



International Journal of Political Science and Public Administration

Publisher's Home Page: <https://www.svedbergopen.com/>



Research Paper

Open Access

Urban Flooding in Neoliberal India: Vulnerabilities and Resilience in Metropolitan Hyderabad

Bala Ramulu Chinnala^{1*} and V.V. Mallika²

¹Visiting Professor, Centre for Economic and Social Studies, Hyderabad, and Formerly Taught Public Administration at Kakatiya University, Warangal, Telangana, India. E-mail prof.balaramulu@gmail.com

²Assistant Professor, Department of Public Administration, Tara Government College (Autonomous), Sangareddy, Telangana, India. E-mail mallikavvdl@gmail.com

Article Info

Volume 5, Issue 1, June 2025

Received : 07 January 2025

Accepted : 13 May 2025

Published : 25 June 2025

doi: [10.51483/IJPSPA.5.1.2025.42-55](https://doi.org/10.51483/IJPSPA.5.1.2025.42-55)

Abstract

Since India's 1991 economic liberalization, urban development has followed a tripartite approach-investment, technological adoption, and innovation-largely shaped by elite interests and aligned with market-oriented, neoliberal imperatives. This paper examines Hyderabad's transformation into a global business hub amid rising vulnerability to urban flooding. Since 2000, recurrent floods have caused significant damage, exposing infrastructural deficiencies and prompting urgent demands for state intervention. The unchecked spread of "cement-concrete urbanization" has intensified flooding, depleted water resources, worsened drinking water scarcity, and exacerbated climate-related risks. Rather than empowering local institutions, the state adopted a "New Localism" model, culminating in the formation of the Hyderabad Disaster Response and Asset Protection Agency (HYDRAA). While intended to enhance flood resilience, HYDRAA has centralized authority, diluted local government autonomy, and narrowed democratic space. These developments raise critical concerns: Does HYDRAA function impartially or cater to elite interests? How effectively does the state address the encroachment and regulatory violations by vested actors? Furthermore, does amending the Greater Hyderabad Municipal Corporation (GHMC) Act of 1955-delegating extensive power to HYDRAA's bureaucratic apparatus-undermine democratic decentralization? These questions call for a critical inquiry into the role of institutions like GHMC, HMDA, and HYDRAA in addressing Hyderabad's environmental challenges under neoliberal urbanism.

Keywords: *Urban reforms, Natural resources, Post-economic era, Flood resilience, Disaster management, New localism*

© 2025 Bala Ramulu Chinnala and V.V. Mallika. This is an open access article under the CC BY license (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

* Corresponding author: Bala Ramulu Chinnala, Visiting Professor, Centre for Economic and Social Studies, Hyderabad, and Formerly Taught Public Administration at Kakatiya University, Warangal, Telangana, India. E-mail prof.balaramulu@gmail.com

1. Introduction

Neoliberalism, widely used to characterize the resurgence of market based institutional shifts and policy realignments, has been extensively studied by urbanists and sociospatial theorists since the late 1990s. Scholars have noted that within this framework, state power subsumes cities under market-oriented governance regimes, significantly impacting urban spaces and residents (Peck and Tickell, 2002; Brenner and Theodore, 2005; Armelle, 2023).

In India, the Central and state governments' policies in the 1990s were greatly influenced by what was happening globally. They made significant changes in urban policy in many sectors and invited private capital participation in the economy. The urban development projects (city-specific master plans, strategic roads, flyovers, metros, airports), ease of doing business initiatives, etc, contributed to the growth of MPCs (population exceeding one million) and Class 1 cities (with populations exceeding 100,000) accounting for 42.6% and 70.2% of the total urban population in India (Prasad *et al.*, 2008; un.org/en/desa/india) posing significant challenges to the urban local bodies, in managing the climatic events be it rainfall, temperature, floods, droughts, drinking water shortages, diseases, etc.

This paper examines Hyderabad as a case study to explore the transformative impact of neoliberal urbanization and its role in shaping the city into a global business hub while exacerbating its vulnerability to floods and other disasters. Hyderabad, the capital city of Telangana, stands as a compelling example of neoliberal urbanization's transformative impact. Over the past three decades, the city has evolved from a traditional cultural hub into a dynamic global business center, attracting investments and driving rapid urban development. However, this transformation has brought significant vulnerabilities. The pressures of "cement-concrete urbanization" have resulted in the loss of natural drainage systems, depletion of groundwater resources, and heightened susceptibility to climate events such as urban flooding. The study analyzes the intersections of urban policies, governance, and environmental challenges and underscores the broader implications for sustainable urban development in India. It provides a framework for comparing Hyderabad's experience with other metropolitan cities facing similar challenges, enriching discussions on urbanization and resilience. These insights lend the study its significance.

1.1. Research Objectives

More specifically, the study focuses on examining urban policy reforms and their role in shaping market-oriented urban development in India and investigates the challenges of governance and their implications for flood resilience in Hyderabad concerning the GHMC and HYDRAA.

2. Methodology

The paper utilizes published materials, including official documents and research studies, and primary data obtained through interactions with the relevant authorities. This approach integrates secondary data with first-hand insights to provide a comprehensive analysis.

3. Urban Policy Reforms for Promoting Market Economy

The Indian state, in the context of the market economy, introduced reforms in urban governance, adopting the PPP (Public-Private Partnership) mode of governance in executing the schemes and allowing private capital investment in many sectors of the urban economy. The important reforms are the 74th Constitutional Amendment Act, of 1992; the Mega Cities Programme in 1993; the Urban Land (Ceiling and Regulation) Repeal Act, 1999; the Urban Reform Incentive Fund, 2003; Disaster Management Act of 2005; Jawaharlal Nehru Urban Renewal Mission (JNNURM), 2005; the Municipal Solid Waste (Management and Handling) Rules, 2000; National Urban Transport Policy, 2006; National Urban Housing and Habitat Policy, 2007; National Urban Sanitation Policy, 2008; The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013; Smart Cities Mission in India, 2015; Atal Mission for Rejuvenation and Urban Transformation (AMRUT), 2015; Real Estate Regulatory Authority, 2016; The National Urban Policy Framework (NUPF), 2018. However, scholars point out that reforms promoting private investment, ease of doing business, and Public-Private Partnerships (PPP) in infrastructure and service management are gradually leading to unregulated extraction and exploitation of natural resources (Anil, 2020).

4. Literature Review

The studies on urban development in the context of economic reforms highlighted several concerns about the governance of cities. The important of them are, *one*, the public and private investments that have facilitated the development of economically dynamic urban corridors of growth in some parts of the country and new urban clusters elsewhere resulting in urban divide growth among the cities; *two*, the magnitude of private investors' investment is higher in Metropolitan cities/regions like Ahmedabad, Mumbai, Pune, Delhi, Chennai, Bangalore, and Hyderabad (Shaw, 2012); three, the degradation of natural resources continues at an alarming pace within our cities violating the spirit of Article 51A (g) of the Indian Constitution (protection and enhancement of the natural environment- forests, lakes, rivers, and wildlife (Vikas and Milap, 2020); four, land encroachments and substandard urban planning have led to stark infrastructure development and disparities in building structures. The buildings inhabited by the less fortunate are often dilapidated and highly susceptible to such calamities (Akash and Khaliq, 2009; Tiya, 2023); five, the class bias of the municipal governance in providing infrastructure and services to the citizens (the affluent colonies and corporate enclaves received priority over the slums/colonies where the poor and middle-class people reside). These developments lead to various disasters – water and climate-related, landslides, natural accidents, industrial, and biological – and disrupt the sustainable environment.

4.1. Increasing Flood Incidences in Urban India

Studies on the incidence of floods have observed that there has been an increase in both number and intensity during the twenty-first century compared to the twentieth century. It is observed that we have had more than 10 devastating floods after 2000. These were experienced in 2005, 2013, and 2015 to 2022. In the 20th century, the most catastrophic floods were recorded in 1943, 1979, 1987, 1988, and 1993 (Central Water Commission, 2020). The worst floods recorded were in August 2018 in Kerala in Wayanad and Idukki districts, causing 400 deaths and about Rs. 30,000 crore in livestock houses and infrastructure losses. The urban floods in Mumbai (July 2005) caused thousands of deaths, and more than 14,000 houses were inundated with a loss to the economy ranging up to Rs. 1000 crore. The Chennai flood of November 2015 caused 500 deaths and about 1.8 million displacements, with 50,000 homes inundated. The total economic loss was in the range of Rs. 50,000 crore (Deshpande, 2022). The other notable instances of such flooding occurred in Hyderabad (2000 and 2020), Ahmedabad (2001, 2017), Delhi (2002, 2003, 2009, 2010), Surat (2006), Kolkata (2007), Jamshedpur (2008), Guwahati and Uttarakhand (2013), Srinagar (2014), Guwahati (2014) (Gupta, 2020). The residents, particularly urban poor living in peri/semi-urban areas and informal settlements, which are often clustered in high-risk zones are facing significant vulnerability to natural hazards-flooding, heat waves; resource scarcity (water, food, and energy), inequalities in the provision of basic resources to different classes/wards (Aprajita, 2015; Tikender, 2021).

5. Telangana State and Business Environment

Telangana State (TS) is the twelfth largest State in terms of geographical area and population size in the country. It is South to North India and North to South-consisting of multicultural people representing all parts of the country, in a way, mini-India. The elite groups and business communities consider Hyderabad City as India's second capital. The Hyderabad, TS capital city, lies in the Deccan Plateau, which rises to an average height of 536 m above sea level and is less prone to earthquakes. The population of Hyderabad is around 1.2 crores in 2024, an increase of over 87% compared to the 2011 census, and the density is approximately 18,480 per km in 2023. The government plans to divide the GHMC into four separate corporations to improve governance and address the city's rapid population growth, which is nearing 15 million. In January 2025, the state government merged 24 nearby municipalities into the GHMC, creating a "Greater City Corporation" (GCC) to oversee an expanded region, ensuring balanced growth and better urban management.

5.1. Marketization Context

The most significant reform of the nineties was the promotion of Hyderabad's Information Technology and Engineering Consultancy (HITEC) City, a trailblazing hub in India's IT sector that nurtured a vibrant start-up ecosystem, resulting in extensive impacts on both the economy and society (Rao and Dev, 2003). The other reforms that promote the market economy are: (1) Outer Ring Road (ORR) – an eight lane expressway encircling

Hyderabad spanning 158 kilometres – connecting to many hubs in the city and between National Highways-44,65,161,765, 163; (2) TS Industrial Policy and TS Industrial Development and Entrepreneur Advancement, 2014 (extending support and guidance and facilitating in the land allotment; creation of an industrial land bank, developing the infrastructure; providing incentives to the entrepreneurs- stamp duty reimbursement, land cost rebate, land conversion cost, power cost reimbursement, investment subsidy; (3) the TS Industrial Project Approval and Self-Certification System (TS-iPASS) Act, 2014 (a single point clearances for setting up of industries); (4) TS Industrial Infrastructure Corporation, 2014 (providing infrastructure through the development of industrial areas); (5) Uninterrupted power supply to the business and industrial activities, since 2014; (6) TS Real Estate (Regulation and Development) Rules, 2017(ensuring transparency and accountability within the real estate sector); (7) TS Building Plan Approval Self-Certification System (TS-bPASS), 2019 (online building permissions for hassle-free); (8) Land Conversion Bill, 2020 (converting agricultural lands to non-agricultural purposes); (9) TS Layout Regularisation Scheme (LRS), 2020 (approving illegal layouts that violate statutory development plans, master plans, and layout rules); (10) TS legislation for farmers Rights in Land and Pattadar Pass Books Act, 2020 (online registration and mutation of agricultural and non-agricultural proprieties and documentation of landowners rights); (11) Repeal of Government Order 111, 2023 (enabling the private investors to take up industries/ construction/ business activities in 84 villages, which are adjacent to the city); (12) the establishment of HYDRAA, July 19, 2024 (to address multiple critical urban challenges, including the protection of government lands from illegal occupation, safeguarding the city’s ponds, and managing human and urban disasters; (13) announcement of roadmap on AI-Powered Telangana’, 2024 a strategy to make Telangana the global hub for AI technological innovation and implementation (<https://www.deccanchronicle.com> September, 5, 2024).

5.2. NeoLiberal-Hyderabad City

Hyderabad has been the most liveable city for six consequent years and is the fastest-growing among India’s top six cities ranked on parameters like infrastructure development and policy initiatives in 2024 (<https://www.deccanherald.com>). With its favorable environment, strategic location, and proactive governance, Hyderabad has become a competitive region within India. By embracing economic reforms and developing infrastructure across key sectors such as roads, power, and irrigation, it has positioned itself as a prime destination for world-class businesses to establish a wide range of industrial and commercial activities. Companies like Amazon, IBM India Private Limited, Google India, and Microsoft India, along with sectors such as life sciences, defence and aerospace, automotive manufacturing, financial services, food processing and seeds, basic materials industries, logistics, and distribution, have been significantly contributing to Telangana’s business ecosystem. In the past two decades, numerous health, pharmaceutical, and educational institutions have been established around the GHMC, competing with world-class institutions within the HMDA/GHMC region in the private sector (Telangana, Socio-Economic Outlook, 2023).

The neoliberal urban development of Hyderabad City began, in the early 1990s, in the eastern region, significantly boosting real estate ventures such as East and West City, Singapur City, as well as Ramoji Film City situated 30-40 kilometers from the state capital’s headquarters and well-connected to national highways, preceding the growth of the city’s western region. The ruling authorities of the time, however, favoured the development of the western region to enhance the value of their properties while overlooking the eastern region. Today, the western part hosts numerous MNCs, IT companies, venture capitalists, real estate businesses, educational institutions, shopping centers, and entertainment venues. The prominent localities Kukatpally, Miyapur, Madhapur, Gachhibouli, Serlingampally-Financial District, and Hite-City are well-connected to major employment hubs due to their proximity to the ORR and NH4.

The southern area of the city, encompassing the International Airport, Hardware Park, and Fab City, is evolving into a residential hotspot attracting investors, with land parcels being purchased for long-term investments. The Telangana government has ambitious plans for developing the ‘fourth city’/‘futuristic city’ at Mucherla, aiming to make it a hub for investments, entertainment, sports, and academia. It is being developed as a new urban area to complement the existing cities of Hyderabad, Secunderabad, and Cyberabad- a significant addition to the Hyderabad metropolitan region. The northern and central areas of the GHMC have seen major infrastructure projects under the Strategic Road Development Plan (SRDP) Phase-2, which introduced new flyovers, underpasses, and bridges to improve traffic flow and reduce commute times.

5.3. Mega Master Plan 2050

Strategic roadmap for the next decade, envisioning a fivefold expansion of the current state economy into a trillion-dollar economy. The plan aims to position the state as a leader in technology, clean energy, and comprehensive development and transforming into a hub of sustainable development, industrial growth, and urban modernization. The state directed the HMDA to prepare plans to develop three regions (i) urban (Hyderabad city region surrounded by an Outer Ring Road (ORR); (ii) semi-urban (area between ORR to the Regional Ring Road (RRR); and (iii) rural areas (areas/ districts between RRR to the rest of the state). It directed the HMDA to take up infrastructural facilities with world-class facilities focusing on ORR to RRR region to create an environment conducive to private investment in the region's growth and increase the land value. The prominent initiatives are: (i) the development of the Musi Riverfront Project to enhance urban aesthetics and ecological balance; and (ii) the creation of a "Future City" spanning 765 sq km, featuring an AI hub and advanced technological infrastructure (The Hindu Bureau, February 18, 2024; Eenadu, April 2, 2024).

5.4. Slums in the City

Neoliberal urbanism, however, has resulted in the proliferation of poverty and slums, a consequence of policies such as land commercialization and housing commodification. About 13% of the population of Hyderabad lives below the poverty line. Hyderabad is home to at least 1,476 slums, which accommodate a population of around 1.7 million. The past decade has seen a 264% increase in the slum population in and around the city, and as of 2014, it is estimated that 30% of the city's residents live in slums. Nearly one-quarter of the slum-dwellers in the city came from other parts of India in the 1990s, with at least 63% having lived in slums for at least a decade. Around 30% of the slums have basic services, while others depend on public services from the government (<https://worldpopulationreview.com/world-cities/hyderabad-population>). Retrieved on March 28, 2025.

6. Hyderabad City's Flood Vulnerabilities

6.1. The Rainfall and Localities Susceptible to Floods

The average rainfall of Hyderabad city is around 906 mms, of which 80% comes from the southwest (June-September) and the remaining from the North-East (October-November). Between 1908 and 2020, localities recorded extreme rainfall events at a single location, varying from 140.5 mm to 300 mm, impacting the localities and affecting local populations and infrastructure. These localities include Begumpet, which experienced 153.7 mm on 27 September 1908, 190.5 mm on 1 August 1954, 140.5 mm on 24 July 1989, and 241.5 mm on 24 August 2000; Alwal with 150 mm on 10 August 2008; Shapurnagar with 150 mm on 18 June 2012; Saroornagar with 226 mm on 21 July 2012; Quthbullapur with 230 mm on 21 September 2016; Malkajgiri with 201.5 mm on 14 September 2017; and Vanasthalipuram and Hayathnagar, both receiving 300 mm on 14 October 2020 (directoratoefvdm.ghmc.telangana.gov.in, 2024).

In 2019, the National Remote Sensing Centre of ISRO Hyderabad, in partnership with GHMC developed maps (using NRSC and GHMC data layers and a terrain-based model-HAND (Height Above Nearest Drainage) to illustrate water bodies and regions with different levels of flood vulnerability across the 30 circles of the GHMC (see Table 1). Madhuri *et al.* (2021), using HEC-RAS 2D in the climate change framework, observed that the catchment area of GHMC consists of 16 zones based on a stormwater drainage network. Higher elevations are found in zones 9 and 11 and the northern parts of zones 12, 14, and 7. Similarly, lower elevations are found near the Musi River, especially in the southern part of zones 1, 4, 5, 6, 12, 13, and 15 (see Figure 1).

6.2. Flood Vulnerability in 2020

The city witnessed one of the worst-ever flood situations down-pour rain spells poured over a week from October (13th to 19th) 2020, resulting in massive flooding that impacted more than 120 colonies, and 20,500 homes and causing as many as 80 deaths (Vinay *et al.*, 2021; Raghu and Srivalli, 2020). In certain areas, such as Hayathnagar and Cherlapally, the rainfall was 30 cm within just six hours, marking the highest recorded in a century and underscoring its devastating impact on the city (directoratoefvdm.ghmc.telangana.gov.in). The other areas that were severely affected were Gandhinagar, Ashoknagar, Padmacolony, Nagamaiahkunta,

Table 1: GHMC Zones (Circles/Localities) Susceptible to Flooding in 2019 and Flood-Affected Localities During 2020

	Zone/(Circles)	ISRO Identified Localities that are Susceptible to Flooding in 2019	Localities that were Affected During the 2020 Floods
1	Charminar (Chandrayaangutta, Charminar, Falaknuma, Malkapet, Rajendranagar, Santhoshnagar)	43	36
2	L.B. Nagar (Hayatnagar, Kapra, L.B. Nagar Saroornagar, Uppal)	42	46
3	Serilingampally (Chandanagar, Yousufguda, Ramchandrapuram, Serilingampally)	23	20
4	Kukatpally (Alwal, Gajularamaram, Kukatpally, Moosapet, Qutbullapur)	39	36
5	Secunderabad (Amberpet, Begumpet, Malkajigiri, Musheerabad, Secunderabad)	29	18
6	Khairatabad (Goshamahal, Jubileehills, Karwan, Khairatabad, Mehdipatnam)	51	31
	Total	227	187
	The average number of localities susceptible/affected	37-38	31

Source: Compiled from GHMC's documents (directoratoefevdm.ghmc.telangana.gov.in, 2024)

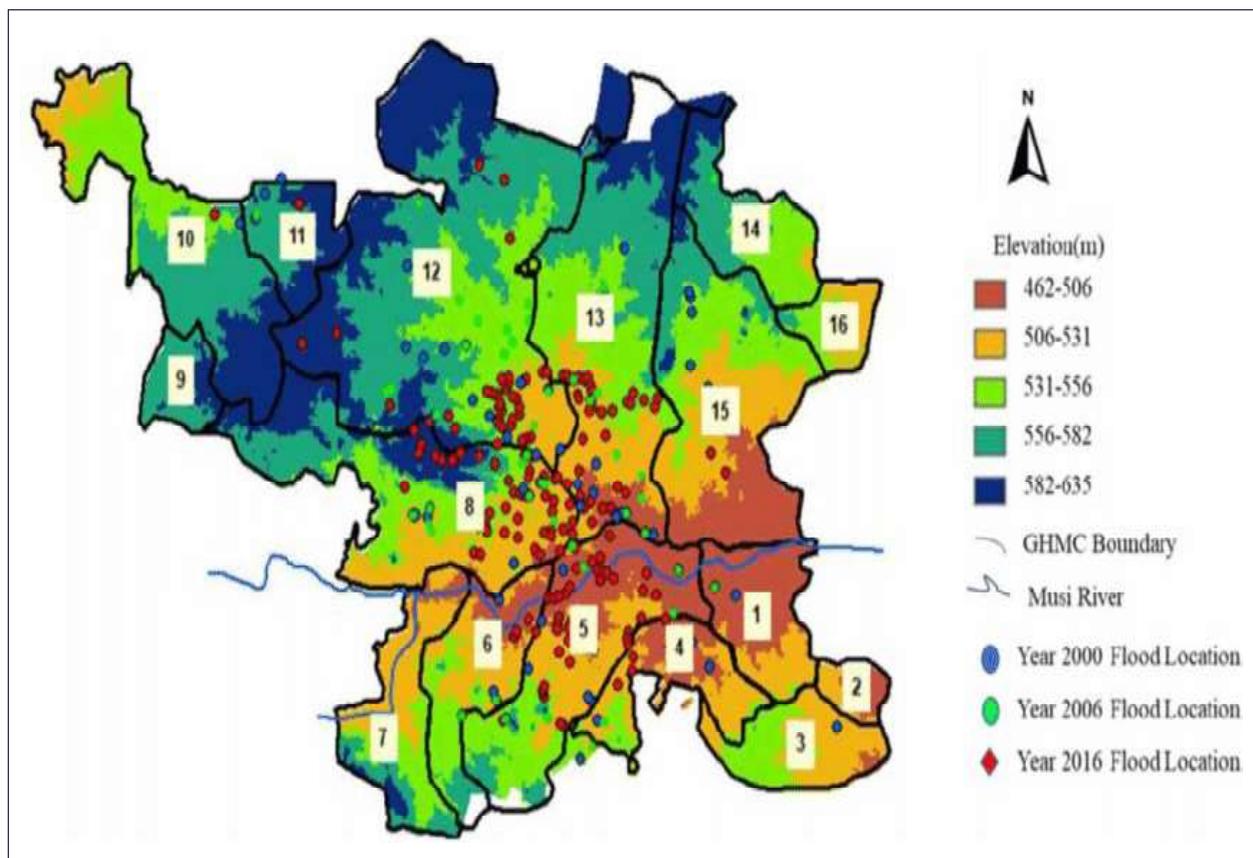


Figure 1: Zones Based on a Storm Water Drainage Network

Source: <https://www.ghmc.gov.in/PSWiseMaps.aspx>

Nallakunta, Vidyanagar, Domalguda, Arundathinagar, Ambedkarnagar, Aravindanagar, and Shivanandanagar (Vinay *et al.*, 2021; www.currentscience.ac.in).

The situation looked so gloomy that it created panic among citizens residing in low-lying areas/buffers and FTL zones of lakes. Most of the low-lying areas were completely inundated, and many lost their lives and livelihoods. Major roads and highways were severely damaged, and several colonies were isolated from the rest of the city. The situation worsened due to the continuation of incessant heavy rains from the 14th to the 19th of October. Most of the water bodies, Nalas overflowed having crossed their percolation and full tank capacities. The heavy runoff inflow-induced surge caused the breaching of 5 lake bunds (Gurnamcheruvu, Pallecheruvu, Bandacheruvu, Patelcheruvu, etc.), leaving behind the submergence of hundreds of houses in the lake vicinities (directoratofevdm.ghmc.telangana.gov.in). The recent instances, i.e., On May 7th, 2024, and 30, 31 August 2024 rainfall ranging from 8-12 mm within two hours caused chaos in Hyderabad, leading to traffic disruptions, power outages, uprooted trees, and loss of life, underscoring the city's vulnerability to such calamities underscores the need to examine the causes and effects of such disasters to take corrective measures.

Studies by Vikas and Milap (2020), Alam and Markandey (2020), Vinay *et al.* (2021), Sharief and Vangipuram (2022), Mousumi *et al.* (2022) and Bonda and Giduturi (2024) highlighted the physical, social, and economic vulnerabilities that posed significant challenges for the authorities concerned in managing flood disasters during the 2020 floods. The physical vulnerabilities are due to the growing need for residential, commercial, and business zones, which has resulted in a lot of construction around lakes, streams, and rainwater wetlands; rainwater-absorbing areas are replaced with hard, impermeable surfaces, increasing runoff volume and speed. Several low-lying localities were deluged in the water from rains and overflowing water bodies.

The most affected people were socially vulnerable groups or rural migrants. It has been noted that migrants from certain social groups or villages who move to the city for employment often reside together in the same localities, whether they construct houses or rent them. They opt for this arrangement even with the threat of flooding, as it provides a sense of security amidst known individuals. Vikas and Milap (2020) also observed that those in informal settlements or slums near the Musi River and in low-lying urban zones suffered from the compounded effects of heavy rains, unplanned development, and societal barriers arising from social stratification. Infrastructure related to social development, such as education, health care support, housing facilities for the poor, and sports and other recreation facilities are not up to the standard and need larger investment and planning efforts.

The floods disturbed economic activity, supply chain disruption, and people into poverty. Alam and Markandey (2020) observed that it was a daunting task for the authorities concerned to manage the social and economic services of the people, especially the poor. The newly developed settlements with multi-storeyed buildings, which had waterbodies to cater to rural needs and transformed into an urban landscape, are now facing significant challenges due to inadequate water supply, sewerage, and drainage infrastructure (Sharief and Vangipuram, 2022; Bonda and Giduturi, 2024).

6.3. Expert Committees Reports

The Kirloskar Committee (2003) reported that in the HMDA region, exacerbated flooding hazards due to: (a) inadequate drainage; (b) overflows from the Musi River, where settlements have taken place in the flood plains; (c) informal settlements in the drain path, improper drainage network, and reduction in drain capacity due to siltation; and (d) land use practices, solid waste management practices and drainage maintenance in the city, etc. The Committee identified 13,500 illegal constructions, and recently, the Voyants Consultancy (2020) reported 28,000 encroachments in the HMDA region. The report emphasizes the need to remove these encroachments and improve drainage systems to mitigate flood risks (The New Indian Express 15 October 2020). Massive encroachments in all shapes and sizes are unabated, reducing water bodies/lakes and streams to narrow, foul-smelling canals in most parts of the city. The existing storm water drainage network in Hyderabad can handle the rainfall intensity of 2 cm/hour only, but the trend of highly intense spells of rain has been increasing year after year. Various assessments have reported that the existing storm water drainage network is already overstressed, insufficient and filled with encroachments (directoratofevdm.ghmc.telangana.gov.in, 2024).

6.4. Past Experience

The Musi floods of 1908 were among the most devastating natural disasters in Hyderabad's history, profoundly impacting the city's physical, social, and economic fabric. This disaster served as a wake-up call for Hyderabad, prompting significant urban planning and infrastructure development to prevent future catastrophes. The floods prompted the Nizam government to invest in long-term flood prevention measures, such as the construction of Osman Sagar and Himayat Sagar reservoirs, which later became critical for flood control and water supply. However, during the post-independent period, particularly the past two decades, they have experienced flood vulnerabilities. Heavy floods in 2000 and 2020 and disruptive floods in 2008, 2016, and 2017 in Hyderabad triggered extensive damage to the infrastructure and loss of life. The August floods of 2000 (241.5 mm in 24 h) caused huge property loss and more than 90 residential colonies were submerged (2-4 m water level). Over two dozen people lost their lives and an estimated loss of Rs. 13.5 million. The severely affected areas are Balapur, LB. Nagar, and Parts of the Old City, such as Hafizbabanagar. In August 2008, 237 mm of rainfall in 36 hours resulted in a property loss of 4.9 million. The ground reports suggest that even with 50-60 mm rainfall in the city, transport remained standstill, and there were deaths from being swept into the manholes and due to the collapse of walls, roofs, and buildings after receding the rainwater in 2005, 2016, and 2017. In September 2016 and October 2017, Hyderabad City experienced a flood-like situation due to incessant high-intensity spells of rain and encroachments of public spaces and residential areas near water bodies/nalas

6.5. Consequences of City's Unregulated Growth

Hyderabad city's unplanned and unregulated development and rapid population growth are exuberating concerns such as the depletion of natural resources, drinking water shortage, chaotic environments, and reduction of overall quality of life for residents.

6.5.1. Depletion of Natural Resources

Before the 1990s, except in the central zone, Hyderabad City boasted a variety of natural resources. The city was known for its mineral resources like coal, limestone, bauxite, and mica; its fertile, predominantly red sandy soil with patches of black cotton soil, suitable for cultivation; and granite, including gray and pink varieties, which are among the world's oldest (https://en.wikipedia.org/wiki/Geography_of_Hyderabad). The GHMC/HMDA region also has had many interconnected waterbodies such as lakes, reservoirs, rivers, streams, aquaculture ponds, tanks, etc, built and used for agriculture, drinking water, and a sustainable environment over the 16th and 17th centuries onward. These lakes have served to mitigate floods, maintain groundwater levels, secure drinking water sources, and provide a sustainable environment for the city over decades (Vani and Kamraju, 2016). However, several lakes gradually either disappeared or shrunk drastically and became the receptacle of sewage and industrial effluents discharged into the drainage (nallas) from its watershed area. The floodwaters carrying channels connecting one water body to the other have been encroached by private and government agencies, and their coalitions are now inundated with sewage and pollutants, contributing to recurrent urban flooding (Ramachandraiah and Prasad, 2004).

The area under the river/streams changed from 762 ha in 1964 to 512 ha in 1974 and further to 312 ha in 1990. The water bodies in the HMDA region reduced from 2.28 to 1.64% from 2001 to 2016 (Rangari *et al.*, 2019). The city's growth has come at the cost of 375 lakes going extinct. It has only 531 lakes as compared to the 906 in 1982 (Raghu and Srivalli, 2020). Further, the expansion in peri-urban areas has been at the cost of vanishing water bodies. This transformation resulted in flooding, leaving citizens vulnerable (<https://www.thehindu.com/news/cities/Hyderabad/the-revenge-of-the-lakes-in-hyderabad/>; (directorateofevdm.ghmc.telangana.gov.in, 2024). The cases in point explain the ground reality:

Khajaguda Talab (Pedda Cheruvu/lake) is in Ranga Reddy District on the western edge of the city of Hyderabad, in the middle of the suburbs of Manikonda and Gachibowli. It is an important ecological and recreational asset for the city. The Khajaguda Hills (Fakhruddin Gutta/Hills with granite rock are as old as 2.5 billion years) on its Southern shore are a popular spot for outdoor activities, such as hiking and bouldering. The lake was the main source of drinking water and cultivation for the villagers.

However, today, Talab faces problems in terms of conservation and water quality. Private investors established their commercial complexes and residential areas in and around the lake. The sights at Kajaguda Lake and the hills show that, due to poor governance, the lake is surrounded by high-rise buildings/complexes. There were allegations of construction being allowed in the Full -Tank-Level (FTL) area of the lake; builders/companies filling up the lake with earth movers; illegal quarrying being carried out, and parts of the rocks being destroyed, even though the High Court directed the GHMC and HMDA to ensure that the boulders were not damaged. The High Court asked the authorities why the extent of Khajaguda Lake had shrunk by 1.5 acres in five years (between 2014 and 2019). Khajaguda Talab carries frothy waters to the downstream Manikonda Yellamma Cheruvu. Heavily polluted liquid wastes are entering the lake from the north and the Engineering Staff College of India (Times of India, July 7, 2020).

6.5.2. Ecological Buffer Zone at Kancha Gachibowli

Another case in point is the 400 acres of land adjacent to the University of Hyderabad (UoH) campus in Kancha Gachibowli, which has currently sparked disputes between the University and Telangana government concerning environmental degradation. While avoiding the claims and counterclaims between UoH and the Telangana government, it is essential to recognize that this land serves as an ecological buffer zone, housing diverse flora and fauna. The government has begun clearing vegetation and using heavy machinery on the site to prepare it for IT infrastructure development. This decision has provoked protests from students, faculty, environmental activists, and political parties, who argue that such development risks causing severe ecological damage. Environmental concerns surrounding this dispute include the loss of biodiversity, deforestation, and the destruction of unique geological formations. It exemplifies the ongoing conflict between urban development and environmental conservation, raising critical questions about sustainable planning and the importance of preserving green spaces in the rapidly urbanizing landscape of Hyderabad.

6.6. Cement-Concrete Urbanisation

Armelle, in her book *Concrete City* (2023), explored contemporary urban life and its links to the global world through concrete, emblematic of rapid urban and capitalistic development. This journey is also connected to ordinary men and women who plan, build, and dream of the Concrete City. Hyderabad City is no exception to this phenomenon. The lack of permeable surfaces hinders groundwater percolation, exacerbating groundwater depletion. The ease of obtaining building permissions under TS-iPASS and TS-bPASS – a catalyst for rapid urbanization – has inadvertently exacerbated the issue of concretization. There is a substantial surge in commercial and residential built-up areas. Vikas and Milap (2020) observed that the total built-up area in the city was 17,092 ha in 1964, which increased to 45,550 ha in 1990 and to 86,535 ha by 2015 and saw a surge of over 500 million sq ft from 2015 to 2021.

The encroachment of waterbodies and over-exploitation of groundwater for construction activities across the HMDA region are causing water shortages. Excessive concretization in the guise of urbanization has triggered water scarcity in Hyderabad, evident even in March 2024, particularly in the IT and financial district corridors. The Indian Institute of Science's latest study underscores a striking resemblance between Hyderabad and Bengaluru in terms of alarming urban expansion rates impacting water availability in the city ([The Economic Times, 2024](#)). These unhealthy developments have made people highly vulnerable to floods.

7. Governance Challenges for Flood Resilience

Hyderabad city is managed by GHMC, covering more than 650 sq km area (it was 175 square kilometers in 2007). Presently, its administration is divided into six Zones (south, east, north, northeast, west, and central zones), 30 circles, and 150 wards. The Hyderabad Metropolitan Development Authority (HMDA) covers an area of 7,257 square kilometers and plays a crucial role in planning, coordinating, supervising, promoting, and securing the planned development of the Hyderabad Metropolitan.

The primary role of GHMC/HMDA is to prepare and implement master plans and zonal plans, regulate construction activities, and issue building permits for the metropolitan region. They also oversee land use management, including residential, commercial, and industrial areas within their jurisdiction, aiming to prevent unauthorized developments and ensure adherence to environmental norms during construction projects. However, a serious concern in recent years has been the state's policies regarding land use changes.

7.1. Changes in Land Use Policies and Compromising Urban Flood Resilience

The state government has initiated measures in land use policies and layout regularization that includes Land Conversation, 2020, Land Pooling Scheme (LPS), TS-biPASS, and Layout Regularization and becoming the primary reasons for the diversion of agricultural, forest lands and waterbodies- for fulfilling real-estate aspirations. The HMDA, under the LPS and Master Plan 2031, earmarks land use zoning (new urban nodes and centers) year after year to promote organized development. For instance, in August 2023, it auctioned plots in adjacent areas of the western suburbs of Hyderabad, a hub for several IT parks, multinational corporations, educational institutions, shopping centers, and entertainment venues. The land acquisition for urban mega projects such as the ORR and Hyderabad Metro project have also compromised urban flood resilience.

Over time, land use in cities and peri-urban areas has transitioned from predominantly agricultural and forested to mainly urban (Mousumi *et al.*, 2022). This shift has resulted in the disruption of water bodies, which were not only crucial for agriculture but also for flood mitigation and environmental sustainability. The studies observed that the changes in land use and land cover (LULC) have impacted ecosystem service values (ESVs) in metropolitan areas, including Hyderabad. Sudardeva (2023) observed that continuous urban growth imparts variations to the urban ecological LULC and urban ecosystem functions that pose serious challenges. A significant reduction in open land can be observed with only a few visible pockets of light red tone and an overall decline in the number of water bodies (dark-bluish tone) and their spread. Zone 12, which had 65% of impervious area in 2000, is now almost 89% covered with impervious surfaces, registering an overall increase of about 23.75%. The increase in imperviousness basically in the form of urban growth, which has occurred at the cost of encroachment of vegetative areas, other open lands and water bodies, was 0.95%, 15% and 0.65%, respectively. The increased imperviousness limits the infiltration process, thereby increasing the total runoff from the urbanized catchments up to six times and peak flows up to 1.8-8 times, thus leading to flooding (Vani and Kamraju 2016; Raghu and Srivalli, 2020). Thus, these government measures cater to real-estate ambitions, potentially compromising environmental resilience and leading to the degradation of vital flood-mitigating systems in Hyderabad.

7.2. Garbage Dumping on Drainage Systems and Flood Risks

Flooding in Hyderabad is often attributed to macro factors like changing climatic conditions and societal issues such as unplanned city expansion and unregulated construction, which cause rainwater to flow directly into drains and nalas. Encroachment of rainwater drainage systems further exacerbates the problem. However, the role of individuals in contributing to the city's flood-prone nature remains largely unnoticed. The Chief Engineer of GHMC highlights that dumping garbage into nalas by households, petty traders (e.g., fruit sellers and eateries), and other businesses worsens the issue. For instance, rotten fruits and other waste are regularly dumped into the Musi River, while residents discard household items into the nala at Talab Katta in the Old City (Sanjay Samuel Paul, Deccan Chronicle, September 2024).

7.3. Institutional Shortcomings and Their Impact on Urban Flood Resilience

The most pressing challenges include:

1. Inadequate powers, personnel, and budgets for municipal bodies GHMC/HMDA to tackle the illegal occupation of government lands and water bodies layout of colonies. There is little chance of rehabilitating the area. Venture developers often support these unlawful occupations with backing from the ruling party; the revenue, irrigation, tourism, and HMDA departments are unable to stop these illegal occupations (www.deccanchronicle.com/retrieved on February 20, 2024; Eenadu, February 27, 2024, Hyderabad edition). At times, they either remain passive observers due to political inference or collude with vested interest groups, failing to enforce government regulations and protect public property and safety;
2. The inadequate administrative mechanisms to enforce compliance with ease of doing business initiatives, such as the TS-bPASS self-certification rules, authorizing irregular layouts and buildings under LRS without proper scrutiny and converting lands owned by state governments and industries engaged in traditional occupations to non-agricultural purposes under the Land Conversation Act of 2020. Additionally, section 47(A) of the Act eliminates the authority of revenue officials/competent authorities;

3. Over the years, a lack of coordination among various government departments – including municipal bodies, revenue agencies, irrigation departments, and law enforcement – has allowed for the unregulated growth of the city. This includes the encroachment of lakes and tanks by private entities, which disrupts the natural flow of water between them. The seriousness of this issue was highlighted when the High Court initiated a motu Public Interest Litigation (PIL) after concerns raised by a High Court judge (Eenadu, 18 and 19 April 2024);
4. Private agencies acquire agricultural lands for farmhouses and later develop them into ventures, significantly impacting flood resilience in Hyderabad. This conversion of agricultural lands into impervious surfaces, such as roads, buildings, and paved areas, leads to haphazard development, decreases water infiltration, and increases surface runoff. It disrupts drainage patterns, resulting in waterlogging and overburdening stormwater drains, thereby contributing to urban flooding. Additionally, the loss of vegetative cover from these lands exacerbates the urban heat island effect, altering local weather patterns;
5. Widespread legal and illegal mining of valuable resources such as sand, rock, feldspar, limestone, and granite, which impacts land availability and quality. Despite court directives, unauthorized mining continues to thrive in various pockets of the new residential colonies, especially within the boundaries of the ORR. Frequent mining explosions in the Manikonda, Puppalaguda, and Vattinagulapally localities were in complete disregard of the norms. The delicate balance between urban development and environmental preservation remains a critical challenge (Vikas and Milap, 2020).

8. Flood Resilience Mechanism and Measures

Flood resilience mechanisms within the GHMC/HMDA jurisdiction include the Disaster Management Unit, the Directorate of Enforcement, Vigilance, and Disaster Management (EV and DM), the Disaster Response Force (DRF), and HYDRAA. These entities focus on mitigating urban flooding and enhancing the city's capacity to handle heavy rainfall. The Municipal Commissioner of GHMC serves as the Nodal Officer for Disaster Management activities within the GHMC limits, supported by the EV and DM and DRF.

The DRF – the first-ever city-specific rescue force in the history of urban local bodies not only in Telangana but at all Indian levels- was established (based on the flood experiences of 2000, 2016, and 2017) in 2018 to tackle various disasters (directorateofevdm.ghmc.telangana.gov.in). The EV and DM, in compliance with the NDMA guidelines and IMD's forecast of heavy rainfall in Northern Telangana, including the Hyderabad district from 12th to 14th October, have installed 122 Automatic Weather Stations (AWS), ensuring at least one AWS per 4 square kilometer area. These are strategically placed within GHMC limits, updating weather parameter data hourly and making it accessible to the public, which reduces response time and minimizes impacts. The rehabilitation measures taken by the GHMC during the 2020 floods included providing Rs. 10,000 to each affected household as immediate financial aid. Additionally, damaged electrical substations and feeders were repaired, and power supply restoration was prioritized after ensuring safety in waterlogged areas (directorateofevdm.ghmc.telangana.gov.in). However, numerous allegations have been made that the financial assistance was directed to members of the ruling party.

8.1. Disaster Management Challenges

The EV and DM in Hyderabad faces several core challenges in mitigating flooding. Rapid urban growth and unregulated construction contribute to the issue, while the encroachment of water bodies disrupts natural drainage systems. Municipal bodies, irrigation departments, and law enforcement agencies fail to collaborate effectively. Outdated storm water drainage systems struggle to handle heavy rainfall, and blockages in nalas caused by waste dumping exacerbate flooding. Additionally, the department operates with constrained budgets, personnel, and equipment, and limited citizen awareness about flood risks and preparedness further complicates the situation. Addressing these challenges requires a multi-pronged approach that includes stricter enforcement of regulations, improved interdepartmental coordination, and public education campaigns.

8.2. The Hyderabad Disaster Response and Asset Protection Agency (HYDRAA)

The state government established this agency through an executive order – Government Order (GO) 99 – on July 19, 2024, as part of its vision to prepare a Mega Master Plan, attract private investments, and address the

city's increasing vulnerability to natural disasters, which exposed gaps in existing mechanisms. The GO defined the agency's formation, responsibilities, and operational procedures. HYDRAA was tasked with addressing natural disasters like heavy rains and urban flooding, enforcing asset protection policies, tackling illegal encroachments, and safeguarding public property within the GHMC limits and surrounding areas. The agency operates under the Municipal Administration & Urban Development (MA & UD) Department, led by a senior All-India Service officer acting as Commissioner.

Legal challenges arose as individuals and political parties questioned the constitutionality of GO 99 in the High Court. In October 2024, the state government replaced GO 99 with an ordinance to provide HYDRAA with legal sanctity and statutory powers. This ordinance amended the Telangana Land Encroachment Act, 1905, to tackle land encroachments and improve disaster management in Hyderabad and the surrounding areas. Additionally, it amended the GHMC Act of 1955 by introducing Section 374-B, which empowers the state government to delegate GHMC's functions to specialized agencies like HYDRAA.

While these amendments aim to enhance disaster management and asset protection, they reduce GHMC's control over vital responsibilities such as asset protection, enforcement, and disaster response. The amendments enable the state government to reallocate financial resources and personnel from GHMC to other agencies, resulting in centralized decision-making and limiting GHMC's autonomy in addressing localized issues effectively. This restructuring creates overlapping jurisdictions between GHMC and HYDRAA, leading to governance challenges and operational inefficiencies.

HYDRAA has reclaimed approximately 200 acres of land, including parks, lakes, and government properties, from illegal encroachments as part of its demolition drive (www.deccanchronicle.com; <https://newsmeter.in/hyderabad>). However, political parties and other stakeholders are expressing concerns about HYDRAA's activities concerning the demolition of houses belonging to lower and middle-class people and raising voices against the government. The civil society organizations emphasize a need for greater engagement with residents to resolve illegal encroachments and tackle grassroots challenges.

What matters most is how prepared the state, local governments – both rural and urban – government departments, and parastatal agencies such as HMDA and HYDRAA are in addressing flood vulnerabilities. Their readiness is crucial for protecting the lives and livelihoods of people in Hyderabad City and peri-urban areas, both in the immediate and long-term contexts.

9. Conclusion

The discussion highlights that marketization in Telangana, combined with resource concentration, uneven growth, and unregulated expansion within HMDA, has created a "top-heavy" urban system with uneven population distribution across cities and towns. The government's flood vulnerability concerns include: (a) regulating urban planning; and (b) integrating Disaster Risk Reduction (DRR) into developmental planning. A critical focus is mainstreaming DRR by incorporating flood resilience measures into HMDA's developmental strategies. This effort goes beyond addressing flood warnings, aiming to build resilient livelihoods and ensure the safety of people, along with critical facilities and services.

The flood resilience of citizens largely hinges on empowering local bodies to: (a) prevent the illegal occupation of community resources by vested interest groups; (b) regulate natural resources, including land use, water management, and green spaces; (c) enforce laws such as building codes, safety standards, and environmental regulations; and (d) adopt inclusive urban policies that prioritize the well-being of all residents, regardless of socioeconomic status. An innovative flood mitigation strategy includes constructing "Urban storm water wetlands," an affordable solution for storm water management with added recreational benefits ([Alokanada and Suchandra, 2021](#)).

Hyderabad City's experience underscores that building sustainable, disaster-resilient cities requires not only top-down economic policies but also active collaboration among rural-urban local bodies, civil society organizations, and residents. However, critical concerns remain regarding the citizens' disaster resilience: whether the state government implements the democratic decentralization framework, empowering urban local bodies in the true letter and spirit of the 74th Constitutional Amendment Act, 1992, or relies on a new

localism framework to address illegal layouts, encroachments on public spaces, and safeguard the lives and livelihoods of poor and marginalized communities.

Key questions arise: Does HYDRAA remain neutral in its activities, or does it serve the ruling class's interests? Can the state government effectively curb vested interest groups that frequently violate norms for personal gain? Is the government actively addressing flood vulnerabilities and environmental challenges? Additionally, does granting statutory powers to HYDRAA – alongside amending the GHMC Act of 1955 and assigning crucial responsibilities like asset protection, enforcement, and disaster response to a bureaucrat – undermine democratic decentralization? The proposed Mega Master Plan for 2050 offers a potential solution, provided it is implemented effectively.

References

- Akash Bag and Khaliq Parkar. (2009). *The Tremoring Earth: Preparing for the Catastrophe. Economic and Political Weekly*, 44(1), 03 Jan.
- Alam, S.M. and Markandey, K. (2020). *Consequences of Unplanned Growth: A Case Study of Metropolitan Hyderabad. in Thakur, R. et al. (Eds.), Urban and Regional Planning and Development*, Springer, Cham. https://doi.org/10.1007/978-3-030-31776-8_13
- Alokananda Banerjee Mukherjee and Suchandra Bardhan. (2021). *Flood Vulnerability and Slum Concentration Mapping in the Indian city of Kolkata: A Post-Amphan Analysis. Water Science*, 35(1), 109-126. doi: 10.1080/23570008.2021.1957641.
- Anil Sadgopal. (2020). *Introductory Note to the Book in Suresh Suratwala. The Rural Development in India-Devapur Experience*, Kishore Bharathi, Bhopal.
- Aprajita Singh. (2015). *Beyond Embankments Uttarakhand and Kashmir Floods. Economic and Political Weekly*, 50(15), 11 April.
- Armelle Choplin. (2023). *Concrete City: Material Flows and Urbanization in West Africa*. <https://www.wiley.com/en-ie/Concrete+City>
- Bonda, K.K. and Giduturi, V.K. (2024). *Addressing Urban Floods and Water Scarcity in Cities: The Case of Hyderabad. in Visvizi, A., Troisi, O. and Corvello, V. (Eds.), Research and Innovation Forum 2023, RIIFORUM 2023, Springer Proceedings in Complexity*, Springer, Cham. https://doi.org/10.1007/978-3-031-44721-1_21
- Brenner, N. and Theodore, N. (2005). *Neoliberalism and the Urban Condition. City*, 9(1), 101-107.
- Deshpande, R.S. (2022). *Disaster Management in India: Are We Fully Equipped?. Journal of Social and Economic Development*, 24(Suppl 1), S242-S281. <https://doi.org/10.1007/s40847-022-00225-w>
- Gupta, K. (2020). *Challenges in Developing Urban Flood Resilience in India, Phil. Trans. R. Soc. A*, 378, 20190211. <http://dx.doi.org/10.1098/rsta.2019.021>
- Madhuri, R. et al. (2021). *Urban Flood Risk Analysis of Buildings Using HEC-RAS 2D in Climate Change Framework. H2Open Journal*, 4(1).
- Mousumi, H. et al. (2022). *A Geospatial Study of Urban Floods in Hyderabad City. International Journal of Science and Research*, 11(7), July.
- Peck, J. and Tickell, A. (2002). *Neoliberalizing Space. in N. Brenner and N. Theodore (Eds.), Spaces of Neoliberalism: Urban Restructuring in Western Europe and North America*, 33-57, Oxford Blackwell.
- Prasad, R.N.C. et al. (Eds.) (2008). *New Public Management in India: Problems and Perspectives*. Shipra Publications, New Delhi.
- Raghu, T.V. and Srivalli. (2020). *Urban Floods: A Study Specific to Hyderabad and Vijayawada Cities. Journal of Emerging Technologies and Innovative Research*.

- Ramachandraiah, C. and Prasad, S. (2004). *Impact of Urban Growth on Water Bodies – The Case of Hyderabad. Report No. 60, Hyderabad.*
- Rangari, V.A. *et al.* (2019). *Floodplain Mapping and Management of Urban Catchment Using HEC-RAS: A Case Study of Hyderabad City. Journal of the Institution of Engineers Series, A*, 100(1).
- Rao Hanumantha, C.H. and Dev, M. (2003). *Andhra Pradesh Development-Economic Reforms and Challenges Ahead. Centre for Economic and Social Studies, Hyderabad.*
- Sharief, M.A.J. and Vangipuram, B. (2022). *Assessment of Socio-Economic Impact of Urban Flooding in Hyderabad Due to Climate Change.* in Ghosh, C. and Kolathayar, S. (Eds.), *A System Engineering Approach to Disaster Resilience: Lecture Notes in Civil Engineering*, 205, Springer, Singapore. doi: https://doi.org/10.1007/978-981-16-7397-9_10.
- Shaw, A. (2012). *Metropolitan City Growth and Management in Post-Liberalized India. Eurasian Geography and Economics*, 53(1), 44-62. doi: https://doi.org/10.1007/978-981-99-4811-6_2.
- Sudardeva Pal, M. (2023). *A Case Study on Estimating the Ecosystem Service Values (ESVs) Under Anthropogenic Influences for Chennai and Hyderabad.* in Pandey, M., Gupta, A.K. and Oliveto, G. (Eds.), *River, Sediment and Hydrological Extremes: Causes, Impacts and Management, Disaster Resilience and Green Growth*, Springer, Singapore. https://doi.org/10.1007/978-981-99-4811-6_2
- The Economic Times. (2024). *Hyderabad Moving Towards Bengaluru-Like Water Crisis? Indian Institute of Science Study Suggests Shocking Similarities. Bangalore News*, April 05.
- Tikender Singh, P. (2021). *Stop the Piecemeal Approach, Constitute a Second National Commission on Urbanisation.* Impact and Policy Research Institute, March 9.
- Tiya Sigh. (2023). *The Tremoring Earth: Preparing for Catastrophe. Economic and Political Weekly*, 58(11), 16 March.
- Vani, M. and Kamraju, M. (2016). *Impact of Urbanisation on Lakes: A Case Study of Hyderabad. Journal of Urban and Regional Studies*, 5(1), August.
- Vikas, S. and Milap, P. (2020). *Overcoming Barriers to Urban Flood Resilience: A Case of Hyderabad, India.* in Guangwei, Huang (Ed.), *Flood Impact Mitigation and Resilience Enhancement*. doi: 10.5772/intechopen.93195.