JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Mapping flood vulnerable zones and mitigation measures in case of Hyderabad city.

Raghu Teja Vemana,

Associate Professor, School of Architecture, REVA University.

Abstract: Urbanization and climate change are possessing numerous challenges. With an ever-growing population of around 10.6 million inhabitants (1.06 crore). From the year 1990 to 2000, City of hyderabad developed from 170 sq. km to 650 sq.km to accommodate the increasing population due to Industrial IT Industry and pharma sector. The current metro area population in 2022 has an increase of 2.58 percent from 2021. This paper attempts to describe the Musi River floods from 1908 to present, impact of climate change and also focuses on interplay between Greater Hyderabad Municipal Corporation (GHMC) a governing body controlling land use zoning and developmental growth indulged in flood related risks and offers recommendations to deal with urban flooding. The potential risks of flooding of Musi River due to rain and upstream of city are evaluated and contextualised with the perspective of climate change and human interventions with environmental change and the loss of water due thrust on land and infrastructure flooding during monsoon indulging in human property loss. Geographical Information system tool is used to calibrate the Land use and Land classification changes, delineation of flood vulnerable zones by analytical hierarchy process and comparative analysis of flood affected zones of GHMC in the 2000 and 2020 are analysed to propose preventive solutions to urban floods, using multiple approaches to deal with urban development for conservation of water bodies and Musi River.

Key words: Vulnerability, Urban Floods, Urban Planning, Flood Mitigation

1. Introduction

Hyderabad city has been dotted with numerous lakes, which formed with very important component of its physical environment the Rapid urbanization over the years created slums, squatter settlements and encroachments of water bodies. Over the years the city had witnessed rapidly increasing population, economic activity due to IT industry. Like many other megacities of India i.e., Delhi, Mumbai, Chennai and Bengaluru, city is affected by floods related risks aggravated by conjunction of heavy rainfall. This current situation is due to shrunken lakes, extension of impervious surface increasing runoff and transformation of lakes into private property and extensive urban growth *(Ramachandraiah & Prasad, 2004)*. The city has gone through several phases of expansion and owing to developmental changes the thrust on land for infrastructure and facilitate commercial activity. The storm water drains (nalas) also played a major role in shaping the city and yet are most negligent zones of hyderabad. This paper focuses on delineation of flood vulnerable by using Arc-GIS 10.2 and are calibrated by analytical hierarchy process and zones with suitable flood management concepts.

1.1 History of Musi River.

Musi river was once a sacred and source of drinking water for the citizens of hyderabad. Annual rise and flooding during monsoon also prompted logistical development captured the in folklore. The river was viewed both as a problem and as component of its beauty. The Nizams played an important role in shaping the river and the floods of 1908 was a result of several interrelated phenomena. Floods of 1908 is due to climatic factors; region was deluged with monsoon subjected to rains of Bay of Bengal and routed to series of tanks upstream burst. The Musi River origins east of the city in the Ananthagiri hills with a drainage basin of 860 square miles and the river bisects

the hyderabad city which was a part of large river network (*Modernising the Urban Environment: The Musi River Flood of 1908 in Hyderabad, India on JSTOR*, n.d.).

2. Materials and Methods – Study site, Rainfall, Storm water zones and Vulnerable areas demarcation.

2.1 Study area

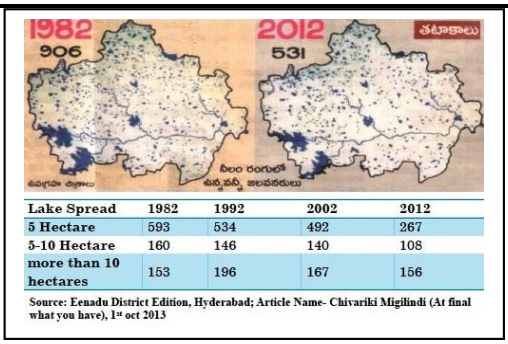
Hyderabad the capital city of Telangana state situated at an average altitude of 542 meters and tropical wet climate with an annual temperature of 26^{o} C and mean monthly temperatures being 21-32^{o}C. Summers are hot and humid. Heavy rains from south-west summer monsoon falls between June and September experiences with most of its annual rainfall of 812.5mm. During the year 24th august 2000 the city had recorded heaviest rainfall of 241mm in 24 hours period. The city had gone through complex evolutionary process from the 1912 after becoming the capital of Andhra Pradesh. In 1975 hyderabad urban development authority constituted to regulate the development around the city. Cyberabad Development Authority (CDA) and Hyderabad Airport Development Authority (HADA) formed under Andhra Pradesh urban area development act of 1975. The first development plan for the area of municipal corporation of hyderabad was for an area of 172.60 square kilometers and eminent engineer M. Visveswaraya prepared City Improvement Plan. The revision of master plan 2020 was suggested with approval of outer ring road(Body et al., 1972). Greater Hyderabad municipal corporation (GHMC) was formed in 2007 with 12 municipalities and 8 grama panchayats. The municipalities are LB Nagar, Gaddi Annaram, Uppal Kalan, Malkajgiri, Kapra, Alwal, Qutubullapur, Kukatpally, Serilingampalle, Rajendra Nagar, Ramachandrapuram, and Patancheru (*About GHMC*, n.d.). The study area GHMC has been experiencing severe accelerated urbanization since last three decades with change in physiological form and hydrological structure. Heavy rain intensity and failure of sewage infrastructure makes the city highly vulnerable to flood risk. The city spatial dynamics changes drastically when driven by rainfall and overflow of waterbodies and nalas. The growth of the city has come at the cost of 375 lakes going extinct. The HUDA is having only 531 lakes as compared to the 906 in 1982(Kumari & Management, 2013). Lakes identified by HMDA in hyderabad, under GHMC there are about 455 lakes that needs conservation. The landscape of the city is dominated by hills, tanks, forests, and rock formation with soil type mainly red sandy soil interspersed with areas of black cotton soil.

Hyderabad has tropical climate with rainy season for June to October and gets mainly rainfall from southwest monsoon. The city is in 17 degrees north latitude and 550meters above mean sea level. Hyderabad is in the tropical cyclone's paths; hence it receives the cyclone affect from June to December gets heavy rainfall that leads to floods. City experiences monsoon at rate of 12mm/hr and Northeast Monsoon from December to February & Southwest monsoon – July – October. It has been seen from the records July, August and September are the months of heavy rainfall and the total rainfall in these months bring to an average of 490.2mm(Ahmed et al., 2013). The table below shows the rainfall of hyderabad from the year 1960 to 2016.

Hyderabad Actual Rainfall in MM				
years	South West	North East	Winter & Hot Weather	Annual
1960	835	147	50	1032
1970	549	335	106	990
1980	511	191	41	743
1990	896	88	359	1343
2000	759	92	75	926
2008	864	79	29	972
2016	698	41	138	877

Table-1: Hyderabad rainfall from 1960 to 2016 – Source -Indian Metrological Department.

Topography of hyderabad is unique with contours varying for 410meters to 560 meters with many undulations during rainfall the rainwater flows low lying areas resulting in inundation The Greater Hyderabad Municipal Corporation is subdivide into 150 wards and to tackle floods 16 stormwater zones are formed to deviate the rescue teams during floods. The city also experiences floods due to encroachment of nalas and waterbodies and city has lost over more 3000 tanks from the year 2000 to 2020.



Lake Spread	1982	1992	2002	2012
5 Hectare	593	534	492	267
5-10 Hectare	160	146	140	108
more than 10 hectares	153	196	167	156

Source: Eenadu District Edition, Hyderabad; Article Name- Chivariki Migilindi (At final what you have), 1st oct 2013

Fig 2 (Left) Satellite Map of Hyderabad Showing Diminishing Lakes for 3 Decades, (Right) Floods in 2016

Storm water drains, storm sewer, surface water drain/sewer or storm water drains is an infrastructure designed to drain excess rain and ground water from impervious surfaces like car parks, sidewalks, or roofs. The stormwater drains or nalas of hyderabad play a major role in discharging the excess water to the Musi River and there by safeguarding the loss of property and human loss during heavy monsoons. The existing drainage system does not fully cover the entire city and has been designed for only 12mm/hr rainfall whereas the average intensity varies from 23mm/hr to 52mm/hr. The discharge of human excreta and solid waste dumped into these nala makes the situation worse. During heavy monsoons nalas are blocked and overflows that results in water logging issues. Storm water drains due to insufficient carrying capacity runoff added with sewerage network performs low during heavy rains.

Fig 3 -Situation of Nala in Begumpet Hyderabad

2.2 Chronological flood events and Impacts:

The city had experienced 153.2 mms of rainfall on September 28, 1908. According to historians, 15,000 people were killed and over 80,000 were rendered homeless. As many as 600,000 people were affected by the river's fury. (Refer Table 2).

S.No	DETAIL	1908 February	2000 August	2008 August
1	Rainfall	430mm	240.5mm	220.7mm
2	Property Loss/Worth	80,000 Homes	35,693 Homes, 135 Lakhs	49.2 Lakhs
3	Human Lives Lost	1500	26	NIL
4	Population Effected	6,00,000	2,00,000	1,50,000

Table 2. Year wise record of heavy rainfall events
Source: Zameer Ahmed, August 2013.

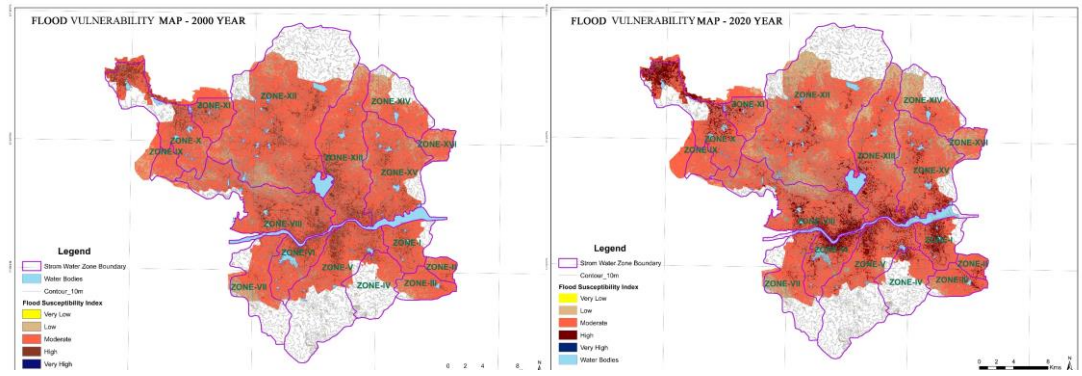
2.3 Materials and Methodology:

S.no	Data Description	Purpose	Year	Source	Resolution
1	SRTM, DEM	Elevation, Slope TWI	2020	USGS Earth Explorer	30m
2	Google earth	Landform	2019	Q-Gis	0.3m
3	LULC	Land use	1990, 2000, 2010, 2020	Bhuvan	
4	Water Stagnation points	Inundation areas	2018	GHMC	
5	Historic Flood Location	Low lying areas	before 2018	News reports, Bhuvan and Physical Survey	

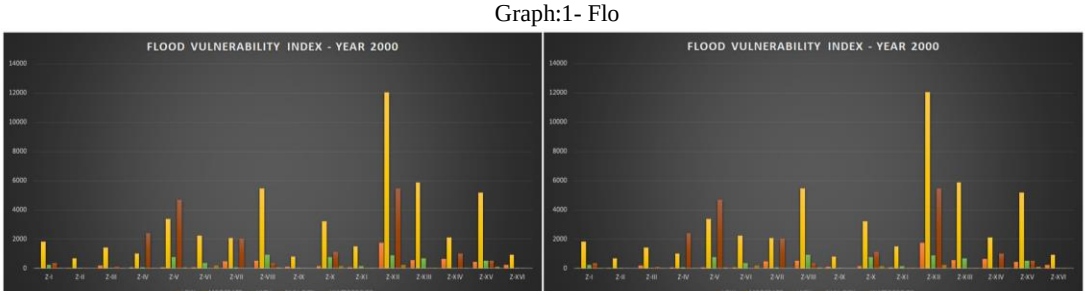
Table 3. Data Sets used for Flood Vulnerability areas.

Identification and Delineation of flood affected areas is carried out collecting data sets and Digital maps are prepared through remote sensing data, LANDSAT imagery and processed in ArcMap (GIS). Flood vulnerability mapping is studied by analytical hierarchy process and the parameters like Topographic Wetness Index, Elevation, Slope, Precipitation, LULC, NDVI, Distance from the water bodies and Distance from roads and drainage density are considered for mapping the flood vulnerability in the year 2000 and 2020.(Natarajan et al., 2021). The 16 storm water zones are overlayed to identify the most vulnerable prone areas of hyderabad. Some of the zones delineated as Zone-I, Zone-V, Zone-VI, Zone VIII, Zone X, Zone XI, Zone XII, Zone XIII. The details of the areas identified will be compared with two maps of vulnerability. The Vulnerability zones are studied by area of land effected during the years and following zone are identified Zone -V, Zone-VI, Zone-VIII, Zone -XII, Zone-XIII and Zone -XV of Greater Hyderabad Municipal Corporation.

Fig 4 -Mapped



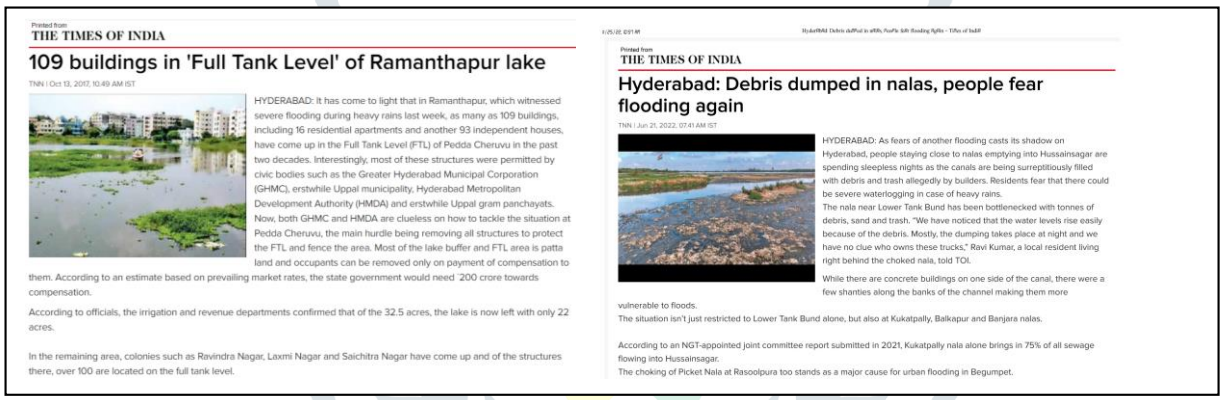
Graph:1- Flo



3. **Results and Discussion- Flood events, Submerged areas, days of flood water stagnation**.

Flood vulnerability areas in **Zone -V, Zone-VI, Zone-VIII, Zone -XII, Zone-XIII and Zone -XV** can be understood by following aspects:

- Rapid Urbanisation led the civic authorities to allot land with no planning
- Change of contours and most of the area in the above zones are low lying and prone to floods during monsoons.
- Haphazard growth of new settlements led to unauthorised construction and change of natural drainage
- Encroachment of waterbodies and disconnection of natural hydrological flow of water form upstream to downstream is observed.
- Waterbodies are flooded with construction debris and plastic waste that choke the nallas.
- Full tank level of waterbodies is completely neglected and there by allotting land for construction.
- Land conversion from agricultural to construction in low lying areas also lead to flooding.
- Disposal of human waste also observed in few of the areas like Begumpet nala and Pedda cheruvu there by pollution of water occurs.
- Solid waste dumped into the nallas is major factor for choking of drains.
- Over 28,000 illegal structures identified on nalas in the city and during 2017 government assured it would use chapter11 section 405 of GHC to remove illegal structures but there is no progress
- Removal of silt in nalas was done or every 15 days by segregating solid and liquid waste. GHMC should ensure widening of nala for free flow of water by clearing the encroachments



Printed from
THE TIMES OF INDIA

109 buildings in 'Full Tank Level' of Ramanthapur lake

TNN | Oct 13, 2017, 10.49 AM IST

HYDERABAD: It has come to light that in Ramanthapur, which witnessed severe flooding during heavy rains last week, as many as 109 buildings, including 16 residential apartments and another 93 independent houses, have come up in the Full Tank Level (FTL) of Pedda Cheruvu in the past two decades. Interestingly, most of these structures were permitted by civic bodies such as the Greater Hyderabad Municipal Corporation (GHMC), erstwhile Uppal municipality, Hyderabad Metropolitan Development Authority (HMDA) and erstwhile Uppal gram panchayats. Now, both GHMC and HMDA are clueless on how to tackle the situation at Pedda Cheruvu, the main hurdle being removing all structures to protect the FTL and fence the area. Most of the lake buffer and FTL area is patta land and occupants can be removed only on payment of compensation to them. According to an estimate based on prevailing market rates, the state government would need `200 crore towards compensation.

According to officials, the irrigation and revenue departments confirmed that of the 32.5 acres, the lake is now left with only 22 acres.

In the remaining area, colonies such as Ravindra Nagar, Laxmi Nagar and Saichitra Nagar have come up and of the structures there, over 100 are located on the full tank level.

Printed from
THE TIMES OF INDIA

Hyderabad: Debris dumped in nalas, people fear flooding again

TNN | Jun 21, 2022, 07.41 AM IST

HYDERABAD: As fears of another flooding casts its shadow on Hyderabad, people staying close to nalas emptying into Hussainsagar are spending sleepless nights as the canals are being surreptitiously filled with debris and trash allegedly by builders. Residents fear that there could be severe waterlogging in case of heavy rains.
The nala near Lower Tank Bund has been bottlenecked with tonnes of debris, sand and trash. "We have noticed that the water levels rise easily because of the debris. Mostly, the dumping takes place at night and we have no clue who owns these trucks," Ravi Kumar, a local resident living right behind the choked nala, told TOI.
While there are concrete buildings on one side of the canal, there were a few shanties along the banks of the channel making them more vulnerable to floods.
The situation isn't just restricted to Lower Tank Bund alone, but also at Kukatpally, Balkapur and Banjara nalas.

According to an NGT-appointed joint committee report submitted in 2021, Kukatpally nala alone brings in 75% of all sewage flowing into Hussainsagar.
The choking of Picket Nala at Rasoolpura too stands as a major cause for urban flooding in Begumpet.

Fig 5 –(Left) Waterbodies encroachment ignoring full tank level. (Right) Nalas with solid waste area threat for flooding
Source: Times of India – Dated-30th Oct 2017 & Times of India article – 21st June 2022.

The Hyderabad city is undergoing rapid urbanization and the vulnerable areas of the city are increasing form moderate to risk zones. Residents living most of the areas are struggling to live a peaceful life especially during monsoons as the situation can get worsen with in no time. Open nalas without adequate safety measures are proven to be the death traps during monsoons. The bridges that pass over the nalas create distress to the commuters as the overflowing of water is observed on the streets. The natural nalas of the city are getting compromised with inlet and outlet of water to the downstream with broken connectivity as it finally reaches river Musi. GHMC officials have permitted new buildings as few of the waterbodies FTL got decreased and revenue officials had led to the destruction of lakes.

4. **Conclusion:**

Hyderabad being one the biggest urban agglomeration in deluge is matter of improper planning and disregard to the waterbodies and nalas by city dwellers. Urban setting and water streams convey a great linkage and bonding which is forgotten by the citizens of hyderabad. Encroachment of nalas, choking the drains, breaking the inlet and outlet flow of waterbodies, dumping of solid waste, debris and letting out untreated water to the river resulting toxic and harmful substances growth is the portrait of hyderabad. On the other hand, highly dense population living near the Musi River and in many zones as discussed above are the major reasons runoff and flooding. Managing runoff and control of flooding is the important challenge in front of stake holders, planners, and engineers. Below are some of the suggestions for control/mitigation of urban flooding in the city.

- Creating more impervious surfaces manages the amount of runoff and ward level house owners can create porous pavement materials, vegetation with sidewalks clearing up storm water drains, managing the solid waste from households.
- Existing waterbodies protection, demarcation of embankment areas, development of vegetation around the natural waterbodies with clear Full Tank level.
- Encouraging rainwater harvesting systems by the government for ground water table improving and managing runoff.
- Clearing encroachments on nalas, improving waterbodies connectivity can improve the movement of water and there by runoff can be managed.
- Improving parallel new storm water drains, desilting of nalas before monsoons can manage the flow of water especially in low lying areas.
- Mitigation measures may be nonstructural measures like warning systems, coordination before and after floods, and managing floods.
- Awareness in public through programs that educate the commons on water and protection of natural waterbodies, groundwater recharge, waste management, and creation of new catchments during peak flows
- Vulnerable areas can be made vacated for avoiding risk and loss of lives.
- Landscaping with locally available trees that hold the soil erosion.

REFERENCES:

About GHMC. (n.d.). Retrieved September 1, 2022, from https://csr.ghmc.gov.in/AboutGhmc.ASPX

Ahmed, Z., Rao, D. R. M., Reddy, K. R. M., & Raj, Y. E. (2013). Urban Flooding – Case Study of Hyderabad. *Global Journal of Engineering,Design {&} Technology*, *2*(4), 63–66.

Body, T. C., Citizen, T., & Body, C. (1972). *Chapter V Urban Planning , Develoment and Management*. 64–119.

Kumari, N., & Management, E. (2013). *Status of lakes in Hyderabad*.

Modernising the Urban Environment: The Musi River Flood of 1908 in Hyderabad, India on JSTOR. (n.d.). Retrieved August 30, 2022, from https://www.jstor.org/stable/41303522?read-now=1&seq=24#page_scan_tab_contents

Natarajan, L., Usha, T., Gowrappan, M., Palpanabhan Kasthuri, B., Moorthy, P., & Chokkalingam, L. (2021). Flood Susceptibility Analysis in Chennai Corporation Using Frequency Ratio Model. *Journal of the Indian Society of Remote Sensing*, *49*(7), 1533–1543. https://doi.org/10.1007/s12524-021-01331-8

Ramachandraiah, C., & Prasad, S. (2004). *Impact of Urban Growth on Water Bodies The Case of Hyderabad CENTRE FOR ECONOMIC AND SOCIAL STUDIES Impact of Urban Growth on Water Bodies The Case of Hyderabad Impact of Urban Growth on Water Bodies The Case of Hyderabad*. *60*. http://www.cess.ac.in/cesshome/wp/wp-60.pdf