GREEN INFRASTRUCTURE STRATEGIES AS COUNTERMEASURES TO URBAN FLOODING

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Abstract

Urban flooding which is becoming a serious concern in cities across the world is a result of increase of impervious surfaces which is in turn affecting the catchment areas . Major cities such as Chicago and Copenhagen are facing the consequences of unplanned urbanization which has radically changed the drainage patterns. This in turn increases the volume and rate of surface runoff and results in the phenomenon of flooding in urban areas. Climate change is a phenomenon which cannot be disregarded as it is emerging as a major cause for extreme weather events. Climate change has altered the frequency as well as duration of rainfall. India has been one of the countries facing extreme rainfall events in the recent years such as the floods which recently affected the entire state of Kerala in 2018 as well annual instances of flooding occurring in major metropolises such as Chennai and Mumbai.

The study will be done with reference to the Bangalore Metropolitan Area where flooding is slowly becoming a major issue due to encroachment of catchment areas and increase of impervious surfaces in spite of not having any major river systems running through the city. This paper will examine the various green infrastructure strategies which have been effectively used for flood control that can be adopted to manage urban flooding in the context of Bangalore City.

Key Words: Urban Flooding, Indiscriminate Urbanization, Climate Change, Bangalore, Green Infrastructure

1.Introduction

Cities are usually planned according to transport needs and generation of economy and it is often much later that issues of environment and natural systems are addressed. This approach needs to be rectified in order to save our cities from getting into a pattern of development that can cause increased environmental damage. Adding to the impact of uncontrolled urbanization are the factors of climate change and increasing amount of natural disasters.

Urban flooding which is a result of increase of impervious surfaces is another major concern in Bangalore. Unplanned urbanization has significantly changed the nature of catchment areas. This in turn increases the quantity and speed of surface runoff and results in the phenomenon of flooding in urban areas. India has been one of the countries facing extreme rainfall events in the recent years such as the floods which recently affected the entire state of Kerala in 2018 as well annual instances of flooding occurring in major metropolises such as Chennai and Mumbai.

There are a number of factors which contribute to urban flooding. First, the carrying capacity of rivers have decreased with increasing silt loads which results in flooding of the banks even during normal rains. Secondly with the increasing demand of water the current the potential of storage basins to hold water has also reduced because of which flooding happens on normal rain days as well. Lastly, the pattern and intensity of rainfall has changed as has been demonstrated in recent years in cities such as Mumbai and Chennai. The population pressures which have resulted in the encroachment of floodplains and unplanned urbanization is a major reason for urban floods.

Bangalore once known as the Garden city has faced unprecedented urbanization in the past couple of decades. This uncontrolled growth has led to the encroachment of natural catchment areas and increased the impervious areas in the city. Traditionally the kere system in Bangalore has functioned as an efficient water management system in Bangalore by collecting the rainwater through a series of interconnected lake system. In the present time most of them have gone dry, or have been filled in and the remaining lakes have become waste and sewage dumps. The traditional linkages in the water systems have been disrupted due to urbanization. Adding to this are the effects of climate change which leads to higher intensity of rain in lesser number of rainy days.

In this scenario it becomes important to devise ways to augment the existing water resources and come up with an efficient water management system utilizing rainwater and the existing keres and incorporate this in the city planning process itself. By implementing guidelines for water management in the design process it would be possible to create settlements which are self-sustaining and at the same time cause minimal impacts on the environment.

Inclusion of Green Infrastructure Strategies in the city planning process can help in disaster risk mitigation and effective management of urban floods.

2.1.Urban Flooding

There is a lack of rainfall management in most urban areas. The stormwater is usually drained through engineered collection systems and discharged into nearby waterbodies. The stormwater carries trash, bacteria, heavy metals, and other pollutants from the urban landscape, degrading the quality of the receiving waters. High intensity rainfalls cause flooding due to improper drainage leading to damage of infrastructure and property.

The three main types of flooding are

- Fluvial or River Flooding
- Coastal Flooding
- Pluvial Flooding-Surface water flooding from intense rainfall

Pluvial Flooding is a common phenomenon in urban areas and is otherwise known as urban flooding.
Urban flooding is typically characterised by

i. Increase in flood peaks by 2-8 times;
ii. Increase in flood volumes by up to 6 times;
iii. Decrease in time required to reach flood peak;
iv. Excessive economic losses

2.2. Cause of Urban Floods

Urban Floods are a result of both natural and manmade activities. Some of the reasons for urban floods are

i. **Planning issues:** Increasing population, habitations coming up in low-lying areas and encroachment of catchment and drainage areas.
ii. **Technical issues:** Increased imperviousness leading to increased runoff. Lack of proper waste disposal resulting in clogged drains, high intensity – high load of runoff.
iii. **Meteorological issues:** Climate Change, resulting in extreme events, Urban Heat Islands.
iv. **Policy issues:** Absence of integrated flood control and implementing agency.

2.2. Impact of Urban Floods

Some of the impacts of urban flooding include

i. Traffic jams
ii. Damage to public and private property
iii. Mixing of solid waste in flood waters causing blockage of drains
iv. Vector and water borne disease
v. Disruption of power supply and telecommunication
vi. Mixing of faecal matter in the flood water due to open defecation

3.1.Bangalore-Background Study

Kempegowda founded the city of Bangalore 481 years back. He also created an efficient drainage system for storing water in Bangalore in the form of its cascading lakes. Bangalore had an excellent flood control system with its many lakes planned along the natural gradient connected with each other in such a way that excess water would flow down to the next lake through connecting canals. The lakes were used for drinking water and sustained for hundred of years till the coming of the British when the piped water supply was brought to Bangalore. The natural drainage system of Bangalore used to serve the purpose of storing rainwater and also acted as a good flood control mechanism.
With the pattern of urbanization that started during the post independent period this natural system was disturbed. Many lakes were filled and used for setting up industries and other infrastructure as well as residential layouts. As these natural reservoirs were filled the connections and linkages between them were also broken.
Today the city is reliant on piped water supply as well as pipe networks for carrying waste water and storm water. Often the sewage is let into the existing waterbodies without adequate treatment and thus polluting them.
The storm water drains are also usually blocked and unable to carry the water during even normal rains causing flooding in many areas of Bangalore.

3.2. Lakes or Kere System in Bangalore

The Garden city image of Bangalore was enhanced by its many lakes which also made it known as "The City of Lakes". Kempegowda, the founder of Bangalore was a visionary who by constructing the many reservoirs and lakes along the natural terrain of Bangalore ensured that the city had its own supply of potable water as well as water for cultivation. This was especially important in the context of Bangalore in the absence of any other source of water or a reliable river system.
Ulsoor lake was one of the earliest lakes constructed by Kempegowda in the 16th century. This was later maintained bt the British. Sankey Tank, Miller's tank are other lakes used for water needs by the people of Bangalore.
Bangalore's has an average rainfall of 850 mm. This rainwater was traditionally captured by the cascading

system of lakes. The outlets connecting these lakes to each other were called Raja Kaluves . The water moves from one lake to the other till it is finally emptied into one the three main valley systems of Bangalore.

With the contamination of sewage into the lake water it soon became prohibited for consumption. In 1960 there were 262 lakes in Bangalore which have come down to 81 now of which only 34 are identified as live lakes.

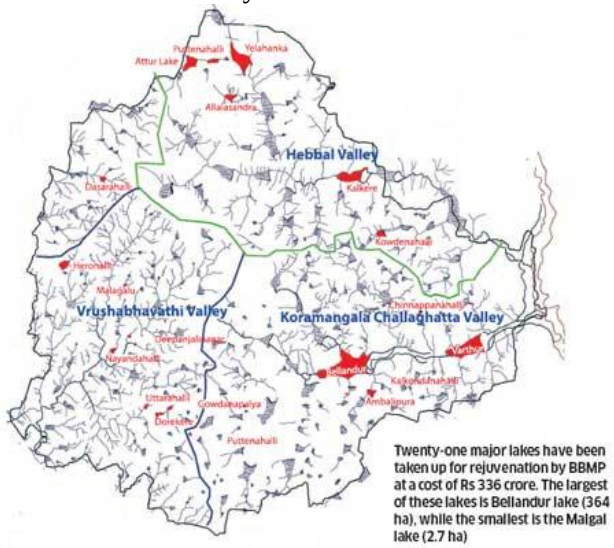

Fig 1: Water tank system in Bangalore

Source: Kollarath 2013

Lakes also form an important ecological system supporting many forms of life in Bangalore.

Working principle of tank system:

The system was based on the following principle.
Principle of cascading: The tanks formed chains
Each tank gets water from its catchment area as well as from the excess water from the tank above them.

Fig 2: Cascading System of Tanks

Source :LDA

3.3.Case of flooding in Bangalore

Urban Flooding has been becoming an increasing phenomenon in Bangalore in the recent years Unplanned and rampant urbanization has had a major impact on the existing natural systems. Infiltration capacity reduces with the expansion of impermeable surfaces. With installation of piped sewage systems the quality of natural retention in the catchment areas are reduced.

With increasing urbanization there are changes in the floodplain elevations which is a cause for urban floods. Infiltration capacity of the ground is reduced during summer time. In urban areas sudden rains are common in summer.

Koramangala Valley	Hebbal Valley	Challaghatta Valley	Vrushabhavathi
City Market Area	Brindavanana gar below Matthikere Tank Market	Miller Tank, Chinnappa Garden	Gubbanna Layout
Sulthan Palya Main Road	KEB Compound Maththikere	Shivajinag ar, Munireddy Palya	Shankarappa Garden Gopalapura
Jayanagar 3rd Block LIC Colony	Tannerana Halli	Saraswath ipuram - Jogu Palya	Cholurpalya
Krishnapa Garden	Anandanagar a	K R Garden	Bapujinagar
Arekempannah alli	Ring Road	Miller Tank, Chinnappa Garden	Minerva Mill
Jurist Colony	New - Bangalore Layout		Dhovi Colony
Marehahalli Tank	Brindavanana gar below Matthikere Tank Market		Tank Slum Area
Bismillanagar - Agencies			Binny Mill Tank Area
Pillappa Garden			Markandayyana gar
Arekempannah alli Area			Sanjaya Gandhi Slum Area
Jurist Colony			Rudrapa Garden
Marehahalli Tank			Gubbana Layout

Table 1: Low lying and Floodprone areas in Bangalore.

4.Green Infrastructure Strategies for Flood Mitigation

Cities are characterized by impervious surfaces. These include roads, parking lots and rooftops. In cities rainfall swiftly becomes surface runoff, with a five-fold increase over an undeveloped watershed .In urban settings various methods can be used to retain storm water and prevent floods from overwhelming storm drain systems and causing urban flooding.

Green infrastructure uses vegetation, soils, and nature based processes to manage water and create healthier urban environments. These methods can range from those deployed at the scale of individual buildings, including porous pavement, “green” (vegetated) roofs, rain gardens and rain barrels, to features that can attenuate runoff for larger areas, including grassy swales, wetlands and detention basins. At macro scale green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At neighborhood scale or site, green infrastructure refers to storm water management systems that mimic nature by soaking up and storing water, such as rain gardens, permeable pavement, and green roofs.

Green streets are a component of green infrastructure within the street right-of-way to manage runoff from both the street and adjacent parcels. A green street is a stormwater management approach that incorporates vegetation (perennials, shrubs, trees), soil, and engineered systems (e.g., permeable pavements) to slow, filter, and cleanse stormwater runoff from impervious surfaces (e.g., streets, sidewalks) instead of directly discharging the stormwater into the surface waters . Green streets are designed to capture rainwater at its source, where rain falls. Green street features can include permeable paving bioretention areas sidewalk planters, landscaped medians, vegetated swales, and street trees.

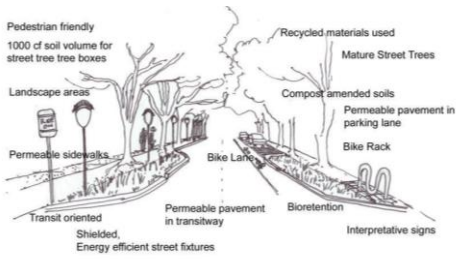

Fig 3. Components of a Green Street
(Source: EPA)

A green roof or living roof is a roof of a building that is partially or completely covered with vegetation and a growing medium. Green roofs act as filtration system and reduce speed of runoff. Green Roofs also help to lower urban air temperatures and mitigate the heat island effect.

Green roofs can help to filter rainwater before storing it either in underground sumps or collecting them in reservoirs. This way built environment can also be used for rainwater harvesting.

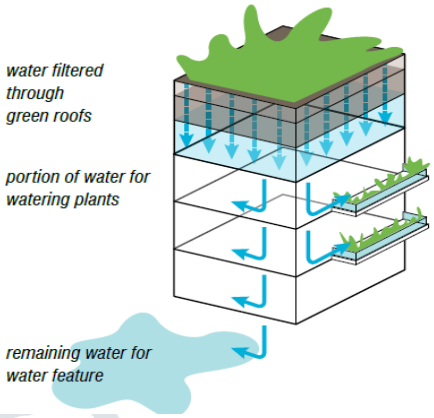

Fig 4. Green Roof
Source: ABC Guidelines

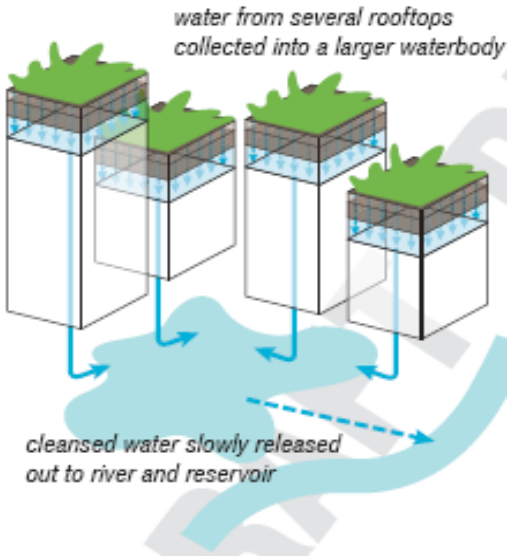

Fig 5. Green Roof System
Source: ABC Guidelines

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Green Streets along with a system of bioswales and use of rooftop gardens will help to reduce the runoff which can then be directed into the existing water bodies where they can again go through another layer of filtration.

4. Conclusions

Urban areas such as Bangalore city face urban flooding due to the increase in impervious surfaces ,increase in surface runoff and encroachment of catchment areas. It

is also facing problems of decreasing green cover and increasing summer temperatures.

The integration of the existing kere system in Bangalore and implementation of green streets and urban gardens would together help in mitigation of urban flooding in Bangalore. In the Bangalore context, the existing kere system can be developed into an efficient blue green infrastructure which will also help to preserve the remaining water bodies and also act as efficient buffers to urban flooding. This along with other green infrastructure strategies will reduce the amount of water entering man-made drainage systems with the help of infiltration, interception, transpiration, storage (temporary and longer term).

Green Infrastructure Strategies for slowing runoff also help make cities greener, healthier, and cooler. They also improve the aesthetics and recreational value of the place. Parks, greenways, daylighted creeks, and urban gardens will all contribute to a more vibrant city that also happens to slow and retain stormwater.

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Reshmi M K is an Architect and Habitat Designer currently working as Associate Professor in BMS College of Architecture, Bangalore. She has experience of over 10 years in various design firms before joining academics. She has worked in various interior, architectural, landscaping and master planning projects during her career. She has also worked as independent consultant for a number of projects. Her rich knowledge and multidisciplinary approach helps her to straddle both academic and professional fields competently.

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