The impact of Musi floods along the catchment areas of Hyderabad-A study

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Abstract. Urban floods threaten the functioning of many states across the country. Mumbai, the economic capital of India, gets affected in most of the monsoon seasons due to heavy rains. Likewise, the state of Kerala too witnessed heavy floods in the recent years. In this background, the current research paper is an attempt based on secondary data to focus on the impact of urban floods in the stretch of river Musi in Hyderabad. The Telangana region experienced heavy rains in October 2020 due to which a flash flood occurred in Hyderabad. This happened after 100 years while the river basin had settlements coming up in low laying or catchment areas. The people who were residing along the coastlines of the slums also got affected during the floods. Historically, river musi was a source of drinking water in that region. However, the scenario got completely changed due to overpopulation, uncontrolled migration and housing affordability in this region which led to devastation of the river basin. According to the (CSE)'s 71-city study, Hyderabad city discharges about 700-800 million litres per day of untreated sewerage water directly into Musi river. So, the drinking water for the entire city is brought from different places. The current research paper is an attempt to focus on the regional issues and determine the social cost and the livelihood along the Musi River stretch in Hyderabad region in a comprehensive manner. Pollution brings an unprecedented fall in agricultural yield and increases the input costs for agriculture like handlooms. It also affects the allied services like dairy, poultry, livestock, fishing, washing clothes, health hazard, unemployment etc. In order to avoid the urban floods in the future, the planning strategies need to be implemented to achieve sustainable development along the stretch of Musi through people's participation and government intervention.

Key words: Urban Floods, Migration, Catchment area, Sustainability development.

1. Introduction

In recent years, urban floods have become a common occurrence that challenge city planners across the globe. Flooding in an urban area can happen in a relatively short period of time and can engulf the entire area with several feet of water. This is common in concrete world since the surface water runoff is interrupted by human beings through unplanned settlements. The issue is worsened by the relocation of people from rural to urban regions. By 2050, it is predicted that 70% of the world's population tend to emigrate [1]. Rapid urbanization and climate change are responsible for urban flooding in most of the global cities. Heavy rainfall in the cities, overflows from upstream dams/rivers, and construction on flood plains or low-lying areas have a significant impact on watershed hydrology by inducing the uncertainties in rainfall and runoff patterns. Moreover, urban heat islands have been identified as a factor that contributes to the increased convective rainfall in the cities.

India is not an exception to the rise in climatic extremes and urbanization issues and its impacts have been manifesting in the form of floods in urban centres for the past few decades. The cities that

experienced recurrent catastrophic flooding include Chennai-2015, Kerala-2018, Patna-2019 and Hyderabad-2020 which illustrate the the seriousness of the problem [2]. Though various initiatives are taken by the governments, urban floods still pose a significant challenge to implement flood-resilience measures in many Indian cities [3]. Though extreme rainfall events are impossible to predict, modern technologies such as GIS allow us to minimize the risks and damages by mapping the extent and severity of the likely events. The current study analyses the impact of urban floods on the livelihood along the Musi river stretch in Hyderabad and discuss about the planning strategies to reduce the flood risk in future.

2. Background Study

The ancient and the iconic river Musi, also known as musinuru or moosa, is a tributary of Krishna River and it runs in Deccan plateau, Telangana, India. Hyderabad is situated on the banks of this river, which divides it into 'old' and 'new' cities [4]. This river originates in Anantagiri hills near Vikarabad, Ranga reddy district, 90 kms to the west of Hyderabad and flows due east for nearly its entire length. After a 240 km journey, it meets the Krishna River near wadapally in nalgonda district. The geographical area of the river basin extends up to 11,270 sq.km approximately that gets sprawled across 71 mandalas in different districts. Being a seasonal river, it flows eastwards and spreads 24 kms in the city with an annual run-off of 1,410 MCM. It has an average rate of flow of 45 cumecs. This river frequently flooded the city until the early 20th century. After the devastating flood in 1908, Mokshagundam Visvesvarayya has constructed a flood control system on the river to prevent the flooding. Two reservoirs were built across the river i.e., the Osmansagar dam with a watershed area of 738 sq.km (3.9 TMC) in 1920's; which is ten miles upstream from the city. Another reservoir was built in 1927 and was named as Himayatsagar with a watershed area of 1311 sq.km (2.7 TMC capacity). Both of these reservoirs are the major drinking water sources of the city today [5]. The river flows east from these reservoirs, downstream the city. It has 24 diversion weirs, locally known as kathwas, which are used to divert the water to over 40 villages. As it flows through the city, the river turns to be a giant sewer filled with garbage and industrial waste. It is known as one of the most polluted rivers in the country because of uncontrolled population growth, urbanization, and industrialization.

Figure 1 Map representing the flow of Musi River in different districts in and around Hyderabad

3. The Flood Profile

The city of Hyderabad has already experienced various disastrous floods in the past, including 'the musi flood' that happened a century ago, triggered by 480.06mm of rain in 48 hours. This unprecedented rains overflowed into depressed regions and caused massive damage to the human life [6]. To tackle such floods and ensure seamless supply of the drinking water to the city, two significant reservoirs were erected along the river i.e., Osmansagar in 1920 and Himayatsagar in 1927. Musi river was responsible for frequent flooding in Hyderabad since 1572 AD, with floods occurring 11 times in the city. In September 1908, 153.2mm of rain fall was recorded which caused the death of 15,000 people whereas 80,000 were left homeless. Due to clogged drains, unauthorized encroachments on the riverbeds and development along the river banks, the natural drainage got blocked and minimized the storm water capacity of the city. Post-Musi floods, the city of Hyderabad has not seen the same amount of rainfall. However, its severity has increased, since then. It is estimated that more than 90 residential colonies (2-4 m water level) were flooded during August 2000 (241.5 mm in 24 hours). The city witnessed another

intense downpour on October 2020 which impacted more than 120 colonies that left 20,500 people homeless. Further, it also caused 81 deaths and the river was flowing at its full capacity by then (Table 1) [7]. In this way, it reminds the repeated warnings that were completely ignored for so many years.

Table 1 Important flood events in Hyderabad

Event	Rainfall (mm)	Deluge depth (mm)	Damage / Affected areas			
			Lives	People (lakh)	Houses	Estimated loss (Rs)
October 2020	192.0	2 - 4	81	>1.8	>20,500	5000 crores
September 2019	133.0	1 - 2	0	>1.2	>30,000	>10 lakhs (goods)
September 2016	167.0	1 - 2	8	>1	>17,000	60 crores
August 2008	137.0	2 - 3	14	>1.5	>32,000	49.2 crores
August 2002	130.0	1 - 2	0	>1	>12,000	>10 lakhs (goods)
August 2001	127.0	1 - 2	0	>1	>15,000	>10 lakhs (goods)
August 2000	241.5	2 - 4	26	>2	>35,693	135 crores
July 1989	187.7	1 - 3	10	>1	>20,500	30 crores

4. Musi River Pollution

At present, the river carries the sewage and industrial effluents from the city. During the last 50 years, the water quality in Musi River has deteriorated heavily as the river has become an ultimate destination for all the waste water produced by the Hyderabad city. The amount of sewage water generated daily is estimated to be about 200 million gallons (MGD). Similarly, the urban agglomeration area, occupied by Hyderabad and Secunderabad, has grown to 727 square km currently [8]. There is a rapid urbanization happening along the Musi River and its bed is encroached by a large number of informal settlements and slums. These activities have shrunk the river into a drain line. According to the Ministry for municipal administration and urban development in March 2020, only 605 MLD of the 1,250 MLD of sewage, generated in greater Hyderabad, is treated by 51 nallas on the 30 km stretch of the river. While Musi river basin moves towards water stress, 38 percent of the state's total estimated usable water comes from musi basin. The per capita accessibility of the state in 2010 was 1,588 m^3/year and the demand is expected to increase by over 50 percent in the next four decades. Now the river crawls through the city, carrying a deadly mix of drainage water, solid wastes and poisonous fumes from 12,000 industries. It is common in most of the developing countries to discharge the untreated sewage into open water bodies. In an effort to address the issue, common effluent treatment plants are set up to handle such industrial effluents. However, they are unable to manage them effectively and this outcome can negatively impact the public health and agricultural sustainability.

5. Musi River Revitalization Project

The conservation of Musi River was taken up only after the realization that Musi is under threat and it needs to be conserved for the environmental sustainability of Hyderabad city and also can be developed as an attraction to the city by beautifying large open spaces of Musi. The history reveals that several flash floods claimed many lives and caused a lot of damages to both property and livestock along the river basin. To control similar situations in the future, the colonial government made use of new concepts to prevent the flooding. In 1920, Osman sagar and Himayat sagar reservoirs were built to prevent the river from flooding and supply water to the city. The government of Andhra Pradesh launched the Nandavanam project with an aim to beautify the river and relocate the people who live along the banks to nearby housing complexes. Under this project, the government agencies built a 20m wide channel on river basin to control the overflowing water. In 2000, the Chief Minister of Andhra Pradesh declared the Nandavanam Project, invalid.

In 2001, people who lived along the river and some downstream villages launched the Musi Bachao Andolan after the occurrence of 1999 floods. The Hyderabad metropolitan water supply and sewerage board and Greater Hyderabad Municipal Corporation launched the abatement of the pollution control in the river in 2005, as a part of National River Conservation Plan (NRCD). The aim of this plan was to beautify the river and build sewage treatment plants to treat the sewage before it enters the river [9]. 'Save musi' project began in 2006 with the goal of cleaning up the extremely-polluted river and restoring it to its former grandeur. As per the plan, the sewage flow into the river was to be intercepted by new sewers and sewer treatment plants. In 2009, the Greater Hyderabad Municipal Corporation built rubber dams to provide a stretch of water for boating and aquatic amusement. A brief trial run was executed in 2010 and it did not prove to be effective at the attapur STP. So, the dam was not put to use. In the same year, the Hyderabad metropolitan development authority published a new Master plan for the core area of the Hyderabad city. The plan outlined the land use and infrastructure requirements for a 172-square-kilometer area. It also proposed to build two 80' wide roads, parallel to the river which will create a new east-west connection through the city.

Figure 2 Proposed 14 New bridges across the river form Afzalgunj to Gowrelly

Source :Municipal and urban development department govt. Telangana

Currently, the government is working on Musi Rejuvenation and Beautification Project that was proposed in 2006 and was taken by Musi Riverfront Development Corporation Limited (MRDCL), which was established on 25th march 2017. The corporation has been tasked with developing a comprehensive plan to reduce the pollution in the river and develop the riverfronts for a distance of 55 km from Gandipet to 47 km ORR east and himayatsagar to bapughat (8 km). In addition, 14 bridges were also planned across the river (fig 2) [10].

6. Study Area

6.1 Slums settlements and socio-economic status

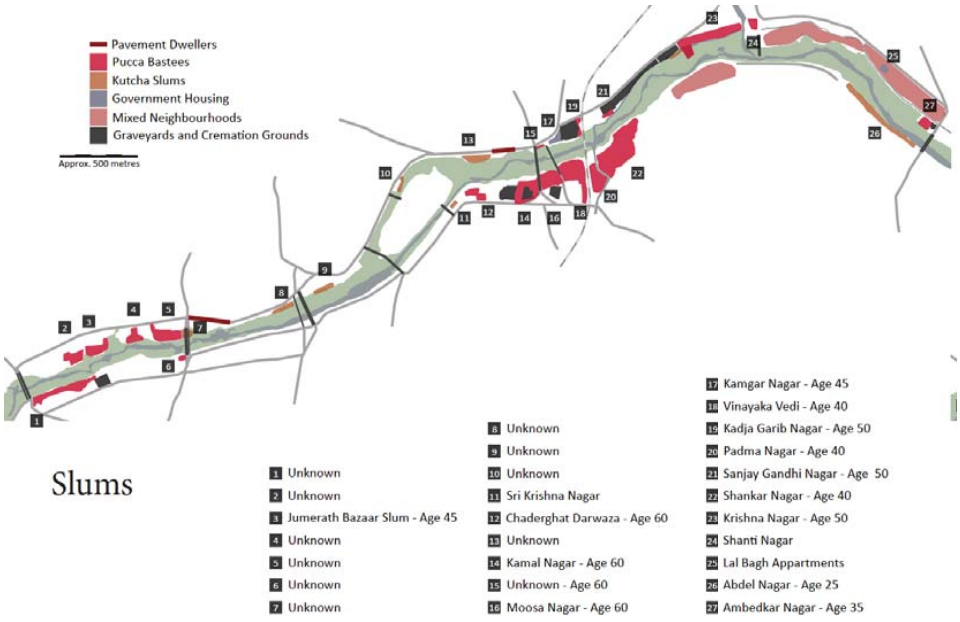
There are 50 plus slum communities located along the Musi River in Hyderabad city which are unauthorized constructions along the river bed (fig 3). The poor migrants often settle on marginal or public sites such as riverbanks since they lack access to official housing and land. On the other hand, the local communities rely only on the riverbed for agriculture, grazing, and washing, and their livelihoods are inextricably linked to it. Due to lack of access to municipal water supply, they are dependent on the heavily polluted river water for their needs (fig 4). Musi river is polluted with industrial effluents and sewage (fig 5). These industrial effluents contain lead-contaminated water that can cause joint pain, visual abnormalities, and even cancer. The challenge is to attenuate the loss of homes and livelihoods and balance the environmental protection and sustainability concerns with the welfare of the city's poor and vulnerable.

Figure 3 Slum residents living in pathetic Condition

Figure 4 Use of polluted water diverted from the Musi River near Hyderabad

Figure 5 View from Chadarghat Bride

Figure 6 Map indicating Slum dwellers along the Musi river, Hyderabad



At a macro level, it has been observed that the urban floods are caused by the obstruction of surface run-off to the catchment areas such as encroachment over drainage channels and in some cases, the residential buildings are built even on top of nallas and drains (fig 6). The city administration may zone an area as 'flood-prone' and halt the activities in the area. It may also demolish the structures that do not adhere to such zoning rules. There are different zoning rules followed throughout the coastal area and river banks. Such zoning rules are often ignored or not followed which results in illegal construction. Flood control techniques such as the prevention of buildings, diversion of the floods away from residential areas and channelling the floods are wonderful. However, implementing such techniques into the action plan is difficult for any developing municipality.

6.2 Digital Elevation Model (DEM)

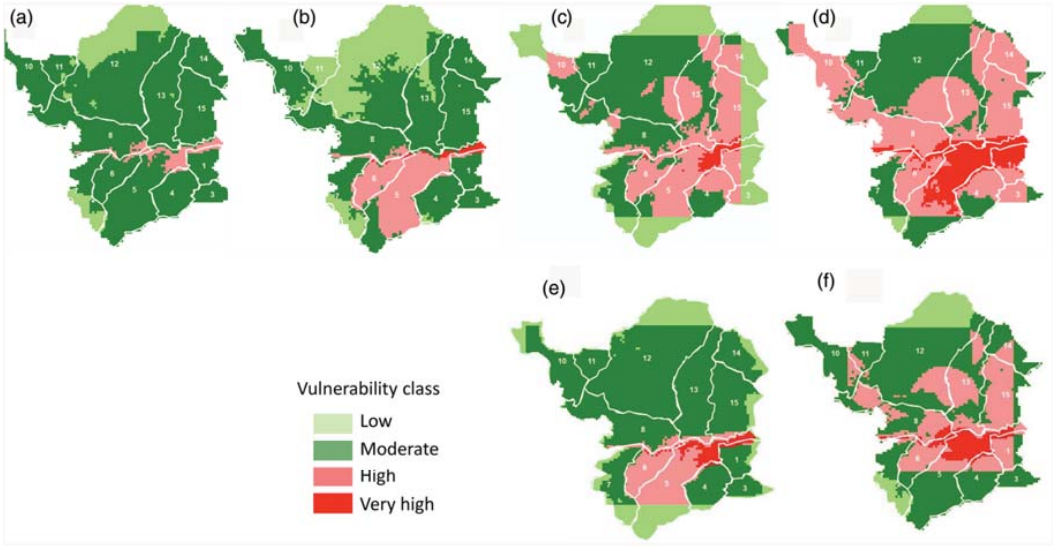
Figure 7 Digital elevation model of Hyderabad

In order to understand and evaluate the study area, a DEM was created (fig. 7). According to the model, the highest altitude can be noticed in the western part of the city whereas the lowest part can be seen in the south-east region. Moderate areas, particularly the ones near lakes and rivers, are unfit for inhabitancy. However, most of such areas have already been densely populated. The city's population increased rapidly from 3.05 million in 1991 to 3.64 million in 2001. After the establishment of GHMC in 2007, it reached 6.81 million in 2011. The most vulnerable populations in metropolitan cities are those with the fewest socioeconomic resources to cope up with calamities. Hyderabad had over 2.29 million people living in slums and squatter settlements in 2011. According to GHMC estimates, 13,509 families got directly affected by the floods in this region.

6.3 Flood zoning map of Hyderabad

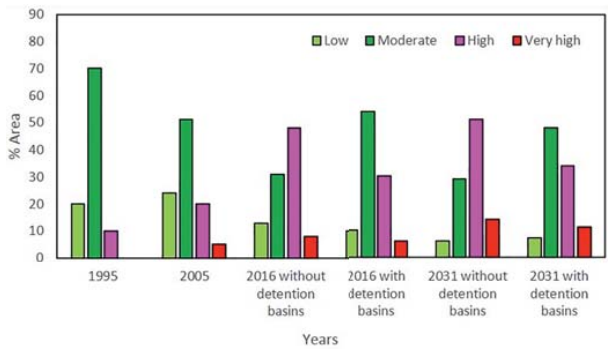
The flood zoning map of Hyderabad was prepared using GIS by Information Technology Research Academy (ITRA), Government of India. To understand the hazards caused in various zones, they are classified into low, moderate, high and very high level.

Figure 8 Flood zoning map of Hyderabad (a) 1995 without detention basins, (b) 2005 without detention basins, (c) 2016 without detention basins, (d) 2031 without detention basins, (e) 2016 with detention basins and (f) 2031 with detention basins.



Source: Information Technology Research Academy (ITRA)

Figure 9 City's flood vulnerability for various scenarios



It is evident from the maps (figs 8,9) that, in 36 years (1995-2031), the area of cities prone to flooding has grown by 150 sq.km when the detention basins were provided in 2016. The moderate zone will decrease from 430 km^2 to 300 km^2, while the low vulnerable area will shrink from 125 km^2 to 44 km^2 and the high flood area of the city will reduce by 37% and 44%, respectively, from the existing catchment situation. During 2016, the areas within zone 5 were found to be very highly vulnerable whereas the areas in the zones such as 1, 4, 10, 12, 13, 14 and 15 were highly vulnerable. In 2031, the zones such as 1, 5, 6 and 8 will be very highly vulnerable whereas the zones such as 1, 3, 4, 5, 6, 8, 10, 13, 14 and 15 will be highly vulnerable. According to the 2016 vulnerability assessment, 48% of the city was highly vulnerable whereas in 2031 vulnerability assessment, 51% of the city will be highly vulnerable. The zones 1, 5 and 6 are very highly vulnerable until 2031. The installation of the detention basins has reduced the highly vulnerable areas of the city by 8 and 9% respectively, since 2016.

Rapid urbanization led to a 55 % increase in impervious areas in the year 1995 and an 80 percent increase in 2031 is expected. While the pervious areas will decrease from 43 percent to 18 percent during the same period. The increase in impervious areas result in a threefold increase in peak runoff too and a

22% increase in the depth of floods in river Musi. The results obtained from the model indicate that the catchments with detention basins reduce the peak runoff by 23% compared to the existing catchments. The development of flood zoning maps can help the policymakers and stakeholders better understand about the flood risks. By developing these maps, we can better understand the policy mechanisms and mitigation strategies. The flood zone maps provide a geographical distribution of the flood mitigation measures, which enable the mitigation of flood to be prioritized based on its location.

7. Policy gaps in flood management

7.1 Macro analysis

The Indian constitution states in article 51A(g) that every citizen has the duty to protect and improve the natural environment, which includes forests, lakes, rivers, and wildlife, as well as to have compassion for all the living things. However, the natural resources have deteriorated over a period of time. The article needs to be realized at the grass-roots level by empowering the local authorities. In the 74th amendment, though the power was decentralized at the municipal level, this has not been achieved. Hyogo and sendai frameworks emphasize the mobilization on national and local levels. However, those international frameworks fail to take into account how global structural factors outside the local government control, contribute to disaster risks.

NDMA is the organization for disaster management in India which provides guidelines for city disaster management committee, formation of community-based disaster management plans and urban citizens' forum for disaster risk reduction in the cities [11]. Unfortunately, the state of Telangana, under which the city of Hyderabad comes, does not have any active bodies or plans coordinated with national and state levels. NDMA also focuses on rescue, relief, rehabilitation and plans/guidelines, but do not addresses the victim identification process. The data on disaster risks is not centralized in the institution, rather the agencies collect data on an ad-hoc basis, rather than as part of a centralized system [12]. Despite the Supreme Court's request for its establishment under Section 47 of the Disaster Management Act of 2005, the financing for DRR still remains a mystery. The centre failed to persuade and communicate the need for an independent disaster management organisation that collaborates with departments from various sectors. [13].

7.2 Miso analysis

Policies have breakouts in their framing and execution, as per the section 14 of SDMAs which are formed for effective disaster administration. Telangana has established the state disaster management response and Fire services in which the guidelines, procedures, and mock drills for flood evacuation are not specific alike how it is, for fire safety. The national disaster response force heavily relied upon the evacuation and rescue efforts during 2016 floods. Under Section 22, the state disaster management plan is mandated in accordance with the national plan, and under Section 28, the SDMA covers all the departments with a disaster management plan. The state action plan for climate change only briefly mentions the floods and does not even address the issue of urban flooding in the cities. The lack of coordination and comprehensive plans result in conflict in disaster mitigation.

Urban policy has a direct impact on the city's land use change. Those residents who are living in low-lying areas, along the musi river such as chaderghat and Shankar Nagar colony, are frequently inundated with sewage water and it enters their homes. Inadequate amenities such as open drainage system that frequently mixes with drinking water, exacerbate the situation. One of the primary reasons behind the development of eco-sensitive areas to real-estate places is the minimal information of zoning provisions in urban policy. Therefore, a regional level policy should be developed considering the needs of in-danger populations. This will motivate the municipal bodies to develop a flood-resilient outlook for the city. Megaprojects like the Hyderabad metro and the outer ring road have also harmed the urban flood resilience. The metro project was highly controversial due to the concerns raised about land acquisition in environmentally-sensitive areas of the city, lack of public engagement and the marginalisation of municipal government [14]. It is alleged that the outer ring road development project violates the Government Order and nearly half of the land acquired was under agriculture [15]. The state government initiatives for riverfront development such as Nandanavanam project and Save Musi Campaign were

poorly conceived leading to eviction and public interest litigations. The latest attempt of the grandeur project was announced in 2017, which was put on hold, while the Musi River continues to be polluted, encroached, and prone to flooding [16].

7.3 Micro analysis

The Hyderabad Urban Development Authority (HUDA) started municipal planning process in 1975 as a new phase of urban development which drastically altered the region. Urban flooding is a geographically-confined phenomena and regional government is at the forefront of dealing with the immediate consequences of the floods. There was no involvement of the city's municipal bodies in the formation or functioning of these bodies like the Hyderabad Airport Development Authority (HADA), Cyberabad Development Authority (CDA), and many other Industrial Area Local Authorities (IALAs), which have compromised the city's flood resilience not only in terms of infrastructure but also by putting more vulnerable people at the risk of flooding.

HADA obtained land in Himayatsagar watershed zone which endangers its existence. The growth of Cyberabad and the adjoining Serilingampally ward resulted in an influx of rural migrants seeking refuge in slums. Due to the violations of building ordinances, the agricultural land, vegetation, and water bodies have been dissipated. This in turn reduced the earth's ability to absorb rainwater and increase the surface runoff. Malkajgiri, Alwal, and Ashok Nagar got completely inundated during the floods in the years, 2016 and 2017. The storm water drains recorded a carrying capacity of only 2 cm rain/hour [17]. The Kirloskar report had suggested the demolition of many structures and widening the drains, which is pending for a long time. The major development activities in Hyderabad are guided by master plan, which is fragmented in its process. Due to poor implementation and a lack of harmonization between the master plans, the city has become more vulnerable to floods over the past few years. The master plan of HUDA's 2003 proposed to increase the area under water bodies to 95.44 sq.km by 2020. But, the area has shrunk by over 10 sq.km, and there were no modalities in plan to reclaim the lost area [18]. The zoning regulation in the latest Development Plan 2031 has no priorities for the protection of farm and scrub land [19].

Table 2 Policy analysis framework

	Politics (A focus on improving governance)	**Polity** (Focus on formal instruments and institutions)	**Policy** (Focus on problems)
Macro	• Decentralization and the mainstreaming of DRR are lacking. • The disaster mitigation fund lacks awareness, mapping, and clarity. • NDMA has no mandatory power and the data is generated on an ad-hoc basis.	• Article 51 A(g), 74th amendment, Hyogo and Sendai framework. • Disaster Management Act 2005, National Disaster Management Policy 2016. • NDMA Plans and Guidelines.	• Global structural factors and coordination issues. • Disaster management act, policies, and financing are being partially implemented. • NDMA guidelines have not been implemented due to the lack of standardized responsibilities.
Meso	• SDMA is not involved in the decision-making process for development. • Flood-proofing, mitigation, and evacuation measures are not prioritized. • Land use and basic amenities are poorly regulated.	• SDMA & Disaster Management cell. • State Disaster Management Plan & State Action Plan for climate change • Urban Policy & Urban mega projects.	• Integration of disaster management with other departments. • The flood management system does not have a comprehensive plan • Exploitative water and land management practices

Micro	• Vacuum in administration & Real-estate aspirations. • Parastatal agencies and supranational organizations • The presence of a storm drainage network is insufficient and the efforts to promote green growth are absent.	• Municipal Corporation & governance. • Building by laws, Municipal finances & AP Vision 2020. • Master plans & Kirloskar report.	• In cities, public involvement is low and environmental matters are rarely addressed. • Concentration on short-term economic gains. • The loss of open spaces and the increase in runoff water.

8. Flood resilience in urban areas

The focus upon the transformative qualities and enduring processes contribute to the system's capacity to absorb shocks and pressures. In those cities that experience speedy development, urban flood resilience strengthens the local resilience through effective coordination and collaboration at multiple administrative levels to ease the transition level. The coordination among the local bodies, national and state bodies contributes to effective governance and disaster resilience. The institutionalized NDMA has the power to enforce the guidelines, execute disaster risk mapping, and data collection. NDRF has acted as a mentor for State Disaster Response Forces in times of crisis and identified the disasters and victims of those disasters, and assisted with Interpol's disaster-related identity information process [20]. A plan, forum, or a committee for disaster management at the local level should be incorporated by community participation in the DDMA to accomplish the objectives of the 74th amendment. The involvement with civic groups such as the Hyderabad Greens, Forum for a Better Hyderabad, etc., can bring an enormous difference in the resilience-building process.

Under the National Disaster Management Policy 2016, emphasis is placed on flood early warning systems, ward level risk mapping, and vulnerability assessments, setting up of the urban flooding cells at municipal levels for integrated flood management, and generating awareness through various means. Innovative solutions are illustrated by NDMA guidelines for effective management of the floods such as rain gardens, detention ponds, and lined channels [21]. So, it should be a priority to coordinate across the agencies and between states through NDMAs and SDMAs. In a ten-point agenda on disaster risk reduction, the Prime Minister outlined how disaster mitigation funds and micro-insurance can be used to fund DRR [22].

The state of Telangana has its own SDMA nodal body, along with the SDRF that are involved in the coordination of disaster preparation, evacuation strategies, conducting mock drills and raising awareness can go a long way towards streamlining the fragmented disaster planning. The Telangana Planning and Development Society (TPDS) monitors real-time weather through sensors and automated stations. The Telangana state remote sensing centre is involved in modelling, forecasting, and providing assessment reports to the policymakers to aid in decision making. The company currently works in the domains of environmental clearance, pollution control, and state environmental impact assessment. By involving the SDMAs more in development decisions, disaster preparedness can be streamlined and mainstreamed.

By protecting the city's lakes, planning the catchment areas, treating and segregating the solid waste, the city can revive the river and reduce the surface runoff during heavy rainfall. Protecting eco-sensitive sites in the city will be facilitated by enforcing the land use and zoning regulations during the execution of mega urban projects. Land-use regulation has become an integral part of flood management in Germany and England in which the governments adopted the concept of "room for rivers." Germany has ensured flood mitigation with a restrictive approach to land use policy based on the return period of 100-year floods [23].

9. Major Findings

In order to strengthen the flood preparedness, the local institutions must actively participate in decision-making process to oversee the supra-local forces of urbanization. Urban flooding can be mitigated by providing the basic amenities. A ward level solution is needed to address the problem of inadequate housing structures and poor amenities, especially in the old city area. Using rainwater harvesting in the

city can reduce the flooding and runoff hazards. There should be a restriction on development activity in the bed of water bodies and the FTL of lakes, ponds, etc. Sustainable urban development and flood resilience should be encouraged with the help of model building bylaws and open spaces. In order to improve the flood resilience in the city, regular inspections and impact assessments of the industries and constructions should be conducted to ensure the compliance and protect the water bodies as per water and waste management acts/regulations.
In order to reduce the congestion and mix of runoff water, sewage and storm drains should be delinked. To ensure the city to have long-term flood resilience, it is essential to maintain an integrated storm water system that takes into account natural contours, existing drainage patterns, and the neighbourhood catchment areas. The master plan should focus more on socio-environmental factors, restoration of the urban water bodies, creation of a network of multifunctional open spaces, and the restoration of the vegetation of urban areas. Auroville adopted the concept of bioregion in which a part of the area has been designated for green growth and environmental restoration, regeneration, and biodiversity. Mandi planning area adopted the zone of 'no construction' in the land below the high flood level and 'green zone' in a belt of 25 m buffer along the banks of the river [24]. The hierarchy of the plans can be developed as a regional plan, a town plan, or a neighbourhood plan along with a master plan. To implement these measures, the planning processes must be reviewed regularly and silos must be broken down.

10. Conclusion

A policy gap still exists among the Sendai framework, national, and provincial level disaster management policies. At the state level, the policy frameworks determine the land-use decisions and how the public services are distributed. Natural resources are degraded and multiple vulnerabilities are created as a consequence of weak land-use regulations. The development activities are framed by broad master plans and built under building bylaws at the microcity level. The regulation and the democratic processes are often bypassed and the parastatal bodies and local market forces violate these laws, leading to settlement clusters in flood-prone areas. If the key institutions are provided necessary authority, cutting across all the sectors and departments on both horizontal and vertical levels, it is possible to overcome the problem of poor multi-institutional coordination. The emphasis on green growth and floodproofing, as well as the participation of all stakeholders remain critical in mainstreaming the DRR. In the future, the water security of Hyderabad is dependent on the integrated management of the musi river's catchment area as well as a number of remaining water bodies in and around the city. Involving public participation in decision making will improve the quality of work. The 42nd amendment of the Indian constitution in 1976 gave priority to public when it comes to protection of the environment.

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