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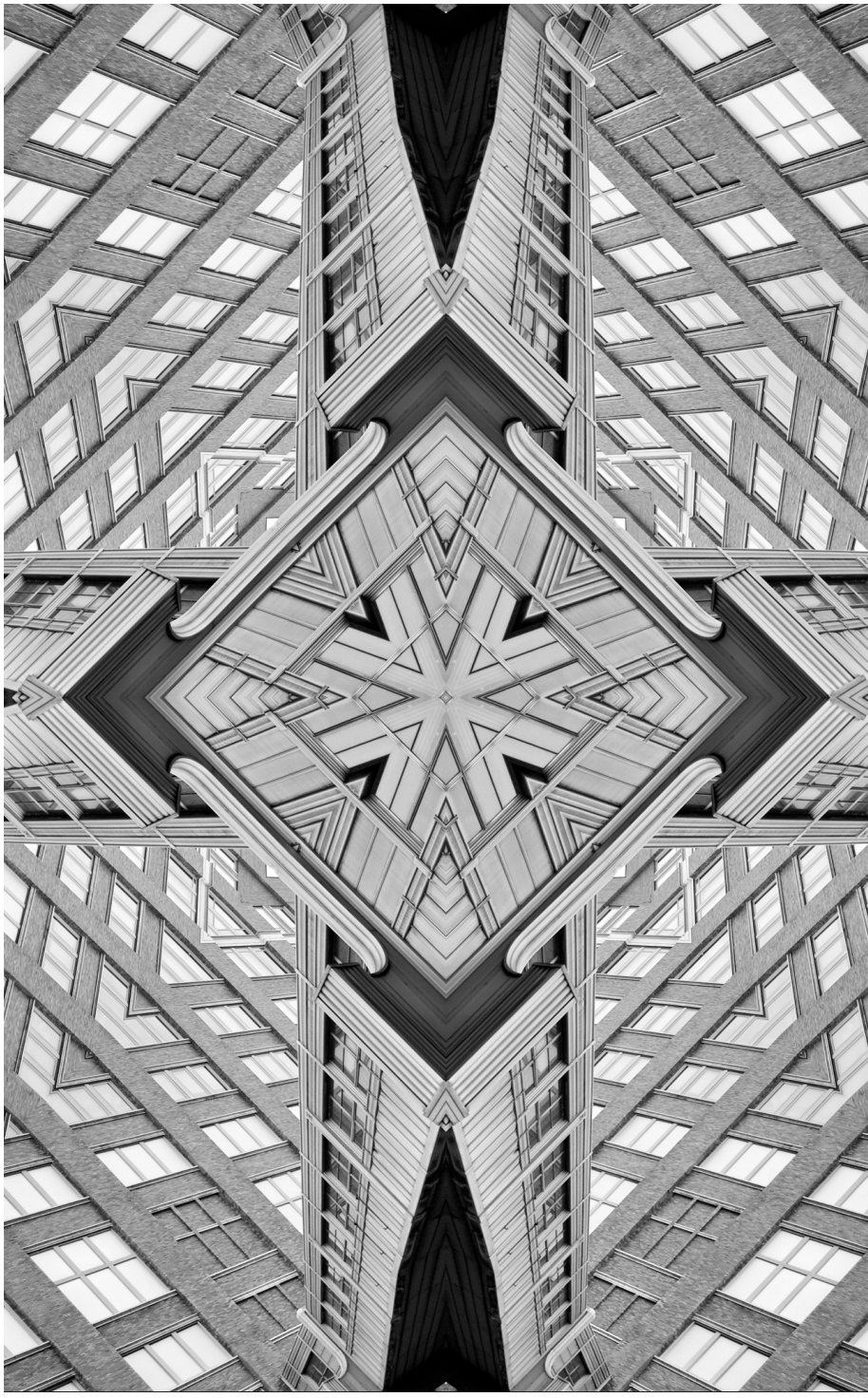

Understanding and Tackling Urban Floods in India

Ramanath Jha

Abstract

Given their frequent recurrence in Indian cities, the problem of urban flooding is gaining focus in policy discussions. Indeed, urban floods can cause massive loss of infrastructure, property, and lives, and have a substantial economic impact. To ensure they remain functional and secure, Indian cities must tackle the issue of floods by examining the urban over-densification problem and adopting innovative mitigation measures with the technical and financial support of the central and state governments.

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Introduction

The term urban floods refer to instances when a city receives massive levels of water due to heavy precipitation or other causes (such as rapid snowmelt or a storm surge caused by a cyclone or tsunami), which lead to the submergence of parts of or the entire city, and is coupled with the inability of the city infrastructure to drain the water quickly enough (or deal with it in other ways) to prevent inundation.[1] Climate change and rising temperatures have intensified the overflow of rivers and lakes, snowmelt, storm surges (such as hurricanes and cyclones), and abnormally heavy rains. This, coupled with locational vulnerabilities, have resulted in increased instances of urban flooding.[2] Flood incidents disrupt normal life, cause economic dislocation, destroy infrastructure, and may even result in the loss of lives. In recent decades, many Indian cities, both big and small, have had to contend with flood incidents, with larger cities such as Mumbai, Hyderabad, Chennai, and Bengaluru facing floods nearly every year.

This brief examines the issue of urban floods in India and globally, and recommends policy measures to tackle the problem.

The Urban Floods Phenomenon

Urban floods were not always a priority issue for the National Disaster Management Authority (NDMA),[3] which remained focused on assessing riverine floods that caused distress in rural areas.[4] Although many Indian cities had routinely experienced flooding in the past, there were no specific attempts to study the incidents and prescribe measures to deal with such disasters. However, the 2005 Mumbai floods—which were caused by an unprecedented cloudburst and resulted in widespread destruction because the civic administration was unprepared to tackle a disaster of that magnitude[5]—forced the NDMA to rethink its approach to urban floods, delinking it from other kinds of floods and addressing it as a separate disaster.[6] Indian cities are densely populated and are centres of economic activity with vital physical, commercial, industrial, and social infrastructure. As such, any disruptions caused by floods—or indeed any other disaster—will have serious national and global implications. This understanding led the NDMA to formulate the 'National Guidelines for the Management of Urban Flooding' to "boost…efforts for urban flood disaster management and strengthen the national vision of moving towards a more proactive pre-disaster preparedness and mitigation centric approach".[7]

Indeed, the threat of urban floods has risen exponentially in recent years.[8] In India, significant flood incidents were recorded in Hyderabad in 2020[9] and 2021;[10] in Chennai in November 2021;[11] in Bengaluru[12] and Ahmedabad in 2022;[13] in parts of Delhi in July 2023;[14] and Nagpur in September 2023 (forcing many residents to abandon the city and flee).[15] Smaller cities like Chandigarh and Gurugram (Haryana), Patna and Gaya (Bihar), Pune (Maharashtra), Jaipur and Sikar (Rajasthan), Bhopal and Indore (in Madhya Pradesh), Lucknow (Uttar Pradesh), Kochi (Kerala), and many in the hill states (such as Dehradun in Uttarakhand and Shimla in Himachal Pradesh) have also faced flood incidents in recent years.[16] Notably, in October 2023, many towns in the Northeastern state of Sikkim experienced flash floods, with a significant number of deaths and widespread destruction.[17,18]

Similar instances of urban flooding have been recorded in countries around the world. Between 2000 and 2009, for instance, many South African cities faced flood disasters, causing huge economic losses and 140 deaths.[19] In 2005, Hurricane Katrina caused floods in New Orleans, US, that resulted in more than 1,800 deaths and US$170 billion in damages.[20] In 2012, the drainage systems in China's Wuhan, Nanjing, and Tianjin could not cope with the severity of rains.[21] In 2021, hurricanes Henri and Ida led to many US cities

on the east coast being inundated.[22] In 2023, Beijing, China, was tormented by severe floods that damaged its transportation system;[23] the US's New York was ravaged by high levels of rainfall, resulting in a state of emergency being declared;[24] and Derna in Libya experienced devastating floods that left over 1,000 dead and about 10,000 missing.[25]

In the 2021 version of its annual report on the impacts of climate change, the Intergovernmental Panel on Climate Change (IPCC) warned that rising temperatures will result in increased and intense monsoon precipitation across South Asia, including India.[26] The 2023 report reiterates that global warming is already causing many weather and climate extremes worldwide. Amid further global warming, global monsoon precipitation and very wet weather events are projected to intensify and adversely impact human health, livelihoods, and key infrastructure.[27] Indeed, data for India reveals that such precipitation events are rising in intensity and frequency. For instance, many cities across India received more than 50 mm of rainfall per day in several instances a year, with some even experiencing over 100 mm of rainfall per hour.[28] Chandigarh, Ahmedabad, and Agartala faced extreme precipitation in 2017,[29] while Mumbai[30] and Delhi[31] were confronted by a similar extreme flood situation in 2023.

Increased instances of urban floods will lead to a substantial loss of local infrastructure, businesses, and human lives, with a significant impact on the local, subnational, and national economies.[32] As economic hubs, any stoppage in city activity will result in enormous financial losses. Roads may be damaged, mobile phone networks may become inoperative, and electricity lines may be disconnected as a safety precaution to prevent electrocution.[33] Infrastructure may have to be rebuilt or repaired before it can be used again. Additionally, as floodwaters recede, cities may need to contend with potential diseases such as cholera and malaria, which can affect large numbers.[34]

> "The 2005 Mumbai deluge forced the National Disaster Management Authority to delink urban floods from other kinds of floods, and address it as a separate disaster."

Understanding the Causes of Urban Floods

Urban floods can be caused by a combination of natural reasons (extreme precipitation, rapid snowmelt, storm surge from a cyclone, or tsunami in coastal locations), planning deficits, governance shortages, and flaws in the overall conceptualisation of urbanisation in a country. Between 2000 and 2019, India recorded the third greatest number of disaster events of all countries worldwide (321 incidents), after China (577) and the US (467).[35] Worsening climate change will certainly exacerbate this situation. In recent years, India has seen storms and hurricanes increase in severity, heatwaves and cold waves, and harsh droughts and floods, and its cities remain vulnerable. For instance, a study revealed that rainfall on India's west coast had acquired greater 'convectivity',[a] resulting in intense rain over a region from deep thunderclouds. Cities are witnessing more such bursts of rain, and their current drainage systems cannot cope, leading to flooding, as was seen in the state of Kerala in 2019.[36,37]

Planning deficits include the lack of poverty planning in cities despite clear indications that migration to cities is fuelled more by the need for employment and survival than by the attraction of urban opportunities.[38] However, there is little evidence of this being considered while planning cities. Consequently, while they contribute to building the economy of the city, poor migrants are unable to find housing in the formal market and often seek shelter on or near riverbanks, mangroves, and land along drains.[39] This results in encroached rivers, heavily silted drains, clogged culverts, and a dysfunctional stormwater system that leaves little outlet for rainwater. This is exacerbated by the inability of most cities to attract migrants because of their weak economies, leaving only a few cities to receive the entire inflow of migrants.

Indian cities also have an extremely fractured governance system. The urban local bodies have truncated functions, and several parastatals have been created to manage separate services. In Bengaluru, for instance, water and wastewater are managed by the Bangalore Water Supply and Sewerage Board, city transport is controlled by the Bangalore Metropolitan Transport Corporation, and fire services are provided by the Karnataka Fire and Emergency Services. On the planning side, the Bangalore Development Authority is the principal planning authority for Bengaluru city, and the Bangalore Metropolitan Management Authority is responsible for the planning of the Bengaluru

a 'Convectivity' is the phenomenon of convection that refers to the process of heat transfer by the movement of liquids or gases. When the Earth's surface is heated by the sun, the air above gets warmer, hence lighter and begins to rise. The upward movement of warm, moist air causes precipitation. Rising temperatures will heat the Earth's surface more, will cause more warm air to rise, and lead to greater precipitation.

metropolitan region. Any coordination among these agencies during a crisis is an enormous problem, leaving little scope for mitigation efforts. [40,41]

Furthermore, modern cities have been hostile to the elaborate ecosystem that sustained the city in the past. Lakes in many cities have been filled up; others have been curtailed through slow and stealthy encroachment and concretisation.[42] Other items of city infrastructure that have a bearing on floods have also been mismanaged. Stormwater drains, generally built on the edge of roads, are designed to drain excess water from impermeable surfaces such as footpaths, streets, and roofs, and empty this water into a larger water system. Most cities in India do not have stormwater drains, and those that exist are poorly maintained. Over time, they get heavily clogged and have little utility. Additionally, the drainage systems have failed to keep pace with the growth of the built city.[43] Solid waste management leaves much to be desired, and many citizens and cities indulge in indiscriminate disposal of solid waste.

Another recent practice in cities is to cover the water-draining *nullahs* (drains) by inserting concrete drainpipes and building roads over them to tackle mounting traffic congestion, but this hampers the capacity of *nullahs* and limits their maintenance. Furthermore, open spaces are concretised, leaving less permeable land in the city. This happens primarily due to demographic pressures and the consequent need for more living spaces, which results in the demand for more traffic space. As such, open areas in cities often get converted into built spaces.

Similarly, another factor is unauthorised construction, with developers usurping public land and water bodies to construct buildings.[44] Rivers, lakes, ponds, and *nullahs* have either disappeared or have been made to dry up in the process of being readied for construction.

Consequently, two patterns emerge. First, cities avidly engage in creating new infrastructure but exhibit a great indifference to the role of maintaining the existing facilities. Over time, this causes infrastructure dystrophy, and the infrastructure becomes non-functional and a liability, endangering lives. Second, excessive human density is against city openness.[45] Every individual in a city requires some built space (housing, a workplace, more roads, schools, hospitals, and recreation facilities). Additionally, the city must provide water and sanitation facilities. Consequently, more infrastructure is constructed. This results in changes in the environment and climate. As such, these antagonistic demands can be satisfied only if they are balanced, which requires a cap on the human footprint in the city. However, this critical issue of rampant human footprint expansion in cities—or the over-densification of cities—is continuously ignored.

Potential Solutions

The NDMA has crafted a comprehensive National Disaster Management Framework that underlines the interrelationship of the economy, environment, and development. It lays emphasis on mitigation and readiness for post-disaster response, recovery, and reconstruction.[46] Institutionally, the agencies dealing with climate change (the environment ministry) and disasters (the home ministry and the NDMA) are well integrated. However, to prepare and mitigate instances of urban floods, states must ensure proper synchronisation between their own agencies and those of the Indian government. States particularly vulnerable to extreme precipitation events should pay greater heed to pre-disaster planning and make climate change mitigation an essential component of disaster risk management.[47]

A committee set up in the aftermath of the 2005 Mumbai deluge recommended the city undertake reclamation and restoration jobs, regulatory steps, and the establishment of a new governance mechanism,[48] specifically a multistakeholder and interdepartmental Disaster Management Authority headed by a professional. It recommended the preparation of contour maps (a map on which the shape of the land surface is shown, indicating the relative slope of the surface), a survey of the city's stormwater drainage network, the implementation of the Brihanmumbai Stormwater Disposal System, the completion of cross drainage works, and the augmentation of pumping and gated structures. Solutions were also suggested for the protection of the airport, including a review of the hydraulic and structural design of the airport runway and taxiway bridge.[49] The committee also suggested a second set of jobs, including the removal of obstructions to stormwater drains, the restoration of four waterways that were reduced in capacity, the removal of blockages caused by floating debris, the refurbishment of the *nullah* system that had been restrained due to encroachments, effective garbage handling, and the desilting and preservation of holding ponds. Regulatory measures included a ban on plastics and the prevention of further encroachments.[50] Other vulnerable cities and states across India can measure their preparedness against the Mumbai experience and the committee's recommendations.

City administrations must also take on some of this responsibility. However, even if urban development is the mandate and responsibility of the states and cities, the central government should not ignore that city infrastructure may be failing to support the requisite quality of life in large Indian cities (especially given their economic importance). Notably, the central government must make concerted efforts to support cities' financial stability to tackle urban floods.[51]

Potential Solutions

Cities must formulate their own climate action plans (CAPs) based on their unique contexts. For instance, the Mumbai Municipal Corporation's CAP identifies city floods as a major concern.[52] Once CAPs are readied, the administrations must ensure they are implemented yearly. The annual municipal budget must include budgetary provisions to implement the CAP, with clear allocations to the relevant departments assigned to carry out specific works. A separate monitoring unit, such as a 'climate cell', could be formed with the municipal commissioner as its head, to oversee and guide departments. Since CAPs are currently not mandatory for the states, they should consider amending their municipal statutes to make such planning a statutory obligation for cities. Beyond the states, community approaches in the future are vital for disaster mitigation and management.[53] This would include integrating disaster risk reduction into local development policies and plans.

Additionally, city regulations must be tightened to prescribe the maintenance of permeability and the use of rooftop rainwater harvesting tanks, among other similar resilience jobs, in all construction activities.

Several innovative methods can be used as mitigation measures. For instance, the adoption of green roofs and infiltration (the process by which water across the ground surface enters or flows into the soil).[54] Mitigation requires that the quantum of infiltration that has been lost on account of the construction of a building should be made up by provisions on the rooftop. Infiltration beds can be installed on roofs. These guide the rainwater through pipes under the ground, compensating for the loss of permeability on the ground caused by construction. Flood risk can be reduced using rooftop rainwater harvesting tanks that can hold vast amounts of water. If installed across the city in large numbers, the volume of floodwater can be meaningfully reduced; for instance, a 100-metre tank could reduce overflows by 11 percent and a 1000-metre tank by 43 percent.[55] Some open areas can also be designed as water detention/holding ponds. Hong Kong has undertaken a massive underground storage scheme called the Tai Hang Stormwater Storage Tank with a capacity of 100,000 cubic metres by upgrading existing drains and constructing 7 km long new box culverts. Permeable pavements also have a great capacity to reduce runoff.[56] Similar initiatives can be undertaken in cities across India.

Conclusion

India must closely examine the over-densification of its cities and articulate a national policy that disincentivises demographic density beyond an accepted limit based on economic, environmental, and social sustainability.[57] At the same time, a sizeable programme will need to be initiated to invest and develop smaller cities to ease the migration and resultant burdens on the large cities. This would encourage the growth of other cities in a sustainable manner. Efforts must also be made to inculcate disaster risk reduction behaviour among citizens. Men, women, and children across the country must be supported in espousing and integrating risk reduction concerns into their daily lives, livelihoods, and occupational patterns. This will require the state to undertake a massive education programme for disaster risk mitigation and management.

Ramanath Jha *is a Distinguished Fellow at ORF Mumbai.*

Endnotes

1 Anna Weber, "What is Urban Flooding?", *NRDC*, January 15, 2019, https://www.nrdc.org/bio/anna-weber/what-urban-flooding.

2 Sonia I. Seneviratne and Neville Nicholas, "Changes in Climate Extremes and their Impacts on the Natural Physical Environment," in *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change*, eds. C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Cambridge and New York: Cambridge University Press, 2012), https://archive.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf

3 National Disaster Management Authority, Government of India, *National Disaster Management Guidelines: Management of Urban Flooding*, 2010, https://nidm.gov.in/pdf/guidelines/new/management_urban_flooding.pdf.

4 *National Disaster Management Guidelines*

5 Pankaj Joshi, "Remember the 2005 floods? Can we prevent it happening again?", *The Hindu*, July 17, 2016, https://www.thehindu.com/news/cities/mumbai/news/Remember-the-2005-floods-Can-we-prevent-it-happening-again/article14494244.ece.

6 *National Disaster Management Guidelines*

7 *National Disaster Management Guidelines*

8 Luis Cea and Pierfranco Constabile, "Flood Risk in Urban Areas: Modelling, Management and Adaptation to Climate Change. A Review," *Hydrology* 9, no. 3 (2022) https://doi.org/10.3390/hydrology9030050.

9 Hirudia Raj, "Hyderabad Floods: Urgent need for better planning and reviving city Lakes", *WaterAid*, November 6, 2020, https://www.wateraid.org/in/blog/hyderabad-floods-urgent-need-for-better-planning-and-reviving-city-lakes.

10 Preeti Biswas, "2020 rerun: Hyderabad wakes up to deluge, many streets sink," *The Times of India*, July 16, 2021, https://timesofindia.indiatimes.com/city/hyderabad/2020-rerun-hyd-wakes-up-to-deluge-many-streets-sink/articleshow/84458414.cms.

11 Idrees Mohammed, "Chennai's floods: the city has learned nothing from the past-here's what it can do," *The Conversation*, December 15, 2021, https://theconversation.com/chennais-floods-the-city-has-learned-nothing-from-the-past-heres-what-it-can-do-172254.

12 Ramanath Jha, "The Bengaluru floods: The rising Challenge of urban floods in India," *Observer Research Foundation*, October 15, 2022, https://www.orfonline.org/expert-speak/the-bengaluru-floods/.

13 "Floods in Ahmedabad," *The Times of India*, June 28, 2023, https://timesofindia.indiatimes.com/calamities/floods-in-ahmedabad/articleshow/101329964.cms?from=mdr.

14 Alok K N Mishra, "Yamuna floods swathes of Capital after 45 years," *Hindustan Times*, July 14, 2023, https://www.hindustantimes.com/cities/delhi-news/surging-waters-of-

Endnotes

yamuna-river-cause-first-floods-in-new-delhi-in-45-years-thousands-forced-to-evacuate-homes-101689275476120.html.

15 Reuters, "Flooding in India forces residents to flee," YouTube video, 0:30, September 23, 2023, https://www.youtube.com/watch?v=eRiY5wOxdEg.

16 R Krishnakumar, "Caught in the deluge: Flooding in India's ill-equipped cities," *Deccan Herald*, July 16, 2023, https://www.deccanherald.com/india/caught-in-the-deluge-flooding-in-india-s-ill-equipped-cities-1237366.html.

17 "Sikkim flash flood toll rises to 40 as army readies airlift rescue operations; bodies recovered in West Bengal," The *Times of India* October 6, 2023, https://timesofindia.indiatimes.com/city/kolkata/sikkim-flash-flood-toll-rises-to-40-as-army-readies-airlift-rescue-operations-bodies-recovered-in-west-bengal/articleshow/104212522.cms?from=mdr.

18 Joydeep Thakur, "Over 3,000 people stranded in Sikkim's Lachen, Lachung towns; rescue ops underway," *mint*, October 9, 2023, https://www.livemint.com/news/india/over-3-000-people-stranded-in-sikkim-s-lachen-lachung-towns-rescue-ops-underway-11696828925328.html.

19 Shivali Jainer, "Urban flooding around the world: Where is India placed?", *Down To Earth*, April 29, 2020, https://www.downtoearth.org.in/blog/water/urban-flooding-around-the-world-where-is-india-placed--70765.

20 US Government Accountability Office, *Natural Disasters: Economic Effects of Hurricanes Katrina, Sandy, Harvey, and Irma*, GAO-20-633R, September 10, 2020, https://www.gao.gov/products/gao-20-633r.

21 Asit K Biswas and Kris Hartley, "THROWBACK: How China's 'sponge cities' aim to re-use 70% of rainwater," *Down To Earth*, July 3, 2019, https://www.downtoearth.org.in/news/water/throwback-how-china-s-sponge-cities-aim-to-re-use-70-of-rainwater-65399.

22 Rachel Ramirez, "The 7 most devastating climate disasters of summer 2021," *CNN*, October 2, 2021, https://edition.cnn.com/2021/10/02/weather/climate-disasters-of-summer-2021/index.html.

23 Rachel Liang and Dan Strumpf, "Beijing Area Hit by Deadliest Flooding in a Decade," *Wall Street Journal*, August 1, 2023, https://www.wsj.com/articles/beijing-area-hit-by-deadliest-flooding-in-a-decade-73c571fc.

24 "NYC flooding recap: Rain drenches tri-state area causing major flooding," live blog, *NBC News*, September 30, 2023, https://www.nbcnews.com/news/us-news/live-blog/new-york-flooding-live-updates-rcna118055.

25 Reuters, "Libya floods wipe out quarter of city, 10,000 feared missing," *The Indian Express*, September 12, 2023, https://indianexpress.com/article/world/libya-floods-wipe-out-quarter-of-city-10000-feared-missing-8936735/.

Endnotes

26 Intergovernmental Panel on Climate Change, *Climate Change 2021: The Physical Science Basis: Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge and New York, IPCC, 2021, https://report.ipcc.ch/ar6/wg1/IPCC_AR6_WGI_FullReport.pdf.

27 Intergovernmental Panel on Climate Change, *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge and New York, IPCC, 2023, https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf.

28 National Institute of Disaster Management, Ministry of Home Affairs, Government of India, "'Urban Flooding: Challenges to Solutions' 'Urban Flooding: Challenges to Solutions'.| NIDM | MHA | COVID-19 | DISASTER IN INDIA | PM 10 POINT'" December 28, 2020, https://www.youtube.com/watch?v=QOGmbAjEdJ4.

29 S Gopalkrishna Warrier, "Extreme rainfall leaves cities floundering," India Climate Dialogue, August 28, 2017, https://indiaclimatedialogue.net/2017/08/28/extreme-rainfall-leaves-cities-floundering/.

30 "Mumbai experienced 100 mm of rainfall in the past 24 hours; 'yellow' alert sounded for Mumbai and Thane on Monday," *The Indian Express,* July 25, 2023, https://indianexpress.com/article/cities/mumbai/mumbai-100-mm-rainfall-24-hours-yellow-alert-imd-8856910/

31 "Highest rainfall in a day in 20 years drowns Delhi in deluge," *The Hindu*, July 9, 2023, https://www.thehindu.com/news/cities/Delhi/highest-rainfall-in-a-day-in-20-years-drowns-delhi-in-deluge/article67058472.ece.

32 "What Are the Consequences Of Flooding?", *Lasko,* April 8, 2019, https://lasko.com/blogs/b-air/what-are-the-consequences-of-flooding.

33 Pooja Yadav, "Explained: What Is Urban Flooding And How Does It Impact India?", *Indiatimes*, November 13, 2002, https://www.indiatimes.com/amp/explainers/news/what-is-urban-flooding-and-how-does-it-impact-india-584613.html.

34 "Floods: How to protect your health," *World Health Organization,* January 29, 2020, https://www.who.int/news-room/questions-and-answers/item/how-do-i-protect-my-health-in-a-flood?gclid=EAIaIQobChMI_bLowNvrgQMVl4VLBR1CRgE_EAAYASAAEgKQA_D_BwE#.

35 Denis McClean, "#DRRday: UN Report charts huge rise in climate disasters," United Nations Office for Disaster Risk Reduction, October 13, 2020, https://www.undrr.org/news/drrday-un-report-charts-huge-rise-climate-disasters#:~:text=GENEVA%2C%2012%20October%202020%20%E2%80%93%20A,in%20the%2021st%20century.

36 Neha Madan, "Short, intense rain events up amid concrete surge: Experts," *Times of India*, September 9, 2022, https://timesofindia.indiatimes.com/city/pune/short-intense-rain-events-up-amid-concrete-surge-experts/articleshow/94085394.cms.

Endnotes

37 A.V. Sreenath, S. Abhilash, P. Vijaykumar, and B.E. Mapes, "West coast India's rainfall, is becoming more convective," *npj Climate and Atmospheric Studies* 5, 36 (2022), https://www.nature.com/articles/s41612-022-00258-2.

38 Sayli Udas-Mankikar, "Redrawing city plans for poverty, welfare – first cap population growth," *Observer Research Foundation*, June 5, 2020, https://www.orfonline.org/expert-speak/redrawing-city-plans-for-poverty-welfare-first-cap-population-growth-67402/.

39 Christin Mathew Philip, "After floods, slum dwellers keen to move from river banks," *The Times of India*, December 14, 2015, https://timesofindia.indiatimes.com/city/chennai/after-floods-slum-dwellers-keen-to-move-from-river-banks/articleshow/50165249.cms.

40 Jha, "The Bengaluru floods: The rising challenge of urban floods in India".

41 Mathew Idiculla, "Who Governs the City? The Powerlessness of City Governments and the Transformation of Governance in Bangalore," (paper presented at the RC21 International Conference, Urbino, Italy, August 27-29, 2015), https://www.rc21.org/en/wp-content/uploads/2014/12/G5.2-Idiculla.pdf.pdf.

42 "Bengaluru today…Waterlogged plush areas of India's tech capital are another grim warning to all cities," *The Times of India*, September 6, 2022, https://timesofindia.indiatimes.com/blogs/toi-editorials/bengaluru-today-waterlogged-plush-areas-of-indias-tech-capital-are-another-grim-warning-to-all-cities/

43 Kapil Gupta, "The drainage systems of India's cities," *Waterlines*, 23, no.4 (2005), https://www.ircwash.org/sites/default/files/Gupta-2005-Drainage.pdf.

44 Ramanath Jha, "Indian cities and floods," *Observer Research Foundation*, October 22, 2019, https://www.orfonline.org/expert-speak/indian-cities-and-floods-56915/.

45 Jha, "Indian cities and floods".

46 National Disaster Management Authority, Ministry of Home Affairs, Government of India, *National Policy on Disaster Management*, 2009, https://nidm.gov.in/PDF/policies/ndm_policy2009.pdf

47 Ramanath Jha, "Lessons from Kerala Floods," *Observer Research Foundation*, August 23, 2018, https://www.orfonline.org/expert-speak/43550-lessons-from-kerala-floods/.

48 Government of Maharashtra, *Fact Finding Committee on Mumbai Floods Final Report*, 2006, https://www.scribd.com/document/293669664/Fact-Finding-Committee-on-Mumbai-Floods-Vol1

49 *Fact Finding Committee on Mumbai Floods Final Report*

50 *Fact Finding Committee on Mumbai Floods Final Report*

51 Meera Mehta, Dinesh Mehta and Dhruv Bhavsar, "Options for Strengthening Municipal Finances," *Economic & Political Weekly* 58, no. 7 (2023), https://www.epw.in/journal/2023/7/commentary/options-strengthening-municipal-finances.html.

Endnotes

52 Saurabh Punamiya Jain and Tanmay Takle, *Mumbai Climate Action Plan 2022*, Brihanmumbai Municipal Corporation, 2022, https://ghhin.org/wp-content/uploads/Mumbai-Climate-Action-Plan-2022.pdf.

53 Sachinkumar N. Bhagat, "Community-Based Disaster Management Strategy in India: An Experience Sharing," PDEU Journal of Energy and Management 2, no. 1 (2018), https://pdpu.ac.in/downloads/1%20Community-Based-Disaster-Management.pdf.

54 National Institute of Disaster Management, "Urban Flooding: Challenges to Solutions," YouTube Video, 2:23:44, December 28, 2020, https://www.youtube.com/watch?v=QOGmbAjEdJ4.

55 National Institute of Disaster Management, "Urban Flooding: Challenges to Solutions".

56 Shivali Jainer, "Urban flooding around the world: Where is India placed?," *Down To Earth*, April 29, 2020, https://www.downtoearth.org.in/blog/water/urban-flooding-around-the-world-where-is-india-placed--70765.

57 Ramanath Jha, "Decentralised urbanisation holds key to healthy urban growth," *Observer Research Foundation*, May 20, 2018, https://www.orfonline.org/expert-speak/decentralised-urbanisation-holds-key-to-healthy-urban-growth/.

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New Delhi - 110 002, INDIA
Ph. : +91-11-35332000. **Fax :** +91-11-35332005
E-mail: contactus@orfonline.org
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