Investigating the Impact of Flood on Low Lying Settlements of Delhi, India: A Planning Perspective

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Abstract: In the past, the Yamuna River and the Najafgarh Drainage System have flooded the city of Delhi severely. In the past 33 years, Yamuna has 25 times exceeded its risk threshold, which is set at 204.83m. Since 1900, Delhi has suffered six significant floods when the Yamuna River has reached a height of one metre or more above the accidental 204.49m on the old railway bridge (2.66m above the accident level). These floods happened in 1924, 1947, 1976, 1978, 1988, and 1995. The Yamuna recently climbed more than two metres beyond the danger threshold in Delhi, breaking the milestone 207 metres for the first time in 32 years. The second highest point, at 206.92 metres, was on September 27, 1988. There is a direct impact of floods on the Yamuna River and the city drainage network. People who live along the Yamuna River Belt, on the river's banks, and in the drain are impacted by this. The amount of the solid regions causing local floods has increased landslides as a result of deforestation and local floods. Low-lying communities, particularly haphazard colonies that fall into the water, will be most impacted by this. Hathinikund erupts high in Haryana because of the persistent, intense rainfall on the high cliffs, draining water upstream, continuing to flood Delhi and harming the lives of those who live in low-lying areas. Therefore, torrential rains caused severe damage to the city, and even more so to those families built on the wrong side, which were the first and most frequent sightings of their homes and property being flooded. Families had already begun to lose livestock and livestock during this time, before being evacuated and their situation remains so dire that one has to leave the rest of the house to relocate and relocate when the water level drops. The purpose of the study was to explore about the kind of impacts generally inhabitants face during and post flooding and to find out the implementation of strategies. The following methods were used: Site survey of the case study area in which structured questionnaire and observations were conducted through primary survey, analysis and assessment, study of issues and concerns. As a result, flood prevention, preparedness and mitigation strategies with reference to low lying area have been analyzed and planning recommendations have been proposed.
***Keywords*:** urban flood, planning, low lying settlements, natural disaster, Delhi, India

1. Introduction

According to India's Atlas Flood prepared by the Central Water Commission, it is evident that the southeastern part of Delhi is an unprotected flood area (about 1.7% or 25 sq kms) and a wide area (about 5% or 74 sq km) in the northeastern part protected by clay bars. The level of flooding in Yamuna falls below the level of danger almost every year and people living in low-lying areas behind 'clusters' (edges) are forced to move over piles or sidewalks to higher ground. The expected flow and flooding levels of the Yamuna River in Delhi are predicted by the Central Water Commission to look at the waters and water currents of the river, especially the headwaters of Tajewala about 130 kilometers from the two canals from Yamuna, one on the left bank (WJC) and one on the right bank (iJ-EJC). Since the Tajewala Barrage / headwork and the two canals have a limited capacity, in the event of heavy rainfall in the Yamuna watershed and its rivers, the lower river floods in, flooding its banks and flooding the underground areas. It has also caused extensive damage in the deepest regions of the region due to backlogs in pipelines aimed at draining large amounts of water from the river (Kumar et al., 2019). Flooding overflows the earth's atmosphere. The European Union (EU) Floods Directive defines a flood as a body of water that is rarely covered with water. Floods can occur in large amounts of water, such as a river or a lake, overflowing or breaking up lakes, with the result that some of the water escapes its normal limits. On the other hand it can be described as a flood in large quantities of water (or mud) in a dry land and is a condition in which - overflow is caused by high flow, or flooding in an established watercourse, such as a river, stream, or canal; or meditation with water in the place where or the rain fell or near it (Figure 1). Floods can strike anywhere without warning, occurring when heavy rains fall in a short period of time (Prasath, 2017).

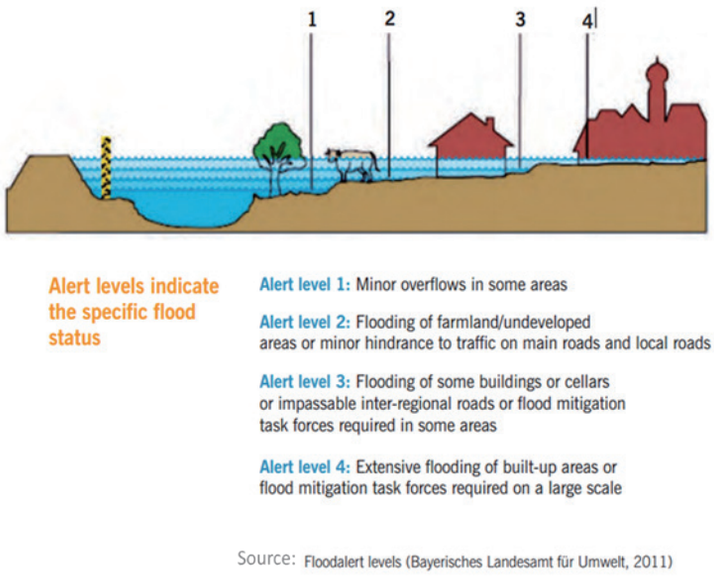

Figure 1. Different alert levels indicating specific status of flood.

Floods can also happen in rivers when the flow is more than what the river channel can handle, particularly when there are curves or maps. If they are flooded into natural river plains, homes and businesses are frequently damaged by floods. Although flood damage can be prevented by avoiding rivers and other bodies of water, people have lived and worked near water since ancient times in order to make a living and have access to the advantages of a simple and straightforward trade. Flooding results from the rivers' inability to handle the large flow of water that is reduced from the water's surface after a lot of rain. The tendency to live in floodplains has been particularly troubling in recent years. Due to the different distribution of rainfall, most of the time, areas that are not prone to flooding also experience significant flooding. Areas with poor drainage systems are flooded with water collected by heavy rainfall. More irrigation water is being introduced into the control and increase in groundwater levels due to the splitting of ditches in the fields and irrigated fields are also factors that emphasize the problem of deforestation. The problem is exacerbated by such things as the silt of river tributaries, the reduction of river carrying capacity, the erosion of beds and banks leading to the reversal of river areas, obstruction of flow due to landslides, flooding of major and major rivers and delays due to wave effects. (NDMA, 2009). The main objective of the study was to explore the role of Yamuna river and its impact on Low Lying settlements in Delhi and also the kind of impacts generally inhabitants face during and post flooding and also to find out the implementation of flood mitigation strategies and how these policies can be better implemented.

2. Research Methodology

A qualitative research method has been used in this paper. A thorough literature review was conducted to accomplish the research's goal. The internet and secondary data from pertinent published academic literature, including journal articles and research papers, have been used to study the systematic literature review. The information used in the qualitative research is gathered through a variety of case study examples that are presented in detail and supplemented with images and photographs to further the arguments made. For doing qualitative study for the impact of flood on Delhi's low lying settlements with reference to a planning viewpoint, the fundamental concepts and backgrounds are studied through literature and online media, observations. The site survey of the case study area i.e. Delhi in which structured questionnaire and observations were conducted through primary survey, analysis and assessment, study of issues and concerns.

3. Major Floods in Delhi Region

When the Yamuna River crossed its danger level of 204.83 m in the years 1924, 1947, 1976, 1978, 1988, 1995, 1998, 2010, and 2013, Delhi saw nine major floods. According to Table 2, the year 1978 saw the worst flood in Delhi's history, with the Yamuna River rising 207.49 metres and releasing 0.253 million cubic feet per second at an old railway bridge (0.7 million cubic feet per second of discharge came from Tajewala). At that time, 130 villages and 25 urban colonies were under water in Delhi. In the past 33 years, the river has 20 times gone beyond its danger threshold (DDMA, 2015). The followings are the major floods which occurred in the Delhi region. They are summarized as below:

3.1 The 1978 Flood

- The River Yamuna was devastated by flooding. A total loss of the kharif crop resulted from widespread breaches in rural embankments that submerged 43 sq km of agricultural area beneath 2 metres of water.
- In addition, north Delhi's Model Town, Mukherjee Nagar, Nirankari Colony, and other colonies experienced considerable flooding, resulting in significant property damage. An estimated Rs 176.1 million worth of crops, homes, and public services were all damaged.
- This was one of the worst floods In Batla House when water crossed NFC. A heavy loss to slum dwellers, life and property in both terms. Perishable alarming, no relief camps after two days, heavy rains make the situation worst. Due to the economic magnet the migration was increased and so do the encroachment in flood plains.

3.2 The 1988 Flood

- The River Yamuna witnessed extremely severe flooding that affected almost 8,000 families and affected numerous villages and communities, including Mukherjee Nagar, Geeta Colony, Shastri Park, Yamuna Bazaar, and the Red Fort area. The area was quickly evacuated, slums saw considerable flooding for a week, but no one was injured.

3.3 The 1995 Flood

- Following severe flows in the upper catchment area and the subsequent release of water from Tajewala water works, the Yamuna witnessed high magnitude floods. The issue was made worse by the Okhla barrage's delayed water flow, which was caused by a lack of coordination between different state entities.
- Nevertheless, it had a severe impact on the villages and impromptu communities located within the riverbed, displacing over 15,000 families. Before returning to living in the riverbed, these people had to be evacuated and temporarily placed on roadsides for nearly two months.
- The encroachment took place on almost 75% of the land; all slum dwellers; builders started heavy construction and due to the heavy calamity in these low lying areas DDA banned the further construction activities.

3.4 The 2010 River Yamuna Flood

- 21st August- Haryana released 0.35 million cusec water from Hathinikund barrage.
- 22nd August- flood in low lying areas in Yamuna nagar (Figure 2).
- 23rd August- old Delhi Railway Bridge closed, 21 trains cancelled, flood in Tibetan monastery.
- 27th August- Haryana released 0.17 million cusec water from Hathinikund barrage.
- 30th August- Delhi flooded; Yamuna crosses danger mark of 204.78 m, heavy rainfall increased the Problems.
- 7th September- due to heavy rainfall, Haryana released 0.575 million cusec water from Hathinikund barrage.
- 8th September- many tatbandh collapsed in Haryana, water level becomes 205.91 m in Delhi, many areas including Yamuna nagar, Tibetan monastery, ISBT and Jamia Nagar's low lying areas became flooded (Figure 3).

Figure 2. View of Batla House locality, at Okhla region, New Delhi in 2010 flooding

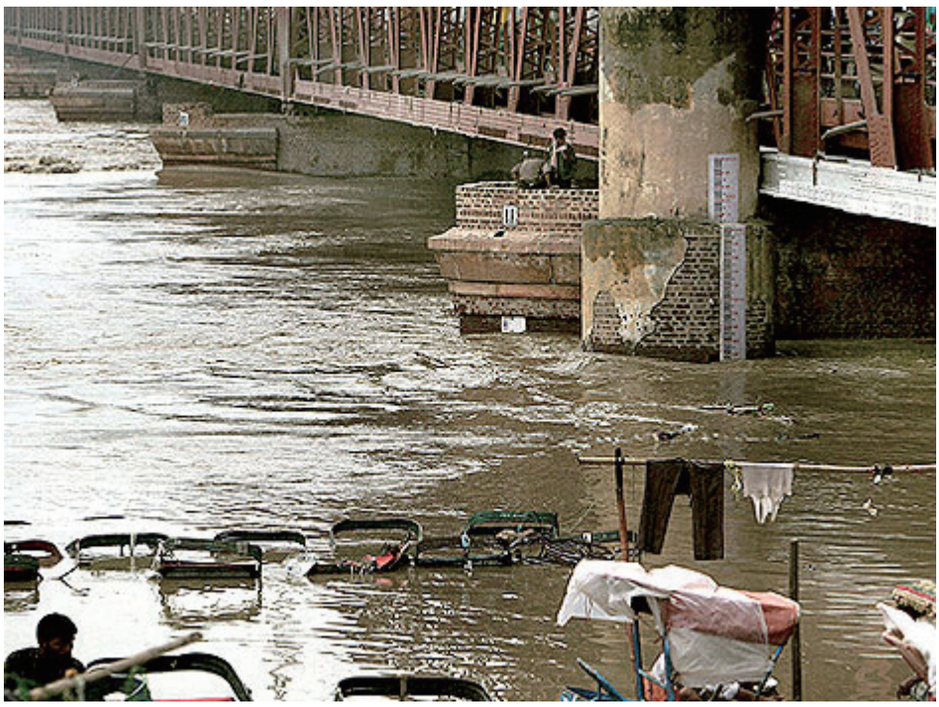

Figure 3. Water crossed the danger mark in 2010 flood.

- 9 September - heavy rainfalls again, water level crossed 206 m, railway and road traffic collapsed, water reached ring road and almost quarter of the Nafees road area in Batla house went waist deep water (Figure 4).
- 18 September- Haryana released 0.75 million cusec water from Hathinikund barrage.
- 20 September- 3 out of 5 gates of Tajewala barrage broken.
- 21 September- water level reached 207 m (almost 2 m above danger mark), 36 trains cancelled
- 22 September- above 2000 people affected (Jamia Nagar flood plains), over 1 m water level remain in flood plains for over 1 day in low lying areas in Batla house.
- 22 September- above 2000 people affected, Usmanpur village completely submerged into water.

Figure 4. View of flooding of road near Shahdra, in Delhi

4. Old Usmanpur Delhi: The Study Context

Constant rains in the hills of North India and the following release of water from the Hathnikund barrage north of Delhi frequently pose a threat to Usmanpura, a village of farmers along the eastern bank of the Yamuna (Figures 5 and 6). Due to its location on the riverbed rather than the riverbank, Usmanpura has experienced flooding in the past. The incorrect side of the embankment is where it is (Figure 7).

Figure 5. Satellite map of the Old Usmanpur in Delhi

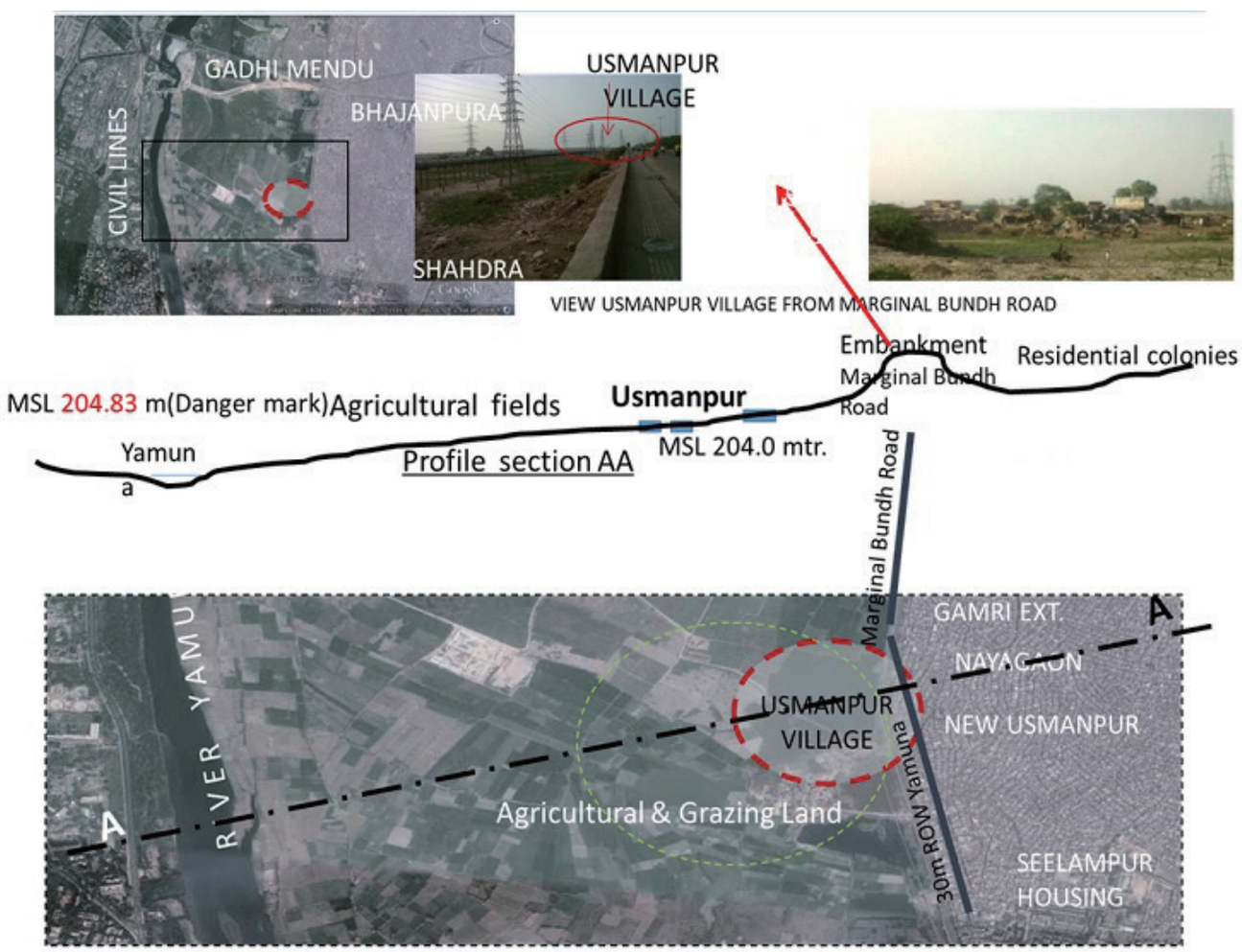

Figure 6. Area profile of the Old Usmanpur Vilage in Delhi

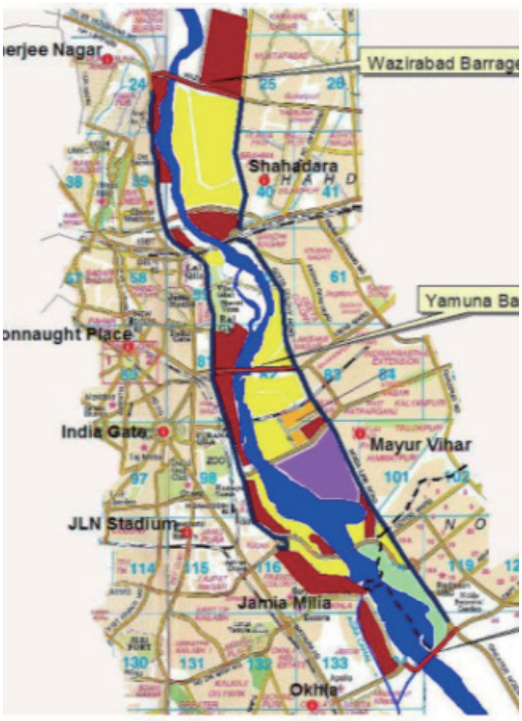

Figure 7. Plan of Usmanpur Pushta Road

5. Impact of Flood on Old Usmanpur, Delhi

The individuals sitting on the riverbank were perplexed by the hourly rising water. The victims continuously check the river's unpredictable flow and water level. There is no other forecasting source that can match their estimate of the upcoming river course and outcome. They had been swimming there for years. Along the river, colonies were submerged as water poured into homes, destroyed artificial barriers, and flooded houses. Above the knees is the water level. While those residing in the concrete homes in these colonies had the choice of accessing the roof of the home with all of their possessions, those in the homes nearly vanished, just as their homes were, with no trace. Some had fled to their villages or sent their children to their hometowns, others living alone under bridges, in crowds, and on the roads, while others found their way to relief camps.

A week-long study, the NDW's Inclusion Monitoring survey included 409 slum families and was conducted in three areas from October 19 to October 25. Dalits made up 79% of the families most impacted by the JJ collections, with Other Backward Castes seeing a second increase at 14%. All of the shacks on their plateau were demolished by the Yamuna floods (Figure 8). In search of a better life and the promised chances for employment, the Dalits, who made up a sizable section of the moved territory from Uttar Pradesh (42%) and Bihar (18%), went to Delhi. Many of them have already been residents of Delhi for more than fifty years.

Figure 8. A farmer waiting for relief at Shashtri Park Bridge

The study's findings revealed the inconsistent nature of the relief efforts without a significant sense of loss. The Delhi government will continue to be aware of survivors' rights and compensation because there will no longer be any such declarations. In the investigated locations, 75% of all households substantially depend on river rental farming and are extremely underprivileged (Figure 9). They will continue to pay interest on the main loan even if they have lost their annual crop production and the rent they paid to the landlord. They were unable to gather what they planted. Even those who kept livestock struggled. A severe river shortage of 38% livestock owners affects 24% of families. Due to this, the women were compelled to carry and safeguard the fodder. 20% of respondents said they were paying between Rs. 150 and Rs. 250 each bag for fodder, while others admitted to paying off security personnel at public garden gates with grass. 23% of the victims have objected to receiving sufficient and healthy food. On some days, the Delhi Jal Board's water tanks may leak, forcing people to drink from overflowing rivers and spreading disease to those near them, especially young children. Because there were no on-site paramedics or medical camps, or because these uninvited victims were positioned far from relief tents, in groups, 43% of people refused to seek medical services from any agency, including the government (those who could not get help tents for their families). The children were majorly affected; they were innocent and silent victims of the flood. A total of 51% of respondents reported the loss of school supplies in their wards; otherwise the post-school flood could not have been started again.

Figure 9. People shifting their household items

The basic services did not meet the expectations set by the government. 68% of respondents refused to go to the toilets and 89% refused to go to the bathroom. Along with providing basic and essential food for expectant and nursing moms, as well as infant clothing, food, and other supplies, women's hygiene products, particularly for adolescent girls, are greatly neglected in the kitchen assistance. Their dignity and safety were unimportant. Women had to deal with the additional suffering of their challenging existence. When it was established that people had lost their homes and other possessions, there was depression. For children, it wasn't simply the loss of their school supplies; for many, it also meant the potential loss of their education, particularly for girls (Figure 10). 98% of respondents were required to say "No" unanimously to the government officials' probe into the damage estimate.

Figure 10. Inadequate number of toilet facilities

The language employed to describe the survivors' suffering in this report cannot do justice to the impact of the flood on them. They have lost everything, are unsure of their eligibility for compensation, and will not make an effort to challenge any authority (Figure 11). The study will provide a factual summary in order to appropriately convey the scope of the numerous socioeconomic issues brought on by the unprecedented Yamuna floods this year. Despite the comparatively modest flood rate, the impact on the victims is enormous. The efficiency of the steps taken by the Delhi government to ensure the safety of the victims' lives and property will then be determined by a careful review of the facts (Gupta, 2017).

Figure 11. Rescue boat for evacuating inhabitants

5.1 The Psychological Impact

All trapped flood victims, regardless of age, experience severe psychological effects that disrupt both their personal lives and society as a whole.

Livestock: Because of urban flooding, live animals are the most severely impacted living things. It is challenging to provide for them, especially when the human race is struggling.

Diseases: Infectious diseases, such as military fever, pneumonic plagues, dermatopathia, dysentery, the common cold, Dengue fever, broken bone fever, etc., are frequently brought on by flooding. When flooding interrupts the electric supply to a food storage location, the likelihood of food contamination also increases.

Public inconveniences: Because of the flooding, the transport and communication networks are disrupted, leaving stranded everyone from schoolchildren to college students to office workers to vegetable and milk vendors, etc. The important basic commodities also do not reach to the common people.

6. Factors Responsible for Flooding

6.1 Role of Hathnikund Barrage(Tajewala)

Figure 12. The location map and view of Hathnikund Barrage.

The Tajewala Barrage on the other side of the Yamuna River was completed in 1873 when it controlled the flow of the Yamuna River in Uttar Pradesh and Haryana through two canals called the West Yamuna Canal and the Eastern Yamuna Canal. It also facilitated the provision of municipal water in Delhi. In the event of heavy rains in a tropical area, much water is drained from Tajewala. When the water level in the barrage is more than 16500 cusecs, too much water cannot be stopped to flow out of line. If Haryana releases water on this road, for the first time the villages around Yamunanagar, Karnal, Panipat and Sonepat, fall into the riverbank, which could flood with water before the floodwaters reach Delhi.

Table 1. Details of river and flooding levels in the Delhi region.

District Name: Delhi	Warning Level (WL)	204(m)
River Name: Yamuna	Danger Level (DL)	204.83(m)
Basin Name: Ganga-Brahmaputra- Meghna	Highest Flood Level (HFL)	207.49(m)
Division Name: Upper Yamuna Division	HFL Attained date	06/09/1978

6.2 Role of Yamuna River

Major flooding in the city is thought to be caused by a variety of factors, including heavy rainfall, urbanization, unauthorized colonies, trespassing on storm water drains, siltation of drains and water bodies, choked water carriers, poor water and sewerage management, flaws in the drainage system, improper pumping installation, and multiple authorities without accountability (Pareva, 2006). The Yamuna River was responsible for most of the major floods. The Yamuna River, a significant tributary of the Ganges, rises from the Yamunotri Glacier at an altitude of around 6387 metres above mean sea level and flows into Delhi near the village of Palla, forming a shared border with UP and Haryana. From Palla to Jaitpur, the river passes through Delhi for roughly 50 kilometers. From Palla to Jaitpur, the river passes through Delhi for roughly 50 kilometers. It is stopped at the Wazirabad water supply facility, the ITO, and the Okhla barrages, which control the flow of the water, before entering Uttar Pradesh. Keeping in view the topography, Yamuna catchments up to Delhi is divided in two parts:

a) The upper catchment from source in Himalayas to Kalanaur in Haryana - which com[rises parts of Himachal Pradesh and hills of West Uttar Pradesh and

b) Tthe lower catchment from Kalanaur to old Delhi Rail Bridge which consists of West Uttar Pradesh and Haryana.

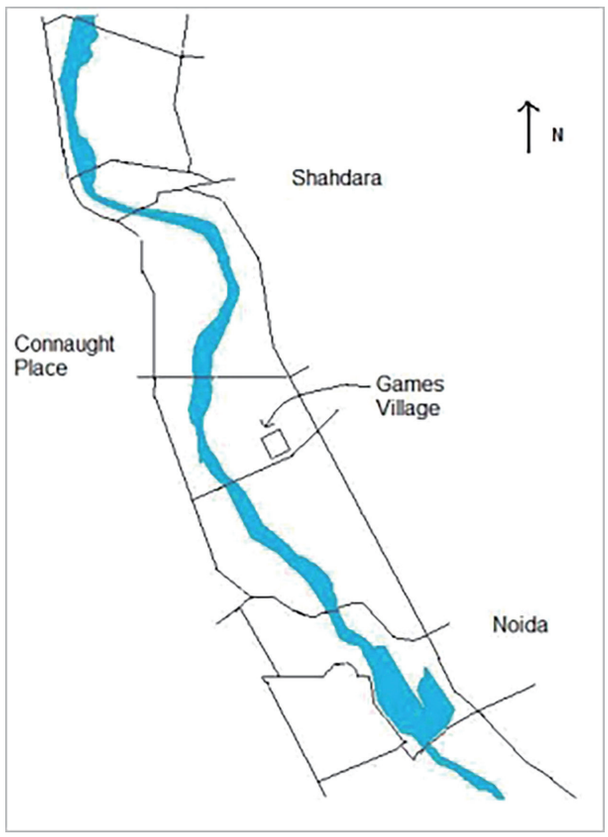

Figure 13. The 22 km Yamuna stretch from Palla to Jaitpur.

The Tajewala Headwork's 240 km upstream release has a significant impact on the Yamuna's flow through Delhi. Tajewala loses a lot of water when there are strong rains in a tropical location. The Yamuna level in Delhi rises throughout the course of 48 hours, depending on the river flow rate below the river. Rising water levels also cause the city's dams to re-fill with water. A network of 18 significant water pipelines that stretch outside the city limits are another reason why the city floods. The Yamuna River's end has six water sources that Delhi can be separated into from the storm water point: the Najafgarh Drain, the Barapulah Nallah, the Wildlife Sanctuary Hro' Haryana, the Dradara Drainage Drainage, the Bawana Drain Basin, and other canals that cross the Yamuna River. The Yamuna River, which receives water from Haryana and the Sahibi River through the Najafgarh drain, frequently floods the Delhi region. Additionally vulnerable to periodic floods are the lower Yamuna (Khadar) flood basins. (DDMA, 2020).

6.3 Role of Sahibi River

The Sahibi River comes from the Jaipur region of Rajasthan. After passing through the Alwar region in Rajasthan and the Gurgaon District in Haryana it enters the U.T. from Delhi near Dance. Years ago, expulsions from Sahibi were often moderate until the same came to Delhi. Due to the blockade of Jahajgarh and other lakes and underground reservoirs in Rajasthan and Haryana, very little water was used to enter the U.T. of Delhi. As a result of land development and the improvement of the pipeline system in Haryana, it is evident that every year, the amount of water entering Delhi increases rapidly and the Najafgarh Jheel areas begin to remain underwater for a year. To monitor Delhi's water inflow, connectors and controller at Dansa were built in 1964 and in the same year a major unprecedented flood in Sahibi caused a breach of the Dansa Bund and led to the immersion of many Najafgarh Vimba areas in deep water. Similar floods in Sahibi occurred in 1967 and 1977. Although the 1967 flood did not cause any damage to the Delhi area but in 1977 the flood created a worse situation than in 1964, when remote distances in Delhi such as Janakpuri, etc. threatened by the Sahibi floods. During 1977 there were two floods in the Sahibi highlands, the first hurricane between 29 and 31 July and the second between 4 and 6 August. Yamuna was already in the floods when Sahibi rose in the floods. The Yamuna level on 27 July on the Old Railway Bridge in Delhi was 204.85m (672.07 feet). It faces a critical level of 204.83 m (672 feet). The highest level of Yamuna recorded on the old railway bridge in 1977 was 205.85m (675.29 feet) on 7 August 1977.

Figure 14. View of Nazafgarh drain

7. Flood Zoning

The district's low quality characteristics in terms of soil, air, water bodies, and biodiversity also contribute to the poor ecosystem services. For instance, due to a scarcity of green space, the DDA's land department has highlighted six water bodies in this district that require more attention in the Master Plan of Delhi (MPD-2021). The city's demand for ground water recharge in this area is attributed to the river bed. In the late 1990s and early 2000s, it saw a rapid transformation. Additionally, bad land use results from the loss of urban green space. The majority of the city is made up of residential districts (Prashar, 2012).

The Atlas flood map created by the central water commission depicts the flood situation. A map of Delhi's floodplains shows that they are split into thirteen sections depending on the likelihood of flooding due to the Yamuna River's rising water level (DDA, 1993). These encompass a depth range at the Yamuna level of 199 to 212 metres. This design map includes practically the whole Trans Yamuna region on the East Bank and a portion of North Delhi on the Yamuna's West Bank. In addition, the NCTD was made into four flood states under the Delhi Flood Control Order, specifically the sectors of Shahadra, Wazirabad-Babrapur, Alipur, and N Nangloi-Najafgarh. Every year, the water level in the Yamuna rises above the danger threshold due to the large population, relocation of Delhi's hills and motorways, and even though the unprotected flood region is just 1.7% or 25 km to the southeast and roughly 5% or 74 sq. km in the northeastern part protected by clay ribs. As previously indicated, the principal causes of this rise in water level are not natural; rather, they are the result of massive water extraction from the Tajewala headworks upstream to the two canals, one on the left bank and one on the right. Rising water levels also induce backflow in the connected canals, which has helped the city's drainage system overflow and contribute to the spread of several diseases associated with hurricanes.

7.1 Local Flooding

The Atlas flood map created by the central water commission depicts the flood situation. The Delhi flood map classifies them into thirteen groups based on the likelihood of flooding in relation to the rising Yamuna water level (DDA, 1993). These span the Yamuna level water distance of 199 to 212 metres. This design map includes practically the whole Trans Yamuna region on the East Bank and a portion of North Delhi on the Yamuna's West Bank. In addition to this, the NCTD was also affected by the Delhi Flood Control Order, flooding Shahadra, Wazirabad-Babrapur, Alipur, and Nangloi-Najafgarh sectors. Although Delhi's vulnerable flood region is about 1.7% of its total land area, or 25 km in the southeast, and around 5%, or 74 km in the northeastern half, which is protected by clay ribs, Yamuna water levels regularly rise above the threshold of risk. As previously indicated, the main causes of this rise in water levels are not natural, but rather the massive amounts of water that are discharged into two canals on the left and right banks of the river from the Tajewala head upstream. Increased water levels also affect the city's water supply system and cause connecting canals to back up, which contributes to many of the illnesses brought on by storms.

7.2 Major Drains in Delhi

Regarding storm water drainage, Delhi can be divided into six drainage basins, including the Najafgarh Drain, the Barapulah Nallah, the Wildlife Sanctuary Area Discharging Through Haryana, the Drainage of Shahdara Area, the Bawana Drain Basin, and other drains directly outfalling into the River Yamuna. The Yamuna River, its catchment in Haryana, and the Sahibi River (in Rajasthan), which enters through the Najafgarh drain, are all potential sources of flooding for the NCT of Delhi. Floods can occur often in the low-lying Yamuna flood plains (Pareva 2006)

The Yamuna and Najafgarh Drain system flooding has caused major flooding in the city in the past. In the past 33 years, Yamuna has 25 times exceeded its risk threshold, which is set at 204.83m. Since 1900, Delhi has seen six significant floods when the Yamuna River reached its greatest level at or beyond the accidental 204.49m on the old railway bridge (2.66m above the accident level) on September 6, 1978. These floods occurred in 1924, 1947, 1976, 1978, 1988, and 1995. On September 27, 1988, 206.92 metres stood as the second-highest point. Catastrophic floods struck the city in the recent past in 1977, 1978, 1988, and 1995, inflicting loss of life and property as well as anguish among the locals. The four floods' histories have demonstrated the extent of the harm these calamities have done. The growing hazard of floods in Delhi since 1978 has been noted in the Delhi Environment Report: The Nature-India WWF (1995). The evacuation of 0.275 million people from Tajewala in 1980 caused a car to flood by 212.15 metres close to the Palla cottage in Delhi.

When it comes to storm water drainage, Delhi can be divided into six drainage basins, all of which empty into the Yamuna River. They are (1) Najafgarh Drain (2) Barapulaah Nallah (3) Wildlife sanctuary area discharging thro` Haryana (4) Drainage of Shahdara area (5) Bawana drain basin (6) Other drains directly out falling into river Yamuna.

The Yamuna River, the catchment area for Haryana, and the Sahibi River (Rajasthan) via the Najafgarh drain frequently flood the NCT of Delhi. Recurrent flooding is also a problem in the lower Yamuna (Khadar) flood plains. The growth of Delhi's cities over the past four decades has resulted in an increase in the amount of paved space and a decrease in the amount of agricultural land that was used as a landfill and is now deteriorating (Net agricultural land planted in 1950–51 was 97067 hac; in 2005–06, only 25000 hac of the total 148300 hac was planted). Delhi usually remained flooded up to 70000 hac (50% of its area 148300 hac from 1953 to 1984). The Capital of India was hit by floods back in 1924, 1947, 1967, 1971, 1975, 1976, 1978, 1988, 1993, 1995, 1998 etc. In 1978 there was the worst flood ever in Delhi where the water level reached 207.49 m (risk level 204.83 m) with 0.253 million cusec removed from the old railway bridge (0.7 million cusec discharged from Tajewala) where the villages -130 and colonies in 25 cities in Delhi submerged in water. In addition, the right-hand lane between Palla and the Bawana Escape out-fall collapsed, submerging a significant portion of the Alipur Block and urban colonies including Adarsh Nagar, Model Town, and Mukerji Nagar in deep water. The region to the left of the bank near to the border is at its lowest point but can still be rescued by raising it in some places with bags full of land. There were approximately 150 million injuries, 18 fatalities, thousands of homeless individuals, and one million people who were impacted. 206 locations, communities, and colonies were inundated by the 1993 floods, while 130 routes had traffic disruptions. The floods spurred both the previous administration and the current administration to form committees and take action to fix the flood damage in Delhi.

7.3 Risk of break in embankments

A false sense of security is created by embankments' protection from the river, which encourages development to occur beneath them. The impact is disastrous if these protective works fail since the pressure of the entire embanked stretch is released at once, as has happened in the past when there have been breaches during floods.

7.4 Storm Water Drainage

Due to the integration of numerous natural and man-made water systems, including five water basins, large natural water pipes, storm water pipes in the streets, and sewer cum water pipes (sometimes as a solution for the passage of blocked sewer lines), the Delhi storm water canal is a complex situation. However, the Yamuna River finally receives the majority of the water gathered through various water systems. The Mughals constructed much of the Old Delhi water supply system, while the British created the New Delhi system. City canals have a variety of fundamental issues. The majority of the major pipes are not in place. Additionally, there are numerous unexpected or damaged medium-sized pipelines. Often, waste is thrown on the side of the road, where it readily makes its way to surrounding ridges, and construction debris in fresh ditches is not collected before transportation. Even driving on the road is being dragged out of the drain. Drain slabs that have convenient holes for compressing trash, waste from construction projects, etc. within the discharge are not fixed. The overflow of sullage and storm water is the result of the open ditches becoming waste dumps until they are entirely filled. Because of this, during the rainy season, the canals are unable to handle the water flow that would otherwise cover the roads. The water delivery system for the slums is nonexistent or insufficient. Some localities' roads have undergone repairs, renovations, or

new construction to raise their quality. Water logging persists even in other DDA colonies like Pitampura and Shalimar Bagh despite various measures adopted.

Figure 15. Storm Water Drainage Network of DelhI

Even with showers of merely middling strength, flooding of the roads and water logging of colonies are extremely typical, resulting in uncomfortable living conditions, discomfort, and traffic congestion.

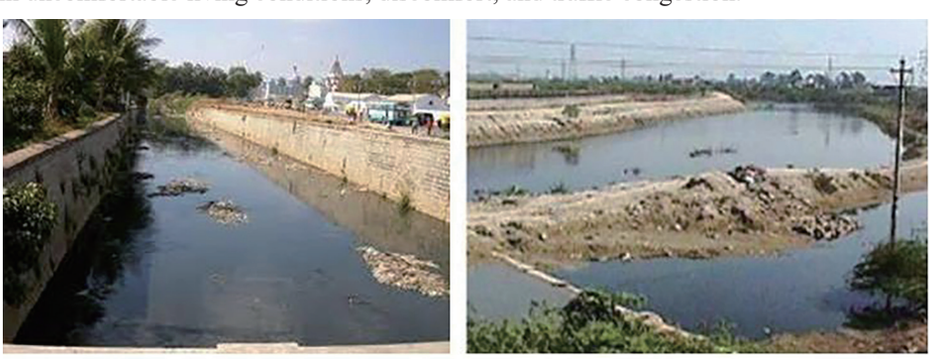

Figure 16. Drainage Channels and Catchments for Delhi

Diseases like dengue, filaria, and malaria are spreading, and digestive illnesses return every year is proof that the flow system is broken. It appears that a comprehensive understanding of the problem is absent, and historical solutions have been applied to various aspects of the city's growth. The example in the paragraph that follows serves as an illustration for this. To treat wastewater from sewage plants and later lessen the load of contaminated water sources, especially the Yamuna River, numerous pipes entering the Najafgarh River and the Yamuna River are diverted to the sewerage system. However, the

transfer channels (already completed) do not actually work due to the restriction.

7.5 Existing Drainage Infrastructure

The terrain of Delhi produced a drainage system that provided a natural drainage by transporting rain and storm water from the higher hills of the West to the Yamuna. The eastern, low-lying side, on the other hand, was once a portion of the river's flood plain and was deemed uninhabitable because of the regular flooding. Settlements in this region, however, also started with the immigration that followed 1947. Currently, 20% of Delhi's population lives in this Eastern wing, commonly known as the Trans Yamuna area.

7.6 Natural Drainage System

Six drainage zones (Northern Zone, Western Zone, Central North West and South East Zone, Central South and South East Zone, East Zone, and South Zone) have been established inside the city. The city's 350 km long natural drain carries a 1000 m3 discharge.

7.7 Man-Made Drainage System

There are 1700 km of drains in all, distributed across 12 municipal zones. There are around 1300 drains, of which 5 km are in Paharganj Sadar and 339 km are in the Civil Lines Area.

8. Findings and Discussion

Knowing that 86% of the victims were aware of the government's early warning systems was reassuring, perhaps as a result of early encounters with the Yamuna floods. Although 94% of families were only relocated to safe regions by these officials during the floods, when the water level had started to rise to dangerous levels, 82% of respondents reportedly received early notice from other officials. Respondents stated that due of the notice they received, they were able to move to safer regions on their own and without support from the government. At Shastri Parkand in the low-lying parts of Vijay Ghat, 78% and 81%, respectively, said that there were no rescue boats on hand. They would then have to take care of their kids, the elderly, and the handicapped. Only in Chilla Khadar, Mayur Vihar-I, do several families have access to maritime services that allow them to safeguard their worldly possessions. According to some responses, access to the services of rescue vessels was also subject to payment. In the thick of the flood, they had to walk on water to preserve their lives while sacrificing their possessions since they lacked money. All of the victims' lives may have been saved if aid services had been supplied sooner and more effectively, but the Delhi government has not yet issued any compensation, and there is no official indication of limited losses and damage to property and life.

8.1 Flood Warning

The pre-flood warning systems seem to have worked, as people have begun to move to safer areas without the need for government assistance with transportation, but there are also those who have not been able to get to safer places at a time when aid services have been lost or charged. Therefore, it would not be a mistake to say that the authorities concerned have failed to fulfill their legal obligations and the decision to build confidence among the people in protecting their property, while they are away from their homes, as in the 2006 NDMA Guidelines for Flood Management.

8.2 Uneven Distribution of Relief Material

Floods and nonstop rain have had a devastating impact on the victims. While 85% of respondents said they generally agreed with the access to relief camps (tents) question, another 12% said they did not. Families who were left out claimed that food and tents could be distributed equally throughout the entire region, excluding only those who were stranded indoors or on the beach. The Pradhans are blamed by the excluded parts for doing nothing for them and facilitating a biased distribution of goods. People who were camping out on the side of the road or on paving stones had already been given food. People who don't have tents are huddled beneath polythene sheets that are wrapped with sticks. People who live in tents do so in hazardous circumstances. The Delhi government gave the victims tents that had been left behind by soldiers. At least three families were housed in each relief tent. The tents protected them from the sweltering sun, but they didn't do much to shield them from the elements.

While the NDMA Flood Management Guidelines call for the creation of community-based emergency management teams, doing so will help with planning and establishing emergency shelters, distributing aid to the affected people, tracking down the missing, and addressing issues with education, health care, water supply, nutrition, provision, and assistance. No such formation has been seen in the impacted neighbourhood, and the survivors were not aware of any such process beginning in their neighbourhoods.

8.3 Camp on Pavement

Pressure from the authorities to return to their houses or other locations before the water receded was one of the key worries of the victims who were camped out in tents from the DND flyover in Noida to Akshardham. The survivors did not want to go because they were making a living by cultivating a riverbed. Even though their farms are dispersed around the floodplain and have already produced the anticipated harvest a few days ago, the survivors nevertheless prefer to remain close to them. From the encampment next to the comparatively clean DND road, they could keep an eye on their domain. The thought of migration therefore struck them as a warning.

8.4 Food Supply

Pressure from the authorities to return to their houses or other locations before the water receded was one of the key worries of the victims who were camped out in tents from the DND flyover in Noida to Akshardham. The survivors did not want to go because they were making a living by cultivating a riverbed. Even though their farms are dispersed around the floodplain and have already produced the anticipated harvest a few days ago, the survivors nevertheless prefer to remain close to them. From the encampment next to the comparatively clean DND road, they could keep an eye on their domain. The thought of migration therefore struck them as a warning to ensure that it was provided. Because these individuals were working for the MP's vote bank, it is likely that the entire political game appeared to be in full gear during the crisis. Respondents who weren't happy with the respite also mentioned that they occasionally had to get their water from a flooded river since so many people, including kids, got sick.

8.5 Education

Even school-age children suffered significant losses as a result of the floods. After the floods, 51% of all respondents said that their children's schooling had been impacted because their children's books and bags had been lost; 49% of the kids were unable to go back to school. Additionally, parents had to hold back their children to prevent them from falling into open pits that were overflowing with water or blocking the road.

8.6 Basic Amenities

Women still lack access to basic facilities in these places, specifically restrooms and showers, which severely intrudes on their privacy. Not all women had access to restrooms during the floods, and there were no bathing facilities, leading to poor hygiene conditions among the victims. Children occasionally urinated in the river.

8.7 Unemployment

The survivors' apparent and unusual sense of powerlessness was evident when they once more participated in efforts to return to their regular lives. Some people claim to have turned to menial tasks as inexpensive labour after their harvests failed.

8.8 Property Loss

The dissemination of information portion of the NDMA Guidelines on Management of Flood lays out provisions for accelerating the dissemination of reliable information on the scope of damage and other specifics of the response actions through electronic and print media shortly after the floods. But as can be seen from the facts, the Delhi government hasn't really followed this idea.

9. Physical Planning Recommendations

To address the problems of urban floods, a systemic shift that fully addresses structural and non-structural issues is necessary (Jainer, 2020). There are some planning recommendations in the form of planning guidelines and flood advisory before the flood, during the flood and after the flood. They are summarized as below:

9.1 Planning Concerns

- There should be Green infrastructure and water-sensitive urban design and planning (WSUDP) are two approaches to managing storm water. To control runoff and lessen urban flooding, open areas and water bodies must be identified, protected, and used as essential green infrastructure. Along with identifying urban catchments and prioritizing projects based on risk and vulnerability, this is necessary.
- Create drainage master plans for cities that include periodic, short-, medium-, and long-term initiatives to improve storm water infrastructure. The most advanced urban watershed modeling is required to help with this.
- Create monsoon action plans for high-risk and vulnerable locations based on the local environment. Because of their

high built-up area density and lack of infrastructure, informal areas are particularly vulnerable. A modern rain atlas for cities that offers spatial rainfall maps with 15-minute intervals is necessary to help with this. Additionally, the rain atlas can function as a flood warning system.

- Create a nodal authority for urban stormwater management that will be in charge of preparing a local drainage masterplan and coordinating strategies with the creation of a city master plan.
- Modifications to design specifications and thorough project reports to include run-off control techniques based on data of spatially variable rainfall. Municipalities and development agencies can take the initiative in putting high-profile, high-impact pilot projects into action that demonstrate the possibilities of gathering rainfall and adopting flood-control measures.
- Create a framework for urban drainage at the federal and state levels with modified service-level benchmarking, such as the share of municipal land covered by water-harvesting features, etc.
- Improve the curriculum to include WSUDP and green infrastructure strategies for infrastructure provision and ongoing professional development of municipal functionaries and consultants to keep abreast of the most recent tools and techniques for planning and designing rain/storm water harvesting features. This will increase the capacity of practitioners at the academic level.
- Minimizing time lag in response and relief is a key component for effective management during floods. It is therefore important to have robust interdepartmental coordination systems with a clear chain of command; SOPs; evacuation plans; and manpower, materials, equipment, ambulances, etc. on standby on a regular basis during and around the monsoon period, ready for immediate deployment/ mobilization.
- Volunteers play an important role during relief distribution. A common centre where relief items are received, repackaged and distributed based on requirements need to be identified. Volunteers can easily coordinate through such centres.
- First responders and disaster marshals from the community itself will help in minimizing response time during floods. It is equally important for the local community to know, who these marshals/ responders are, to be able to approach them in the time of disaster. This could be done through information dissemination during preparatory phase or some form of dress code, badges, caps etc.
- Real-time scenario monitoring employing ICT-based surveillance systems, dashboards, apps, and other tools can greatly improve response, rescue, and relief efforts. Kerala rescue portal of Govt. of Kerala is a good example of such an initiative.
- Appropriate arrangements for access to safe water and sanitation, medicines, medical support etc. are another important aspect that needs to be ensured during floods to minimize the risks of water-borne diseases and epidemics.

9.2 The Flood Advisory

The content of the flood advisory bulletins should include:

- Present and expected situation of the meteorological cause of flooding.
- Present and forecasted hydrological situation.
- Areas likely to be affected.
- Time and severity of flooding
- Precautionary measures recommended.
- Routine announcement of next bulletin.
- Safety precautions to be taken before the flood, when Advisories are issued and during and after the flood.

9.2.1 Advisory before the Flood

- Know the flood warning system in your community and ensure that your family knows the warnings.
- Learn all you can about the flooding

- Monitor weather conditions
- Keep on hand material like lumber, plywood, nails, roped, wires, plastic sheeting, sandbags, etc.
- Keep a portable transistor radio with spare batteries and emergency equipment.
- Store all chemicals away from flood waters.
- Store livestock feed and supplies above expected water levels.

9.2.2 Advisory during the Warning

- Listen for emergency instructions
- Watch for rapidly rising water
- Store drinking water in sealed plastic containers as water service may be interrupted.
- Move household items to higher levels
- Get livestock to higher ground
- Evacuate if necessary when it is safe to do so, don't move quickly.
- Turn off electricity at the main switch before evacuating

9.2.3 Advisory during the Flood

- Avoid areas subject to flash flooding
- Don't attempt to cross rivers or flowing streams where water us above the knees.
- Beware of water-covered roads and bridges

9.2.4 Advisory after the Flood

- Re-enter building with caution. Use flashlights, not lanterns or torches as flammables may be inside.
- Be alert for fire hazards such as broken electrical wires.
- If the building has been under water, do not switch on the main, wait for professional assistance. Never touch electrical switches while wet or standing in water
- Don't use appliances or equipment until they have been cleaned, dried and thoroughly checked for damage.
- Report utility lines (electricity, water, gas and telephone) to the appropriate authorities.
- Boil all water and don't eat left-over food until it is checked for contamination
- Keep away from disaster areas as your presence may hamper rescue efforts

10. Conclusions

Delhi's current approach to disaster management is deficient in a number of ways. For instance, the municipal development plan does not fully or sufficiently incorporates risk mitigation strategies. The relevant industries make little investment in planning for catastrophe risk reduction in terms of infrastructure and human resources. The ability of local authorities to put catastrophe risk reduction measures into action is also lacking. There is no doubt that Government to develop more strategic and strategic strategies to reduce risk and to spend more money to ensure the safety of citizens, but with the main study many perceptions are calculated namely communication between public servants (liberal) and the inhabitants were found empty. After a significant loss of annual harvests, it will take some time for these agricultural labourers, who live in the Yamuna River bed, to get back to normal. The damage created by these impoverished families, who primarily rely on agriculture for their living, had to be repaired while keeping in mind the vulnerability of these flood victims in the flooded area..

10.1 NDMA Guidelines on Food, Water, Health, Hygiene and Sanitation

The concept of "community participation," which emphasizes the involvement of those impacted by catastrophes in decision-making and the creation of equitable and successful programs that increase people's feeling of dignity, has a common thread. It continues by stating that extra measures must be taken to guarantee the inclusion of women and other vulnerable

groups in the aid system.

10.2 NDMA draft guidelines on Minimum standards for Medical Relief

Provides support to local community health workers and is integrated with health services, taking into account gender and racial equality. Organizers play a key role in raising awareness of floods in the community and in reducing the impact of floods on communities. This is achieved in many ways. A key approach is the use of non-construction methods that include careful planning of development in flood-prone areas. This should be supported by appropriate laws, public information and education programs (to ensure that residents understand the risk of flooding), flood insurance, and flood warning systems (to reduce the impact of floods). The most important non-invasive approach is to create a system of planning and land allocation legislation that puts proper controls on development in flood-prone areas. These controls should be based on flood risk assessments determined by a comprehensive hydrological and hydraulic analysis of flooding in the wetland area. The task of implementing these controls is currently in the hands of Government and Local Authorities (Bhaduri, 2011).

The flood has many impacts on human lives, animals, trees, fields, eco-systems. If taken seriously, it can lead to a positive return on civilization. Urban flooding can be avoided through protective measures including increased pipeline efficiency, the building of flood protection structures, the development of growing regions around cities to act as storage areas, the use of rainwater collecting systems, the refilling of water stations, etc. The Delhi Government Department of Irrigation and Flood Management, which is primarily responsible for controlling flooding in Delhi, has taken a number of actions in this regard, including strengthening the Yamuna River barriers and increasing the river's depth and transmission lines to increase its carrying capacity to 5000 cusecs.

The appropriate authority under the head of state should look at ways to control floods by implementing them in the prescribed manner as there is nothing more expensive than life on earth. and capacity building at the Government's disaster risk reduction, preparedness and sustainability Department The Department has also made efforts to build a database on the risks, risks and vulnerabilities of the Delhi NCT. The Emergency Operation Center at Government and regional level has been set up to coordinate emergency relief and assistance. The DRM Program has also been instrumental in partnering with educational institutions and the private sector to develop disaster risk management programs and projects. Various construction and non-construction measures are underway to mitigate the effects of the disaster and to improve management skills and to improve the skills of the community, local authorities, the urban body

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