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Infrastructural challenges of floods in India: Urban, flash floods and riverine floods

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Abstract
This paper discusses the multi-faceted challenges faced by India in its efforts to mitigate disasters caused due to floods. It takes in its purview not only the riverine floods and flash floods, but also the recent destruction caused by urban floods. It discusses the infrastructural as well as administrative challenges faced due to lack of planning in developing urban areas, especially in the metropolitan cities.
This paper further discusses the various techniques which are being used to combat riverine floods, and attempts to investigate into the preventable causes of flash floods.

Keywords: infrastructural floods, drainage-system, natural disasters, NDMA, pre-emptive planning

Introduction

From the time of the inception of the Earth to its present form, geomorphological changes have greatly contributed in shaping up the Earth. For Mankind, these changes have often been harbingers of destruction, and as such, these changes which have often been referred to as "natural calamities". As these calamities have been a regular occurrence in many areas and across all geomorphic ages, we have acknowledged that they shall continue to occur in the future also. No means of preventing these calamities have been discovered, hence, they will occur whenever

The degrees of their destructive power are highly variable. These calamities have supposedly been the sole cause of the destruction of many an ancient civilization, and even today, they continue to pose a grave threat to the future of human civilization. Nevertheless, with rapid advances in science and technology, the human race has succeeded in developing various tools and mechanisms to reduce, if not entirely prevent, the damage caused by natural calamities. This human attempt to minimise the impact of natural calamity can be described as the fundamental concept of Disaster management.

An interesting distinction has been made between a "disaster" and a "calamity". It is usually accepted that any large-scale geological change which causes disruption of the any particular area of the Earth's topography falls into the category of a calamity, while a disaster is classified as that calamity which causes considerable damage of human life and property.

In this century, in view of the ever-changing thermo-dynamics of global warming and climate change, preparedness in the domain of disaster-management is indispensable to the survival of mankind. Although science has been making giant strides in dealing with climate change, but we still cannot afford to be complacent, especially in light of the latest geographical dynamics. Therefore, it is imperative to study each branch of disaster management in its full depth and innovate newer ideas to mitigate the dangers posed by different natural calamities.

There are many branches of disaster management which vary from type to type of calamities. There are many types of natural calamities, like volcano eruptions, cyclones, floods, tsunamis, earthquakes, wildfires, etc., but perhaps the highest amount of destruction has been witnessed due to floods and earthquakes. No doubt, volcano eruptions or deep-sea tsunamis have a greater geographical scale of destruction, but the loss of human life and property has been recorded maximum in cases of floods and earthquakes.

From 2002 to 2013, India was among the five countries most frequently hit by natural disasters. According to the World Risk Index 2014, India is in the top half of all countries at risk from natural hazards.

India is vulnerable in varying degrees to a large number of natural as well as man-made disasters —

- 58.6 per cent of the landmass is prone to earthquakes of moderate to very high intensity;
- Over 40 million hectares (12 per cent of land) is prone to floods and river erosion;
- Of the 7,516 km longcoastline, close to 5,700 km is prone to cyclones and tsunamis;
- 68 per cent of the cultivable area is vulnerable to drought
- Hilly areas are at risk from landslides and avalanches.

Disaster risks in India are further compounded by increasing vulnerabilities. These include the ever-growing population, the vast disparities in income, rapid urbanisation, increasing industrialisation, development within high-risk zones, environmental degradation, climate change, etc. Clearly, all these point to a future where disasters seriously threaten India's population, national security, economy and its sustainable development.

Existing Flood Management Mechanisms in India

- **Central Water Commission (1945):** to achieve the goal of furthering and promoting measures of flood control,

conservation and utilization of water resources throughout the country in the areas of beneficial uses, irrigation and hydropower generation, flood management and river conservation.

- **Brahmaputra Board (1980):** it includes among others preparation of master plans to control floods, bank erosion and improvement of drainage system for Brahmaputra and Barak basin
- **Ganga Flood Control Commission (1972):** Set up for preparation of comprehensive plan of flood control for Ganga Basin and to draw out a phased coordinated programme of implementation of works and monitoring & appraisal of flood management schemes of Ganga basin States
- **Farakka Barrage Project Authority:** To carry out anti-erosion and river bank protection works in its jurisdiction
- **National Disaster Management Authority (2005):** the Government of India has set up NDMA under Chairmanship of PM of India to prevent and mitigate effects of disasters including flood disasters and for undertaking a holistic, coordinated and prompt response to any disaster situation

On 23 December 2005, the Government of India (GoI) took a defining step towards holistic DM by enacting the Disaster Management Act, 2005. Furthermore, Section 23 of the DM Act 2005 provided that there shall be a Disaster Management plan for every state. It also provides for annual review and updating of the state plan, it provides for the departments of the state governments to draw up their own plans in accordance with the state plan.

Sendai Framework

India's National Disaster Management Plan is consistent with the approaches promoted globally by the United Nations, in particular the Sendai Framework for Disaster Risk Reduction 2015-2030 (hereafter "Sendai Framework") adopted at the Third UN World Conference in Sendai, Japan, on March 18, 2015 (UNISDR 2015a) as the successor instrument to the Hyogo Framework for Action 2005-2015. It is a non-binding agreement, which the signatory nations, including India, will attempt to comply with on a voluntary basis.

The approach to disaster management has changed as now it is more outcome-centric rather than just a set of guidelines for actions post the disaster. It has ensured that there must be an exclusive governance approach for disasters, i.e. it has ushered Disaster Management in the domain of policy-making, thereby making the government responsibility.

Most importantly, the Sendai Framework has placed almost equal importance on all kinds of disasters and not only on those arising from natural hazards. Further, it also incorporates as loss the environmental damage that occurs as a result of a natural calamity.

Early Warning Systems in place

Cyclones

- Indian Meteorological Department (IMD) is mandated to monitor and give warnings regarding Tropical Cyclone (TC). Monitoring process has been revolutionized by the advent of remote sensing techniques. A TC intensity analysis and forecast scheme has been worked out using satellite image interpretation techniques which facilitate forecasting of storm surges.
- The meteorological satellite has made a tremendous impact on the analysis of cyclones. INSAT data has also been used to study the structures of different TCs in the Bay of Bengal. IMD is also producing Cloud Motion Vectors (CMVs). Very High Resolution Radiometer (VHRR) payload onboard INSAT –2E which have been improved upon to provide water vapour channel data in addition to VIS and IR onboard INSAT – 2E. A separate payload known as Charged Couple Device (CCD) has also been deployed onboard this satellite.

Flood

At present there are 166 flood forecasting stations on various rivers in the country which includes 134 level forecasting and 32 inflow forecasting stations, river-wise break up. The flood forecasting involves the following four main activities:

1. Observation and collection of hydrological and hydro-meteorological data.
2. Transmission of data to forecasting centres.
3. Analysis of data and formulation of forecast.
4. Dissemination of forecast

In the contemporary era, global warming has accelerated the rate of increase in the earth's temperature. This rise is slowly resulting in the melting of glaciers at the poles and ultimately causing the sea-levels to rise to unprecedented levels. This has increased the probability of frequent flooding in the near future. The coastal areas and sea-islands have become alarmingly vulnerable to tsunamis in this scenario. In the interior landmass, the floods are manifesting into many other forms of challenges. These can be broadly divided into - (a) The urban infrastructural challenges owing to floods and, (b) The flash floods in hilly terrains.

Urban Infrastructural Floods

Population residing in urban areas in India, according to 1901 census, was 11.4%. This count increased to 28.53% according to 2001 census, and crossing 30% as per 2011 census, standing at 31.16%. According to a survey by UN State of the World Population report in 2007, by 2030, 40.76% of country's population is expected to reside in urban areas. As per World Bank, India, along with China, Indonesia, Nigeria, and the United States, will lead the world's urban population surge by 2050.

Most geographical areas have a naturally-developed drainage owing to choes, streams and rivulets but over time, rampant urbanization has overtaken these drainage-outlets with unauthorized constructions, leading to drainage concession.

- **Gurgaon, a city without a systemized drainage:** This is a prime example of such a development, where its sudden urbanization and needs of the IT-industry and growing population led to a responsive rather than a pre-emptive approach. Urban infrastructure came up much faster to accommodate the residential needs, and disaster-preparedness disappeared in to the background. As a result, the city's infrastructure is hardly synchronous with its geographical drainage, and the post-dated efforts are

causing not only financially stress on the government, rather are also not as effective in prevention of huge losses in case a calamity strikes.

- **Repeated Mumbai Floods:** Yet, Gurgaon is only a recent example. The well-known example of a city like Mumbai, which suffers huge irreparable losses every year in the monsoon due to heavy downpour is a glaring proof of the insurmountable challenge of trying reduce an established city's vulnerability to disasters. The inconvenience and destruction caused by the heavy monsoon rain brought the financial capital of India to a virtual standstill. Mumbai, being a coastal area, is prone to the problem of high tides which results in backflow of this water to the interior of city. This backflow is compounded by heavy rains which go on to flood the roads and streets of Mumbai with water. Thus, there is an urgent need to construct compact gates (similar in nature to the sensor gates of Netherlands, half of which stays below sea-level) on the entry points from where the water enters the city. Secondly, since it is obvious that heavy monsoon is likely to cause heavy destruction, it is advisable that the drains of the city should be cleaned properly atleast two months before the arrival of monsoon. Plastic Waste and garbage which creates blockades in the drains must be cleaned well in time to ensure that water easily seeps into the ground without to stagnating on the roads and streets.
- **Chennai under deluge:** An important factor in the deterioration of urban environmental infrastructure is the unplanned construction of houses on an inadequate level of elevations. High-rise buildings are being constructed on low-lying areas foundational causing them huge damage during floods. A glaring example of this negligence is the Chennai airport which was recently devastated due to severe flooding of the Chennai City. The flooding has been entirely blamed on visionless infrastructure development as it has been constructed on a low lying area.

Indian urbanization has suffered from lack of comprehensive pre-emptive city planning. The vulnerability of urban infrastructure to natural disasters, such as earthquakes, flooding due to torrential rains, etc., is the biggest challenge to the governmental schemes of mitigating the impact of climate change. Owing to the sporadic growth of urban areas, cities have been built in a largely unplanned manner without any far-sightedness to the future contingencies of natural calamities. There are very few cities which were developed from scratch, rather most of India's cities are urban islands which grew on their own due to amalgamation of people from various nearby rural regions owing to these areas being a focal point for the population to converge due to their comparatively better connectivity, educational or vocational avenues or professional opportunities. It would not be entirely wrong to state that India hardly has any pre-planned cities which are developed with a dedicated earmarked plan which takes into account all future challenges, be it weather-preparedness, future expansion, or even a basic well-drained sewerage system.

Compounding these problems are the developers of private-colonies who routinely indulge in blatant violation of construction rules laid down by the Indian laws. It is an established truth that the government allows these multi-storey residential accommodations to proliferate unchecked, as our Building-Violation Code has witnessed unsatisfactory implementation. Hence, the architecture of these buildings pays mere lip service to the structural requirements as per municipal corporations of any urban area, devised to safeguard the urban infrastructure.

The other aspect of our failure to counter natural disasters is the lack of preparedness on part of respective municipal corporations in the Metropolitan cities. The civic officials and our government have to often rely on our Army and other defence and paramilitary services to tackle the situation and bail us out. Even after 70 years of Independence, we are still in the cradle in view of our disaster-management abilities. This is mainly because of lack of trained personnel in municipal corporations and other local governance bodies. The local governments must be empowered so that they can take spontaneous and independent decisions without delay in such emergency situations when they are needed the most. There also exists a lack of proper co-ordination between the Centre and States, due to which the damage inflicted by the natural calamities reach unprecedented levels.

Flash Floods

Deforestation was the primary cause of floods in Uttarakhand. The worst damage has been observed in those regions which have largest tracts of forested land diverted for hydro-projects, road infrastructure, etc.

As per reports from the Union Ministry of Environment and Forests (MoEF), 44,868 ha of forest land have been brought under non-forest use in Uttarakhand since 1980. Minimal damage has been reported in those areas where the natural topography has been dealt with consideration while planning any infrastructure. In this very calamity, Kedar Valley saw very few landslides as compared to the Valley of Flowers, Nanda Devi Biosphere Reserve and regions around Joshimath where many villages were swept away by landslides due to cloudburst.

The second are the river bank encroachments which have also accelerated problems caused by floods to higher levels as these encroachments destroy the natural border between the river bodies and the land. The guidelines clearly state the many hazards of building any infrastructure on river-bank encroachments without proper assessment of their carrying capacity.

Thirdly, sand-mining and quarrying have hollowed out huge tracts of land leading to destabilizing the earth in adjacent areas. This poses as the greatest danger as in case of some geological disturbance, the entire ground shifts which impacts the foundations of the buildings causing their collapse.

The conservation of wetlands can also help a great deal to minimise the impact of floods. Wetlands are considered as the Kidneys of the ecosystem because they act as a natural buffer between the river bodies and land. If actively conserved, these can help in slowing down the flow of floods.

River Floods

The oldest and most commonly occurring water-based disasters

are geomorphological floods. In India, the most severely hit areas are those of the Ganga and Brahmaputra basins, especially the deltaic areas.

These encompass Central-East and Eastern India. As these rivers reach their mature stage, they slow down due to the heavy silt they carry, which is deposited across these areas and thus, it causes shifting in the course of river-flow. This makes it extremely difficult to anticipate their courses every year.

Studies have reported that over the next two or three decades, the Ganges-Brahmaputra-Meghna basin, will be at increasing risk due to multiple factors such as rise in sea-level, growing population pressure, and poor maintenance of reservoir of dams on these rivers. These are basins with high economic dependence on water resources, low levels of social well-being and high exposure to floods and droughts.

This will prove to be a greater administrative challenge as these areas are also simultaneously afflicted with poverty, extremism and armed conflict.

- **De-siltation Plan:** The Ministry of Water Resources, River Development and Ganga Rejuvenation, has constituted a committee to prepare guidelines for desiltation of river Ganga from Bhimgauda (Uttarakhand) to Farakka (West Bengal). The bank area of a deltaic river channel is highly influence by tidal conditions. When the river is in low tidal level, the bank of river channel is further exposed, but in a high tide situation, when the river is full to its brim, much of its bank area is inundated.
- **Inter-linking of rivers:** Although the most capital-intensive, yet it is the most efficient use of excess waters from constant flooding of rivers. This water shall be transported to drought-prone areas, thereby effectively solving twin problems of floods and droughts.
- **Flood plain zoning:** It is a concept central to flood plain management. It recognises the basic fact that the flood plain of a river is essentially its domain and any intrusion into or developmental activity therein must recognise the river's 'right of way'. Thus, this follows that it is the administration's duty to make people aware of the flood-plain zone of a river and dissuade the creation of permanent settlement of the people in the areas subject to frequent flooding.
- **Flood-proofing:** The government must create necessary infrastructure to ensure that villages in flood-prone areas are raised above the dangerous levels, and given proper road connectivity to safer districts.
- **Lift canal/ Lift Barrage Systems:** In this water is not transported by natural flow but lifted with pumps, etc. First this water is carried to the main delivery chamber from the water source. Then water is distributed to the beneficiary area by means of proper and suitable irrigation.

Recently, we have successfully completed the Pattiseema Lift Barrage to avoid flooding of the new canal built between the rivers Krishna and Godavari, and also to ensure proper distribution of water to nearby areas.

Research Methodology

Extensive review of literature was done to collect information and get a fair understanding of previously conducted research on similar issues, and analyzed in order to understand the different aspects of the problem and its preclusion.

Qualitative content analysis was conducted as per the need of the study. Content analysis is a methodology by which the researcher seeks to determine the content of written, spoken or published communication by systematic objective and quantitative analysis.

Present paper is an evaluative analysis in which the most recent data was used from policy documents, surveys and updated results published by Government of India and its various Ministry portals.

Conclusion

The first hour after the calamity strikes is the Golden hour which must be fully utilized to control the complexities in their initial phase itself. Disaster Management has ceased to be merely a reactive practice, rather now has developed a holistic approach to countering all types of disasters, natural and man-made. It includes not only a set of guidelines to be followed after disaster strikes, but also all the preventive efforts as well as the pre-emptive planning, that requires to be made. In a world experiencing the unprecedented effects of climate change, we must be well-equipped to mitigate with future disasters and ensure minimum loss of life and property.

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