

# Proposing Solutions for Flood Resilience

Vaidehee Padghan, Sukanya Jha, Goransh Ahuja, Nivid Sablok

## Research Question

How might structural advancements be incorporated into the local flood resilience and risk management plan in Delhi?

## Methodology of Research

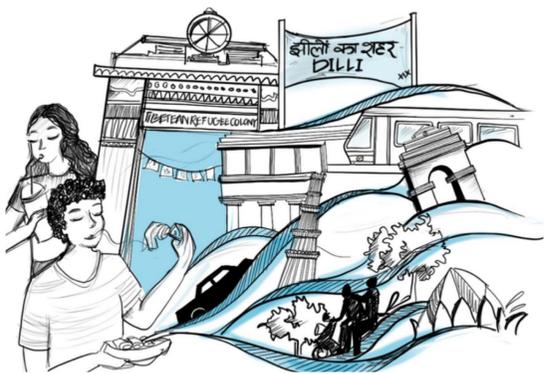
Based on historical data, spatial analysis, mapping flood extents, and identifying vulnerable zones, studied using Geographic Information System (GIS) techniques, and field surveys including firsthand observations and interviews with local residents, reveal information about the existing state of urban infrastructure and resilience strategies of the areas.

## Study Area

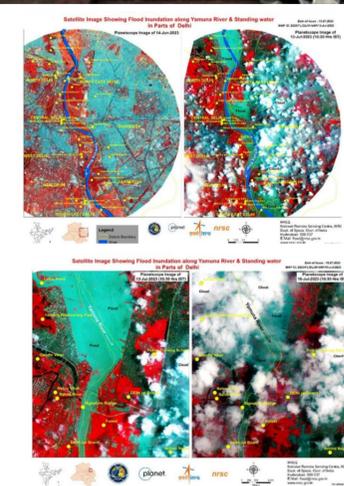
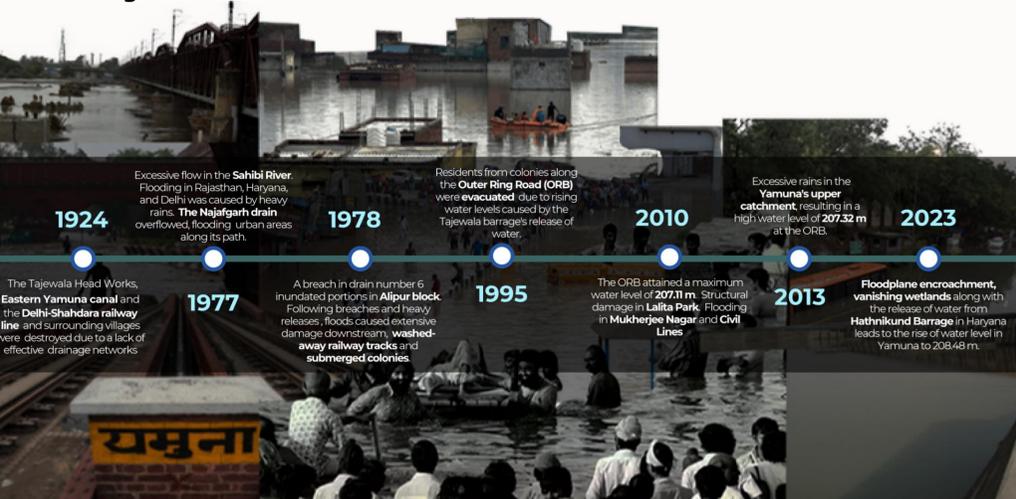
Residents of northeast, east, north, and central Delhi are especially sensitive to flood catastrophes due to higher population density. This research studies analyses the issues of Delhi by primarily focusing on ITO and Majnu ka Tila region, assuming Delhi is a larger fabric of similar areas.

## Abstract

Frequent flooding challenges urban regions, and Delhi is no exception. Various factors including its geographic position, urban infrastructure, and socio-economic status make some localities in Delhi particularly susceptible to flood threats. It is significant to highlight that these components frequently interact to create vulnerability to flooding, showing the need for effective flood risk management methods that must be developed in order to improve the overall resilience of the localities. The research intends to contribute to the understanding of flood patterns while also providing practical consequences for policymakers and urban planners. The research aims to inform targeted mitigation strategies, resilience-building measures, and sustainable urban development practices that can be applied not only in Delhi but also in other urban environments facing similar challenges by identifying the specific challenges and opportunities presented by floods in regions around ITO and Majnu ka Tila.



## History of Delhi Floods



## Case Study – Permeable Pavers Across the World



Permeable paving surfaces are made of either a porous material that enables stormwater to flow through it or nonporous blocks spaced so that water can flow between the gaps. Permeable paving can also include a variety of surfacing techniques for roads, parking lots, and pedestrian walkways. They may be composed of: pervious concrete, porous asphalt, paving stones, or interlocking pavers. In addition to reducing surface runoff, permeable paving systems can trap suspended solids, thereby filtering pollutants from stormwater.

## Reasons of Flooding in Delhi

Majnu ka Tila's drainage and sewage systems are in disrepair. The drainage network lacks integrated planning and spans territories in neighbouring states, resulting in problems such as untreated sewage flow and encroachments that clog drains. (Parvin et al., 2011).

Research employing satellite imagery on the Delhi metropolitan area between 1989 and 2011 indicated considerable changes in land cover and land use. This investigation revealed a tremendous increase in built-up areas in watersheds, as well as a loss of forest cover and changes in agricultural land.

In July 2023, the ITO regulator failed, allowing Yamuna River water to inundate parts of ITO, IP Estate, Rajghat, and the neighboring regions. One of the clogged gates of the ITO barrage were opened, and attempts were underway to fix the remaining gates. Delhi's I&FC minister stated that opening all of the gates could take up to 60 hours. Non-responsive infrastructure makes it difficult to cater to floods.

- Infrastructure Issues
- Poorly Managed Drainage Network
- Overpopulation
- Failure of Regulators
- Excess Rainfall
- Natural/Man-made Obstruction
- Snowmelt
- Agricultural Practices
- Riverbed Sedimentation
- Deforestation

## Delhi flood data

Year	Gauge (m)
1976	206.7
1978	207.49
1988	206.92
1995	206.93
1998	206.36
2010	207
2023	208.48

Sr.No.	District	Inundated Area (ha)	Inundated Area (sq.m.)
1	North Delhi	226	2260000
2	South West Delhi	1490	14900000
3	Central Delhi	112	1120000
4	North West Delhi	942	9420000
5	North East Delhi	453	4530000
6	West Delhi	152	1520000
	<b>Total</b>	<b>6375</b>	<b>63750000</b>

**Observations:**

- Significant flooding was seen in the districts of North Delhi, South West Delhi, and Central Delhi.
- The inundation may include water accumulation in low-lying areas as a result of heavy, continuous rainfall.

The River has set 208.66 meter as new HFL (Highest Flood Levels) for the site at 18:00 hours on 13 July 2023 which is 1.17 meter higher than the 1978's HFL. (SANDRP, 2023)

## Calculating current sponginess of Delhi

INDICATORS	DESCRIPTION	HOW TO CALCULATE	POINTS
INDICATOR 1	ASSESSMENT OF BLUE LINE DELINEATION:	1) Vegetation buffer on waterside space 2) Permeable pavement of the waterfront walkway >70% 3) green cover >95%	0
INDICATOR 2	PERCENTAGE OF PERMEABLE SURFACES	total terrestrial area / total permeable area X 100%	0
INDICATOR 3	ASSESSMENT OF GROUNDWATER LEVEL	No calculation needed	3 (1.7cm/year)
INDICATOR 4	PERCENTAGE OF GREEN COVER	(canopy cover = green cover) - (total terrestrial area of the city) X 100%	1 (23.6%)
INDICATOR 5	SEPARATION OF WASTEWATER AND STORMWATER INFRASTRUCTURE	No calculation needed	2
INDICATOR 6	ASSESSMENT OF GROUNDWATER QUALITY	Groundwater > Standard III	0

**Comprehensive Approach to Evaluate Sponge Cities: Development of an Assessment Framework**  
By Yanniss Fouquet, Department of Planning, Aalborg University

The framework emphasises the amount of water management measures, the quality of execution, ecological functionality, and community co-benefits. The city of Delhi received a troubling score of **11 out of 56** in the Sponge City Assessment methodology, highlighting the major issues it confronts in water management. The figure shows a part of the assessment that was conducted in Delhi.

## Inferences and Conclusion

The floods in ITO (Income Tax Office) and Majnu Ka Tila provide two distinct scenarios, each with its own set of geographical, infrastructure, and community problems. ITO, located in central Delhi, frequently encounters flooding issues, owing to its proximity to the Yamuna River and susceptibility to breaches or overflow from water regulators. Majnu Ka Tila, a densely inhabited Tibetan settlement on the banks of the Yamuna River, on the other hand, has its own set of flood-related concerns. Its flood risk may be influenced by elements such as the quality of embankments, drainage systems, and the settlement's elevation in relation to the river. While ITO faces urban-centric challenges as a result of its key location and critical infrastructure, Majnu Ka Tila's flooding issues are frequently linked to its unique settlement dynamics and the impact of riverine circumstances. Both situations show the necessity for specific flood control methods. As urbanisation continues to pose water management challenges, particularly in the face of climate change, the Sponge City concept and associated assessment framework presented in this paper are valuable contributions to the ongoing discourse on resilient and sustainable urban development.

## Construction design of permeable pavers

- Permeable Pavers (Min. 80mm thickness)
- Aggregate Bedding Course - not sand (50mm depth)
- Open Graded Base (depth varies by design application)
- Open Graded Sub-base (depth varies by design application)
- Subsoil - flat and scarified in infiltration designs
- Geotextile on All Sides of Reservoir
- Optional Reinforcing Grid for Heavy Loads
- Perforated Drain Pipe 150mm Dia. Min.
- Geotextile Adhered to Drain at Opening
- Flow Restrictor Assembly
- Secondary Overflow Inlet at Catch Basin
- Outlet Pipe/G Storm Drain or Swale System. Locate Crown of Pipe Below Open Graded Base (no. 3) to Prevent Heaving During Freeze/Thaw Cycle
- Trench Dams at All Utility Crossings

**Full Infiltration**  
Where rainfall is intended to infiltrate into the underlying subsoil. Elements in sites with subsoil permeability > 15mm/hr.

**Partial Infiltration**  
Designed so that most water may infiltrate into the underlying soil while the surplus overflow is drained by perforated pipes that are placed near the top of the drain rock reservoir. Suitable for subsoil permeability >1 and < 15mm/hr.

## Hardscape to Permeable Hardscape

The concept of "sponge cities," introduced by Professor Kongjian Yu in 2013, represents a revolutionary shift in urban water management away from conventional concrete structures. This innovative approach harnesses natural elements, such as grass, trees, ponds, lakes, and soil, to efficiently absorb rainwater, offering a nature-based solution to the challenges posed by heavy rainfall and climate change.

Delhi, with its increasing urbanisation and significant hardscape construction, faces significant difficulties connected to stormwater runoff and flooding. Natural rainwater absorption and infiltration into the soil are considerably hampered in a high hardscape environment dominated by concrete surfaces. Surface runoff is exacerbated by the limited permeable surfaces and overwhelming drainage systems during heavy rainfall. This results in rapid runoff that can contribute to localised flooding, infrastructure damage, and interruptions to daily life.

