



A Report on

Impact Assessment of Bridges and Barrages on River

YAMUNA

(WAZIRABAD - OKHLA SECTION)

2009



Environics Trust



PEACE Institute Charitable Trust



Disclaimer

PEACE Institute Charitable Trust and Environics Trust cannot be held responsible for errors or consequences arising from the use of information contained in this report. Any opinions expressed are those of the writers and do not necessarily reflect those of PEACE Institute Charitable Trust and Environics Trust.

All rights, reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without prior written permission of PEACE Institute Charitable Trust and Environics Trust.

First Published in 2009

Copyright © PEACE Institute Charitable Trust and Environics Trust

Report on

Impact Assessment of Bridges and Barrages on River

YAMUNA

(WAZIRABAD – OKHLA SECTION)

BY

ENVIRONICS TRUST, NEW DELHI

&

PEACE INSTITUTE CHARITABLE TRUST, DELHI

September, 2009

This report is a part of Ford Foundation sponsored project titled “Mainstreaming the river as a popular civil action ‘cause’ through motivating actions for the revival of people - river close links as a precursor to citizen’s mandated actions for the revival of the life-line river in the city” of which this study report is one of the outputs.

PREFACE AND ACKNOWLEDGEMENTS

Structures across rivers have been built since times immemorial until this day - logjams and Bamboo bridges to Steel and Concrete structures. However, the rapidity at which rivers are being stopped, bridged, dammed and altered has begun to reach alarming proportions that threatens the very life of the River. River Yamuna as it flows through the highly urbanized corridor of Delhi is a matter of concern because of pollution, constructions across the river and relentless encroachment of the floodplains. The eviction of poor slum dwellers in pockets along the banks of Yamuna was a phase when the city administration prided itself with saving the river but ironically, this has not led to compatible use but has witnessed much more destructive activities in the floodplains. Yamuna's water flows are regulated through barrages upstream and the seasonal flows depend on rainfall in the upper catchment and release from barrages upstream. Environmental concerns of a river system owing to increased invasion of activities over and within it demands comprehensive evaluation of impacts. This study has attempted to understand and document these impacts in the 22 Km stretch of the river passing through the predominantly urbanised section of the city.

Today, River Yamuna is a longitudinal district, segmented by several road and rail bridges to provide regional and local connectivity. These structures, largely for economic considerations, have been built as embankments for all but the small segment of the flow-channel thus hindering the natural expanse of floodplains and increasing flood vulnerability. Transportation projects like Delhi MRTS, Road and rail bridges pass through the river with their approaches at both ends forming a pocket of restriction or static pockets. More we concretise and erect structures lesser is going to be the capacity of floodplains as the latest case of Delhi Metro which has erected its facilities at two places in the floodplains. Plethora of institutions involved seems loosely integrated with institutional responsibilities and each one's bias is visible.

There are several critical questions needing deeper enquiry - Should the Land Acquisition Act be allowed to be used as a tool to acquire and hoard land resources with the private players or developers? Can the land acquired for a specific purpose i.e. Channelisation of River Yamuna be transferred or given on lease to developers thus compromising the very purpose? Are there guidelines for design while clearances are granted for projects dependent on riverbed? Why information on all aspects is not available in Public Domain?

Urbanisation and land use planning are intrinsically linked with each other. They are interdependent and shape the structure and image of a city stated Kevin Lynch, a noted urban planners' most famous work in 1960s 'Image of The City' is still relevant to urban planning and environmental psychology. This is unfortunately not realised by the modern day implementers. The river itself has forewarned the community repeatedly, with floods and the disastrous floods of 1978 remain a standard reference point against which any structure standing in the river bed deserves an evaluation.

Public Information Officers (PIOs) of various institutions answered the call of their duty and responded without undue delays. We are thankful to several field staff at various levels, and officials who have informally shared their insights on the fate of River Yamuna.

CONTENTS

Abbreviations

Terminology

1. Background	1
2. Methodology Adopted for the Study	3
3. Literature Review	5
4. Delhi – Growth Trends and Development Paradigm	9
5. River Yamuna in Delhi – River Characteristics & Structural Briefs	13
a. The Facts & Issues Pertaining to River Yamuna in NCTD	
6. Land Acquisition	23
7. Description of Structures Over River Yamuna	27
8. Descriptive Impacts of Structures over River Yamuna	41
9. Illustrative and Quantified Impacts of Structures Over River Yamuna	47
10. Recommendations	71

List of Tables, Figures & Maps

Table 1 – Decadal Growth Rate of Delhi	9
Table 2 - District Wise Population in Ascending Order	9
Table 3 - Features of River Yamuna in Different Reaches	14
Table 4 - List of Structures over River Yamuna	28
Table 5 – Salient Features of Structures over River Yamuna	29
Table 6 - Select Parameters of bridge structures across River Yamuna	31
Table 7 - Possible relationship between Parameters as an outcome of Construction with River Elements	44
Table 8 - Possible relationship between Parameters Leading to Protection, River Training	45
Table 9 – Probable Increase in Water Level in Changed Situations & Required Changes	46
Table 9.1 Tentative list of structures with land details	46
Table 10 - Broad Land Cover Type Change Detection (1990-2000)	57
Table 11 - Broad Land Cover/Class	63
Table 12 - Breakup of Table 11 (Broad Land Cover/Class)	63
Fig.1 – Population Density of Delhi's Districts	10
Fig. 2 – Districts of Delhi NCT	10
Fig 3 - Master Plans of Various Periods depicting the growth of Delhi	11
Fig. 4 – Delhi's Growth Pattern in Different Master Plan Periods	12
Fig. 5 – River Yamuna	15
Fig. 6 – Sectional Overview of Activity Areas in Stretches of Yamuna	16
Fig. 6.1 – Sectional Overview of Activity Areas in Stretches of Yamuna	17

Fig. 7 – Maximum Water Level Attained by Yamuna in Delhi	18
Fig. 8 - Depicting top level of embankments along the river Yamuna	18
Fig. 9 – Depicting ‘purpose’ of land acquisition for the years	23
Fig. 10 & 10.1 – Land Acquisition in Different Localities	24
Fig 11 – Features in u/s & d/s of Barrage	33
Fig 11.1 – Okhla Barrage and Drains in Vicinity	34
Fig 11.2 – Flyovers in the Floodplain	35
Fig. 11.3 – Changing Skyline Along River Yamuna	36
Fig. 11.4 to 11.7 – Land Transformation & Infrastructure Improvement	37 - 40
Fig. 12 – Bubble diagram of impacts	41
Fig. 13 – Increase in water level due to bridge	44
Fig. 14 – Water Surface Profile at Bridge locations	45
Map 1 – Yamuna River	27
Map 2 – Landsat MSS (1977)	48
Map 3 – Landsat Classified MSS (1977)	49
Map 4 – Landsat TM (1990)	50
Map 5 – Landsat Classified TM (1990)	51
Map 6 – River Course	52
Map 7 – Landsat ETM (2000)	53
Map 8 – Landsat Classified ETM (2000)	54
Map 9 – Landsat ETM (2006)	55
Map 10 – Decadal Change	56
Map 11 – NDVI (TM – 1990)	59
Map 12 – NDVI (ETM – 2000)	60
Map 13 – DEM - Elevation Map	61
Map 14 – Wazirabad to Okhla Yamuna in NCT Delhi	62
Map 15 – Section I (Wazirabad to I.S.B.T)	65
Map 16 – Section II (I.S.B.T – Old Railway Bridge)	66
Map 17 – Section III (Old Railway Bridge – I.P.Barrage)	67
Map 18 – Section IV (I.P.Barrage – NH-24)	68
Map 19 – Section V (NH-24 – Okhla Barrage)	69
Map 20 – Section VI (DND – Okhla Barrage)	70

Annexure

Characteristics of Development along River Yamuna	74
Embankments in and around NCT Delhi	75
Drains Under IFC	76
Land Acquisition by Various Agencies	78
Change in Landuse	82
IFC Drains	83
Information and Development Agencies	85
Land Acquired by IFC	91
References	93

ABBREVIATIONS

BCM	Billion Cubic Metre
CAG	Comptroller and Auditor General
CGWA	Central Ground Water Authority
CGWB	Central Ground Water Board
CUSEC	Cubic Feet per Second
CUMEC	Cubic Meter per Second
CWC	Central Water Commission
BIS	Bureau of Indian Standards
DDA	Delhi Development Authority
DEM	Digital Elevation Model
DJB	Delhi Jal Board
DMRC	Delhi Metro Rail Corporation
DPCC	Delhi Pollution Control Committee
DTL	Delhi Transco Limited
DTTDC	Delhi Tourism and Transport Development Corporation
DUAC	Delhi Urban Arts Commission
EC	Environmental Clearance
EIA	Environment Impact Assessment
ETM	Enhanced Thematic Mapper
GoI	Government of India
Ha.	Hectare
HFL	High Flood Level
I.T.	Information Technology
IFC	Irrigation and Flood Control
IRC	Indian Roads Congress
MCD	Municipal Corporation of Delhi
MLD	Million Litres per Day
MoEF	Ministry of Environment and Forest
MoU	Memorandum of Understanding
MoUD	Ministry of Urban Development
MoWR	Ministry of Water Resources
MPD	Master Plan of Delhi
MRTS	Mass Rapid Transportation System
NCTD	National Capital Territory of Delhi
NDVI	Normalised Difference Vegetation Index
NEERI	National Environmental Engineering Research Institute
NOIDA	New Okhla Industrial Development Authority
NRCD	National River Conservation Directorate
PIO	Public Information Officer
PWD	Public Works Department
RM	River Management
SRTM	Shuttle Radar Topography Mission
TM	Thematic Mapper
UYRB	Upper Yamuna River Board
RTI	Right to Information
YAP	Yamuna Action Plan
YSC	Yamuna Standing Committee

TERMINOLOGY

Flood - A flood is an overflow or accumulation of an expanse of water that submerges land

Waterway - A navigable passage of water

Pier - A pier is a raised walkway over water, supported by widely spread piles or pillars. The lighter structure of a pier allows tides and currents to flow almost unhindered, whereas the more solid foundations of a quay or the closely-spaced piles of a wharf can act as breakwaters, and are consequently more liable to silting.

Spur - These are structures constructed transverse to the flow of the river and extend from the bank into the river. These are intended to induce silting and diverting the flow away from the point of attack.

Embankment - An artificial bank raised above the immediately-surrounding land to redirect or prevent flooding by a river, lake or sea

Guide bund - These are embankments meant to confine and guide the river flow past a bridge without causing damage to it and its approaches. These are generally constructed in the direction of flow on one or both flanks, depending on the site conditions.

Afflux - the rise in flood level of the river immediately on the upstream of the bridge as a result of obstruction to natural flow caused by the construction of the bridge and its approaches.

Liquefaction - Soil liquefaction describes the behavior of soils that, when loaded, suddenly suffer a transition from a solid state to a liquefied state, or having the consistency of a heavy liquid. Liquefaction is more likely to occur in loose to moderately saturated granular soils with poor drainage, such as silty sands or sands and gravels capped or containing seams of impermeable sediments

Seismic hazard - Study of expected earthquake ground motions at any point on the earth

Seismic microzonation - The process of subdividing a potential seismic or earthquake prone area into zones with respect to some geological and geophysical characteristics of the sites such as ground shaking, liquefaction susceptibility, landslide and rock fall hazard, earthquake-related flooding, so that seismic hazards at different locations within the area can correctly be identified

1. BACKGROUND

River Yamuna's most threatened section is perhaps the Delhi section – when it enters Wazirabad and leaves Okhla. The massive scale of construction works for improving storage of water or improving land connectivity causes a series of impacts both in the immediate time and extends over a long duration. Over the years, physical development in the form of Bridges and Barrages has taken place along this stretch resulting in transformations of different nature – surface level transformations, drainage modification etc. When a number of them come across a river the health of the river could be jeopardized along with host of unmitigated environmental and social impacts on the banks and the flood plains.

The shrinking of active flood plains of River Yamuna over the years lessens the scope of recharge and sub surface flows which could further deteriorate the river character – meaning the flow regulation, lessening of dilution capacities would thus lead to higher pollution loads, which could be attributed to the construction activities.

Some of the other common concerns have been

- (i) Insensitivity for other sectors while taking decisions for one sector and what steps/methods could be taken for mitigating or finding alternatives
- (ii) Paucity of recorded or anecdotal and historical information for understanding changes due to such construction projects and their larger environmental and ecological linkages with river system?
- (iii) Roles and responsibilities of institutions involved in the management and conservation of River Yamuna

a. Scope of Work

The scope of work is to understand and assess the impacts due to rail/road bridges and barrages on the river's environment and river hydrology on the whole. Following are the Stretches in the urban Delhi Section

- Wazirabad – ISBT Bridge
- ISBT Bridge – Old Rail Bridge
- Old Rail Bridge – IP Barrage (ITO)
- IP Barrage (ITO) – New Railway Bridge (Nizammudin Bridge)
- New Railway Bridge (Nizammudin Bridge) – Nizammudin Road Bridge (NH24)
- Nizammudin Road Bridge – DND Flyway
- DND Flyway - Okhla Barrage

b. Methodology of the Study

The methodology of the study would like to look at the whole aspect of impacts in a time horizon from the point of development of several of facilities in the flood plains and capturing some of the recent developments in this stretch of 22 kms or so.

c. Phase – I: January 09 to March 09

Literature Research and Study of Background Documents

The stretch of Yamuna, 22 kms from Wazirabad Barrage to Okhla Barrage runs through the urbanized region where significant developments have been taking place from last 5-6 decades. It thus becomes imperative to understand the phased development along the River and its consequences. Some of the major transformations have taken place over the recent past where interstate linkages (between Delhi-Noida) in the form of DND flyover and development of infrastructure for the Commonwealth Games 2010 have been more alarming. The process of impact assessment would therefore require information on historical as well as recent developments for arriving at a useful methodology for impact assessment.

The outline of process under literature

Using Right to Information Act

Review of documents pertaining to different components of bridges and barrages

Approaching officials of responsible agencies for interviews and institutional perspectives

Summarizing various methods / methodologies for assessing impacts of bridges and barrages in the national and international context in particular reference to river systems and highlighting critical aspects for adaptation

Mapping Hydrogeological features which directly link to the sub surface flows and recharge aspects to enable understanding of physical development with respect to geological conditions.

d. Phase II: March 09 – July 09

Mapping and Building an inventory of land acquisitions for such projects.

Procuring maps of different periods to capture the physical growth and shrinkage of the River and

Understanding the purpose-design-modification considerations of the facilities and the methodology adopted in assessing impacts on the River.

e. Third Phase

Collating information generated and analysed and preparation of draft report for discussions and review.

f. Time Frame

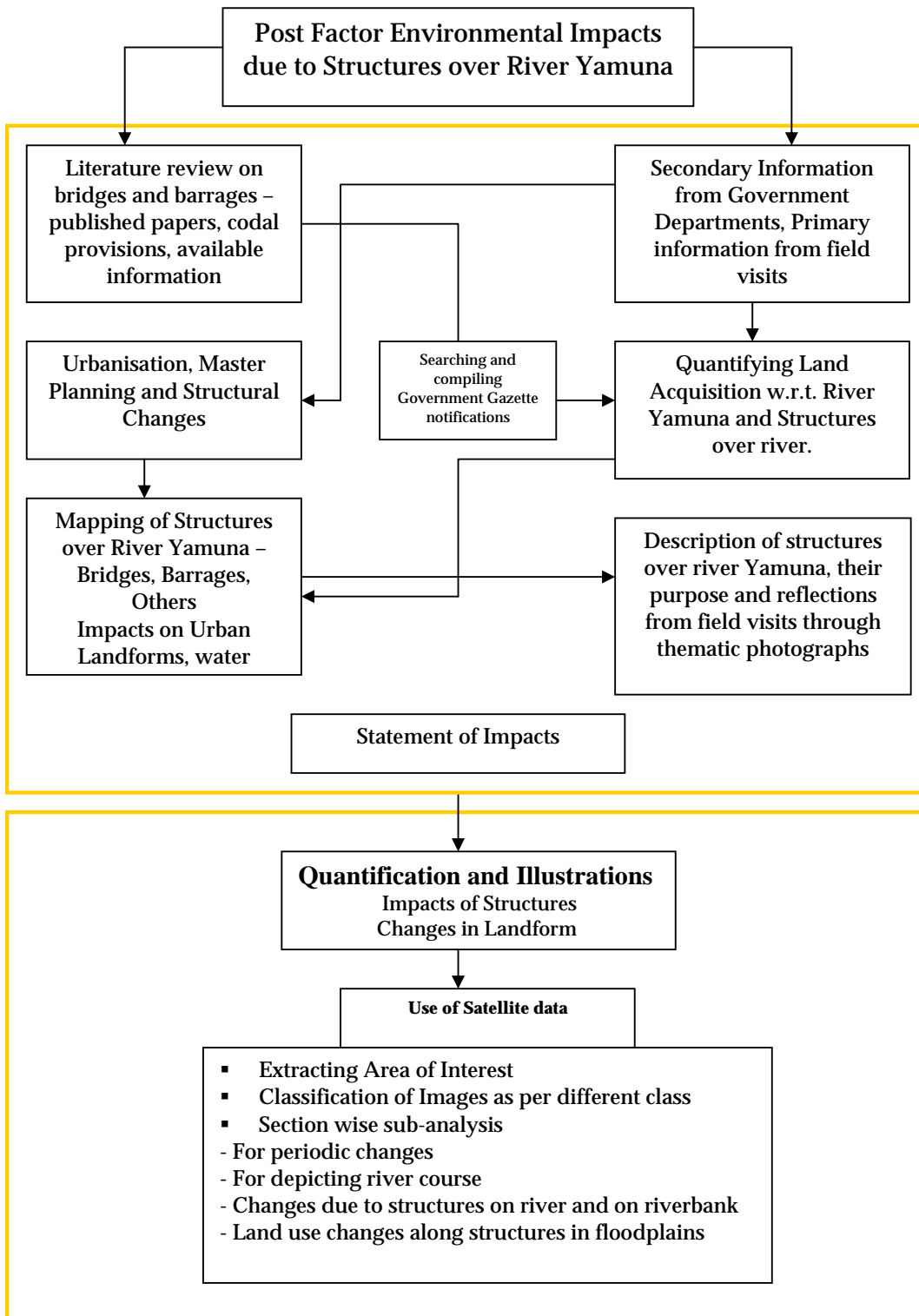
The time frame for the whole study is 7 months – starting January 2009 and ending August 2009

2. METHODOLOGY ADOPTED FOR THE STUDY

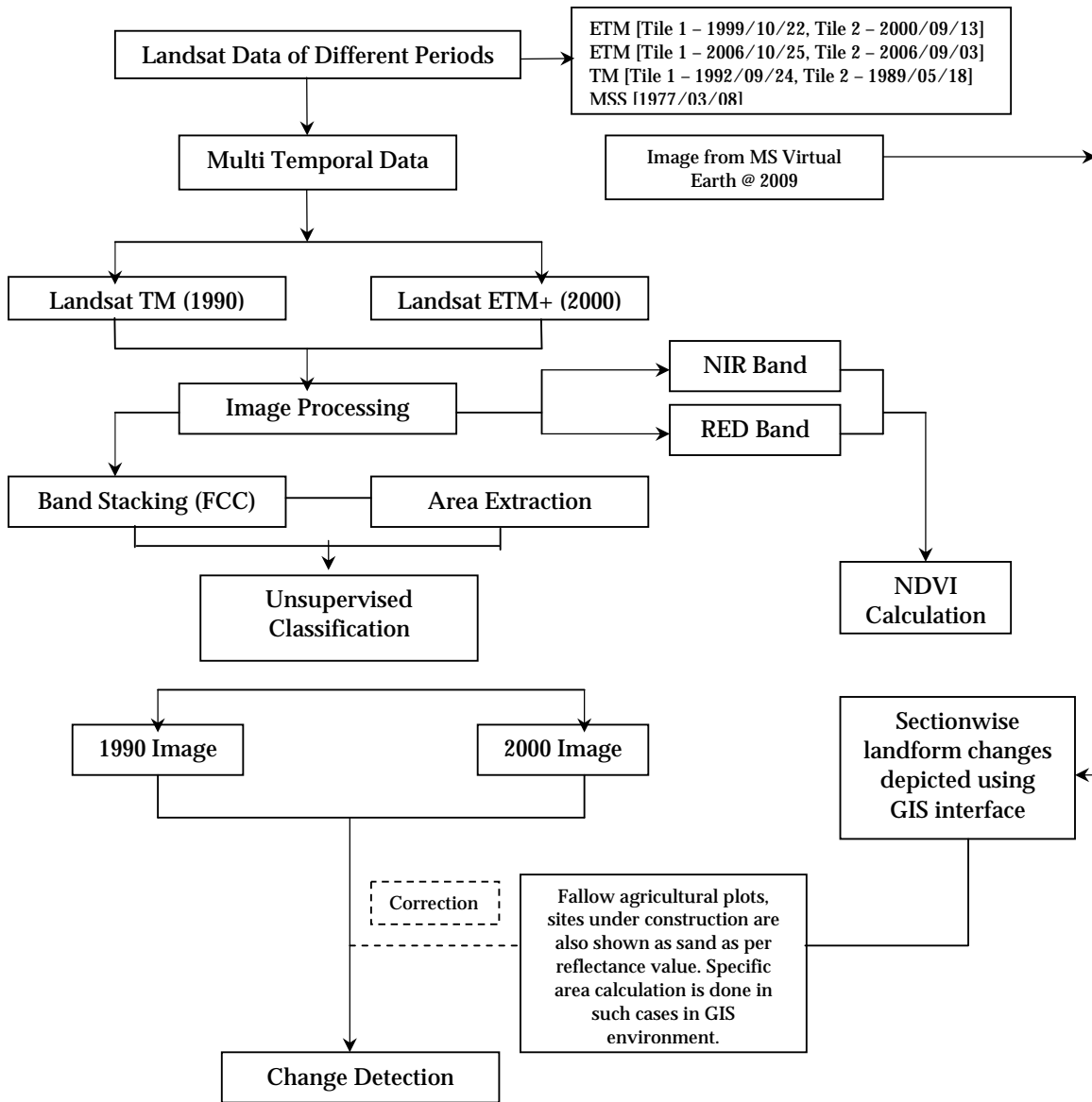
The methodology described below is an outcome of study and reference of several technical papers published in international & national journals as well as standard provisions by Indian organisations.

Understanding a river, as we understand, is a process and cannot be resolved either only by engineering or by social measures in a limited perspective and limited time. But with the rapid urbanization, physical planning and capability of engineering organizations (with available instrumentation, engineering background) look more proactively towards urban infrastructure improvement as a remedy to urbanization which looks primarily at 'economical methods' of construction rather than 'optimal' methods of development. It all depends how much such processes value a natural resource or urban river around which planning happens. Whether river is treated as a planning unit or how and what to plan along rivers has never been given enough weight. Pollution for that matter, appears as frontrunner among concerns over environment but urban development as a whole adds to the problem. Once the perspective is changed i.e. from merely urban infrastructure project, as a singular entity to see in totality of impacts it may have on natural setting of the region will make remarkable difference. River is a complex system in itself, and this methodology is an attempt to understand some issues related to urban rivers w.r.t. bridges and barrages. It is difficult to get a first hand technical data within the scope of this study but an attempt has been made to procure, to the extent possible, data from apex organizations. To understand the spatial overview of the area and to correlate it with the ground realities, satellite data was used to analyse and portray a picture of periodical changes and impacts.

Framework



Methodology Adopted for Analysing Various Satellite Data



3. LITERATURE REVIEW

As there are no specialized studies of impact of bridges and barrages over rivers or these deal only with specific engineering aspects like structural safety and operation of bridges, several articles, papers were reviewed which are presented as below:

S.No.	Description	Remarks
1	Hydrodynamic Simulation of River Yamuna for Riverbed Assessment: A Case Study of Delhi Region: The paper established the links between river hydrodynamics and availability of land with respect to flood return periods for riverbed development with	Submergence areas as simulated for 10, 25, 50 and 100 years of return period of floods and depicting it alongwith channel bed. The paper establishes the fact that there is sudden drop in water levels at bridge locations due to smaller opening

S.No.	Description	Remarks
	the help of RiverCAD model.	compared to the river width but there is no section on bridge designs or alternatives for better river management.
2	Impacts on water levels of new Bridge footings and associated Cofferdams for the International bridge of Cornwall (ontario) Using detailed 2d Hydrodynamic modelling	A simulation model done for bridge of cornwall provided the recommendations in order to reduce the impacts i.e. optimisation of the design of the new footings and piles in order to be more “hydrodynamic” and modification of the shape of the old piles and footings, i.e. “sculpting it” by removing the angles (corners) in its downstream portion. In research teams’ opinion, these two options would probably reduce the impact on the discharge to a similar magnitude than the proposed design by 30%.
3	<p>Design and construction aspects of a bridge over river Yamuna:</p> <p>Incrementally launched technique for construction of bridge over river Yamuna is discussed. The study concludes that this technique is highly recommended for spans of 40-50 m and it is beneficial over traditional techniques for such spans. Jack down method for sinking of wells is employed.</p>	<p>The building of metro involves prefabricated super structures whereas the pillars are constructed in situ. This technique is praised due to its cost-effectiveness whereas environmental parameters are not discussed in the methodology. The paper concludes that ‘the adoption of “jack down” method for well foundation and incremental launching of the superstructure proved extremely beneficial and speeded up construction.</p> <p>It is during the design stage that the probable impacts need to be understood rather than only praising the technique on its cost effectiveness. It would have been more important to underline the process and parameters considered for maintaining the river hydrology intact while designing the foundations of the pillars.</p>
4	Gazette of Rural Delhi	Some information on development of Delhi along Yamuna and institutional arrangements (gaon panchayat), plant species and fishing in Yamuna and several other generic information.
5	Flood control order, 2006 & 2009	Details of embankments (about 9 of

S.No.	Description	Remarks
		them), maximum water level attained from 1963 to 2005, list of totally exposed areas of villages/old abadi Village across 6 sectors.
6	Corridors, Networks and Watersheds: Discusses the key elements of network, corridor, watershed vis-à-vis development.	A river oriented framework drawing is useful in monitoring and managing a diverse list of individual projects within a larger system of river connections presenting variety of implementation options.
7	The birds of Okhla barrage bird sanctuary, Delhi, India by Abdul Jamil Urfi, Printed in FORKTAIL in 2003; Listing of Birds and slightly discusses on development induced impacts	Habitat disappearance, growth of reeds due to shallow waters, particularly at the junction of the weir and the left afflux bund and also in the areas between the spurs. In what ways these changes in the water depth will affect the communities of wintering and resident waterfowl remains to be investigated. Has a listing of birds with status and notes which would be interesting to see post development and pre development of barrage....
8	IRC Codal provisions	IRC: 005-1998, IRC:89-1997, IRC:78-2000
9	BIS Standards for Barrages, Weirs	IS 7720:1991, IS 12892:1989, IS: 7349-1989
10	Overview of Delhi Master Plans - Delhi Development Authority	Planning approach, land acquisition and other related planning issues in the territory of Delhi. Zonal development plan for River Yamuna (zone 'o' and part zone 'p'). The zonal plan recognizes this zone as an eco-sensitive zone on the one hand but has also been allowing changes to land use (as the predominant and compatible land use in this zone is agriculture, water, vegetation etc) i.e. from open land in the floodplains put to agriculture, open spaces to commercial, residential, transportation and public-semi public uses. ¹
11	Environmental Management Plan for Rejuvenation of River Yamuna in NCT - NEERI	DDA's proposal to utilize land in the floodplains (dry land during non-monsoon) was mooted in 1994 for which NEERI carried out a detailed study. In its study, NEERI pointed

¹ Characteristics of Development in Different River Stretches

S.No.	Description	Remarks
		<p>out that channelisation is unviable as proposed activities require huge investments and still pose considerable risk of flooding city area. <i>'The channelisation proposal suggested creation of embankment of approximately 550 m wide watercourse and recover the remaining land. Since this will cause rise in water surface elevation during floods above drain elevations, cross regulators comprising gates and pumping arrangements were proposed in order to pump drain water into the channel.'</i></p>

4. DELHI – GROWTH TRENDS AND DEVELOPMENT PARADIGM

The 22 kms stretch of River Yamuna runs through the highly urbanized Delhi Urban area and several of the structures have come up in this stretch. A brief look at the development of city and planning response through Master planning would form an important component as part of the process.

The total population of Delhi was 13.85 million persons by 2001 of which 93%

population represents the urban component. The population distribution in nine districts of delhi represents that the North, North East, West and South West districts have the highest percentage of population. As per the 2001 census there were 165 villages, of which 158 were inhabited. The National Capital Territory of Delhi has attained the status of fastest growing metropolitan city with influx of population continuing to pour the urban fringes of the city. The city's form infact looks like that of a bubble which expands towards NW-SW periphery. As of 2001, the city population grew at 47.02% and if one has to take conservation figures of 2009 projected population the population growth is pegged at 25.89%. The blueprint for development planning was initiated with the coming up of 1962 Master Plan which conceived planned development of Delhi till 1981-82.

Year	Population	Decadal growth
1951	1744072	
1961	2658612	52.44
1971	4065698	52.93
1981	6220406	53.00
1991	9420644	51.45
2001	13850507	47.02
2009*	17437000	25.89
* - provisional Source: Census of India		

Table 2 - District Wise Population in Ascending Order

District	Population	% Distribution of Population in Urban		% Urban Population	Rural Population	Households
		Districts	Population			
New Delhi	179,112	1.29	179,112	100	-	39,633
Central	646,385	4.67	646,385	100	-	120,616
North	781,525	5.64	734,940	94	46,585	148,927
East	1,463,583	10.57	1,445,360	99	18,223	287,638
South West	1,755,041	12.67	1,529,587	87	225,454	364,511
North East	1,768,061	12.77	1,626,514	92	141,547	310,887
West	2,128,908	15.37	2,042,114	96	86,794	4,332,782
South	2,267,023	16.37	2,106,262	93	160,761	466,444
North West	2,860,869	20.66	2,595,506	91	265,363	561,945
Total	13,850,507	100.00	12,905,780	93	944,727	6,633,383

Source: Census of India, 2001

Delhi's limited environmental resources and its geographical location provides very little scope for replenishing the loss of these resources which needs much planned, regulated and sustainable planning measures from mere physical development. As the city grew over time, the prime development agency² i.e. Delhi Development Authority which was enacted in 1957 under the provisions of the Delhi Development Act has taken the task to promote and secure the development of Delhi. River Yamuna becomes a dividing line for the city of Delhi bifurcating into two units along its length while it enters at Palla / Wazirabad till Okhla barrage in the downstream. Though the river is a major element for any city through which it passes but the state of Yamuna changes immediately as it leaves the himalayan stretch and enters Haryana before entering into Delhi.

² DDA has so far acquired 28,302 hectares of land out of which 24,091 has been developed i.e. 88.34%

The concentration of population (see table 1 and fig. 1) is clearly in the northern and the north western district of the state. Delhi's positioning in the NCR is such that it's road hierarchy has been developed to cater to arterial traffic as well as interdistrict movement with close integrity to the satellite localities like trans yamuna, east delhi and several towns in immediate vicinity of the metropolis.

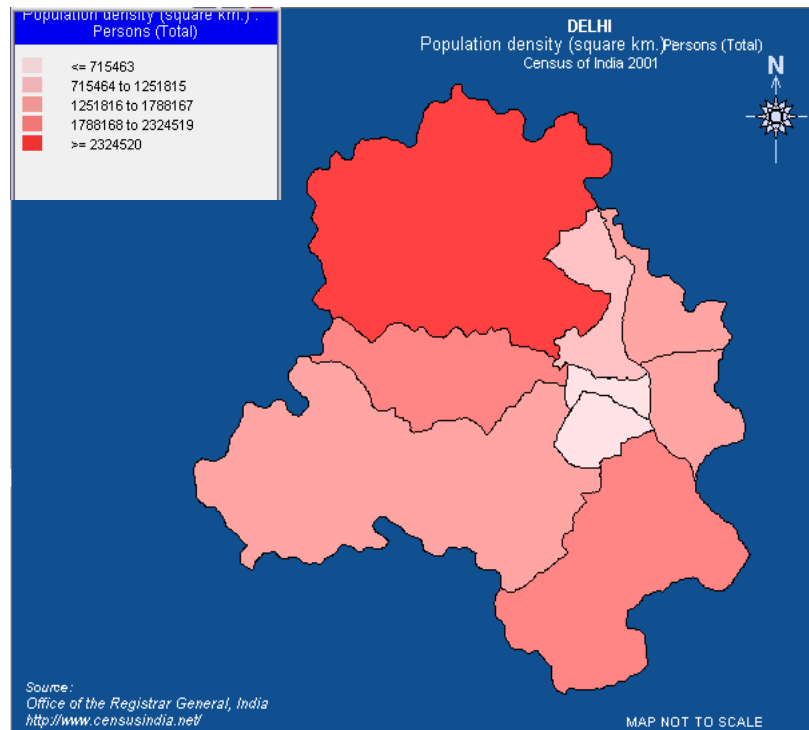


Fig.1 – Population Density of Delhi's

Districts;

Source: censusindia.gov.in

[Not to Scale]



Fig. 2 – Districts of Delhi NCT

[Note: A new district i.e. South East has come into existence after 2001 census, details are not available in public domain]

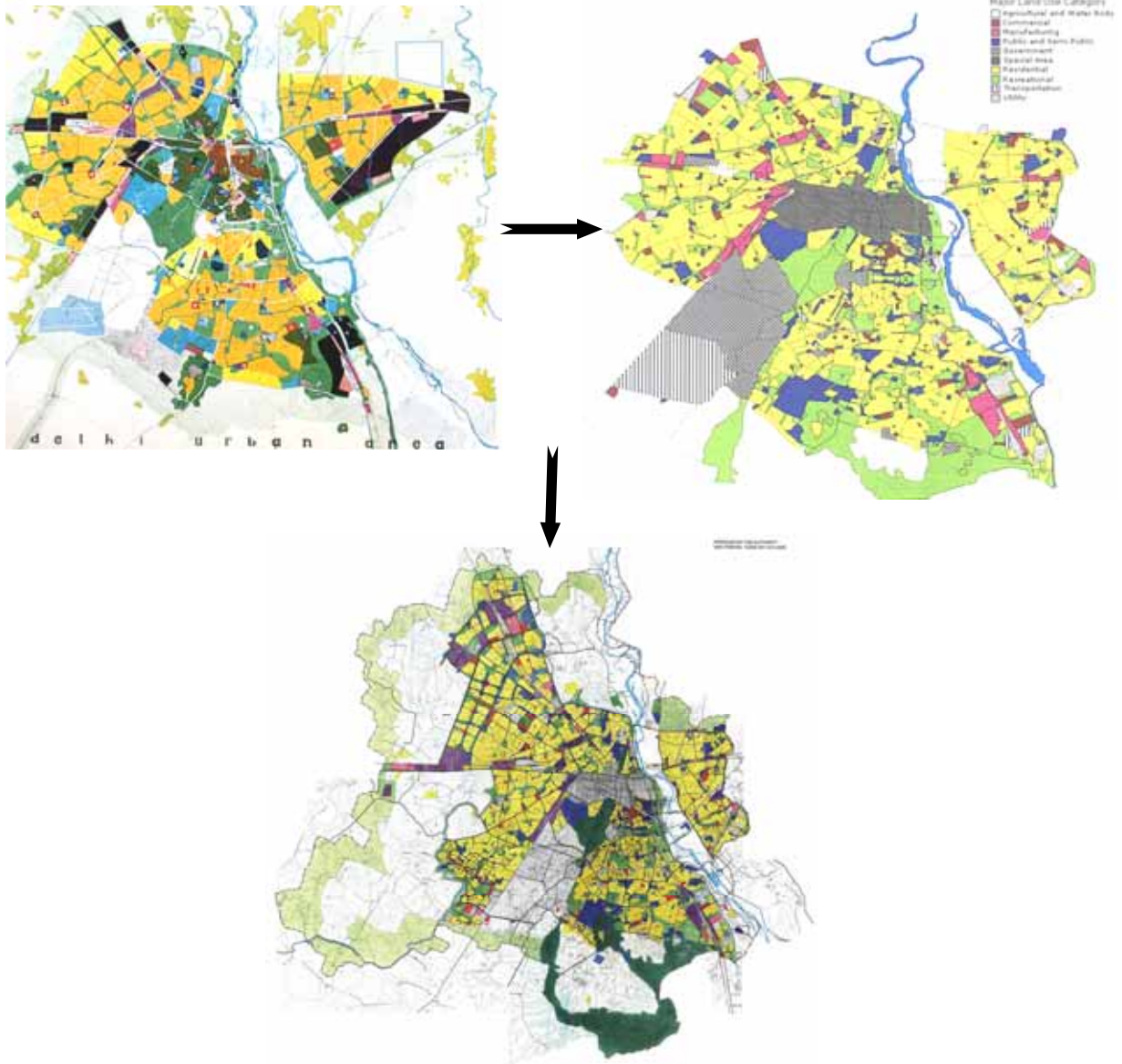
Approximately 23% of the Delhi population lives in trans yamuna area which is mostly concentrated in the North East and East District of the State.

MPD - 1961

- Provided for green belt on the periphery of the proposed urban area to control the spill over of urbanization.
- Large-scale land acquisition
- Plan did not propose integration of the informal sector leading to their exponential growth which outstripped infrastructural facilities.
- Land was put to extensive use resulting in overshooting of envisaged densities
- Comprehensive planning for rural and urban areas earmarked 45,000 ha for urbanization

MPD - 2001

- Master Plan of Delhi - 2001 projected population of 128 lacs
- Proposed urbanization of further 18000 – 24000 ha. to accommodate the additional population in urban extension areas like Dwarka, Rohini and Narela sub cities.
- Introduced the following new concepts for further detailing at Zonal Plan Level.
 - Mixed use, pedestrianization, Urban design & Policy on Tall Buildings, Environment & Heritage Conservation



MPD - 2021

Civil construction public purpose is an outcome of urban development process, which every city comes through. Delhi's urbanization is rapid, haphazard and spread over a large territory and has implications for the whole NCR region as such. Yamuna characterizes the plight of such urbanization where the pressures are mounting and despite large investments in physical infrastructure over the years only some like CNG initiative has worked to some extent.

Fig 3 - Master Plans of Various Periods depicting the growth of Delhi

Source (Delhi Development Authority, www.dda.org.in/planning) [Not to Scale]

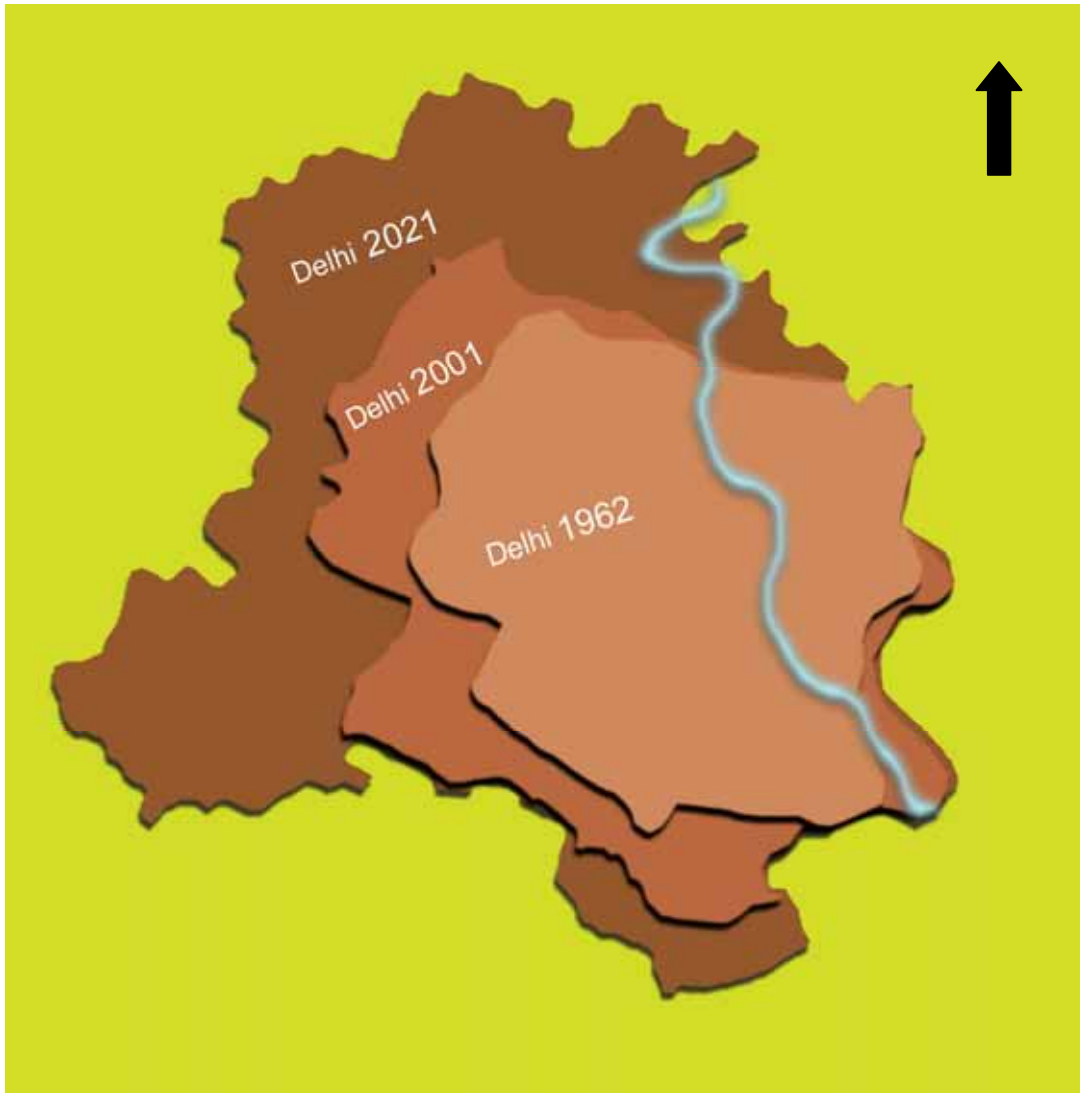
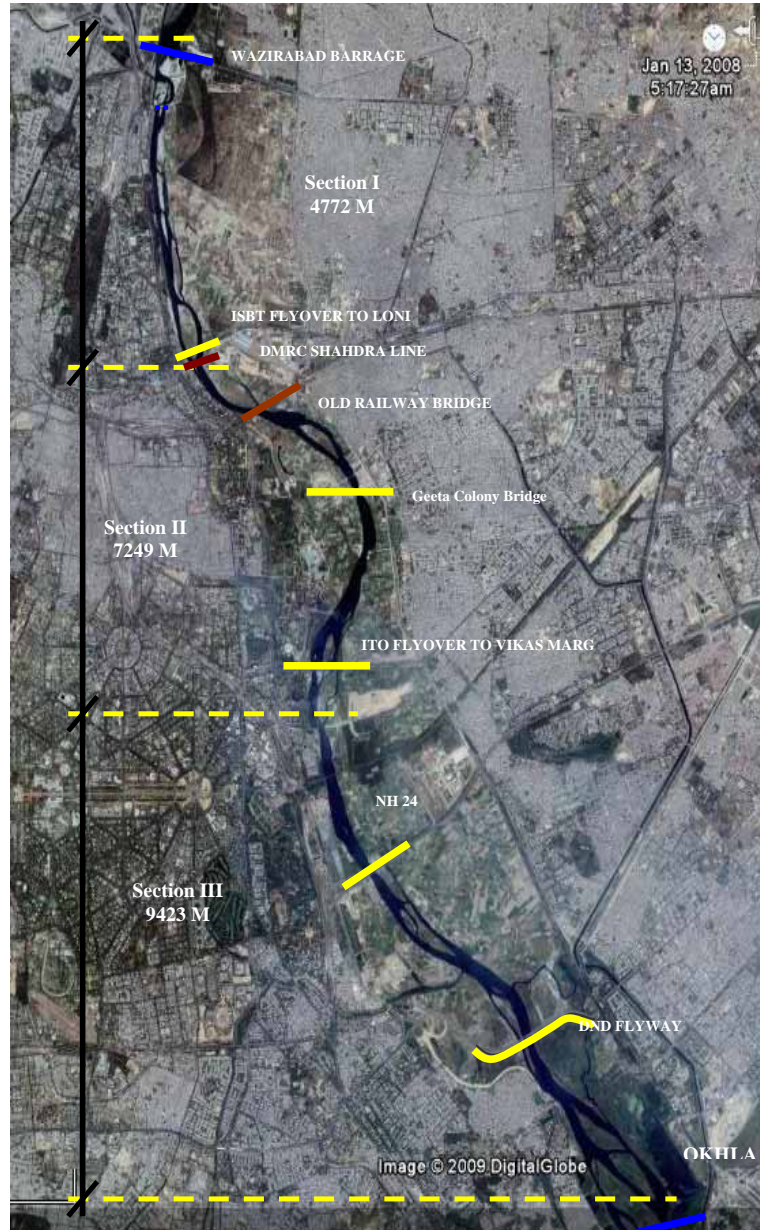


Fig. 4 – Overlay of Delhi National Capital Territory Master plan areas formulated over the three periods from 1962-1981; 1982-2001 and 2001-2021. This is an approximate representation of the Delhi NCT from maps available from DDA’s website for different periods. The development axis of the Delhi NCT is in the NNE, NW and WSW.

Source: Adapted from DDA Masterplans, overlaid and produced by Environics Trust (Not to Scale)

5. RIVER YAMUNA IN DELHI – RIVER CHARACTERISTICS AND STRUCTURAL BRIEFS

River Yamuna is a semi meandering river (a river that winds a course not in a straight line but in a sinusoidal pattern) in small portion from old railway bridge to Vikas Marg bridge. It is the continued action of the secondary flow developed on the river bends that cause further erosion on the outer bank and deposition on the inner bank. The meandering action increases the length of the stream or river and tends to reduce the slope. The three broad sections w.r.t the meandering of Yamuna in the Delhi territory i.e. from Wazirabad barrage to Okhla barrage can be seen in the map. Each section is marked with the flyovers and bridges in a particular section. The protection measures or river training works have to be aligned more closely with the nature of meandering in each of the sections. Section I is more or less linear whereas section II curves at a larger radius and the final section III is moderately meandering.



Google Earth Image

Structures over the river are often planned with a specific purpose of regulating water flows (like barrages), providing linkages (like bridges and flyovers). The Bureau of Indian Standards adopted several of the standards approved by the committees formed for different purposes. The Indian standard IS 7720:1991 was adopted after the draft finalized by the Barrages and Weirs Sectional Committee got approval from the River Valley Division Council in 1975. Delhi forms the reach III of River Yamuna.

Table – 3 Features of River Yamuna in Different Reaches

S.No.	Reach		Distance	Features
1	Reach I	Comprises from origin to Tajewala barrage in the Himalayan segment.	172 km	Canals on both banks at Tajewala / Hathnikund withdraw water for various uses.
2	Reach II	upper segment Tajewala barrage to Wazirabad	224 km. Its Dry Weather Flow (DWF) is comprised of fresh water and waste water from urban and rural settlement in the catchments	Barrage at Wazirabad stores water for meeting the domestic water demand of Delhi.
3	Reach III	Wazirabad to Okhla barrage in Delhi	22 Kms	DWF is comprised of wastewater originating in Delhi. The barrage at Okhla diverts water through Agra Canal to the states of UP & Haryana for irrigation.
4	Reach IV	Okhla barrage in Delhi to confluence with Chambal river	490 Km	No water is released from the Okhla barrage. The DWF is comprised of wastewater from urban and rural settlements.
5	Reach V	Chambal confluence to confluence with Ganga river at Allahabad	468 km	Dilution potential from Chambal River and other streams / rivers

Source: Available from YAP

In the recent Master Plan for the NCT of Delhi, the floodplains of river Yamuna are designated in Zone 'O' expanding to an area of 9700 hectares or 97 sq. kms. Under the statutory provisions of the modified master plan the zone is described as "The area under reference bears special characteristics in terms of being an eco-sensitive area, consisting natural feature with large stretches of land between water course and existing bunds on the sides of river Yamuna. The whole expanse of these stretches are not to be used for development, therefore need to be taken up under Section 8 (Zonal Development Plan) of the DDA Act, but once approved in principal will act as policy framework for formulating action/area plans leading to eco friendly development.

The total area of river Zone is about 9700 hectare of which 6100 hectare is in the southern reach of Wazirabad barrage and 3600 hectares in the northern reach. As per the estimates around 1600 hectares of land is under water (river extent) and rest 8100 hectares as dry land (floodplains). The reach from Wazirabad barrage to Okhla barrage is approximately 4700 hectares.

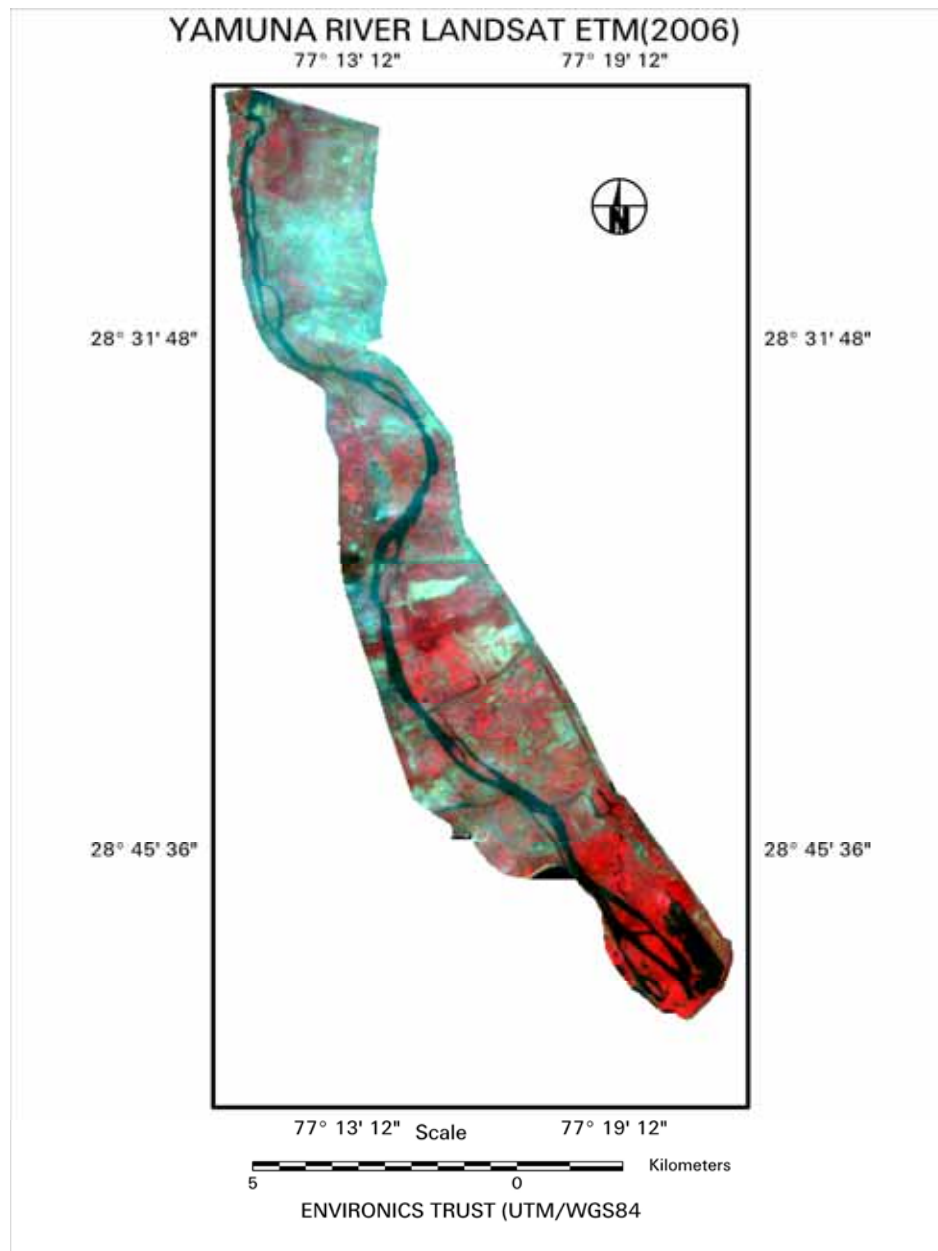


Fig. 5 River Yamuna as seen in Landsat ETM 2006



Wazirabad Barrage-I.S.B.T
(Distance – 3.50 Km)

Parameters	Key Features (w.r.t River & Wzb. Barrage)
North	Sonia Vihar WTP (100m)
South	I.S.B.T. Bridge (3500 m)
East	Colonies (less than 100 m from right bank)
West	Marginal Bund Road (2300 m)

I.S.B.T Flyover-Old Rly. Bridge
(Distance – 1.25 Km)

Parameters	Activity Area 1 – Left Bank (DMRC S.P Depot)
North	Adjoining ISBT
South	Old Rly. Bridge (500 m)
East	Marginal Bund Road (250 m)
West	River Yamuna (275 m)

Old Rly. Bridge - Vikas Marg (ITO) (Distance ~3.9 Km)

Parameters	Activity Area 1 – Left Bank (Geeta Colony Flyover)	Activity Area 2 – Right Bank (Thermal Power Plant, I.G. Stadium, Delhi Secretariat)
North	Old Delhi Bridge (1.3 km)	3 spurs protecting structures
South	IP Barrage d/s (2.5 k m)	
East	Marginal Bund Rd	Close proximity to the river (150-250m)
West	Ring Road	

Fig. 6 – Sectional Overview of Activity Areas in Stretches of Yamuna, generated by ET

Pic. 1



Pic. 2 & 3



Vikas Marg (ITO) - NH 24 (Distance - 2.75 Kms) Pic. 1

Parameters	Activity Area 1 – Left Bank (CWG Village abutting Adham Complex)	Activity Area 2 – Left Bank (DMRC Yamuna Bank Depot)	Activity Area 2 – Right Bank
North	Yamuna Bank, DMRC depot (700 m)	Vikas Marg	Pragati Power and I.P.Power are located between the ring road and the right bank of River Yamuna
South	NH – 24 (50 m)	CWG Village	
East	Noida Link Road (1.05 km)	Noida Link Road	
West	River Yamuna (1.28 km)	River Yamuna (guide bund protecting DMRC property is 330 m from river bank)	Ash Pond enclosed between ring road and the river bank.

NH - 24 To DND (Distance - 3.5 Km) Pic. 2 & 3

Parameters	Activity Area 1: Left bank (DND* Flyway – almost 7-8 km length within floodplains, protected by two guide bunds on the L & R bank.)	Activity Area 2: Left Bank	Activity Area 2: Right Bank
North	NH - 24 (2.47 km)	Memorial park opposite sector 15 running for almost 2-3 kms in length and 400-500 m in width	Casting Yards set up by construction companies for infrastructure projects enclosed between NH 24 (N), Right river bank (E), Barapulla Nallah (S) and Ring Road (W)
South	Okhla Barrage (3.95 km) Okhla Sanctuary (100 m)		
East	Settlements adjoining river		
West	Dadri Road (from left bank) (1.31 km)		

* distances from central DND stretch

Fig. 6.1 – Sectional Overview of Activity Areas in Stretches of Yamuna

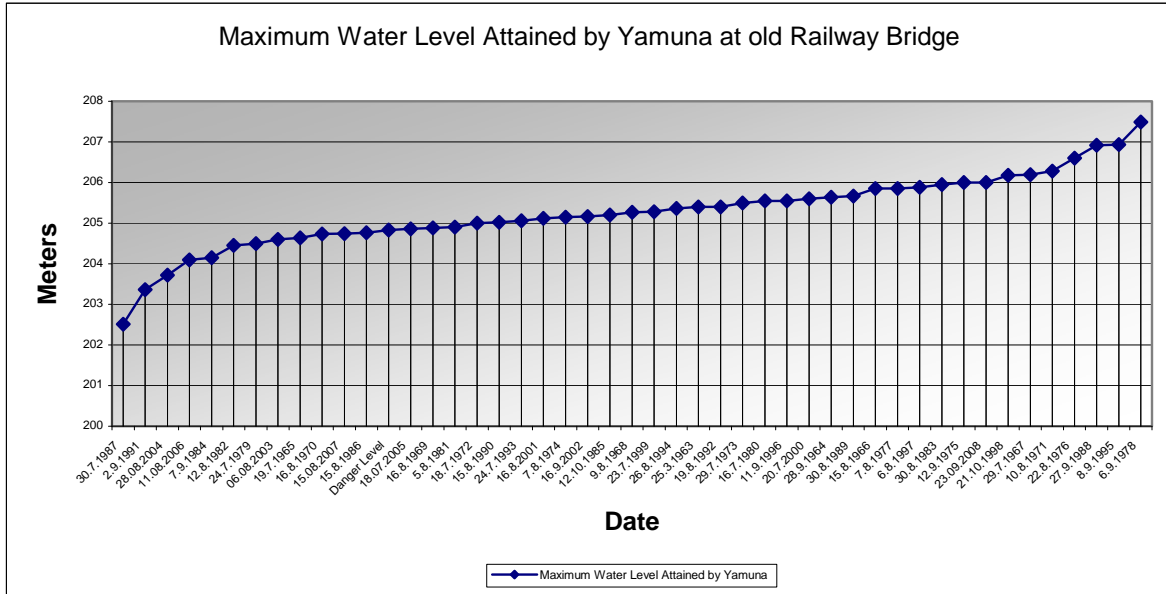


Fig. 7 – Maximum Water Level Attained by Yamuna in Delhi
 Source (fig. 7&8) : Flood Order of 2009, Irrigation and Flood Control Department, Government of Delhi

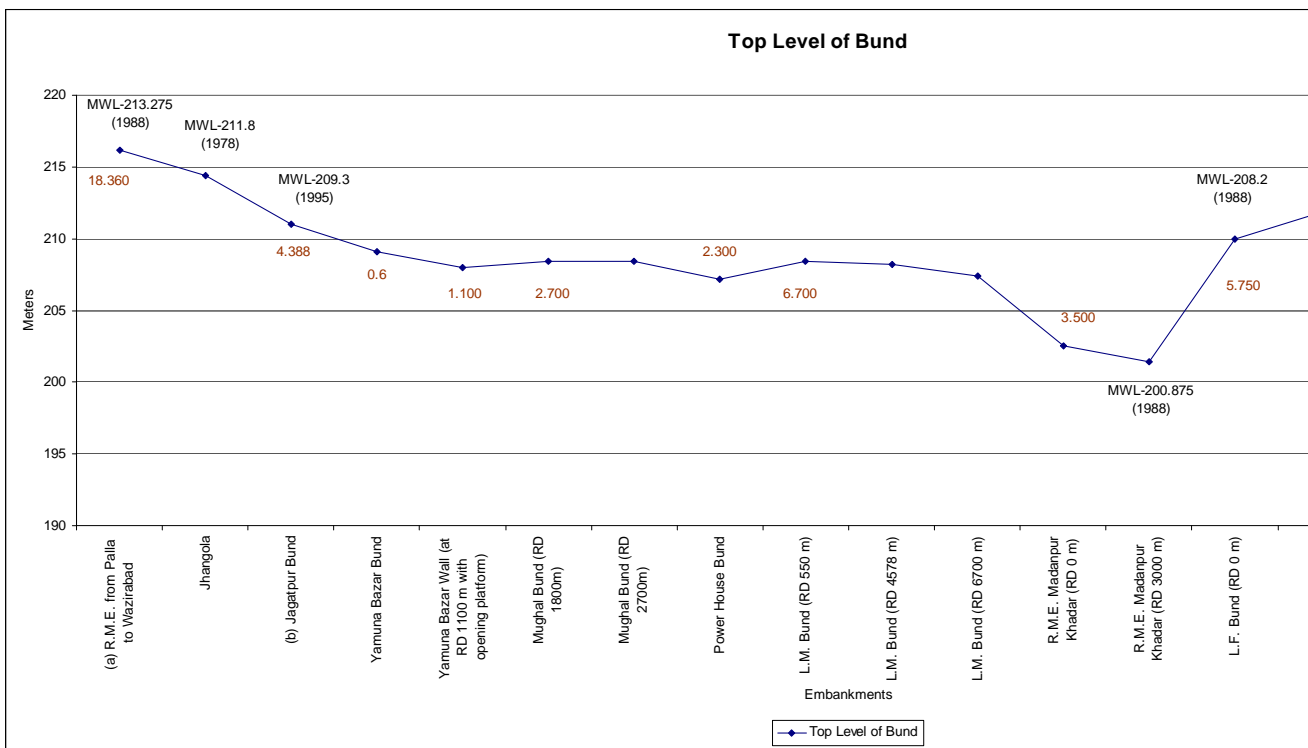


Fig. 8 - Depicting top level of embankments along the river Yamuna.
 Number in red indicate the respective length of embankment.

Around 58 Kms of embankments³ run along Yamuna in the NCT of Delhi (under the control of I&FC) and some peripheral parts touching Haryana. The time series data of maximum water level attained in River Yamuna over years reveal that in almost 34 events the water level has crossed the danger level of 204.83 m as stated by the I&FC department in its latest flood order of 2009. Around 406 kms of drains⁴ under control of Irrigation and Flood

³ see annexure – Embankments in and around NCT Delhi

⁴ see annexure – IFC drains

Control department run through different blocks of Delhi. Most of the transportation linkages connecting eastern Delhi have been planned on and over this region. As more and more linkages are provided, strengthening and provision for further training works is expected.

a. THE FACTS & ISSUES PERTAINING TO RIVER YAMUNA IN NCTD

Upper Yamuna River Board	Minimum Flow
---------------------------------	---------------------

Maintenance of minimum flow is the responsibility of Upper Yamuna River Board for which an MOU was signed between the Governments of Uttar Pradesh, Haryana, Rajasthan, Himachal Pradesh and NCT of Delhi on 12.05.1994 regarding allocation of surface flow of Yamuna upto Okhla which provides that ‘a minimum flow in proportion of completion of upstream storages going upto 10 cumec shall be maintained downstream of Tajewala and downstream of Okhla headworks throughout the year from ecological considerations, as upstream storages are built up progressively in phased manner.’ It is to mention here that this provision is regarding releases of water in the downstream from Tajewala & Okhla barrages and not for any particular section.

The release of 10 cumec is the upper limit when the upstream storages are created. No lower limit has been prescribed in the MoU. It may be mentioned here that till date no storage capacity has been created, even when all the storages are created, the maximum prescribed release in the MoU for ecological purposes is only 10 cumec (or 352 cusec). Although the upstream storages are yet to be built up, 160 cusec of water is being released from Tajewala barrage into river Yamuna as per the statement of discharges ex-Tajewala supplied by Haryana. Besides this 140 cusec is also released by Haryana into river Yamuna through Najafgarh drain downstream of Wazirabad barrage, as stated by Haryana.

As per the MoU pending construction of the storages in the upstream reaches of the river in the basin, an interim seasonal allocation of the annual utilizable flow of River Yamuna to NCT of Delhi is

July - Oct (BCM)	Nov-Feb (BCM)	March - June (BCM)	Annual (BCM)
0.580	0.068	0.076	0.724

Provided that the above interim seasonal allocation shall get progressively modified, as storages are constructed. As per distribution of water made by UYRB to basin states, 381 cusec of water at Tajewala and 369 cusec water at Wazirabad is provided to NCT of Delhi. This includes 51 cusec water for irrigation purposes.

Central Water Commission Irrigation and Flood Control, Delhi ⁵	Management of Water Resources (floods, river management) / Clearances Drain, Flood Management
---	---

CWC, a premier technical organisation in the field of water resources functions as an attached office of Ministry of Water Resources, GoI. As far as planning, design and

⁵ (i) Construction and maintenance of trunk storm water drains in Delhi including certain inter-state drains bringing storm water from neighboring states of Rajasthan and Haryana (ii) Construction, Maintenance and improvement of marginal embankments and execution of anti erosion and river training works on both banks of river Yamuna for the safety of Delhi against Floods and (iii) Providing irrigation facilities to the rural areas of Delhi by installation of shallow/deep tubewells and providing lift irrigation by utilizing the treated sewage effluent available from sewage treatment plants at Keshopur, coronation treatment Plant and Okhla Treatment Plant.

execution of water⁶ regulatory structures and flood management is concerned; the responsibility lies with the government of NCTD for regulating, guiding and appraising physical development pertaining to River Yamuna. Central Water Commission or River Management wing of CWC⁷ does not have a mandate for regulating, guiding and appraising physical development pertaining to Yamuna River in the city of Delhi.

Designs of embankments, guide bunds forming part of flood control schemes are examined in CWC. The designs of various components of flyovers/bridges like piers, columns, foundations in general are not referred to CWC for appraisal, however structural components forming part of the specific flood management schemes requiring appraisal as per guidelines of the planning commission/MoWR are appraised by the RM wing/other specified wings of CWC with respect to their relevance in flood management. CWC appraises the flood management schemes costing more than Rs. 7.5 crores on River Yamuna lying between Hathnikund barrage and Okhla barrage. CWC does not accord ecological clearance.

Yamuna Standing Committee	Accord Clearance to Development Projects concerning River Yamuna and its floodplains
---------------------------	--

The proposals for construction of the flood protection works in River Yamuna and public utilities structures like bridges over river Yamuna submitted by the GoUP, Haryana and Delhi are examined by the YSC in context of functions mandated to it. If considered necessary, the model studies are carried out to know any adverse effects of structures proposed.

Yamuna Standing Committee was constituted in 1961 under the chairmanship of Member (RM) CWC [erstwhile member (flood)]. The director (FM-I) [erstwhile director (floods)], CWC provides secretariat services to YSC. YSC was constituted to study the interests of Delhi, its suburbs and the northern railway bridge and other studies on Yamuna at Delhi against undue increase in maximum flood level in Yamuna at Delhi on account of flood control works upstream and to safeguard the interest of Haryana, UP and Delhi against adverse effects of flood control works.

In its 37th meeting in 1979, it was decided that the minimum spacing between future embankments on the banks of river Yamuna should be 5 km. And the embankment should be aligned at a minimum distance of atleast 600 metres from the active river edge at the time of construction of embankments. On these similar lines, the Hon'ble High Court of Delhi issued an order in 2005 stating that no structure should be allowed to exist within 300m on either side of river, in the first instance.

Central Water and Power Research Station (CWPRS), Pune	Hydraulics Research, Mathematical and Physical Modeling of River Yamuna
--	---

CWPRS is a part of Union Ministry of Water Resources and is one the foremost organizations in the world in the field of hydraulics and allied research. It is perhaps the

⁶ The entry 17 of list - II (state list) of constitution of India, includes the provision of water, that is to say, water supplies, irrigation and canals drainage and embankments, water storage and power subject to the provision of entry 56 of List - I (Union List). The Union MOWR is responsible for laying down policy guidelines and programmes for the water resources development and regulation of country's water resources.

⁷ As recommended by a group of hydrologists presided over by Member (WP&P) , CWC in 1998, a flood discharge equal to 9910 cumecs as design flood and 12750 cumecs as check flood should be used for all structures and embankments on river Yamuna in Delhi reach (as per letter dated 5.6.03 by Director (Hydrology - N) Directorate, CWC.

only organisation ultimately being chased for technical clarifications and advise is Central Water and Power Research Station based in Pune. CWPRS conducts modeling studies with regard to structures coming up on the riverbank / floodplains. Several mathematical and model studies from time to time have been taken by CWPRS. However there is no master plan or a comprehensive study of the city stretch of River Yamuna to present the overall scenario with a consideration of all the proposed (master plan) bridges in place and analyzing the river behaviour.

National River Conservation Directorate	River Conservation: Pollution Abatement
--	--

NRCD has a mandate to prepare National River Conservation Plan to tackle the pollution load of domestic sewage entering into the rivers based on the proposal received from the state government.

Initiated by GoI in April 1993	Funding from Japan Bank for International Corporation (JBIC)		
Closure in February 2003	Total Cost incurred Rs. 678 Crores		
State	Sewage Treatment Capacity Created (mld)	Expenditure (Rs. Crores)	
Haryana	309	245	
Uttar Pradesh	402	273	
Delhi	30	160	
Total	741	678	

Source: NRCD, MoWR, GoI - Complied by ET

DJB and MCD are the implementing agencies for the YAP – II in Delhi. Under YAP – II major works in Delhi include creation of sewage treatment capacity of 135 mld (new) and 324 mld of rehabilitation works along with laying of 30.82 km (new/rehabilitation) sewer lines. The government of Delhi has made a major proposal of interceptor sewer for the three major drains namely Najafgarh, Shahdara and supplementary which are entering into the river. The tentative cost is more than Rs. 4000 crore.

Delhi Urban Arts Commission	Urban Form & Clearances to Physical Development Projects
------------------------------------	---

DUAC's role is to advise on matters concerning quality of urban and environmental design of facilities in the NCT of Delhi. Such facilities pertain to physical development including building designs, aesthetics with the surroundings and overall view of the project design. Most of the projects cleared by the DUAC in the recent past are traffic and transportation projects (MRTS, Flyovers, Bridges across Yamuna) where the concerns have been to analyse the design as such without going into the viability or requirement of the project per se and to identify gaps in the existing proposals looking at the integrity factor with surrounding activities and thereby giving its recommendations and subsequent clearances from urban form and design aspect of it.

Ministry of Environment & Forests (MoEF)	Environment Impact Assessment, Environment Clearances, Forest Clearances
---	---

The role of MoEF is to appraise and accord environmental clearance to sectoral projects. In the 2006 EIA notification, the scope for environment impact assessment for highways has been restricted by the threshold limit i.e. EIA needed in case of highways extending 30kms or more or for new highways. It is pertinent to note that mega cities grow at a rapid pace and need for bridges/roads is unavoidable to provide linkages but there has been no

process to have a comprehensive statement of the environmental impacts of such structures. The impact assessment statement becomes more important when such structures interfere with the limited floodplains of the river. The only criterion is to provide 'consent' by the state authorities if the MoEF considers that the project does not require 'environmental clearance'. In case of such projects in the NCT of Delhi, DPCC accords consent to establish for such projects like in case of Wazirabad bridge⁸.

Central Ground Water Authority	Regulation and Control of Ground Water Management and Development
---------------------------------------	--

CGWA constituted under Section 3(3) of EPA Act, 1986 is an authority responsible for protection of environment through balanced ground water development. In this backdrop, the CGWA based on the study conducted by the CGWB identified the aquifers underlying the entire flood plain of Yamuna River within the NCTD as the potential aquifers for development and management of ground water resources through dewatering and refilling to meet the drinking and domestic needs of NCT. To do so i.e. judicious protection and management of aquifers, proposed to regulate the activity of construction, installation and drilling of any new abstraction structure for extraction of ground water in the entire Yamuna flood plain of NCTD by declaring the entire floodplain as 'Notified Area'.

Though the authority has limited itself to regulation of construction, installation and drilling of any new abstraction structures for extraction of ground water in the floodplains other than drinking and domestic purposes, it has not mentioned about the management of floodplains as a comprehensive planning unit looking at the risks of shrinking of floodplains and also increased surface runoffs due to concretization.

⁸ In the 39th meeting of committee constituted for deciding the consent under orange category dated 05-02-08 gave consent to establish on the grounds that DTTDC has produced a letter from MoEF stating that Environmental Clearance is not required for such projects.

6. LAND ACQUISITION

In the NCT of Delhi land is acquired by Land and Building Department on behalf of all Government agencies in Delhi under the “Large Scale Acquisition, Development and Disposal of Land in Delhi” scheme, introduced in 1961. Departments have to send demands for acquisition to the Land Acquisition Collector concerned for identification of the land, following which a notification under the Land Acquisition Act is issued.

The government of NCTD in the year 1989-1990 issued Gazettee notifications to acquire lands for various purposes and the most expanded acquisition was for the public purpose i.e. channelisation⁹ of River Yamuna apart from lands acquired by L&B department for various activities like construction of drains, remodeling of drains, resettlement of affected persons due to 1962 floods. Since 2000 onwards, most of the notifications issued for land acquisition are for the development of mass rapid transportation system being developed by DMRC over different routes in the state of Delhi. Some reflections of these acquisitions are being showcased in the following sections with the help of snapshots of areas with details of lands acquired for the purpose of ‘channelisation of River Yamuna’¹⁰. The current paradox is that now most of the land vests with the government (in the immediate floodplain of River Yamuna) and the construction of transportation projects like flyovers, bridges etc would only require transfer of land from one department to the other¹¹. The departments involved in such transfers are Delhi Development Authority (transferred 660 Sq. mts of land for Ghazipur grade separator), Irrigation and Flood Department of Delhi, which acquired some 420 acres or 170 hectares for drains and flood plain areas so far. The gazette notifications for 1961, 1990, 2001, 2003, 2004 and 2006 were studied to understand the purpose of acquisition as well as the extent and location of such an acquisition.

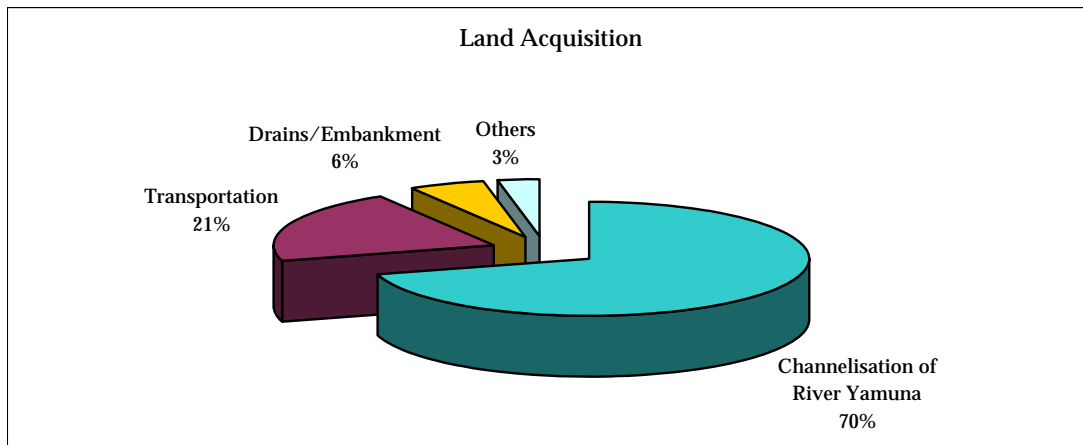


Fig. 9 – Depicting ‘purpose’ of land acquisition for the years mentioned above. Large share of land acquisition in the name of channelisation of river Yamuna. Transportation category includes majorly land acquired for MRTS systems being set up followed by land acquired for embankments and remodeling of drains.

⁹ See annexure – Land Acquisition by Various Agencies

¹⁰ Notification No. F9(1)/89-L&B-15504, F9(1)/89-L&B/LA-15221, F9(1)/89-L&B/LA(iii)/15505

¹¹ Change in Land Use and Proposals

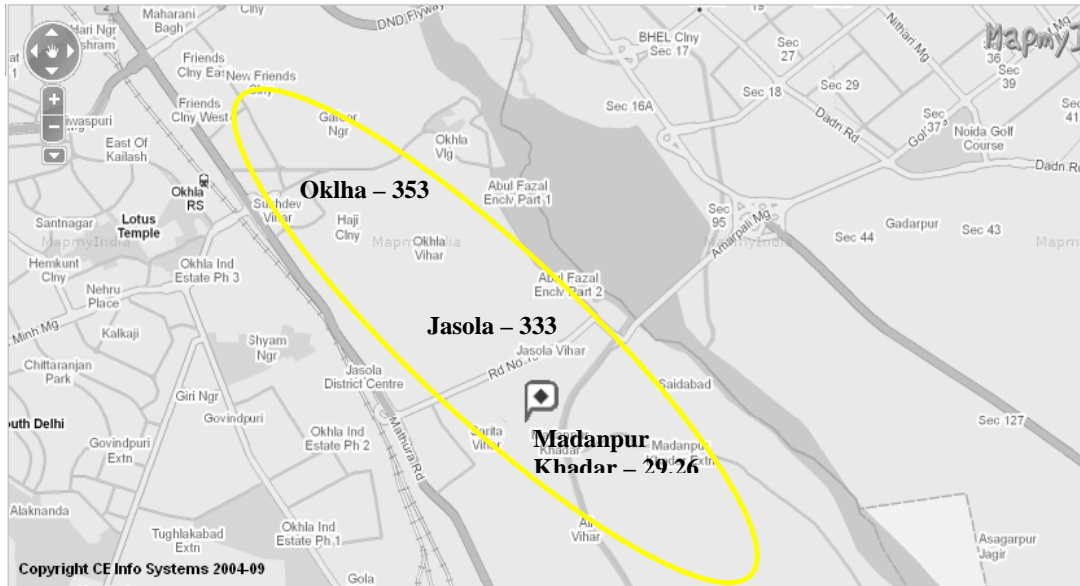
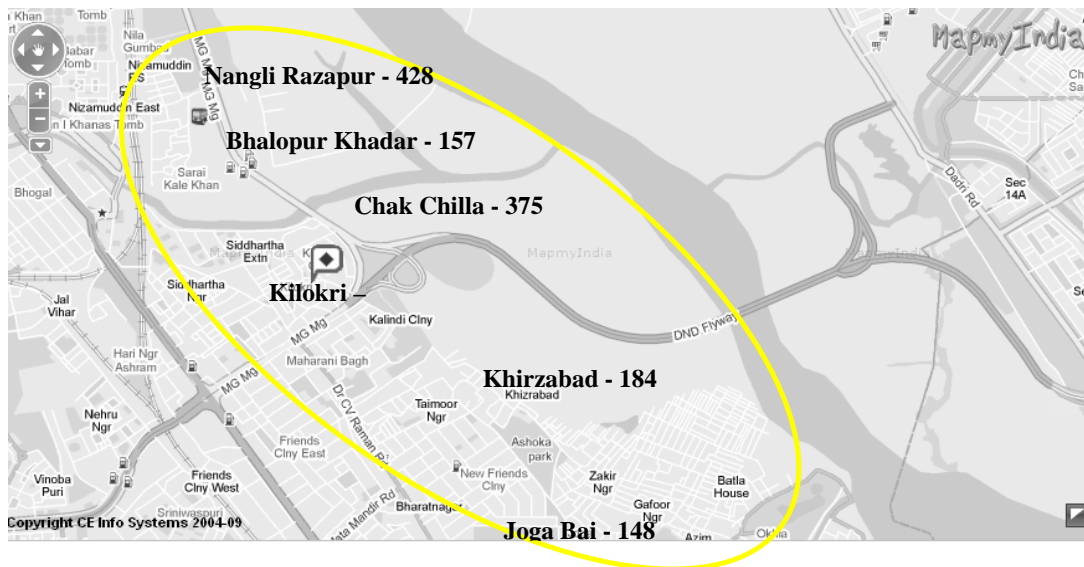


Fig. 10 (above) & 10.1 (below) representing snapshot of localities where lands were acquired for channelisation of River Yamuna, almost two decades back. The exceedingly favoured concept of channelisation of rivers through engineering measures without looking at competing resource needs as well as need for floodplains as an essential element for flood moderation, water recharge, flood containment etc. and the moderator of local environmental conditions has increased over the years. The villages of Nangli Razapur, Bhalopur Khadar, Chak Chila, Kilokri, Khirzabad and Joga bai are presented in the map below indicating their proximity to the river and also seen is the DND flyway in 2001 expanding on the eastern and western bank of River Yamuna.



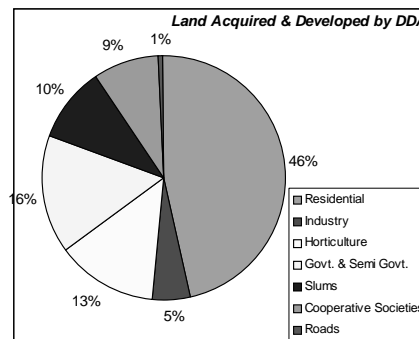
With an overarching goal of greater control over resources in the city, land acquisition is a perfect fit for making decisions where lopsided resource balance becomes a deciding factor for environmental fate. Application of clauses to procure land through land acquisition Act of 1894 reflects the state power that it can exercise to have larger control over resources. Development of cities in the current context is a perfect example of abusing our environment and its basic elements i.e. water, air and soil which are the basic livelihood and living elements.

The administration of land acquisition and the liberty of using special provisions by the government without any thoughtful thinking indicates lack of planning, desire to have greater control over resources, causing delays and cost overruns which ultimately cause impact on the public exchequer. CAG, the supreme audit agency audited¹² the land acquisition records in the Land and building department and Land Acquisition Collectors from 1996-97 to 2001-02 which revealed that

In almost 60% of the total test check records of land acquisition (92 cases) urgency clause was invoked by the LAC. However, the department failed to take possession of land in 50% of the cases even upto the date of declaration of the awards which was done only after periods ranging from 368 to 739 days reckoned from the issue of notification under Section 6 of the Act. In remaining 50% cases possession of land was taken by the departments 16 to 693 days after the issue of notification under section 6. CAG concluded that in the circumstances, the purpose of invoking the enabling provision on grounds of urgency would appear to have been defeated apart from adversely affecting the projects for which the lands were to be acquired. But it did not comment on the hardships which the people might have faced as a result of State's decision to invoke urgency clause and then defeating the purpose by exceedingly delaying the possession.

Major Achievements, DDA				
S.No.	Function	2002-03	2003-04	2004-05
1	Land handed over to DDA by LAC (Acres)	2129.78	770.697	1781.92
2	Demolition operations carried out (Nos.)	472	354	326
3	Land reclaimed by removing JJ Clusters (Acres)	374.54	259.44	181
4	Structures/buildings removed	14567	13077	14937
5	Recovery of damages made (Rs. Crores)	1.15	1.37	1.57
6	No. of damage cases decided	835	887	321
7	Prosecution cases launched	599	183	390
8	Fine imposed by court (Rs. Lacs)	4.21	13.69	17.3

Another way of reclaiming land i.e. by evicting JJ clusters has been termed as achievements by the prime development agency i.e. Delhi Development Authority. So far DDA has acquired 27270 hectares or 272.70 square kilometers of area in Delhi. It also claims to have developed 88% of the area acquired so far.



¹² Report on Government of NCT of Delhi of 2003, Chapter 3 (3.3 – Irregularities in Land Acquisition), Page57

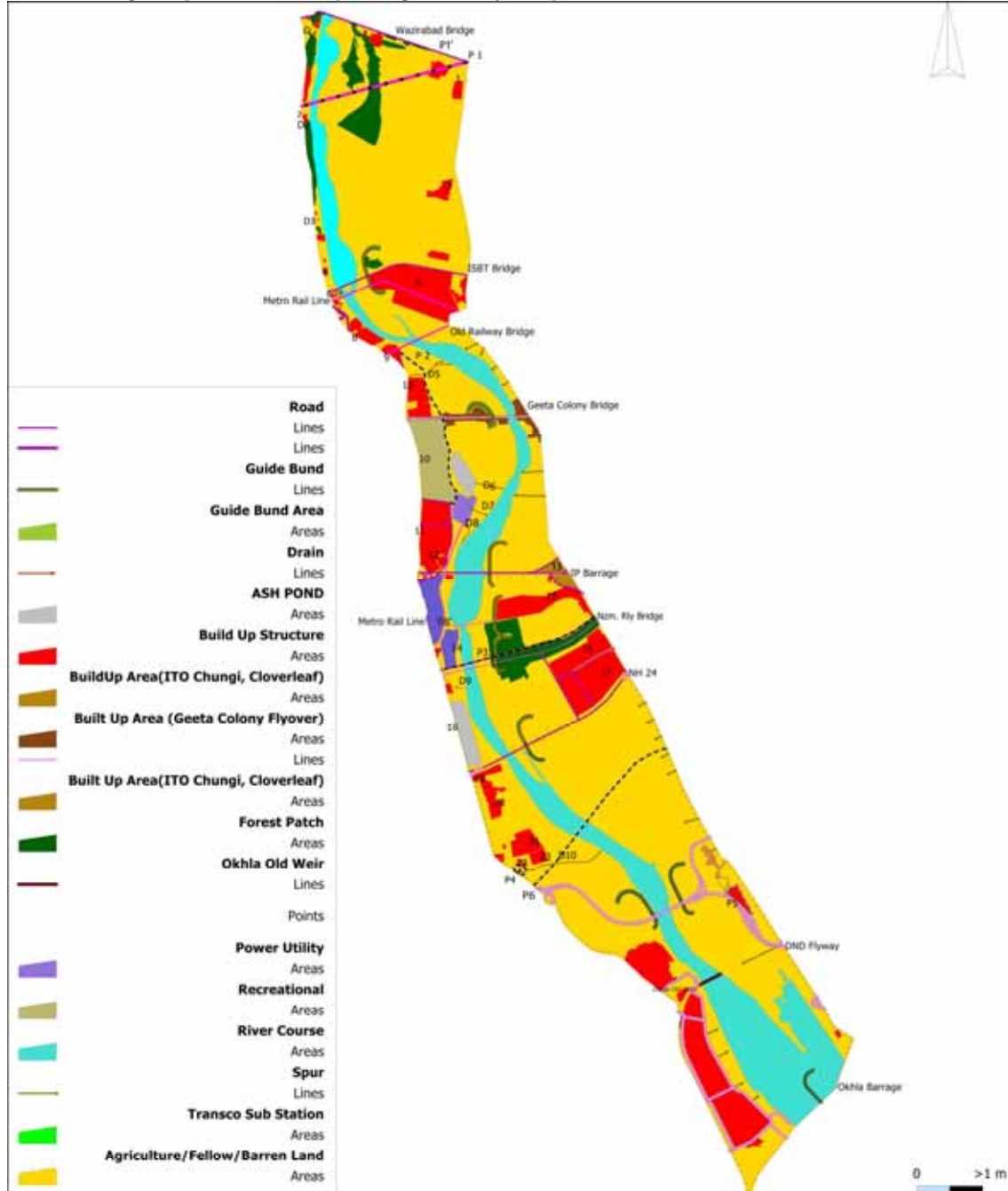
Extreme Cases:

In case of Delhi MRTS (DMRC), land acquisition was done under urgency clause of the Land Acquisition Act 1894 and the courts upheld this. However, the same was not used in the other Metro rail systems being developed in the country and wherever tried, the courts struck them down. In some of the cases, the land acquisition exceeded its requirements even more than 350% as audited by CAG.

The GNCTD through its order dated 30.03.1998 ordered for resumption of 206.72 acres of land from DDA out of the acquired land for transfer on lease to NOIDA [four villages of Kilokri (153.43 acres), Khirzabad (11.05 acres), Chak Chilla (42.24 acres)], meant originally for channelisation of River Yamuna by DDA, for the construction of DND flyway. The possession of the same land was handed over to NOIDA on 24.04.1998. Subsequently, land measuring 141 acres from four villages of Khirzabad, Okhla, Jogabai and Chakchilla was acquired under provisions of section 4 (02.04.1998) was given on lease to the company i.e. NBTCL for the same purpose. An area of approximately 100 acres was kept as an event organizing site in the name of Times Global Village on the north of DND. This forms a huge chunk of land transferred in name of a company managing road operations. The lease deed was executed on 23.10.1998 for a period of 31 years on annual lease rent of Re 1/- and payment of Rs. 50/- was received in consideration of possible extension of the lease period upto 50 years.

7. DESCRIPTION OF STRUCTURES OVER RIVER YAMUNA

River Yamuna in Delhi has a series of barrages and bridges which got developed to regulate river flow as well as connectivity to the trans Yamuna region and to the satellite towns in the vicinity. Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS) have devised guidelines for road bridges, river training works, barrages operation and maintenance etc. an overview is presented in the following section on structures over River Yamuna alongwith photo features explaining the utility and problems.



YAMUNA RIVER

ENVIRONICS TRUST
 Mercator
 Lon: 77°15'46" E
 Lat: 28°37'27" N

Map 1

Table 4 - List of Structures over River Yamuna

S.No.	Bridge/Flyover	Year	Purpose	Agency	Approx. Distance between two bridges (m)	River Width (m) at bridging point
1	Wazirabad Barrage	1959	Water Storage	NPCC	0	450
2	ISBT Flyover	1990*	Trans Yamuna Connectivity	NBCC	4500	340
3	ISBT-Dilshad Garden Metro Line	2005	MRTS - Ph I	DMRC & Consultants	160	209
4	Old Railway Bridge	1909	River bridge	N. Railway	1390	185
5	Bye Pass Road (Salimgarh Fort - Velodrome)	u/c	Relieving load on existing ring road	PWD	Runs along river	n.a.
6	Geeta Colony Bridge	2009	Additional linkage	PWD	3540	100
7	Vikas Marg flyover (IP Barrage)	1966-68	Linking Trans Yamuna	Haryana Irrigation	2870	470
8	Yamuna Bank Metro	2009	MRTS - Ph II	DMRC	900	140
9	East West Corridor	Proposed	East-West connectivity	PWD	Tentative alignment	Not available
10	NH 24	1992/1998	Bypass	L&T	2350	158, 348
11	Barapulla elevated road	u/c	Smoothen linkages to games village	PWD	n.a.	n.a.
12	DND Flyway	2001	Delhi Noida express link	ILFS	3690	255
13	Okhla Barrage	1986	Water diversion to Agra through Agra Canal	Irrigation Department	4120	575
14	Metro Phase III & IV ¹³	Proposed	City wide connectivity	DMRC	Tentative alignment	

Source: Extracted from Google Earth [River width or distance between visible left and right banks as observed and measured from Google Earth] [* - approximate; u/c - under construction; n.a. - not applicable]

Indian Roads Congress (IRC) has a series of guidelines for bridges across rivers and other related aspects.


- As per the definition of linear waterway, which is the total width of the waterway of the bridge at HFL, whereas effective linear waterway would be a subtraction of effective width of obstruction (i.e. piers / columns / abutments) from the width of the waterway of the bridge at HFL. As per the codal provisions of IRC: 005-1998, the width of obstruction due to each pier shall be taken as the mean submerged width of the pier and its foundation upto the normal socur level.
- As per 104.8 of IRC:005-1998; Effect of presence of Dams, Barrages, Wiers, Sluice Gates etc. on the rivers affect their hydraulic characteristics like causing obliquity and concentration of flow, scour, silting of bed, change in flow levels, bed levels etc. These effects shall be considered in the design of bridges depending upon whether

¹³ DMRC map from http://www.delhimetrorail.com/commuters/images - master_map.jpg


the proposed site of the bridge is upstream or downstream of a dam, barrage or a river. *Since the above parameters depend on many factors which are varying from site to site, no uniform guidelines can possibly be laid down, Such problems may be jointly taken up with the concerned department and suitable provisions made in the project design.*

- 105 – Spacing and Location of Piers and Abutments alignment of the piers and abutments shall as far as possible, be parallel to the mean direction of flow in the channel, as well as the direction of other piers and abutments in the vicinity, but provision shall be made against harmful effects on the stability of the bridge structure and on the maintenance of the channel banks, contiguous to the bridge due to any temporary variations in the direction and velocity of the current. Placing a pier at the deepest portion of an active channel may be avoided by suitably adjusting the number and length of the spans.

Table 5 – Salient Features of Structures over River Yamuna

S.No.	Bridge/Flyover/Barrage	Description	Technical Features
1	Metro Link (Crossing at ISBT) Phase I of the MRTS project of creating a network of 52 kms.	14*46.2 m & 2* 26.00 spans with a linear waterway of 612 m was constructed on well foundations <ul style="list-style-type: none"> ▪ The foundation of bridge is on well foundation of 8m dia and approximately 35m deep. During construction, the water channel was diverted temporarily at two locations and wells were sunk ▪ The well foundation in dry river bed, there was a clear access and wells were sunk. The piers were constructed with ready built steel shuttering and ready mixed cement concrete ▪ The bridge was constructed in such a manner that there was assumably no impact on environment 	<ul style="list-style-type: none"> ▪ The site about 860m downstream of Lok Nayak road bridge was found suitable for locating the proposed railway bridge from hydraulic considerations. ▪ Orientation of the proposed bridge axis i.e. 860 m downstream of Lok Nayak road bridge on the right and 823 m downstream of Lok Nayak road bridge on the left side was recommended ▪ A waterway of 600.6 m would cause afflux of 9-10 cm only at the proposed bridge axis which is considered to be negligible. At the lok nayak road bridge, the afflux will be reduced to 8-9 cm and upstream of Indraprastha barrage it will be only 6-7 cm that means the effect of afflux would be negligible beyond the I.P barrage also ▪ Further the construction has been approved by the Yamuna standing committee. 
2	DND Flyover Acting as node for bringing in	<ul style="list-style-type: none"> ▪ 8 Lane expressway (Delhi – Noida – Delhi) ▪ 7 – 8 km links with 552 metre long main bridge across the river. 	<ul style="list-style-type: none"> ▪ 1.36 km upstream of Okhla weir ▪ Waterway of 552 m ▪ Mayur Vihar link built on an earthen embankment through the floodplain areas of Yamuna river

S.No.	Bridge/Flyover/Barrage	Description	Technical Features
	and taking out arterial traffic at a faster pace	<ul style="list-style-type: none"> ▪ 3 minor bridges ▪ Barapullah Nallah diversion 	
3	<p>Geeta Colony To Facilitate traffic movement to and from trans Yamuna, Cental & North Delhi. The other reason given is: since old Yamuna road cum rail bridge has out lived its life as such for augmenting the trans Yamuna traffic flow, this alternate bridge at Geeta colony was constructed</p>	<ul style="list-style-type: none"> ▪ 560m (14 spans of 40m each). A single span is provided over creek near Shantivan. ▪ 30 wells and piers (flat piers tapering at base and resting over 8m diameter with 35.5 m deep single well below each pier. ▪ 32 m is the depth to bedrock ▪ H.F.L. - 208.21 m ▪ Technology used in well foundation with prestressed concrete. ▪ Guide bund to channelise river flow. Widening of Marginal bund road from Rajghat power house to Shantivan (flyash core) ▪ 129.07 Crores 	<ul style="list-style-type: none"> ▪ Guide bunds at height more than HFL as suggested by CWPRS ▪ Land transferred from government to government ▪ Work of eastern guide bund was held up due to land dispute with U. P. Government ▪ Pier is provided with semi circular cut waters at u/s and d/s sides to reduce the impact of water current forces ▪ Wells have been sunk to a depth of 36.5m below the low water level of R.L.210.50m ▪ The bridge is connected on the western side (i.e. Shantivan side) by approach embankments approximately 1800 mtrs long. ▪ On the Eastern side (i.e. Geeta Colony Side), the original proposal was to connect the bridge to the existing bund road by approximately 540 mtrs long approach road. ▪ A water way of 560 m would cause an afflux of 15-20 cm at the proposed bridge axis. At the old rail-cum-road bridge the afflux was reduced to 10-15 cm. That means the effect of afflux will not be going beyond old rail-cum-road bridge.
4	<p>Wazirabad bridge – Claim is to construct this cable strayed bridge to improve traffic movement</p>	<ul style="list-style-type: none"> ▪ 600 m d/s of Wazirabad barrage ▪ Main span is 251 m long and remaining 36m each. ▪ Main bridge – cable stay system with inclined steel pylon & composite deck with steel girders ▪ Depth to bedrock varies from 3 – 30m ▪ Depth to G.W. varies from 07 – 20 m ▪ H.F.L – 209.66 m ▪ Rs. 887.29 crores 	<ul style="list-style-type: none"> ▪ Location of proposed bridge & waterway of 570 m would cause an afflux of 18-20 cm at proposed bridge axis. Such a high afflux can cause drainage congestion in the Najafgarh drain / supplementary drain during monsoons. An additional waterway on left bank should be provided. Final afflux to be at 10-12 cm with increased waterway of 675 m ▪ Transfer of government land from DDA & L&DO and no private land to be acquired.

S.No.	Bridge/Flyover/Barrage	Description	Technical Features
5	Yamuna Bank (Metro Link)	<ul style="list-style-type: none"> ▪ A bridge of Length 698.8 metres between Indraprastha Metro Station to Yamuna bank depot costing 39.18 crores. ▪ Total No. of Spans – 16 includes 2 Cast-in-situ of 26 metres ▪ Length of Span – 46.2 metres Total No. of Segments – 224 No. of segments between 2 piers – 16 segments ▪ Total No of Piers – 17 ▪ Foundation Type – Well Foundation as this is good for sandy soil ▪ Depth of Foundation – 35.5 metres ▪ No. of Wells – 17 ▪ Outer Diameter of the well – 8 metres ▪ Inner Diameter – 6 metres 	

Source: Compiled from Various Documents

Table 6 - Select Parameters of Bridge Structures Proposed/Implemented across River Yamuna

S.No.	Features	Yamuna Bank	ISBT	Wazirabad Bridge	Geeta Colony
1	No. of Piers	17	14 (14*46.2m)	-	30
	Mono Pier/Pair of Columns	Mono	Mono	Cable Stay and composite deck with girders	Pair of Columns
2	Distance between span	46.2 m	42.5 m		40 m
3	Pier design		Capsule shaped pier with rounded edges	-	Semi circular
4	Technology / Method used for bridge construction	Well foundation	Well Foundation	-	Well foundation
	Well Diameter	8m (2m thick)	10 m	-	8m
	Depth of Well	35.5 m	39 m	-	36.5 m
	Maximum Scour level	Not available	181.3 m (22.7 from B.L)	Not available	Not available
	HFL	-	208.90 m	209.66	208.21
	Waterway	-	612 / 600.6	675 m	560 m
	Afflux	-	9-10 cm at bridge axis 8-9 cm at lok nayak setu 6-7 cm upstream of IP barrage	18-20 revised to 10-12 cm	15-20 cm at bridge axis; 10-15 cm at old rail cum road bridge
5	Embankments	-	Structural barrier	Under construction	approach embankments approximately 1800 mtrs long (shantivan side)
6	Guide bunds	On left bank			Right bank

Source: Compiled from Various Documents (Minutes, Annual Reports, Articles)

Well foundation technique is being employed in almost all the piers erected for the bridges spanning across Yamuna. In this technique a hollow circular steel edge is installed on the ground followed by a steel shuttering. Concrete is poured inside the wall structure or about 1-2 m thickness. Under the weight of jack base assembly the well is sunk at about 34 to 39 metres below the ground. Several studies indicate that this region is seismically active and prone to liquefaction for which seismic parameters, apart from hydraulic parameters need to be factored for site specific activity. For lack of information it could not be determined, if this had been done or not!

Barrage

A barrier across a river intended to control the flow of water.

A Pontoon bridge and the Wazirabad Barrage seen in the background. A new Wazirabad bridge is planned approx. 600 m downstream of existing barrage cum bridge.

Wazirabad barrage pondage, several people can be seen camping for fishing at this location.



Downstream of Wazirabad barrage, even minimum flow conditions don't prevail throughout the year. One can notice the raised central portion of river bed, the flow is through the right bank.



Water pipeline from Sonia Vihar Plant running almost parallel to Marginal Bund Road leaking at a 'shower rate'

Barrages have gained importance as an engineering measure to tap water for different purposes like irrigation, flood control and water supply. But management of existing water supply system and level of treatment facilities remain as dismal as ever. Scene at the Wazirabad Barrage which was built by NPPC in year 1957 and completed in a record one year period (Upstream of Wazirabad Barrage)

Fig 11 – Features in u/s & d/s of Wazirabad Barrage



Downstream of Okhla Barrage - located 2.5 kms d/s of old Okhla Weir with a design flood of 3 L cusecs. Pond level is 201.35 m with upstream bed level at 194.85 m and d/s bed level at 194.45m. Water is diverted to Agra Canal (4000 cusec) and Gurgaon Canal (2240 cusec) just before the barrage



Criss crossing pipelines - a common scene in the urban areas is a result of unplanned infrastructure thereby leading to inefficiencies.



Agra Canal running alongside the Kalindi Road, on the left is Madanpur Khadar road.



Water hyacinth (*Eichhornia Crassipes*) growing near the old Okhla weir.



Flood waters (2008) at the door step of high rises (including Amity University Campus) standing in the river bed in NOIDA



Upstream of Okhla Barrage: Okhla weir - Okhla bird Sanctuary is an integrated system of this water reservoir.

Interactions with a fishermen near Okhla Barrage



Flyash quite visible as seen, this is an area designated as fly ash dumping ground. (see inset for ash dump area.)



Outfall from the flyash disposal ground being flushed into the drain leading towards river and opposite to it are residential areas located along the road.



Fig 11.1 – Okhla Barrage and Drains in Vicinity



Land excavation in progress and dumps over the floodplains is a common sight now a days due to lots of construction activities on the left bank of the river like the Common Wealth Games Village, DMRC works, Traffic Improvement works like flyovers, bridges etc.



Flood waters (2008) rushing in to inundate farms standing in the flood plain down stream of Nizamuddin Bridge (NH 24)

Flood waters close to Jamia Nagar and Batla House Extension standing in the river bed



Land requirements for toll roads increase as the toll plazas require several lanes (nearly 3-4 times the existing lanes) for collecting toll and easing traffic movement so that no congestion takes place at gates.
 Width of toll plaza: - 117 m (approx.)
 Lane Length (including kerbs etc.) - 32 m
 Increase in road section at toll plaza,
 Ratio = 1:3.65 The variation in Length continues for around 500 metres.



Disturbance along the road alignment and cut-off zones between loops



Yamuna floodplain is in Zone 'O' of the Master Plan of Delhi. DDA has several of such sites marked 'DDA land' along this floodplain. Development can be witnessed in future in these green patches too!



DND photographs from internet sources



Fig 11.2 – Flyovers in the Floodplain

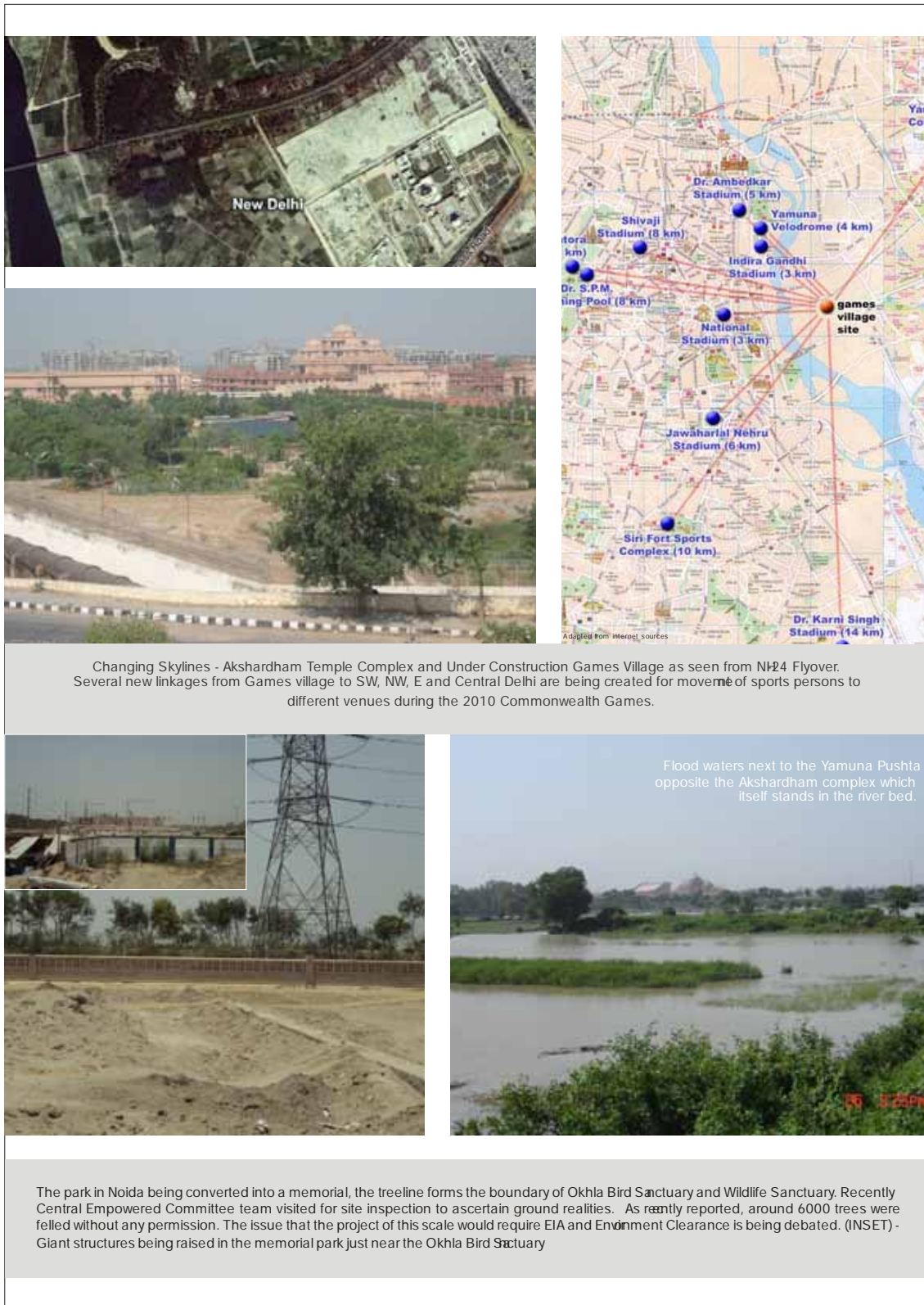


Fig. 11.3 – Changing Skyline along River Yamuna

DMRC's Yamuna Bank depot (ph-II) has come on the flood plains of Yamuna. The site is 3-3.5 mts below the adjoining road / area as quoted in the EIA report for phase - II projects which shall be filled with 1.2 million cu.m of earth. This will be a junction where one line will be from IP Stn. To Mayur Vihar and another leading to Anand Vihar ISBT. (Yamuna Bank depot as seen from google earth)



High end apartments being constructed in the games village.

With increasing traffic in metropolitans, traffic congestion is a regular feature on roads, cloverleaf flyovers have gained popularity as an end treatment to the traffic problems. Due to its multiple linkages for serving directional traffic, land requirements increase and creates small pockets of land which affect the drainage of the larger catchment. One can notice the under construction flyover blocking way of the drainage. In the background are the tall buildings of DDA, Delhi Secretariat, et.



Sudden increase in infrastructure creation in the state of Delhi has not only resulted in inconvenience to general public but it would have an ever lasting impact on Delhi's landform.



Most of the road - rail projects either land up with structure in the riverbed or in the floodplains. Diversion of drains / channels, cutting and filling of soil & vegetation, diversion of routes create short to long term impacts on the land environment which is intrinsically linked to soil and water. To protect such structures from the impacts of high water flows engineering measures are adopted which are more or less destined towards channelisation of River Yamuna and ultimately impacting its functional as well as secondary pockets of flood moderation, recharge and landforms.



Debris management has been a problem with all the construction projects. With the availability of heavy machinery, excavation of earth has fastened but improper management leads to environmental degradation. As these debris are left unattended these become permanent features in small pockets thus changing the landform.

Flyash being spread at DMRC's construction site (Yamuna Bank). Flyash is being promoted as an alternate filling & dressing material, despite its toxic nature which can become dangerous for human health and resources to which it comes in contact.



Fig. 11.4 – Land Transformation & Infrastructure Improvement



The pollutant carried by several drains across Delhi NCT represent the same picture

Chilla regulator:- a junction for hindon cut canal and Shahdara outfall drain which carries pollutants



Northwards view from the Okhla barrage of water spreading over the floodplains during water release from upstream storages (Sep., 2009)

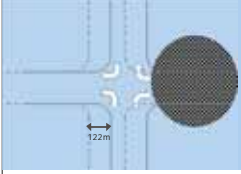


Thermal Power Plant on right bank of river Yamuna just before I.P. barrage.



Fig. 11.5

This is an extended arm of the floodplain of River Yamuna where multiple elevated roads have been designed to regulate the directional traffic.



Approximate representation of Marginal Bund road - Vikas marg junction shift due to construction of 4 clover leafs to facilitate right turns. Junction shifting chosen as an alternative due to congested eastward area. This arrangement took around 14 hectares of land in floodplains.



One can notice the raised earthen platform built for movement of construction machinery. Dumping has been done a little ahead (in the background) by the contractor.

Huge volumes of flyash use during construction of Geeta Colony road bridge



Froth accumulating while pumping water near the left bank of Yamuna



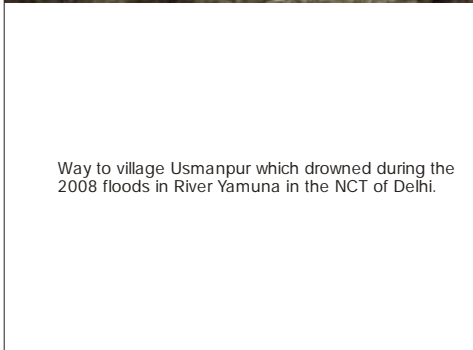
Contractor's labour camp where people stay during work and as a raw estimate 10-15% of the spoils/waste is left over when the site is vacated. One can see waste dumps by side of the camp which ultimately settles and becomes a permanent feature.



Fig. 11.6



Old Railway Bridge



Way to village Usmanpur which drowned during the 2008 floods in River Yamuna in the NCT of Delhi.



Yamuna as seen just before the Wazirabad pontoon bridge



Sand pockets on the left bank of River Yamuna

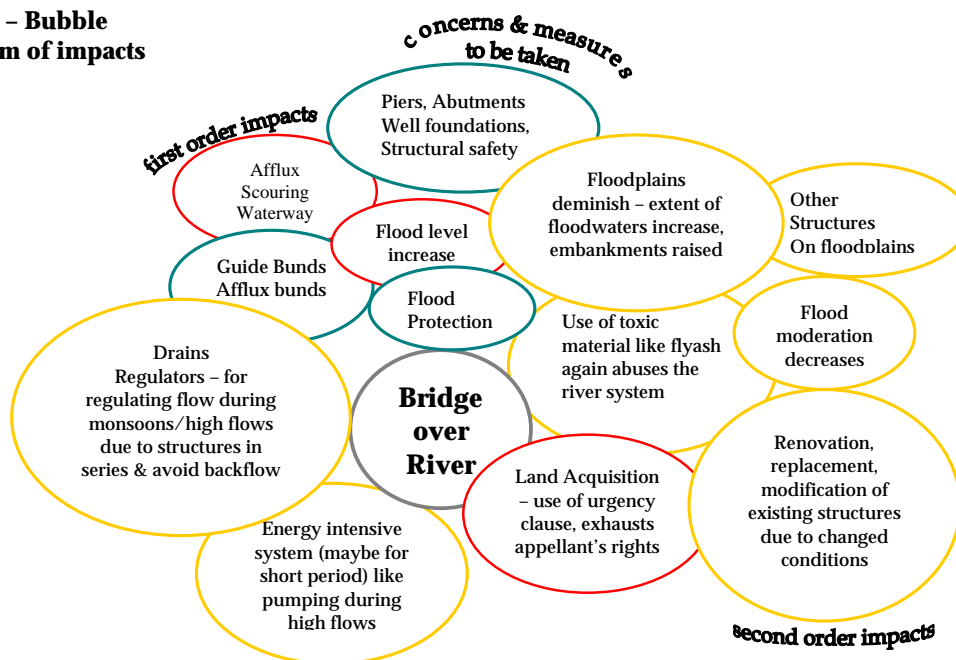


Fig. 11.7

8. DESCRIPTIVE IMPACTS OF STRUCTURES OVER RIVER YAMUNA

In this section, a specific focus on impacts of bridges and barrages over river Yamuna is described and emphasis has been to reflect the objectivity of such impacts and correlate it to the alike linkages and anecdotal facts. A free flowing river makes its own meander belt and active floodplain width but the requirement of bridges over rivers require further river training works to be done for ensuring safety, channelising the flow etc. The embankments and guide bunds thus created have to be catering to the HFL or peak flows that the river system has to accommodate during a given period in a year. Though there are no visible or measurable impacts of such facilities created over the years but once such facilities are created, financial and physical inputs keep focusing around such activity as recurring for maintenance, improvement in designs etc.

Fig. 12 – Bubble diagram of impacts



Impacts due to construction of linkages (flyovers, roads, bridges) and barriers (barrages) is not only limited to the specific physical development but it gives rise to several other interlinked elements which can cumulatively impact the environment which reduces the replenishment of resources in the long run and turns the practice into process most commonly adopted by administration. In case of 22kms stretch of Yamuna which merely flows as a sewer drain for most part of the year, the relative or interlinked elements other than main structures are guide bunds, embankments and their development thereby restricting the river to a channel and restrict its natural course. Here we discuss some of these elements in brief before looking into the changes in the river stretch observed and analysed using different combinations of satellite data available which will infact illustrate the overall picture of River Yamuna in the Delhi territory between Wazirabad and Okhla barrages.

- The Irrigation and Flood Control Department of NCTD is responsible for management of drains, embankments etc. The silt brought down by several drains (as per recent estimate it is 3.8 lakh cu.m¹⁴ of silt) has been removed from 17 drains of Delhi and it is dumped in nearby depressions as well as along the banks of drain

¹⁴ annexure - IFC

which ultimately transforms the landform in immediate surroundings and divert the natural drainage pattern resulting in water logging or impacts on ground water recharge. *It is not known whether any action plan has been formulated for dumping of silt vis-à-vis drainage modification or change expected and resultant impacts on ground water scenario in the active Yamuna floodplains.*

- Taking the average depth of well at 39 m and per day sinking at the rate of 4.75m (on the higher side) or 3m on a conservative side, it reveals that the impacts during the construction period last for approximately 6-8 months for sinking of 14 wells alone at the site of operation which largely remains on the river bed. This brings in the management aspect of cut and fill operations and the borrowpits formed due to the construction activity. If left unattended, it forms a permanent feature thereby making it almost a permanent feature impacting the local drainage pattern of the floodplains.
- The other important aspect in terms of a systemic approach is that once a facility is created at a given place, its implications or risks due to upstream river components as well the resultant downstream aspects need a thorough review of situation as such a facility cannot be planned as a stand alone entity. A common technique adopted for erecting piers is the well sinking technique in the riverbed of Yamuna but a complete profiling of floodplains of Delhi would reveal liquefaction regions within the Delhi territory. With each structure coming over on the river bank or floodplain would create an incremental effect on the structures in the d/s and u/s of proposed activity for a particular flow. These concerns will arise from time to time as most of the projects are an outcome of some major activity which needs integrated facilities to be created or are not well conceived. Strong interrelationships between backward and forward linkages hold an utmost importance. [To quote an example, for a discharge of 12750 cumecs, an afflux of 0.1 m at Noida Toll Bridge will occur which can be taken care of only with appropriate designed flood protection works].
- Coordination among line departments is another major problem, which may be due to lack of well defined procedures and processes for seeking actions on development / prior approvals for projects on river banks or floodplains. Three cases confirm such a lethargy in process (see box on page 43)
- RTI responses reveal that certain departments like PWD do not have information about the infrastructure created by them over the past few decades – even though PWD has evolved as a large institution in itself but it seems that it has not emerged as an integrated management unit as the responses reveal. Similarly there have been several other problems like providing limited information in the time period thereby delaying the access to information which has been noticed in several cases. In some instances the information provided is very generic in nature against the questions framed for information required which adds to the overall time taken for responding to information query¹⁵.

¹⁵ Information and Development Agencies

Firstly, DTL started construction work without any approval from YSC with a presumption that DDA must have taken clearance for the site for construction of sub-station in an area of 16 hectares near Maharani Bagh – site filling and boundary wall construction had neared completion;

Second case is a case of construction of pump house by DJB and it came to light only when C.E. (YWS) pointed it out to YSC when substantial progress in project had taken place,

Third case is a case of DMRC where committee in 2003 had given clear directions for not using further vacant lands for developmental activities like depot extension, residential etc. But DMRC utilized some part of the vacant land available for the construction of staff quarters. [The Site between G.T.Road and metro lines was cut off from the river flow after the construction of metro line]

DMRC submitted a proposal for IT Park on 6 Ha. and essential complex on 10.6 Ha land (thus a total of 16.6 ha) available with them to the east of the coach maintenance depot. The committee decided that the approval of I.T. park on 6 ha only can be considered as a special case provided DMRC confirms the following:

- No further development activities in floodplains towards south of Shastri Park depot and no additional land for expansion.
- No further residential development in the reclaimed area

Committee cleared the proposal subject to the condition that approval of Hon'ble High Court in view of its orders would be separately obtained by DMRC. It is still unknown whether DMRC has taken the abovesaid approval from Hon'ble High Court of Delhi!

- The other socio-economic impacts of bridges and barrages is the requirement of public-private lands for construction purposes, some temporarily and some permanently. In Delhi Gazette of 1985, it is mentioned that most of the land acquired during the period 1970s was for the purpose of flood control measures¹⁶ which is also justified by the I&FC. As reported by different divisions of I&FC, 1838 acres of land was acquired / transferred between 1972-1973. Agricultural practices in the floodplain belt offer better yield to the cultivators or agriculturists but once the land is acquired, such benefits to the people are lost forever and compensation mechanisms do not consider such factors before deciding upon compensation amounts to the affected.
- As several constructions (bridges and other structures) prevail in the floodplains closer look at the seismic hazard needs attention as Delhi comes under seismic zone – IV. A first level microzonation map¹⁷ discretizes the territory of NCT Delhi in 9 units where it demarcates the floodplains/trans Yamuna region as 'newer alluvium proximal to Yamuna river which has high hazard due to liquefaction potential. With the bridges (its components like foundations, piers, abutments etc) resting on the river bed raise concerns due to high hazard due to liquefaction potential – what would be the response of structures to an seismic event in case of dry conditions as well as in flood conditions; a safety cushion for selecting the scour depths in case of

¹⁶ See Annexure – Land Acquired by IFC

¹⁷ Seismic Microzonation of NCT Delhi

seismic events would directly link to the design and costs of structures. Though there have been broad categorization of seismic hazard microzonation which calls for micro estimations based on ground situations (geo-technical investigations, shear wave velocity and density profiles) and historical data of seismic events. Delhi is a typical example of a city on the banks of river that has left several palaeo channels over which presently human settlements exist. The engineering projects employ bore hole¹⁸ investigations as a measure for designing foundations and superstructures but usually shear wave velocity is not routinely measured and this has been the limiting factor for understanding local soil effects, liquefaction susceptibility and vulnerability analysis.

The current paradox of development and thereby abusing of resources as rivers in urban areas have not figured as an environmental resource and is rather been used as a derelict channel conveying city waste. The pace of urban development and increasing density of population has even defeated the large chunk of investments on cleaning of Yamuna over the years.

- Invariably, the floodplains are being converted into built up structures like bridges, flyovers and other structural built forms concentration on the riverbank or floodplains. Every structure coming up on the river brings in play several other elements which have impacts on the river as well as the incremental costs required as an answer to the proposed

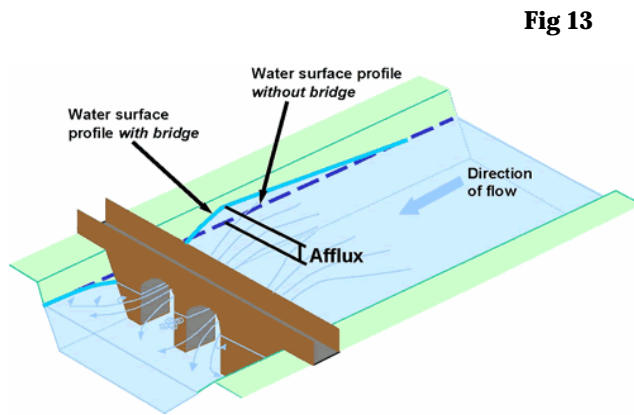


Fig 13

development like river training or protection works. Afflux i.e. effect of structures over river is explained in this diagram (adapted from internet source) which increases the flood level in immediate upstream of the bridge as a result of obstruction to natural flow of river which reduces its effective waterway. Once structures come in close vicinity of each other, the leverage to play with river expanse decreases. The piecemeal approach for assessment of impacts over river due to different kind of structures coming on riverbed or floodplains from time to time gives a notion of adhocism in urban planning and river management. Ultimately the river is trained in a way by engineering measures that the natural river meandering is restricted and river regime impacted.

Table 7 - Possible relationship between Parameters as an outcome of Construction with River Elements

Parameters	Floodplains	Flood Moderation	Effective Waterway	River Regime	Flood levels	Recharge Zones	Freeboard
Bridge Piers		● -	● -		● +		
Abutments	● -		● -				
Foundations	● -		● -				
Discrete Structures	● -	● -		● -	● -	● -	
Scour depth			● -				
Afflux	● -	● -		● -	● +		● -
Channelisation		● -		● -	● +	● -	● -

● - Relationship
 - reduces
 + increases

¹⁸ Microzonation of Earthquake hazard in Greater Delhi Area

Table 8 - Possible relationship between Parameters Leading to Protection, River Training

	Guide bunds	Embankments	Borrowpits	Structural Safety	Structural Safety Cost & measures*	Spurs
Bridge Piers	● +	● +	● +		● +	●
Abutments					● +	
Foundations			Const./diversion			
Discrete Structures	● +		● +			
Scour depth				● -	● +	
Afflux	● +	● +		● -	● +	●
Channelisation		● +		● -	● +	●

* - protection for piers with increase afflux, tackling with low deck problems of existing bridges like the old railway bridge etc

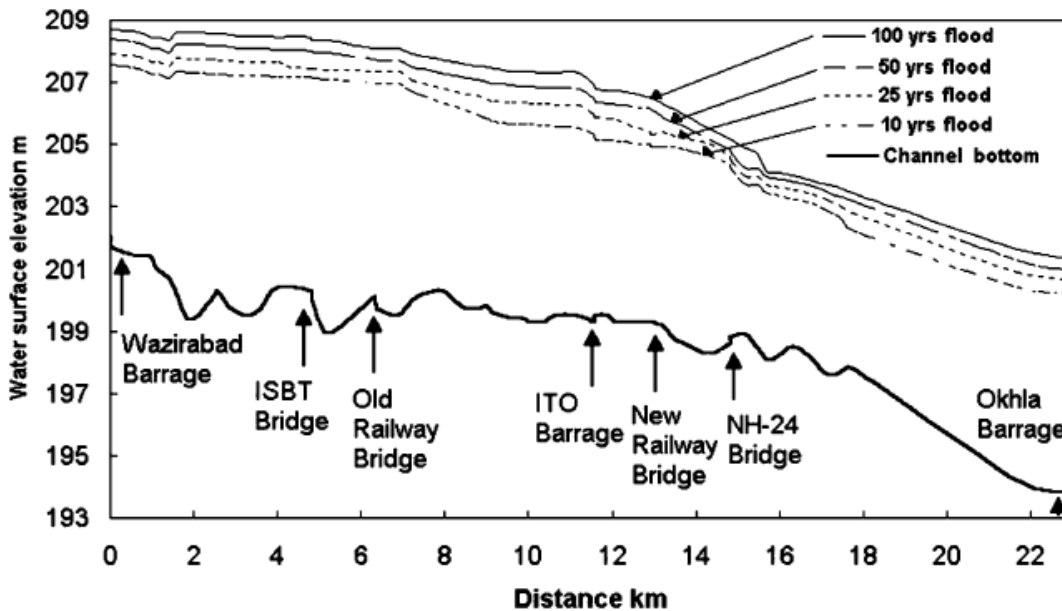


Fig. 14 – Water Surface Profile at Bridge locations

In the immediate vicinity of bridges, one can notice the change in surface water profiles i.e. the channel bottom dips downwards immediately after the bridge which most likely represents scouring and afflux it may generate in the immediate surroundings of the bridge structures (*commonly known as braided channels*). The section between blue lines indicate the flowing river section (upstream of Wazirabad barrage and downstream of Okhla barrage). As simulated by scientists of NEERI, in a flood return period of 1 in 10 years, the land free from submergence would be 1147.60 (75.39% area would be submerged) hectares whereas in case of flood return periods of 1 in 100 years it would reduce to 762.60 hectares (83% area would be submerged)

Source: Ritesh Vijay, Aabha Sargoankar, Apurba Gupta, Hydrodynamic Simulation of River Yamuna for Riverbed Assessment: A Case Study of Delhi Region (2007); Environmental Monitoring Assessment

- With every structure coming up over the river (Table 9), thereby increasing afflux or backwaters would require strengthening of embankments and providing sufficient free board, remodeling of drains due to risk of backflow due to increase in water level in river in which case wastewater has to be pumped out rather than through gates, provisioning of more drain regulators

to control the flow of drains in events of high flows, replacing existing infrastructure due to changed conditions with new one's like old Delhi Railway bridge. Several construction measures owing to different development programmes of channelisation of river such as a stand alone activity would require civil works in close integration of bridging points from Wazirabad and Okhla which would cause increase in discharge intensity and would require strengthening of piers, aprons, spurs etc. A reflection of scenario from available research is presented below alongwith characteristics of few activities proposed / already under implementation in the floodplains:

Table 9 – Probable Increase in Water Level in Changed Situations & Required Changes

Structures	R.L. (m)	Water level (R.L)	Situations
Bottom decking of Wazirabad barrage	209.75	211.1	requires renovation of this bridge
Wazirabad bridge*	Likely alignment from ring road towards Khajuri khas		
ISBT	215.74	209.9	freeboard of 5.84 m available
Shastri Park Metro	-	-	Approximate – 209.50
Bottom of Old Rail cum road bridge	206.35	209.3	renovation would be required
Geeta Colony Bridge	-	207.58	Existing / under const.
Salimgarh Fort – Velodrome bye pass Road*	Bye pass to start from Salimgarh fort and run almost parallel to River and connect ring road near Delhi Secretariat.		
Cloverleaves at MB road-Vikas Marg intersection	Under construction on floodplains		
Bottom of deck of IP barrage	207.8	206.8	freeboard of 1m available
Yamuna Bank Depot	207	-	Formation level
East West Corridor*	Phase I i.e. from marginal bund road to ring road (near pragati power) approved, rest of the stretch is under scrutiny		
Level of Nzm. Rly. Bridge	215	205.65	freeboard of 10m available
Level of Nzm. Road Bridge	209.7	205.55	freeboard of 4.25m available
Barapulla Elevated Road*	Landing near ring road (opp. Sarai kale khan) to provide connectivity to CWG village in East Delhi		
DND flyway	-	-	Existing
Mayur Vihar Link	207.25		Finished road level

Source: Compiled from various sources (Col. 2 & 4 adapted from book on river pollution)

Development in the floodplains of Yamuna is being taken up owing to different needs which is certainly reducing the expanse of the floodplains. In the recent past several of the activities have been proposed and almost all of them have got cleared by YSC subject to some specific conditions (see table 9.1)

Table 9.1 Tentative list of structures with land details

S.No.	Structures	Area (Ha.)	Remarks
1	Petrol pump, DND	0.1	Approved with partial structure on piers
2	DMRC S.P Depot, IT Park, Quarters	16.60	YSC's nod on certain conditions but DMRC went ahead with extension.
3	Theme Park (right bank)	10.12	Downstream of Okhla barrage
4	STP	5.50	Eastward of ring road, near electric crematorium
5	DTL	16	Maharani Bagh, adjacent electric crematorium
6	Cloverleaves (vikas marg – marginal bund road) – ITO Chungi	14	Congestion on the eastern side of junction needed a shift of 122 m towards ITO.

S.No.	Structures	Area (Ha.)	Remarks
7	Commonwealth Games Village	59	Under Construction without any specific approval from YSC
8	Yamuna Depot	36	Levels to be raised, mobility to be integrated with ITO chung junction.
9	Geeta Colony Bridge	49	Land transferred from U.P. Irrigation Department from floodplains to PWD, DDA, I&FC, MoUD
10	Akshardham Complex	40	Existing. No specific approval from YSC.
11	Times Global Village*	41	With NTBCL
12	Others	5	Flyash manufacturing, CRPF camp, Electric Crematorium, Petrol Pumps
	Total Area (approx.)	292.32	

Source: YSC Reports and RTI responses. * Temporary structures.

Several proposed road/bridge connectivity's are on the envil viz. bye pass from Salimgarh fort to Velodrome road, East West corridor and elevated road over barapulla drain. The utility of drains as urban drainage is important but with the recent constructions over the drain tend to restrict the effective width and flow given the fact that its bed level would rise more frequently due to accumulation of organic matter and sewage.

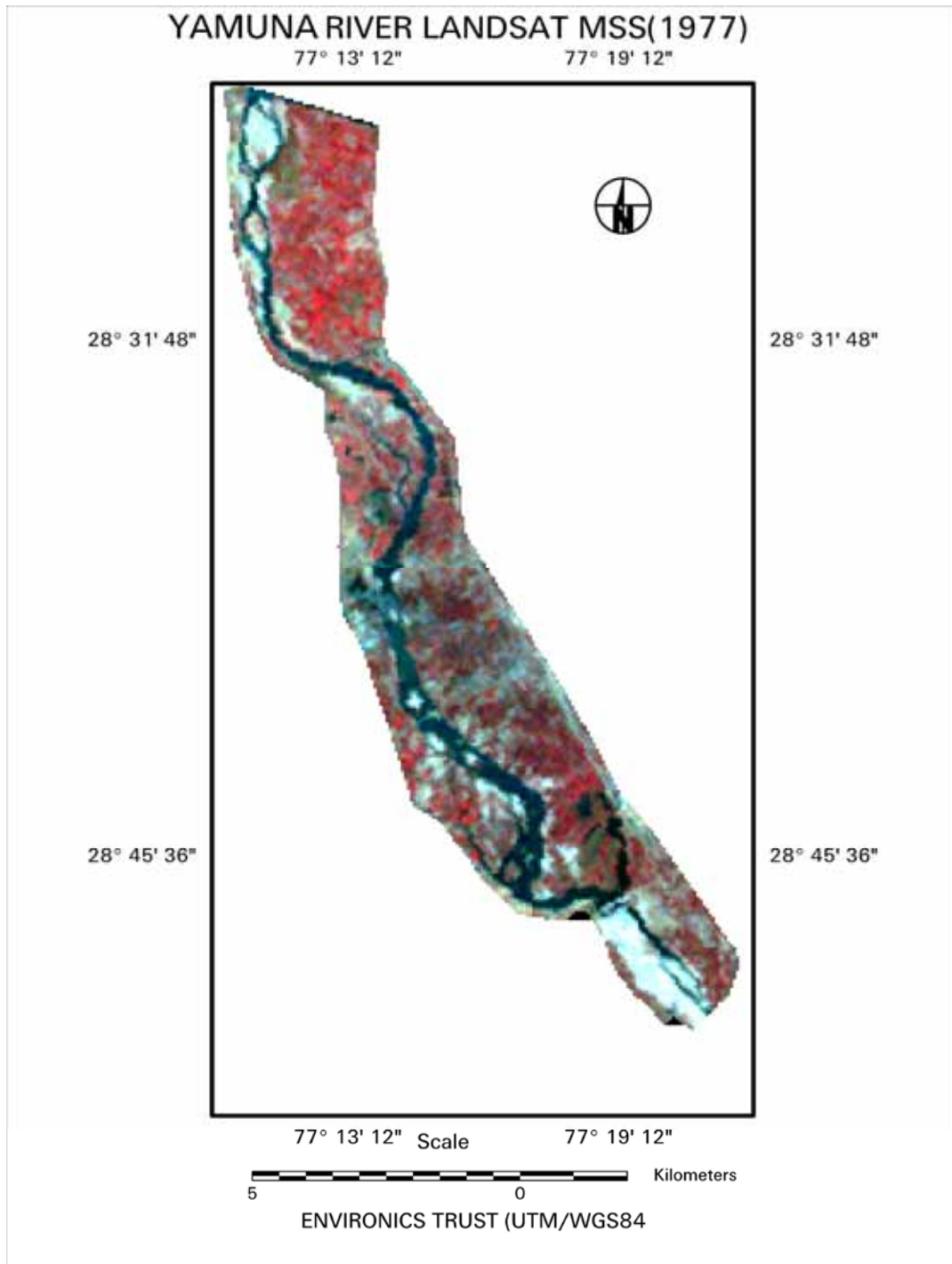
Given the situation, it has definitely resulted in structural changes in the urban fabric of Delhi territory and especially along the active and extended floodplains of Yamuna River in the heavily urbanised 22km stretch. The city has grown to a size where it becomes imperative to respond through mere physical measures, which resultantly will have detrimental impact on the urban environment as a whole (energy for lighting, fuel consumption, urban heat islands). Instead more thoughtful planning and alignment of bridges in future will mark more concerned efforts towards securing the floodplains, which are remnants of urban expansion. The lethargy of state institutions in planning is quite visible from the fact that an 'ex post facto' considerations are asked from the YSC which is the nodal agency in approving projects from flood risks. Why are there no stringent measures in such situations? In many instances (CWG village, Akshardham) no consultation with YSC took place and in some (DTL, DMRC) fait accompli situations were presented.

9. Illustrative and Quantified Impacts of Structures Over River Yamuna

Quantification of combined impacts of structures over River Yamuna is best provided by analyzing the ground situations and supervising the imagery data of various periods by classification based on the quality of data and interpretation capabilities of the programme. An area of interest was defined using right and left embankments as the limits so that a comprehensive view of the river, floodplains and other features is captured. A first set of check run was done for the period between 1977 to 2000 to find the change in the river course as few construction took place before 1977 i.e. wazirabad barrage (1959) whereas Okhla barrage was built in mid 80s.

Landsat (Delhi Sub Zone – Yamuna) MSS (1977)

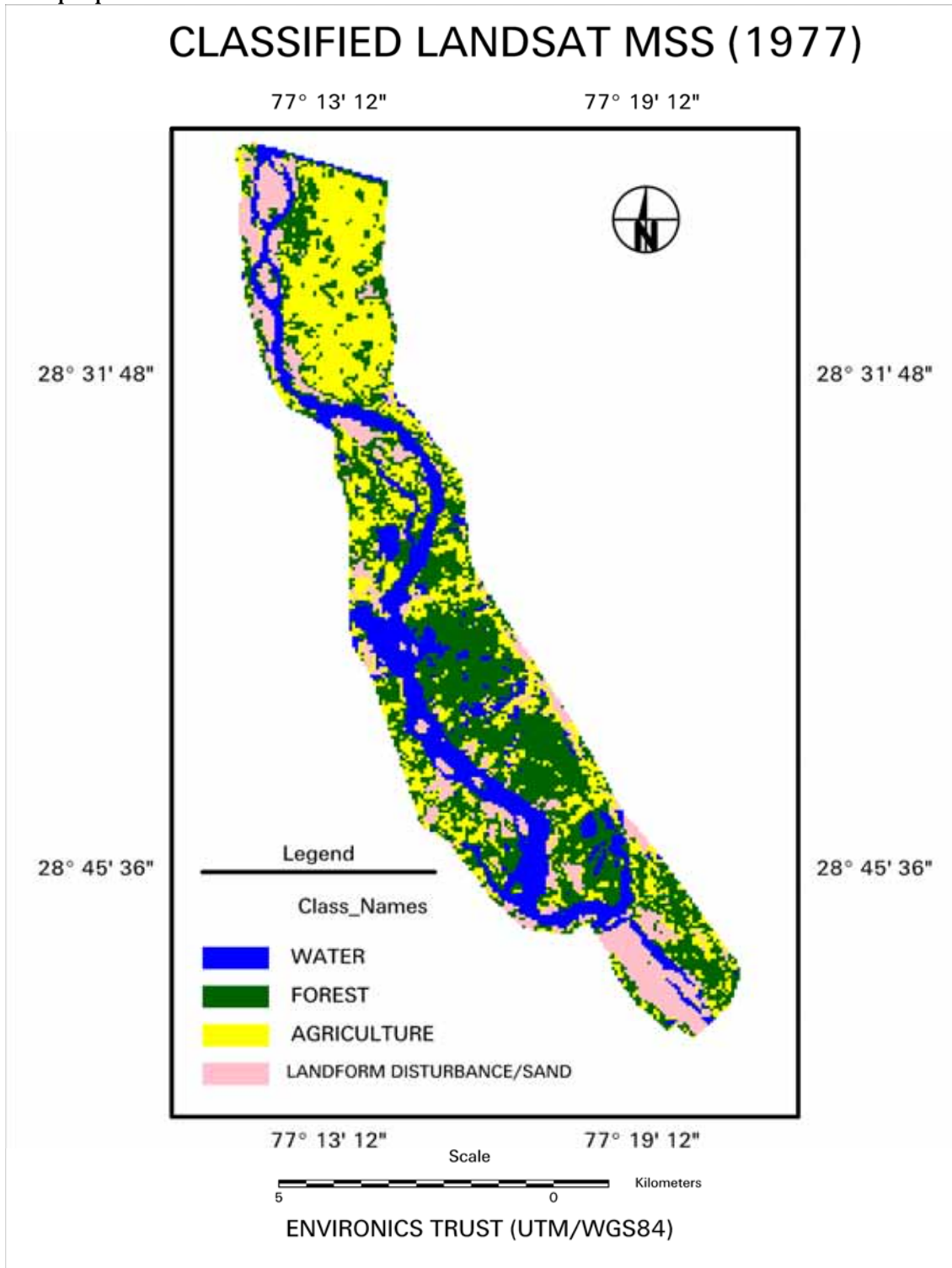
Situation pre-existing before the construction of the Okhla Barrage where Yamuna leaves Delhi. Okhla weir used to be the only structure during this period in the downstream. River meanders immediately after the Wazirabad barrage in the upstream and just before the Okhla barrage is a slight meander (westwards)



Map 2 – Landsat MSS (1977)

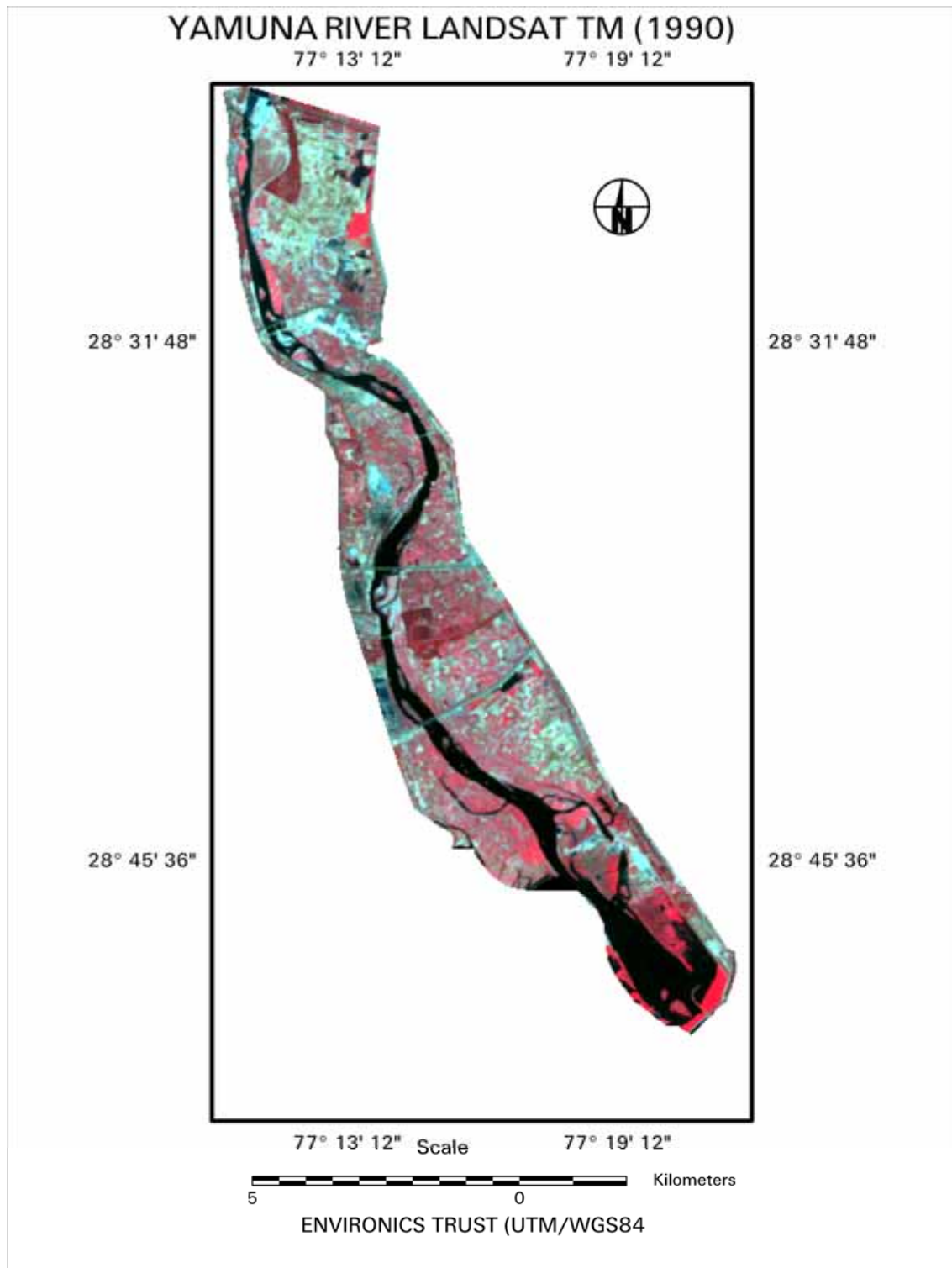
Classified MSS (Delhi Sub Zone – Yamuna) MSS 1977

Numerous Channels along the River noticed alongwith dense forest/vegetation in the central portion on the left bank of Yamuna. Least disturbed period as far as physical construction is concerned in the floodplains. In 1978, Delhi witnessed the worst floods in its recorded history. Only the Old Railway bridge existed during this period which served the twin purpose of rail and road traffic.



Map 3 – Landsat Classified MSS (1977)

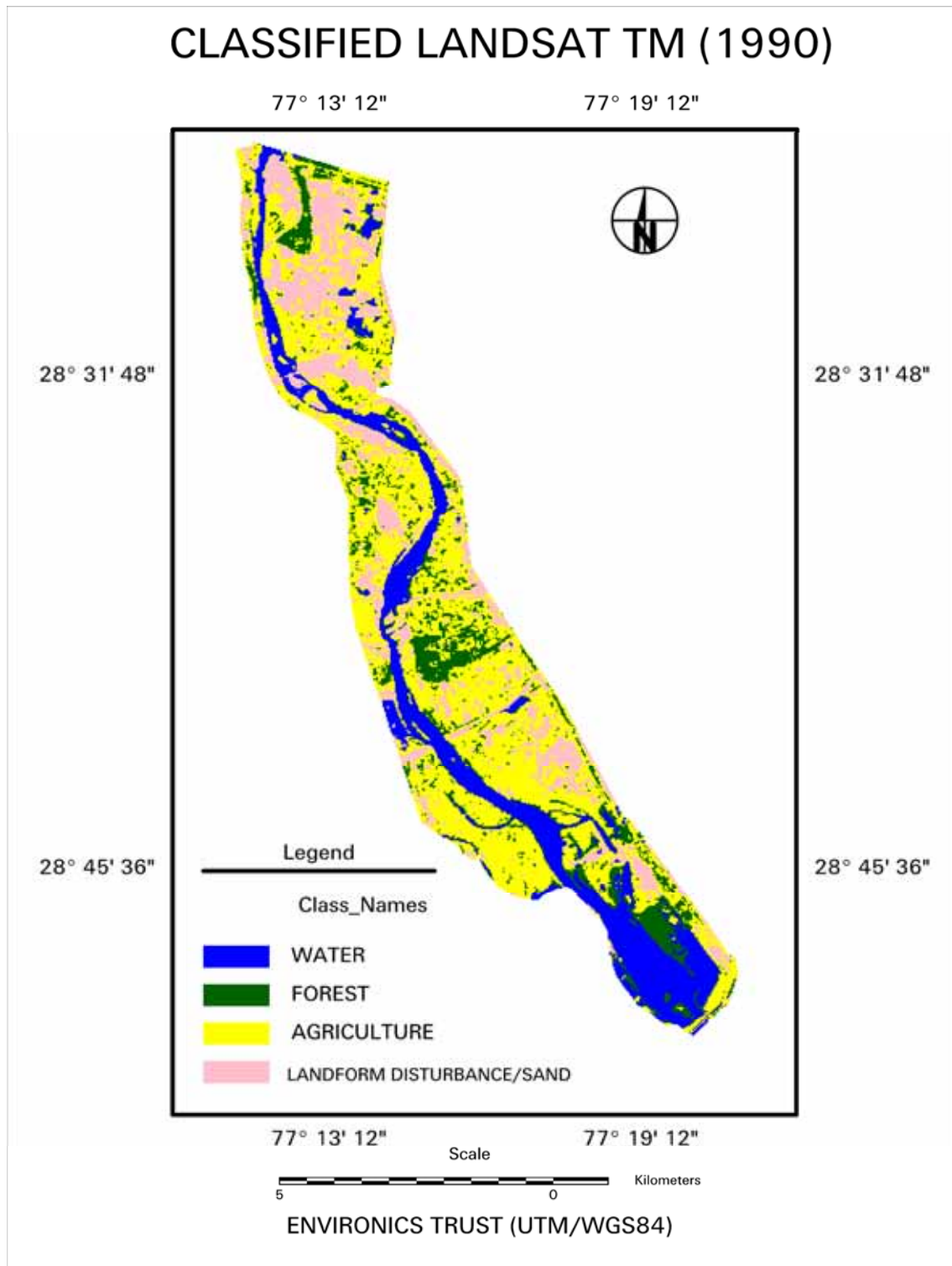
Landsat TM ((Delhi Sub Zone – Yamuna) 1990



After coming up of Okhla barrage in mid 80's the river pattern has changed. Straightening of river is clearly visible with protections on the western banks and thereby restricting the river to flow without meander. Two clear forest patches – one immediate downstream of Wazirabad barrage and one between IP Barrage and NH-24 are visible.

Map 4 – Landsat TM (1990)

Classified TM (Delhi Sub Zone – Yamuna) 1990

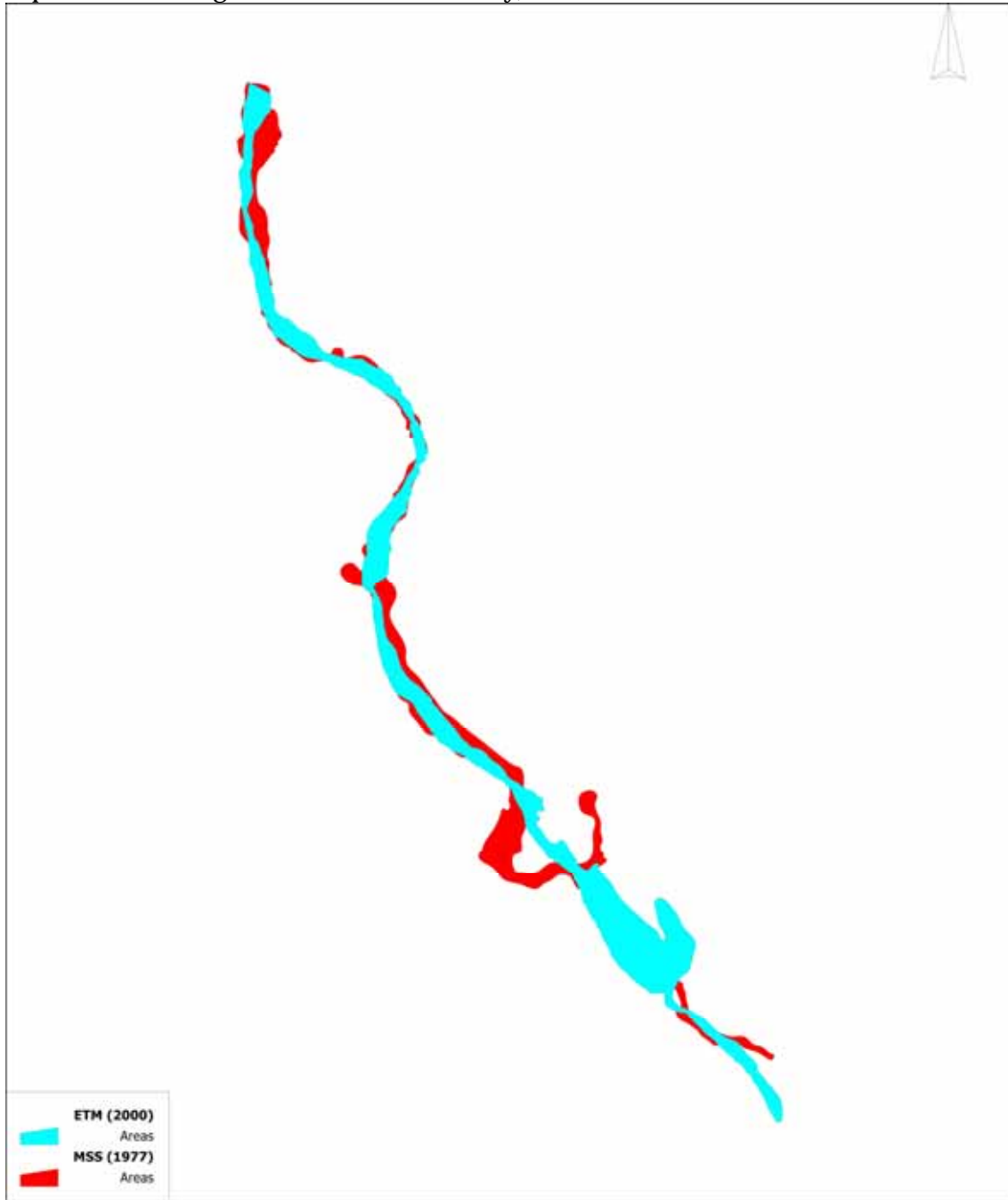


Agriculture being the predominant use in the floodplains of Yamuna in NCT is depicted in this classification. The pink colour indicates sand along the banks of River and lands that are left fallow or barren. Two forest patches are clearly visible apart from the sparse vegetation or shrubs.

Map 5 - Landsat Classified TM (1990)

River Course Overlay - Landsat MSS (1977) and ETM+ (2000)

Disturbances noticed in the eastern and western banks of River Yamuna. The noticeable change is in its last reach in the Delhi section i.e. before Okhla where the meandering can be noticed whereas in a period of 23 years the river's channelisation resulted in straightening of river course probably after the construction of Okhla barrage where more land would have been brought under the influence of barrage. Okhla bird sanctuary was notified in year 1990 and forms an integral part of the Okhla barrage system (the southern defined blue color depicts okhla barrage and okhla bird sanctuary)

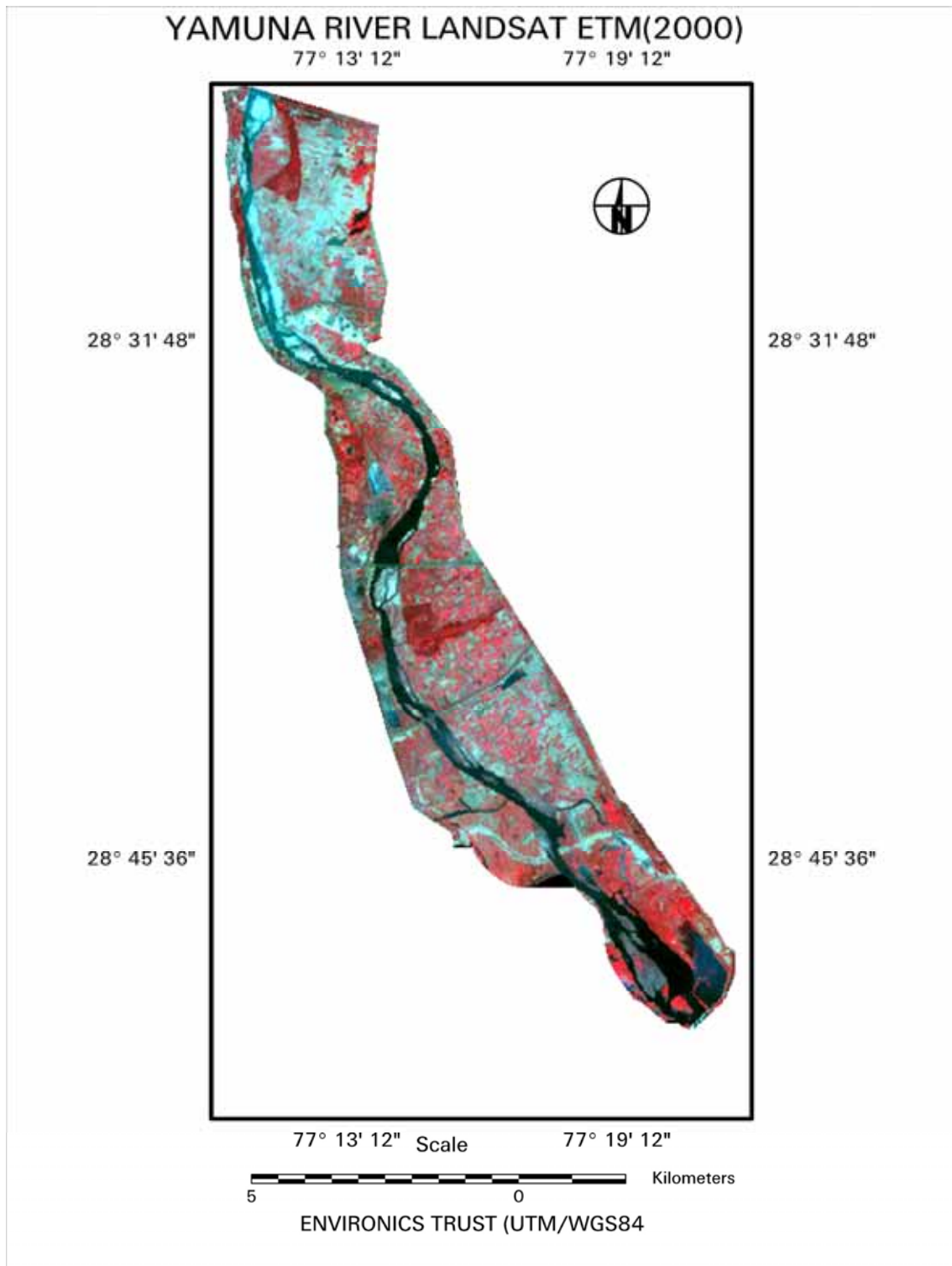


CHANGE IN YAMUNA RIVER COURSE BETWEEN 1977-2000

ENVIRONICS TRUST
Universal Transverse Mercator - Zone 43 (N)
Lon: 77°16'58" E
Lat: 28°37'03" N

Map 6 - River Course Change

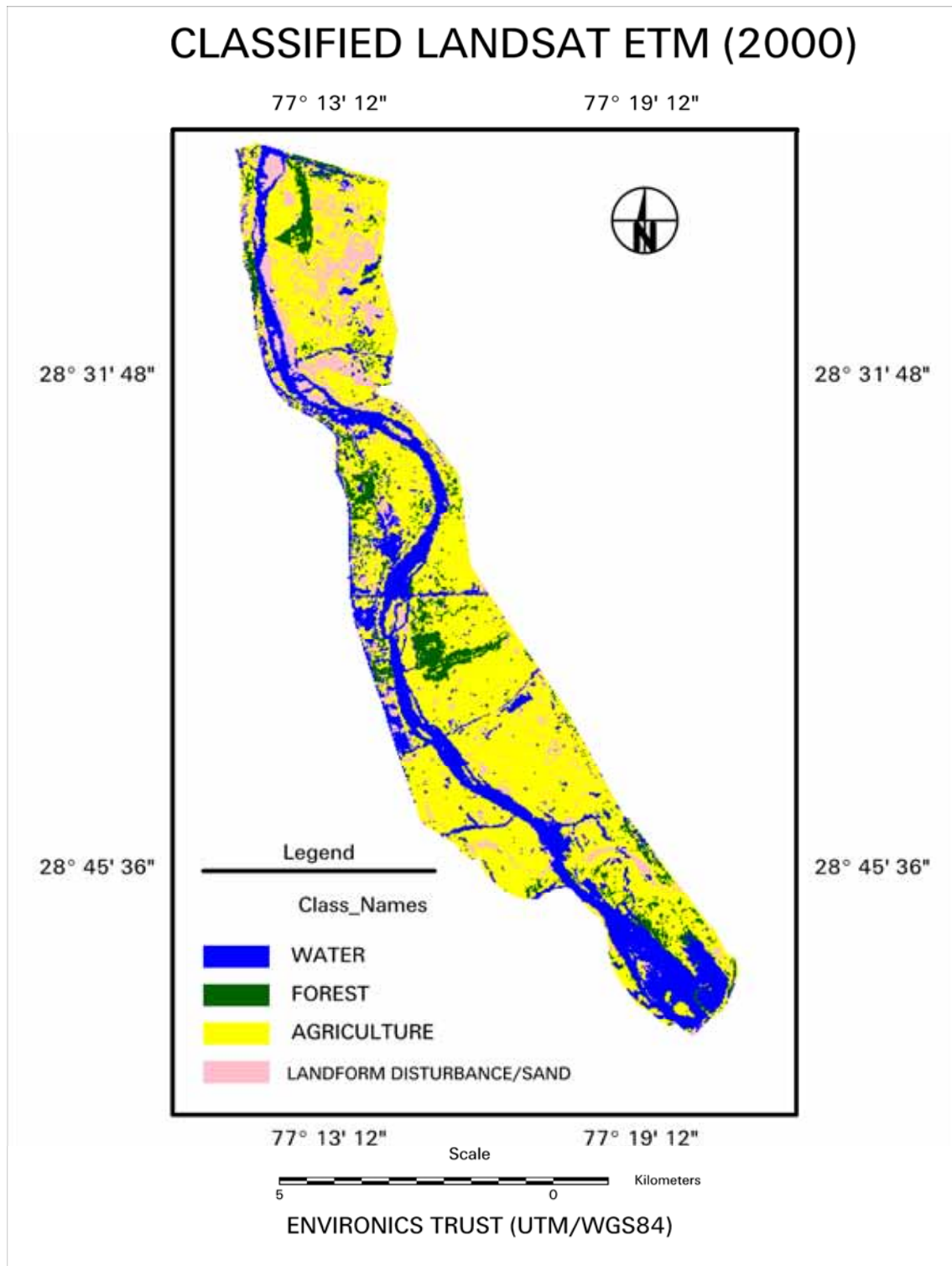
Landsat ETM (Delhi Sub Zone – Yamuna) 2000



An arterial link between Delhi and Noida planned (DND Flyway) and this was the time when the Metro Rail System i.e. Mass Rapid Transportation System was planned for the NCT of Delhi, the first link came up near the existing ISBT bridge (Shahdra-Rithala line). Forest patches are still more or less intact.

Map 7 – Landsat ETM (2000)

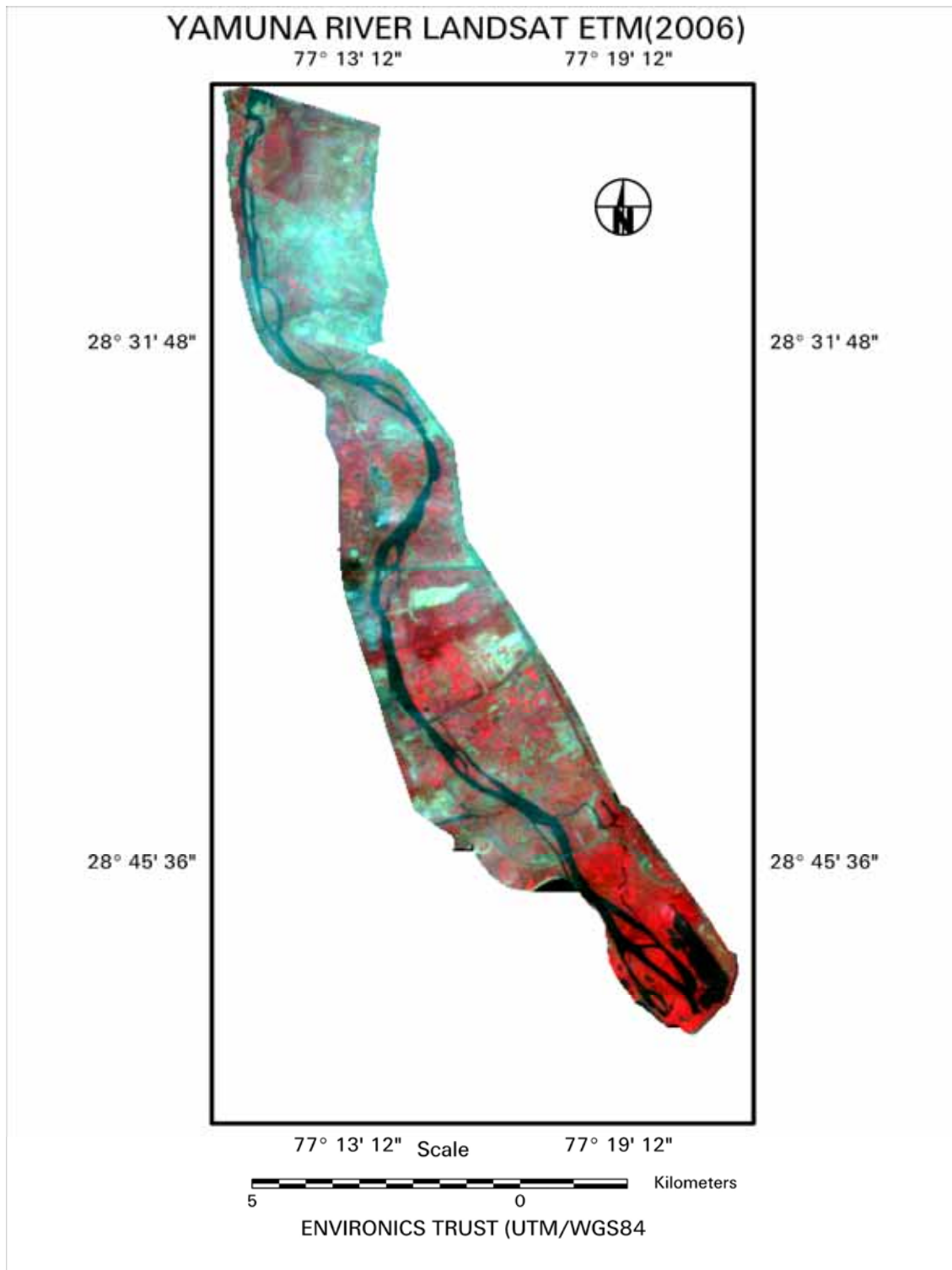
Classified Landsat ETM ((Delhi Sub Zone – Yamuna) 2000



Agriculture still remains the predominant land use in the floodplains of Yamuna in NCT of Delhi. Disturbances are noticed between NH-24 and Okhla Barrage where DND flyway came up in 2001 and near the enclosed area between ISBT bridge and Old Railway cum Road bridge where Shastri Park Depot came up.

Map 8 – Landsat Classified ETM (2000)

Landsat ETM (Delhi Sub Zone - Yamuna) 2006

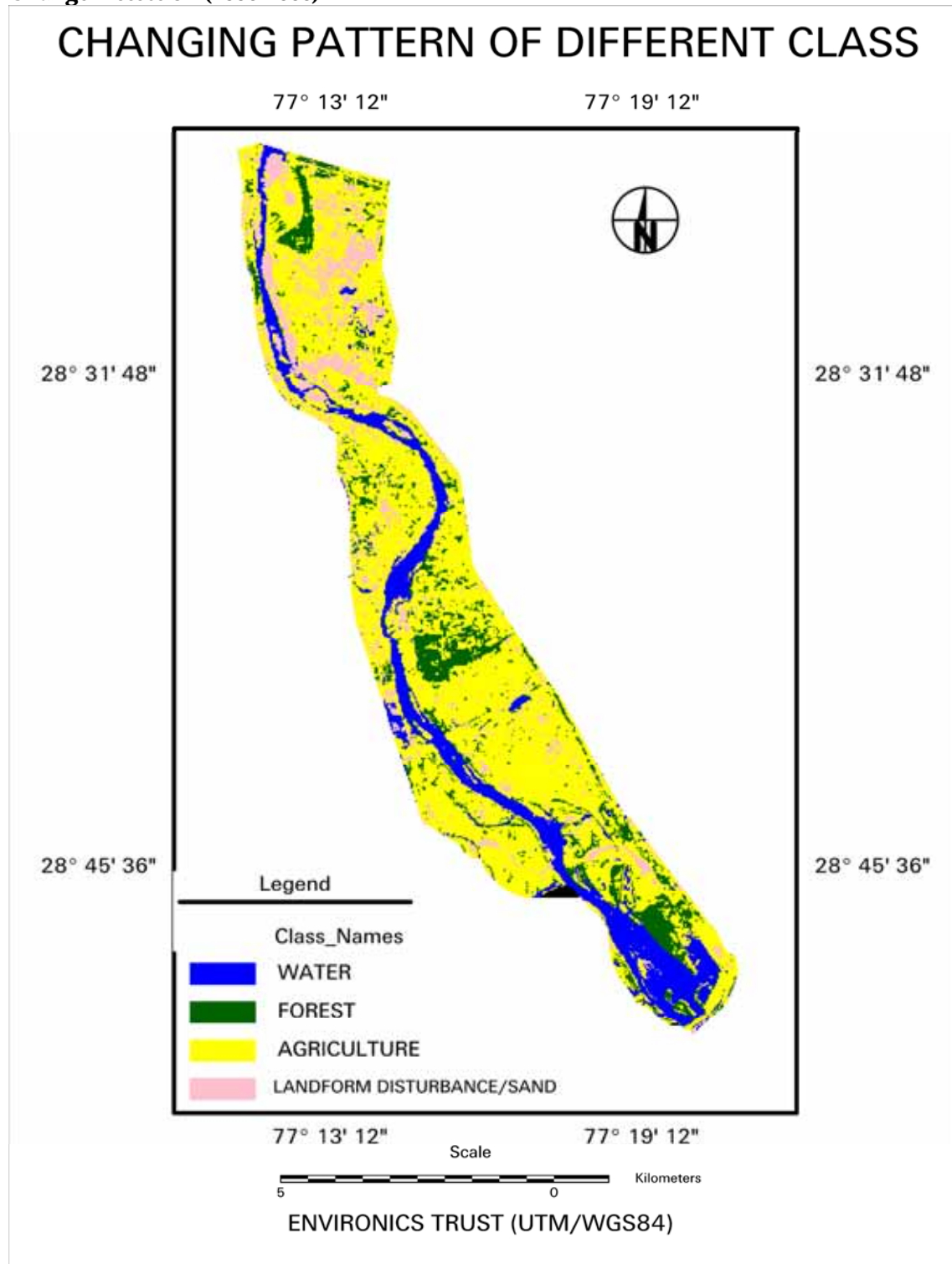


Map 9 - Landsat ETM (2006)

More disturbance noticed between NH-24 and IP Barrage where Akshardham Temple and DMRC Yamuna Bank Depot came up on the left bank vicinity of River Yamuna. In the upstream of IP Barrage, a new bridge i.e. Geeta Colony Bridge is proposed. Protection works form another order of disturbance in the near vicinity of these structures like guide bunds, embankments etc. Though these protection measures safeguard the structures but the land

enclosed between them become non utilizable by the river and slowly turns into one unit comprising large areas which form an integrated unit of structure thereby increasing the cumulative landform change.

Change Detection (1990-2000)



Map 10 - Decadal Change

Table 10 - Broad Land Cover Type Change Detection (1990-2000)

LAND COVER TYPE	1990(TM) Area in hectare	% of Area	2000(ETM+) Area in hectare	% of Area	% Change between both Area
Water	942.07	19.38	1111.81	22.88	18.02
Forest	616.27	12.68	419.74	8.64	-31.89
Agriculture	2378.47	48.94	2793.73	57.48	17.46
Sand/Barren/ Construction/Fallow	1000.57	20.59	619.2	25.48	-38.12

Source: Landsat (TM & ETM) – Classified and Analysed by Environics Trust

Four broad classes were used to depict changes that occurred during the 10 year period from 1990 to 2000. The landsat (TM and ETM) in urban context present limitations in terms of increased interference of components interspersed with several classes. An effort was made to differentiate such a difference with the limited capabilities of the available landsat data. The probable change in area under water is due to seasonal variations in the region i.e. monsoon and non-monsoon periods. As indicated by periodic NDVI classification there has been a marked difference or decrease in the dense vegetation over the decade giving space to lower class of vegetation or less denser vegetation, a current interpretation would rather reveal more exact nature of variations. Agriculture being the predominant activity in the floodplains also has several pockets/patches left fallow or unattended during certain periods, thus agriculture shows a shift from time to time depending on the areas taken up for agriculture during a particular year. Agriculture has shown an increase of 17.46% over the period of ten years. This holds more true when seen in conjunction with the fourth category i.e. sand/barren/construction/fallow – this category has been clubbed due to the fact that reflectance of such nature of lands is similar and it becomes difficult to distinguish sand from barren or concrete as they have similar reflectance. Change in class due to natural degradation or disturbance in natural vegetation due to construction activities etc. is quite possible and indicative in this category. The decrease in fourth category (sand/barren/const/fallow) would mean that certain areas have been taken up under agriculture but it is definite to say that there would be an positive increase in the ‘construction’ category within category IV for which a GIS environment based mapping has been done based on the areas demarcated as available from secondary sources and with some primary checks.

Normalised Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index is a model for converting satellite-based measurements into surface vegetation types. The NDVI uses a complex ratio of reflectance in the red and near-infrared portions of the spectrum to accomplish this. Reflectance in the red region decreases with increasing chlorophyll content of the plant canopy, while reflectance in the infrared increases with increasing wet plant biomass. It has been defined in three classes – Low Vegetation/Shadow, Medium Vegetation and Dense Vegetation in the map.

The broad classes of vegetation are complimentary to each other i.e. the three classifications are in interrelation with each other within the study area. The classification of the best available vegetation would be termed as dense whereas the rest classes will be classified as medium and low with respect to the upper available class.

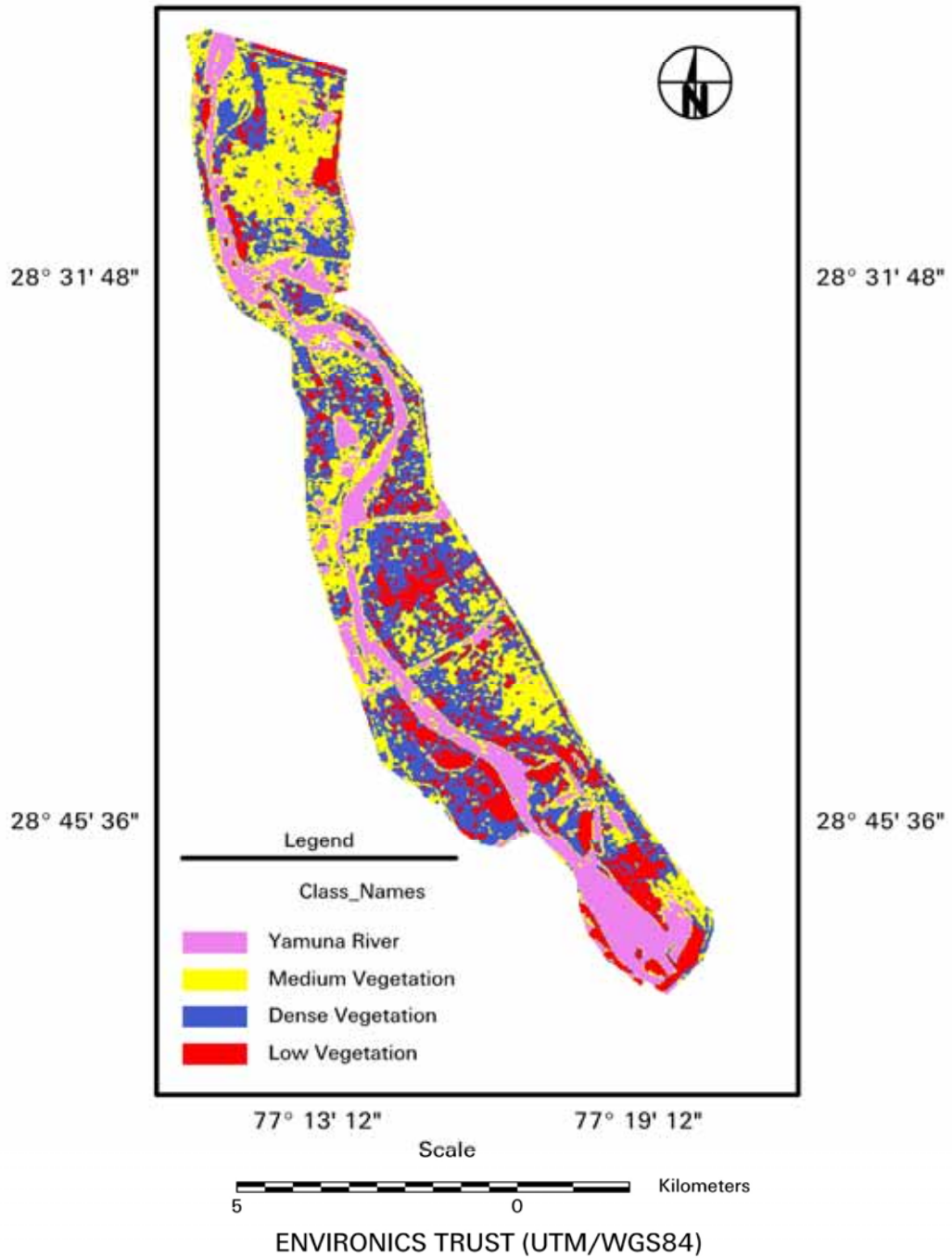
Dense vegetation is sparsely distributed over the region, it is noticed where a cluster of trees or green belts around the activity areas are available. The medium to low class vegetation depicts low reflectance values depending on the density of cover i.e. it varies with the type of growth on land is taking place.

Comparative broad indication indicates that there has been decrease in dense vegetation class and increase in medium to low vegetation classes as is depicted in the images. Degradation in vegetation class is noticed along structures coming up in the floodplains of River Yamuna like clear indication between NH-24 and IP Barrage as well as on the left and right banks of river through its course.

NDVI YAMUNA RIVER TM (1990)

77° 13' 12"

77° 19' 12"

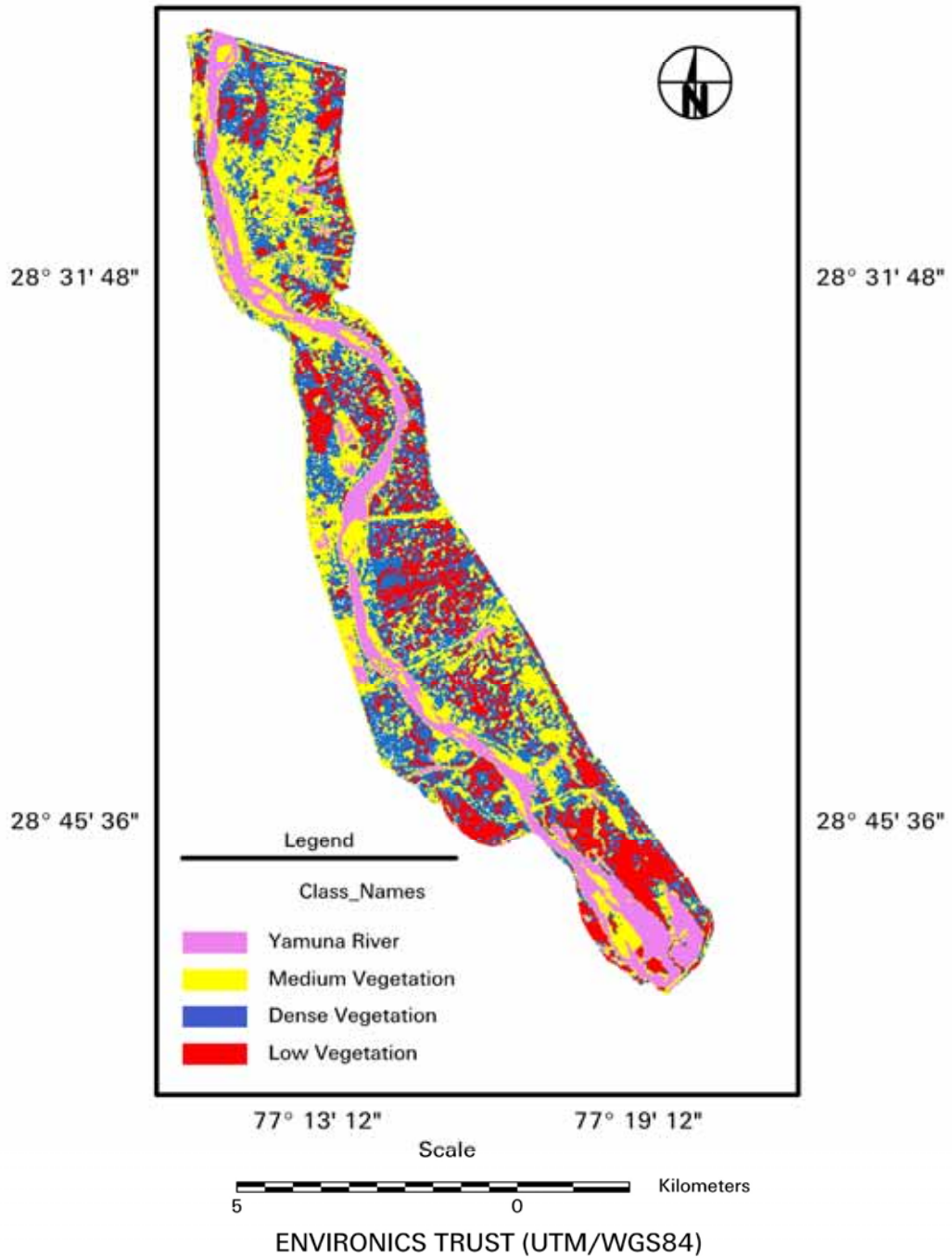


Map 11 - NDVI (TM - 1990)

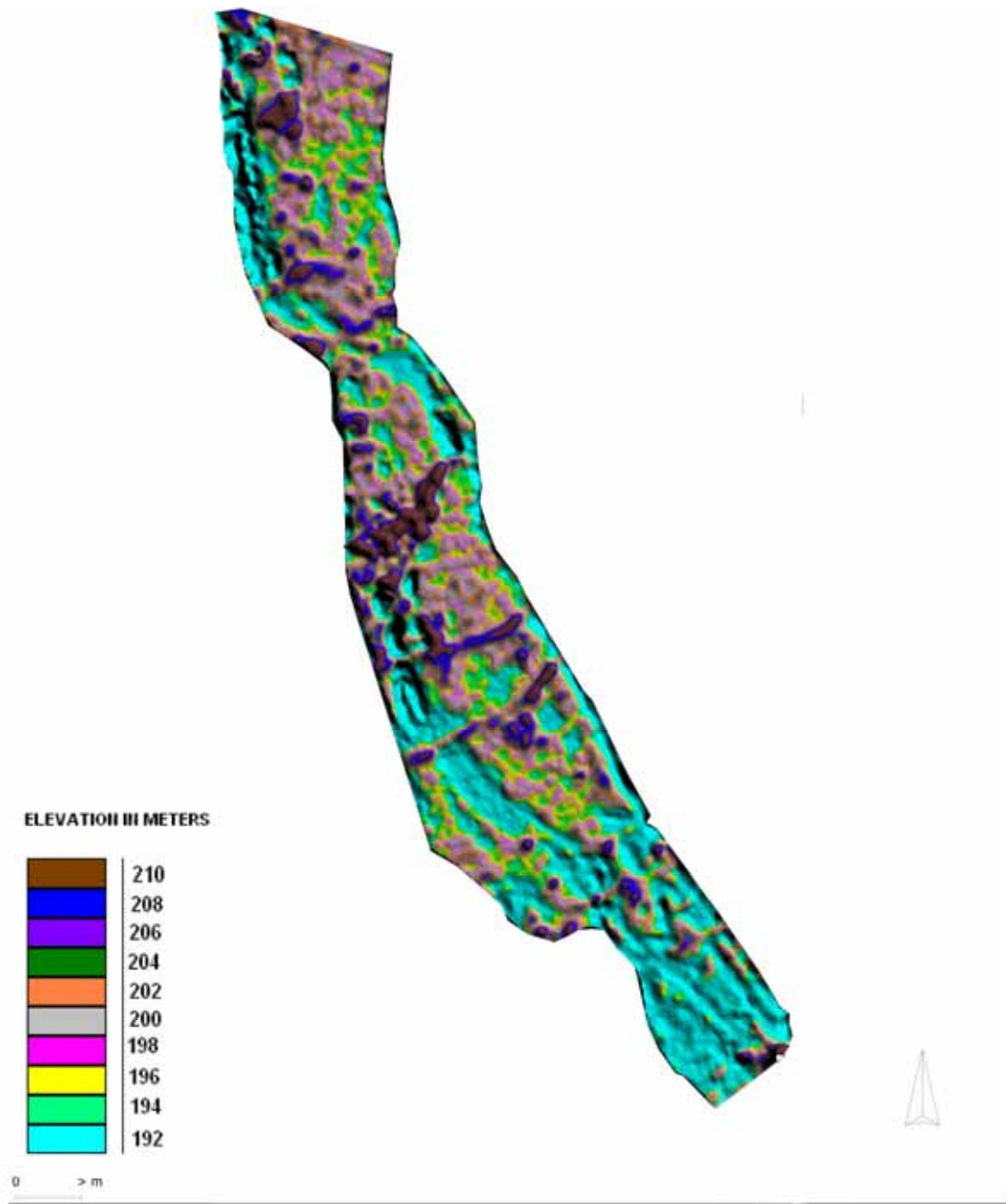
NDVI YAMUNA RIVER ETM (2000)

77° 13' 12"

77° 19' 12"

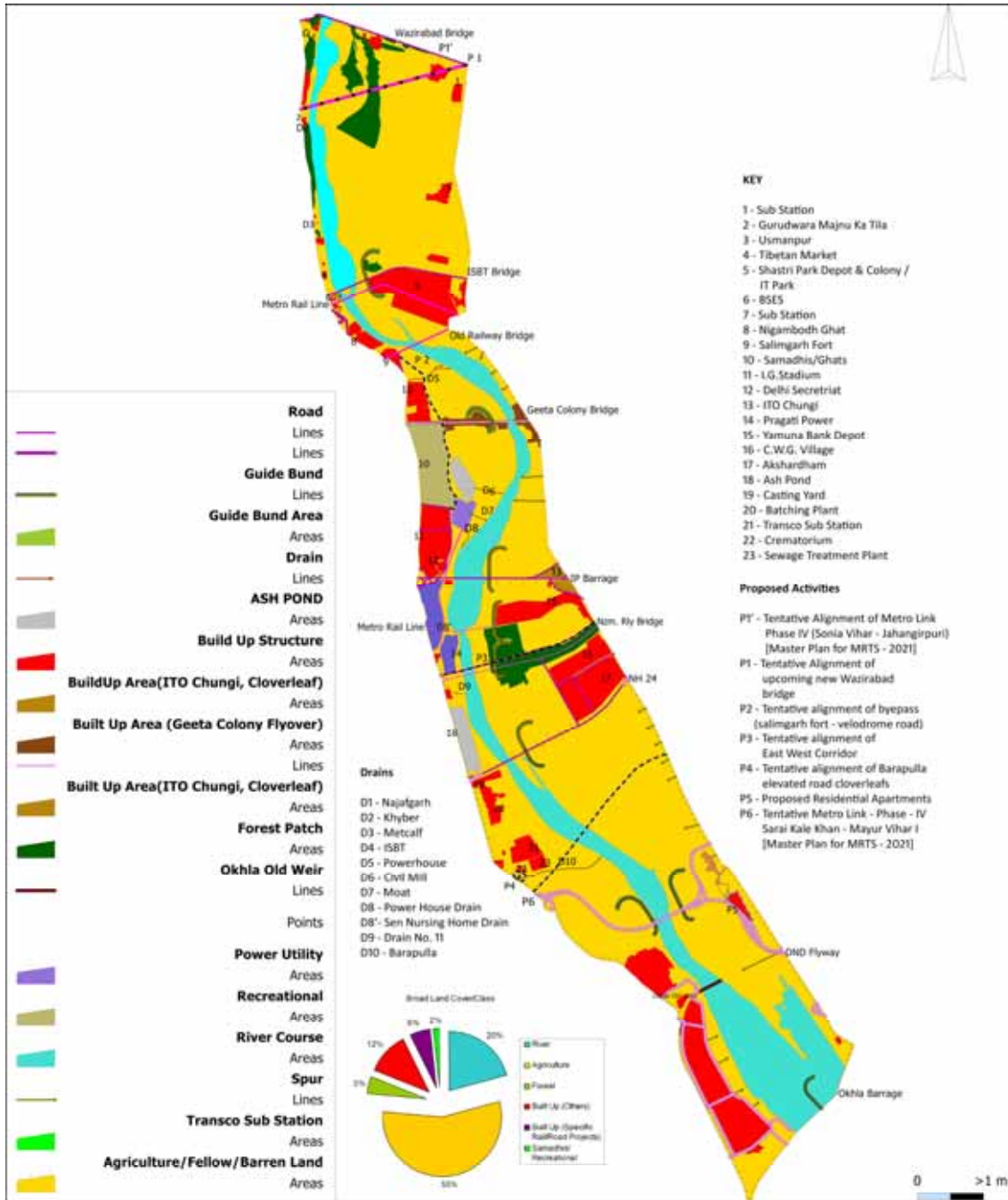


Map 12 - NDVI (ETM - 2000)



DEM of Riverbed Yamuna

Map 13 - DEM - Elevation Map



YAMUNA RIVER

ENVIRONICS TRUST
 Mercator
 Lon: 77°15'46" E
 Lat: 28°37'27" N

Map 14 – Wazirabad to Okhla Yamuna in NCT Delhi

The analysis of the areas enclosed between the study area has taken note of the structures existing on the left and right bank of Yamuna based on the last available updated images of the area on Virtual Earth server. It has been noticed that when bridge structures or for that matter other structures come up in the floodplains, landform disturbances around that structure and its associated elements like protection measures has also been taken care of.

Table 11 - Broad Land Cover/Class

Land Cover Type	Wazirabad to ISBT Bridge	% Area	ISBT to Old Railway Bridge	% Area	Old Railway Bridge to ITO (IP Barrage)	% Area
River	141.18	10.73	28.29	12.36	116.08	21.43
Agriculture	991	75.30	85.89	37.52	347.08	44.78
Forest	129.92	9.87	-	-	-	-
Built Up (Others)	48.73	3.70	25.33	11.07	113.52	14.65
Built Up (Specific Rail/Road Projects)	5.17	0.39	89.40	39.05	57.80	7.46
Samadhis/ City level Recreational	-	-	-	-	90.55	11.68
TOTAL	1316	100	228.91	100.00	775.03	100.00

Table 11 - Broad Land Cover/Class

Land Cover Type	ITO (IP Barrage) to NH24	% Area	NH24 to DND	% Area	DND to Okhla Barrage	% Area	Area All Sections (Ha)	% Area
River	116.63	15.24	160.26	15.20	454.48	45.08	1066.92	20.72
Agriculture	294.14	38.44	775.71	73.55	376.60	37.35	2870.42	55.76
Forest	106.58	13.93	-	-	-	-	236.50	4.59
Built Up (Others)	184.08	24.06	53.7	5.09	170.70	16.93	596.06	11.58
Built Up (Specific Rail/Road Projects)	63.81	8.34	64.93	6.16	6.44	0.63	287.55	5.59
Samadhis/ City level Recreational	-	-	-	-	-	-	90.55	1.76
TOTAL	765.24	100.00	1054.60	100.00	1008.22	100	5148.00	100.00

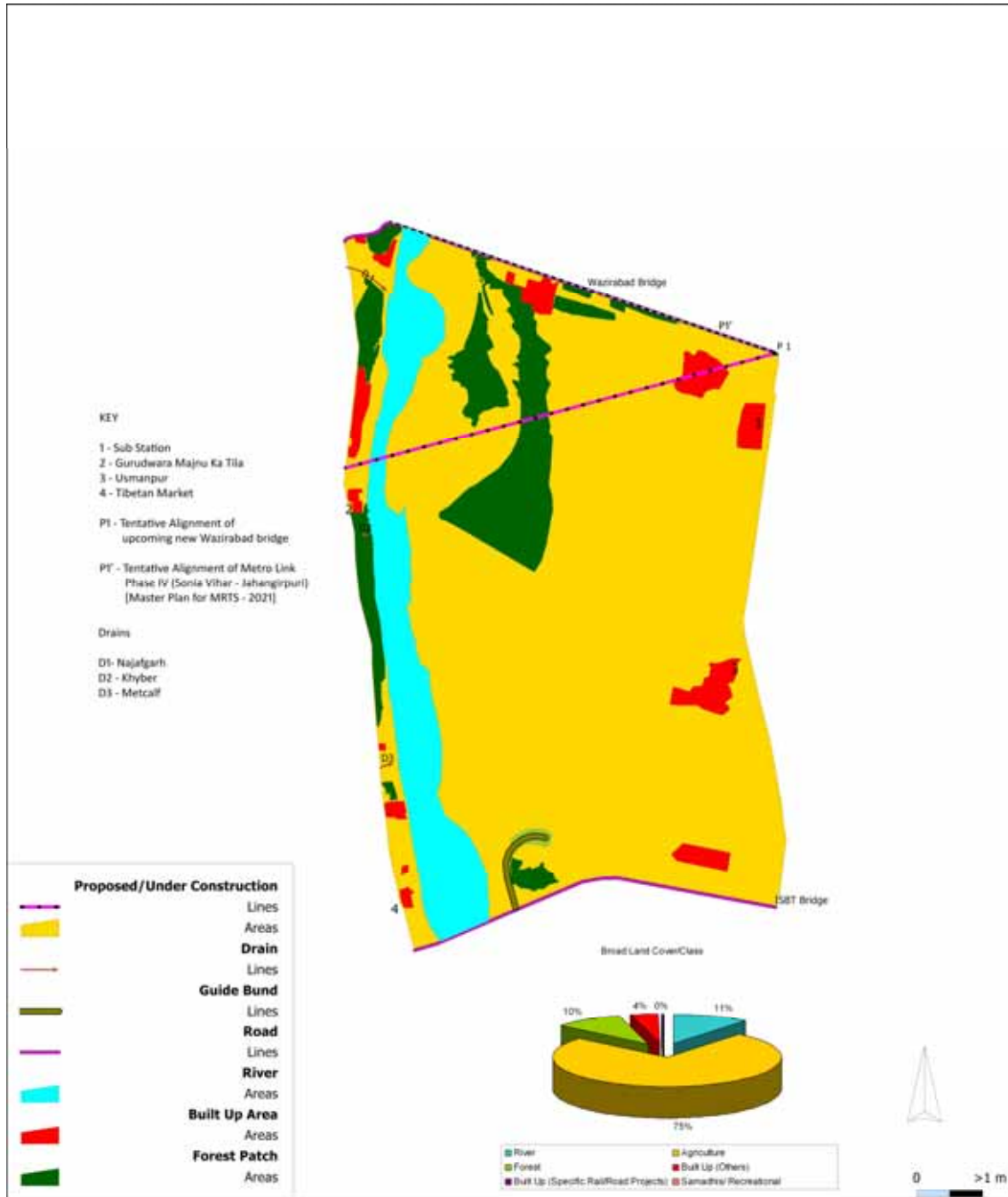
Area in hectares

Source: Created by Environics Trust using MS Virtual Earth Services (updated till 2009) integrated with GIS Environment

Table 12 - Breakup of Table 11 (Broad Land Cover/Class)

Land Cover Type	Wazirabad to ISBT Bridge	% Area	ISBT to Old Railway Bridge	% Area	Old Railway Bridge to ITO (IP Barrage)	% Area	ITO (IP Barrage) to NH24	% Area	NH24 to DND	% Area	DND to Okhla Barrage	% Area	Area All Sections (Ha)	% Area
area in hectares														
River	141.18	10.73	28.29	12.36	166.08	21.42	116.63	15.24	150.63	14.28	438.94	43.54	1041.75	20.24
Agriculture	991.00	75.30	85.89	37.52	347.08	44.77	294.14	38.44	775.71	73.55	376.60	37.35	2870.42	55.76
Forest	129.92	9.87	-	-	-	-	106.58	13.93	-	-	-	-	236.50	4.59
Built Up	48.73	3.70	25.33	11.07	73.47	9.48	97.22	12.70	53.70	5.09	170.70	16.93	469.15	9.11
Shastri Park Metro Yard	-	-	85.51	37.36	-	-	-	-	-	-	-	-	85.51	1.66
Yamuna Bank Metro	-	-	-	-	-	-	39.01	5.10	-	-	-	-	39.01	0.76
Geeta Colony Bridge	-	-	-	-	48.97	6.32	-	-	-	-	-	-	48.97	0.95
ITO Chungi Cloverleaf	-	-	-	-	6.77	0.87	7.69	1.00	-	-	-	-	14.46	0.28
DND Flyway	-	-	-	-	-	-	-	-	47.14	4.47	-	-	47.14	0.92
Power Utility	-	-	-	-	19.26	2.48	54.71	7.15	-	-	-	-	73.97	1.44
Ash Pond	-	-	-	-	20.99	2.71	32.15	4.20	-	-	-	-	53.14	1.03
Protection Structures	5.17	0.39	3.89	-	2.06	0.27	17.11	2.24	17.79	1.69	6.44	0.64	52.46	1.02
Samadhis/ Recreational	-	-	-	-	90.55	11.68	-	-	-	-	-	-	90.55	1.76
Hindon Cut	-	-	-	-	-	-	-	-	9.63	0.91	15.54	1.54	25.17	0.49
Total	1316.00	100	228.91	100	775.23	100	765.24	100	1054.60	100	1008.22	100	5148.20	100

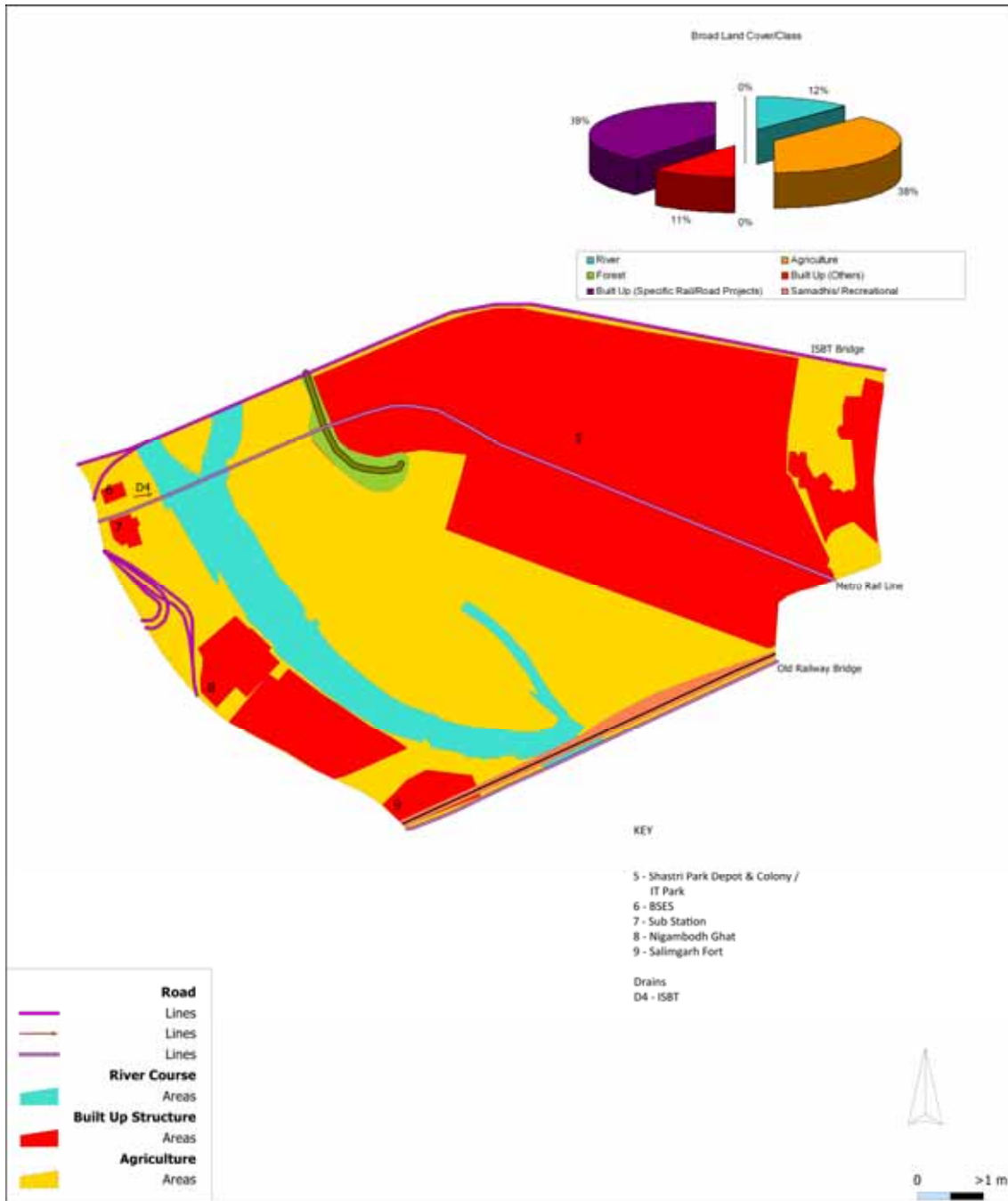
As per assessments and even considering the conservative estimates, around 17% of the entire floodplains are under built up category. Agriculture remains the predominant activity enclosed between some of the sections contained between the embankments, some lands are also left fallow for some periods. As indicated in NDVI, the level of vegetation has degraded over years and there has been considerable decrease in the forest clusters too.



WAZIRABAD BARRAGE TO ISBT BRIDGE

Map 15 – Section I (Wazirabad to I.S.B.T)

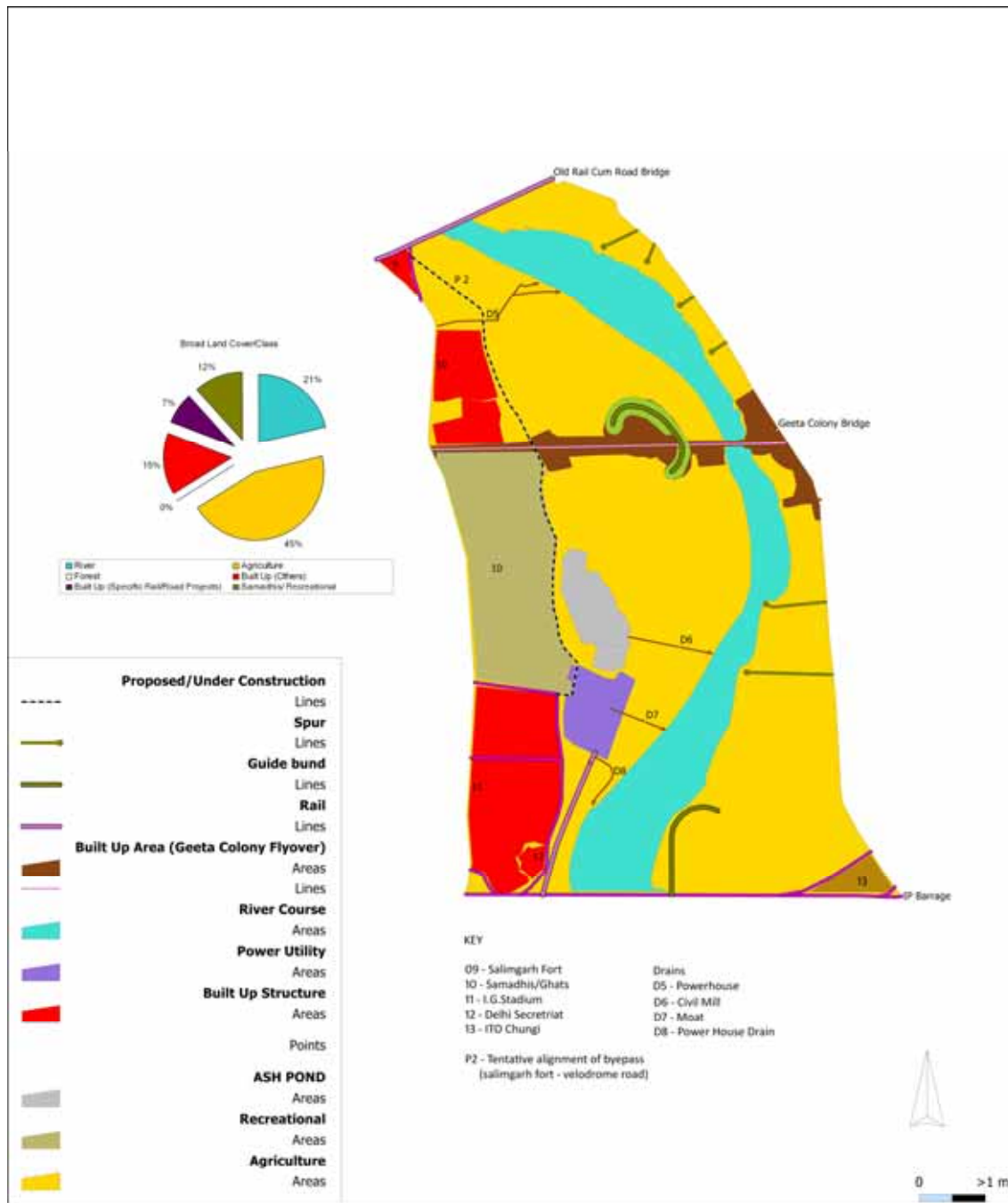
Predominantly agricultural (cultivable) in nature and one forest/scrub patch immediately downstream of Wazirabad barrage with a wide expanse makes this section critical for conservation purposes as these regions are subject to flood proneness.



ISBT BRIDGE TO OLD RAILWAY BRIDGE
 ENVIRONICS TRUST
 Mercator
 Lon: 77°14'41" E
 Lat: 28°40'00" N

Map 16 – Section II (I.S.B.T – Old Railway Bridge)

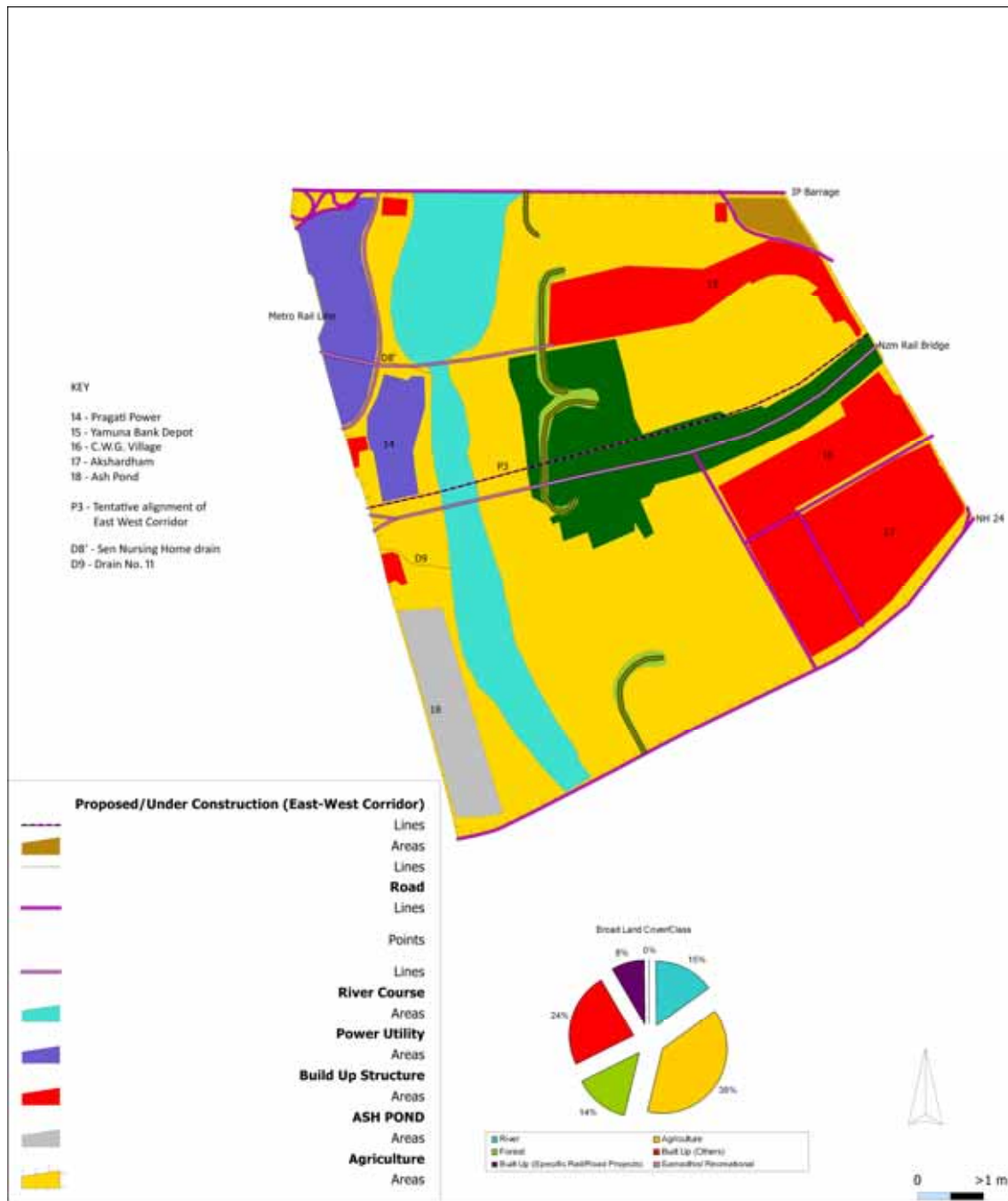
The smallest section between most bridges i.e. between I.S.B.T bridge to Old Railway Bridge is the most critical as almost 51.20% of the area enclosed in this section is built up (39.05% under the specific rail/roads and 11.07% under other built up on the right bank of Yamuna). Most of the area between this stretch has been almost built up and restricts the flood moderation in its upstream i.e. less exit way for water to flow downstream after the area was cut off due to coming up of DMRC metro line and other structures.



OLD RAILWAY BRIDGE & ITO (IP BARRAGE)
 ENVIRONICS TRUST
 Mercator
 Lon: 77°15'00" E
 Lat: 28°38'35" N

Map 17 – Section III (Old Railway Bridge – I.P.Barrage)

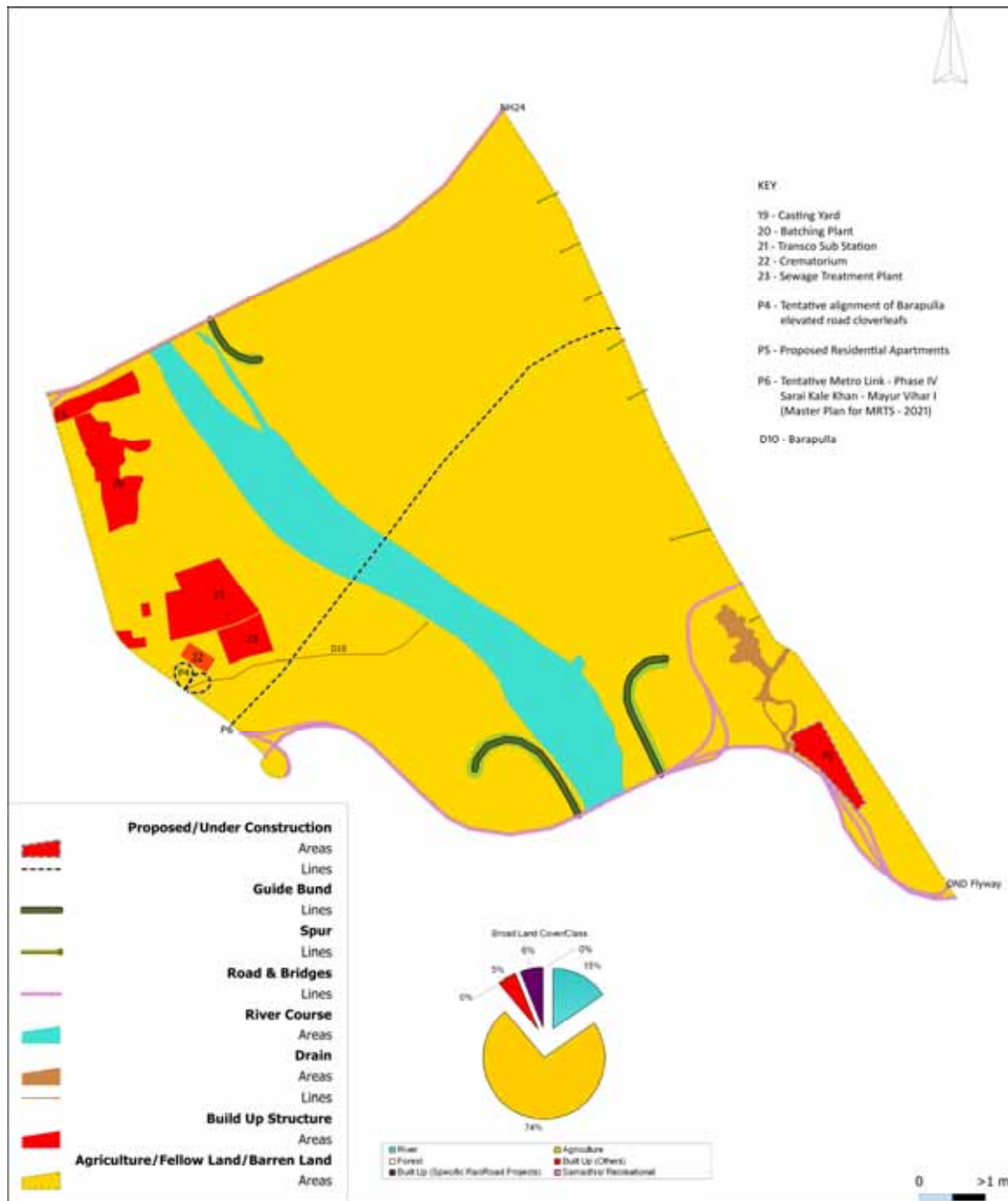
This subsequent section (Old Railway Bridge – I.P. Barrage) is also predominantly agricultural followed by city level recreational spaces running longitudinally along the right bank of River Yamuna (see map 17). Geeta colony bridge forms the predominant bridge structure other than rest of the built up spaces in this section which is a recent change in landform in this section. A bye pass road is also planned from Salimgarh fort to Velodrome. Around 49 hectares of land from the floodplains has been transferred by U.P. Irrigation department to PWD and other land owning agencies for facilitating construction of Geeta Colony bridge.



ITO (IP BARRAGE) AND NH 24

Map 18 – Section IV (I.P.Barrage – NH-24)

Section between I.P.Barrage – NH-24 again depicts a mixed land cover/class. In this section the predominant use is agriculture (38.44%) followed closely by built up area (32.40%) which is the second most physically disturbed section after the I.S.B.T-Old Railway Bridge. Among the built up 8.34% is attributed to road/rail projects and rest 24.06% pertains to structures like Akshardham Temple and Commonwealth Games village. Yamuna bank Metro rail depot is the recent addition in this section. Also junction improvement at I.T.O chungi has taken up considerable land in the floodplains due to non-availability of other alternatives as the other section towards Laxminagar are congested.

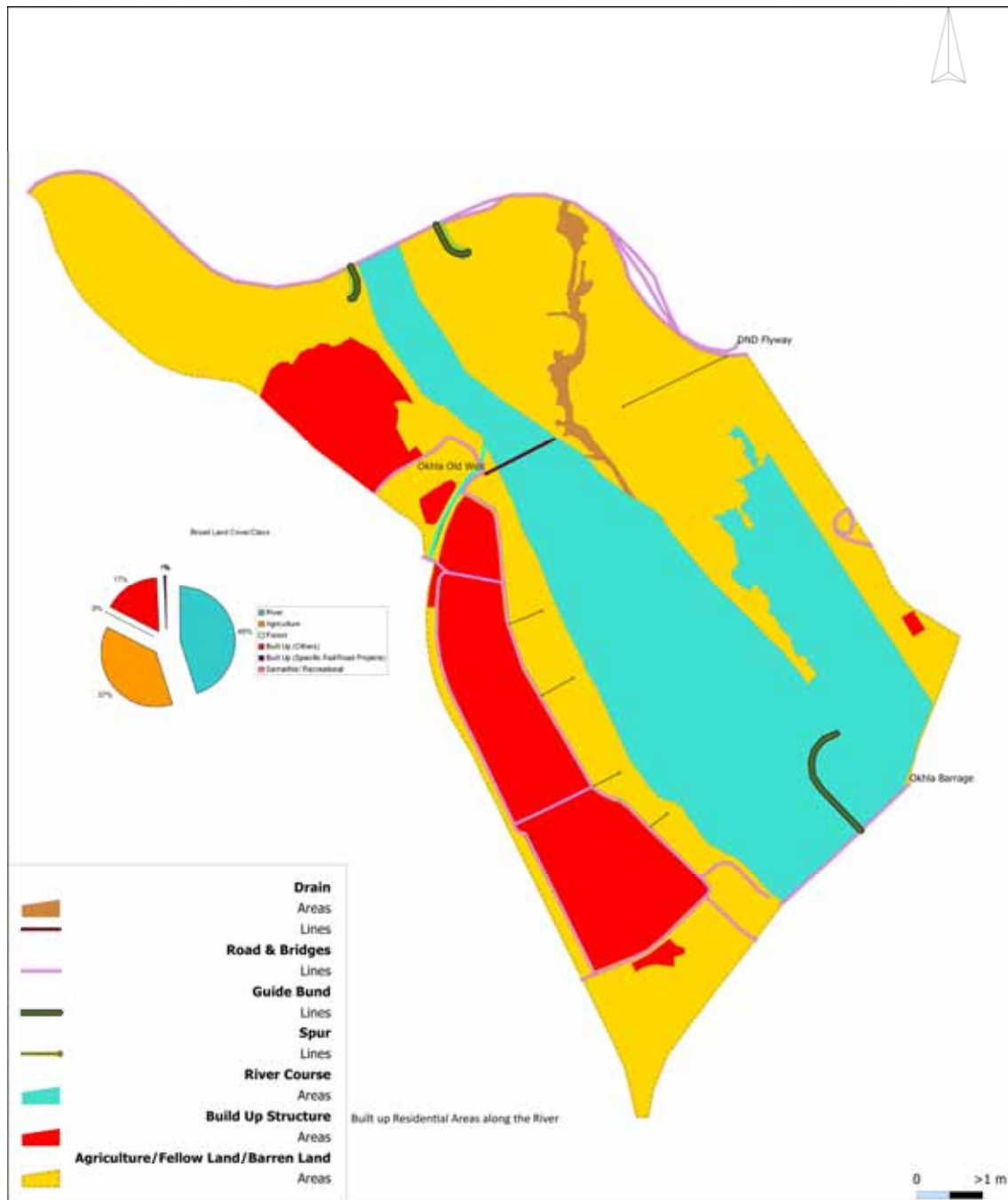


NH24 to DND FLYWAY

ENVIRONIC TRUST
 Mercator
 Lon: 77°17'00" E
 Lat: 28°35'15" N

Map 19 - Section V (NH-24 - DND)

The penultimate section between NH-24 to DND depicts large patch of lands as open/agriculture. It should also be noted that large chunks of land are already with the NTBCL which were acquired and given on lease some 10 years back. Some of the activities are proposed like residential apartments by NOIDA authorities in the immediate east of mayur vihar link from DND. A total of 11.25% of the area is built up. Several casting yards, batching plants have come up in this section due to construction of several projects. This is the section where large scale acquisitions have already taken place by development authorities nearly two decades ago for the purpose of channelisation of River Yamuna.



DND FLYWAY to OKHLA BARRAGE

ENVIRONIC TRUST
 Mercator
 Lon: 77°17'46" E
 Lat: 28°33'37" N

Map 20 – Section VI (DND – Okhla Barrage)

The last section between DND to Okhla Barrage the largest area under residential / mixed land use along the right bank of River Yamuna which is within the zone 'o' of DDA master plan. There is also considerable area under open/agricultural/protected areas which is close to 37% followed by built up i.e. 17.56%. In this section too, the lands were acquired for channelisation of river Yamuna. The region saw remarkable changes (see map. 2, 6, 7 & 10 for visual changes) after the coming up of Okhla barrage.

10. RECOMMENDATIONS

The conditions in the 22 km stretch call for River Conservation as the Primary focus - rather than sacrificing it in the name of urban connectivity- with utmost environmental sensitivity.

- (i) *No land transformations like that in case of Shastri Park Metro and expansion of other activities around it which has cut off river flow through that particular section. This raises questions about compatibility issues as to whether easing traffic congestion is the prime motive or river conservation. Can river conservation be done away with while improving mobility in the city should be the question requiring more probing?*

Based on the observations and analysis, the foremost task should be to freeze any physical development activity in the floodplains of Yamuna in NCT of Delhi. Some of the sections are almost congested due to construction of transport projects in the recent past and have resulted in transformation of landforms thereby leading to channel congestion during peak flows and reducing flood moderation in the upstream thereby leading to greater degree of flood impacts affecting larger populations as has been witnessed in floods in recent preceding years.

The conversion of available land in the floodplains (especially zone O/P) should not be allowed for any incompatible/physical development activities.

- a) *DMRC's master plan indicates integration of phase I & II with tentative plan of phase III and IV. The projects are at the initial stage of DPR preparation but master plan depicts that the linkages will cross over river Yamuna at two to three places. The already existing depots and interchange points located in the floodplains are good enough to understand the implications of sacrificing the floodplains. These two or three lines alongwith already under construction road bridges would reduce the effective linear distance between two subsequent bridge structures thereby reducing the waterway, increased obstructions and flows. Facilities like depots and interchange points have resulted in consumption of larger surface area of the floodplains as well as in the riverbed which has to be strictly a 'no-no' whereas possibility should be looked at developing linear routes to interconnect with already available linkages over river to take a call on river's future.*
- (ii) *Construction projects that are covered under the 'orange' category for approval shall also be strictly routed through the environment clearance process of the MoEF in such critical cases where the River is already constricted. Even the investment or area criteria should not be relaxed for projects coming over river Yamuna.*

Considering the typical nature of River Yamuna in NCT of Delhi, each structure coming over the River adds multiple impacts of different orders as indicated in the earlier sections of this report. A careful examination and integration of process – E.I.A with a special focus on upstream and downstream structures already existing along with simultaneous hydraulic study & alternatives before taking any decisions on the clearance of a project. The use of flyash utilization for road/metro bridges has a detrimental impact on the floodplain systems and

there is no standing instruction on non-usage of toxic waste for projects in vicinity of river which gives a free hand to the developer to use such a material.

Most of the proposals are being given a green signal as these pretend to be providing the only solution in the climax situation of urban development of a city like Delhi through physical measures. As such there is no restraining of activities or infrastructure within the floodplains and checks are merely for marginal improvements or alteration in the sub critical components.

Structures built along and across the river need comprehensive and cumulative analysis using time series data to overcome limitations of current modeling methods.

- (iii) *Though there have been technical reports prepared by institutions on hydraulic impacts of structures over river Yamuna in the NCT of Delhi but these pertain to location specific study for a particular bridge. A comprehensive analysis of the 22 km river stretch and structures existing and proposed over it would give a holistic overview of the situations in case of worst case scenario i.e. if flood of the intensity of 1978 comes again.*

Modeling studies have been done to depict level of submergence of floodplains under different flood return periods of varying flows but the floods during the last year (September 2008) revealed that eastern Delhi areas were submerged in water for several days and in some areas water receded only after several weeks. At the time of assessment only 8 bridges were considered by NEERI, so a situational analysis with the existing and proposed structures would hold much importance when the protection measures have also been completed or proposed and assessing reachwise consequent impacts which a particular element like bridge, bund, reduced waterway, relevance of gaps between bunds (implications of closing such gaps) can have on the overall scenario of floodplains. High resolution satellite data could be of much use to understand the limitation of models¹⁹ and bring the actual scenario or measured impact of a particular event like floods of 1978 and 2008 vis-à-vis correlating with the structures existing then and at present.

With each structure or infrastructure coming up in the floodplains, it is extremely important to understand flow conditions vis-à-vis rise in water levels in the floodplains due to channelised sections of river. This would provide factual evidence rather than estimations or assumptions and one can then work backwards to understand the behaviour.

- (iv) *Specific model studies for already skewed sections like between ISBT-Old Railway Bridge vis-à-vis hydraulic behaviour and potential impacts in case of worst scenario could be taken up for providing management plan and mitigative measures.*

Yamuna in NCT of Delhi being an embanked river through its course, needs investigation on several accounts. With the increasing intensity of physical construction (bridges, structures) the concerns for backflows in the upstream of every structure (reduction in waterway at embanked cross sections) could cause

¹⁹ A two-dimensional hydrodynamic model for flood inundation simulation: a case study in the lower Mekong river basin, Hydrological Processes; Wiley

drainage congestion²⁰. It is quite possible that even with the same peak average flows the water level may rise considerably given the pre-embanked and embanked scenario and with change in floodplain's landform. Correlation between overall assessment in changed situations could be another possibility of understanding the impacts in greater details for which a much comprehensive benchmarks, reference points, time series data would be required.

- (v) *Comprehensive assessment of river behaviour using time series satellite data for strategic action plans by identifying discrete elements which indicate change w.r.t time series data. A more supervised check or ground truthing can link the causative factors as well as resultant factors with such discrete elements identified. This can also take away the limitations of models which are usually adopted for simulation or atleast can be validated using the actual changes.*

- (vi) *Delhi (NCTD) lying seismically in zone IV require a far rigorous impact assessment studies (this study had neither the time nor the resources for it) to prepare for a worst case scenario of a 1978 intensity floods coupled with a plus 6 richter scale earthquake.*

²⁰ It must also be noted that structures over drains like elevated roads on piers resting in drain channel also impact the carrying capacity of drain given the circumstances of heavy rainfall and increased runoff due to increase in built up areas in the catchment.

ANNEXURE - CHARACTERISTICS OF DEVELOPMENT ALONG RIVER YAMUNA

S.No	Zone	Development in & along River Yamuna Banks	
		West	East
1	NCTD Boundary to Wazirabad Barrage	Agriculture Biodiversity Park, Jagatpur Village, Unauthorized colony, Water works,	Agriculture, Water works, Facility centre CRPF Camp, Delhi Police Firing Range, Unauthorized colony
2	Wazirabad Barrage to ISBT Bridge	Metcalf house, Chandrawal water works, Unauthorised colony, Religious structures, bathing Ghat	220 KV ESS, water ponds grass farms & Marshes
3	ISBT Bridge to Old Yamuna Rail cum Road Bridge	Nigambodh Ghat, unauthorized development of Yamuna Bazaar, Salimgarh fort	Unauthorized encroachment. Agriculture, DMRC Depot, IT Park
4	Old Yamuna Bridge to ITO Barrage	Red Fort Electric Crematorium, Vijay Ghat, Shanti Van, Shakti Sathal, Raghat, I.G. Stadium, Power house, Delhi Secretariat,	Unauthorized encroachment, Agriculture, cremation ground
5	ITO Barrage to Nizamuddin Rly Bridge	I P Power house, Gas Turbine power house, STP,IP Depot, Exhibition ground	Agriculture, Forest,
6	Nizamuddin Rly Bridge to N H 24	Fly ash pond Fly Brick plant unauthorized encroachment, Indraprastha Millennium park	Agriculture, PSP area Akshardham Temple Complex
7	NH24 to Okhla Barrage	Electric crematorium, Rajiv Gandhi Smriti Van, unauthorized encroachment, Electric sub-station, Sarai Kale Khan ISBT, Okhla STP, Sarita Vihar Group Housing Friends colony	Agriculture, New Residential colonies along the embankment
8	Okhla barrage to NCTD Boundary	Unauthorized colonies, water Body, agriculture, Madanpur Khadar resettlement Scheme ,LPG Bottling Plant	Agriculture water body

Source: Draft DDA Zone 'O' Master Plan, 2008

ANNEXURE - EMBANKMENT IN AND AROUND NCT DELHI

S.No.	Name of Embankment	Length (meters)	Top Level of the Bund	MWL 1978	MWL 1988	MWL 1995	Description
			(in Mtrs.)	(in Mtrs.)			
1	(a) R.M.E. from Palla to Wazirabad	18360	216.2	212.35	213.275	212.8	at Palla
	Jhangola		214.4	211.8	211.75	211.6	at Jhangola
	(b) Jagatpur Bund		4388	211		208.975	209.3
2	Yamuna Bazar Bund	600	209.12				
3	Yamuna Bazar Wall (at RD 1100 m with opening platform)	1100	207.98				Sill level of 206.70 m
4	Mughal Bund (RD 1800m)	2700	208.43				at RD 1800 m
	Mughal Bund (RD 2700m)		208.45				at RD 2700 m
5	Power House Bund	2300	207.14				
6	L.M. Bund (RD 550 m)	6700	208.44				at RD 550 m
	L.M. Bund (RD 4578 m)		208.24				at RD 4578 m
	L.M. Bund (RD 6700 m)		207.425				at RD 6700 m
7	R.M.E. Madanpur Khadar (RD 0 m)	3500	202.55				at RD 0 m
	R.M.E. Madanpur Khadar (RD 3000 m)		201.42		200.875	199.625	at RD 3000 m
8	L.F. Bund (RD 0 m)	5750	210	208.2			at RD 0 m
	L.F. Bund (RD 5750 m)		211.8				at RD 5750 m
9	S.M. Bund (RD 0m)	11900	209		207		at RD 0 m
	S.M. Bund (RD 4200m)		210.5			not affected due to const. Of LM bund	at RD 4200 m
	S.M. Bund (RD 11900m)		212				at RD 11900 m
	Total (Embankment length)	57298					

MWL – Maximum Water level

Source: Flood Control Order of 2009, I&FC

ANNEXURE - DRAINS UNDER IFC

LIST OF DRAINS UNDER CONTROL OF I. & F.C. DEPARTMENT						
No.	Name of Drain	Length (in km.)	Catchment Area in		Discharge in	
			Sq. Miles	Hectares	Cumecs	Cusecs
1	Alipur Block-North Delhi					
	1. Supplementary Drain (Under Const.)	34.5	486.49	1,26,000	141.57	5000
	2. Bawana Escape	19.79	70.39	18,231	19.29	681
	3. Drain No. 6	14.73	34	8,807	13	462
	4. Burari Creek	8.86	5.7	1,476	2.1	74
	5. Burari Drain	5.79	2.49	644	0.71	25
	6. Bankner Link Drain	5.5	12.92	3,348	3.34	118
	7. New Drain	5.4	108.25	28,038	33.4	1180
	8. Khera Khurd Drain	5.21	3.91	1,013	2	71
	9. Ghoga Link Drain	6.18	5.71	1,480	1.63	58
	10. Naya Bas Link Drain	3	3.2	829	0.91	32
	11. Sanoth Link Drain	3	4.1	1,062	1.16	41
	12. Alipur Link Drain	2.35	2.4	622	0.89	31
	13. Jagatpur Link Drain	1.6	0.39	250	0.28	10
	14. Tikri Khurd Link Drain	1.94	2.39	620	0.32	11
	15. Khera Kalan Drain (Link)	0.72	1.7	440	0.04	1.41
	16. Jahangir Puri Outfall drain (under const.)	5.47	6.25	1619.43	48.15	1700
	17. Toe Drain	4	0.58	150	0.52	18
	18. Drain No.2	2.8	0.39	101	0.28	10
	SUB TOTAL	130.84	751.26	68730.43	269.59	9523.41
2	Kanjhawala Block - West Delhi					
	1. Mungesh Pur Drain	36.85	182	47138	51.54	1820
	2. Bazidpur Drain	8.05	8.5	2202	2.41	85
	3. Bawana Drain	11.4	10	2590	2.83	100
	4. Daryapur Pond Drain (Covered Drain)	0.82	1	259	0.28	10
	5. Ladpur Link Drain	2.53	2	518	0.57	20
	6. Katewara Link Drain	1.55	2	518	0.23	8
	7. Jatkhori Link Drain	3.76	1.75	453	0.5	17.5
	8. Nangal Thakran Link Drain	2.59	0.6	155.4	0.17	6
	9. Bawana Jheel Link Drain	1.98	0.6	155.4	0.17	6
	10. Nangloi Drain	8.6	13.75	3561	3.14	111
	11. Madanpur Drain	8.23	19	4921	5.38	190
	12. Karari Suleman Nagar Drain	7.8	11.1	2875	3.11	110
	13. Sultanpur Drain	9.02	6.49	1657.6	1.7	60
	14. Rasulpur Link Drain	0.76	0.5	129.5	0.14	5
	15. Mundka Drain	2.5	2.65	686.4	0.37	13
	16. Ranhola Pond Drain	0.65	1	259	0.28	10
	SUB TOTAL	107.09	262.94	68078.3	72.82	2571.5
3	Najafgarh Block-South West Delhi					
	1. Najafgarh Drain	57.4	4223.57	1093900	283.13	10000
	2. Palam Drain	8.78	19.79	5125.6	86	3037
	3. Palam Link Drain	1.65	3.17	821	14.4	509
	4. Nawada Drain	2.35	0.68	176	0.88	31
	5. Nasirpur Link Drain	2.9	4.01	1038.6	28.88	1020
	6. Bijwasan Drain	4.2	10.64	2755.8	4.81	170
	7. Pankha Road Drain	5.3	3.16	818	28.32	1000

	8. Shahbad Mohammadpur	0.56	9.37	2427	4.39	155
	9. Bijwasan Pond Drain	0.38	1	259	0.28	10
	10. Bhupania Chudania Drain	8.55	14.3	370.37	40.49	1430
	11. Mundhela Drain (Revised)	12.5	6	1554	1.7	60
	12. Nangli Sakrawati Link Drain	2.34	0.08	20.7	0.68	24
	13. Dichaon Kalan Link Drain	0.48	0.05	12.95	0.37	13
	14. Kharkari Rondh Link Drain	1.53	0.05	12.95	0.42	15
	<i>SUB TOTAL</i>	<i>108.92</i>	<i>4295.87</i>	<i>1109292</i>	<i>494.75</i>	<i>17474</i>
4	Trans Yamuna Area - North East and East Delhi					
	1. Trunk Drain No. I	13.62	25.7	6660	86	3037
	2. Trunk Drain No. II	4.54	10.58	2740	50	1766
	3 Shahdara Outfall Drain	5.943	23.55	6099	157.5	5562
	4. Ghazipur Drain	6.241	26.03	6741.9	145.63	5143
	5. Shahdara Link Drain	4.54	0.58	151.7	32.83	1159
	6. Karawal Nagar Drain	2.48	0.05	12.5	14.1	498
	7. Biharipur Drain	1.01	0.06	14.56	0.93	33
	8. Bund Drain	2.835	0.66	170.44	6	212
	9. Escape Drain No. I	3	0.39	100	8	283
	10. Escape Drain No. II	0.425	0.03	9.06	1	35
	11. Relief Drain	6.025	1.93	500	0.11	4
	<i>SUB TOTAL</i>	<i>50.659</i>	<i>89.56</i>	<i>23199.16</i>	<i>502.1</i>	<i>17732</i>
5	Mehrauli Block - South Delhi					
	1. Ali Drain	2.78	9126	3693	78.8	2500
	2. Asola Drain	2.61	3.67	951.05	6.65	235
	3. Molar Bund Extension Drain	1.4	0.19	48.56	1.7	60
	4. Sarita Vihar Drain	1.3	5	1294.99	58.91	2070
	<i>SUB TOTAL</i>	<i>8.09</i>	<i>9134.86</i>	<i>5987.6</i>	<i>146.06</i>	<i>4865</i>
	<i>Grand Total</i>	<i>405.599</i>	<i>14534.49</i>	<i>1275287</i>	<i>1485.32</i>	<i>52165.91</i>

Source: Flood Control Order, 2009 of I&FC

LAND ACQUIRED BY VARIOUS AGENCIES

Subject	Gazette No.	Notification No.	Purpose of Acquisition	Date of Acquisition	Village	Area	
						Bigha	Biswa
Channelisation of River Yamuna	Part 4 (1-175) (1990)	F9(1)/89-L&B-15504	Channelisation of River Yamuna	22.06.1990	Madanpur Khadar	139	7
					Khizrabad	874	4
					Behlopur Khadar	743	19
					Chak Chilla	1779	1
					Kilokri	2228	5
	F9(1)/89-L&B/LA-15221	Channelisation of River Yamuna	23.06.1989	Ghonda Gujran Khadar	919	3	
				Ghonda Chauhan Khadar	28	4	
				Civil Station	1	11	
				Garhi Mendu	1563	16	
				Khajoori Khas	28	2	
F9(1)/89-L&B/LA(iii)/15505	Channelisation of River Yamuna		Sadatpur Gujran	315	14		
			Mangli Razapur	2009	10		
			Okhla	1660	10		
			Jogabai	699	2		
			Jasola	1565	2		
<i>Sub Total (Channelisation of River Yamuna)</i>						<i>14550</i>	<i>110</i>
		F11(30)/03/L&B/LA/6600	Development of bio diversity park, phase II	18.07.03	Burari	1448	11
<i>1.1 Sub Total (1.1)</i>						<i>1448</i>	<i>0</i>
Transportation							
	Part 4, No. 1-80 (2003)	NCTD No. 14, F7(32)/91/L&B/LA/17039	Grade separator cum road over bridge at G.T. Road, Shahdra		Jhilmil/Tahirpur	1	2
		7(10)/2001/L&B/LA/17058	NH 2, Kalindi Bypass		Okhla	71	
	Part 4 (Extry) No. 1-100 (2006)	NCTD No. 659, F8(114)/COT/CFD/06/732/7327	Vishwavidyala-Jahangirpuri (underground)			19.76	

Subject	Gazette No.	Notification No.	Purpose of Acquisition	Date of Acquisition	Village	Area	
						Bigha	Biswa
			Vishwavidyala-Jahangirpuri (elevated)			185.27	
			Shahdra-Dilshad Garden			96.71	
			Indraprastha-New Ashok Nagar			125.25	
			Yamuna Bank-Indraprastha			481.72	
			Inderlok-Mundka			223.56	
		F7(1)2006/L&B/MRTS(E)/80	GTB enclave station and elevated corridor of Shahdra-Dilshad Garden Corridor		Chandrawali	0.00	
		F7(5)/2005/L&B/LA/MRTS(NE)/255	Phase II, Shahdra-Dilshad Garden		Jhilmil	16	16
	Part 4 (1-175) (1990)	F7(23)/2001/LA/L&B/MRTS/14310	MRTS	25.11.02	Pooth Khurd	1043	16
	<i>Sub Total (Transportation)</i>					<i>2263.27</i>	<i>34</i>
Drains, Embankments & Bunds	Part 4 (Extry) No. 1-100 (2004)	NCTD No. 24, F7(5)/98/L&B/LA/24444	land for drain from daryapur fields to new ghogha link drain at RD 770m		Daryapur Kalan	5	3
		NCTD No. 71, F7(25) 2002/L&B/LA/DJB/28689	parallel lined channel from Munak (Haryana) to Haiderpur (Delhi)	Sec 6 issued on 12.11.03	Bawana	14	19
					Harevli	42	12
					Siraspur	39	12
					Prehladpur Banger	1	13
					Khera Khurd	89	7.13
					Daryapur Kalan	71	5
					Khera Kalan	94	8
	Part 4 (Extry) No. 1-100 (2006)	F11(6)/99/L&B/LA/PtII/1903	STP		Singhola	35	3
	Part 4 (Extry) No. 51-100 (2001)	NCTD No. F7(46)/99/L&B/LA/3456	Raising & strengthening of the right marginal embankment		Ibrahimpur	2	8
	Part 4 (1962) Delhi 27.12.1961	No. F15(303)/61-LSG I	Continuation of channel (hindon cut) by chief commissioner		Chilla Saroda Khadar	53	5
		F15(1)/62-LSG.I	construction of link drains		Gheora	53	19

Subject	Gazette No.	Notification No.	Purpose of Acquisition	Date of Acquisition	Village	Area		
						Bigha	Biswa	
		F15(2)/62-LSG	extension of najafgarh drain		Wazirabad	6	0	
		F15(2)/62-LSG (I)	extension of najafgarh drain		Wazirabad	16	14	
		F15(18)/62-LSG (ii)	construction of link drains		Naharpur, Pitampura, Saleempur, Majra, Shakarpur	51	5	
		F15(23)/62-LSG-I	construction of sultanpur drain		Pooth Khurd, Sultanpur Dabas	29	11	
		F15(22)/62-LSG (I)	construction of link drains in khanjhawala block		Rasulpur, Rani Khera, Madanpur Dabas	27	9	
		F15(17)/62-LSG	temporary occupation & use of the waste or arable land required for reconditioning of existing bunds in Mehrauli		Asola	6	19	
		F15(15)/62LSG	reconditioning of najafgarh drain		Chaukri Mubarakpur, Neemri	30	16	
		F15(3)/62-LSG (I)	construction of link drain in Khanjawala block		Rithala	8	14	
		F15(3)/62-LSG (v)	construction of link drain in Khanjawala block		Rithala	10	15	
		F15(67)/62-LSG(I)	construction of link drain		Jaffarpur alias hiran kadna, Nilwal	94	31	
		F15(30)/62-LSG(I)	construction of sultanpur drain		Kerala	18	0	
		F15(58)/62-LSG(I)	remodeling of nangloi drain		Puth Kalan	5	7	
		F15(56)/62-LSG(I)	remodeling of nangloi drain		Nangloi Jat, Nangloi Said, Sultanpur Majri, Rithala Patti, Mangolpur Khurd	155	14	
		F15(42)/62-LSG(I)	remodeling of bawana drain		Kanjhawala, Ladpur, Budhapur, Chandpur, Sultanpur Dabas, Nangal Thakran	109	22	
		F15(57)/62-LSGI	construction of link drain from Rithala to Badli		Rithala	3	0	
		F15(57)/62-LSG(iv)	construction of link drain from Rithala to Badli		Rithala	12	7	
		F15(97)/62-LSG	construction of bund		Deoli	56	7	
		<i>Sub Total (drains, embankments & bunds)</i>					<i>1133</i>	<i>305.13</i>
OTHERS	Part 4 (Extry) No. 101- 125 (2001)	F9(1)/99/L&B/LA/4352	Master Plan of Jamia Milia Islamia		Okhla	17	14	
	Part 4 (1962) Delhi 27.12.1961	F4(1)/61-L&H	planned development of Delhi		Joga Bai	11	10	

Subject	Gazette No.	Notification No.	Purpose of Acquisition	Date of Acquisition	Village	Area	
						Bigha	Biswa
		F15(49)/62-LSG	rehabilitation of the villagers of flood affected village mohamedpur ramzanpur		Mohamedpur	29	7
		F4(83)/62-L&H(ii)	planned development of Delhi		Sadhora Khurd, Sadhora Kalan	95	16
		F4(83)/62-L&H	planned development of Delhi			178	17
		F4(91)/62-L&H	planned development of Delhi			8	27
		F4(14)/61-L&H				71	0
		F4(14)/61-L&H				36	13
		F15(211)/61-LSG	planned development of Delhi		Chandrawali	166	16
		<i>Sub Total (others)</i>				<i>611</i>	<i>120</i>
		Grand Total				2005.27	569.13

Source: Delhi Gazettee (Part IV - Extraordinary) Volumes for Different Years, Delhi Public Library, Delhi

ANNEXURE - CHANGE IN LANDUSE

S. No.	Total Area (hectares)	Change of Landuse		Location
		From	To	
1.	26.0	Agriculture & Water Body	Manufacturing (M-2)	Near Jaitpur
2.	4.04	Agriculture & Water body	Manufacturing (M -2)	Near Rajghat Thermal Power Station
3.	42.5	Agriculture & Water Body	Public & Semi- Public	North of NH -24, near Akshardham Temple Common wealth Games Village.
4.	4.0	Agriculture & Water body	Manufacture (M -2)	Near Nangla Machi
5.	14.21	Rural use Zone	Residential	Madanpur Khadar Resettlement colony
6.	51.9	River bed/Green	Transportation	Near Shastri Park in River Bed
7.	6.0	Agriculture & Water Body	Commercial	Near Shastri Park
8	28	Agriculture & Water Body'	Commercial' (IOC Bottling Plant)	Madanpur Khadar
9	16.5	Recreational	Residential (11.0 Ha) and Commercial (5.5 Ha.)	Common Wealth Games Village Complex.
10	38.05	Agriculture & Water Body	Residential & Public & Semi-Public	Madanpur Khadar
11	1.74	Agriculture & Water Body	Public & Semi-Public	Buland Masjid Shastri Park Extn.
Total	232.79 hectares of land use change from river compatible uses to structural uses/built up			

Source: DDA Zonal Master Plan

ANNEXURE – IFC DRAINS

S.No.	Name of Drain.	Length of the drain where the desilting is required (in Mtrs.)	Estimated quantity of silt to be removed (in cum.)	Place of disposal earmarked	Disposal site identified by Department/ MLA	Qty. of silt removed as on 07.08.2006
1.	Trunk Drain No.1 FCI/CDIII & CDIV	4750 2335 7085	98789 cum. (by contracts) 29,700 cum. (by deptt. Machines.) 128489 cum.	I & FC land, on the banks of the drain, DDA land in Seemapuri along road No.70 and Tahirpur, Facility Centre No.10 Tahirpur.	By Department + D.D.A. land with permission from DDA	i) 76,200 cum. (by Contracts) ii) 49,590 cum. (by Deptt. <u>Machines</u>) 1,19,790 cum.
2.	Escape drain No.1 FC-I/CD-IV	1983 <u>0954</u> 2937	17351 cum. (by contracts) 8700cum. (by Deptt. <u>Machines</u>). 26051cum.	On the banks & nearby local depressions within 3 km. periphery	By department	i) 13,145 cum. (by contracts) ii) 8,760cum. (By departmental <u>Machines</u>) 21,905cum.
3.	Bund drain FC-I/CD-IV	2300	6191	Disposal in local nearby depressions.	By Department	5,150
4.	Biharipur drain FC-I/CD-IV	1000	1520	Disposal in local nearby depressions.	By Department	1,225
5.	Gaziapur drain	6175	42000	On banks of drain.	By Department	42,135
6.	Shahdara Outfall Drain	5800	14000	On banks of drain.	By Department	20,954
7.	Burari Drain. FC II/CD III	5400	3000	On banks of drain.	By Department	3,000
8	Karari Suleman Drain i) 2800m FC II/CD XII ii) 10m FC II/CDVIII	1300 3735	3000 180	Disposal site not available with the deptt. Silt to be carried by the contractor at his own as per directions of area MLA	By MLA	3,300 180
9.	Burari Creek FC II/CDVI	8863	1700	On bank of drain.	By Department	1,700
10	Toe Drain. FC II/CDVI	3500	4339	On banks of drain.	By Department	4,300
11	Link Drain No.2 FC II/CDVI	2800	1372	On banks of drain.	By Department	1,350
12	Ranhola Pond drain	1154	667	On left side of Karari Suleman	By Department	650

S.No.	Name of Drain.	Length of the drain where the desilting is required (in Mtrs.)	Estimated quantity of silt to be removed (in cum.)	Place of disposal earmarked	Disposal site identified by Department/ MLA	Qty. of silt removed as on 07.08.2006
	FC II/CDXII			Nagar Drain near RD 215m.		
13	Supplementary drain FC III/CDIX	6000	34500	On banks of drain.	By Department	69,240
14	Najafgarh Drain FC III/CDII	6235	19000	On banks of drain.	By Department	29,085
15	Pankha Road Drain FC IV/CDI	5300	12000	Right bank of NG Drain near Amberhai	By Department	10,500
16	Palam Link Drain FC IV/CDI	1465	6000	Right bank of NG Drain near Amberhai	By Department	5,500
17	Jahangirpuri Drain. FC I/CDX	5470	16000	On banks of drain.	By Department	32,280
Grand Total:-		76,519	3,20,009			3,72,262

Source: IF&C

ANNEXURE - INFORMATION AND DEVELOPMENT AGENCIES

RTI Information	First letter	First Reply Received	Second application on account of incomplete information	Status
<p>1. What are the key parameters, which are considered for ensuring minimal impact to the river flow, river morphology, floodplains management. Kindly provide copy of the same 2. No. of clearances obtained (technical, budget) from different departments (provide copies of such clearances)</p>				
PWD	June 15, 2009	06.08.09	17.08.09	Second reply received on 24.08.09 informing about copying of material but silent on point 2.
DTTDC	June 15, 2009	07.08.09	17.08.09	No replies so far on point 1 & 2
Northern Railway	June 15, 2009	31.07.09		States that old railway bridge over river Yamuna is more than 100 years old and new Railway bridge is over 50 years old. The information asked in letter is not available in this office.
			17.08.09	Information on above points missing
PWD	30.07.09	13.08.09		Zonal divisions of PWD only maintain and information asked with flyover divisions. Partial information received for two flyovers only.
	09.03.09	13.07.09	08.05.09 & 30.07.09 <i>(stating undue delay and loss of resources)</i>	PIO/O/o E-in_Chief on 15.05.09 transfers application to M-1, M-2, M-3 & F-1
		PWD, M-113 & M-111 on 21.06.09 says doesn't pertain to this office		
		E.E./O/o/C.E. on 29.05.09 says that 'this office understands that the work mentioned pertain to different divisions and requested suitable replies.		

RTI Information	First letter	First Reply Received	Second application on account of incomplete information	Status
		CE/M-2 letter dated 22.05.09 S.E. zone M-21 stating that information pertains to his office and supply information		Office of Chief Engineer - that Wazirabad barrage, ISBT bridge, I.P. barrage (ITO) & Nzm. Bridge are only maintained by this department. The construction of above structures is too old and no document is available in this department. Therefore, information be treated as nil.
		EE(P)/PIO MZ-3 - not related to this office		
		Karyapalak Engg. M-213, on 04.08.09 that not under his jurisdiction so information be treated as nil		
		KE, M-211 not under his jurisdiction A.E., M-212, on 24.08.09 'not under his jurisdiction'		
	30.07.09	02.09.09		Only mentions constructing agencies for three bridges and rest information is not available with this particular office because only maintenance is done. Works related to flyovers/bridges was done under the Yamuna Bridge Project and now these works are undertaken by different zone of PWD.

RTI Information	First letter	First Reply Received	Second application on account of incomplete information	Status
Land and Building Department	07.03.09 [on land acquisition by L&B for respective bridges or flyovers]	22.05.09 11.06.09	08.05.09 on account of no information received from the department 16.06.2009 30.07.09	No such information, as desired by you, is available in this office. Hearing notice on 28.05.09 by Appellate Authority Passes order – states that PIO should have called the appellant. Therefore PIO is directed to ask from the appellant to specify as to which copy of document or specific information of which village and which notification is required by him which may be provided to him within 15 days of receipt of the orders PIO did not responded Letter by appellant to PIO following the Appellate Authority Order dated 11.06.09 explaining the type of information required by giving an example. No reply Letter to appellate authority by applicant stating the status and provided a tentative list of villages but no reply so far.

RTI Information	First letter	First Reply Received	Second application on account of incomplete information	Status
Irrigation and Flood Control	08.05.09	17.06.09	12.06.09 23.06.09 30.07.09	<p>Stating that no reply received Not received by department</p> <p>Applied afresh due to department's claim that <i>earlier application not received</i> alongwith additional information as mentioned by CWC (pertaining to IFC in its letter dated 18.06.09) After passing of stipulated 30 days period, a reminder was sent to the PIO following which partial information received till now (30/06, 24/07, 13/08) but no information on points mentioned by CWC that particular information available with IFC - <i>still awaited. (quote reference to CWC points</i></p>

RTI Information	First letter	First Reply Received	Second application on account of incomplete information	Status
Central Water Commission	09.05.09 ²¹ 18.07.09 [pre & post monsoon observed flood data and cross section at palla and old railway bridge]	18.06.09 13.07.09 18.08.09	22.06.09 04.09.09	Generic information provided (point 1, 3 as per Annexure – RM) Requested for providing specific information in context of Delhi like in concern to specific flood control schemes; providing 'model studies carried out to know adverse effects of structures proposed' PIO responds that information already provided as on 18.06.09 No information provided after the lapse of 30 days but informs that certain formalities need to be done for consideration of authority to whether such information can be provided or not. Follow up of the above.

²¹ See Annexure – RM

ANNEXURE - RM

1. Whether CWC or RM wing has a mandate for regulating, guiding and appraising physical development pertaining to Yamuna River in the City of Delhi	
a. <i>If Yes, Kindly provide:</i> Such reports and/or notes for guidelines, regulations and appraisal of existing, proposed and already implemented railway bridges and flyovers ²² across River Yamuna in NCT of Delhi with a purpose of river management.	
b. Institutional linkages with respect to approvals and clearances to different projects involving river Yamuna component in the NCT of Delhi.	
c. <i>If No, kindly mention:</i> Organisation performing such functions 'in particular' as mentioned in 1. a) & b) above	
2. Whether CWC or RM wing appraise the design criteria of embankments, guide bunds, design of various components of flyovers /bridges ²³ like piers, columns, foundations on river bed over Yamuna river flowing through Delhi Urban Area territory.	
a. <i>If yes, kindly provide:</i> Such design assessments, appraisals and modifications suggested in embankments, guide bunds and design or bridges, flyovers over rivers in general and river Yamuna in specific	
b. <i>If No,</i> organisation performing such functions 'in particular' as mentioned in 2. a) above.	
3. What is the role of CWC or RM wing (and other agencies) in appraising, giving techno economic and ecological clearances to projects in Yamuna floodplains and network projects in / over river Yamuna in NCT Delhi. See point a) & b) below for details	Generic Information provided
a. <i>Projects in Yamuna Floodplains</i> – housing, river front development, other public utilities	
b. <i>Network Projects</i> – Various bridges and flyovers (as mentioned in annexure I also) in the NCT of Delhi over River Yamuna	
4. Kindly provide information pertaining to River Yamuna flowing through NCT of Delhi for the following	Advised to contact Irrigation and Flood Control Department, Government of NCT Delhi. IFC has not responded yet on these technical issues.
a. Observed flood level of the river immediately on the upstream of different bridges ²⁴ i.e. afflux or backwater over the last decade	
b. Technical details of the guide bunds in relation to different bridges (kindly refer footnote for name of bridges) on both the flanks indicating measures or methods taken to guide the river flow past a bridge without causing damage to it.	
c. Kindly provide illustrative (map) and technical details of maximum width over which River Yamuna meanders during high floods in the NCT of Delhi.	
d. Details of measures taken for river bank protection e:g slope turfing, spurs, weirs etc.	
e. Details of River course during high floods and dry season through its course in the city	
f. Kindly provide cross sectional details showing bed and bank levels, L.W.L and H.F.L. at the bridge, flyover sites	
g. Maximum depth of scour with corresponding H.F.L. and details of obstruction or any other special causes responsible for this scour.	
h. Studies or technical assessment on River Yamuna's behavioural studies or characteristics in the vicinity of the bridges, flyovers i.e. whether aggrading, degrading, braided. Any limitations shall also be provided.	
i. River bed slope, flood slope and natural ground slope	

ANNEXURE - LANDS ACQUIRED BY I&FC

S.No.	Details of Project	Land Area (Acres)	Location of Land	Source of Procurement
1	S.W. Drainage Scheme of Shahdara	4.68	Chilla Saroda Khadar RD 20000 - RD 21000	Acq. By DDA
	S.W. Drainage Scheme of Shahdara		Gharonda Neem Ka Khadar RD 25100 - RD 26600	Acq. By DDA
	S.W. Drainage Scheme of Shahdara		Shakarpur khas RD 42900 - RD 33700	Acq. By DDA
2	S.W. Drainage Scheme of Shahdara	22	Chilla Saroda Khadar	Others
3	S.W.Drainage scheme of Shahdara	4.4	Chilla Saroda Khadar	Others
4	S.W.Drainage scheme of Shahdara area, Shahdara drain	7.24	Gharonda Neem Ka Khadar RD 25100 - RD 26600	Acq. By DDA
5	S.W.Drainage scheme of Shahdara area, Shahdara Drain	1.14	Shakarpur khas	Acq. By DDA
6	S.W.Drainage scheme of Shahdara area, Shahdara Drain	18.83	shakarpur khas	Acq. By DDA
7	S.W.Drainage scheme of Shahdara area, Shahdara Drain	3.22	Shakarpur Baramad RD 32100 - 32900	Acq. By DDA
8	S.W.Drainage scheme of Shahdara area, Shahdara Drain	37.36	Dalupura 5000-8800	Acq. By DDA
9	S.W.Drainage scheme of Shahdara area, Shahdara Drain	5.35	Gharonda Neem ka Bangar	others
10	S.W.Drainage scheme of Shahdara area, Shahdara Drain	25.07	Kondli	Others
11	S.W.Drainage scheme of Shahdara area, Shahdara Drain (Ghazipur Drain)	50.34	Chilla, Saroda Bangar	Others
12	S.W. Drainage Scheme of Shahdara	0.6	Chilla, Saroda Bangar	others
13	S.W. Drainage Scheme of Shahdara	17.03	Samaspur Jagir	Others
14	S.W.Drainage scheme of Shahdara area, Shahdara Drain	37.05	Chelera Khadar	Others
15	S.W.Drainage scheme of Shahdara area, Shahdara Drain	38.37	Naya Bans	Others
16	S.W.Drainage scheme of Shahdara area, Shahdara Drain	30.37	Chalera Banger	Others
17	Storm Water Drainage scheme	0.6	Oldpur Ghodli	Others
18	S.W.Drainage scheme of Shahdara area, Shahdara Drain	15	Nawrangabad	Others
19	Construction of Supplementary Drain	102	Rithala	Others
20	Construction of CETP	2.96	Basaaidpur (along left bank of Najafgarh Drain)	Transfer from IFC to DSIDC
21	Construction of Supplementary Drain (RD 0m to RD 16436m)	66.213	Wazirabad	
		31.342	Dheerpur	
		32.373	Jharoda Majra Burari	
		172.504	Bhalswa Jhangirpuri	
		110.128	Badli	
		110.117	Rithala	
	Construction of Supplementary Drain from RD 34500 to RD 22471m	2.81	Nangli Sakrawati	Acq. By IFC
		71.68	Baprola	Acq. By IFC
		22.96	Kotla	Acq. By IFC
		57.50	Ranhola	Acq. By IFC

		127.23	Nilothi	Acq. By IFC
	Construction of Supplementary drain from RD 26060m to RD 25075m	25.18	Nangloi Sayed	transfer from DDA
	RD 25075m to 22471	40.86	Rohtak Road Bridge	transfer from DDA
22	Land transferred from DDA to IFC	234.61	Samaypur Badli, Sahibabad Daulatpur, Rithala, Nangloi, Pooth Kalan	
23	Land transferred from IFC to DDA	307.51	Rithala, Pooth Khurd	
24	Store for IFC	1.00	NH - 10, Rohtak Road	transfer from DDA
25	Transferred to DMRC	1.60	Adjoing shahdra link drain near mayur vihar	
	Total (including interdepartmental land transfers)	1839.24		

Source: Irrigation and Flood Control Department, NCTD

REFERENCES

1. Vijay R, Sargoankar A & Gupta A (2006), Hydrodynamic Simulation of River Yamuna for Riverbed Assessment: A Case Study of Delhi Region, *Environ Monit Assess* (2007) 130:381-387
2. Dutta D, Alam J, Umeda K, Hayashi M and Hironaka S (2007) A two-dimensional hydrodynamic model for flood inundation simulation: a case study in the lower Mekong river basin, *Hydrological Processes*; Wiley
3. S.E. Smith, F. Szilagyi, L. Horvath; (2002), Environmental impacts of the Gabčíkovo Barrage System to the Szigetköz region, *Clean Techn Environ Policy*
4. Environmental Management Plan for Rejuvenation of River Yamuna in NCT (2005), NEERI
5. Regional Plan – 2021, National Capital Region, National Capital Region Planning Board, MoUD, GoI
6. Menghnani L, Pahuja J.S., Sangkaranlingam C (2002), Design and Construction Aspects of a bridge over River Yamuna, *The Indian Concrete Journal*
7. Gazettes of Delhi, Part IV (Extra Ordinary)
 - a. 2007 (all volumes)
 - b. 2006 (No. 1-100)
 - c. 2004 (No. 1-100)
 - d. 2003 (No.1 – 207)
 - e. 2002 (No. 1-206)
 - f. 2001 (No. 51-100 & No. 101-125)
 - g. 1990 Part 4 (No. 1-175)
 - h. Part 4 (1962) Delhi 27.12.1961
8. Census of India, 2001
9. Minutes of Meeting, Yamuna Standing Committee
10. Report on Government of NCT of Delhi of 2003
11. Flood Control Order 2009, Irrigation and Flood Control, NCT Delhi
12. Survey of India Toposheet (53H6)
13. IS: 7349-1989, Barrages and Weirs – Operation and Maintenance – Guidelines, Second Reprint, May 2007
14. IS 12892:1989, Safety of Barrages and Weir Structures – Guidelines
15. IS 7720:1991, Criteria for Investigation, Planning and Layout of Barrages and Weirs
16. IRC:89-1997, Guidelines for Design and Construction of River Training and Control Works for Road Bridges (first revision)
17. Paper No. 109 & 112, Standard Specifications and code of Practice for Road Bridges (Section I) and Standard Specifications and Code of Practice for Road Bridges (Section II)
18. Morin, Jean, Champoux O and Boudreau P, *Research report No R-888: (2007) Impacts on water levels of new bridge footings and associated cofferdams for the international*

- bridge of Cornwall (ontario) using detailed 2d hydrodynamic modeling, Institut National de la Recherche Scientifique
19. Corridors, Networks and Watersheds (Urban Design and Ecology) – (1994), University of Minnesota
 20. Cherian, D. – Strategy framework for Delhi beyond the Commonwealth Games 2010 (2004), Massachusetts Institute of Technology
 21. Shukla A.K., Prakash R, Singh D, Singh R.K., Pandey A.P., Mandal H.S. and Nayal B.M.S. Seismic Microzonation of NCT Delhi – Earthquake Risk Evaluation Center, Indian Meteorological Department, New Delhi
 22. Iyengar R.N. and Ghosh S, (2004) Microzonation of earthquake hazard in Greater Delhi area – Current Science, Vol. 87, No. 9
 23. .Pandey Y and Dharmaraju R, C.B.R.I, Subsurface map of Delhi – GISdevelopment.net
 24. Central Ground Water Authority, Notification – davp 4054/35/2000, Time of India, 02-09-2000
 25. Krishna S, Delhi Metro: What counts, What doesn't (2009) - <http://www.livemint.com>
 26. Chapter VI, Land Management – CAG (Performance Audit) Report No. PA 17 of 2008 and Annexure XIII, page 45



For copies and further information, please contact

Environics Trust

33-B, Third Floor, Saidullajab, M-B Road, New Delhi-110030, India
Tel.: 011-2953 1814 • www.environicsindia.in

PEACE Institute Charitable Trust

178-F, Pocket 4, Mayur Vihar, Phase 1, Delhi-110 091, India
Tel.: 011-2271 9005 • www.peaceinst.org