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Pragyambu

cGanga
Centre for Ganga River Basin Management and Studies

The purpose of this quarterly digest brought out by the Centre for Ganga River Basin Management and Studies (cGanga) led by the Indian Institute of Technology Kanpur is to disseminate valuable traditional and scientific knowledge assimilated from national and international sources on various aspects of management of water and river restoration and conservation among concerned institutions and citizens.

IS SAFETY FROM FLOODS POSSIBLE?

The year 2023 witnessed several natural disasters all over the world. Some of these disasters such as floods and landslides were attributed to heavy rains. China, Libya Bangladesh and several African nations such as Kenya, Ethiopia and Somalia suffered heavy losses due to floods. In India also, several states such as Himachal Pradesh, Uttarakhand, Punjab, Delhi and Tamil Nadu faced severe floods. According to research studies, frequency of such events is likely to increase in the future. Available data show that India experiences the third-highest number of natural disasters among all countries in the world. And floods constitute about 41% of natural disasters occurring in India every year.

It is ironical that while many rivers in our country are drying up and facing extinction, many urban and rural areas are facing flood hazards. The country has witnessed severe floods every year from 2000 to 2023. The heavy floods in Mumbai in 2005, in Chennai in 2015, in Kerala in 2018, and in Uttarakhand in 2013 were not only disastrous but became tragic with hundreds of deaths and loss of property worth millions. More recently, in the monsoon of 2023, Himachal Pradesh, Punjab, Chandigarh, Uttarakhand, Jammu Kashmir, Haryana, Rajasthan and Delhi suffered heavy floods. These floods damaged crops in agricultural fields in rural areas and gravely disrupted the daily lives of residents in megacities. A report by the State Bank of India in this regard estimated the losses at 10 to 15 thousand crore rupees in North Indian states due to floods and the cyclone Biparjoy. Every year a large fraction of national assets is spent on relief and rehabilitation after these natural disasters. On the other hand, the losses to finance, trade and life can never be recovered. The seriousness of this issue can be gauged from the fact that around 17 thousand people lost their lives due to heavy rains and floods between 2012 and 2021. The loss of life and property is one of the direct consequences of floods that is immediately visible; however, floods also have secondary and tertiary impacts, which are seldom evident at first glance. One such consequence is the change in the size of rivers and on river nutrients. Due to these factors, the habitats of aquatic creatures get destroyed, which eventually affect the aquatic and land ecosystems as well as the food chain.

There are mainly three reasons leading to floods. First is due to marine storms and cyclones. The second is floods caused by rivers due to heavy rainfall whereby excessive water reaches rivers beyond their capacity. The third type of flood problem is ponding and water-logging in cities due to heavy rains. In this case, it is not necessary that a city be located near the sea or a large river. In this issue of Pragyambu, we will analyse the flood situation caused by water-logging after heavy rains and swelling of rivers. We will also try to understand whether protection is possible from such situations.

MANY REASONS, MANY FACTORS

There are many factors affecting rainfall, and there are many reasons affecting those factors. They are mostly natural reasons. How rainwater replenishes groundwater and waterbodies, and make gardens thrive are all ensured by nature. But human intervention has hampered the natural flow routes of water. This intervention sometimes directly causes a severe flood or contributes to it when the flood has been caused by other factors. In summary, natural and anthropogenic imbalances together create the circumstances leading to flood disasters. In addition, climate change is also responsible for untimely rainfall and sudden floods. Let us now understand these reasons.

TEMPERATURE INCREASE

An increase in temperature leads to increase in the rate of evaporation, which results in increase in the water holding capacity of air. This creates conditions conducive to excess rainfall. There are several factors that contribute to increase in temperature. The impacts of climate change are being seen the world over.

WATER ABSORPTION AND RETENTION CAPACITY OF SOILS

The water absorption and retention capacities of soils also determine whether rainwater contributes to soil moisture or in floods. If soil is completely dry, then absorption of water takes place slowly. However, if moisture is already present in the soil, then water absorption is rapid. In addition to topsoil, the composition of sub-soil also plays an important role in absorption. A porous sub-soil results in better absorption of water. It is noteworthy that the presence of microorganisms, earthworms and insects in soil makes the soil porous, leading to better water absorption. In a similar way, mulch applied on top of the soil keeps the soil moist, which not only benefits crops but also leads to better water absorption. Another advantage of mulching is that it helps in controlling soil erosion in case of heavy flows caused by heavy rains.

OTHER FACTORS

The size and shape of basin and the intensity of rainfall are other factors that affect the flow of rainwater. If the rainfall intensity is high, then water absorption will be less, and flow will be rapid. And if the basin has good vegetal cover, then water absorption will be more and the flow will be slower. In mountainous regions and on slopes, the downward flow of water will be fast and absorption will be less. The locations of other streams in the basin also determine whether water reaches the main river gradually or quickly.

WORSENING SCENARIO DUE TO HUMAN INTERFERENCES

India is urbanising rapidly and our cities are continually expanding. These pleasant areas, however, are either lacking in stormwater lines or such lines are poorly maintained. That is why it appears as if our cities are about to drown during heavy showers over a couple of days.

Our cities' developments have been poorly managed. According to the Council of Energy Environment and Water, the landscape of 45 percent of the districts in our country have had their landscapes changed by human interference and construction works. Due to unsystematic development, cities have become concrete-covered while forests and meadows have diminished. Thus, neither is the absorption of water likely nor the paths by which the water can drain be found. When nature bestows her loving rains on these concrete surfaces, the ground is unable to absorb the water. As a result, roads and even houses get waterlogged. Many of the natural drainage routes in our cities have fallen prey to illegal construction works, due to which these pathways have either been obstructed or have narrowed. Thus whenever large quantities of water pass through these narrow paths, the water velocities increase, and the rainwater becomes a problem with the rapidity of flow becoming very destructive. According to National Disaster Management Authority, the swelling of rivers is not the only reason behind urban floods. Lack of drainage due to unplanned development of cities increases the risk of urban floods by 2 to 8 times.

On the other hand, in the case of cities located on the banks of rivers, during their development, the rivers' catchments, floodplains and wetlands have been rapidly encroached. It is not surprising, therefore, that developing areas get submerged during rains.

Processes like eutrophication (growth of water hyacinths and other aquatic plants in lakes and rivers) reduce the depths of lakes and rivers. Such reduction in water depths lead to reduced water retention capacities, due to which even moderate rains create a flood-like situation.

Stormwater drains are an important means of urban drainage, but these drains are also becoming extinct or choked, due to which runoff from rains have few escape routes, thereby causing submerged or waterlogged roads.

In megacities like Delhi, Hyderabad and Bangalore which are frequently flooded we find that while urban expansion has not been accompanied by corresponding rainwater drainage facilities, even the natural or manmade water retention facilities have been decreasing in number and size. For example, there were 400 lakes and 48 ponds in Hyderabad till 1929, while today only 169 lakes are left. Bangalore once had 1000 lakes, but this number decreased to 260 by 1960 and today only 189 lakes are left. These lakes and ponds used to store rainwater, which could be used for drinking, washing clothes, gardening and other purposes. In addition, these water reservoirs had a positive influence on groundwater levels also.

The Najafgarh Lake near Delhi, which is a wetland located between Delhi and Haryana, has suffered the same fate. The lake was a buffer zone during floods and was also a means of recharging groundwater and temporary habitat of migratory birds. Once spread over an area of 220 square kilometres, the lake has now shrunk to merely 7 square kilometer area. The impact of shrinking of this wetland which acted as a buffer zone against floods in Delhi becomes evident during the monsoons.

In India and several other countries flood protection is attempted by constructing embankments to contain overflowing rivers. Many embankments were constructed on rivers in India during the British era. Experts are not in agreement over whether constructing embankments on rivers provides effective flood protection or not. In the absence of embankments, whenever a river overflows, the surplus water spreads sideways slowly. But when embankments are constructed, this

lateral spread is restricted and the water is forced to rise vertically, due to which the river starts flowing above the danger mark, and flow velocities also increase beyond control and make the downstream areas vulnerable.

Construction of embankments not only controls floods, but also prevents fertile river silt from spreading across the adjacent fields. Even in British era, there were protests against large-scale construction of embankments in Uttar Pradesh, Bihar, Bengal and Assam states. The argument behind these protests was that embankments put obstacles in natural river processes. The adverse effects of construction of embankments have been witnessed not only in India but also in China.

According to experts, deforestation in the Himalayan region is the main reason behind floods in Uttar Pradesh and Bihar. Due to deforestation in Garhwal, Kumaon and Nepal, rainfall in these regions leads to soil erosion. The eroded soil deposits on river beds and make them shallow, thereby increasing the water levels. On the other hand, these forests used to function as sponge by absorbing rainwater. With deforestation, this sponge is destroyed and more water reaches the river. These factors together lead to greater amounts of water reaching downstream areas rapidly as floods.

The destruction caused by heavy flow of water in high altitudes carries debris such as vehicle parts, signboards/ hoardings, concrete, and construction materials, domestic wastes, etc. reach the downstream regions with the floodwaters. Nature made rivers responsible for distributing soil and nutrients. Even floodwater bring fertile soils useful for agriculture. Due to unplanned urbanisation, however, on one hand floods have become more frequent, and on the other hand, agricultural fields and grasslands are being deprived of natural benefits usually brought by floodwaters. Unplanned construction in cities have also resulted in water not seeping into the ground so that in spite of heavy rains and waterlogging, the groundwater levels do not increase. In spite of monsoon floods, cities face water crisis during summer.

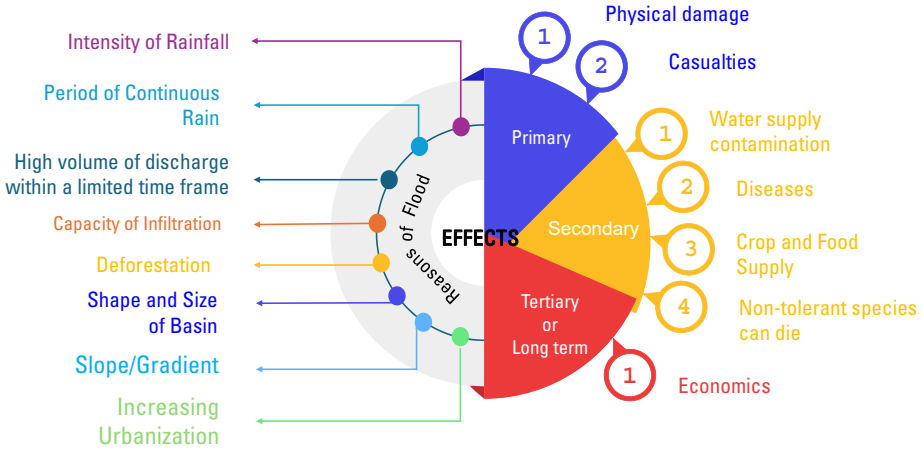

Table: Floods and their effects in India during 1915 - 2015

Types of Flood	No. of Events	Total Deaths	No. of Affected People	Damage (USD)
Riverine Flood	143	29,810	333,442,962	41,404,929
Flash Flood	23	7,436	23,443,526	416,200
Costal Flood	04	569	11,500,000	275,000
Others	132	33,611	462,703,212	11,898,059
	302	**71,426**	**831,089,700**	**53,994,188**

Source: Report of working group on Flood Management and Region-specific Issues (2011)

India has faced 649 disasters from 1915 to 2015. Out of these 649 events 302 disaster were caused by flood with on an average of 3 flood per year.

In 2018 the state of Kerala suffered its most severe flood of the century which caused a loss of 40 thousand crore rupees and 33 thousand people were forced to abandon their homes and take refuge in shelters. Even after such heavy rainfall, the state had to face drought.

In Indian cities, non-availability of sewerage system in most portions is another factor contributing to worsening flood situation. On one hand wastewater management and on the other hand rainfall drainage facilities both being inadequate, rainwater mixes with wastewater which can pose risks for public health.

URBAN HEAT ISLAND EFFECT

Urban heat island effect results from temperature increase in cities due to anthropogenic activities. Due to several human activities, city temperatures are higher than in surrounding areas, hence the air in cities is hotter. Hot air rises upwards in the atmosphere and stimulates the formation of clouds followed by condensation. This effect is one of the factors behind sudden floods in cities.

Flood-related deaths increased from an average of 1000 per year in the 1965-1975 decade to 1700 per year in the 2005-2015 decade. Cumulative economic loss in 2005-2015 was nearly 2% of the GDP of India.

Source: Centre for Research on the Epidemiology of Disasters (CRED)

SOLUTION IS POSSIBLE

Granting that man is a dwarf compared to nature, yet it is possible to attempt to achieve safety from natural disasters like floods. Just as multifarious factors have contributed to the immensity of the flood problem, likewise it is possible to protect ourselves from floods by adopting a multi-faceted approach. Making use of science, technology, sub-structural changes and nature-based solutions and keeping in mind various factors like the geography of a city, condition of water resources and water retention capacity, it is possible to control this problem.

In order to control the disasters caused by floods, it is of utmost importance to reduce the flow velocity of water. Slow flowing water is easy to control and is more readily absorbed by soil. Therefore, we need to find innovative solutions to reduce the flow rates of water that spill over the riverbanks. There are several possible ways in which this can be achieved such as by creating large green belts around rivers in cities, by developing urban forests near rivers, and by constructing ponds and lakes for storing excess water.

To prevent flood disasters, China is working on the idea of sponge city, through which parks, ponds, wetlands, artificial forests, drainage for excess water and structures for its storage are being constructed in 19 cities. Such projects are underway in India also, for example, there is a plan to revive 500 lakes in Delhi, and preparing a blue-green master plan (in progress) in the capital city of Madhya Pradesh – Bhopal - where water management, waste water treatment and reuse are in focus. Similarly, work is in progress in Chennai, Mumbai and Kochi on developing sponge city roadmap, which is aimed at increasing the capacity of water absorption, harvesting excess water and recharging of groundwater.

INFRASTRUCTURAL EFFORTS

In several cities of the world, flood control was achieved by changes and new constructions of the flood control infrastructure. It is a costly exercise but has far-reaching results. For example, after massive floods in 2001 in Bangkok, a 2800 sq.km. network of 1682 canals was created. Besides, 25 ponds and several other projects were implemented to preserve rainwater. Such ideas can be introduced in India also after proper research, and considering local geographical conditions and the needs and difficulties of local population. Till 1970, 3200 hectares area of Singapore was flood prone. However, by carrying out urban development in a planned way since 1970, the flood prone area has been reduced to a mere 30 hectares. In India 40 million hectare is flood prone. Considering the geographical diversity and socio-economic differences, we cannot copy Singapore's example blindly. Still, we can take it as an example and attempt to develop the flood prone areas in a planned manner to mitigate damages from future disasters. Proper flood management basically needs to reduce the flow rates of water. By reducing the flow rates, the possible damages caused by floods can be mitigated. This can be achieved by constructing detention ponds in flood prone areas. In Netherlands, dykes (small dams made of stone) are constructed over an area of several hectares. During flood or storms, water is stopped by these dams, and flows at low speeds even after large volumes of water have collected. In public places use of Permeable Interlocking Concrete Pavers (PICP) increases the possibility of water seeping into the ground even on solid construction. In many cities the use of interlocking tiles with grass growing between them keeps the soil moist and increases the probability of water absorption by soils.

A LOOK AT THE ATTEMPTED SOLUTIONS: TECHNOLOGY-BASED SOLUTION

A flood control centre has been set up in Bangkok city, which can issue warnings before an actual flood comes. The loss of life and property due to floods can thus be prevented. In Singapore, sensors have been installed at 1400 places which regularly issue rainwater level data, which helps in forecasting floods in advance and thereby preventing mortalities.

NATURE-BASED SOLUTION

In Alwar, Rajasthan, the traditional method of rainwater storage is adopted on a large scale. In Mumbai, flood control is being done with the help of mangrove forests. In Chennai, rivers are being revived so that instead of homes and roads rainwater reaches rivers, thus rejuvenating them. Wetlands are being conserved in Kolkata so that they can assist in absorbing rainwater like sponges. In addition to these methods, temporary leaking dams can be constructed around rivers before the onset of monsoon so that rapid flows of rivers and rapid overflow of floodwaters can be prevented. Leaking dams are made of tree trunks and branches, which do not stop the flow of water completely but can reduce its speed. In the same way, the flow of water can also be reduced by constructing small dams, embankments, etc. on rivers.

STRICT ADHERENCE TO LAND USE LAWS

Flood management necessitates strict following of land usage laws. Change in land use methods damage rivers at first and then harm the whole environment. Forests and grasslands in the plains of Phalgu river basin in Bihar were converted into agricultural land, whose repercussions on the river have become evident today.

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