

ANALYSING AND ASSESSING THE VULNERABLE AREAS OF BHOPAL FOR URBAN FLOODING

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Abstract

Around the globe, there's a surge in city flooding instances. Accompanied with the aid of using fast temperature and rainfall sample fluctuations that are the characteristic of weather alternate. This renders us at risk of those disasters. Moreover, human sports like concretization, deforestation, and land cowl alternate have irritated the trouble. Bhopal, being one of the fastest-developing town India is going through the identical trouble for decades, which has emerged as outstanding in those latest years. Furthermore, the town's undulating topography acts as both, boon and bane to the town's populace. The paper tries to locate the insights for city flooding with the assist of GIS strategies to construct an inclusive city flood vulnerability map and duly prescribe a few coverage interventions on numerous tiers to include average sustainable improvement and resilience.

Keywords

Urban floods vulnerability assessment, Climate change, Urban Flood resiliency; Urban planning and development, GIS Techniques

1. Introduction

Urban flooding must turn out to be a frequent phenomenon withinside the latest decade especially as a final result of different factors along with severe urbanization, weather change, unplanned waste control, and dilapidation of city ecology. The size of city flooding is converting in city regions nowadays. A variety of essential cities all over the sector has started a series of devastating open floods in latest decades. Mainly, metropolitan flooding in city groups is discovered as flash floods and waterlogging of roads because of excessive ferocity shorts spell rainfall. Over time, the extent to those catastrophes has improved due to improved precipitation spillover extent and extra outstanding presentation of people and sources because of asset fixation. (Sato 2006). According to (MoUD, 2017), whilst submergence of the dry regions with the aid of using a huge quantity of water sourced from immoderate rainfall, excessive tide, overflowing river, or melting snow happens, the phenomenon is called flooding. The aftereffects of inundation can variety from being feeble to catastrophic, in diverse components along with infection of water, epidemics, financial loss, inflation, meals dearth, infrastructure harm and casualties withinside the human society. Population inflow to the city regions because of migration from geographical region modifications the land-use sample of the catchment region (Kulkarni, 2014), and alteration in land-use land cover (LULC) influences the runoff method and boom in flood peaks withinside the low-mendacity regions specifically river streams (Amini, 2011). Also because of severe concretization and unthoughtful making plans, the water infiltration ability of urbanized regions has substantially reduced inflicting city floods. Most susceptible to those city flooding are the those who encroach and create unregulated improvement in city region to occupy the dangerous region (Kamat R., 2013). To verify the diverse factor inflicting city floods, the paper duly demarcates the maximum inclined regions of

Bhopal city, that's the capital of Madhya Pradesh, and cross-sectionally analyses the incidents of city flood. The evaluation of the city flooding hotspots is illustrated withinside the maps giving insights approximately the making plans paradigm and coverage interventions that ought to be included to beautify resilience of city fringes closer to inundation.

2. Literature Review

Flooding in fashionable and concrete flooding specifically isn't an unknown occasion withinside the international and in India. The choppy distribution of rainfall coupled with Mindless urbanization, encroaching upon and filling up herbal drainage channels and concrete lakes to apply the excessive-fee city land for homes is the motive of city flooding. Unregulated development in city regions makes human beings in growing international locations occupy the unsafe places, thus, making them susceptible to failures (Kamat R. 2013). Vulnerability is the primary assemble in flood danger control. One of the maximum huge objectives of flood vulnerability assessments is to make a clean affiliation among the theoretical conceptions of flood vulnerability and the everyday administrative process (Hajar Nasiri, 2016). Gross domestic product (GDP) liable to flooding in India, the international's second-maximum populous kingdom, may also surge 10-fold with the aid of using 2030 as towns amplify and weather demanding situations worsen, in line with the World Resources Institute (WRI). The harm because of the herbal failures to the human and physical capital is same for both, growing and advanced international locations, however growing international locations go through extra in comparison to advanced ones (Kahn, 2005). It has been located that herbal catastrophe slows down the financial boom of the kingdom to affordable ranges (Noy, 2010). Emphasizing on urban floods as a herbal catastrophe, it's miles described as extra of water on land, that is generally dry. This takes place because of the excessive flow, or overflow of water in an established water direction or accumulation of water at or close to a factor of rainfall occurrence (Pareva, 2006). Urban floods are majorly triggered because of excessive rainfall, in which weather extra de has intensified the water cycle (Huntington, 2006), growing the depth and frequency of heavy rainfall periods, especially in from of mid-range summertime season precipitation in Japanese Asia (Sarmah, 2018). On the same note, (M. Rajeevan, 2008), (Goswami B. N., 2006) located that the boom in the possibility of severe rainfall occasions is a characteristic of the growing traits of sea surface temperatures of the Indian Ocean, once more a final result of Global warming. According to (Roxy, 2017) seeing that 1901 until 2015, a 3-fold upward push in the intense rainfall occasions throughout components of Western Ghats – Goa, north Karnataka, and South Kerala important and northerly India – Gujarat, Maharashtra, Madhya Pradesh, Chhattisgarh, Telangana, Odisha, Jharkhand, Assam has been located. There have been primary boom withinside the fashion of city flooding in India for beyond numerous years, in which primary towns were affected on more ranges shown in table-1. Urban floods are a characteristic to extrude in climate styles which can be because of worldwide weather extrude. Intense urbanisation additionally has diverse climate affecting elements which include city warmth island impact which will increase the ambient temperature with the aid of using sure degrees (Stone, 2001).

Table 1 Vulnerability Parameters

Parameter	Exposure	Susceptibility	Resilience
Physical	Topography	Frequency of Flood	Storm Water Drainage System
Economic	Proximity to Drainage Proximity to Inundation Areas	Occurrence Preparedness & Alertness	Investment in Resilient
Social	Population Density	Rainfall	Infrastructure Past Experience
Environment	Density of Urbanisation		Warning System Institutional Capacity Evacuation Routes Percentage of area developed under the concept of Low Impact Development

Source: (Adekola, 2017).

Encroachment of flood plains and permeable land results in a lack of herbal drainage gadget, furthermore the impervious land cowl forbids water to infiltrate and reasons an extra quantity of run-off. The clogging of drainage gadgets and absence of proper solid waste control gadgets additionally reasons the hassle to aggravate. A metropolis is shaken with the aid of using its crux, whilst hit with the aid of using any catastrophe in any part of the metropolis and consequently, it's miles important to make that metropolis resilient. According to (Banerjee, 2018), Flooding reasons stagnation of site visitors and disruption withinside the shipping services. The vulnerability of the city fringes to the floods has been primarily based totally on majorly 3 elements: resilience of drainage gadgets, the persistence of city regions to floods and the capacity to evacuate floodwater (Bertilsson, 2018), and in reality the insights and idea are placed forth to mitigate hassle in those 3 areas. It has been highlighted in (McClymont, 2020) that sustainable drainage gadgets encompassing additives which include rain barrels, bio-retention tanks, and flora grass swales, particularly permeable pavements and inexperienced roofs have been extraordinarily powerful in lessening city flooding problems. A lot of studies have been determined to address the hassle of Urban Flooding with the aid of using assessing the answer in special arenas. It has been determined that the possibility of city flooding reduces to around 50% due to the advent of inexperienced areas place at sure optimized places in place of conventional impervious land use (Kim, 2016). The making plans paradigm additionally has been modified in phrases to concurrently include improvement without annoying city ecology. Low Impact Development has come forth as a green technique related to lessen typhoon water run-off with the aid of using growing the water infiltration potential the usage of precise materials (Tredway, 2016) (Sohn, 2017), and it's been determined to be economically, environmentally and socially viable (Zhan, 2016). Disasters can result in failed development, but failures in development planning can also lead to disaster risk, which is the case in most of the cities which are disaster prone in developing countries (Kamat, R.).

Policy intervention has been there to examine the reasons and locate insights to relieve the situation. According to (Gupta K., 2016), an included method combining watershed and land use. control with improvement making plans, engineering techniques, flood readiness, and emergency control must be carried out for regulating city floods. Australia, new policies, supported up with the aid of using legislation, administrative and monetary agreements on the nation and federal ranges of government, offer surroundings beneficial to the implementation of complete floodplain control policies (Smith, 1984). The comparable coverage implications were determined to manage floods and decrease their universal effect in Nigeria (Adekola, 2017).

Flood Vulnerability Index- For the city improvement to capture up speedy tempo with none obstacle, it's miles immensely vital to form the destiny city boom far far from danger regions. A more simple resilient-district idea that determines the maximum inclined regions of metropolis might be exceptionally suited (Hajar Nasiri, 2013). Moreover, desk 1 highlights the definition of vulnerability integrated withinside the preceding studies.

3. Methodology

For the purpose of this study a literature review exercise was held first to study about the concept of urban floods and flood vulnerability. After the literature review, study area delineation was done based on slope, improper drainage, available infrastructure, difference in contour etc. Selecting the desired zones based on the following points gave us the desired data for further analysis. After the analysis of the available data, proper proposals and recommendations have been made to decrease the magnitude of urban floods in the selected area shown in fig-1 .



4. Study Area: Bhopal, Madhya Pradesh

Bhopal, the capital metropolis of Madhya Pradesh is located withinside the valuable part of India. A metropolis is witnessing speedy city improvement concurrently with clever making plans initiatives to redesign the metropolis. According to Census 2011 (MHA, 2012), Bhopal's populace become measured to be 1458416, which has now grown to 2368145 (District Bhopal, 2021). The district is bounded via way of means of Guna district withinside the north, Rajgarh district withinside the northwest, Vidisha district withinside the northeast, Raisen district withinside the south-east, and Sehore district withinside the south-west. The implied peak of the district is 472 and 630 meters above the implied sea level. The entire metropolis encompasses several nullahs and streams which denude, albeit those streams stay dry withinside the warm weather. Even with such topographical blessings still, the instances of city flooding have risen. Rapid urbanization in Bhopal withinside the beyond 4 a long time has added improvement withinside the peri-city regions, which acted as percolation sector to the city rainwater run-off (Kamat R., 2019). The current flooding incidents had been highlighted prominently. On twenty-sixth July 2021, in only five hours of period four. five inches of rainfall become recorded, previous to this, Bhopal has acquired 297. four mm in 24 hrs via way of means of five.30 pm on July 9, 2016. This broke an in the advance document set on twenty-second July 1973#via way of means of receiving rainfall of 275.7mm. In the 12 months of 2006, Bhopal acquired 290mms of rain in a span of five hours withinside the month of August. Water did inundate 15 low-mendacity regions proving that the incident become an intense

occasion of heavy rainfall noting a 54#percentage extra downpour. The occasion recorded deaths of 26 human beings and 8728 homes has been partly or absolutely broken throughout the occasion (Kamat R., 2019). Figure 1 highlights the once-a-year rainfall records of Bhopal, which illustrates the current peaking of rainfall. The evaluation renders at the part of considerate insights of mismanagement of city-making plans and coverage interventions. The rainfall records additionally recommend the hike withinside the rainfall acquired via way of means of Bhopal in current years. Following zones had been decided on for a similar study. The choice of zones is according to their demographic capabilities and additionally the topographic capabilities. The 3 zones decided have their own unique traits associated with their slope.

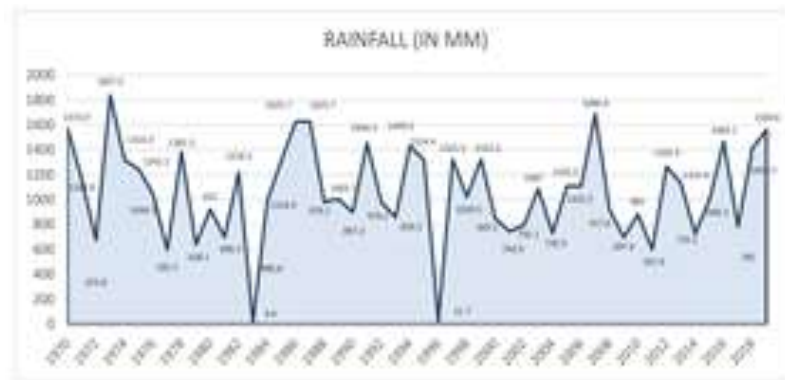


Figure 2 Year wise rainfall data of Bhopal

4.1 Selection of Zones

The zones which are selected for further study are done based on certain factors like topography, different income groups living in the area, the existing condition of physical infrastructure of the area, construction of buildings on the natural drainage paths, number of low-lying areas in the zone, and these factors adds Zone 2, 10 and 12 amongst the worst affected areas due to urban floods in Bhopal shown in fig- 3 & table -2.

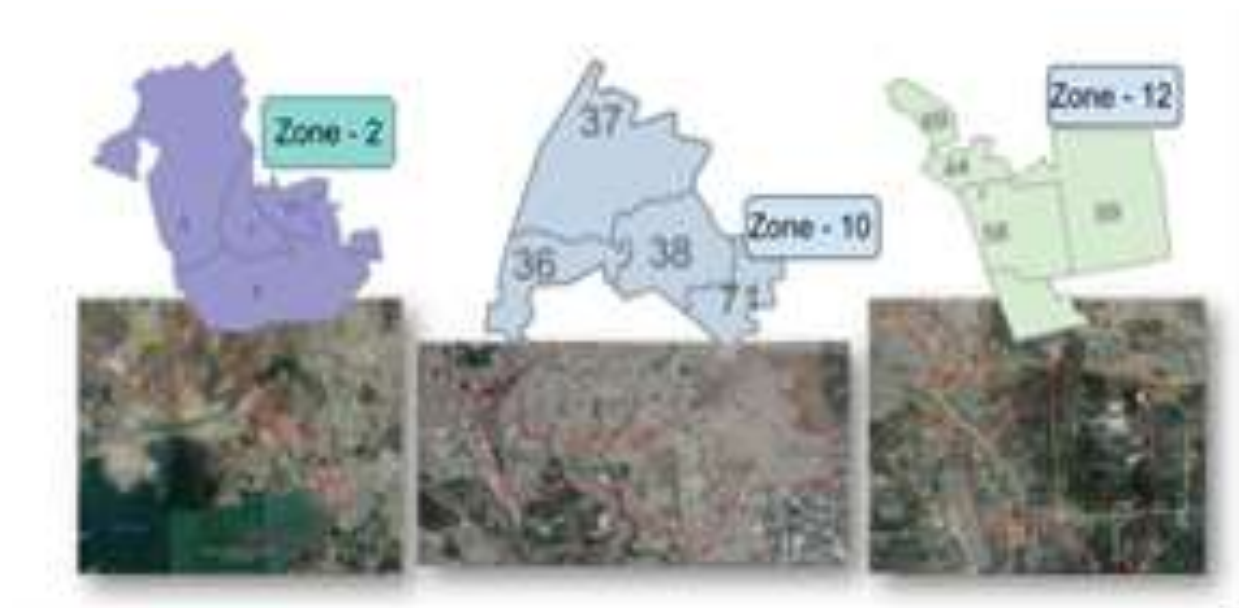


Figure 3 Selected Zones for Study Source: Author

Table 2 Wards in selected zones

Zone	Zone 2	Zone 10	Zone 12
Wards	Ward- 6 Mahagiri Ward- 7 Kohefiza Ward- 8 Royal Market Ward- 10 Idgah hills Ward- 21 Jain Mandir	Ward- 36 Chandabad Ward- 37 Kapda mill Ward- 38 Semara Ward- 71 Dussehra Maidan ashoka garden	Ward- 44 Subhash Chandra Bose Ward- 58 Kasturba

Source: Author

4.2 Contour Analysis

Contour analysis gives an edge to understand the topography and direction of flow of water during flash floods, catchment areas, rain water harvesting and urban flood prone area. Bhopal has slopes and can see a declination of contour from west to east shown in fig- 4.



Figure 4 Slope analysis of zone 2 Source: Author

Zone 2: The zone's highest and lowest contour is 505.6m and 608.7 m. there are two major protruding sites in the area shown in Fig-5, one at the upper side and the other at the lower portion. Due to this reason a valley is formed which leads to rainwater accumulation. This contour characteristics leads to flash floods in the zone during heavy rain.



Figure 5 Google Earth image of zone 2 Source: Author

Also, it should be noted that the zone is at higher alternative but still experiences flood sometimes due to lack of proper infrastructure and management of utilities and services. This area is dense in terms of settlement hence should be improved to decrease the loss of socioeconomic assets.



Figure 6 Analysis of zone 2 Source: Author

Zone 10: The contour of zone 10 varies from 487.8m above sea level to 504.8m. The topography at the edges is higher in terms of the middle area which creates a valley as a catchment area during rains. The zone's areas are lower than the average altitude of Bhopal leading to high probability of accumulation of water and speed of flash floods. This area is most vulnerable regarding risk and hazardous consequences after floods being very dense. Zone 10 lacks the basic evacuation transport line inside the zone but has proper connectivity alongside the zone area shown in fig – 7 & 8. The major reason for urban flooding in the area is improper management of utilities and services. Drainage network and sewerage lines are not proper in the demarcated area which causes flash flood due to accumulation of water. The water comes

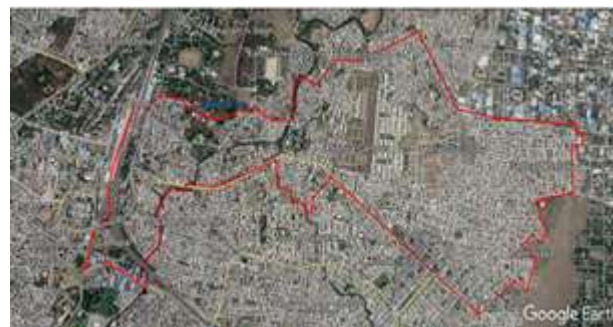


Figure 7 Google earth image of zone 10 Source: Author

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No hospitals or major community halls are present in this zone making it extremely vulnerable to floods and dangerous by looking at its density of population.



Figure 8 zone 10 contours Source: Author

Zone 12: The contour of zone 12 varies from 48.m above sea level to 511.3m which is a lot of variation. The area of Old Subhash Nagar is situated on the higher altitude and is quite dense shown in fig-9



Figure 9 Google Earth image of Zone 12. Source: Author

There are less instances when urban flood occurred in Subhash Nagar making it safer. But on the other hand, areas surrounding Subhash Nagar experiences faster run off during heavy rains due to being situated just beside a higher altitude.

5. Conclusion

After reading information few proposals and pointers were proposed to enhance the situation. As in step with coverage and statutory mandates are concerned, it's immensely essential to test the execution and abundance of legal guidelines laid for the catastrophe control and percolation surfaces within the metropolis. Surveillance at the boom of encroachment is essential, which is going hand in hand with the city housing state of affairs and the practices touching on accommodating the susceptible populace at those encroachments in well-evolved housing websites. The making plans paradigm and concrete layout of the metropolis ought to awareness at the studies and improvement of low effect improvement, to lessen city flooding instances. Intense urbanization ought to be decreased and mandates to renovate and retrofit the unique regions ought to be duly executed. Stormwater control is to manipulate floor runoff. It may be carried out in rural regions (e.g. to reap precipitation water), however is critical in city regions wherein run-off cannot infiltrate due to the fact the surfaces are impermeable. Stormwater control may be achieved via way of means of: Construction of RCC drain, Re-phase Anning of VIP roadside drain, Providing pumping stations at distinct places to alleviate drain congestion, Installation of trolley established pump sets, Stop encroachments within the hill regions, wetlands, and drainage channels of the metropolis, Strict ban on rubbish dumping on wetlands and drainage channels, Fixation of street levels, Preservation of all present water bodies/swamps within the metropolis vicinity, Removal of drainage congestion to carry greater regions below shielding vicinity, Watershed control, Construction of drainage channels, culverts and sluice gates anyplace essential Embracing generation Use of Space Technology for Project Planning as the usage of present day generation in forecasting and evaluation may be extraordinarily beneficial in imparting correct information associated with flood forecasting. Plantation, Use of Vetiver Grass for Reducing Soil Loss in Embankment, Putting an stop to felling of bushes and venture afforestation in catchment regions, this may forestall soil erosion on the headstream areas and siltation of river beds within the plains Infrastructure improvement, Construction of raised systems close to the settlements of the flood-susceptible vicinity for taking safe haven throughout the length of the excessive flood via schemes like SGRY (Special Component) and pulling down of hillocks, etc. to be used as raised systems. -Preparedness & Awareness Even alevn though Bhopal is a low susceptible region to flooding nevertheless current flash floods brought about because of extreme rain and urbanization have brought about a amazing loss economically. (State Disaster Management Plan – Madhya Pradesh) defines preparedness to be sports and measures taken prior to make sure an

powerful reaction to the effect of hazards, which includes the problem of well timed and powerful early warnings and the provisional evacuation of human beings and assets from threatened places. The Bhopal District catastrophe control plan is awaited, however the State catastrophe control plan exists or even the report for flood protection (Flood Safety). Moreover, non-stop surveillance of the Indian Meteorological Department is tracking the adjustments withinside the climate efficiently caution for extreme rainfall, that is the distinguished motive for flash floods in Bhopal, because the vicinity encompassed via way of means of Bhopal is relatively smaller. Awareness resembles the ownership of information to address the issues of city floods, with to be had resources. The webweb sites wherein floods have took place function a lesson for the human beings to benefit information touching on first-rate protection practices in city floods. In addition to this, throughout such situations of calamities, safety government and numerous different firms are particularly attentive withinside the rescue program.

VI References

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