DEVELOPING DISASTER RISK RESILIENCE IN CITY,URBAN FLOODS : A CASE OF DELHI

A Project Submitted

in Partial Fulfillment of the Requirementsfor the

Degree of

MASTER

In

Urban And Regional Planning

by

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BABU BANARASI DAS UNIVERSITY

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2021-22

ANNEXURE II

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It is certified that the work contained in this thesis entitled **"DEVELOPING DISASTER RISK RESILIENCE IN CITY, URBAN FLOODS, A CASE OF DELHI"** by **ANSHUMAN SRIVASTAVA** (Roll No. 1200106005), for the award of **Master of Urban and Regional Planning** from Babu Banarasi Das University has been carried out under my/our supervision and that this work has not been submitted elsewhere for a degree.

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ANSHUMAN SRIVASTAVA

ABSTRACT

Urban floods are very destructive and have significant socioeconomic repercussions in regions with a common flooding prevalence. Various researchers have laid down numerous approaches for analyzing the evolution of floods and their consequences. One primary goal of such approaches is to identify the areas vulnerable to floods for risk reduction and management purposes. The present paper proposes field survey-based approach for identifying and predicting urban flood-prone areas. The work is unique in theory since the methodology proposed finds application in urban areas wherein the cause of flooding, in addition to heavy rainfall, is also the inefficient urban drainage system. The work has been carried out in Delhi's Yamuna River National Capital Territory (NCT) area, considered one of India's most frequently flooded urban centers, to analyze the causes of its flooding and supplement the existing forecasting models. Research is based on an integrated strategy to evaluate and map the highest flood boundary and identify the area affected along the Yamuna River NCT of Delhi. In addition to understanding the causal factors behind frequent flooding in the area, using field-based information. The identification of areas susceptible to floods shall act as an early warning tool to safeguard life and property and help authorities plan in advance for such events.

The major incidences of heavy rainfall and the consequent urban flooding and their causes are briefly described. The recent flood disaster management and mitigation measures carried out by the Central, State and Local Government are highlighted. The flood resilience initiatives and challenges are then discussed. However, a lot still needs to be done to make the cities in India flood resilient.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Urban floods

Urban flooding is the flooding of land or property particularly in more densely populated areas, caused by rainfall overwhelming the capacity of drainage systems, such as storm sewers. In urban areas, flood effects can be exacerbated by existing paved streets and roads, which increase the speed of flowing water. Impervious surfaces prevent rainfall from infiltrating into the ground, thereby causing a higher surface run-off that may be in excess of local drainage capacity. Recent phenomenon has highlighted the human-made causes that are responsible for recurring and prolonged nature of floods. Flood hazards result from the overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions, deposition of materials in stream channels during flood recession, rise of ground water coincident with increased stream flow, and other problems.

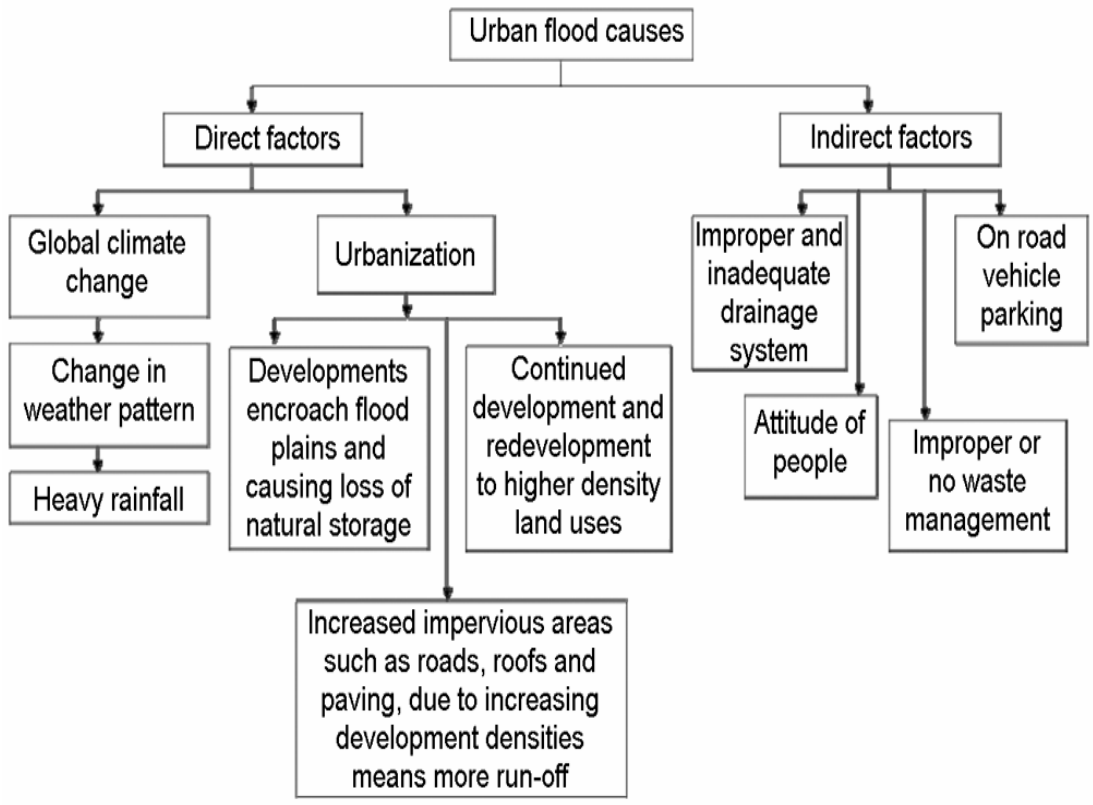


FIG 1.1 : CAUSES OF URBAN FLOODS

1.2 Background study

- Increasingly, the city has become especially vulnerable to climate-related hazards such as floods caused by unpredictable rainfall patterns.
- The city has been experiencing floods of various magnitudes due to floods in the rivers Yamuna and Sahibi (through Najafgarh drain).
- The rise in water level also causes a backflow effect on the city's drains.
- The city also experiences floods due to its network of 98 drains whose catchment area extends well beyond the city limits.
- The Delhi region exhibits a very gentle southerly master slope as indicated by the southerly flow of the Yamuna River, except at some places where the slopes have been locally reversed.
- With rapid population growth, the city is getting highly urbanized and becoming prone to floods, heat and cold waves, earthquakes, fires, epidemics, and terrorist attacks. The city vulnerability is increasing due to urban stresses such as rapid urbanization, environment degradation, and infrastructure pressure, housing shortage, and slums and quatters settlements

FIG 1.2 : FLOOD EVENTS,DELHI

SOURCE :- TOI NEWS ARTICLE,DELHI FLOOD

1.3 Problem and Need of study

- Due to the massive urban floods in every year creates a huge loss of life and property in Delhi. According to the study and secondary data sources it is clearly visible that there is a loss of life and property and this shows that flood are very frequent and of very high intensity in every monsoon season (Starting of July to 1st week of September).
- So, it is necessary to study reason behind the urban planning issues which falls under these areas which are mainly responsible for this hazard.

Table 1.1 : LOSES DUE TO FLOODS,DELHI

DATA SHOWING LOSSES OCCURRED DURING URBAN FLOOD IN DELHI	
Avg Affected area (m.ha)	0.023
Avg population affected (m)	0.098
Avg damage to crops (m.ha)	0.009
Avg damage to houses (nos.)	3608
Avg human lives lost (nos.)	3

Source:- BMTPC,FLOOD HAZARD ATLAS, DELHI

1.4 Aim and Objectives of the Study

A. AIM:

To adapt & overcome urban flooding through planning and infrastructure designing.

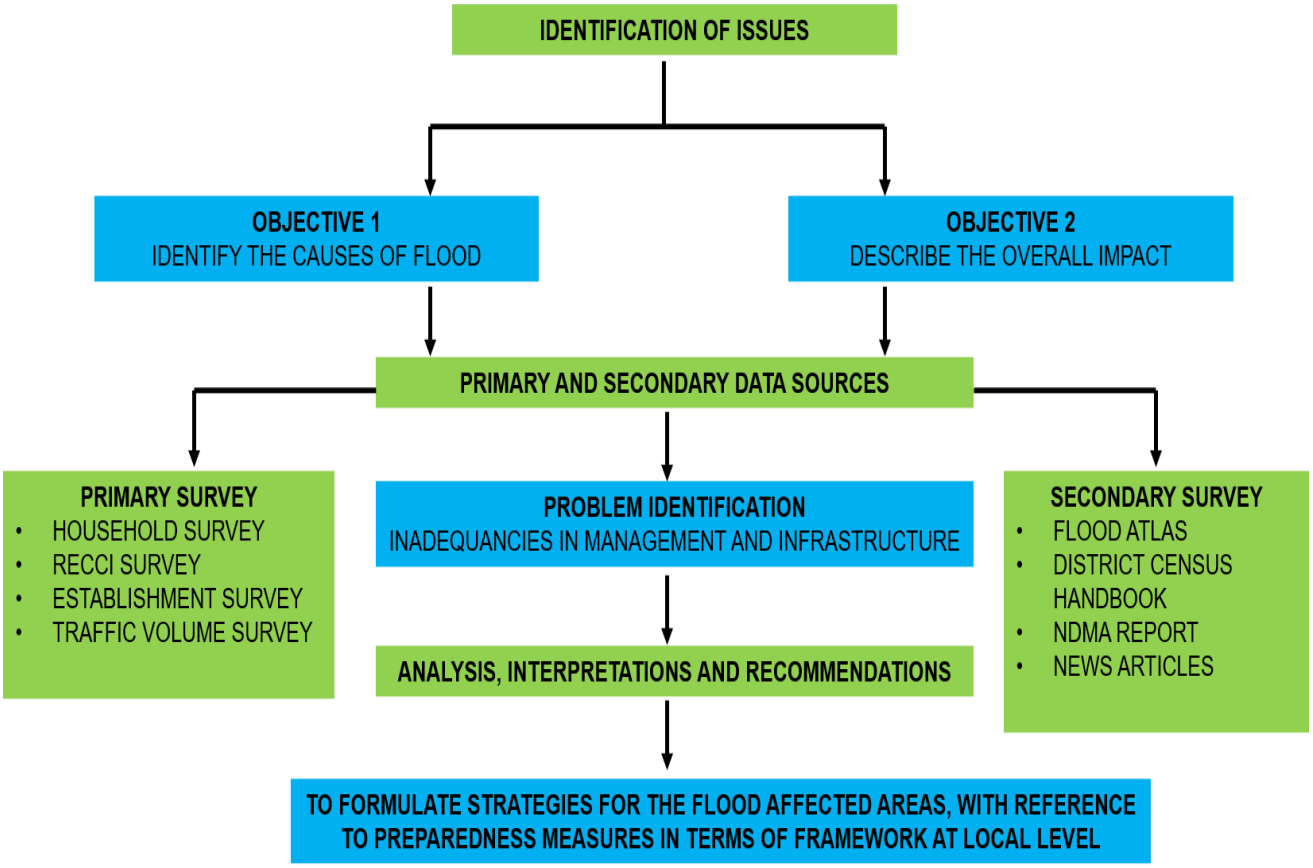
B. OBJECTIVES:

- To study the case study and literature study of urban flooding in urban areas.
- To study the need and their impacts.
- To determine the reasons and preventive measures in the urban flooding.
- To provide necessary proposals for the urban site to lower the impact of flooding.

1.5 METHODOLOGY

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. Typically, it encompasses concepts such as paradigm, theoretical model, phases, and quantitative or qualitative techniques. A methodology does not set out to provide solutions - it is, therefore, not the same as a method. Instead, a methodology offers the theoretical underpinning for understanding which method, set of methods, or best practices can be applied to specific case, for example, to calculate a specific result.

FIG 1.3 : METHODOLOGY



1.6 Limitations and Future Scope

- The present work mapped the areas susceptible to flooding under the most extreme gauge level scenario at the Old Delhi Railway discharge station to date.
- However, due to data limitations, many aspects of the present work remained untouched, which can be added once the data becomes available.
- One of the unexplored problems is the assessment of how the headwater at the Tajewala Barrage could be managed to regulate the entry of flood waters into Delhi (NCT).
- To address this issue, a water supply and demand scenario between these two locations can be modelled using models like WEAP (Water Evaluation and Planning).
- The results from this analysis can be used to depict how much extra water during floods can be allocated towards different areas/sectors to save the Delhi NCT from excessive damage.
- Further, in order to better analyze the urban flooding, the Stormwater Management Model (SWMM) can be used to assess the efficiency of the present urban drainage system of Delhi (NCT).
- The fulfillment of these information gaps in the present study shall, in the future, provide a completely different understanding of the Delhi (NCT) flooding process and help the government devise a more comprehensive flood management and mitigation plan.

2. CASE STUDY

2.1 CASE STUDY 1 : URBAN FLOODS,STUDY OF CHENNAI

- Chennai is the capital city of the State of Tamil Nadu and one of the important district. The district city is one of the metropolitan cities of India.
- Chennai is situated on the north-east end of Tamil Nadu on the coast of Bay of Bengal.
- The topography of Chennai city is extremely flat, with very few isolated hillocks in the south-west.
- The average elevation of about 20 feet**.**

2.1.1 CLIMATE AND RAINFALL

- The weather in Chennai is hot and humid.
- The city gets most from the north-east monsoon winds.
- The average annual rainfall is about 1,300 mm (51 inches).
- The average rainy days are about 52 days.

2.1.2 DEMOGRAPHIC PROFILE

- Chennai is today the fourth largest metropolis in India, with a geographical spread of 170.98 sq. km. or 17,098 hectares.
- It extends over 1189 sq.km. and includes Chennai City Corporation area (Chennai District)
- Population : 7,088,000
- Population density : 17,000/km^2

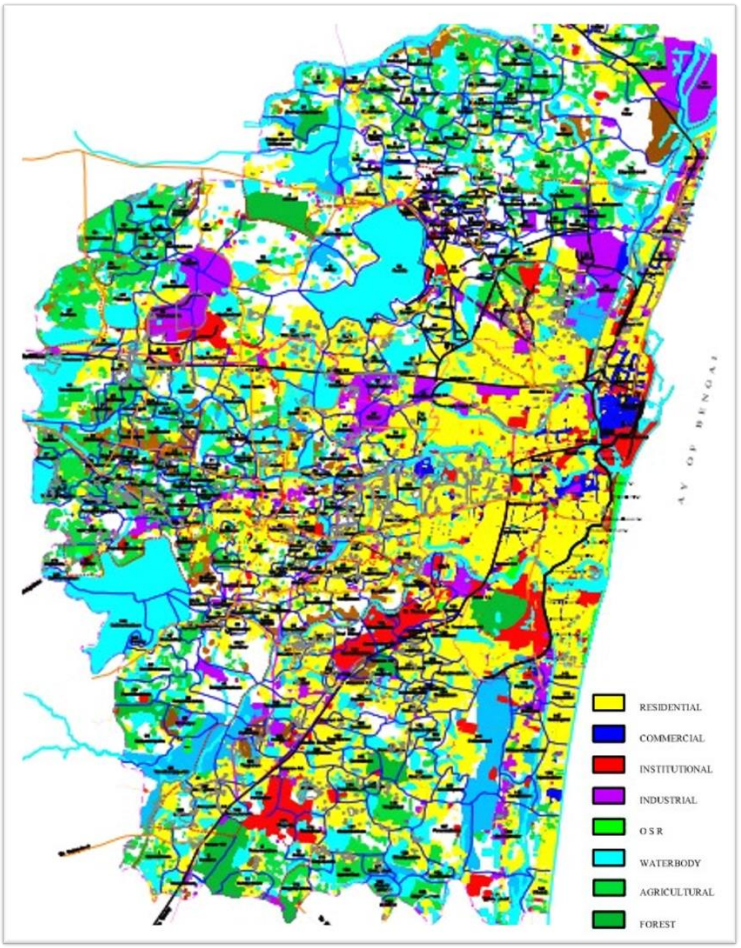


FIG 2.1 : LAND USE MAP, CHENNAI
SOURCE : CMDA, CHENNAI

2.1.2 CITY INFRASTRUCTURE

i. SEWERAGE SYSTEM

- The wastewater system for the city has been divided into five drainage zones.
- Kodungaiyur Zone - I & II : 110
- Koyambedu Zone – III :60
- Nesapakkam Zone – IV : 40
- Perungudi - Zone V : 54
- Total : 264 (MLD)
- The present capacity of the treatment plant is 486 MLD.
- CMWSS Board has opted Clean Development Mechanism which generates revenue of Rs.3.50 - 4.00 cr/p.a.

ii. ROAD NETWORK

- The roads of Chennai is dominated by a radial pattern.
- The total length of roads in Chennai city is 2,847 km.

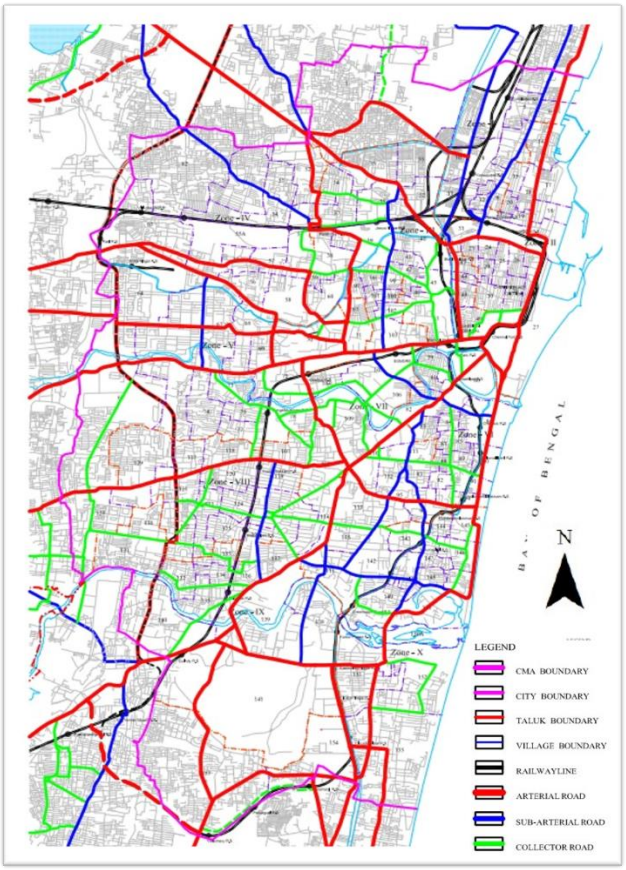


FIG 2.2 : ROAD NETWORK MAP, CHENNAI
SOURCE : CMDA, CHENNAI

iii. STORM WATER DRAINAGE SYSTEM

- There is a necessity of an effective storm water drainage system in Chennai due to its plain terrain and lack of natural gradient for free run off.
- The storm water drainage system can be largely divided into:
- Micro Drainage System
- Macro Drainage System

iv. FLOOD HAZARD ZONES, CHENNAI

- As per intensity of watershed area, flood prone areas were categorized into:

➢ Low Flood Prone

➢ Medium Flood Prone

➢ High Flood Prone

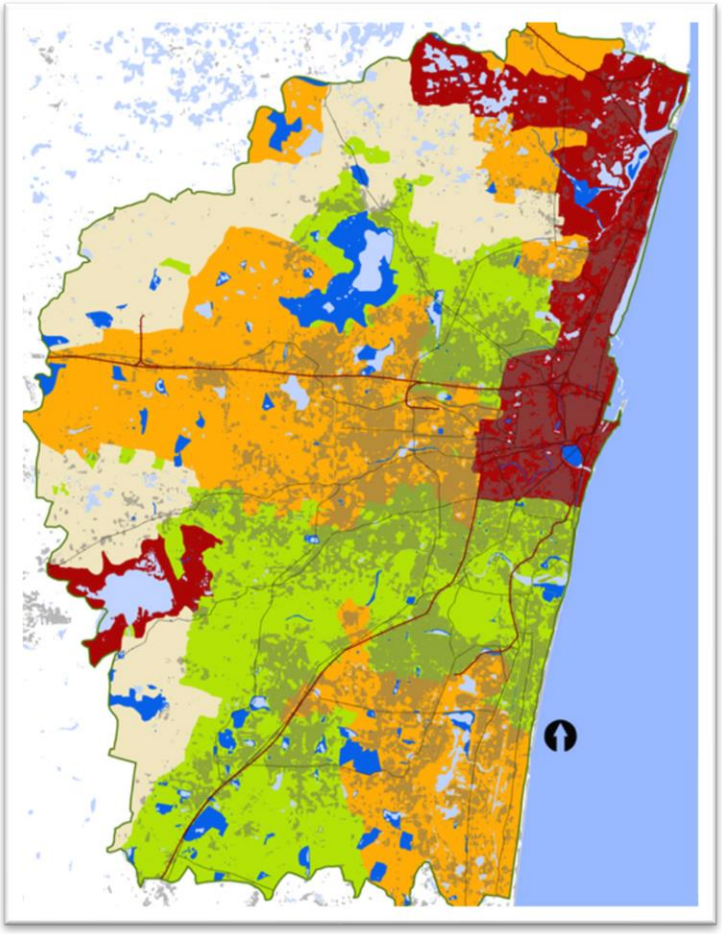


FIG 2.3 : FLOOD HAZARD MAP, CHENNAI
SOURCE : CMDA, CHENNAI

2.1.3 MAJOR FLOOD EVENTS

- Chennai recorded an exceptionally heavy rainfall during November - December 2015 due to the North East Monsoons.
- November 30 to December 07, 2015 which again hit Chennai and the large parts of the metropolis causing severe damage and destruction, and marooning large parts of the metropolis with people stranded on rooftops for days together, especially in the low-lying areas.

2.1.4 EFFECTS OF FLOODS

- It is estimated that around 500 people lost their lives and over 18 lakh people were displaced. With approximations of damages and losses ranging from ₹50000 crore to ₹100000 crore the floods were the costliest to have occurred in 2015, and were among the costliest natural disasters of the year.
- The outcome of this transformed Chennai into islands of houses in a vast expanse of water many feet high. This flood put a large number of urban populaces of these areas in great difficulty and caused severe damages to public and private property.

2.1.4 MAJOR FACTORS RESPONSIBLE

- The rapid urbanization has attributed a lot in the 2015 floods. As a consequence of urbanization there is reduction in infiltration component of the hydrological cycle, which will increase the peak run off discharge. It has also led to encroachment of waterways which reduces their vent away.
- Chennai during the flood has experienced the “compound wall effect”. This resulted in alteration of local overland flow paths and some even blocked the local channels. This turn changed the local flooding pattern, by blocking the natural flow and cross drainage they

contributed in localized flooding.

- In 2010-11, along with marshlands, all other wetlands of Chennai became sites of waste disposal, housing, commercial and industrial purposes, which destroyed flood sink of the city and resulted in citywide floods.

2.1.5 KEY INITIATIVES

- Special drive to clean channels leading to water tanks is undertaken before the monsoon season.
- Teams of NDRF, SDRF and Columns from Army, Navy and Coast Guard were mobilized and pre-positioned in vulnerable areas.
- Tamil Nadu Thowheed Jamath mobilized over 700 volunteers for carrying out rescue, relief and reconstruction work, like arranging food, shelter, cleaning up after flood, waste management, spraying of insecticides and distribution of relief kit.
- Funds under JNNURM project have been visualized for implementation of underground sewerage schemes.
- In 2010, State Government has launched a massive flood mitigation project for the city, involving construction of new micro and macro drainage systems in four basins and making improvements to existing drainage, at a cost of Rs.1, 447 crores under JNNURM.

3. LITERATURE STUDIES

3.1.1 LITERATURE STUDY 1 : URBAN FLOODS,STUDY OF BIHAR

- Many areas of Bihar experienced heavy rains on 21st September. Water entered 80% of the houses in the capital Patna.
- The four rivers near Patna, Son, Ganga, Gandak and Punpun, had risen above the danger mark.
- The release of 2.75 lakhs cusecs of water from Indrapuri barrage across the Sone river worsened the situation in river Ganga which caused panic among people living in Patna. During the flood, some of worst impacted areas were slums in Patna.
- The slum areas Rajendra Nagar area, Ramakrishna Nagar, boring road, Nala Road, Gandhi Maidan were among the worst-affected localities in Patna.
- The Pataliputra Colony and Kurji were also severely water logged. These slums faced severe flooding; causing damages to the houses and remained inhabitable for many days afterwards.
- The unhygienic living conditions in slums and water accumulation during and after rain, which made the situation worse and slum areas flood almost each year now.

3.1.2 EFFECTS OF FLOODS

- 28 districts including the capital city Patna is affected. The names of affected districts are Araria, Kishanganj, Madhubani, East Champaran, Sitamarhi, Sheohar, Supaul, Darbhanga, Muzaffarpur, Saharsa, Katihar, Purnea, West Champaran, Buxar, Bhojpur, Samastipur, Lakhisarai, Begusarai, Khagaria, Bhagalpur, Munger, Patna, Saran, Vaishali, Arwal, Jehanabad, Nalanda and Nawada.

Table 3.1 : LOSSES DUE TO FLOODS, BIHAR

DATA SHOWING LOSSES OCCURRED DURING URBAN FLOOD IN BIHAR (2015-20)	
Total Affected area (m.ha)	20.49
Total population affected (million)	76.49
Total damage to crops (m.ha)	4.77
Total damage to houses (nos.)	220437
Total human lives lost (nos.)	4518.06

Source:- BMTPC,FLOOD HAZARD ATLAS, BIHAR

FIG 3.1 PATNA FLOODS ,2019

3.1.3 MAJOR FINDINGS

- Flooding in the city appeared to have been caused by a choked, damaged and dysfunctional drainage system, and delayed activation of pumps at the sump houses.
- As per assessment, there are 40 slums are fully affected by the flood and 16825 families were the victims of flood. In most of the slums water level was 3 feet and 4 slums are not in accessible condition.
- The water resources are fully contaminated due to the situation, 66.52 % families were denied by safe drinking water too.
- Flood in Patna impacted the shelter in slums in various ways. The impact ranges from complete collapse of houses to partial damages and minor damages. The slum dwellers need support to

help them recover from the impact of flood. In many places, people who lost their homes were unable to return to their home and getting back to normalcy. 3.3% of the houses were completely collapsed and these houses will require reconstruction and major repair work. Shelter support should include options from provision of material and technical support to labor and cash.

3.1.4 KEY INITIATIVES

- Bihar has been undertaking primarily structural measures to deal with floods such as building of embankments, channel improvement and embankment protection works. Around 5287 kms of embankments have been constructed until 2017. A total cost of around INR 12.5 billion was spent in flood protection in2018.
- However, according to the report of 2008 on Kosi floods, embankments have been straightjacketing rivers forcing rivers to change its natural course and enhancing the flood-prone land from 2.5 million hectares to 6.89 million hectares by 2004.

FIG 3.2 BIHAR FLOODS ,2020

3.2 LITERATURE STUDY 2 : URBAN FLOODS,STUDY OF HYDERABAD

3.2.1 FLOOD EVENTS

- On October 14, 2020, after night long rain, the daily rainfall recorded at the weather monitoring station of the India Meteorological Department was 19.2 cm. The water drowned the roads and inundated homes worth crores of rupees in upmarket localities such as Manikonda, Gachibowli, Rajendranagar and Madhapur on the western part of the city.

FIG 3.3 HYDERABAD FLOODS ,2020

3.2.2 EFFECTS OF FLOODS

- As per the Greater Hyderabad Municipal Corporation data, parts of the Nadeem Colony abutting Shah Hatim Talab had water rise to 12 feet after the downpour on October 13.
- Devi Nagar and Chudi Bazaar colonies in Goshamahal saw the water rise to 10 feet.
- Similar were the scenes in several other colonies like Hafiz Baba Nagar, Al Jubail Colony, Ghazi-e-millat colony, Chandrayangutta, Ghouse Nagar, Moin Bagh, Edi Bazaar, Talab Katta and Riyasat Nagar in the old city area.
- All these localities witnessed water rise to 4 feet. Close to two dozen colonies around LB Nagar too faced a similar fate.
- 33 lives were lost to heavy rains and floods in the city, with the Greater Hyderabad Municipal Corporation estimating that at least 37,409 families were affected.
- The Municipal Administration minister pegged the city’s losses at Rs 670 crore.

3.2.3 MAJOR FINDINGS

- Much of the damage was due to the overflowing of lakes in particular, the Hussain Sagar Lake in the middle of the city and the breaching of storm water drains. Construction over lake beds and encroachments of drainage channels have been identified as problems that have exacerbated flooding and inundation in the city.

3.2.4 KEY INITIATIVES

- An order was issued regarding the establishment of the Strategic Nala Development Programme (SNDP).
- The SNDP is allowed to induct officials and other field experts.
- The policies, programme, and activities of this new wing will be subjected to frequent review.

4. INTRODUCTION TO THE STUDY AREA: DELHI

4.1 LOCATION

Delhi is the capital of India located in the northern part of the country. The capital is also called as National Capital Territory (NCT) of Delhi. The state is spread over an area of about 1,484 km² of which about 470 km² is urban area. Its maximum length is 51.90 km and greatest width is 48.48 km. Delhi is among the seven world's largest cities and is increasing in population. The total population of the city increased from 14 million in 2001 census to 16 million in 2011 census making it one of the densely populated areas in the country (Census, 2001, 2011; Singh, 2010). By 2030, Delhi is projected as second world's largest city after Tokyo.

It comprises of nine revenue districts – Central Delhi, North Delhi, South Delhi, East Delhi, North East Delhi, South West Delhi, New Delhi, North West Delhi, and West Delhi

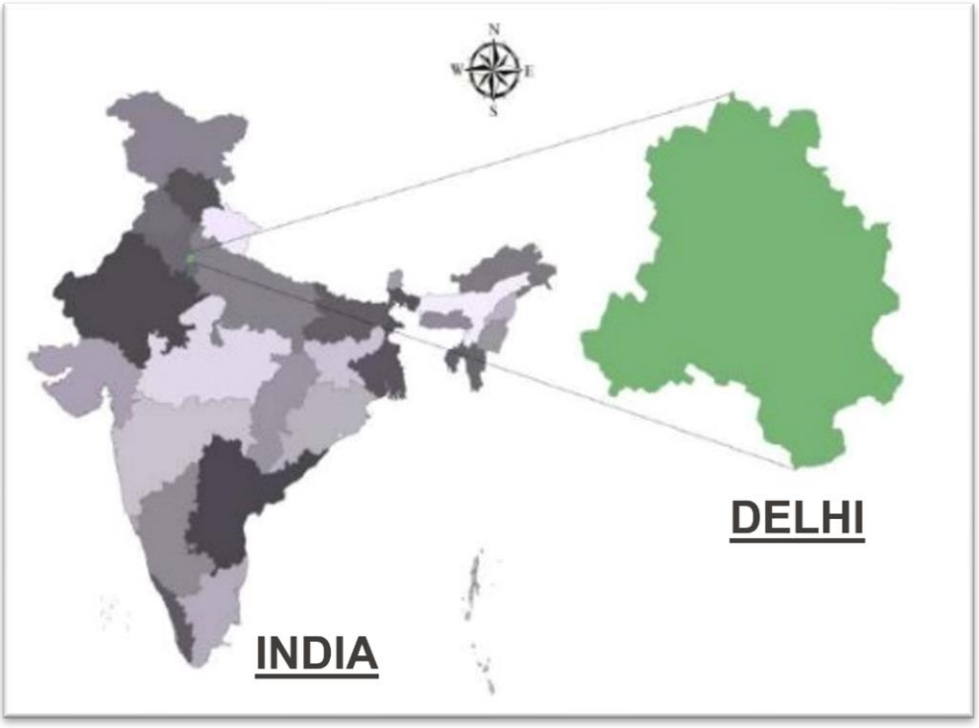


FIG 4.1 LOCATION OF DELHI WITHIN INDIA

4.2 CONNECTIVITY

- Delhi is well connected with the rest of India via numerous Railway Stations and forms the headquarters of the Northern Rail Network System with the New Delhi Railway Station, Old Delhi Railway Station, Nizzamuddin Railway Station and Sarai Rohilla Railway Station constituting of the main Railheads in the city.
- Delhi has well maintained National Highways and Expressways that connect to other neighboring states. There are a total of six Expressways out of which three are still under construction. The Delhi-Gurgaon-Delhi Expressway connects the city the International Airport and with Gurgaon and the DND expressway-cum-Flyover connects the city with Noida and Greater Noida that has made accessibility to the still awaited new Airport and the Indian Grand Prix track very easy. There are a total of five National Highways namely NH-1, NH-2, NH-8, NH-10 and NH-24 connecting the city to other states.
- The Indira Gandhi International Airport or DEL, the abbreviated form, connects Delhi with other States and International cities serving over 23 million domestic and International passengers that convert it into the busiest Airport in Southeast Asia.
- Most of the Buses originate and terminate at the Inter-State Bus Terminal or ISBT that take passengers who travel within Delhi.
- The one thing that has caught on to the craze and Transport Pulse of Delhi is the recent addition of the much awaited Delhi Metro Link operated by the Delhi Metro Rail Corporation or DMRC.

4.3 VEGETATION

- Delhi geography divides the state into three parts- the Delhi ridge, the Yamuna flood plain and the plains.
- The Yamuna river plains are very fertile as they are flooded by the river and is rich in alluvial soil. The Delhi ridge is the most important characteristic of the state and is a part of the Aravalli range that passes through Delhi. It is interesting to note here that each of these regions is marked by distinct type of vegetation.
- The ridge area of the city offers the right factors that favor the growth of acacias and other cacti . However, during the monsoon, herbaceous plants grow in abundance in the ridge. As far as the plain region of Delhi is concerned, it is characterized by shisham trees. And finally, riverine type of vegetation grows along the plain of Yamuna.
- Vegetation of Delhi mainly comprise ofmedium size trees and herbs. However Delhi is known for its varied flowering plants.Weeds and grass grow on the banks of the Yamuna river.
- According to the Delhi weather records, extreme temperatures dominate the statecapital. Delhi experiences extreme summer and winter seasons. Besides this, winter season also experiences immense fog which covers the city in its blanket.

4.4 HYDROLOGY

- Fresh water is available up to 60 meters depth below ground level for over 90 per cent of the city, and the quality of water is potable.

4.5 TOPOGRAPHY

- It is located in the North-west portion of the country at latitude 28.68 N and longitude 77.21 E.
- The eastern portion of the Delhi Union Territory is adjacent to the State of Uttar Pradesh, simultaneously; the northern, southern and western portion is adjacent to the State of Haryana.
- In the east portion of the Delhi Union Territory, Yamuna River, a tributary of Ganges River flows to the south, and in the west, Aravalli Mountains forms the administrative boundary with the Uttar Pradesh Region.
- The Delhi region exhibits a very gentle southerly master slope as indicated by the southerly flow of the Yamuna River, except at some places where the slopes have been locally reversed.
- The general slope in the region east of the Yamuna River is westerly. Similarly, the change in slope direction is also noticed west of the Yamuna adjoining Okhala Barrage.

4.6 CLIMATE AND RAINFALL

- Delhi's has an **extreme climate**. It is very hot in summer (April - July) and cold in winter (December - January).
- The average temperature can vary from 25ºC to 45ºC during the summer and 22ºC to 5ºC during the winter.

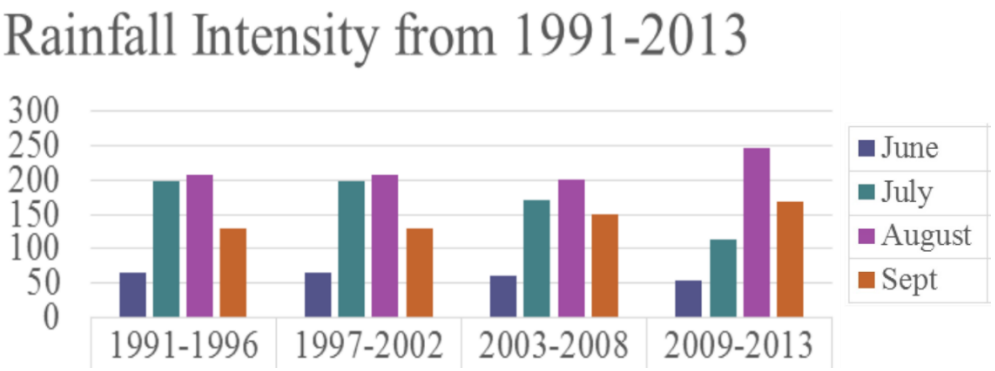


FIG 4.2 RAINFALL INTENSITY, DELHI REGION

4.7 DEMOGRAPHIC PROFILE

- The population of Delhi has increased at a rate of 2.1% per annum during the decade from 2001 TO 2011.
- Delhi ranks first in terms of population (1.67 crores)
- Delhi's population has grown from a meager 405,800 in 1901 to a staggering 16,753,200 in 2021, making it one of the largest growing cities in the world.
- The Delhi City is divided into the following three municipality areas:

➢ Cantonment area in the western central part of the city.

➢ New Delhi in the eastern central part of the city.

➢ Old Delhi is surrounding the above two municipality areas .

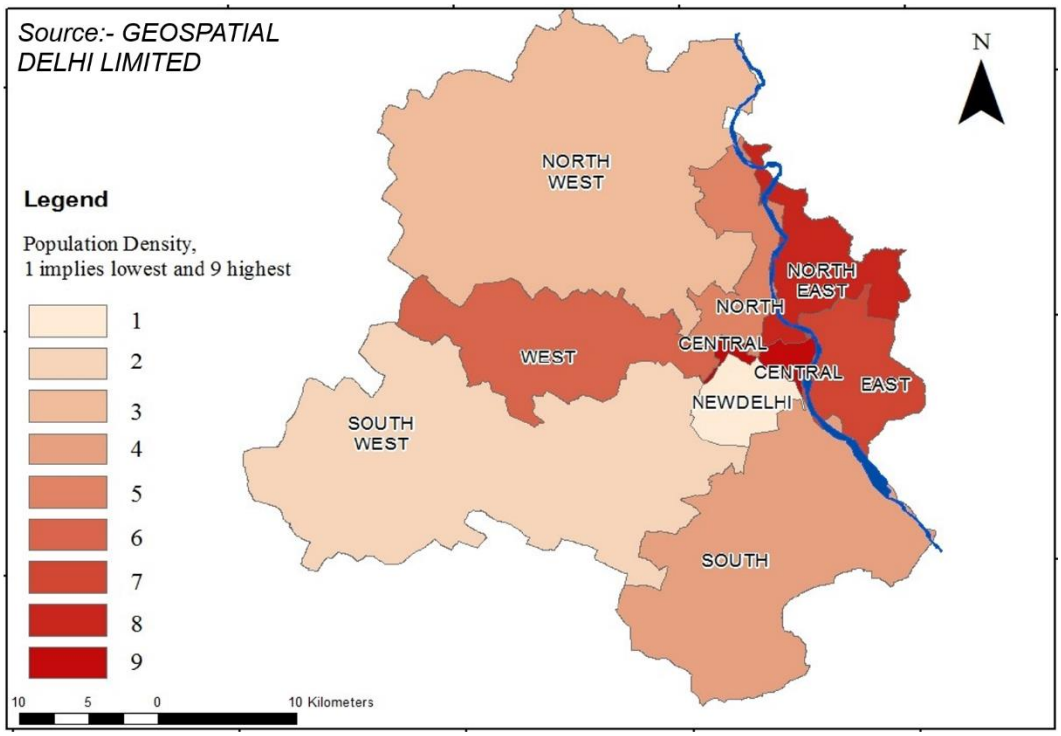


FIG 4.3 POPULATION DENSITY MAP, DELHI

- The predominant shift from agriculture to urban work services created job opportunities that have attracted people from different states to search for employment.
- These factors caused the flooding phenomenon in region that damages properties, environment.

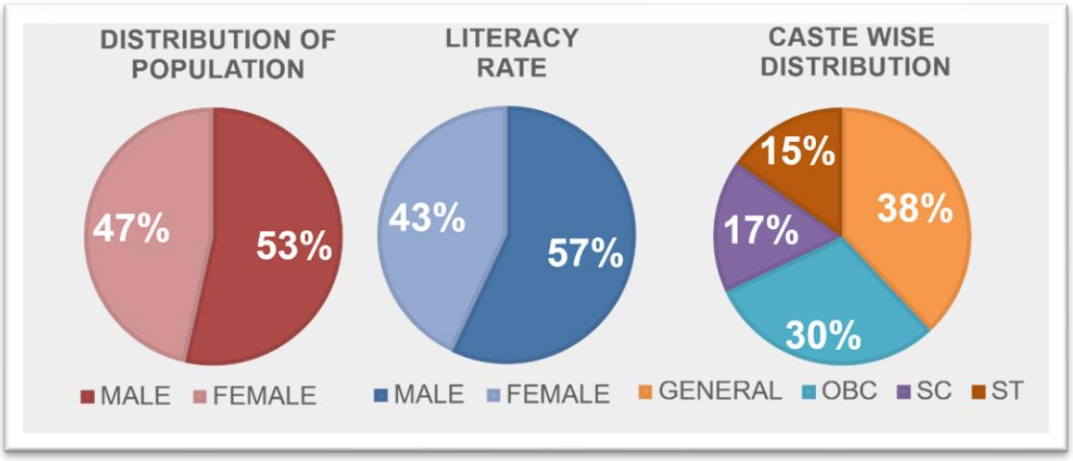


FIG 4.4 DISTRIBUTION OF POPULATION, DELHI

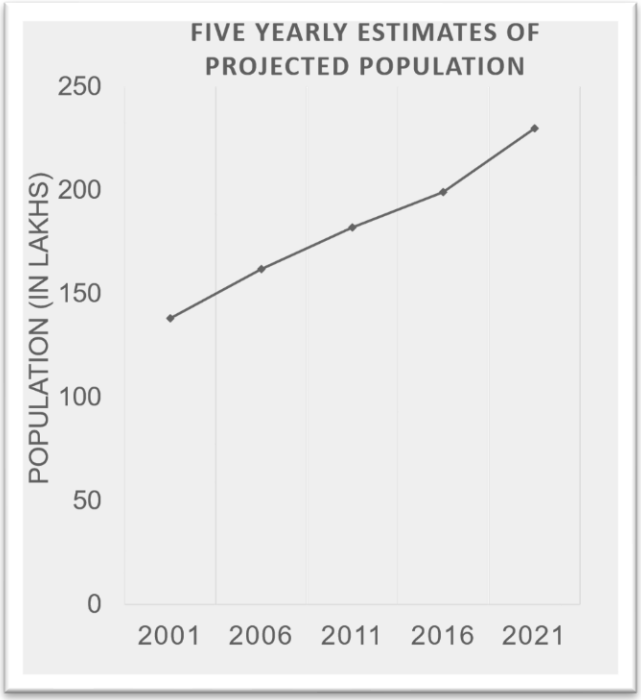


FIG 4.5 POPULATION GROWTH, DELHI

4.8 LAND USE PATTERN

- Land in the Urban Extension is proposed to be broadly distributed in different land uses.
- On an average the space required per person would be 40 sqm, covering about 920 sqkm of urban area for the projected population of 230 lakh in year 2021.
- The NCTD has been divided in 15 Zones (Divisions).
- "Therefore, increasing incidents of Urban Flooding is directly related to increasing urban area."

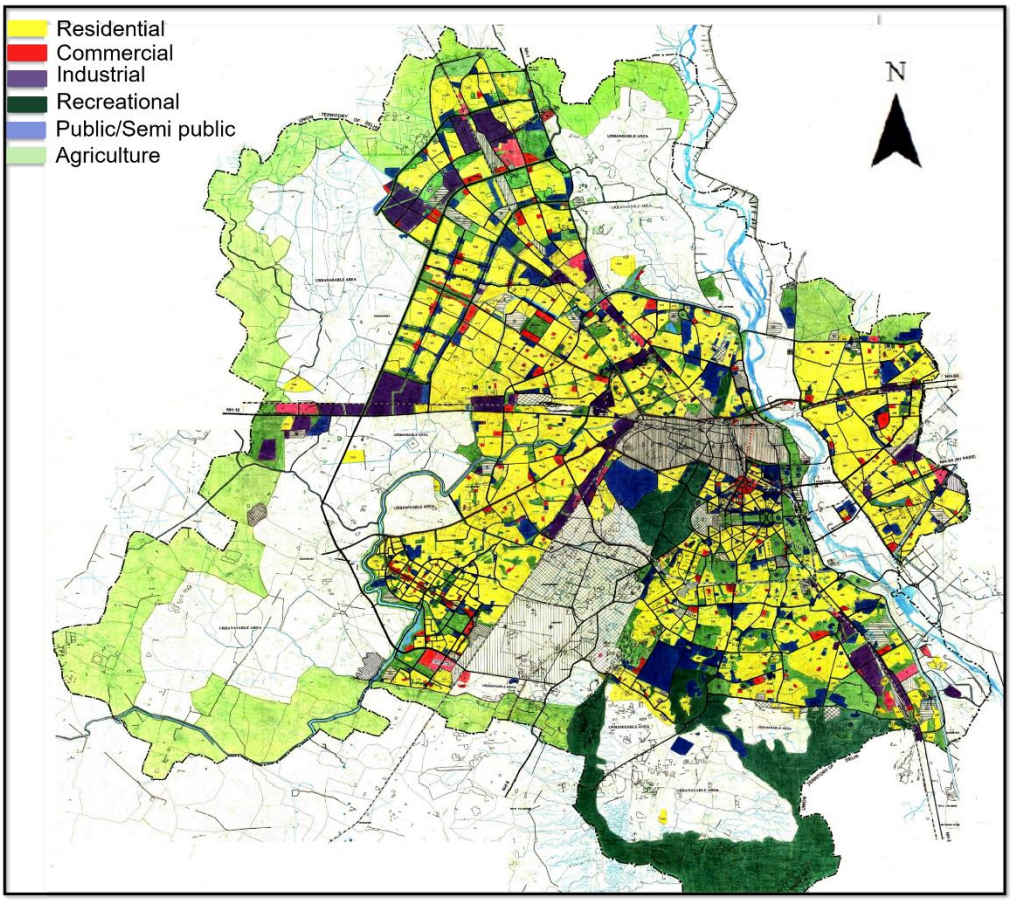


FIG 4.6 LAND USE MAP, DELHI Source:- DDA, DELHI

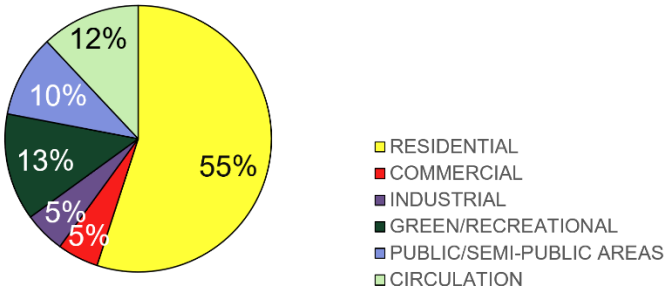


FIG 4.7 LAND USE DISTRIBUTION, DELHI

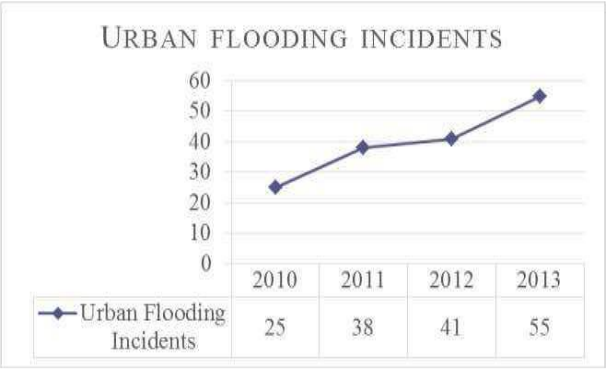


FIG 4.9 URBAN FLOOD EVENTS , DELHI

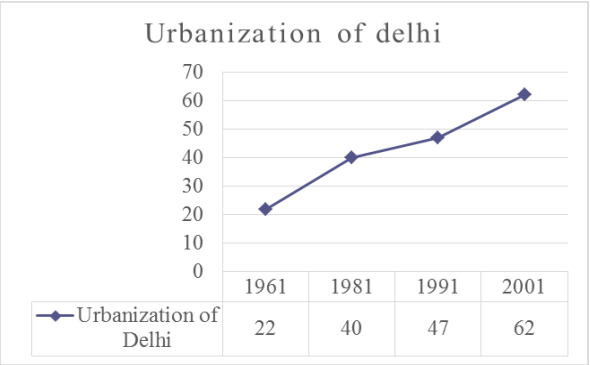


FIG 4.9 URBAN GROWTH , DELHI

- Being one of the most urbanized cities in the country, Delhi is always at high risk of urban flooding.
- The rate of urbanization can be gauged from the fact that the built-up area increased by seven times between the 1970s and 2000s.
- Tajewala is the main barrage that is used by the Department of Irrigation and Flood Control (I&FC), Government of Delhi to regulate the Yamuna waters entering Delhi NCT.
- The critical analysis of the flood zoning pattern reveals that the high-risk zones are the areas that have earlier been identified as unplanned or poorly planned areas having high population densities and sub-standard housing structures. These include areas of North Delhi and the Trans-Yamuna Area.

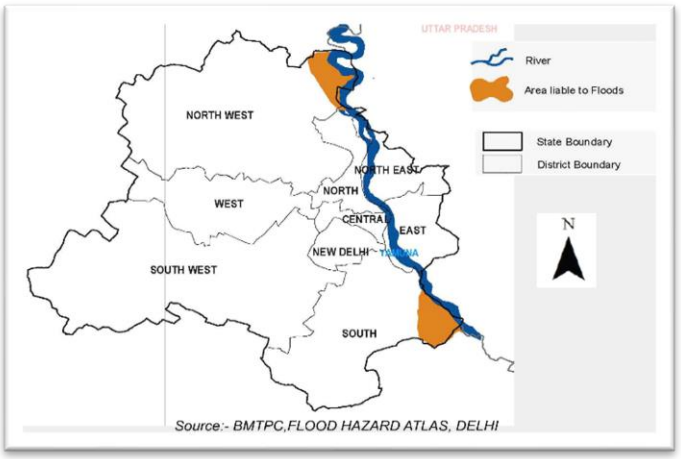


FIG 4.10 FLOOD HAZARD MAP , DELHI

4.9 CITY INFRASTRUCTURE

4.9.1 ROAD NETWORK AND THEIR CONDITIONS

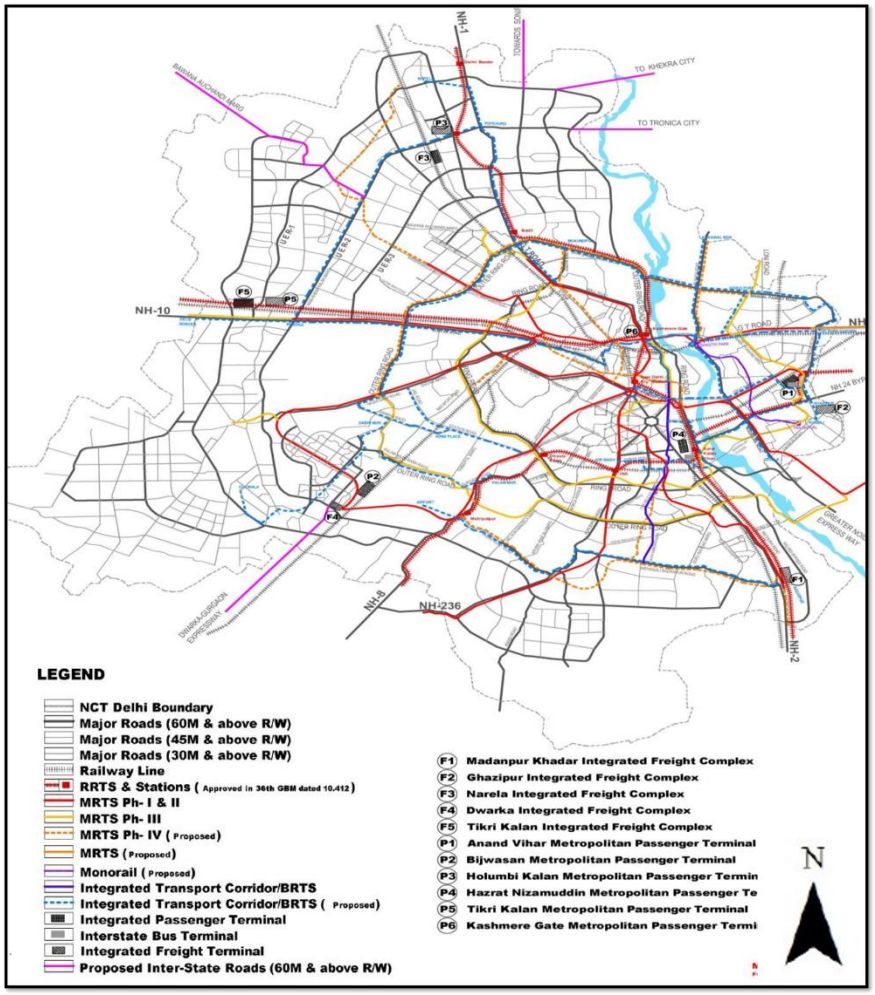


FIG 4.11 TRANSPORT NETWORK MAP , DELHI
Source:- DDA, DELHI

- The National Capital Territory of Delhi comprises a vast network of hierarchical transportation network.
- The road network exists in a hierarchy of National Highways, arterial roads, sub-arterials, collectors and local roads at neighborhood level.
- The length of road network has extended four times from 8,231 kilometers in 1985 to 34,012 kilometers in 2016.

- A large number of police personnel, especially females, deployed in traffic duty for long hours in the city do not have public toilets and urinals to use.
- Due to heavy traffic and road encroachments it becomes difficult for the visitors to park vehicles.
- No regulatory measure are taken by the Municipal Corporation against the encroachers to coming out on footpaths and roads.

FIG 4.12 ROAD CONDITIONS , DELHI

4.9.2 DRAINAGE PATTERN

- Delhi comprises of 24,840 hectares of flood plains of which 68 per cent forms a part of river Yamuna floodplains.
- The city has three drainage basins based on the watershed of drains that includes North Basin with a basin area of 26,694 hectare; West basin with an area of 75,633 hectares and South East Basin spread over an area of 45,973 hectares.
- The flood plains have reduced in width from an average 800 meters in 1986 to an average of 300 meters in 2019 as a result of construction and developments that came up on the flood plains and resultant loss of the eco-fragile ecosystem.

- The Irrigation and Flood Control Department, Government of NCT of Delhi demarcates the city into six drainage zones namely (i) Northern Zone, (ii) Western Zone, (iii) Central North West and South East Zone, (iv) Central South and South East Zone, (v) East Zone and (vi) South Zone,

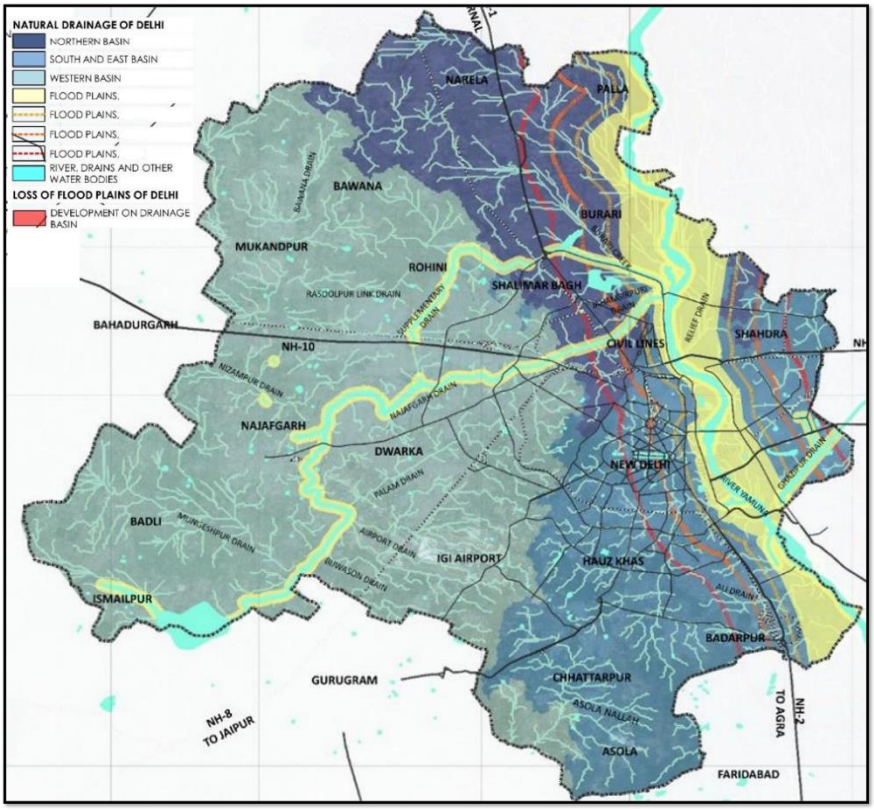


FIG 4.13 DRAINAGE PATTERN , DELHI

Source:- USGS, DELHI

- Drainage has two aspects: flood protection and storm water discharge, which are interrelated.
- The storm water and flood protection in Delhi are not local but have regional bearing including areas of Haryana and Rajasthan.
- The main drainage system of Delhi is such that all water collected through main drains, link drains and small rivulets is discharged into Yamuna.

4.9.3 WATER LOGGED AREAS

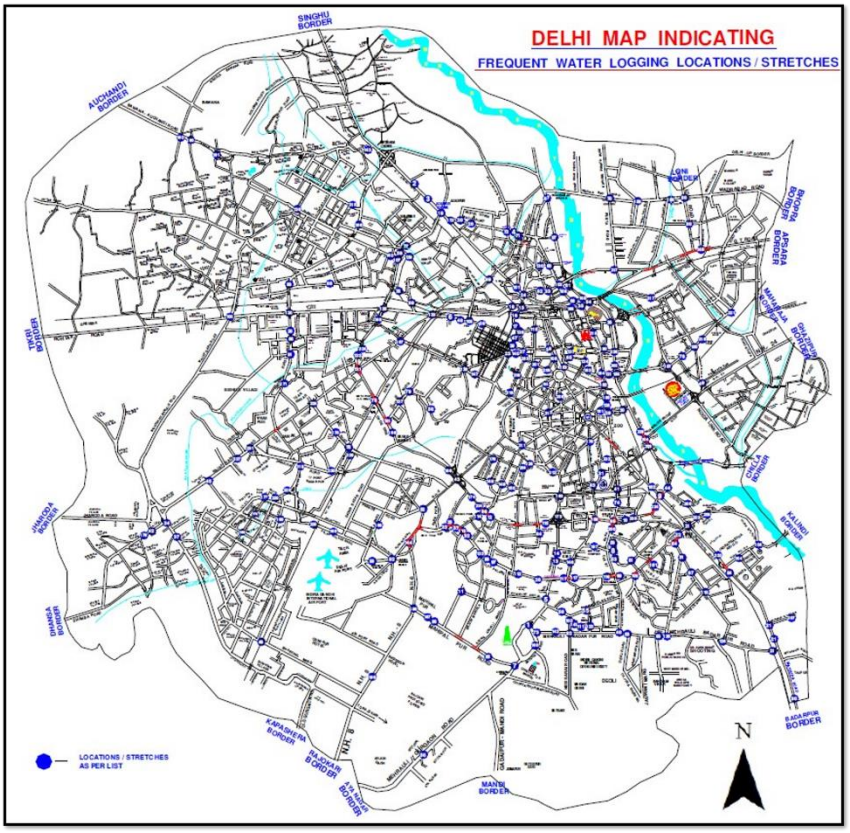


FIG 4.14 WATER LOGGING LOCATIONS , DELHI
Source:- DDA, DELHI

- Inundation occurs in some localized places of the urban area after heavy rainfall in absence of appropriate drains and routes.
- The depth and duration of inundation vary from place to place.
- Such areas are freed from inundation by the process of evaporation and infiltration.
- The reasons for inundation/water logging are technical, social and institutional.
- These water-logged areas have been considered and should be brought under proposed drainage network.

➢ **EFFECTS OF WATER LOGGING**

- The logged water becomes polluted with solid waste, silt and contaminants that are washed off from roads.
- The increase in volume and rate of logged water causes erosion and siltation.
- It becomes a burden for the inhabitants of that urban area, leading to unhygienic environment and creating adviser social, physical, economical as well as environmental impacts.

FIG 4.15 WATER LOGGING LOCATIONS , DELHI

4.10 SOCIAL INFRASTRUCTURE

4.10.1 GARBAGE

- Garbage problems on the main arterial roads
- The dustbins are at a distance of 1km on each stretch due to which areas in between are filled with garbage on roads which results in choaked drains.
- The area lacks in the provision of adequate street lights which is a big issue at night.
- The people travelling face problems and the crime rate is more after 11pm.
- Improper and choaked drains at the present.

FIG 4.16 GARBAGE INNUNDATION , DELHI

4.10.2 DRAINAGE

- People dump their garbage and debris directly into the drains, which tends to block the flow of water in them, and the filth laden water, simply overflows onto the open land. In many places, the cleaning of the drains is not carried out regularly or the drains being old and decrepit are unable to handle the water content.
- Many houses have been constructed above these drains, thus obstructing the path of the drained water. Waterlogging, is thus on the rise.

FIG 4.17 DRAINAGE CLOGGED , DELHI

4.10.3 WASTE GALORE

- The city generates about 1000 metric tonnes of solid waste per day, but only has the capacity to dispose 65 percent of the total generated solid waste.
- Waste that is collected spills over into the roads during transportation. The roads remain dirty, unhygienic.
- Most of the waste is dumped on to a waste site, about 22 km away from the city, without any form of segregation or treatment.

4.10.4 ECO SYSTEM LOSS

- Patna is fast losing its green cover and existing water bodies. Unchecked dumping of garbage or raw sewage in these water bodies is slowly killing them.
- As per Master Plan 2030, only one percent of the
- area is occupied by waterbodies.
- Agricultural land around the city has been taken over by brick kilns.
- The biodiversity of the periurban areas is being affected and the livelihood of the marginal farmers is at stake here.
- The water pipelines leak at several places, an invitation to pollution and also causing a loss of nearly 40 percent of a precious resource.

FIG 4.18 EFFECTED ECO SYSTEM , DELHI

4.11 SWOT ANALYSIS

4.11.1 STRENGTHS

- Strong legal framework and policy regime cutting across sectors.
- Extensive Institutional Infrastructure already in place.
- Rich experience, good practices and related learning.
- Availability of resources under different programmes.

4.11.2 WEAKNESSES

- Lack of common multi-sectoral vision for disaster management, and related frameworks, perspectives, plans and benchmarks.
- Disconnect between policy and practice.
- Primary focus on disaster response and relief, and lack of attention on risk reduction.
- Gaps in policy, design and delivery of training and capacity building programmes.

4.11.3 OPPURTUNITIES

- Various national flagship programmes provide a ready platform.
- Growing capacity building institutions and related infrastructure are readily available.
- Strong network of civil society organizations is already working on the subject in vulnerable parts of the country.
- Community organizations are emerging in a fast growing movement and can form the base of national capacity building efforts.

4.11.4 THREATS

- Investment in long term benefits of disaster risk reduction is overshadowed by opportunity costs of short term projects with immediate gains.
- Ongoing trends of unsafe development are creating risk at a pace faster than risk reduction efforts.

4.12 IDENTIFICATION OF PROBLEM

Impacts of flooding include loss of human life, damage to property, destruction of crops, loss of livestock, and deterioration of health conditions owing to waterborne diseases

As communication links and infrastructure such as power plants, roads and bridges are damaged and disrupted, some economic activities may come to a standstill, people are forced to leave their homes and normal life is disrupted.

Due to saucer shaped topography of the city the problem if water logging is always there in the low lying areas.

It is running on the old drainage system which is to be removed or repaired with the proper construction of new drains.

Preparedness plans do not work accordingly as per the disaster and other works related to master plan.

4.13 CONCLUSIONS

- Urbanization is a phenomenon which will take over the future of all land available.
- Land under agriculture, forest, grass lands is reducing exponentially.
- Climate conditions are changing, cities receive higher rainfall than the suburbs.
- Though at present Delhi didn't face any increase in rainfall intensity, but in future it might. As such, Urban Flooding incidents would grow even faster than now.
- If we depend on the traditional approach of solving Urban Flooding, not only will it be economically not feasible but ecologically unsustainable. Simple design solutions as adopted in Housing Scheme B, like pervious paving of turf blocks and depressed play areas can reduce the peak discharge and time of concentration, thus preventing urban flooding at the source. If one

includes green roofs and other techniques of SUDS, the percentage of reduction will get significantly higher.

- The housing scheme may be a very micro level intervention, but preventing urban flooding at the source will later add up to reduce overall urban flooding incident.

4.14 ISSUES AND RECOMMENDATION

➢ *Flood forecasting:* Flood forecasting enables forewarning as to when the river is going to use its floodplains, to what extent and for how long. With reliable advance information/warning about impending floods, loss of human lives and moveable properties and human miseries can be reduced to a considerable extent.

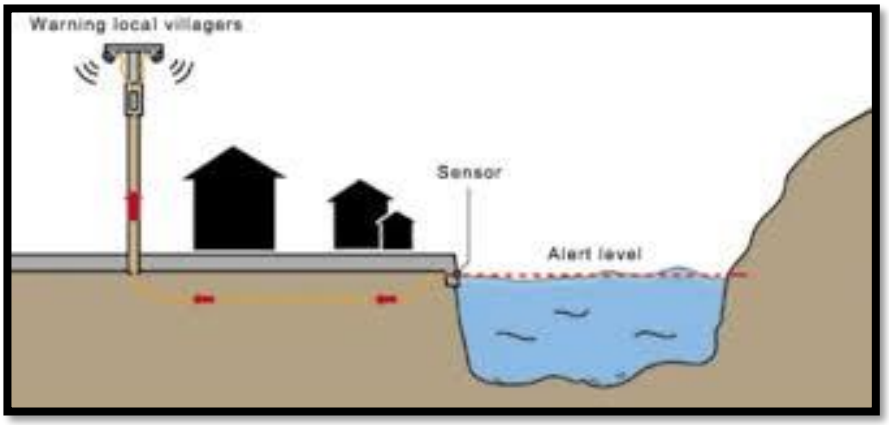


FIG 4.19 FLOOD FORECASTING REPRESENTATION

➢ *Dam break flood wave simulation*: Worldwide many types of dam break models exist ranging from simple computations based on historical dam failure data that can be analyzed to complex models that require computer analysis. These models simulate them breach on the dam, and route the flood through the downstream terrain of the valley. Such information is very useful for planning purposes.

- *Flood inundation mapping:* For flood mitigation measures and land use planning, flood inundation mapping is an important activity. The Satellite remote sensing technology is also extremely useful in monitoring the dynamics of water spreads during the floods. Analysis of remotely sensed data gives a reasonable accurate assessment of water spread directly from the satellite images as a just processed information.

- *Flood plain zoning:* Preparation of flood plain zoning maps takes into consideration the inputs from flood inundation, flood hazard and flood risk zone maps (NIH, 1988-89). The important aspect of zoning is that it can be used to regulate what uses the land can be put to and what kind of construction can be carried out on such areas. Zoning is also used to restrict riverine or coastal areas to particular uses, specify where the uses may be located and establish minimum elevation or flood proofing requirements for the uses.

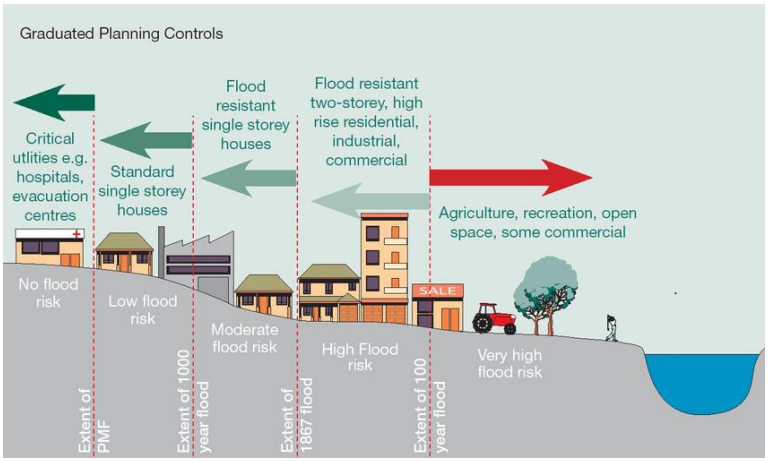


FIG 4.20 FIGURE FOR FLOOD PLAIN ZONING

- ***Decision support system for real time flood warning and management****:* Decision support system for issuing the flood warning and managing the flood in real-time is an advance software which is capable of providing the information to the decision makers for taking the necessary measures for managing the floods in real-time. Such information is very much useful for the decision makers to take necessary actions for preparing the evacuation plan in real time during the flood.

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