need for adapting to a multi-disciplinary approach, we recognize that qualified and specialized personnel in various service domains are essential. Unfortunately, in ULBs in India, the qualification of personnel who get the responsibilities of these activities, very widely. In utilities with inadequate technical expertise, even simple water supply and treatment projects cannot be planned appropriately and existing plant and equipment maintained efficiently. Given these challenges, upskilling and re-skilling of the personnel in the latest technological tools inwater supply, wastewater treatment, solid waste management and disaster management is essential.

In the following paragraphs, we discuss some of the areas of skill development such as improvement in professional education, enhancement of technical skills, development of soft skills among professionals, knowledge of conflict resolution mechanisms, water education for children and youth and general water awareness in one and all.Skill development for water professionals must go beyond the technical knowledge of hydrological sciences, water resources assessment, planning, design and construction of urban water systems, plumbing, laying water supply and sewer networks etc.

Although rainwater harvesting is a simple technology, it requires technical skills for installation and regular maintenance of RWH structures. A body of RWH technicians needs to be created at different levels to maintain the systems.

[31] Ministry of Skill Development, “Pradhan Mantri Kaushal Vikas Yojna: Guidelines 2016-2020”, Government of India. http://pmkvyofficial.org/App_Documents/News/PMKVY%20Guidelines%20(2016-2020).pdf

Box 2: List of Vocational Trainings Areas

Public health engineering - *Sewage work technician, Municipal Engineering assistants, Solid waste disposal technician*
Urban planning - *Urban planning technician, Land survey technicians;*
Urban water management - *Pump operators, Hydraulic Engineering technician, Skilled operators of WTPs/STPs;*
Urban drainage - *Rainwater harvesting technicians, Hydro-geologic Technicians;*
Urban Road Transport - *Road Technicians and Road Surfacing equipment operators;*
Flood management: *Hydro-meteorological technician, Flood hazard mapping surveyors, and hydrographic technician;*
Disaster management:

Social, interpersonal and people skills, also known as soft skills are crucial for communicating with users, persuasiveness in implementing and building a relationship with the users.Personnel engaged in facilitating community participation such as disaster managers are often required to organize public consultations on specific programs or activities, build awareness on preparedness plans, manage emergency evacuations, and mediate with warring water user groups. While a project manager could engage a social scientistfor project-specific stakeholder consultations, managers equipped with soft skills can confidently deal with such situations on a day to day basis.

5.2 Water Literacy

We need to start a national campaign on water literacy for the capacity development of different stakeholders in the stormwater drainage domain. We must ingrain the children and the youth with water consciousness. Behavioural changes water users and water services beneficiaries are essential for water conservation. Objectives of water literacy programs in the context of urban flood risk management can be briefly articulated as follows.

- To impart concepts on the impact of urbanization on urban drainage for the public, planners, architects and engineers;
- To train engineers from the municipality and private enterprise in urban drainage control techniques;
- To organize public information campaign through the media (newspapers and television); and,
- Talks with trade associations – architects, engineers, builders, etc.;

Water education should be a significant component of the school curriculum. Community civil sense, water ethos, helping attitudes and ingrain good water preservation habits in young minds. To make curricula more effective in changing students' attitudes and behaviourtowardswater conservation, water-topics should be taught in accessible ways using values-driven education and innovative methods, field trips and school life activities. Although formal education systems can be the main focus, other informal initiatives need to be considered, such as the development of water-related activities in children's eco-clubs, sports clubs, and explorer groups. The program should also aim to improve the capacity of teachers and informal educators to better understand flood and drainage issues at the local, regional and national scales, and to commit to water ethics enshrined in our ancient culture.

Updating the school curricula by including water awareness is just the first step in the right direction. Concerted efforts are required to be made for providing **water education materials** that are appropriate for different age groups and regions and offer comprehensive coverage of the broad topic of water. Educators will also be provided with **training** at all levels, formal and non-formal, on diverse water topics so that those educators can reach children with objective, experiential, science-based water education.

Promoting water awareness of flood and drainage issues through informal water education is essential for the professionals and various stakeholders involved. Communities can be more actively involved in flood preparedness if they are adequately informed and organized. The scientific and social understanding of the flood issues is essential for a healthy debate on various options to develop.At the same time, the communities need to understand the critical role of water bodies in flood risk reduction.

It is imperative that citizens from all walks of life: businessmen, workers, commuters, construction workers, municipal workers, road workers, including state and central governments, agencies, institutions, civil society organizations, municipalities, involved in planning, development and maintenance of drainage infrastructure understand how hydrologic cycle interacts with various development activities, and how the water systems work, is essential when creating a disaster management plan or rainwater harvesting intervention.

Developing communication that educates drainage/water issues to land-use planners, urban planners, flood disaster managers, and the public is a vital strategy utilized in disaster management and rainwater harvesting.Distributed community-based involvements inrainwater harvesting, has the potential to reduce the flood hazard magnitude. There is a need to conserve rainwater and recharge aquifers in urban areas through water harvesting structures using rooftops and open spaces. Harvesting rainwater in urban areas not only reduces the possibility of flooding but also decreases the community's dependence on groundwater for domestic usesas well as reduce urban flooding and avoid water overloading in sewage treatment plants.

5.3 Community Education

User communities through civil society organizations such as Resident Welfare Associations (RWAs), need to be engaged in building water sensitization and awareness program.There is a need to change the mindset of the people so that they stop considering the water bodies as dumping grounds for litter, waste and refuse. Educating yourself on where rainwater and snowmelt flow on your property,and why it gets absorbed or doesn't get infiltrated into the ground is thefirst essential step. Implementing best management practices to reduce runoff and to make sure that it is clean when it leaves your property is the next step.

There are a number of successful examples of campaigns that have benefitted from community action.Reducing stormwater pollution can be successfully linked to litter reduction programs by aligning it with the Swatch Bharat program. These activities could be: Drain Marking, adopting a water body or waterway, sub-catchment, mass media campaigns to prevent stormwater pollution and stormwater pollution.

Through Community Education (CE), citizens can develop a relationship with the environment around them, relate to the natural resources such as water resources, and can equip themselves with problem-solving skills to solve the challenges being faced by the society. Formal and informal learning opportunities have to be sought for residents of all ages in a variety of community settings such as fairs, sports and social events etc. Developing information material, organizing the events and sustaining them, mostly by citizens themselves, requires professional training.

5.4 Proposed plan of action

Given the water security challenges being faced by the country, there is a need for a focused approach to the skill development in water domain by establishing a Skill Development Council for Water Domain (SDCW) for building human resource base: trainers, researchers and water management professionals with multi-disciplinary skills, and technicians to successfully tackle the future water management challenges in the country duly supported by users and other stakeholders through informed participation.The proposal here is limited to urban stormwater flood risk management, which can work as a nucleus and further be developed into a full-fledged SDWC.

Given the enormous training requirements to cover the country and differential capabilities of training institutions around the country, this objective is proposed to be met primarily through distance learning.Setting up of an e-learning program on the water is described in this section.

E-Learning ProgramsinWater

Distance learning or e-learning is a formalized teaching and learning system specifically designed to be carried out remotely by using electronic communication. Itis a versatile instructive tool that has the capacity of reaching remotest parts of the country and many trainees simultaneously, effectively contributing towards achieving the above goals. With the accessibility to IT, learning through the internet has become more affordable, accessible and flexible. The method is based on building knowledge through self-learning and interactive learning, thereby encouraging the development of skills, values and attitudes, in addition to the use of cutting-edge technology.

Presently, in the water domain, e-learning facility forthe engineering and core science courses has been established under a project funded by the Ministry of Human Resource Development (MHRD) named as the National Program on Technology Enhanced Learning (NPTEL)[32].It provides free online Web and Video courses in Advanced Hydraulic, Advanced Hydrology, Computational Hydraulics, Design of Hydraulic Structures, Ground Water Hydrology, Waste Water Management, Water Resources Engineering, Watershed Management etc. In designing these courses, NPTEL adheres to the syllabi of All India Council for Technical Education and the slightly modified curricula of major affiliating Universities.

Apart from this,CEPT UNIVERSITY[33] also offers a paid certificate course of 6-month duration on Water Resources Planning and management with 12 modules: Water and Environment, Water Resources Planning and Decision Making, Watershed Management and Public Participation, Water Harvesting, Ground Water Management and Artificial Recharge, Urban Flood Management, Water Budgeting, Wastewater Treatment, Recycle and Reuse, etc. Many other national and international institutes[34]foreign universities, and professional NGO like International Water Association[35]have developed courses meant primarily for imparting higher technical education.

Proposed WE-Learning program for water

It is proposed to develop an e-learning program dealing with various facets of the water sector, starting with a broad spectrum of urban flooding, stormwater drainage management and disaster management.For this purpose, the Water e-Learning (**WE-Learning**) Foundation is proposed to be

[32] https://nptel.ac.in/about_nptel.html
[33] https://**www.cept.ac.in**
[34] https://www.un-ihe.org/online-course-urban-drainage-and-sewerage
[35] https://iwa-network.org/iwa-learn-self-paced-courses

established to create a Virtual Learning Center (or a network of centres) to enhance national capacities at all levels for the development and implementation of sustainable urban stormwater drainage in India. The program goal is to develop the skill development materials for technical skills, soft skills, water education and water awareness **with the long-term objective to establish a professional certification for urban stormwater management**on the lines of NPET and make it available to the common man. WE-Learning is anticipatedto advance:

- **Awareness building** – Making various stakeholders aware of the issues facing the water as a resource;
- **Growth of scientific understanding** - Using basic scientific knowledge to solve problems;
- **Technical competencies** – Providing technical skills to operators in collaboration with the industry;
- **Social perceptiveness** - Being aware of others' needs and issues;
- **Informed decision making** - Considering the relative pros and cons of potential actions to choose the most appropriate option;
- **Problem-solving** - Identifying problems and reviewing related information to develop and evaluate options and implement solutions;
- **Active Learning** - Understanding the implications of new information for both current and future problem-solving and decision-making; and
- **Instructing**–Training the trainers.

The course content for various target groups as well as tiers/levels shall be suitably designed, keeping in view the basic education level as high school and multiple languages. At the end of the course, an online examination and certification system can also be put in place to assess trainee's understanding of the topic. A combination of appropriate modules and vocational training in collaboration with the private partners could lead to professional certification in trades such as those listed in Box 2.

In the initial stages, the program is proposed to address various aspects of Urban Water Management, Sustainable Urban Drainage Systems, Urban Flood Risk Management, Disaster Management, as well as Rainwater harvesting.

WE-Learning target audience and mechanism

The WE-learning training modules for Urban Flood Risk Management may be designed to meet the needs of the common man who is interested in the subject and is just capable of reading and using smartphones. It will contain practical methods, applications, readings, case studies, and assignments. The contents will be tailored to the needs of Urban planners, PHE professionals, PWD professionals engaged in road construction and maintenance; technicians involved in rainwater harvesting etc.They will also meet the needs of urban administrators, professionals working in environmental issues, road construction and non-professionals and technicians working in the ULBs, personnel working with Resident Welfare Associations (RWAs), NGOs, VOs, self-help groups and in disaster preparedness and planning.

The modules will be useful to one and all starting fromcommon man, workers involved in the water and environment sector, civil society functionaries, journalists, lawyer, and social scientists. Learners can choose the module which best suits their interest at self-paced speed and can be scheduled around work and family commitments.Given the wide range of the target audience, the modules may be designed for various levels of learners witha progressive level of details and competence and on multiple topics related to urban flood risk management including urban stormwater management.

The WE-Learningis proposed to be a platform run by a consortium of institutions, both government and non-government, engaged in various facets of urban flooding, stormwater drainage management and disaster management,to begin with. The consortium will be duly supported by educational and training institutions. The consortium will be a loosely bound partnership, to be formalized at a later stage, if and when required. The platform will be run through a Scientific Committeecomposed of representatives from the participating institutions and other interested organizations. It will have the responsibility to establish the online program curriculum and deals with the certification process.Crowdsourcing of contents makes the entire exercise a platform of exchange of information, experiences and knowledge.

Partner institutions and individual experts having interest and expertise in the related disciplines are expected to participate voluntarily. Members of the and Scientific Committee will also participate voluntarily.Subject matter experts (SMEs) from various fields will help create the outlines for each module provide content (including ideas for graphics) and to review the final product will be engaged.IWP is willing to serve as the secretariat till a formal arrangement is available. The process can later be dovetailed with the Skill India Program of Government of India.
