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Opportunities of "Sponge City" as a Solution for Urban Waterlogging & Water Scarcity in India

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Abstract: ***The rapid development of social economy, unfettered expansion of urbanization and increased urban population has caused serious problems in India. The main problems are associated with waterlogging, water resources and the aquatic environment, for example, a heavy rain in a city inevitably leads to waterlogging, which leads to a great threat to the livelihood, property and transportation facilities. Disasters due to urban flood are a key problem that restricts the development of urban ecology in the nation. This is due to increase of impermeable surface, which leads to a decrease in rainfall infiltration and increase in surface runoff. It was also noticed that the Indian cities are prone to water scarcity and heavy temperature during the seasons other than monsoon. This article briefly introduces opportunities of Sponge City, which was successfully implemented in China to overcome the above problems, in cities of India. The study was also expected to provide a deeper thinking to solve the waterlogging and water scarcity of the nation in a sustainable and green manner.***
Keywords: Sponge City, Waterlogging, Water scarcity, Precipitation, Green city

I. INTRODUCTION

India in the last years experiences several disasters including flooding, cyclones, droughts, water scarcity and storms etc… This all are mainly due to the geographical location of the country. India is a peninsular nation in the Indian Ocean surrounded by ocean in 3 sides, which determines the special climatic characteristics of the nation. The nation is affected by heavy rainfall during the monsoon due to this climatic condition. Apart from these pollution and climate changes has also impacted Indian cities. It is important to note that building a "gray" infrastructure through a single-objective engineering approach has been widely used to solve complex and systemic water problems until today.

However, the problem has not been solved; instead it goes into a vicious circle. Combined with the domestic and international theoretical achievements and practical experience in urban rainwater management, the "sponge city" theory encompassing the natural infiltration and natural purification has been proposed and developed.

In 2013, General Secretary Xi Jinping proposed the construction of "Sponge City", which indicates that China's urban rainwater management has entered the stage of system's management.

Beijing has conducted research and applied rainwater utilization since 1989. It is the earliest city in China and has achieved good results. It has played an important role in reducing and controlling urban rainfall runoff, reducing non-point source pollution and preventing urban infighting.

Therefore, studying the current situation of sponge cities in Beijing, especially in the management of storms and floods, will help to provide experience and reference for the Indian cities for reconstruction of cities affected by floods.

Nearly 50 per cent of India grappling with drought-like conditions, the situation has been particularly grim this year in western and southern states. Looking at the current situation, there is a need for a paradigm shift. We urgently require a transition from this 'supply-and-supply-more water' provision to measures which lead towards improving water use efficiency, reducing leakages, recharging/restoring local water bodies as well as applying for higher tariffs and ownership by various stakeholders. Sponge city technology will be a great solution for both the problems that country faces today.

II. PRECIPITATION CHARACTERISTIC ZONES AND RAINFALL DETAILS IN CITIES

Rainfall in India emanate from two main sources: Bay of Bengal branch and Arabian Sea branch. The distribution of rainfall is uneven in India. Parts of western coast and north eastern India Receive over about 400 cm of rainfall annually. Less than 60 cm in western Rajasthan and adjoining parts of Gujarat, Haryana and Punjab. A third area of low precipitation is around Leh in Jammu and Kashmir. The rest of the country receives moderate rainfall.

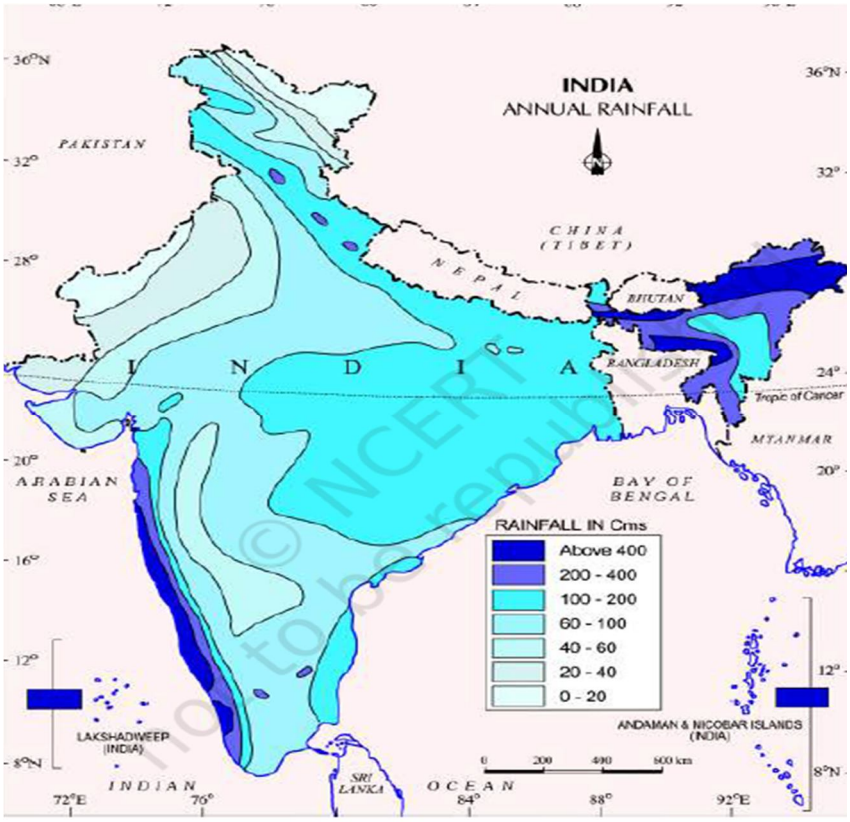

Fig 1. Rainfall characteristics in India (http://ncert.nic.in/ncerts/l/iess104.pdf)

From Fig 1 it can be noticed that main cities of the nation is coming under the area with rainfall above 100 cm. This causes floods and water logging in these cities. The main cities like Mumbai, Chennai, Pune, Kolkata, Kochi, and Mangalore etc… are located in this area. The rainfall in these areas lead to drastic flooding due to many reasons.

III. URBAN FLOODING AND WATER SCARCITY

The cities like Chennai, Mumbai and Kochi is more prone to flood. The state of Kerala completely faced flood in the year 2018. Chennai faced flood in the year 2016 and 2017. Finally in 2019 Mumbai also faced heavy flood. Figure 2 shows the reasons of urban flooding in these cities. The rain water does not penetrate into the surface and the surface runoff increases. This cause damage to the public life and lot of inconvenience for the city life.

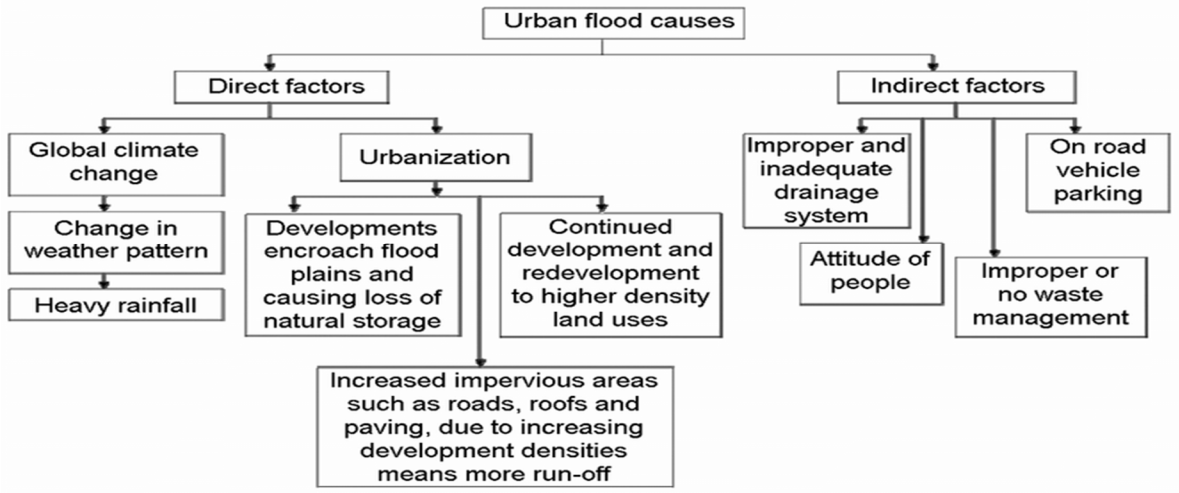

Fig 2: Causes of Urban Flooding in India (source https://www.researchgate.net/figure/Causes-of-urban-floods-in-India)

From the figure it can be concluded that improper urban planning is the major reason of flooding and water logging. The concrete and bituminous pavements, parking slots, buildings etc. have destroyed the natural process of absorbing of water. Thus the water scarcity in these places also increases As a result these cities face water in rainy season and drought in other seasons. This phenomenon has made the city life in the country difficult.

The country is facing the worst water crisis in its history, and 21 Indian cities will run out of groundwater by 2020, a new report from the NITI Aayog – a government think tank – said, highlighting the need for "urgent and improved" management of water resources.

Thus a conclusion can be made; the flood water during the rainy season should be made usable in other season as a solution to water scarcity. The flood mitigation method adopted should be in such a manner, that the rain water should not cause flood and it must be usable for the city dwellers.

The implementation of Sponge City is the best solution for these problems. Our neighboring country China has successfully implemented this technology.

IV. SPONGE CITY

"Sponge City" is the integration of a series of specific rainwater management technology, and is the result of extensive practical experience. It covers concepts and technologies such as Low Impact Development (LID) in the United States, Sustainable Urban Drainage Systems (SUDS) in France, and Water-sensitive Urban Design (WSUD) in Australia.

LID refers to a rainwater management method based on the principle of simulating natural hydrological conditions, and using source control concept to realize rainwater control and utilization. The main objective is to maintain or restore the previous hydrological characteristics of a development area, after the construction. Such measures include protection of water quality, replenishment of groundwater, reduction of flood peak, conservation of land, reduction of runoff accumulation time, prevention of river pollution, and reduction of pressure on municipal pipe network facilities. SUDS has evolved from a simple "emission" based drainage system to a sustainable and benign water cycle drainage system. It focuses on water quality, landscape value, entertainment and rest value of the urban environment.

V. SPONGE CITY IN PINGXIANG: CASE STUDY

Pingxiang City, Jiangxi Province, as the first pilot sponge city established in China, has ranked first in the annual performance appraisal for two consecutive years . This section takes Pingxiang City in a humid area as an example to discuss its construction mode and characteristics.

Pingxiang is a prefecture-level city in Jiangxi Province. It is located in the western part of Jiangxi Province. And it is located between 113°35′~114°17′ east longitude and 27°20′~28°0′ north latitude. The total area is 3831 km2. In 2015, the population was about 1.93 million. Pingxiang is a typical subtropical humid monsoon climate with an annual average temperature of 17.3 °C. The annual precipitation is abundant, and the annual average precipitation reaches 1596.7mm, which is between the wet and rainy belts. The average monthly precipitation and monthly average temperature distribution in Pingxiang are shown in Figure 2. It can be seen from the figure that the annual precipitation distribution in Pingxiang is uneven, mainly concentrated in April to June.

Water shortage Pingxiang is a typical mountainous and hilly city. It shows the characteristics of high surrounding terrain, low intermediate terrain and poor water storage capacity. The central city of Pingxiang has concentrated most of the population, industrial and mining enterprises and high-water consumption industries. It has typical water quality, resource and engineering water shortage characteristics.

Water pollution In recent years, urban expansion, road construction, coal mining, industrial wastewater and domestic sewage discharge in Pingxiang City have led to the narrowing, turbidity and odor of water in many rivers. Uneven precipitation and water use time The precipitation and water use time in Pingxiang are uneven.

The rainfall from April to June accounts for 44.5% of the total, while the urban water consumption only accounts for 20% of the whole year. From July to September, the city's rainfall accounts for 20% of the year, while urban water consumption accounts for 70% of the year.

Urban internal waterlogging The special terrain of Pingxiang is easy to cause mountain runoff to flow into the urban area along the Pingshui River during heavy rains, which often leads to a serious increase in the short-term internal diameter flow in the urban area. Taking Wanlong Bay, the most serious waterlogging, as an example, an internal waterlogging of about 30km2 has been formed over the years. The average submergence depth during rainstorms is 50~120cm.

A. Construction Results

1) *Water Ecology*: total annual runoff control rate increased from 30% to over 75% in pilot zones, and the diversity of aquatic vegetation was increased significantly.
2) *Water Environment:* Removal rate of suspended solids was over 50% in rivers, and the water quality of main rivers and lakes have basically reached the IV water standard.
3) *Water Sources:* Rainwater utilization achieved 8%, and it was widely used in municipal cleaning, landscaping, green plant watering and river replenishment. Annual water saving was about 2 million and 560 thousand tons.
4) *Water Safety:* 49 water accumulation points have been eliminated or obviously relieved; 43 residential blocks never suffer the city floods.

Fig 3 Sponge City in Pingxiang

VI. CONCLUSION

Although Indian cities are suffering from floods more often than previously, this has also created an opportunity for innovative urban design. As per the present climatic conditions in India, Sponge City Technology has a great opportunity. The objective of this paper is to realize the possibilities of Sponge city in India. India is a developing country. Proper town planning can improve the life in cities. Implementation of sponge cities will be a great solution for the mitigation of flood and prevention of water scarcity. Sponge city concept can be implemented successfully in cities like Chennai and Mumbai. It also helps to make the cities green. Fresh air, Fresh water etc. will be available after sponge city construction. It also helps to reduce the temperature in cities. Sponge cities increase the greenery of the city too. The water absorbing pavements and roads in sponge city increases road safety too. Thus sponge city will be a breakthrough in Indian cities if implemented properly. Proper town planning and going green can change the face of Indian cities.

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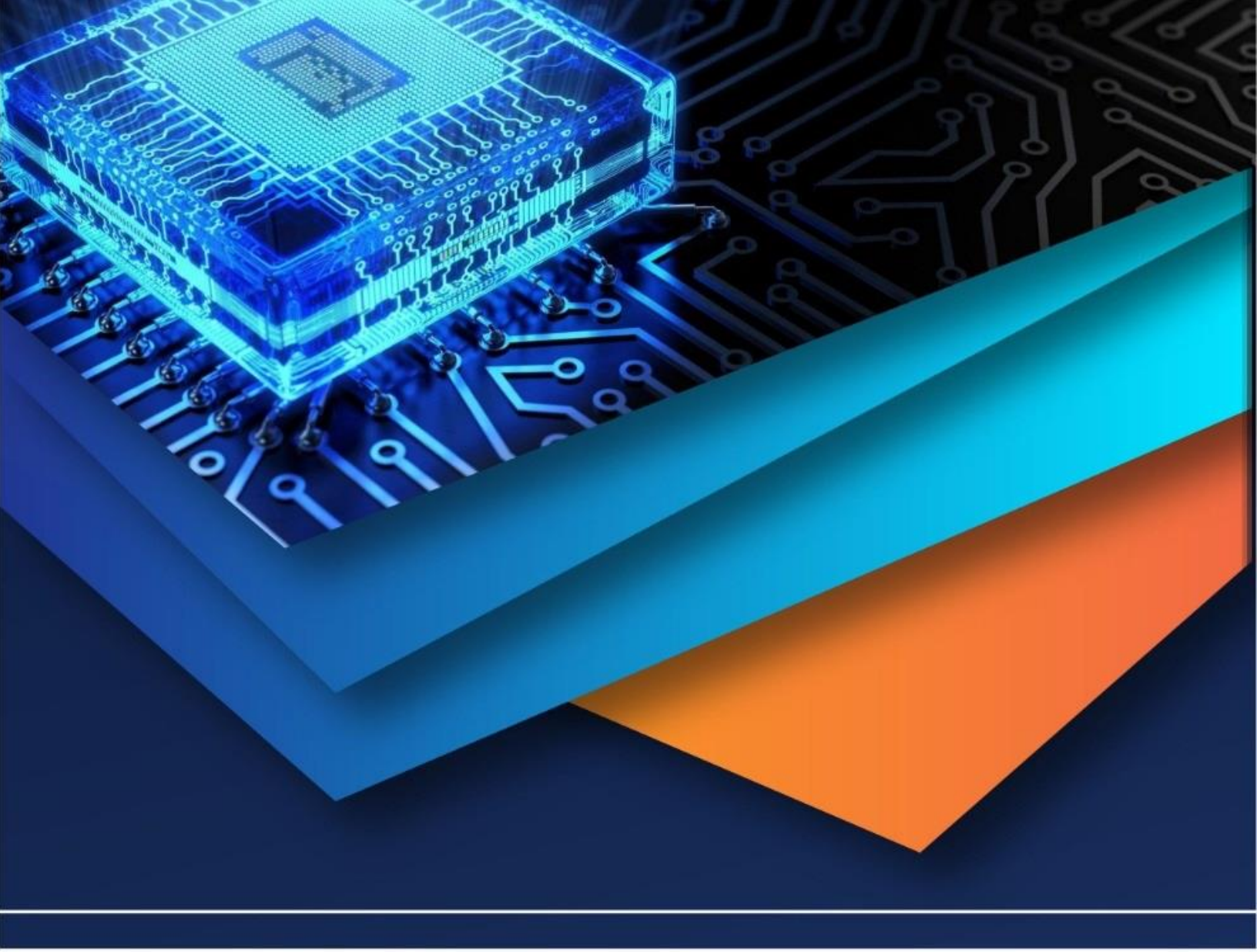

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