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Climate Change and the Yamuna Floodplain in Delhi : Implications of Land Use Planning

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Abstract

Floodplains play an important role in providing various ecosystem services like groundwater recharge, reduction of flood risks, open space and recreation, improve water quality etc. Over the past century, Delhi has become increasingly populated as well as polluted. This paper discusses the climate change which aggravated the change in rainfall pattern with increase in temperature. Vegetation, soil and land surfaces area removed for construction of road and buildings where the permeable surface is replaced by impermeable surfaces which reduces the infiltration and increases the runoff. This paper also discusses all the possible policies which can be implemented to protect the floodplains from various developmental activities to avoid the flooding in rainy season.

Key Words-Landuse planning, Climate change, Environmental policies.

Research Article

1. Introduction

Floodplains play an important role in providing various ecosystem services like groundwater recharge, reduction of flood risks, open space and recreation, improve water quality etc. Today much of the importance is given to the developmental activities without considering the economic and other values of the floodplains over developmental activities. Over the past century, Delhi has become increasingly populated as well as polluted. The change in land use and development activities affects flooding in many ways and floodplains are reducing as the pressure on land is rising for developmental purposes. Development on floodplain areas is now more exposed to flood hazard. The climate change aggravated the change in rainfall pattern with increase in temperature. Vegetation, soil and land surfaces are removed for construction of roads and buildings where the permeable surface is replaced by impermeable surfaces which reduces the infiltration and increases the runoff. It is important to protect the floodplains from various developmental activities to avoid the flooding in rainy seasons [6]. Objective of this paper is to review and discuss all the policies which can be taken into consideration to protect the floodplain from all inhuman actions. Also discusses the rainfall variation which impacts this change.

2. Theoretical Background

The River Yamuna enters from Palla (on north side) traverses a length of 48 kilometer through National Capital Territory of Delhi and leaves it at Jaitpur (south side) [2]. The River Yamuna in Delhi covers a length of 48 kilometer including 22 kilometer in urban area and its spread diverges from 1.5 km to 3.0 km was once defined as the lifeline of the city, but today it has become one of the dirtiest rivers in the country. According to the

CPCB the water quality of the river Yamuna falls under the category "E" which makes it fit only for the recreation. [9] Floodplains are the most widespread of the wetland ecosystems present in the river Yamuna corridor in Delhi stretch comprising approximately 95 percent of the total area. The extent varies depending upon the change in land use pattern by anthropogenic pressures.

2.1 Functions of Natural Floodplains

Because of hydrologic and hydraulic functions, Floodplain Rivers have lower flood peaks and velocities, and smaller flood discharges in downstream locations, compared to other types of rivers. As a floodplain converts urbanized, its functions and are often exchanged by artificially enhanced channel capacity, drainage efficiency, and upstream impoundment. At the same time, the river sees higher peak flows with increased downstream discharges leading to higher flood risk. The urbanized floodplain becomes fewer tolerant of flooding for there is less land functioning to carry and store floodwater and sediments [7].

2.2 Benefits from Flood Plains

Floodplains can play a key role in reducing flood risk, they also provide a diverse range of other values and benefits. These benefits can be characterized as ecosystem services – products and processes generated by functioning ecosystems that economically benefit society [3].

2.3 Causes of urban flooding

Heavy Rainfall / Flash floods Water of Heavy rainfall concentrates and flows quickly through urban paved area and stored in to low lying area raising the water level. It creates more havoc when a main drain or a river passing through the area over-flows or breaks. When areas become smaller, their ability to regulate the flow become less and hence flooding.

3. Introduction to Study Area

The Yamuna Floodplain falls has been classified as a separate zone (zone "O") of Delhi, which covers about 9700 ha area (as per MPD 2001) from Northern boundary of National Capital Territory of Delhi up to the Southern boundary of the National Capital Territory of Delhi (Table 1). It plays different functions and benefits besides the ecological functions and recreational activities. Floodplains play a crucial role in ground water recharge to the sandy aquifers present in the study area and connected aquifers in Delhi city. These floodplain aquifers provide huge resource of fresh ground water that can be used for supplying drinking water to Delhi and for practicing agriculture. The importance of the water recharge function of the wetlands is abundantly reflected in the economic value, which is the highest among all the economic estimates of all ecological functions.

4. Introduction to Yamuna Floodplains

Floodplains are land areas adjacent to rivers and streams that are subjected to recurring inundation. Owing to their constantly changing nature, floodplains and other flood-prone areas need to be examined in the light of how they might affect or be affected by land use change. Floodplains carry water when floods exceed the ability of the river channel to transport the flood between its banks (the "channel capacity"). Floodplains provide numerous goods and services for humans such as, ground water recharge, floodwater retention and control, nutrient cycling, sedimentation control, recreation, and habitat for a diversity of species (floodplains value).

4.1 Land use of zone 'O'

Table-1: Land use distribution of zone 'O' (2011)

S.No.	Land use	Area (Ha)	Percentage

1.	Residential		
	A*	62.21	0.64
	B**	980.00	10.10
2.	Commercial	39.50	0.41
3.	Industrial	34.04	0.35
4.	Recreational	528.40	5.45
5.	Transportation***	345.65	3.56
6.	Utilities	166.00	1.71
7.	Government	1.80	0.02
8.	Public & Semipublic	179.84	1.85
9.	River & Water Body (including Agriculture)	7362.56	75.90
	Total	**9700.00**	**100.00**

A* - Approved residential schemes (Mandanpur KKhadar Resettlement colony (51.21) Ha and 11.0 Ha Residential Use at CWG-Village)

B**-Unauthorized colonies falling in Zone 'O'.

***The Transportations use includes the DMRC Depot & Station at Shastri Park and south of Vikas Marg in addition to the area under circulation such as roads, rail and metro corridor.

The Yamuna Standing Committee (YSC) of Central Water Commission (CWC), in its 37th meeting at May 1979 had fixed that the minimum gap between future defenses on the banks of the Yamuna river should be 5 km and the mound should be aligned at a minimum distance of at least 600 m from the active river edge at the time of construction of embankments." The Yamuna Standing Committee at its conference on fifth January 2008 decided that a width of 1650 m must be reserved for the river. Inappropriately, this decision has not been shadowed and today, the extreme distance between the two mounds of the Yamuna river is less than two km, and later the floodwater carrying capacity of the river has been greatly negotiated [4].

4.2 Flooding in 'O' Zone

The city has experienced occurrence of floods at least once each decade since 1947. High floods arisen in 1947, 1956, 1966, 1978, 1988, 1995, 1998, 2010 and 2013. The 1978 flood with water level accomplishment 207.4 m at old railway bridge had flooded. With the top elevation of the embankment on the west side being at about the same level, high floods with much lower discharge at the Old Railway bridge touch the mounds. The entire zone 'O' is flooded each year.

Anthropogenic Causes:

- Population pressure: Large amount of people, materials are needed, like wood, land, food, etc. aggravates soil erosion, developmental pressure which increases the risk of flooding.
- Deforestation: Forests near the rivers/catchment of cities are used for settlements, roads and farmlands causing overflow and in turn urban flooding.
- Trespassing on water storm drains: The areas created by the storm water drains to drain the flood water are encroached for developmental purposes result in blockade of water flow.
- Urbanization: Increased paved surfaces which decreases ground absorption and increases the surface runoff. Unplanned urbanization is the key cause of urban flooding. Various low-lying areas near or around the cities which were act as cushions and flood absorbers are now filled with built-up due to urbanization pressure.
- Un Authorized settlements settled on the agricultural land as well as on floodplains which is generally flooded during heavy rainfall.
- Poor Sewerage Management, Old drains and sewerage system has not been able to cater the load. The most of the drainage and sewer systems in many parts of Delhi are collapsed

and are not able to work properly during rainy seasons.

- Lack of attention to the nature of hydrological system. Lack of flood control measures taken.

4.3 Implication of Land use planning on Yamuna Floodplains

Land-use planning in the Flood Plains recently initiated the drive to clear Yamuna (the floodplains of the river Yamuna) and to convert the area into a national tourism cum-cultural site. This raises the impact of development on the floodplain. For development activities the Government of Delhi evicted the various slum dwellings on the Yamuna Banks for cleaning and developmental activities.

Table 2: Areas excluded from zone 'O'

Sl. No.	Land parcel to be excluded from zone 'O'	Excluded Areas to be included in adjacent zones	Area to be excluded (Ha)
1	Rajghat	A (walled city)	213
2	Millennium Bus Depot	D	33
3	IP Power station	D	112
4	Sonia vihar area	E	718
5	Akshardham Temple, CWG village	E	109
6	Shastri park DMRC land	E	104
7	Yamuna bank, Delhi Metro Rail Corporation land	F	40
8	Okhla, Jaitpur, Meethapur,	F	1310
9	Batla house area	F	73
10	Jagatpur	P-II	385
11	Area under circulation	D & F	12

The flood plains are being used for various purposes: Delhi Police Training Complex, Metro Depot, Akshardham Temple, Common Wealth Games Village, Indira Gandhi Indoor Stadium, Yamuna Riverfront, Bus Depot, and office complexes, and recently by the Cultural Programme, Art of Living (AOL) three-day event. Development Plan of Delhi envisaged that on the Yamuna river banks various recreational and other developments to be implemented [8].

There are various aspects that disturb flood frequency including topographic features, environmental structures, river morphology and human activities. One of the most significant effects of human activities on flood occurrence is the land use change and its inconformity with the land capabilities. In this respect, the importance of floodplain mapping, which has ample utilization in floodplain management [1].

Various activities on the Yamuna Floodplains are:

- Construction of roads, embankments, infrastructure and houses development within 300 m from the river channel.
- Creation of bathing ghats and reclamation on floodplain and consequent encroachment from place to place at ghats,
- Cultivation of vegetables in the floodplains
- Alteration of river morphology by various developmental activities.
- Decrease in flood carrying capacity of the river.
- Conversion of wetlands into agricultural fields.
- Building of drains inside the active floodplains for fulfilment of sewage of newly developed towns and settlements around the banks.
- Formation of Bus depots and Site of ash dykes on the abandoned ash dykes.
- Sand mining at areas exposed to erosion.
- Release of messes from Power Plants.

- Countless numbers of bore wells in upstream.
- Dumping of religious material and plastics into rivers situated outside the banks.

Growths on the floodplain in at river front development and any reduction in the places of the "O" Zone will completely finish rivers – particularly its flood carrying capacity and water quality that will in turn loom the city on both the sides. The DDA has been carried out a public notice on rezoning and re-delimitation of the Zone 'O' as a part of the review of Master Plan Delhi 2021 as per the provisions of Master Plan Delhi on 28 Sep 2013 to regulate the human settlements (legal and illegal residential areas and villages) by transfer from Zone 'O' to connecting zones such as D, E, F and P II etc (table 2). The areas consist of Rajghat, IP Power Station, Millennium Bus Depot, Sonia Vihar, Batla House Area, Shastri Park, Jaitpur, Delhi Metrorail Corporation land, Akshardham temple, CWG, Yamuna Bank Delhi Metro Rail Corporation land, Okhla, Jagatpur, Meethapur, and area under circulation (all of which cover an area of 3109 ha). It also cited that the total area under Zone 'O' was 8534 ha in its place of 9700 ha as cited in MPD 2021. The difference of 1700 ha is not liable.

5. Government initiatives in various plans

MPD 1962-82 recommended that on the western part of the river southward of Wazirabad barrage for growth of play grounds, district parks, and open areas. MPD 1981 to 2001 recommended that the river must pollution free and huge recreational spaces must be developed on the river bank, channelization of the river, Yamuna riverfront development. MPD 2001-2021 includes rejuvenation of Yamuna by means of various measures such as conserving the natural features like wildlife forest and waterbodies of the riverbed with restriction on unplanned development. Although National Capital Regional Plan (NCRP) 2021 recognized the river zone as a natural conservation zone where the water body held in reserve free from any type of growth or encroachment activity. But most of the plans remained unimplemented and the development took place to degrade the riparian ecosystem.

Proposed Land use from MPD 2021

Table 1 summaries the proposed MPD 2021 Land use.

Table 3: Proposed Land use from MPD 2021

Land use Type	Proposed Area (Ha)	% of total area
Residential	62.210	0.640
Commercial	39.500	0.410
Recreational	2045.000	21.080
Industrial	34.040	0.350
Transportation	582.930	6.010
Utilities	172.660	1.780
Public & Semi-public	181.740	1.870
Government	1.800	0.020
River & Waterbody	6591.120	67.840
Total	9700	100

** No supplementary areas other than existing/reserved have been planned under residential, industrial, commercial, public and semi-public, government and use zones.*

*** Commercial contains standing Information Technology Park in 6.0 Ha, Bottling Plant in 28.0 Ha at Madanpur Khadar, Commercial or Hotel in 5.5 Ha site at CWG Village.*

**** Proposed Recreational uses will be considered as herbal park/Green Park, science park, etc. will be allowed without any permanent construction.*

***** The area of 'River & Waterbody' may diminution by 980 Ha (approximately) after the regulation and consequent change of land use of unsanctioned*

colonies as per Govt. Rules/Govt. policy, falling in Zone 'O

DDA defined zone 'O' without any well-defined boundaries where the development and encroachment take place in the ecologically functional floodplain ecosystem. High Court of Delhi in its order of 29 March 2006 (in the case of WP(C) No. 2112/2002 and WP(C) No. 6891/2004 approved that no construction to take place within 300m on any one side of Yamuna river apart from in case of Majnu Ka Tilla and Kalindi bypass where a minimum distance of 120 meter from the edge of river Yamuna is legalized (vide order of 11 August 2006 by HC). After all the orders by courts DDA brought a notice to re-delineate and rezoning of Zone 'O' as part of Municipal Plan Delhi 2021 review, to regularize the settlements including both authorized and unauthorized areas and transfer them into adjoining D, E, F and P-II etc (Table 3). zones. The areas contain Rajghat, Millennium Bus Depot, IP Power Station, Sonia Vihar, Shastri Park, Yamuna Bank DMRC land, Delhi Metro Rail Corporation Land, Akshardham temple, CWG, Batla House Area, Jaitpur, Meethapur, Jagatpur, Okhla, and area under circulation comprising 31.09 sq.km.

6. Conclusion

It is evident that the floodplains play a major role in providing various services and act as a buffer, even in the case of Yamuna it can act as an important tool for improving quality of it. The floodplain is affected by various land use changes over a period of time. Floodplains are beneficial for wildlife by creating a variety of habitats for fish and other animals. In addition, floodplains are important because of storage and conveyance, protection of water quality, and recharge of ground water. It is necessary to protect floodplains and natural course of river from the adverse effect of developmental activities. Enforcement in case of Yamuna flood plains of Master plan provision needs to be strengthened. So, we need to understand the importance of floodplains and the services it provides.

Conflict of Interest

The authors declare no conflict of interest.

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