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Climate Catastrophes: Analyzing the Impact of Changing Landscape of Yamuna Floodplains on Livelihood of Women

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ABSTRACT: *Floodplains are vital ecosystems that provide natural flood control and support diverse wildlife in urban areas. Due to urbanization, pollution, and habitat destruction, their ecological integrity and resilience is compromised. In the context of climate change, the sudden inundations are a hurdle to social and economic growth of women from marginalized communities who depend on these resources for their livelihood and bear a disproportionate burden of these impacts. The recent flooding event of July 2023 in Delhi, has set the new HFL (Highest Flood Level) as 208.66 m in Yamuna River. The aim of this research is to analyze the situation of a recent flood and its impact on women living in low-lying areas of Yamuna floodplains to identify the issues related to their existence. The methods adopted for the study involved conducting a qualitative survey of women living in the flood-affected areas and mapping the land use land cover (LULC) in two stretches of floodplains to identify the impact of recurring floods on the agricultural communities due to unplanned development. The study highlighted that the various infrastructure projects have altered the terrain in floodplains of Yamuna River over the years that are responsible for changing course of the river and yearly floods in the area. The findings of the survey associated the changing climatic pattern in the region in the last 20 years with survival threats to the most vulnerable group i.e. women and cattle in these Urban agricultural societies. This study opens the path for future research to inform policy-makers to formulate stringent policies and regulations in order to control the unplanned development in the floodplains and building resilience to ecologically sensitive areas.*

KEYWORDS: *Climate change, Ecologically sensitive areas, Floodplains, Women*

INTRODUCTION

Flooding is a recurring and significant issue in many urban areas and Delhi has not been immune to its devastating impacts. Human activities including urbanization, deforestation, constrained capacity of river canals, presence of human settlements in low-lying areas, and unplanned development without concurrent improvements in drainage infrastructure have predominantly played a role in causing urban floods. Furthermore, the altering climate patterns, characterized by a heightened occurrence of extreme precipitation events, serve as a key factor amplifying the issue of flooding. In light of the persistent occurrence of floods, particularly in urban settings, the consequences are felt by local, regional, and global economies. There is an urgent need for the development of an effective flood modeling approach to prevent such disasters. Over the years, Delhi has faced numerous flood events with the Yamuna River playing a pivotal role in these occurrences. As a lifeline for the region, the Yamuna River's fluctuations have had far-reaching consequences often leading to inundated streets, disrupted livelihoods, and jeopardized safety for Delhi's inhabitants. In the realm of disaster studies, a gendered perspective offers a profound lens to understand the multifaceted impacts of catastrophic events especially related to economic damage. It transcends mere physical destruction to encompass the transformation of the social landscape, and this shift is integral to the perception and response to disasters. At its core, this perspective highlights the embodiment of terrain as inherently gendered – a concept that resonates deeply with the lived experiences, memories, and future concerns of individuals and communities. In moments of crisis, the stark reality emerges that certain individuals and groups are disproportionately impacted as a result of gender-based disparities. Yet, it is crucial to recognize that disasters are not merely moments of destruction and despair. They also serve as powerful catalysts for social change and growth.

In the wake of tragedy, movements emerge that push for social justice and equality, challenging the existing power structures and demanding a reevaluation of societal norms. The reconfiguration of gender roles and expectations can be a powerful outcome, as individuals and communities collectively question and reshape their identities and responsibilities. In essence, disasters are not just moments of devastation; they are also moments of reckoning. They offer an opportunity to critically examine the social landscape, laying bare the inequalities that persist and inspiring to embark on a journey towards a society characterized by justice and equity.

LITERATURE REVIEW

1867 - 2000
1. Old railway bridge (1867) 2. Okhla barrage (1874) 3. Wazirabad barrage (1959) 4. ITO barrage (1960)
2001 – TILL DATE
5. Shastri Park Metro Bridge (2002) 6. Akshardham temple (2005) 7. Geeta Colony Double Lane bridge (2008) 8. Yamuna Bank Metro Bridge (2009) 9. Yamuna bank metro station (2009) 10. Akshardham temple metro station (2009) 11. CWG village (2010) 12. Okhla Metro Bridge (2017) 13. Signature bridge (2018)

Table 1: Yearwise data of major infrastructure interventions in Yamuna floodplains

The Yamuna is a tributary of the Ganga River system, originating from the Yamunotri Glacier at an elevation of 6,387 meters Uttarakhand, Haridwar. The river flows through various states including Uttarakhand, Haryana, and Delhi. In the Delhi catchment area, the Yamuna spans 1485 km2. Notably, the Yamuna River contributes to over 70 percent of Delhi's water supplies.

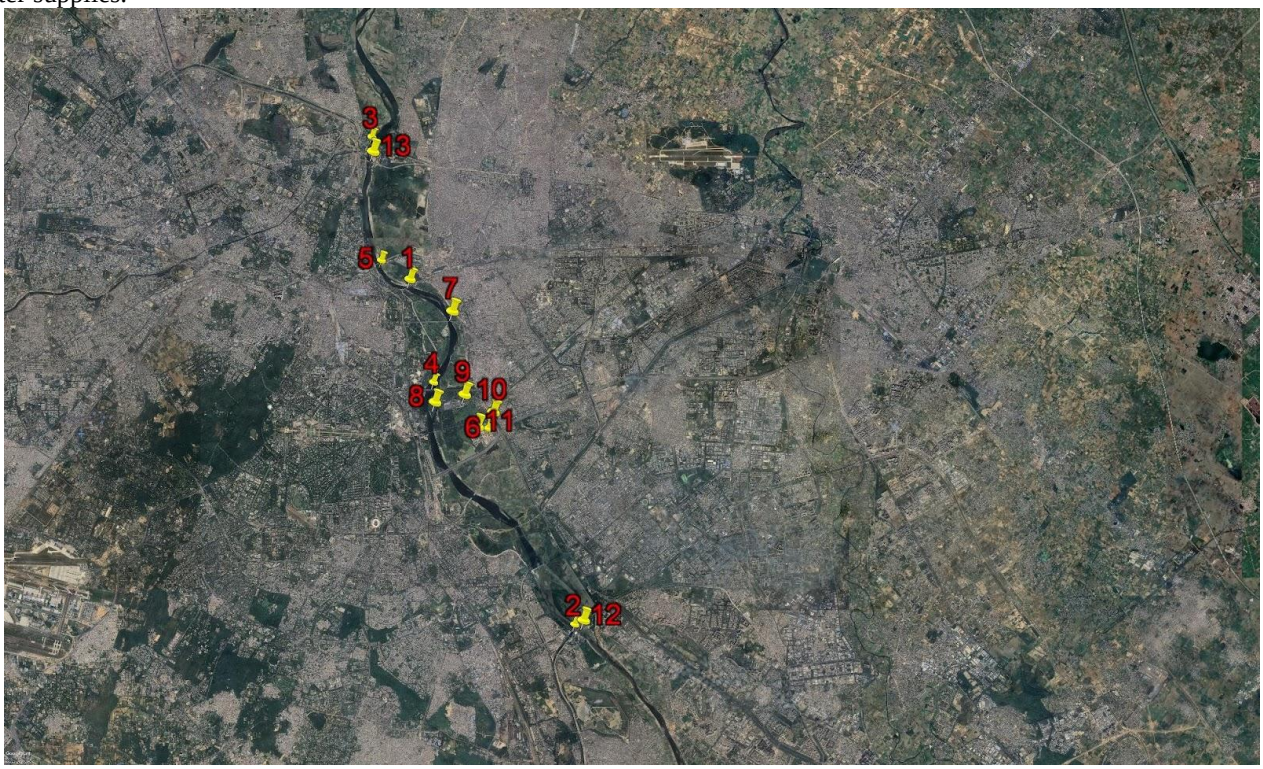


Fig 1: Map showing location of major infrastructure interventions in Yamuna floodplains

Over the years, encroachments on the floodplain and riverbed of the Yamuna River in Delhi have diminished its capacity to carry floods effectively. The floodplain is experiencing a significant reduction and encroachment, compromising both its longitudinal and lateral connectivity. Currently, out of the total 9,700 hectares of the Yamuna's floodplain in Delhi,

approximately 3,638 hectares are under the regulation of the Delhi Development Authority (DDA). It remains unclear whether this regulated area is entirely developed. Nonetheless, as per survey more than 1,000 hectares of the Yamuna's floodplain have been encroached upon by permanent structures over the past decade and a half. Notable encroachers include the Common Wealth Games (CWG) Village, Akshardham Temple, Yamuna Bank Metro Depot, Shashtri Park Metro Depot, and IT Park Rawat (2023).

Reflecting on the reasons for the July 2023 Delhi floods, South Asia Network on Dams, River and People (SANDRP) explores possible reasons aggravating the flood situation in the city. The study provides data regarding water discharges from Hathnikund Barrage from 1978 to 2023. Through analysis of data, the results show that high rainfall has not been a major factor in increasing Yamuna flood levels and set a new HFL. Encroachment of floodplains and construction of permanent structures, new bridges, and roads along and across the river have affected the passage of water. The ground observations suggest that the Yamuna riverbed is gradually rising due to sedimentation load. There is an increase in the number and size of mid-stream sand bars. The study concludes by highlighting the reasons for flooding as changes in land use, an increase in built-up areas with growing urbanization and concretization, decline in water bodies and green spaces are the major drivers of change Rawat (2023).

Feroz (2022) highlights the challenges faced by women, girls, and other marginalized groups during a Flood crisis. These challenges include access to humanitarian assistance, lack of education and information, limited access to resources, economic conditions, and cultural issues. “Moreover, women with disabilities and religious minorities face discrimination during such natural disasters.” Due to limitations on women’s mobility and education, women have minimal outside exposure due to the conservative and patriarchal nature of a few cultural societies. As a result, women are not fully equipped with life-saving skills such as swimming, navigation, or self-defense techniques. Due to damage to water supply, sanitation, and hygiene infrastructure during a flood, women’s hygiene and sanitation needs are not met as due to homelessness they are unable to manage their menstrual hygiene. Women’s specific needs are neglected. The challenge is particularly acute for pregnant and lactating women. Pregnant women have nowhere to give birth safely because the floods have washed away homes and health facilities, and access is compromised due to damage to roads and bridges. Their lives and the lives of their babies are at risk as they can’t access proper maternal health care. It has been highlighted that in the aftermath of a disaster, many women and young girls are at a high risk of gender-based violence, sexual abuse, and harassment even in relief camps and shelter homes set up for flood victims. With entire villages washed away, families broken up, and many people sleeping under the sky, the usual social structures that keep people safe have fallen away, and this can be very dangerous for women and girls.

To study the gendered vulnerability and adaptation in the Hindu-Kush Himalayas, Goodrich (2019) studied “vulnerability to climate change as a multi-layer and multi-faceted phenomenon, determined by both biophysical and socio-economic factors.” It has been highlighted in that study that vulnerabilities vary in nature and type. While conceptualizing gendered vulnerability to climate change, it is important to explore the issue of intersectionality. Social hierarchies are primarily shaped by people's positions within a specific social and cultural context. Understanding these contextual factors is essential to grasp the complexities of vulnerability, especially its gender-related aspects. Gender and other contextual elements influence and are influenced by socioeconomic factors, giving rise to distinct gender vulnerabilities. Due to disasters, migration takes place. Often, men migrate from villages to cities from environmentally stressed regions and women have to engage themselves in the public domain like the marketplace which is the most gender-unfriendly place where women’s safety is at stake. The study concludes by stating that the change in climate and socio-economic conditions in the Hindu Kush Himalayas led to changes in the experiences of the various groups of people, changing the genderscapes itself. These impacts differ based on gender as well as other categories, interplay, and interlinkages of these categories.

Padmanaban (2021) explores reasons about vulnerability of women to flooding in India in her article. Research data points out that there is an increase in IHDI (inequality-adjusted human development), an indicator to measure inequality in human development. The increase in IHDI has minimized male and female mortality but female mortality is disproportionate to male mortality. Researchers say this difference suggests that inequality in development has a differential impact on women. In rural India, women’s involvement in agriculture is substantially high, making women more vulnerable to floods. This is compounded by social norms where women have to take care of children and are unable to move to other occupations. In a state-wise analysis, the study modeled the IHDI of each state with flood-related female deaths. It was observed that Bihar, a flood-prone state has the second-largest number of female deaths from floods while Maharashtra had the highest number of flood-related female deaths. Kerala, the state with the highest IHDI, was found to have the lowest number of female deaths from floods.

To examine the flood-induced vulnerabilities and gender discriminatory norms among women in northern Bangladesh, Azad (2013) conducted a combination of qualitative and quantitative research to collect primary information for the study. The higher percentage of poverty among children and women, particularly in female-headed households makes children and women more vulnerable to natural disasters. In flood-affected areas, women suffered from physical injuries and were affected by waterborne diseases. Also, food security was identified as an acute problem after the flood, and shortage of food led to malnutrition among the flood-affected women. As a result, women could not work properly but had to cook and perform daily activities despite sickness or injuries.

Vulnerability here refers to exposure to contingencies as well as stress and difficulty in coping with them. Vulnerability has two sides: an external side of risks, shocks, and stress to which an individual or household is subject; and an internal side which is defenselessness, meaning a lack of means to cope without damaging loss Chambers (1989). Amongst all types of vulnerabilities, lack of clothing and food are indicated as significant problems that contributed to women's vulnerability during or after the flood (Fig 2).

Fig 2: Women are bound to stay in unhygienic conditions during July 2023 floods in Delhi

This study shows that both men and women are more prone to risks due to dynamic, external pressures but women are more sensitive to flood impacts Chambers (1989). Among the root causes of vulnerability, the geographical location focuses on proximity to rivers and the frequency of floods. Due to the disruption of communication systems and infrastructure - roads, culverts, bridges, embankments, and boats, women have to move many times on foot through flooded areas.

In the wake of disaster, women bear a disproportionate burden as they face difficulties in finding adequate shelter, food, safe water, and fuel for cooking, as well as problems in maintaining personal hygiene and sanitation. They face challenges related to caregiving, safety, and access to resources. Disrupted healthcare, increased risks of gender-based violence, and limited economic opportunities further aggravate their vulnerability. All of these issues pertain to the gender identity and societal roles of women. In the aftermath of disasters, women and girls often face greater challenges due to societal gender roles, increased vulnerability to violence, disrupted healthcare and education, limited economic opportunities, lack of representation, social stigma, and unequal access to resources. Addressing these issues is crucial for promoting gender equality and ensuring a more equitable recovery process for all.

Fig 3: Flood affected families have taken refuge under temporary roadside shelters during July 2023 floods in Delhi

MATERIALS AND METHODS

The existing body of knowledge in this domain suggests increasing risks to health and well-being of women relying on their livelihoods from river floodplains. There is a need to explore the aspects related to economic vulnerability of women living in floodplains of Yamuna River. To understand the impact of a new HFL in Yamuna River in Delhi on women living in low-lying areas of river floodplains, the following aspects were probed into for data set generation.

1. What are the factors contributing to flooding in low-lying areas near the Yamuna flood plains?
2. What is the impact of urban floods on livelihood of women?
3. How does access to education influence community resilience during disasters?

To answer the first research question mapping of physical features was done on area maps of the two chosen study areas to assess the change in LULC of floodplains to identify the impact of recurring floods on the agricultural communities due to unplanned development. To answer the second and third research questions, a qualitative survey of women living in these areas was done to collect evidence for the impact of floods on their livelihoods and to gather information about the role of education in building resilience.

THE STUDY AREAS

Two study areas i.e. GarhiMendu village and MajnukaTilla in NCT Delhi were selected from floodplains of Yamuna River. The rationale behind the selection of these areas was established based on the following criteria:

To understand the variation in impacts of floods, two distinct regions have been selected comprising of:

- Site located on a floodplain
- Site located near a floodplain

Furthermore, the sample population selected for the survey was done using simple random sampling technique and the following criteria was adopted:

- The participant should have resided in the same place for at least two consecutive years
- The participant had experience of floods (July 2023) or earlier ones

RESULTS AND FINDINGS

STUDY AREA 1 – GARHI MENDU

GarhiMendu village, nestled in the SeelamPur tehsil of the North East Delhi district in Delhi, occupies a total geographical area of 132.8 hectares. As per the Census of India in 2011, the village sustains a population of 2,572. Positioned merely 2 kilometers away from the Yamuna River, GarhiMendu finds itself situated on the floodplains, making it susceptible to the annual deluges. The recent inundation on 11th July 2023 witnessed the water level surpassing the lower elevations, submerging the entire village. The demographic composition of GarhiMendu is predominantly shaped by migrants engaged in diverse sectors, encompassing industries, grocery and vending, painting, and manual labor. While a segment of the community has established roots here over the past 15 years, others have recently migrated from villages in the states of Bihar and Uttar Pradesh. This migration dynamic adds a layer of diversity to the village, reflecting a blend of cultural influences and varied regional backgrounds. The occupational diversity within GarhiMendu mirrors the complex tapestry of livelihoods, with individuals contributing to the local economy across various sectors. However, the recent flooding event has underscored the vulnerabilities faced by the village, emphasizing the need for resilient infrastructure and disaster preparedness measure.

Fig 4: Context map of GarhiMenduw.r.t Yamuna River

Fig 5: Village Map of GarhiMendu Village

Fig 6: View of Approach Road to GarhiMendu

Fig 7: Floodplains near GarhiMendu

Fig 8: View of villageGarhiMendu

Fig 9: View of village GarhiMendu

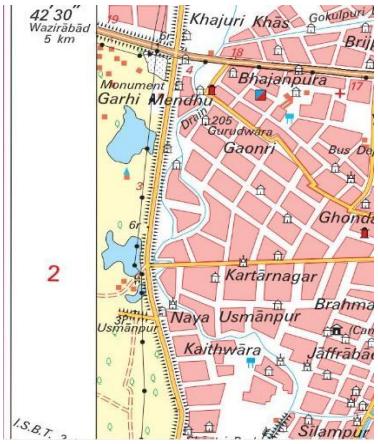


Fig 10: Survey of India map – GarhiMendu Fig 11: Localised flooding in floodplain area near GarhiMendu

Through Survey of India map and a comprehensive on-site ground analysis, it has been found that GarhiMendu is positioned at an elevation level of +204m and revealed signs of localized flooding upon closer inspection.

On July 11th, 2023, a rapid onset of flooding unfolded within the village, engulfing the entire settlement within few hours. As the water level rose, the inhabitants found themselves in a precarious situation, necessitating rescue operations conducted via boats. For those unable to immediately access this mode of transport, an arduous journey unfolded, with individuals wading through the rising waters as they awaited the arrival of rescue boats. In a collective effort to seek refuge from the inundation, the villagers sought shelter at higher points, on the bridge to protect themselves from drowning.

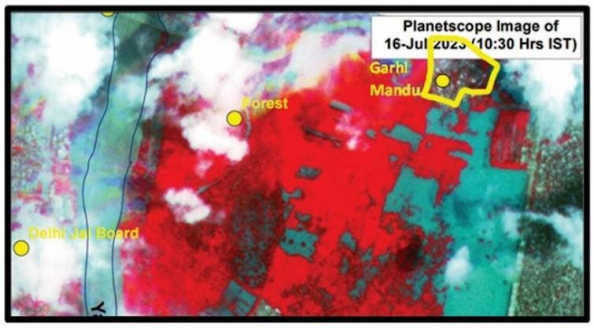


Fig 12: Satellite image showing flooded areas (Source: ISRO Bhuvan)

Fig 13: Flooded areas near village settlement

Fig 14: People taking refuge on bridge

Fig 15: Woman pointing at water level mark during flooding

"Handicapped son… had to push him out of first floor window"
"Snakes entered everywhere... Dead animals floating away"
"All got infected with eye flu… no medicine"
"We were scared of living in the tents... I used to hold on tight to my daughter"
"Had surgery one day before the floods… had to walk in water… got infected badly"
"While waiting for boats... Wished I knew how to swim"
"9 months pregnant… walked all the way submerged neck deep in water to save myself and baby"
"Walked in water in plastered foot…made the injury worse. haven't been able to recover since"
"The boys and men walked easily in water in their easy clothing… our saris kept getting drenched and weighed us down"

Respondents said that during the flooding event, they experienced both physical and mental distress. During menstruation, they had to rely on mutual help to take care of sanitary needs. Almost everyone got infected with eye flu during floods, they had no medication or knowledge to carry out the necessary treatment. While some respondents were aware that water gets polluted after floods, most of them didn't know anything about water-borne diseases and life-saving medical treatment.

While enquiring about the elderly, it was reported that they were evacuated first as soon as the water breached the highest level. No loss of human life was reported during the floods. When enquired about awareness about women's self-help groups in Delhi, the respondents had no knowledge. The women seem to have accepted their fate and roles in a household, where men have the upper hand. When the women were made aware of the possibilities that could be turned into reality through their proactive participation, they were interested in improving their current situation.

Some respondents were conscious that their settlement is positioned along the river's course and not the other way around. This awareness indicates a clear understanding among of the geographical factors influencing their living conditions. Acknowledging that their settlement is in the path of the river highlights a level of environmental awareness, suggesting an understanding of the potential risks associated with living close to the river and the impact it may have during periods of increased water flow or flooding. This perception underscores the community's awareness of their environment and its implications for their daily lives, emphasizing the importance of informed decision-making in settlement planning and risk management.

The data analysis of Garhi Mendu reveals challenges at the floodplain site, worsened by gender dynamics, loss of green cover, and increase in built structures. The traditional patriarchal societal structure further compounds the issue, as women are not sufficiently informed and proactive in adopting disaster resilience measures within this challenging environmental context.

STUDY AREA 2 – MAJNU KA TILLA

Majnu-ka-Tilla is a neighborhood nestled along the banks of the Yamuna River in North Delhi. It was established around the year 1950. Referred to as 'MajnukaTila' or 'MKT,' this locale uniquely merges tradition and modernity, attracting visitors. The narrow lanes of Majnu-ka-Tilla wind through a vibrant Tibetan colony, offering a distinct atmosphere that sets it apart from the bustling urban landscape of Delhi. Home to a thriving Tibetan community, this enclave has become a melting pot of diverse cultures, where ancient monasteries, bustling marketplaces, and the warm hospitality of its residents converge to create an experience that resonates with both locals and tourists alike.

According to the Survey of India map, a thorough ground assessment reveals that MajnukaTilla is located at a level of +217 m and Yamuna River is located at +203m. Despite its proximity to the Yamuna River, the settlement area has remained free from inundation due to the construction of a 2.4-meter-high protective wall along the road. However, during the floods in July 2023, the water level surpassed the wall, leading to the inundation of the road.

Fig 16: Context map of MajnukaTilla

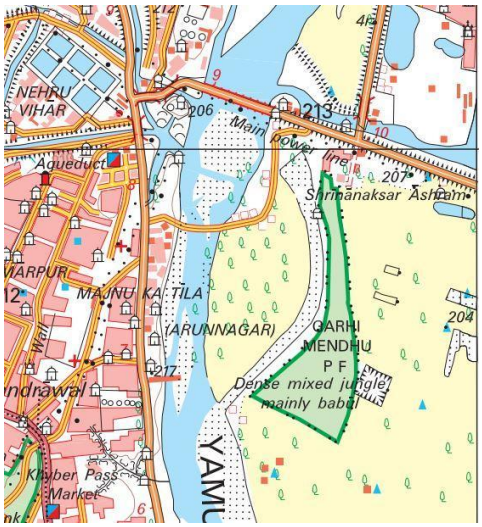
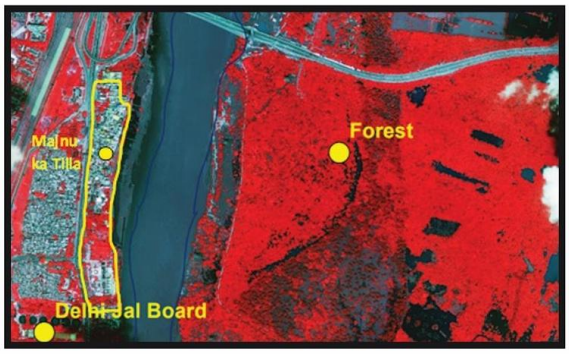


Fig 17: Survey of India map – MajnukaTilla

Fig 18: View towards boundary wall between site and floodplains



BHUVAN SATELLITE MAPS SHOWING FLOODED AREAS
(16TH JULY 2023)

Fig 20: View of flooded roads

"Water everywhere… silt and bad odour was all around after the water receded"
"Constant stress… affected my menstrual cycles for few months"
" Electric wires were hanging everywhere… danger of electric shocks"
"Prolonged respiratory health problems"
"Everyone kept falling sick due to bad water"
"Work commitments … aftermath of the floods was mentally and physically draining"
"Had to evacuate home… took shelter… left us vulnerable and anxious"
"Loss of personal belongings…"
" We all put efforts to combat crisis… men and women worked alongside"
"Got back on our feet soon… didn't wait for outside help"

MajnuKaTilla showed remarkable resilience during floods, transcending gender roles and norms. The community's cohesive effort and collaborative approach were crucial in facing challenges and expediting recovery. The absence of rigid gender norms allowed for seamless task distribution, showcasing adaptability and unity. Breaking free from traditional constraints enabled residents to pool strengths, resulting in a more efficient crisis response.

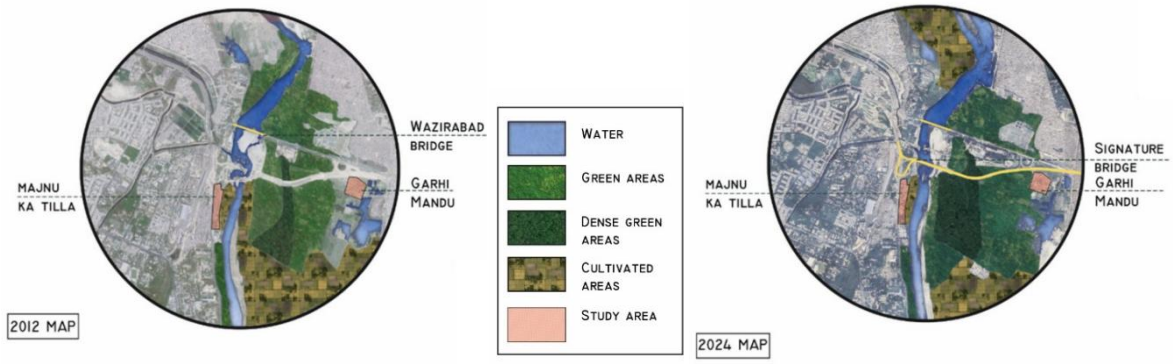


Fig 21: Encroachment in study areas between 2012- 2024

Between the year 2012 – 2024, it is observed that there is reduction in the permeable green areas in the surrounding study areas of GarhiMendu and MajnukaTilla. Signature Bridge was also constructed near the study area. Additionally, there has been a marked change in cultivated areas, with agricultural land giving way to urban development. This shift has resulted in increased impervious surfaces, which have led to higher surface runoff and decreased groundwater recharge.

CONCLUSION

When comparing the cases, it becomes evident that a community is more adept at coping with challenges during disasters, such as floods, when the societal structure does not confine women to gender-based roles. Instead, a collaborative approach is taken to address crisis situations. When women face limitations due to lack of information, restricted access to resources, and subjugation by men, there was heightened panic, anxiety, and mismanagement, resulting in a slower recovery rate as observed in case of GarhiMendu village. On the other hand, minimal damage and a swifter recovery were observed at MajnukaTilla, attributed to community cohesion with women actively participating alongside men in various duties. The stark difference in the impact of floods is evident when comparing the well-constructed homes that shield residents from the overflow of the Yamuna to the economically disadvantaged section of society situated on the opposite side. This less privileged group faced substantial challenges, compelling them to relocate to higher ground and live in temporary makeshift arrangements, primarily tents. The disparity in living conditions highlights the socioeconomic divide and underscores the need for targeted interventions and support systems to address the unique vulnerabilities faced by economically disadvantaged communities during the flood crisis. Moreover, indirect impacts such as climate change, altered landcover including deforestation, grazing, crops, urbanization, land drainage and infrastructure development projects can be tackled with proper management of river basin for the stretches flowing through city limits. This research opens doors for the new interventions such as resilient landscapes which are likely to return to initial conditions following a disturbance. The path suggested by this study takes into considerations the needs of most vulnerable group in modern cities and advocates the incorporation of more stringent building codes and regulations for development projects in floodplains of rivers.

REFERENCES

Journal Papers:

[1] Rawat, B. S., July 2023 Delhi Floods: Why Unprecedented Yamuna water levels even at moderate releases? 2023, Retrieved from SANDRP: htttp://sandrp.in/20223/07/16/delhi-july-2023-possible-reasons-key-lessons-from-unprecedented-floods-in-yamuna/

[2] Feroz, N., Friday Times, 2022. Retrieved from Friday Times: https://thefridaytimes.com/analysis

[3] Chanda G. Goodrich, A. P., Gendered vulnerability and adaptation in Hindu-Kush Himalayas: Research insights, Environmental Development, 2019, 1-8.

[4] Padmanaban, D., Why Are Women More Vulnerable to Flooding in India? 2021. Retrieved from Eos: https://eos.org/articles/why-are-women-more-vulnerable-to-flooding-in-india

[5] AbulKalam Azad, K. M, Application of fuzzy theory to writer recognition of Chinese characters Flood-Induced Vulnerabilities and Problems Encountered by Women in Northern Bangladesh, Int. J. Disaster Risk Sci, 4(4), 2013, 190-199.

[6] Chambers, Vulnerability, IDS Bulletin, 20 (2), 2014, 1-7.