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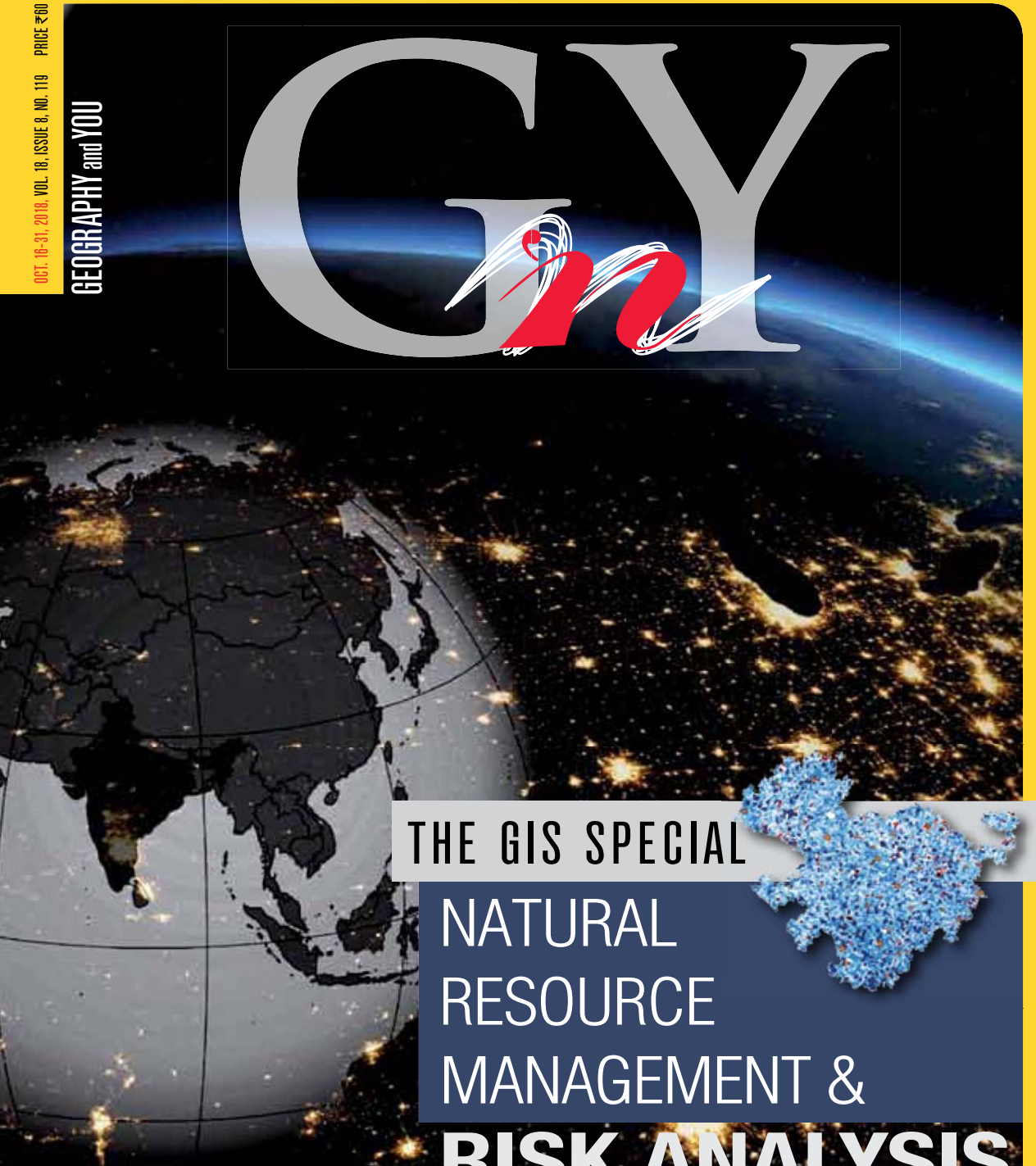

THE GIS SPECIAL

NATURAL RESOURCE MANAGEMENT & RISK ANALYSIS

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■ g-Governance in India ■ GIS and Higher Education ■ GIS and River Floods ■ New Techniques to Avoid a Kerala like Disaster ■ Soil Erosion Risk and GIS Techniques

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With the help of GIS we can build models highlighting the flood-susceptible areas. These models will further aid in the creation of flood prediction and early warning systems.

GIS & RESOURCE

GIS and Remote Sensing in Natural Resource Management
Pushpanjali, Josily Samuel & Visha Kumari
GIS and remote sensing serve as a platform to generate information and make wise decisions for sustainable development of natural resources.

Role of Geospatial Technology for Monitoring Natural Resources
Neeti
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GIS & DISASTERS

New Techniques to Avoid a Kerala like Disaster
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GIS and River Floods
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Soil Erosion Risk and GIS Techniques
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Predicting natural disasters in advance through GIS will help to efficiently plan disaster management strategies.

IN BRIEF
Letters; Editor's note; GIS Updates; Term Power; Term Power Rating; Books & Websites

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COVER PHOTO
NIGHT LIGHTS IN INDIA AND A GIS WATER-USE MAP OVERLAY

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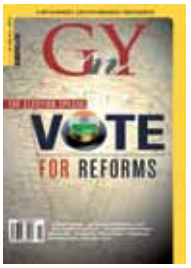

OCTOBER 1-15, 2018 VOL. 18 ISSUE 7, No. 118: The article on public funding of elections was quite informative. It highlighted the importance of this key part of our democratic process, and what public funding of elections would entail, using examples from all around the world. The equalising influence, as proposed by John Rawls, when applied to the visible lack of the same in the 2014 General Elections, firmly puts the spotlight on the need for strict regulations and transparency in our election process. Please continue publishing such informative articles.—VENKATESH SHANKAR *via Email*

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ALTHOUGH I HAVE NO complaint about the content, but I find the quality of the print-copy binding very poor. Having said that, I must mention that the 'Water Ownership and Accountability' Vol. 18, issue no. 113 was simply great.—ADARSH KUMAR SINGH *via Customer Feedback*

I WILL HAVE TO say that G'nY publishes very informative content. In my opinion more articles pertaining to recent trends in geomorphologic studies must be incorporated in the magazine. Also, not all the articles should be theme based, some articles from other domains may also be included to make the magazine more interesting.—KAVIYARASAN R *via Customer Feedback*

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The Editorial Advisor.

Extreme rainfall events need not result in debilitating floods. With proper monitoring and forecasting disasters like Kerala may be avoided.

PHOTO COURTESY: STEPHANIEMONOT

By **Giriraj Amarnath**

NEW TECHNIQUES TO AVOID A KERALA LIKE DISASTER

Kerala has witnessed one of the most devastating floods in 2018. To reduce future occurrence and the impact of such disastrous floods, it is imperative to focus on measures of greater resilience.

Kerala, with its magnificent natural landscapes and fertile valleys, is often described as 'God's own country'. During June to August 2018, unusually heavy summer monsoon rains dashed this idyllic image, causing disastrous floods across the State. These were the worst floods the state has witnessed since 1924, resulting in the death of more than 324 people and requiring at least a million to be relocated (Babu, 2018). The districts suffering the severest damage were Chengannur, Pandanad, Aranmula, Aluva, Chalakudy, Kuttanad and Pandalam. However, all 14 districts of Kerala were placed on red alert (Varghese, 2018, G R, 2018, BBC News, 2018, Mathrubhumi News, 2018). According to the Kerala government, one-sixth of its total population was directly affected by floods and related incidents (Press Trust of India, 2018). The Indian government declared this a level three calamity, or 'calamity of a severe nature'.

In an unprecedented response to the heavy rainfall (Fig. 2), floodgates of 35 of Kerala's 54 dams were opened. At Idukki, for example, all five floodgates of the dam were opened simultaneously for the first time in 26 years. Heavy rains in Wayanad and Idukki caused severe landslides and left the hilly districts isolated (Mathrubhumbi News, 2018).

Crop damage

Continuous heavy rainfall in Kerala led to extensive flooding of agricultural lands, resulting in crop losses with an estimated value equivalent to INR 150 to 200 billion (Shenoy, 2018). Coffee, rubber, tea and black pepper were amongst the crops most affected. The extent of the damage to coffee, tea, cardamom, and rubber plantations is not yet clear. In rural Kerala, many farmers may not be able to harvest at all this season. Also, many lack adequate access to insurance to aid their recovery.

Insurers to take a big hit

Insurance claims resulting from the floods have been initially estimated at INR 5000 million. The situation for insurance companies is not as disastrous as the case of floods in Chennai or Jammu and Kashmir where approximately INR 50,000 million and INR 20,000 million were paid, respectively (Sinha, 2018). The Insurance Regulatory and Development Authority (IRDA) of India has instructed the insurance companies to settle all claims expeditiously. Given the magnitude of the tragedy, there is considerable pressure on insurers to ensure immediate cash flows. Health insurance companies could also take a hit due to an increase in waterborne diseases resulting from the floods.

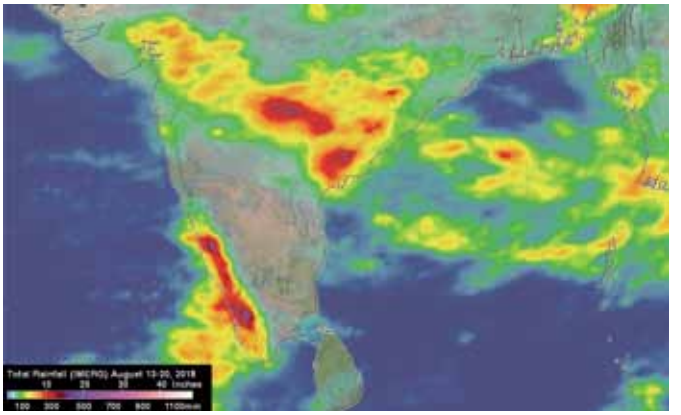
Responding to future disasters

In addition to examining and managing the immediate consequences of the Kerala floods, the obvious question to ask now is what can be done to cope more effectively with future water related disasters, thus reducing damage and loss of life. Described below are ten measures that could contribute to greater resilience, as such threats become more frequent and severe.

Improved flood forecasting: The first step is to take advantage of recent improvements in flood forecasting. One critical limitation in India and other developing countries is the lack of monitoring networks, which prevents near real-time flood prediction. In response, researchers at International Water Management Institute (IWMI) and elsewhere are developing new techniques that use increasingly available satellite sensors to forecast floods based on river discharge. Radar altimetry, for example, accurately estimates water levels and river discharge—showing much potential for places where there is no river monitoring network (Tarpanelli et al, 2018). This technique is limited, however, by the low revisit time of the satellite, leading to delays in flood prediction. To overcome this, researchers have used the artificial neural network technique to merge data from multiple sources, including different satellite missions and optical sensors as well as radar altimetry. In a study, researchers found this multi- mission approach to be the most reliable tool for estimating river discharge (ibid).

Better insurance products: Flood insurance for crop damage and insurance pooling for extreme flood events is a must. IWMI and Consortium of International Agricultural Research Centers' (CGIARs) Research Programme on Climate Change, Agriculture and Food Security (CCAFS) developed the index based flood insurance (IBFI) for Bihar (Fig. 5) in collaboration with global reinsurer Swiss Re (Amarnath and Sikka, 2018). Scientists first examined past satellite images to

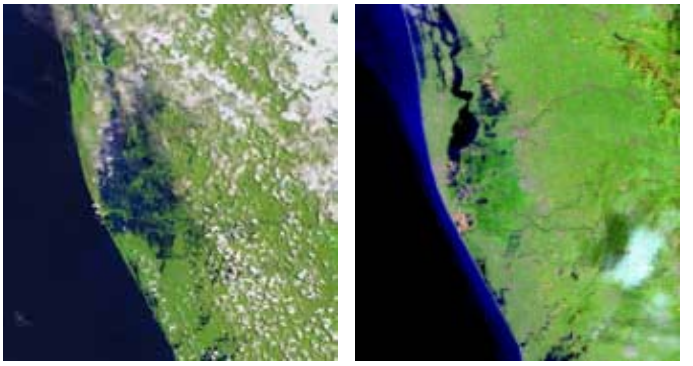
Fig. 1: Rainfall in India during August 13-20, 2018



Kerala witnessed an average rainfall of more than 300 mm in the month of August, 2018.

Source: NASA

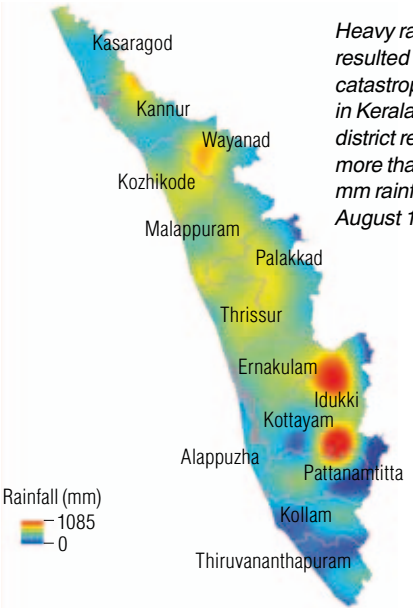
Fig. 2: Satellite images showing Kerala before flooding (left), i.e., on February 6, 2018, and during flooding (right) on August 22, 2018



These are false-colour images, in which floodwaters appear dark blue and vegetation bright green.

Source: US National Aeronautics and Space Administration (NASA)

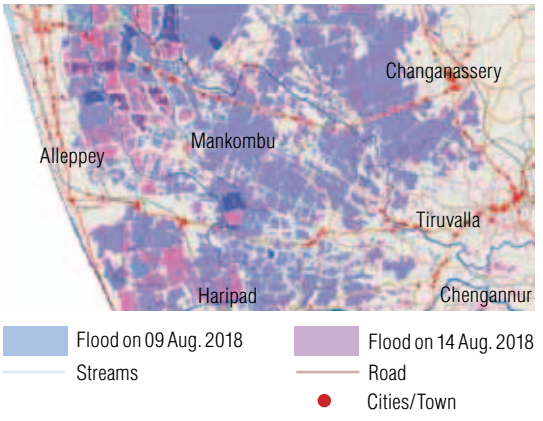
Fig. 3: Rainfall pattern in Kerala during August 12-18, 2018, which resulted in catastrophic floods



Heavy rainfall resulted in catastrophic floods in Kerala, with Idukki district receiving more than 1,085 mm rainfall between August 12 and 18.

Source: India Meteorological Department, Pune

Fig. 4: Flooded areas detected using data from the JAXAALOS-2 PALSAR-2 satellite during August 9-14, 2018



Following heavy rainfall in Kerala over almost all the districts were inundated. The initial map estimates the overall flooding across these districts, based on data from European Space Agency.

Source: International Water Management Institute

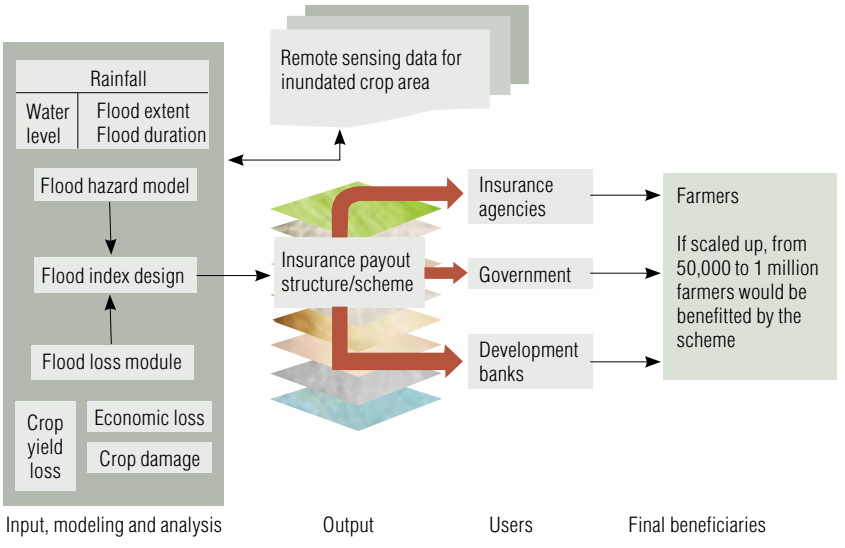
identify historic floods and prepare a flood risk map. Villages in three locations were selected for the pilot; one in an area at high risk of flooding, one in a place with a medium risk and one with a low risk of inundation. The scheme went live in July 2018, with a total insured sum of around INR 5 million (about USD 78,000). For the pilot, the Agriculture Insurance Company of India (AICI) agreed to pay out money to farmers based on scientific data indicating the actual depth and duration of flood waters in the paddy fields. In the initial stage of the pilot, which covered rice crops for the 2017 monsoon season (from early July until the end of October), the insurance product was fully subsidised, with the project making premium payments on behalf of the farmers, for a total insured value of INR 46 million. Crop insurance has become critical, particularly in view of increased agricultural shocks due to vagaries of nature and it is not only vital for smallholders' wellbeing, but also for the national food security and stability.

Giving the floodplain back to nature: Much of the damage caused by floods in Kerala and Chennai was a direct consequence of indiscriminate human encroachment on the river and other water bodies. As long as primary economic activity continues on the floodplain, measures such as improved forecasting will be of little help. To fundamentally reduce vulnerability in the face of future disasters, government authorities need to delineate the 100 year floodplain—i.e., the area in which occurs more than 1 per cent chance of flooding in any given year; and strictly regulate development in this area.

Climate screening of development projects: To better manage current and future risks in these areas, the government and its development partners can resort to strict use of climate screening tools to clear development projects for implementation, based on the risks they pose in terms of land, water and ecosystems. Projects involving a higher risk level, given increasing climate variability, would require further innovation in order to proceed. There is clear need for a more holistic systems approach to agri-food system that takes into account the impacts with interactions between nature, humans, and agri-food systems which is being implemented by CGIAR Research Programme on Water, Land and Ecosystems (Amarnath et. al, 2017).

Healing the ecosystem: Over time, settlements must be shifted out of the floodplain, giving it back to nature. Sound plans need to be implemented to help the river basin ecosystem heal. These plans should include measures such as strict regulation

Fig. 5: Concept of Index Based Flood Insurance (IBFI), integrated flood hazard model, economic loss data and satellite images for index development



Source: IWMI

Dams can mitigate adverse impacts of water variability and extreme climatic events .

of sand mining and other activities that directly affect river flow. Also important are planned flooding of the river downstream, which mimics the annual flood cycle, to manage fluvial sediment in the river and the reservoir. Encroachment of roads, houses and other structures onto the floodplain, as well as various types of land use (such as high-value agriculture) may limit the scope for controlled flooding, although some degree of high-flow restoration should still be possible. Enhanced water releases from dams are sometimes used to dilute downstream discharge of wastewater. In these cases, restoring naturally low levels of flow can be quite difficult, if not impossible, due to human health concerns (Yoon et. al., 2015).

More built infrastructure: Reservoirs constructed at the centre of river basins, based on feasibility studies, are vital to reduce the risk of water-related disasters through increased capacity for storing surface water. Dams provide numerous economic benefits and can mitigate the adverse impacts of water variability and extreme climate events. However, such large-scale water infrastructure has also caused significant social and environmental costs, prompting calls for alternative, nature-based solutions. The solution to this dichotomy is not to forego investment in built infrastructure, which remains essential for socio-economic development, but to give greater consideration to the role of nature in planning and operating large, built infrastructure.

Managing difficult tradeoffs: Sediment trapping in reservoirs may modify, to a large extent, the sediment transport downstream of the dam. This often results in modified channel and floodplain geometry, which in many cases represents a fundamentally different physical habitat to support native ecosystems. It may prove impossible to maintain some semblance of natural flow and sediment transport, including connections between the river and its floodplain. In that case, one must ask whether the ecosystem and species that can be supported through dam re-operation actually justify the social and economic costs.

Dam re-operation: Dam operation contributed, at least partly, to the flooding in Kerala (BBC, 2018). Physical constraints posed by dam infrastructure, especially the design of outlet works, can severely limit the rate at which controlled water releases from a dam can be managed, making it difficult or impossible to release water of variable amounts, ranging from low-flow to flood-flow rates (Richter and Thomas, 2007; Mul et al. 2015). In contrast to the large sums of money being invested in new dam construction, financers and international development organisations have not adequately supported dam re-operation that leads to modification of dam operations. Correcting this imbalance is critical for better enabling of low-income counties to operate dams as an integrated system rather than in isolation (Richter and Thomas, 2007).

A holistic approach: Individual measures aimed at mitigating flood risk and ecosystem impacts should form part of a holistic approach, based on an understanding of the various components of the urban water system as well as upstream and downstream relationships. Referred to as integrated urban water management (IUWM),the approach not only relies on flood models and the use of embankments to divert water but encompasses the entire water cycle—water sources and supplies as well as wastewater (such as its use for urban cropping) and storm water—viewing urban water in the wider basin context.

Institutional reforms: Better management of disaster risks, with the ultimate aim of achieving water security, can be a key driver for sustainable growth. To foster quicker progress toward this aim, responsibility for water management should lay with a single institution, which is able to take high level decisions on water use, implement measures to reduce disparities in water resources and respond to water related disasters.

Using nature for climate change adaptation in urban areas

In the wake of disasters like the floods in Kerala,

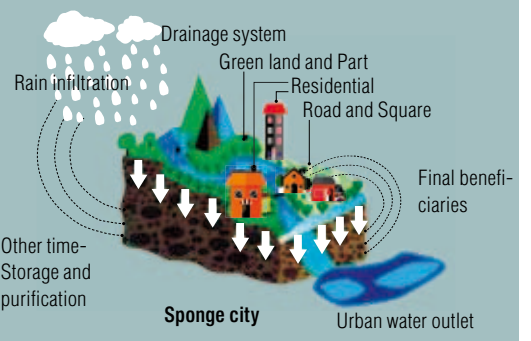
the standard response is to boost expenditures on dams and other 'grey' or built infrastructure. To achieve water security, however, societies need to invest as well in 'green' or natural infrastructure, such as wetlands, watersheds and floodplains (Boelee et al. 2017). These nature-based solutions have a proven ability to mitigate the impacts of water related disasters, while delivering other developments as well, such as food production and biodiversity preservation (Nesshöver et al. ,2017).

Nature-based solutions promoting green and blue urban areas have significant potential to decrease the vulnerability and enhance the resilience of cities in the light of climate change. Building on existing evidence and needs for future science and policy agendas when dealing with nature-based solutions are: (i) produce stronger evidence on nature-based solutions for climate change adaptation and mitigation and raise awareness by increasing implementation; (ii) adapt for governance challenges in implementing nature-based solutions by using reflexive approaches, which implies bringing together new networks of society, nature-based solution ambassadors, and practitioners; (iii) consider socio-environmental justice and social cohesion when implementing nature-based solutions by using integrated governance approaches that take into account an integrative and trans-disciplinary participation of diverse actors. Nature-based solutions can serve as climate mitigation and adaptation tools that produce additional co-benefits for societal well being, thereby serving as strong investment options for sustainable urban planning (Kabisch et al. 2016).

The solutions are often implemented in an ad-hoc manner, as is the case with conventional built infrastructure. Moreover, while there have been significant advances in the design and testing of nature-based solutions for risk mitigation, they have yet to be fully evaluated and standardised. As a result, some nature-based projects for climate adaptation and disaster risk reduction have been improperly designed, leading to unsatisfactory and unsustainable results.

There can be no 'one-size-fits-all' approach, given that weather hazards as well as the wider climatic and ecological conditions are variable and often poorly understood. Nonetheless, the conventional engineering sector has a long history

Sponge Cities: Flooding is widely considered to be the most serious water-related problem affecting many large south Asian cities. Rapid urbanisation; land use change and socio-economic development are making an already sizeable problem steadily worse. To address the problems of increasing flooding, water shortage and pollution caused by the traditional model of urban development, a new model—the Sponge City, is being developed. The concept is based on natural and ecological flows that allow storm water to be managed with natural infiltration, natural retention and detention, and natural cleaning facilities. It reflects new thinking about how to tackle surface-water flooding as well as related issues in urban water management, such as the purification of urban runoff, reduction of peak run-off and water conservation. The idea is to make better use of 'blue' and 'green' spaces in the urban environment for storm water management and control. This and related practices enhance natural ecosystems and provide more aesthetically pleasing surroundings for people living and working in urban environments, in addition to enhancing urban habitats for birds and other organisms. China has already begun to implement this approach in several cities, with the aim of achieving sustainable water use and better flood control (Fig. 6).



of fully developed protocols and standards, from which there is much to learn. Such guidance can aid project development and implementation, while also helping achieve a common understanding of the likely effectiveness of such solutions in reducing risks.

Endnote

The recent incidents of floods across Kerala have shed a light on the severe problems that induced the flood events. Given the reality of climate change, these flood disasters will escalate until some proactive measures are taken to mitigate them. There are several natural and man made ways to reduce the impact of these disasters and ensure societal well-being.

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