

## Managed retreat as an adaptation tool for inland and coastal flooding

Increasing instances of flooding by inland rivers in India are making large populations vulnerable. Globally, rise in sea-water levels is likely to affect more than 300 million people by 2050. By the end of 21st century, sea levels in the Indian Ocean are likely to rise by about 0.5–0.8 m depending on how the climate evolves. Global warming will trigger more intense cyclones, storm surges and heavy rainfall. Sea-level rise will also increase saltwater intrusion in coastal aquifers.

Broadly, three types of adaptation mechanisms are followed to manage floodwater. First, keep away the harm-causing water by structural measures such as dams/diversions. Second, live in manageable proximity to water. The third measure is getting out of the water's way. This is useful when water threat is unmanageable and the best option is move away. This migration approach is termed as managed retreat (MR).

Since time immemorial, people have migrated to escape water and climate-related long-term disasters. Climate change is one of the likely causes behind the decline of the Indus Valley Civilization. Migration of population from the region due to a prolonged, 200 years or longer, drought may have triggered the decline of this Civilization. Climate change also accelerated migration of people in the western Roman Empire around AD 480 and Mayan Empire (AD 660–1000). Migration is practiced in the current times as well; for example, to avoid harsh climate, some states have two capitals – summer and winter. Temporary relocation is a common strategy to minimize damages during cyclones or similar events. Migration is not restricted to humans. It is a natural phenomenon in some animals too. Migratory birds fly thousands of kilometres to overcome harsh winter climate, food shortage, etc.

Responding to natural disasters, people adopt different measures. Floodplain zoning is a scientific and effective adaptation method to manage riverine flooding. *In situ* adaptations are actions that are carried out while continuing to stay at the same place. Traditional communities frequently prefer *in situ* adaptation over resettlement. Such adaptation, however, has its limitation; it fails if the magnitude of a disaster exceeds a certain value. In such cases, it may be often better to relocate to a safe location. Adaptation measures for sea-level rise include building barriers such as seawall

and lifting small houses to higher levels. These measures, however, can only provide relief for some time, which may be utilized to plan for a coordinated retreat. MR is defined as 'the purposeful, coordinated movement of people and assets out of the harm's way'. The word 'retreat' should not be seen in a negative sense; it implies 'strategic relocation' and migration is often seen as a measure of last resort. Well thought-out plans are necessary so that people do not relocate from one hazard-prone area to another.

Although MR is an old concept, it is gaining prominence now because some emerging threats due to climate change will be impossible to manage by conventional measures. Floodplain zoning is also a form of MR. Despite its advantages, MR has its own set of psychological, institutional, and practical challenges. Different methods have been proposed to overcome these, e.g. interdisciplinary collaboration, research–practice partnership, communication, leadership, vision, etc.

Several countries, including USA, are now practising MR. The Netherlands has successfully completed a project known as 'Room for the river', wherein people living in areas adjacent to rivers which are likely to be inundated by floods, were relocated to safer places. In Japan, new towns have been built to relocate people hit by a tsunami generated by the massive earthquake of 2011. In India, people are temporarily relocated to shelters in case of severe cyclones and this has dramatically reduced the number of deaths due to calamities. MR is considered as a mitigation option as it 'avoids the unmanageable (mitigation)' instead of 'managing the unavoidable (adaptation)'.

India's coastline extends to about 7500 km. By 2100, 36 million people are likely to be living in areas prone to flooding. Some infrastructure in many Indian coastal cities (Mumbai, Chennai, Kochi, Vishakhapatnam, Thiruvananthapuram and Mangaluru) may be submerged by 2050 due to sea-level rise. Many landmarks in Mumbai are at the risk of submergence. However, rather than retreat, we are witnessing advancement towards coasts. Maps of urban sprawl of coastal cities such as Chennai, Mumbai, etc. show that the number of people living near the coasts is increasing. In addition, a large (and increasing) population is living dangerously close to rivers and other disaster-prone areas.

India has a high population density. Among the large countries, India has nearly 420 persons/km<sup>2</sup> compared to

3.8, 25 and 33.5 persons/km<sup>2</sup> in Canada, Brazil and USA respectively. Per-capita land is rather limited. The vulnerable population in India is much more than in other countries and is likely to increase with time. The tendency to construct houses near water bodies could not be satisfactorily controlled so far. At present, a relief-centric approach is commonly followed, wherein compensation is provided to people affected by, for example, river flooding.

India lacks resources to move all vulnerable people to 'safe' areas. Almost all fertile and habitable areas are overpopulated. Large parts of the country are facing water scarcity and are drought-disaster-prone, and these should be avoided while making relocation plans. Large tracts (e.g. the Western Ghats) are restricted areas due to environmental and other reasons. Metropolitan cities which have better job opportunities are already over-crowded.

India has a long experience of rehabilitation and resettlement (R&R) of people affected by infra projects. The provisions of the R&R Act, 2013 apply to land acquisition, compensation, rehabilitation and resettlement, when the Government acquires land for its own use for infrastructure projects or other strategic purposes. R&R policies have evolved with time and currently good compensation is provided to those affected by infra projects. Other related Acts/policies are the National Disaster Management Act, 2005; the National Policy on Disaster Management, 2009; the National Disaster Management Plan, 2019, and the Coastal Zone Regulation Act, 2018. Currently, MR is not covered in these Acts. These Acts/policies need updating in view of emerging threats. Mechanisms concerning funding are to be developed. For example, who will fund the expenses – Central or State Governments? Which costs will be funded (lands, houses, etc.)? And so on.

In many documented cases (Kendrapada district, Odisha; Sundarbans in the Ganga–Brahmaputra Delta, West Bengal and Majuli Island, Brahmaputra Valley, Assam), relocation was found to be an adaptation option less preferred due to high economic and socio-cultural costs. However, it is emphasized that in many situations, relocation is the only viable option. Among the inland locations, Assam is highly vulnerable to extreme climate events such as floods and droughts.

In India, many people live in disaster-prone areas. In future, people living on lands likely to be affected by water would have to be relocated inland, preferably in the same state. New developments in disaster-prone/vulnerable areas should be carried out after thorough risk assessments.

A good practice would be to begin relocating people at the earliest to lessen their hardships, gain experience, feedback and improve. To this end, it will help identify places that are likely to become unlivable in next the 25, 50 years, etc. and also, those to which people can migrate. Suitable relocation sites should be identified based on multiple considerations, e.g. hydrological, climatological, geological and environmental. One must also consider the possibility of damage due to compound disasters. The published literature contains case studies that demonstrate how to prepare hazard, risk, vulnerability and exposure maps of an area. Such maps are invaluable in identifying hotspots of hydro-climatic disasters and enable the decision-makers to take risk-informed decisions.

India lacks a comprehensive policy to address displacement of people due to climate or natural hazards. Hence, we need to make enabling policies and implement them. The Indian states are preparing action plans to manage climate change impacts. These plans need to consciously consider MR.

In India, communities mostly prefer *in situ* adaptation over relocation. Despite risks, most people vulnerable to climate-related disasters do not want to leave their homes. They attempt to develop new livelihoods and coping strategies, and consider that migration would mean losing their social relationships and networks that help them survive in the aftermath of disasters. IPCC notes that *in situ* adaptation options are frequently the preference of communities over resettlement and in many documented cases, relocation – both planned and autonomous – is not a preferred adaptation option. Hence, it is desirable to develop and implement MR plans that address the concerns of vulnerable communities. Finally, a single adaptation measure will not work for all the situations. We need to design adaptation plans at regional and local levels in consultation with stakeholders and learn from the experiences of other countries.

Sharad K. Jain<sup>1,\*</sup>  
Subhankar Karmakar<sup>2</sup>

<sup>1</sup>Indian Institute of Technology Roorkee,  
Roorke 247 667, India

<sup>2</sup>Indian Institute of Technology Bombay,  
Mumbai 400 076, India

\*e-mail: s\_k\_jain@yahoo.com