# The Waterfront Engine: Proposal for a 21st Century Delhi

Under What Conditions Would a More Intensive Use of the Yamuna Waterfront Be Attractive and Sustainable?

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Abstract

Delhi, a 14 million people megacity, has a huge open space area available in its heart along the banks of the Yamuna River. At the same time, Delhi, which would like to become a fully-fledged global city, does not have a real modern business district yet, which explains why companies are moving to business-friendly neighbouring States such as Haryana and Uttar Pradesh, even as these companies would be much useful for the economic and social development of the capital of India. The banks of the Yamuna appear like an ideal location for a new business center. Or is it really? Research shows that creating a business-oriented waterfront along the Yamuna would be a valuable option and would bring in more revenue to the city than other solutions for the site, but only if certain conditions are respected in terms of environment, infrastructure and politics. Soil improvement and earthquake engineering techniques, renovated systems of transportation, water supply and treatment and electricity generation, mixed land use as well as institutional reforms and an intelligent real estate strategy are all necessary conditions for creating a waterfront that will be both attractive and sustainable. These conditions create minimu and maximum thresholds for development, between which conditions vary and create three different designs: a "Central Park model", a "Lutyens model" and a "Singapore" one.

**Key-Words**

Delhi - Yamuna - floods - waterfront - global city - megacity - soil improvement - economic development - real estate - capital city - development project

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**Introduction**

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**A. Change and cities**

Small changes can sometimes lead to great successes in cities. Sometimes, however, it is not enough. Cities need to make drastic changes in order to gear themselves for a new era, not only shedding their old clothes for new ones, but adapting their very stucture to new challenges. Cities have often been compared to organisms, and as such, they can progressively evolve to survive. But other times, the transformation needs to be deeper, and needs the helping hand of enlightened leaders. Thus, Haussmann for Paris, the marquis of Pombal for Lisbon, Reg Ward for the London Docklands, have undertaken major successful transformation of their cities.

It seems that these days, "top-down" planning is out of fashion, replaced by "bottom-up" approaches (planning from below) and local participation. This may be well for small changes, but only government and big businesses have the political clout and the economic power to make major transformations concerning water treatment, infrastructure, the creation or redevelopment of entire neighbourhoods. What must in fact be criticized more than the "top-down" approach, which can be complemtentary rather than opposed to the bottom-up one, is the bureaucratic inefficiency sometimes associated with large administrations. However, "bottom-up approaches" can be the other face of impotence as well. New Orleans is a good example of a tragic failure of the government at all levels, both before, during, and after the disaster. As a result, it has been replaced by a host of isolated initiatives coming from NGO's and planners, but with little effect on the general situation of New Orleans, for want of any strong, unified leadership such as the one that one could expect from the Federal Government.

In the case of developing countries, bottom-up approaches have sometimes have some successes, but always as proxy to the failure of governments. Top-down approaches have managed to produce amazing successes, such as in the Chinese case, provided that educational, cultural, social, economic and political factors make the population ready for change.

**B. Change and modern global cities**

I use the word "global city" in the use Saskia Sassen makes of it[1]. According to the Globalization and World Cities Study Group and Network, Delhi is not a global city but is in the formation process of becoming one. Global cities, as opposed to megacities, which are only defined by the size of their population, happen when the linkages binding a city have a direct and tangible effect on global affairs through more than just socio-economic means, with influence in terms of culture and politics. In order to keep their rank in the international competition where these cities are engaged, they have to invest in three major areas: business opportunities, infrastructure and prestige. By business opportunities, I mean how easy it is to come to these cities and open businesses there (whether it is office space, commercial uses or industries). This is determined by the economic legislation as well as the zoning regulations. A tool which combines both of these aspects is for instance the Special Economic Zone. By infrastructure, I mean transportation means and amenities used for persons and goods (airport, port, roads, water, and electricity) as well as for information (internet, optic fiber networks, etc). By prestige, I mean symbolic capital, that is, buildings and places which define a city and make it unique.

By their very nature, global cities must be open to change to survive: thriving on exchanges and communications, in a perpetual competition with each other to attract investment, staying immobile does not mean simply not going up anymore, it means going down.

**C. Waterfront and global cities**

Waterfronts can be key assets for global cities, as seen in London, Paris, Shanghai, Osaka or New York. These cities find in waterfronts a way to celebrate their economic might, their cultural heritage as well as their modernity. For instance, London has the Parliament or the Tate Gallery along the Thames as well as the Millenium Dome or Canary Wharf, and in Shanghai, the historical buildings of the Bund face the modern Pudong district on the other side of the Huangpu River. Working both ways, dynamic waterfronts contribute to the creation of global cities and global cities contribute to the creation of dynamic waterfronts.

1 Sassen Saskia, The Global City: New York, London, Tokyo, 1991

## II. The case of Delhi

### A. Untapped opportunities

#### 1. Lack of a major business district and of enough economic opportunities in Delhi, a would-be global city

Delhi is a megacity and a would-be global city. n the past fifty years, Delhi has grown enormously, it is now the home of 13.7 million people. It has the prestige of an ancient capital but that the quality of its infrastructure is still insufficient and that it lacks a real business center which would attract large foreign companies. A certain number of places in Delhi are both business centers and shopping districts, like Connaught Place in New Delhi, Chandni Chowk or Karol Bagh, but there is no modern office district on any significant scale. Thus, offices of foreign companies locate in other States at the periphery of Delhi, in cities such as Gurgaon and Noida. As the federal capital of India and the capital of the State of Delhi, a significant part of the city is occupied by official buildings and by civil servants' housing, as well as by people employed by the civil servants and by small businesses. Even if the middle class is now growing, the current economic model of the city is unable to provide jobs and decent living conditions to enough people: 46% of the city is still made of illegal settlements and slums, which vary from relatively comfortable, with water and electricity, to miserable, lacking the necessary infrastructure to supply even basic human needs. However, increasing affordable housing for instance is not going to solve all the problems: many poor people who had been given a house have then resold it to make some profit and have returned to their slums: only a stronger economic development will allow people to have a sustainable stream of income and to secure housing on a long term basis.

Until now, the Delhi Development Authority has maintained an anti-growth stance for fear that significant economic growth in the city would attract more people from the countryside and would make the situation uncontrollable. Thus, the DDA has opposed the development of any modern business district in Delhi, while cities in neighbouring States are teeming with projects of expansion. However, the population of Delhi is increasing anyway, though at a slightly slower pace than in the past, and economic opportunities should be, according to me, increased as well.

#### 2. A river runs through it?

The city has grown, and yet, its river has remained widely ignored. Once located only on the Western bank of the river, the city has now extended on its Eastern part. Thus, the Yamuna River, which had never been a central element of the city because of the threat that floods represented and because of the marshy nature of the soils, now occupies a much more central position. In terms of perception however, the Yamuna is still not part of the city, except as a terminal of its sewer lines. Access to the river is uneasy: East of the

parks and fortifications which stretch along the capital, the visitor penetrates into a completely different world, made of meadows, unkempt vegetation of weeds and trees, dirt roads and a few illegal settlements, until he reaches the river along which nothing is to be seen except a few treatment plants and, here and there, bridges flying high over the banks, connecting central Delhi to its satellite cities on the Eastern bank. Such an amount of unused land in a megacity like Delhi is puzzling, even more so as dams on the upstream part of the Yamuna prevent many of the dreaded floods of the past.

**3. The waterfront as the great plan for 21st century Delhi**

Delhi is now in a transition phase. If we say that there are three major components to a global city: attractiveness for companies, level of infrastructures, and symbolic/cultural/historical value – with the three components working together in a systematic way – we can say that Delhi has the symbolic value but still lacks the economic engine and is still insufficient in terms of infrastructures (mainly roads, water and water treatment, electricity – the great quality of the metro is a noticeable exception). Even the symbolic value of the city comes almost exclusively from the past, not of the present or of the future, as the physical form of the city is the one shaped by its Mogul and British imperial past. Two major planning efforts have been done in Delhi in the past: Shah Jahan, the great Moghul ruler who built the Taj Mahal, created between 1638 and 1649 the old Delhi comprising Shahjahanabad (Chandni Chowk) and the Red Fort (Lal Qila). Between 1912 and 1929, Edwin Lutyens created New Delhi, the new capital of the British Empire. Today, the city is still living on this double heritage, even as the conditions have radically changed. Construction since the creation of New Delhi has most of the time not followed any organized effort, with the exception of the planned development of Dwarka, and has often been made out of illegal colonies and settlements regularized afterwards. Even the Delhi Master Plan for 2021 is still heavily relying on the first Master Plan of 1962. As India has opened itself to foreign investments and as the population of Delhi has increased 25-fold since the beginning of the century, a third plan for the Indian national capital, one that could start along the Yamuna River, seems the logical next step.

Building a waterfront on the land available land along the Yamuna would add symbolic value to the city by showing that it can reinvent itself while keeping true to its values; it would also contribute to attract both foreign and national investors in the city itself, and would provide more employment opportunities for the poor, provided that the jobs created address different levels of education. It would also showcase best practices in terms of infrastructure, practices which could then be extended to the rest of the city.

**4. Optimal land use for the waterfront, optimal location for a business district**

A wide open space in the middle of the city on one hand, on the other, the need for a new business district... it would be tempting to bring these two ideas together and suggest the building of a business oriented waterfront without studying the question more closely. For it *may* well be that the best use for the Yamuna banks is a business district, and it *may* be that the best location for a new business district is the Yamuna river, but nothing else than intuition tells us that here, and it will be the purpose of this thesis to examine the validity of such a prediction. First of all, would the great open space of the Yamuna not be better used for something else, such as park and recreation or housing? Then, would the Yamuna banks be the best place for a new CBD anyway? Only after building the case for creating a business district along the waterfront can we speak about the specific design of this new development.

**B. A waterfront, what for?**

**A. Creating a socially, economically and environmentally sustainable and attractive waterfront**

Many reasons justify the creation of a waterfront in Delhi. However, the success of such an enterprise depends also on the way it is achieved, and on its precise objectives. What characteristics should a Delhi waterfront possess to be successful? Our goal should be to create a socially, economically and environmentally sustainable and attractive waterfront, and this goal informs my research question, "Under what conditions would a more intensive use of the waterfront be attractive and sustainable?"

By attractive, I mean that this waterfront should be appealing for one or more important categories of stakeholders, such as Delhi citizens and business-men. By sustainable, I mean that a waterfront created on the Yamuna should be economically, politically and environmentally viable without any systemic defect likely to cause its own doom over the longer term.

This question could be divided into three sub-questions:

- What is technically feasible?
- What is economically, socially and environmentally desirable?
- What is politically acceptable?

Each of these questions corresponds to a step in the research process: if no development can occur on the site for technical reasons, there is no point trying to go any further in the research process.
Once we know what could be done from a technical standpoint, we have to know what should be done which would be economically, socially and environmentally desirable.
Finally, we should be aware that such a development would not happen in a vacuum but would be politically difficult to implement. As for the present

time, the Delhi Development Authority opposes any development there. But perhaps it is so because no credible alternative has yet been presented to the present absence of development. We should try to modify our proposal so that it can be acceptable for all the major political players.

**B. Under what conditions would this goal be achieved?**

In the process through which my research went, the conditions of success for the site went from being a simple part of the site analysis as a preliminary to design to becoming the major part of my work. From a careful study of these conditions the choices made for the development of the site are inferred. The first, second and third part of the thesis are about the goals to achieve for the site and the conditions to achieve these goals. They will answer the following questions:

I. What should be done on the site?

II. What are the conditions for success?

III. Are these conditions present (and if no, what can we do?)

The fourth part of the thesis is not a full design proposal, but proposes several development scenarios that could happen within the boundaries of the conditions determined in the first three parts of this study. This thesis is not merely about urban design, it is first and foremost a research study done in order to support an urban design argument. Thus, this work comprises recommendations that do not pertain to urban design exclusively but also to planning policies in general, to transportation, water, electricity, etc. For instance, how could we plan a new CBD for Delhi without adressing the question of unsufficient power supply or poor infrastructure, when a new CBD would mean a new strain on transportation infrastructure and on power generation with a surge in the use of computers and air conditioning?

The problems of Delhi are all interrelated and the solution to them can only be systemic:

- physical conditions of the site
- real estate feasibility analysis
- infrastructure (electricity, water supply and sewer treatment, transportation)
- economics and demographics
- institutions

Studying these conditions would enable to give authorities, planners and designers useful information in their decision process concerning the site:

- first, they will determine what kind of use is feasible and appropriate for the

site, by setting maximum and minimum thresholds in terms of attractiveness and sustainability. Environmental thresholds (cost of development according to the physical conditions and to environmental protection), social thresholds (percentage of educational institutions within the new development, etc.), transportation thresholds (number of parking spaces required, roads, proximity to major transit nodes), financial and zoning thresholds (land use, property rights building height necessary to offset the cost of development, etc.). I will demonstrate that according to these thresholds, the optimal use for the Yamuna River is a business and entertainment waterfront.

- Second, within the boundaries of a business district waterfront concept and within the differrent thresholds' limits, varying these parameters, both quantitatively and qualitatively, in terms of financial cost and revenue, percentage of open space, etc. will lead to three choices of development for a Yamuna waterfront.

**III Assets and Liabilities**

What are the assets and liabilities of the city and of the site that may facilitate or on the contrary slow down the project of a waterfront along the river? How to leverage the assets, and how to turn the liabilities into new assets, or at least try to minimize their negative effect on the project? Defining these assets and liabilities will help us understand which condition for success for our site is already present and which one is not.

| Liabilities | Assets |
|---|---|
| Poor soil conditions, floods and earthquake hazard | River in the middle of the city |
| | Competent engineers and cheap manual workforce |
| Poor water supply and treatment, sewerage and electricity | - |
| Poor traffic conditions and degraded roads | Extensive bus system and new Delhi metro |
| 46% of the city made out of illegal settlements and slums | Highly % of educated, English speaking workforce in the country |
| Low efficiency bureaucratic institutions | Capital city of India |
| Lack of modern CBD | Possible leverage of capital ($$$) if it has a better strategy |
| Lack of housing | Hot real estate market |

Before confronting the assets and liabilities of Delhi and of the Yamuna banks to the conditions for success, we should first determine what needs to be done on the riverfront.

# Part I. What should be done on the site?

**Summary**

Three major challenges await anyone interested in the development of the Yamuna waterfront: managing to overcome the difficult nature of soils, improving the infrastructure to make a future development functional, and finally attract business there.

## I. The Yamuna banks, a challenging site

### A. Many cities have created waterfronts in their history, but Delhi has carefully avoided the Yamuna River

Most of the major cities of the world have claimed land over water by draining swamps and channelizing rivers between dykes. This is not a recent phenomenon, allowed by modern engineering techniques. Drainage and land reclamation works are as old as cities themselves and have been performed throughout history for various reasons, often complementary: creating more developable space at the heart of the city for commercial and residential uses in case of demographic and real estate pressure, enhancing the prestige of the city and the power of its ruler by creating a majestic waterfront, channelizing the river to enable better navigation and the creation of a port to export and import goods, etc. Flood control too has always been a major reason, even if high embankments often mean a higher flood risk upstream and downstream of the protected area. Paris first developed on the islands of the Seine and the left bank before the marshy right bank was drained to make place for new development. Important buildings were lined up along the river as soon as the Middle Ages, both for the strategic importance of being near the Seine and for the symbolic and aesthetic display of power it offered: Le Louvre, la Conciergerie (Palais de Justice), la Préfecture de Police, Notre-Dame, and its modern iron-made equivalent la Tour Eiffel are all along the river or on the Ile de la Cité. The same process happened with London, surrounded by marshes during Roman times. Other examples include parts of Washington, D.C., some of which is built on land that was once a swamp; Helsinki, of which the major part of the city center is built on reclaimed land; the Cape Town foreshore; the Chicago shoreline, Back Bay in Boston; the port of Zeebrugge in Belgium and the polders of the Netherlands. Hong Kong, Macau and the city-state of Singapore are also famous for their efforts on land reclamation. Land reclamation was also essential to the rebuilding of the Central Business District in Rio de Janeiro. Hills were being destroyed and used as infill to develop marshy land.

Why has not it been the case in Delhi? A map of the capital clearly shows that a great part of the floodplain has been carefully avoided until now. The Red Fort itself and the ramparts of the city have been built at a safe distance from the river. Only poor people have dared to live in slums in the flood plain, most of it still wetlands, woods, pastures and fields. With the major exception of the left bank of the river, a marshy land now built upon up to a point where 20% of the population of Delhi lives there, most of the flood plain remains undeveloped. Riverfronts are often seen by modern developers as prime locations where major development or redevelopment operations can occur, and we may wonder why this has not been the case here.

The site of the Yamuna River presents in fact much more complexities for development than other waterfronts, due to the physical characteristics of the river and its flood plain as well as to conflicting human needs.

**B. The monsoon factor**

The particular hydrologic regime of the Yamuna explains this situation. The Yamuna River takes its source at a glacier in the Himalayas, at Yamunotra, but its flow is only slightly due to the summer melt of ice and snow in the mountains; on the contrary, it is overwhelmingly influenced by the monsoon rains that occur in July, August and September. The average annual rainfall of 714mm for Delhi masks huge discrepancies between the very small quantity of rain falling during most of the year and the one falling during the monsoon.

Hence, contrary to rivers of other major cities in the world, the water flow in Delhi varies hugely during the year, leaving the flood plain flooded during a few months and dry the rest of the time. Even relatively frequent floods are sufficient to flood the whole flood plain, such as a 2132 m3/s flood that has a 1/25 chance of happening per year. At a discharge of more than 3000 m3/s, large areas along the river are flooded to depths of up to 2m. The Yamuna River has exceeded dangerous flood levels (fixed at 204.83m in Delhi) 25 times in the past 33 years. In modern times, the city faced six extensive floods in 1924, 1947, 1976, 1978, 1988 and 1995, with greatest danger recorded on September 6th, 1978, with a record flow rate of 7022 m3/s, and on September 27th, 1988. In all incidents, the low-lying eastern-bank of the river was inundated often as far as four kilometers from the riverbed center.

This situation is a challenge for waterfront development since such projects rely on the presence of water as an amenity: how can it still be true when there is either no more water, or too much of it?


Picture 1 Satellite picture of Delhi and open space area along the Yamuna

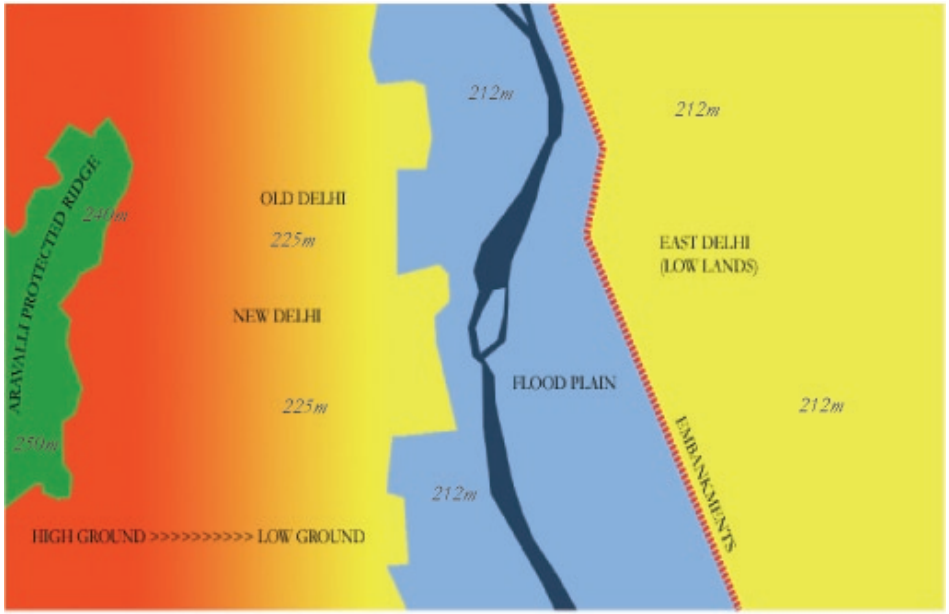



Fig. 1 Topography of Delhi

Let us note that water levels for 1% annual probability are not well known, and estimates from different sources vary: according to the Tata Energy Research Institute, this flood could discharge more than 0.45 million cusecs (12 000 m3/s), when the present capacity of Delhi embankments can only withstand a discharge of 0.25 million cusecs (7000 m3/s). In any case, numbers show that Delhi is unprepared to face such a major flood.

N.B. One should talk of floods in terms of probability, not of frequency. Speaking of a centennial flow is for instance technically incorrect, since it would mean that such a flood would regularly occur every one hundred years. Instead, this means a flood that has a 1/100 or 0.01 probability of happening in one year.

Monsoon rains affect the greatest part of India, but the fact that the Yamuna has been avoided throughout history in the case of Delhi is quite unique among major Indian cities. Bombay is built on the seaside and has experienced floods from the Mithi River but the danger seems less great and less frequent than in the Yamuna case and the city has developed till the river itself. In the case of Calcutta, the Hoogly River also threatens the city with floods, but the bank of the river has developed as a natural levee and the general slope of the land is eastwards from the river bank, so that the city, whose main part lies westwards of the river, has been able to develop along the river. On the contrary, Allahabad along the Yamuna River has like Delhi avoided building along this river, stretching instead on the shore of the Ganges. In the south, Bangalore has been inundated because of lakes overflowing but flooding there as well as in many Indian cities seems as much due to water logging because of poor infrastructure than to the rivers themselves.

**C. Inadequate soils**

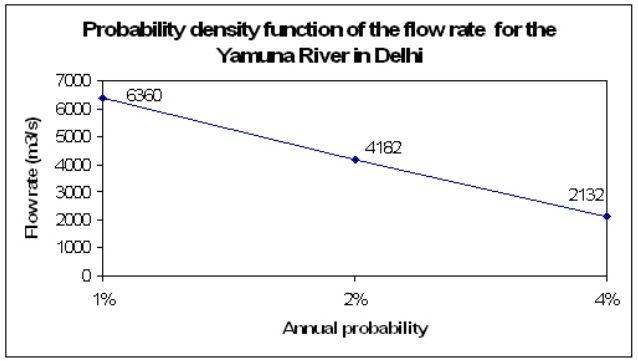
The flood plain soils are of poor quality for construction, being mostly made out of deep loamy sands (85% sands, 15% clay) and sandy loam (30% silt, 60% sand and 10% clay). They are highly stratified soil with uniform, poorly graded, gray, river sand till at least nine meters below ground level. The first sand layer extends till 20 meters below ground level and is followed by an impermeable, 10 meters thick layer of sand, silt and kankar (calcareous concretions). The proximity to the river and continued hydraulic pressure from the eastward shift of the river has saturated the top sand layer on the Eastern bank.

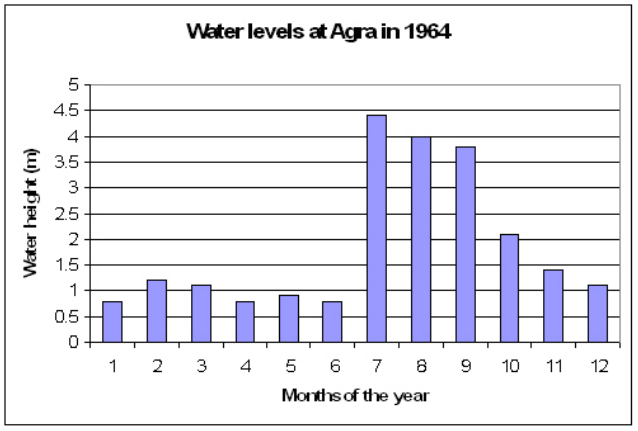
Fig. 2 (right) Yamuna watershed

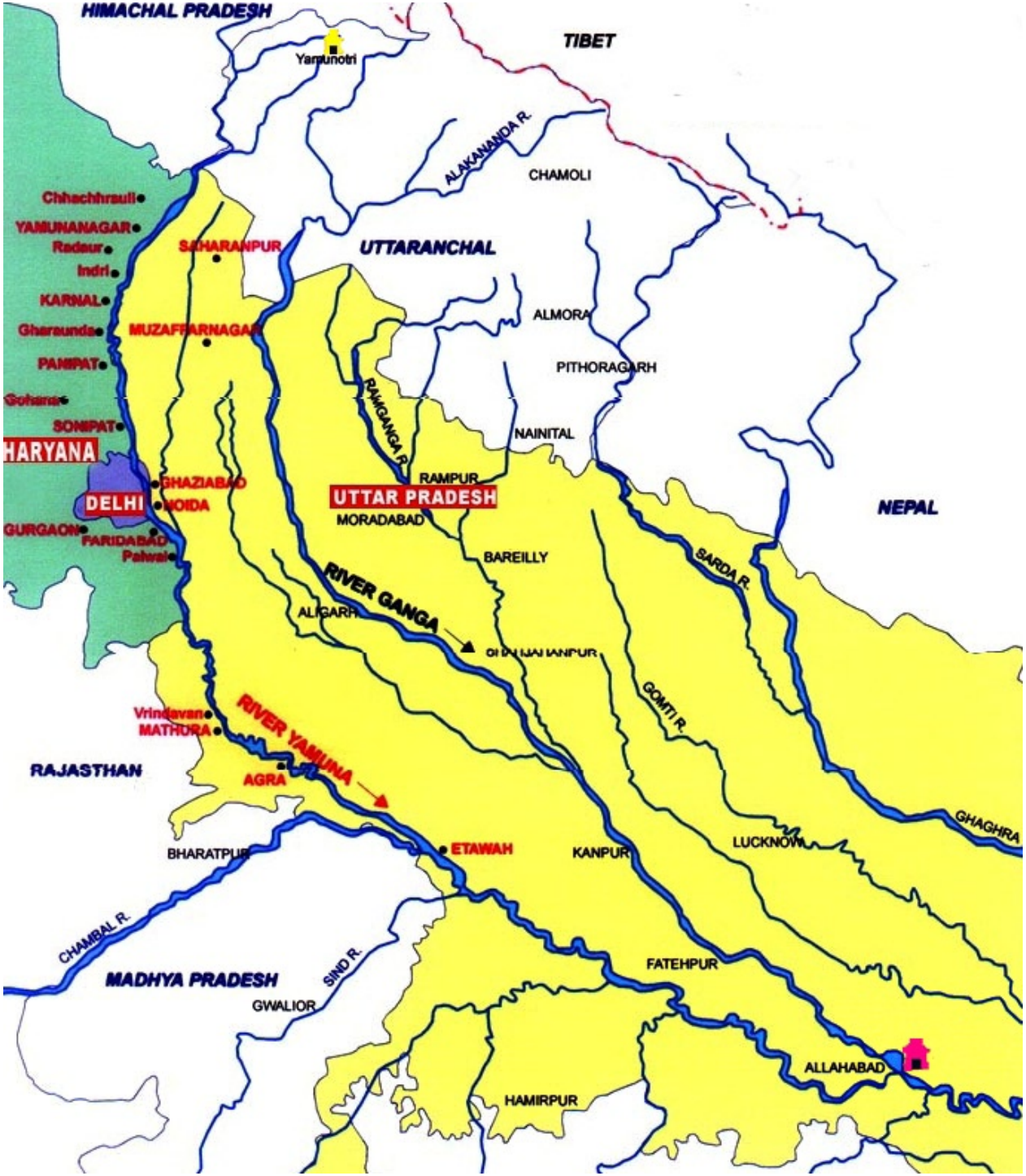
Gr. 1 (first below) Probability function of the Yamuna flow rate in Delhi

Gr. 2 (second below) Water levels at Agra in 1964

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20.3 | 15.0 | 15.8 | 6.7 | 17.5 | 54.9 | 231.5 | 258.7 | 127.8 | 36.3 | 5.0 | 7.8 |



The Yamuna River has had a heavy discharge of alluvium from the Himalayas and its own banks and it has built a thick layer of silt over the bedrock. It means that it makes it more difficult for construction to occur since buildings need to be anchored to some sufficiently hard surface in order to avoid subsidence effects or horizontal displacement in the sedimentary layers. The first relatively stable layer of consolidated clay begins at 40 meters below ground level, and bedrock around 100 meters BGL.

Delhi is also located in a level IV seismic zone, on a fault line, and the flood plain is even more vulnerable to earthquakes because of the resonance effect of seismic waves in soft sedimentary layers like these.

Channelizing the river and developing the waterfront would allow the city to come closer to the water, which is presently totally ignored even as it could represent an important asset for Delhi. However, channelizing could also lead to severe inconveniences if no mitigation measures are taken:

- It would force the river in a narrower bed and would provoke higher water levels during the monsoon time and thus more severe floods.
- Constructions on alluvium soils would raise imperviousness and prevent the water from recharging water tables, thus diminishing the water available for the citizens of Delhi.
- Construction would be hazardous if no special techniques are undertaken due to the nature of soils in the flood plain and the earthquake hazard. Danger for constructions include unequal settling of foundations, seepage and corrosion of infrastructure; high subsoil water pressure from the underground water tables during monsoon rains, amplification of seismic waves due to the deep sedimentary ground underneath and landslides sweeping the foundations of buildings away.

**D. Contradictory goals for the river: upstream irrigation and water supply for Delhi**

The present state of the river is anything but natural: if it was not being heavily used for irrigation, the Yamuna would have a much higher flow even in dry season. A succession of dams for irrigation and water supply takes out most of the water before the Yamuna even reaches Delhi. The Green Revolution has meant a huge rise in productivity for the Indian agriculture, but also a much higher use of water resources: 90% of the water of the Yamuna is used for irrigation. The river has a vital importance for 57 million people in its watershed, and interstate and usage conflicts are ceaseless.

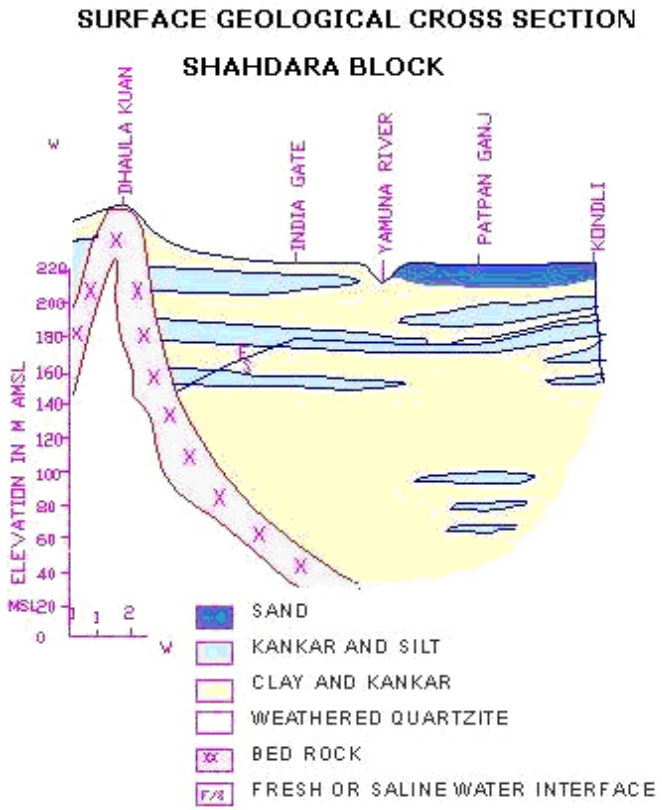



Fig. 3 Surface geological cross-section of the Yamuna river banks

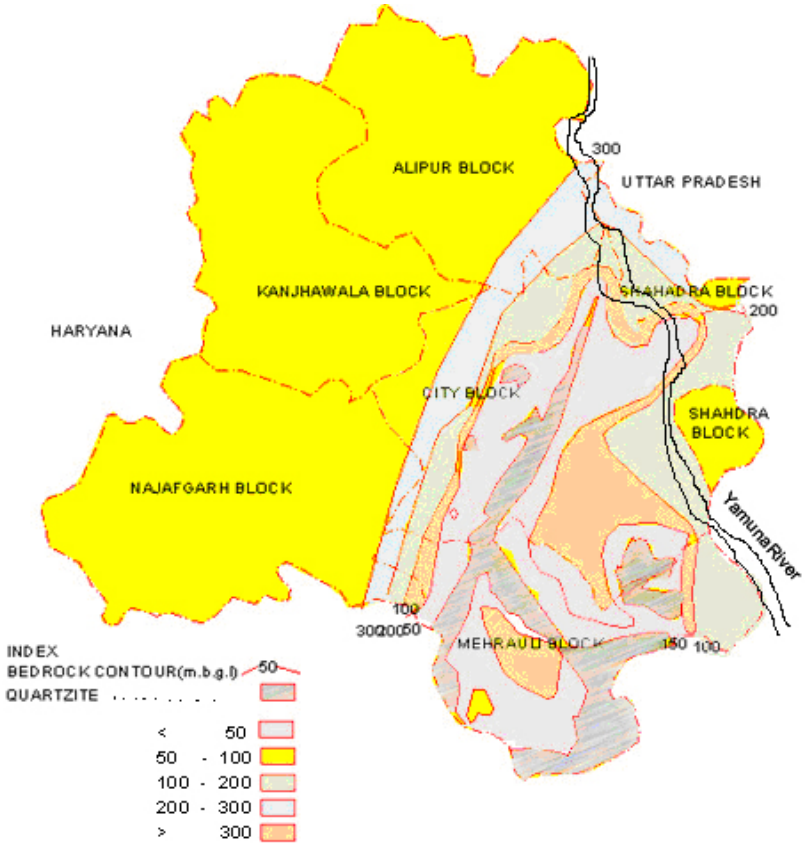



Fig. 4 Sub-surface bedrock depth in the National Territory of Delhi

A simple description of the Yamuna watershed helps us understand how intensively it is being used and how complex a problem bringing more water to Delhi is. From its origins in Yamunotra in the Himalayan state of Uttaranchal, the Yamuna reaches Hathnikund/Tajewala in Yamuna Nagar district of Haryana state, where the river water is again diverted into Western Yamuna canal and Eastern Yamuna canal for irrigation. Per agreement, Haryana receives over two-third of flows available at Tajewala Headworks. During the dry season, no water is allowed to flow in the river downstream of Tajewala barrage and the river remains dry in some stretches between Tajewala and Delhi. The river regains water because of ground water accrual and contributions of feeding canal through Som nadi (seasonal stream) upstream of Kalanaur. The river is again tapped at Wazirabad, just before the river enters Delhi itself, through a barrage for drinking water supply to the capital city. Generally, no water is allowed to flow beyond Wazirabad barrage in dry season, as the available water cannot adequately fulfil the demand of water supply of Delhi.

Whatever water flows downstream of Wazirabad barrage is the untreated or partially treated domestic and industrial wastewater coming from several Delhi drains along with the water transported by the Haryana Irrigation Department from Western Yamuna Canal (WYC) to Agra Canal via Nazafgarh Drain and the Yamuna. 22 km downstream of Wazirabad barrage, after passing under ITO[1] bridge and other bridges, there is another barrage, Okhla barrage, at the southern border of Delhi, through which the Yamuna water is diverted into Agra Canal for irrigation. After receiving water through tributaries, the Yamuna joins the river Ganga and the underground Saraswati at Prayag (Allahabad) after traversing about 950 km. Thus, the Yamuna river can not be designated as continuous river, particularly in dry seasons (almost 9 months).

This intensive use of the water conflicts with the growing needs of the national capital. The present population of Delhi is 13.7 million hab. (census 2001), probably 14 million hab. in 2007. Demographic estimates state that the population of Delhi should be around 19 million by 2011 and 23 million by 2021. The water requirements will thus rise dramatically, even as the present water supply is already insufficient. In addition, the river is highly polluted and any waterfront development would first necessitate a cleaning up of the river, as it has happened in many waterfront redevelopments in the world.

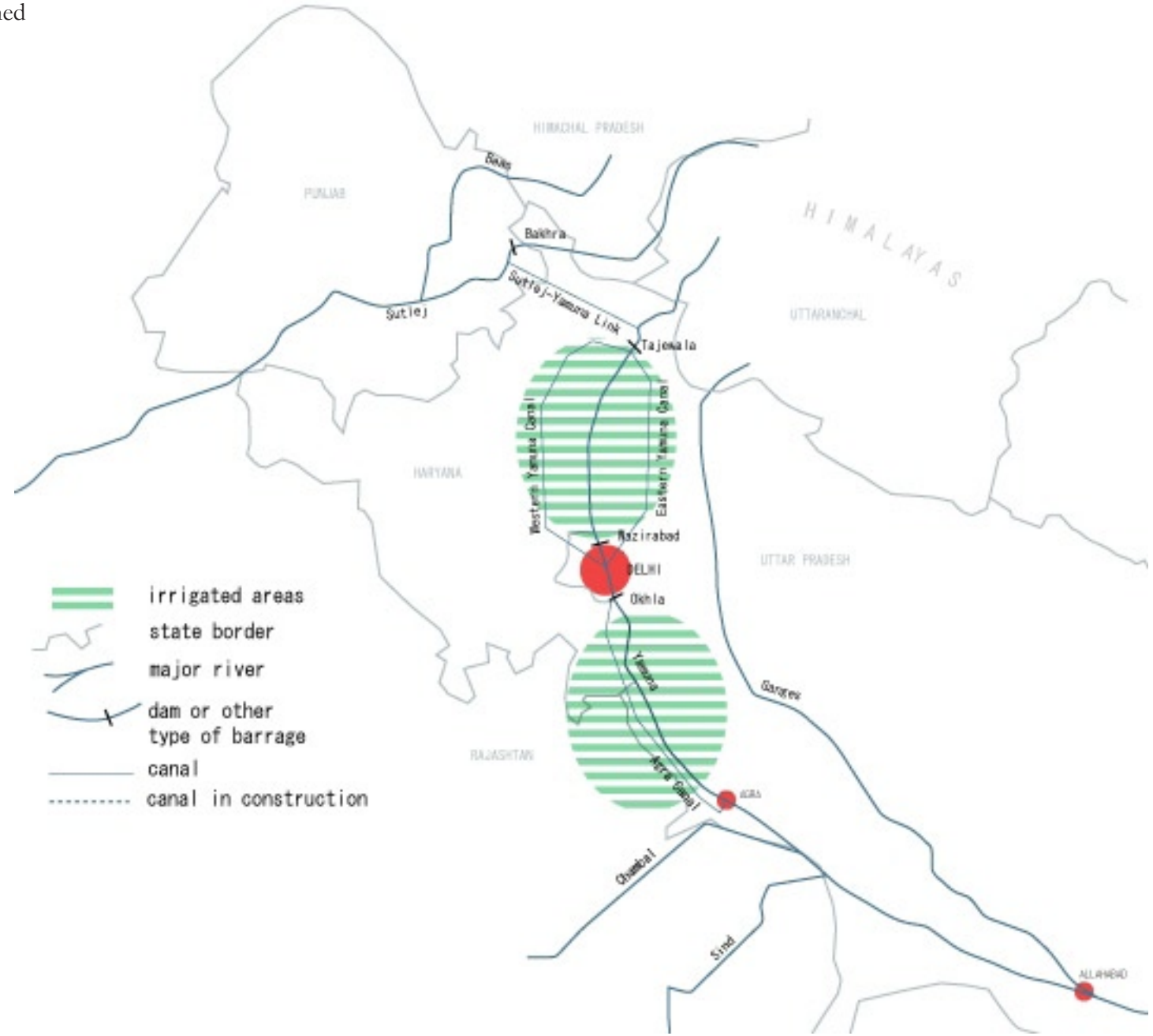
**E. A highly polluted river**

Discharge of untreated or only partially treated waste water through 19 major drains in the river is responsible for the high level of pollution of the river. Six of these drains contribute to almost 90% of the flow and to 80% of the BOD[2] load. Extreme levels of BOD and coliforms make the river danger-

1 ITO : Income Tax Office Bridge, linking ITO and Lakshmi Nagar, in Delhi.

2 Biochemical or Biological Oxygen Demand: concentration of biodegradable organic matter present in a sample of water.

Fig. 5 Hydro-management of the Yamuna watershed

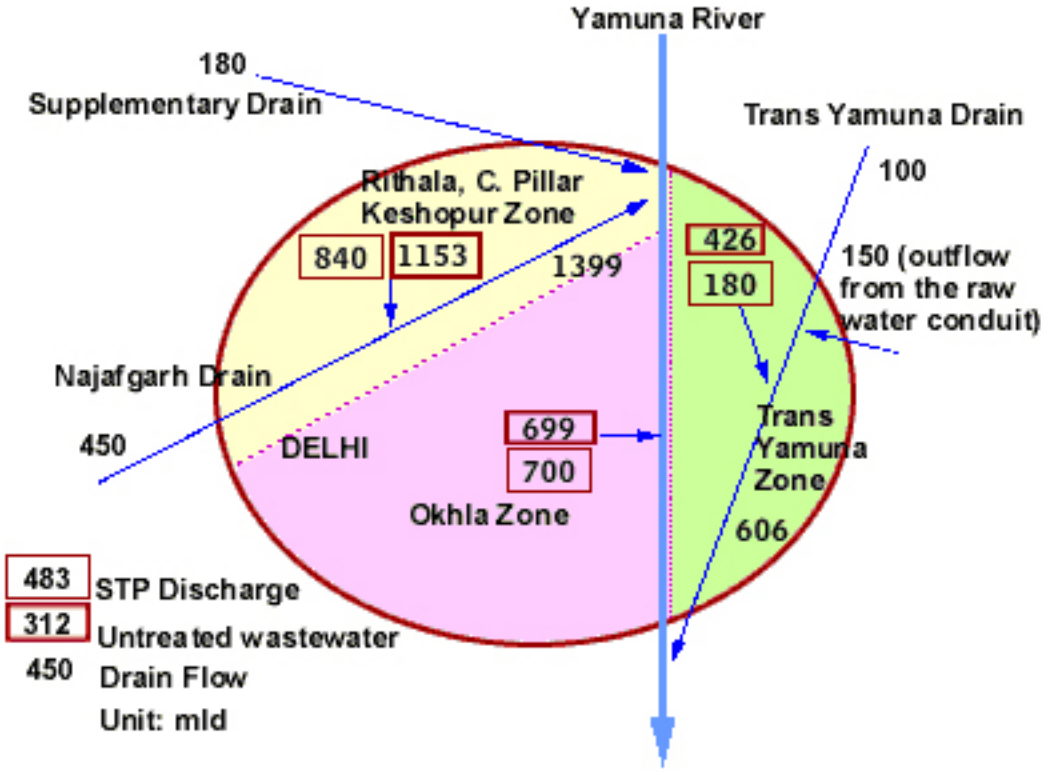


ous for drinking and bathing. Moreover, because almost all the water has been pumped out upstream for irrigation and for urban uses, except during the monsoon period, the weak flow of the Yamuna is unable to evacuate waste water and polluted silt. The Yamuna Action Plan, funded by the Japan Bank for International Cooperation, tries to find remedies to this situation by building new treatment plants on the nallahs[3], electronic crematoria, community toilets, etc.

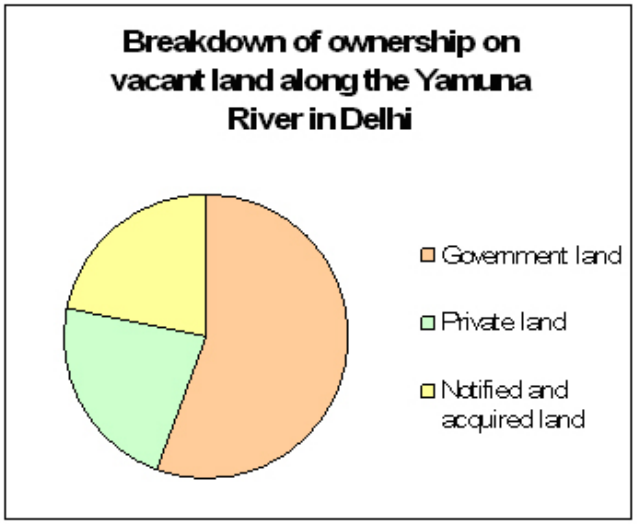
**F. Slum-dwellers living by the river**

6100 ha of land fall within Delhi State jurisdiction, of which 4891 ha are available, or so it seems. In fact, on top of all the previous problems, slum-dwellers have settled near the river. The Yamuna Pushta jhuggis[4] for instance stretch from the old Yamuna bridge to the Indraprastha Estate Gas Turbine, on both sides of the river. Dozens of thousands of slum-dwellings have already been destroyed and their inhabitants expelled from the banks of the Yamuna. The problem is that these slum-dwellers often have a job in the city, such as rickshaw drivers, domestic aids, waste pickers, street hawkers… they are often relocated fairly far from the center of the city and their revenues then decrease significantly. Any attempt to develop the waterfront should look at sustainable solutions for these people.

3 Open-air sewers, now sometimes covered
4 slums settlements




Gr. 3 Breakdown of water discharge in Delhi




Gr. 4 Breakdown of ownership on vacant land along the Yamuna in Delhi

Picture 2 Slum clearance along the Yamuna, 2004

Picture 3 Slum along the river, Delhi, 2007

## II. A deficient infrastructure

### A. Water, sewerage and electricity networks

*1. Water and sewerage networks*

Rainwater coming from the street into the drainpipes reminds us how water also is an essential issue at stake here. Quantity and quality are equally important. Between 2001 and 2021, the population of Delhi will grow from 13.7 million people to an estimated 21 million people. The current water supply is already "grossly insufficient" according to the DMP itself, which means that a major effort must be realized to keep up with the increase of the population. The capital city requires 750 mgd (millions of (British) gallons per day, 3.5 million cubic meter/day), but during summer, when the demand goes up, supply falls below 600 mgd

*2. Electricity network*

The quantity of electricity available is insufficient, as the DMP points out. Power shortages are happening on a daily basis in the capital of India, even if their duration is relatively short. Even if companies and citizens use generators in case of power shortage, this is not a sustainable solution, it is polluting as people use generators working with gasoline, and it does not provide companies with the kind of safety required by white collar workers who need to be able to use their electrical appliances without any risk of sudden interruption. Of course, Delhi already has many companies and they are coping with it thanks to generators and inverters; students who don't have any light anymore to do their homework can cope with it, people deprived of AC for a few hours can also cope with it, as a major part of the population does every day, just as people can cope with a hectic traffic, dilapidated sidewalks, and so on. But a city, if it wants to achieve a world-class standard, cannot afford these insufficiencies. Besides, the population is growing anyway and if nothing is done, more shortages are likely to occur. Each year, the power requirement of Delhi is growing at a 7-8 % rate.

In 2021, if Delhi wants to accommodate all new citizens and new companies – either offices or factories - needing a lot of power, it will have to more than double the current power capacity. Current needs are estimated at 3900 MW (megawatt), and needs in 2021 are estimated at 11 000 MW. This is without including a new development on the Yamuna River, which could still increase this number with additional power needed for computers, air conditioning in tall buildings, lights, new metro or tramway line... Auckland's CBD, in New Zealand, requires 170 MW[1], for a workforce of 30 000 and 5000 inhabitant,

1 See http://www.skmconsulting.com/news/1998/The_Auckland_CBD_Power_Failure.htm

some numbers that a development on the Yamuna could easily reach. We should then use 11 200 MW in 2021 as our threshold for electricity.

**B. Sidewalks and streetscape, traffic and transportation**

The new waterfront development should be an opportunity to put forward best practices in terms of transportation. I detail below the problems encountered in Delhi in terms of traffic, and I then make recommendations for the new development. These recommendations should then be extended to the whole city.

Traffic is increasing in Delhi with the improvement of the living conditions.[2] Owning a car is a sign of wealth. Even if three quarters of Delhiites still use public buses as their main means of transportation, the part of cars is increasing exponentially. This would be still manageable if the road network of Delhi was in a satisfactory condition, but the truth is that this network may be sufficient in quantity but it is not in quality. Very often, the roads are in poor condition, with many bumps and potholes. The roads which were laid out under the British rule and the independence are wide ones, which might seem like a good idea but is not since they do not guide the traffic efficiently. For an effective traffic flow, the road should be used as much as possible in a longitudinal way and not in a transversal one, which means there should be as little moves from one lane to another as is possible.

Besides, traffic regulations are not obeyed by drivers since the roads are wide and you have to cross many lanes to reach the exits which means that instead of passing other drivers on the right side exclusively as it should be done in the Indian case, drivers don't abide by any rules and pass other cars either on the left or the right side. This creates a dangerous and unpredictable situation which leads to an exaggerated use of horns. This exaggerate honking is also due to an indiscriminate flow of vehicles of all sorts which disturb the traffic calculations which are primarily aimed at cars and not at buses, rickshaws, motorbikes, bikes or pedestrians walking on the road. In particular, rickshaws, motorbikes and scooters have a much smaller width than cars, which means that on a road where optimal use would be three cars upfront, this optimal use is disturbed by rickshaws and motorbikes slipping through the traffic. Trucks should also, as the Delhi Master Plan suggests, unload their cargo in the outskirts of the city as much as possible in order to limit their presence in the inner city. Moreover, the traffic lanes on major arterial roads of Delhi are not well delimitated since the markings on the road are often faded, although they could give a precious visual indication of the trajectory that everyone should follow.

2 See Tiwari Geetam, "Transport and Land Use Policies in Delhi", Bulletin of the World Health Organization, vol.81 no.6, Geneva, 2003 (http://www.scielosp.org/scielo.php?pid=S0042-96862003000600015&script=sci_arttext) and A.K Jain, "Delhi's Traffic and Transportation Condition", ITPI Journal July-September 2006, Vol.3, ITPI, Delhi

The sidewalks are also an issue. In many residential neighbourhoods, there are no sidewalks or only on some parts of the streets. Usually, the roads do not have a clear delimitation but seem to end in dirt on both sides of the streets and their edges are worn out by erosion. When sidewalks do exist, they are used by cars for parking or are otherwise impracticable due to garbage littering or to shops and street hawkers blocking the greatest part of the sidewalk width. The consequences are that pedestrians have to walk on the street instead, which puts them into danger and is another reason for constant honking by the drivers and for slowing down the traffic flow.

Picture 4 (left)
Waterlogging in Delhi after monsoon rain

**Waterlogging near Green Park, Delhi. There is no gutter and drain pipe at proximity and water cannot be evacuated. Notice the cars parked on the sidewalk, preventing pedestrians from having a safe (and dry) walk.**

Picture 5 (right)
Street shops encroachments in residential South Delhi

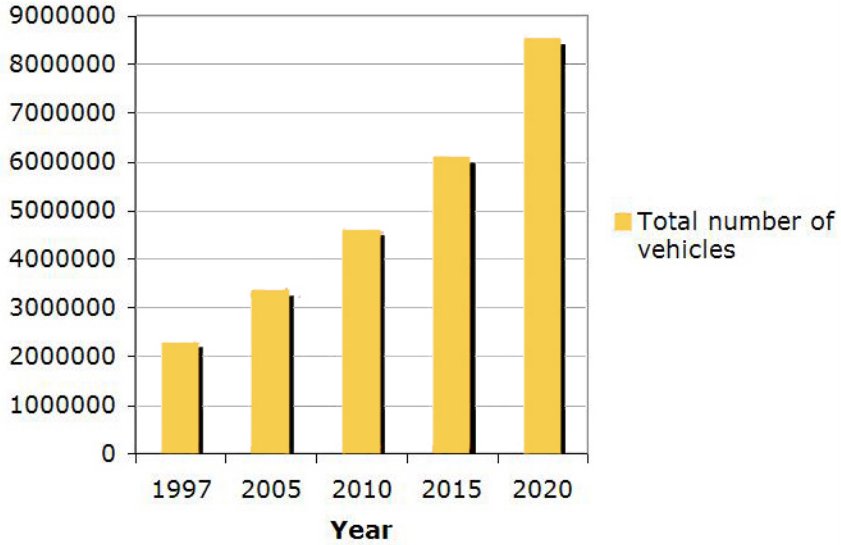

**Street shops are taking the whole sidewalk and spilling over the street in this case. Subdasdan Development Area, Delhi.**

Picture 6 (left)
Other types of encroachments

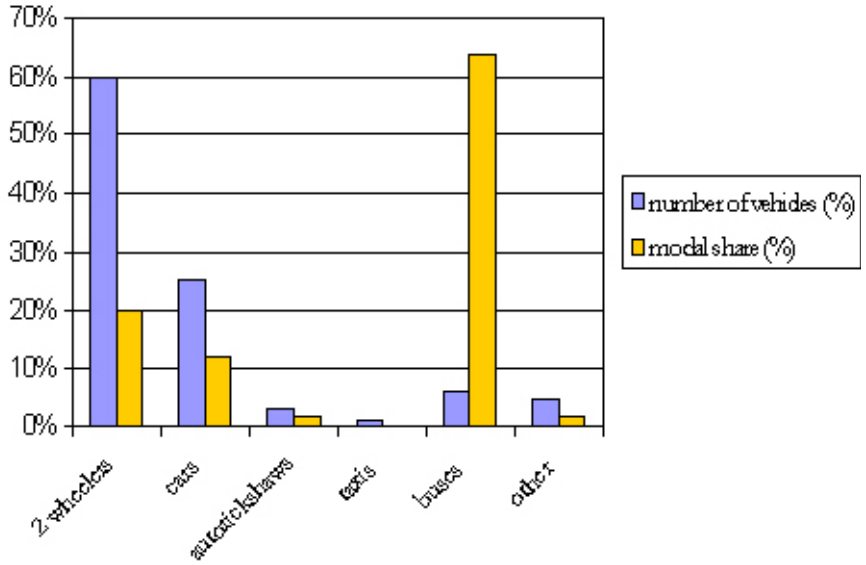
**The sidewalks are not only taken by cars, but also by abutters spilling over the sidewalk with their own pavement, their plantings (see background), the access ramp of their garage. Sometimes, there are even... the famous Indian cows! Subdasdan Development Area, Delhi.**

Picture 7 (right)
Residential street near Paris

**A street in Neuilly-sur-Seine, a residential suburb of Paris. The street is one-way and allows on-street parking on both sides. Notice also the gutter evacuating the run-off towards the sewage system.**




Gr. 5 Projection of automobile vehicles increase in Delhi 1997-2020




Gr. 6 Number of vehicles and modal share in Delhi (1998)

Picture 8 (left) good days...(Safdarjung overpass)

Picture 9 (right) ... and bad days (New Delhi)

## III. Attracting business to Delhi

### A. Why

*1. Challenges*

The Delhi Master Plan (hereafter DMP) wants to transform Delhi into a "global metropolis", a "world-class city". But world-class cities are few and have to constantly maintain their lead to keep their rank. In a city where 46% of the population lives in slums or other types of precarious settlements, the ambition to become in 20 years a world class city sounds like a very ambitious challenge and will require dramatic improvements to occur. At the same time, this is not an impossible task. Shenzhen, China, was thirty years ago a fishing village made of a few wooden shacks and has now become one of the important business hubs of Eastern Asia, attracting over 20 years time more than $30 billion of foreign investment for building factories and forming joint ventures. Being unable to start from scratch as in Shenzhen may prove to be a liability to some extent because of the challenges posed by the existing dilapidated urban structures. On the other end, Delhi enjoys great assets which are the result of the remarkable achievements made by India in terms of education, life expectancy, infrastructures and economic growth, thanks to the quality and the know-how of its engineers and planners.

The challenges that remain are daunting: a significant part of the population of Delhi has had access to basic education but could not attain a very high educational level and is thus not skilled or only semi-skilled. Even if the government of India stresses the importance of higher education in the global economy, employment has to be found for this unskilled or semi-skilled part of the population as well, if we want to improve their well-being and the chances of their children to move upward in the society.

Such employment cannot come from existing small businesses only, like the ones already existing in the Walled City. Services like groceries, bike repairs or dry-cleaners can only grow to a certain extent because the demand for them is only increasing slowly – because the buying power of newcomers from the countryside is limited, just as the commercial housing stock.

We notice that the DMP barely mentions any strategies to attract capital intensive businesses in or around the capital city. It is a pity, since more investments coming to Delhi would mean more money that could be levied to increase the financial means allotted to the upgrading of public infrastructures and facilities, poverty alleviation, education and other planning and public policy measures.

Delhi has a huge potential to become a world class city. It is already one of the major cities in Asia, with a GDP of US$ 16 billion for the year 2004-2005 for the State of Delhi, attracting major national and international companies, with the tertiary sector contributing to 70.95% of Delhi's GDP. A whole middle class has emerged in Delhi, and the average income is US$1000 per year, which is 2.5 times the national average. Because of the many economic opportunities, the unemployment rate decreased from 12.5% in 1999-2000 to 4.6% in 2003. If the city continuously attracts newcomers, it is because it is very successful. Because of Delhi's institutional status, 620 000 persons still work for the Union, State and city government, while only 219 000 work in the organized private sector. At the same time, a much bigger number of people work in the informal private sector.

Delhi's service sector has expanded due to a large consumer market coupled with a qualified, English-speaking workforce, as well as Delhi's position as the capital of India and seat of government and ministries. Key service industries include information technology, telecommunications, hotels, banking, media and tourism. Delhi's manufacturing industry has also grown considerably as many consumer goods industries have established manufacturing units and headquarters in and around Delhi. In 2001, the manufacturing sector employed 1 440 000 workers while the number of industrial units was 129 000. Construction, power, telecommunications, health and community services, retail industry and real estate are important parts of Delhi's economy.


Picture 10 Traditional retail shops in Gurgaon

Picture 11 New middle class housing in Gurgaon

Picture 12 Microsoft, Canon, Nokia and ABN Amro offices in Gurgaon


Picture 13 (left) Shopping center in Gurgaon. Note the banners with the Reliance telecom banner, an emblem of modernity

Picture 14 (right) View of Gurgaon from Xerox office, DLF square, Gurgaon: the whole city is a giant construction site

# Part II. What are the conditions for success?

**Summary**

Certain conditions must exist so that the challenges enounced in the first part can be overcome: the possibility to improve the land and use earthquake engineering techniques for construction; the possibility to improve the infrastructure of the city; the implementation of an effective strategy to attract business and investors in the city; the fact that the project must be financially profitable; and finally the existence of a competent planning authority to carry the project.

## I. Improve quality of soils and use earthquake engineering techniques in construction

**Summary**

Hydrological and geotechnical reasons make the Yamuna banks a difficult site to develop, with threat of monsoon floods, poor soil conditions, earthquakes, as well as the importance to preserve some permeability along the river so as to allow rainwater to infiltrate and recharge ground water tables. However, soil improvement techniques, earthquake engineering, channelization of the river and the creation of parks to allow water infiltration, can make the project feasible.

**Conditions and thresholds**

- soil improvement
- earthquake engineering
- channelization of the Yamuna and construction of a bypass canal
- creation of parks serving as collectors for rainwater

### A. Previous attempts were a failure

The DDA seems to have chosen an anti-development and nature preservation position concerning the Yamuna River, if we follow the 2021 Delhi Master Plan. At the same time, a closer look at the DDA stances in the past toward this issue shows a more complicated picture: In a 1998 "zonal development plan for river Yamuna area", the DDA advocates for the chanellization of the river and the development of open space and commercial areas, on the "Thames River model". However, this plan was reviewed by the National Capital Region Board in 1998, which suggested that Environmental Impact Assessment studies be conducted for these zones and a detailed Zonal De-

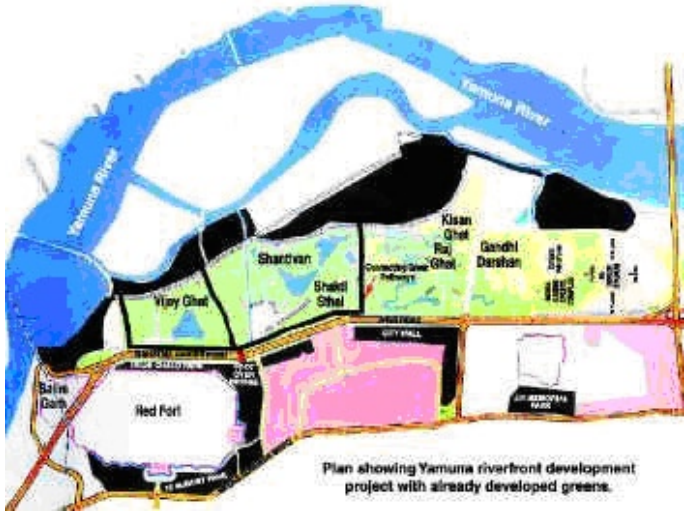



Fig. 6 1998 DDA zonal plan for the development of the Yamuna banks

velopment Plan on the eco-based concept involving augmentation of water recharge, reduction in pollution of Yamuna water, conservation of natural areas, hierarchy of green areas, recreation limited to eco-tourism and continuation and renewal of existing areas be considered but no urban uses like commercial, public or semi public activitiesbe envisioned. This proposal was rejected by the Delhi Development Authority (DDA). It seems that the DDA has taken an ambiguous stance on the development of the river: even as it promotes open spaces etc. it also prepares plans, not open to the public, for the development of the river. The 1998 plan advocates the development of 24,250 acres in the flood plain. The cost of developing this land has been put at Rs 800(US$18) per square meter, and its sale price at Rs 2,660 (US$ 59) per square meter, going up to Rs 15,960 (US$355) per square meter for commercial property.[1] Said a senior officer in the planning department: "Only 5% of the entire Yamuna river area will be developed under the draft zonal plan. The majority of the zone has been kept as green area."[2] Estimates for project cost amounts to 200 million $. In fact, we shall see in a subsequent cost analysis that this cost is underestimated if an environmentally sensitive development is to take place.

Officials claim most of the development will take place along the eastern bank of Yamuna, with the area being earmarked for public and semi-public activities/uses.

The plan earmarks the area south of NH-24, opposite Mayur Vihar, for an international sports complex, with a cricket and football stadium planned for south of the DND Flyway.
This is apart from the existing Akshardham temple as well as the upcoming Commonwealth Games village. A socio-cultural centre, as well as 45 ha for residential and commercial/hotel plot, has also been carved out.

Access to Zone O (Yamuna banks) has also been augmented in the draft zonal plan. For instance, Pontoon bridge will now be converted into a 30-metre road, while a bridge — for the time being called Signature Bridge — will be coming up to connect NH-2 to the Marginal Bund road south of Wazirabad road, along with Geeta Colony bridge road connecting Ring Road.

Of course, environmentalists oppose any development along the river, because of the danger of higher floods, the earthquake hazard and the decrease in groundwater recharge. DDA planners seem to dismiss these issues without really paying attention to the potential consequences:

A former DDA planning commissioner said: "In the eighties too when DDA was planning development on the river-bed, the primary concern was harnessing and channelizing the river. Once that takes place, all kinds of development are possible," he added.

1 http://www.countercurrents.org/hr-adve290404.htm
2 http://timesofindia.indiatimes.com/articleshow/1762066.cms

Environmentalists and other experts are right to point out this mistake: the problem here is not merely about channelizing the river, but about floods, soils, water supply, etc. Developing the riverfront without taking these issues into consideration would be a terrible mistake and an oversimplification of the situation. However, does it mean that the riverfront should not be developed, provided that systemic solutions can answer the host of issues that have been mentioned above?

**B. The importance of being sensitive to the physical conditions of the site**

It seems that environmentalists oppose any development for the sake of opposition, in the name of "Nature": For them, engineering is likened to playing God. Man should try to minimize its "ecological footprint" to avoid disasters. Granted, massive-scale engineering projects have sometimes led to environmental disasters in the 20th century; at the same time, even without a waterfront project, seeing the current Yamuna River as "natural" is somewhat imaginary. Very few rivers in the world can be said to be in a "natural state". Reverting the Yamuna to "nature" would mean removing dams, upstream canals, embankments, and flooding all the Eastern part of the capital where one third of the population is living, as well a significant part of the Western side of the city. The status quo is not acceptable either, were it only for the high level of pollution of the river among other reasons. Of course, we could also have an alternative course which would simply consist in cleaning the river and leaving the banks undeveloped or transforming them in a giant park.

However, leaving this area entirely as open space would be a waste of prime land at a time when Delhi could use it to accommodate high value economic activities and to market itself in the global economy. Besides, unless the area is left as it is today, even creating a great park would require dealing with the flood problem, unless one wants this park to be inaccessible and damaged by the water during two to three months each year. It is legitimate to be opposed to a development that would be completely insensitive to site conditions, but big scale engineering and land reclamation can be done in a way which does not harm the environment and on the contrary promotes a better relationship between the city and its "natural" elements. That this relationship be deemed "sustainable" doesn't imply the submission of the city to "nature", but an efficient integration of nature within the city dynamics.

- Allocation of additional water supply from the Yamuna by the Ministry of Water Resources during the lean period to meet the drinking needs of Delhi
- New dams being built in mountainous states of Himachal Pradesh and Uttaranchal
- Decreasing losses in canals
- Rainwater harvesting efforts in Delhi
- Stepping up extraction from groundwater tables with tubewells.
- *Dual pipe system in new developments to collect household waste water and use it for flushing toilets*

## C. Finding innovative and sustainable solutions

*1. Remediation measures according to the 2021 Delhi Master Plan*

Pollution

- increasing the number and the capacity of sewage treatment plants
- increasing ground recharge from the river, by creating regulated flood plan reservoirs for storing the excess monsoon overflow at suitable locations and releasing it during the dry season
- taking environmental conservation measures for the Yamuna floodplain: a Yamuna biodiversity park is for instance being created in the north of Delhi, near Wazirabad, over an area of 156 acres in the first phase, 300 acres being added in a second phase.

Water supply

*2. Measures that I recommend in addition to the ones of the DMP*

One gets easily lost in the complexity of the problems associated with the Yamuna River. These can be classified according to different priorities which are sometimes conflicting, such as the classic opposition between upstream irrigation and downstream water supply.

- upstream irrigation
- groundwater recharge and water supply for Delhi
- flood control
- pollution prevention

- site beautification and potential development

The solutions which are developed here address all the above issues.

- The upstream irrigation can be curbed thanks to micro-irrigation techniques such as the ones developed in Israel, so as to limit waste of water and water pollution from pesticides and cattle. New dams in the Himalayan states as well as inter-river water transfers should also help bring more water to be shared between agricultural and urban uses.

- In the dry season, the Yamuna flow should increase in quantity, speed and quality in order to take care of the pollution problem: in addition to the extension of the sewerage system and to bigger and better treatment plants on nallahs and on the river upstream of Delhi, a greater flow will help flush away waste water and silt – silting of the river makes its bed more shallow, increases flood probability and decreases flow speed and river workload. The following solutions show how a greater flow can be obtained:

o Increasing the flow coming from upstream by decreasing irrigation, increasing water from dams and inter-river transfers – for instance, completing the Yamuna-Sutlej Link which is supposed to bring water to Haryana from Punjab by transferring water from the Sutlej River to the Yamuna.[3]

o Channelizing and dredging the waterbed to concentrate and speed up river flow, which will help carry silt and pollution away. Dredging will also help diminish flood risk.

If a waterfront is developed, a more or less constant water flow must be guaranteed, which is especially difficult in the case of a river like the Yamuna because of seasonal monsoon rains and irrigation which pumps out water in the already dry season. Even with dredging and forcing the river to dig deeper into the sedimentary layers, channelizing the river would help having a high enough water flow during the dry season because of the more limited width of the riverbed, but it would also make the flood risk higher during monsoon time. The construction of reservoirs upstream seems like a way to store water during the monsoon time and redistribute it during the dry season, but other examples show that this strategy is not completely satisfactory: reservoirs fill up usually pretty quickly and in case of massive rains, they could overflow and generate even greater floods. A better solution is the following one:

o Building reservoirs to store monsoon water and redistribute it during

3 Punjab chief minister does not seem in a hurry to complete the digging of the canal and provide water to Haryana State, so that in June 2004, the Supreme Court had the responsibility of this work transferred to the Centre (Federal Government).

the dry season, and connecting these reservoirs to a canal allowing the excess water to bypass Delhi. A repartition dam at the confluence of the river and the canal would serve to partition the water between the Yamuna and the bypass canal. This bypass canal should be deep and wide enough to accommodate large amounts of water. Another dam downstream of Delhi could help slow down the water flow and keep the water at an acceptable level during the dry season. This type of infrastructure has already been built in other large cities, such as San Antonio, Texas, where a 550m long tunnel diverts water to avoid floods during rainy months and pumps it back upstream during the summer to supplement river flow. San Jose, California, has also built bypass channels to protect itself after de-vastating floods of the Guadalupe River had occurred. National and international organizations such as the International Commission for the Protection of the Rhine now recommend more bypasses and flood zones along the Rhine to give the water more space during floods. In Tempe, a major suburb of Phoenix, water from the Salt River is even retained during summertime thanks to inflatable rubber dams, thus creating the to Tempe Town Lake, used for recreational purposes.

Similar measures should allow the Yamuna to flow at a constant level throughout the year, in dry as well as rainy season.

*3. Ground water, site beautification and potential development*

If the whole floodplain of the Yamuna is being converted to impervious surfaces, water runoff will increase and water table recharge will decrease, thus diminishing the water supply potential of the aquifers below the flood plain. Parks with artificial wetlands could be built and serve as collectors for bringing monsoon rain water to the aquifers. Sewers should be systematically built along the streets of the new development and these streets should have the appropriate transversal curvature and gradient which will allow the water to be directly collected by the sewer pipes and then brought to wetland areas in the parks. These areas should be planted so that there is still some vegetation present in the wetlands during the dry season.

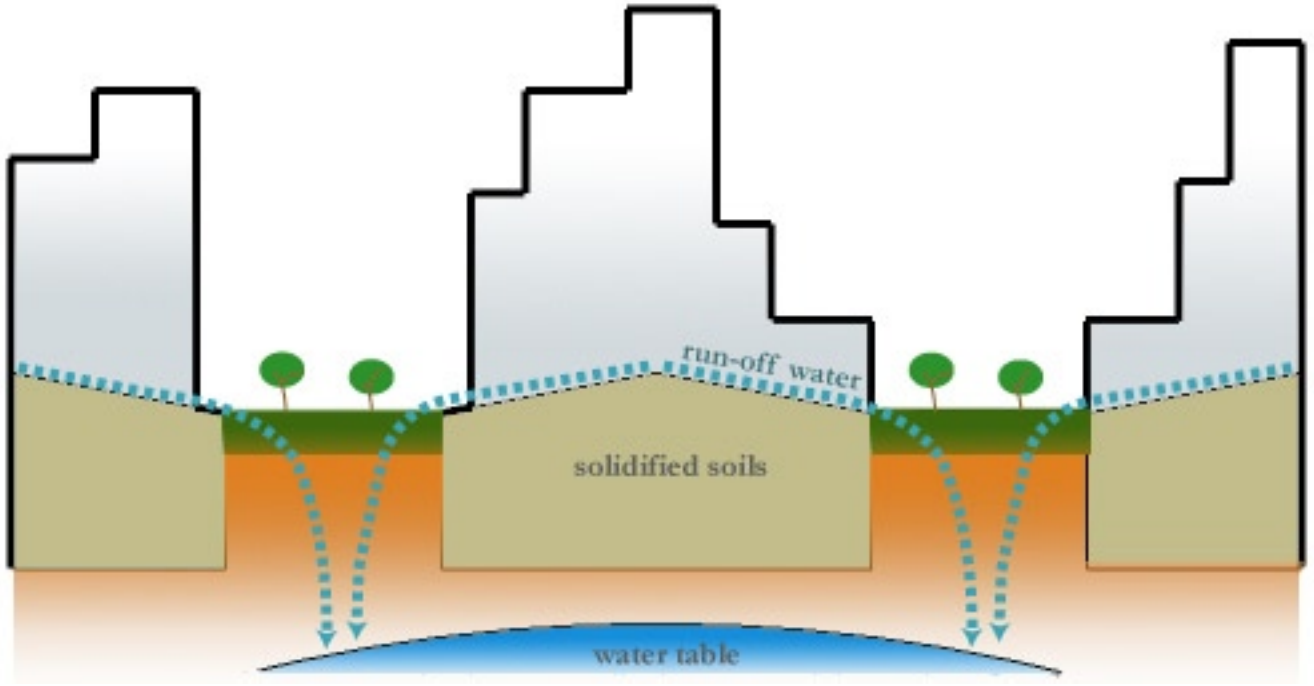



Fig. 7 Parks acting as collectors to allow rain water infiltration and ground water recharge

*4. Land reclamation techniques*

The site itself, along a river chanellized and controlled by the measures enounced above, would constitute a very promising place for a developer. At the same time, we have seen that the physical conditions, even without the threat of flooding, were difficult because of the nature of soils and the earthquake hazard. It does not mean that nothing can be built there. Modern land reclamation techniques can improve soil conditions for development with a cost still reasonable for such a location for prime real estate.

*a. Land improvement techniques to be used on the Yamuna banks*

We have seen that an analysis of the soils along the Yamuna River reveals the following composition, which can vary of course according to specific locations: sands (85% sands, 15% clay), and sandy loam (30% silt, 60% sand and 10% clay), alternating with kankar, which are calcareous concretions, from 10 meters below the surface and deeper. Contrary to clayish soils, the sands are quite permeable and allow the water to run quickly through them unto the water table. At the same time, and for the same reason, it is important that the fill necessary for the site be prevented from polluting the water tables, and that the permeability of selected parts of our site where water might be able to penetrate the ground be preserved. This last preoccupation has been addressed by our recommendation to direct running water to green areas where it will percolate into the ground. For the sites that we target for development, the following actions should be taken:

- stabilization of the bank and dredging of the river bed
- drainage by prefabricated drains with preloading
- geosynthetics to avoid pollution of the water table
- in-fill to compensate for soil compaction
- compaction by vibrocompaction technique to densify the soils
- grouting

Picture 15 Marshy vegetation along the eastern bank of the Yamuna, south Delhi

Picture 16 Forest on the eastern bank of the Yamuna, south Delhi

Let's examine these actions one by one:

· Stabilization of the bank and dredging of the river bed

(see above)

· Drainage

Drainage helps consolidating soils by expelling the pore water and decreasing the void ratio (interstitial space between particles in the ground). The consolidation rate is governed by the compression, permeability and length of the drainage path. Prefabricated vertical drains, band-shaped or circular, with preloading (vacuum pressure or surcharge) should be used. It involves loading the ground surface to induce most of the ultimate settlement of the underlying soft formation. Drainage is above all useful for the portions of our site that are more clayish and in general less granular than sand which has a high permeability level and does not retain water.

· Geosynthetics

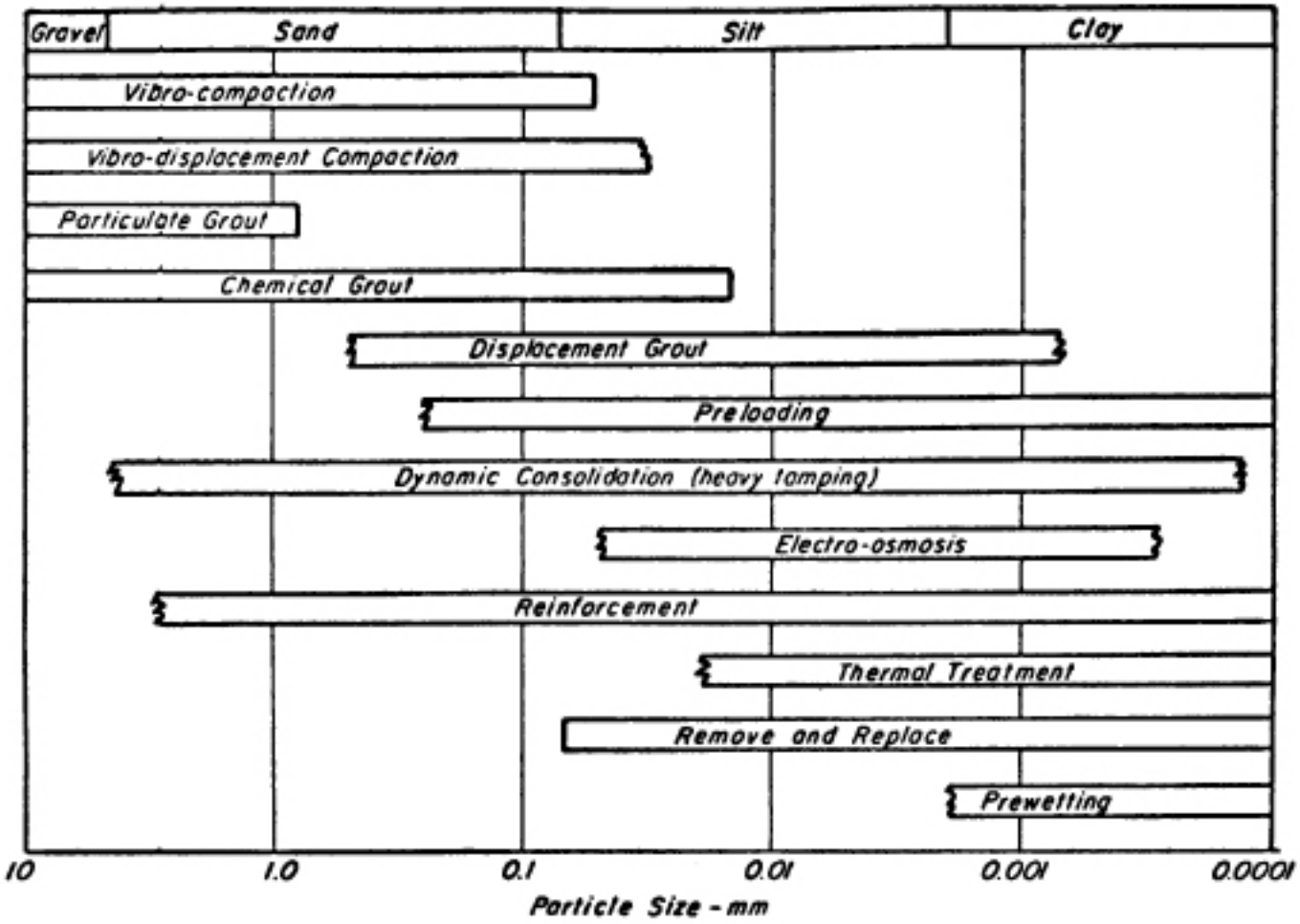
Geosynthetics are generally synthetic products used to solve geotechnical problems. The term encompasses four main products: geotextiles, geonets/ geogrids, geomembranes and geocomposites. They could be used to stabilize the ground, avoid unwanted percolation and pollution, especially during the heavy monsoon rains. Geosynthetics can help secure particles while letting water through.

- In-fill

Compaction of the soil as well as possible replacement of some of the weakest soils necessitate in-fill to compensate for the losses in soil. River silt could be used to partially fill the site, which would also be interesting because it would make the river canal deeper and would contribute to flood prevention. The same has been done for many places in the world, for instance recently with Kitakyushu airport in Japan where fill was taken from the dredging of the Kanmon / Shimonoseki straits. Fly-ash is widely used as fill in India but it should be considered carefully since it can percolate and pollute the water table.

· Vibro-compaction

Vibro-compaction or vibroflotation is used to densify clean, cohesionless soils. The action of the vibrator, usually accompanied by water jetting, re-




Gr. 7 Soil improvement techniques according to type of soil

duces the inter-granular forces between the soil particles, allowing them to move into a denser configuration, typically achieving a relative density of 70 to 85 percent. Compaction is achieved above and below the water table.
With sand, the effectiveness of vibro-compaction is excellent, with silty sands, marginal to good.

These measures also help decrease the risk of soil liquefaction in case of an earthquake in a region of soft soils.[4] In this case, a combination of structural retrofitting and/or geotechnical remediation (ground improvement) is usually implemented, such as placing vibro-replacement stone columns in the ground to help stabilize it. Vibratory and impact methods work with most of the coarse grained soils with fines content (amount of particles smaller than 0.06 mm) below 10% and are good for loose and water permeated soils (which is our case), while they are inefficient in the case of pure silt or clay. They can be performed with a maximum depth of 65m.

· Grouting

Sand and cement are mixed in the process known as "jetgrouting" and produce a new kind of cement called sandcrete that solidifies soils. Jet grouting is a versatile and effective technique which can be used across a wide range of ground conditions. The inclusions formed by this process may be used for structural support, or for the control of groundwater.

*b. Earthquake engineering*

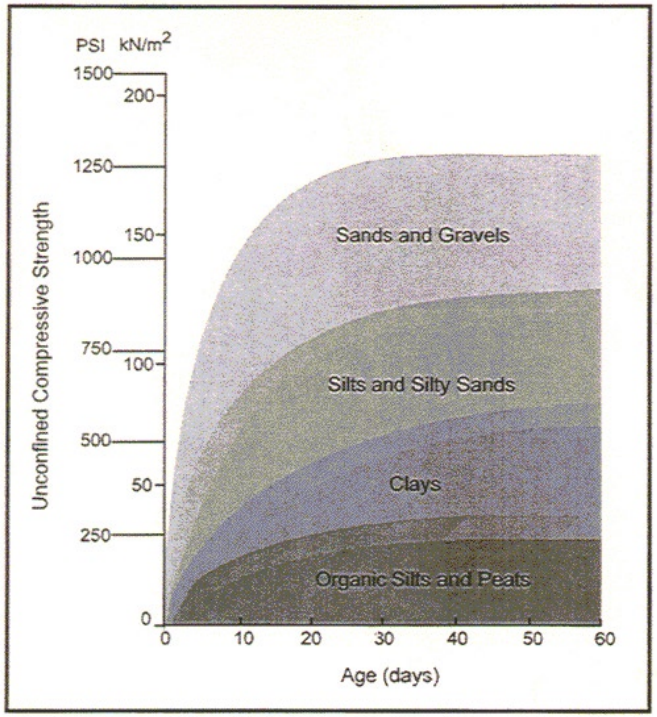
What follows is a summary of techniques described on the website of the Multidisciplinary Center for Earthquake Engineering Research (MCEER) of the State University of New York at Buffalo. [5]

Techniques for existing buildings are known as seismic retrofitting and involve reinforcing the structure of buildings and making them more flexible, but even more effective measures can be incorporated in the design of new buildings. A few of these techniques are described below.

· Base isolation

4 See case of Greater Vancouver Region, British Columbia, in Wijewickreme Dharma, Upul D. Atukorala, "Ground Improvement for Mitigating Liquefaction-Induced Geotechnical Hazards", Ground Improvement Techniques, chapter 16.

5 http://mceer.buffalo.edu/infoservice/Reference_Services/advEQdesign.asp




Gr. 8 Effectiveness of compaction according to type of soil

Picture 17 Vibrocompaction machines

This method utilizes a structure made up of thin layers of rubber and steel plating that lie in between the building and the ground , cushion the impact of a strong earthquake and serve as a buffer. A base isolated structure is supported by a series of bearing pads which are placed between the building and the building's foundation.

- Lead-rubber bearings

A lead-rubber bearing is made from layers of rubbers sandwiched together with layers of steel. In the middle of the bearing is a solid lead "plug." On top and bottom, the bearing is fitted with steel plates which are used to attach the bearing to the building and foundation. The bearing is very stiff and strong in the vertical direction, but flexible in the horizontal direction.

The base-isolated building retains its original, rectangular shape. It is the lead-rubber bearings supporting the building that are deformed. The base-isolated building itself escapes the deformation and damage - which implies that the inertial forces acting on the base-isolated building have been reduced. Experiments and observations of base-isolated buildings in earthquakes have been shown to reduce building accelerations to as little as 1/4 of the acceleration of comparable fixed-base buildings.

Since they are highly elastic, the rubber isolation bearings don't suffer any damage. The lead plug in the middle of the bearing experiences the same deformation as the rubber but it also generates heat as it does so, thus dissipating kinetic energy by converting it into heat and damping the building's vibrations.

- Spherical sliding isolation systems

Spherical Sliding Isolation Systems are another type of base isolation. The building is supported by bearing pads that have a curved surface and low friction. During an earthquake, the building is free to slide on the bearings. Since the bearings have a curved surface, the building slides both horizontally and vertically.

· Energy dissipation devices

The second of the major new techniques for improving the earthquake resistance of buildings also relies upon damping and energy dissipation, but it greatly extends the damping and energy dissipation provided by lead-rubber bearings. Energy dissipation devices are also often called damping devices.

These include:

· Friction Dampers: utilize frictional forces to dissipate energy
· Metallic Dampers : utilize the deformation of metal elements with in the damper
· Viscoelastic Dampers : utilize the controlled shearing of solids

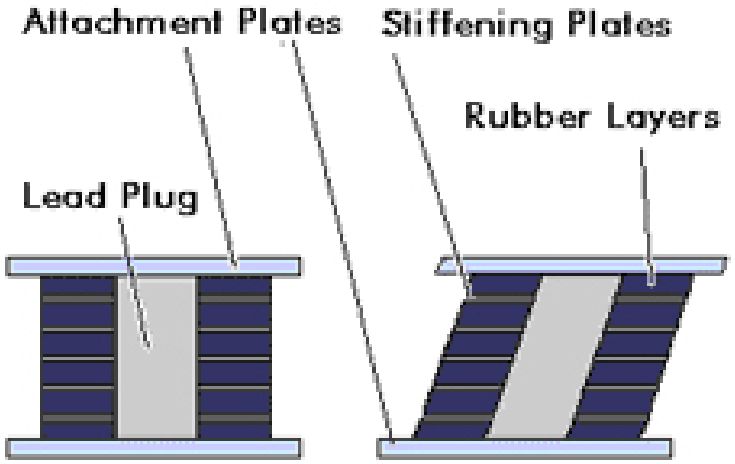



Fig. 8 Functioning of lead-rubber bearings

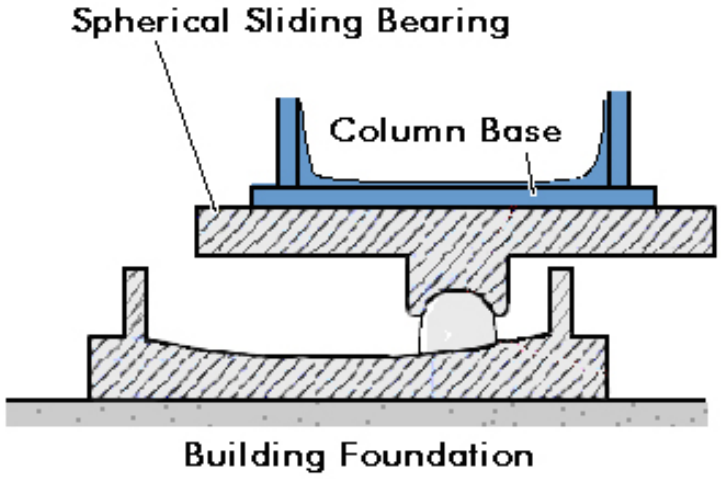



Fig. 9 Spherical sliding isolation systems

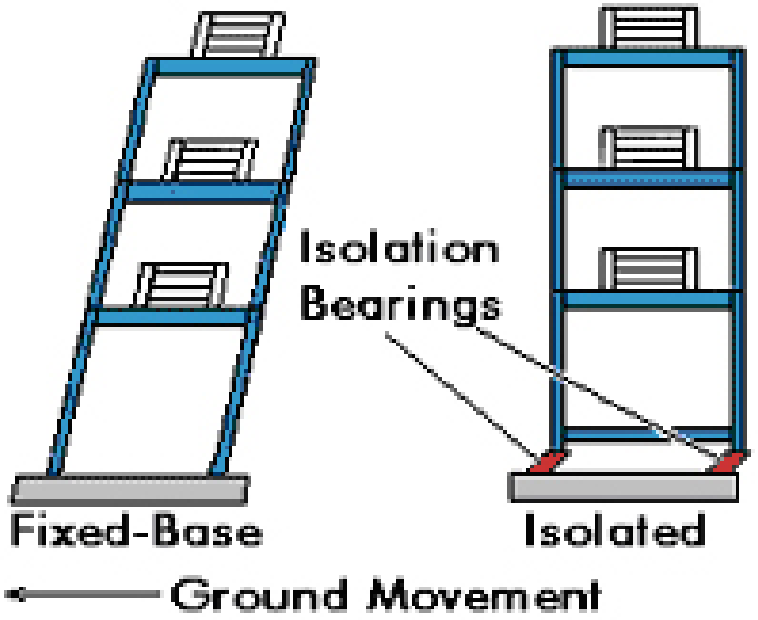



Fig. 10 Fixed-base and base-isolated buildings

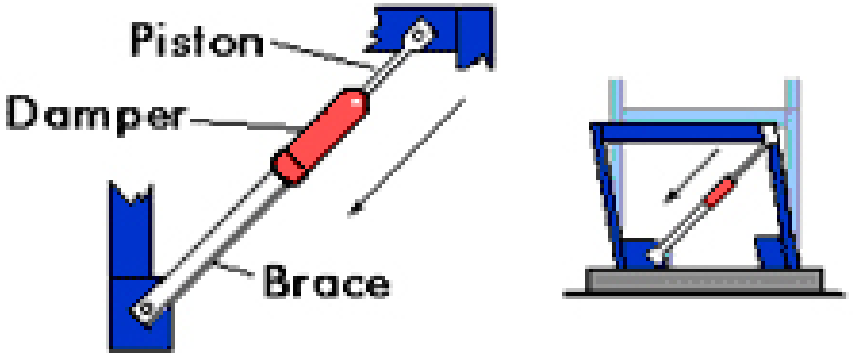



Fig. 11 Damping device

· Viscous Dampers: utilize the forced movement (orificing) of fluids within the damper

Damping devices are usually installed as part of bracing systems, as seen on the picture on the right.

· Tuned-mass dampers

For tall buildings, another device that can be used is called tuned-mass damper, or harmonic absorber, which is a device mounted in structures to prevent discomfort, damage or outright structural failure by vibration. Typically, the dampers are huge concrete blocks mounted in skyscrapers or other structures, and moved in opposition to the resonant frequency oscillations of the structure by means of springs, fluid or pendulums. Some tuned-mass dampers are installed in modern skyscrapers such as Taipei 101, One Wall Centre in Vancouver or the Landmark Tower in Yokohama.

## II. Improve infrastructure: water supply and treatment, electricity, transportation

**Summary**

Delhi's infrastructure is insufficient for today's needs. The new Yamuna development would mean an additional strain on water supply and treatment, on power generation and on roads and transportation. Power shortages threaten computers, air conditioning. Insufficient water means unsatisfactory living conditions and insufficient water treatment means an additional pollution of the river. Dilapidated, waterlogged and traffic-jammed roads means difficult access to the waterfront. This one will neither be sustainable nor attractive if a solution is not found to these problems. This chapter attempts at giving a few answers to that question.

**Conditions and thresholds**

- sufficient water (1840 millions gallons per day in 2021) and water treatment
- sufficient electricity (11 200 MW in 2021)
- proper roads and access: traffic segregation, quality of road surface, access from city and ring roads, proximity of public transportation (metro, tramway)
- enough parking spaces (see below for requirements)

### A. Water, sewerage and electricity networks

*1. Water and sewerage networks*

- Increasing and diversifying the water supply for Delhi

First, ground water should be carefully assessed as the DMP recommends. We should have a clear picture of the part of non-renewable water coming from fossil water tables in the total quantity of groundwater, the quantity of renewable groundwater available each year and the average time it takes for groundwater tables to fill up and at which period (accurate assessment of fallen water and infiltrated water during the monsoon period in particular). Measurement devices should be linked to water management software in order to assess and manage with accuracy available ground water, water from the river and water from the reservoirs as well as their optimal distribution in the city. The DMP measures seem adequate, though several programs are likely to be delayed such as the water supply from Sonia Vihar water treatment plant which should have begun in 2004 and where it seems that some pumps and reservoirs have not been installed yet, so that the plant will not be bringing any water until 2007[1]. Besides, one can wonder why the water extracted from the sub-surface (ranney wells, private pumps...) is not reduced

1 Officials are currently working to provide water to Delhi at an earlier time, but as for now, it is not clear how effective their efforts will be.

in the water supply scenario for the future but increased, while the DMP acknowledges the necessity to look after the level of groundwater tables more carefully. Ultra-filtration and inverse osmosis for recycling (currently tested in Okhla) could also prove useful in order to increase the quantity of available recycled water if it could be done at a reasonable price.

- estimates of water needs in the future

750 mgd is what Delhi needs now to supply current demand. In fact, this demand is only what people would currently take if there was no shortage of water in the summer, but it does not mean that the real need for water is not higher even today. The DMP estimates for current demand are actually higher, at 1000 mgd. This quantity is likely to be increased because of two things: the general increase of the population - and its increasing wealth and use of water, and the increase of the demand if a waterfront is created on the Yamuna. The Delhi Jal Board anticipates that by the year 2011 about 1140 mgd potable water at 60 gallon per capita per day (gpcd) for a population of 19 million people will be needed. The DDA has projected the 2011 water demand as 1520 mgd at 80 gpcd. According to the DJB, in 2021, about 1380 mgd potable water at 60 gpcd for a population of 23 million people shall be required. However, the DDA has projected the 2021 water demand as 1840 mgd at 80 gpcd, probably to take into account the evolution of the living standards of Delhi's citizens. We can take this estimate as a threshold for the Yamuna waterfront: a 1840 mgd water supply for Delhi in 2021 is one of the conditions for success for a development of the waterfront.

- Recycling sewerage water and developing dual pipe systems

Some sewers are clogged by silt and many are old and damaged by tear and wear and by illegal connections. Due to these losses, the real quantity of water is much less than the theoretical one. Another problem is that many pipes had been built for a certain amount of population and that they are now proving inadequate even in the very diameter of the tubes, now that the volume of water has to be increased due to population growth. A major hurdle lies in the fact that many pipes are in areas that have been heavily built on since then and that repairing or replacing them bears a huge financial cost and much trouble to inhabitants. Probing and water measurements should enable to assess where the most important losses are and thus where pipe repair or replacement becomes a true necessity. At the same time, we suggest that when this proves difficult due to technical and financial difficulties, a second network of sewers be laid out so as to bypass the first one which would be subsequently sealed off. Left over waste from sewers could be utilized instead of being simply disposed of in a dumping ground. As DMP points out, thermal plants could use it to produce methane gas. It would also constitute an excellent natural fertilizer in the countryside if the psychological hurdle can be overcome and provided excessive quantities don't contribute to ad-

ditional water pollution.

- Public water service vs. private providers

Private providers are present in areas of Delhi where the Delhi Jal Board cannot bring water that is sufficient in quantity and in quality. These private water providers charge a higher price for the water and they bore wells that contribute to groundwater depletion. Moreover, they are often active in poor areas where the public water infrastructure is not adequate or non-existing, so that the poor pay a higher price for their water than richer people who often choose to have their own water pump. Privatization is not always the most effective way of providing better services for everybody. A better management in public companies can sometimes achieve better results, for instance when a control authority enforces strict management practices. Differentiated fees can also be charged to the rich or the poor according to their revenues so that the rich can help the poor pay the water (or electricity) bill, even if enforcement of these measures can prove difficult.

### *2. Electricity network*

Gas turbines are being built, but this might not be sufficient. Besides, gas and oil dependency can have dangerous geostrategic consequences. I advocate the construction of at least one nuclear plant to accommodate the needs of Delhi and its region. Provided that all safety measures are taken and knowing that nuclear waste recycling is constantly improving, it would provide a cheap, clean and almost infinite energy to Delhi and its region.[2] It would also replace some of the existing power plants now running at only 20% of the capacity they had when they were built, due to poor maintenance, lack of spare parts, etc. These plants' marginal utility is constantly decreasing and they will soon be costing more than what they provide. Delhi's electricity company has been recently privatized and one can hope that this will make the situation better.[3] One can also expect a significant increase of the electricity provided to Delhi as Reliance Energy is going to build the largest gas generation plant of the world in the district of Dadri in Uttar Pradesh, with a capacity of 5500 MW, but one should not only rely on this solution as other growing Northern

2 India will have sufficient nuclear combustible available for this purpose, as the US House of Representatives' decision on July 27th, 2006, to authorize nuclear combustible exports to India will boost India's civil nuclear capacities.

3 The power company of Delhi, which was called Delhi Vidyut Board, has been privatized in 2002 and divided in a holding company, a generator company (the Indraprastha Power Generation Company), a Transmission Company (Delhi Power Supply Company Ltd.) and several distributing companies: North Delhi Power Ltd. (a joint venture of Tata Power Company and of the government of the NCT) and BSES (Brihanmumbai Suburban Electric Supply, now Reliance Energy).

cities will also use this increase of available power and as needs are likely to grow further in the future anyway, thus prompting us to seek long-term solutions for power supply.

**B. Sidewalks and streetscape, traffic and transportation**

Recommendations:

· Traffic delimitation

Different lanes must be clearly delimitated by painted stripes and lines on each side of them. Traffic signalization and signage should also be improved so as to make clear at crossroads which road has priority over the other one.

· Traffic segregation

The traffic flow is impinged by the mix of vehicles which represent a constant threat for each other. Depending on the width of the road, cars and motorbikes could have for instance two or three lanes. Buses, taxis and rickshaws could have another lane, and scooters and bikes could share the last one. These three sections of the roads should be separated by concrete dividers whenever possible in order to enforce the segregation more strictly. Whenever this proves not possible, the bus/taxi/rickshaw lane should be separated by paint markings on the road and if possible have a different colour than the car lanes. Bike/scooter lanes should also at least be separated from the traffic by a different colour on the ground. Traffic segregation should be strictly enforced.

· Traffic education

Right-side overtaking - Indians drive on the left side like the British, red lights, should be strictly enforced, pedestrian crossings increased and crossings at non authorized locations discouraged. Fines should be more systematically given, traffic police should be more visible, educational programs should be created in schools, stricter criteria should be implemented in the driving license examination. Use of seatbelts for car passengers and helmets for motorbike drivers and passengers should be enforced.

· New parking lots and on-street parking

Parking is an issue in Delhi. The number of cars has increased dramatically in last years thanks to the economic growth and a growing middle class. Public transportation can be a partial answer to this reality, but it does not provide the kind of ubiquitous means of transportation provided by a car, even if the metro could partly change that. Buses are still perceived as the poor man's way of transportation, while cars are associated with wealth, success and prosperity.

Cars and parking are an issue in all the major cities of the world. London's mayor Ken Livingstone has for instance created a commuter fee for downtown London, monitored by license plates detection optoelectronic devices. This innovation proved hard to implement in London and would be impossible to do in Delhi where urban poor are half of the population. In Paris, Mayor Bertrand Delanoë has chosen to crack down on car traffic by narrowing traffic lanes and creating dedicated lanes for buses separated by cement dividers from the automobile traffic. His idea was to decrease car traffic and at the same time to increase public transportation. However, the initiative has been an overall failure until now. Unless there is an even more serious crackdown on cars and a simultaneous extraordinary improvement of the public transportation means, it is bound to fail. Traffic jams have actually increased in Paris since these measures were taken because lanes have been narrowed without a real decrease of the utilization of cars. The transportation network has been improved but not enough to approximate the ubiquity of private transportation means.

The number of parking lots has to been increased, as the DMP foresees, in order to accommodate the growing number of cars, either with multi-floor open-air parking spaces (which saves some space and money as no mechanical devices are needed for aeration) or with underground parking spaces. Another issue of importance is on-street parking. Cars should not be allowed to park on the sidewalks anymore and they should not been able to park sideways either but should park parallel to the direction of the street. Available parking spots should been make apparent by appropriate markings on the road, while an appropriate signage should also make clear where the places are where cars are not allowed to park - for instance, car exits, official buildings, etc.

The width of the residential streets in Delhi is by no means inferior to most of residential streets in the United States or in Europe. On-street parking on one side or both sides of the street should thus not be a problem if pedestrians are in the meantime able to walk safely on sidewalks. Whenever sidewalks or/and on-street parking creation becomes an issue due to the breadth of the street, streets should be changed from two-ways streets to one-way streets with one-way street signs. This kind of street currently seems quasi non-

existent. Enforcement of one-way driving in one-way streets should be very strictly enforced. Creation of one-way streets should be carefully planned so that it does not impinge the traffic flow and so that neighbouring streets still allow the driver to go in the direction he wants to go.

· Sidewalks upgrading and upkeep

Sidewalks should be kept free of any trespassing from street traffic or on-street parking. The DMP makes good suggestions here:

All the encroachments on residential streets in the form of kitchen gardens/ roadside private greens, large projections/ramps, etc. need to be removed (in DMP, p. 102)

The numerous shops encroaching on the streets in commercial areas and to a lesser degree in residential zones play nonetheless an important economic role. Provided that they comply with certain requirements in terms of pedestrian right-of-way, they could be regularized by the government of Delhi.

· Road repair

The roads themselves should be improved so as to limit waterlogging during the monsoon season, which leads to pedestrians being soaked by cars, and so as to make the drainage easier and decrease the run-off of the water and the splash effect. They should have no bumps or potholes but should present a uniform surface; they should have a certain width gradient on each side of their axis so that water can be evacuated along the sidewalks; this should be made easier by the construction of gutters along the sidewalks from where the water can be evacuated through drain pipes.

*2. Specific requirements for business district*

A business district demands particular requirements in terms of transportation and parking spaces. First, an easy access to the site by public and private transportation means must be guaranteed. In the case of the Yamuna bank, large ring roads on the West and East sides, bus lines as well as metro lines north and south of the development give a good access to the site, even if current metro lines, which run on a west-east axis, should be supplemented by a north-south mode of transportation, either another metro line, a tramway or another bus line.

Second, if we propose to develop a waterfront focused on offices, shopping and entertainment, specific requirements apply in terms of parking spaces.

Typical standards are:

Office

1 space for 300 sq ft (28m²) of office space

Retail

1 space for 250 sq ft (23m²) of retail

Entertainment

1 space for 4 seats

Hotels

1 space/guest room + 1 space/15 guest rooms (employees)

## III. Use the waterfront to attract business to Delhi

**Summary**

Delhi is growing and nothing save unacceptable authoritarian measures could help prevent that. It is thus worthless to fight against growth, growth has to be *managed*. Delhi needs new streams of revenue if it wants to educate its population, give it new economic opportunities, upgrade its crumbling infrastructure and attain global city status. Creating a new city business district along the river would allow the city to achieve these goals.

**Conditions and thresholds**

- Creation of a new central business district for the capital, with no or little new housing being built
- Creation of a service-oriented SEZ without or with little tax incentives but with special zoning bylaws, providing jobs to citizens of Delhi
- Educational and research facilities working in synergy with businesses in order to connect businesses and workforce at all qualification levels
- Retail and entertainment facilities to avoid the classic "empty CBD" effect after office hours and to add up to the new parks and promenade along the waterfront in order to attract Delhi residents in the new development and along the water

### A. How

*1. Giving up on the anti-growth policy*

*a. An unproductive policy*

Since the first Master Plan of 1962, the strategy of the DDA has basically been the same: to prevent further growth in Delhi because this would lead to an overcrowded and unmanageable city, whereas the problem is not really the growth of the city but the fact that because the government does not want to cope with it, the city is in effect becoming unmanageable, thus justifying the DDA's grim predictions and anti-growth policies. This state of fact is not due to fate but to a self-fulfilling prophecy from Delhi's authorities and planners.

Growth is actually a sign that the city has a great attraction power. It is not bad. There is no small world-class city. The Delhi region has 19 million people, the LA conurbation 15 millions, the Greater Tokyo Region 35 million! However, the city does need larger clothes. Even the DDA itself confesses that until now its anti-growth policy has been a failure. To succeed, it would

first need strict enforcement policies which are not put in place: illegal constructions should be systematically destroyed, zoning should be very restrictive for most of the uses; then, real estate prices would go up due to an increasing demand and a decreasing offer, and only rich people will be able to live in Delhi, which could lead to more taxes and improvements in the richer part of the city, while the other parts of the city would be emptied from their inhabitants. Of course, this scenario is very unlikely to happen because zoning is not strictly enforced, slum clearances are not systematic for political and humanitarian reasons, and real estate pressure is too strong.

In fact, the growth will continue until several factors happen:

- Until the countryside is depleted of all non-necessary workers. This rural exodus has been created by the Green Revolution: mechanization of the agriculture, use of improved species, use of fertilizers and pesticides – as well as by the growth of cities and by their attraction power

- Until citizens in the countryside enjoy incomes comparable with the cities (this will happen when the consequences of the Green Revolution have been totally achieved. Rural households won't have to support large families anymore and lots will be regrouped into larger properties managed as modern agro-businesses.

- Until the city loses its attraction power due to an overheated real estate market and to the development of employment alternatives elsewhere

An institution like the National Capital Region Planning Board wants to develop these employment alternatives right now. They might contribute to curb the growth a bit, but the city will still be growing, because the countryside's pressure is too strong to be accommodated by smaller size cities only and because this would require the agreement of the neighbouring states around Delhi and they will not give it, as Delhi's growth leads to the growth of their own cities which are close to Delhi, like Gurgaon or Noida: these cities would not grow if Delhi was not growing.

The DDA should thus stop the Malthusian stance it has taken almost from the very beginning: it is, along with other institutions, responsible for many of the current problems of Delhi instead of contributing to solve them: because the DDA does not want to accommodate the growth of automobiles, roads and transportation networks don't get improved – Delhi's first class metro is out of control of the DDA. The DDA planners don't want to attract businesses in the city, which could give people more jobs and higher wages, their ideal city seems to be one where only bureaucrats and their servants would be living. This strategy is according to me totally counter-productive and resorts more to ideology than to realism. The DDA planners are afraid that the city

gets congested, but the growth of the city would be spreading to cities like Gurgaon and Noida even if the DDA planners were not taking their anti-growth measures. Delhi cannot come back to the days of the independence, when its population was below two millions people. It has to move forward. Of course - and in this regard the DDA planners are correct, additional amenities and business opportunities are likely to attract even more people. But these people will come anyway; between having a growing city made of poor people and one made of a growing middle class who will be given the means of its social rise, a choice has to be made.

*b. Alternative solutions: densification, education and employment in the city*

The density of the city is already fairly high with 9294 persons per km² but could be increased with the construction of high rises similar to those observed in a city like Hong Kong: some preserved areas along the mountainous slopes keep the density at 6200 people per km² in the territory of Hong Kong, but the actual density of a district such as Kowloon is 44 000 people/km².

The Chinese solution would be to curb down population by taking coercitive measures to decrease the birth rate and to prevent further migration to the cities. However, these measures are not likely to be taken in in the Indian democracy. Besides, even if the migration rate to the city has decreased in the last decade, with 40% of the population growth due to migrations and 60% to natural population increase, Delhi has acquired such a massive population that the sheer number of its inhabitants will lead to a steady demographic increase in the coming years. Education and an increase of income as well as higher real estate prices should eventually lead to a stabilization of the demographics. Building new housing for poor people along the Yamuna won't solve the problem because it does not address the roots of demographic increase. Encouraging higher education and offering new higher level employment opportunities will create a virtuous circle of higher income and lower birth rate. As the NCRPB report points out, there are already many high level scientific and technical institutions in Delhi, such as India Institute of Technology Delhi (IIT-Delhi), All India Institute of Medical Sciences (AIIMS), Center for the Development of Telematics (C-DOT), National Physical Laboratory (NPL), National Informatics Centre (NIC), Council of Scientific and Industrial Research (CSIR), etc. This type of organization should be encouraged and should be closely associated with Indian companies to develop new technologies. Job-training centers should also be created to enable upward mobility of current residents of Delhi and to provide companies locating in

Delhi with qualified workers.

*2. Attracting national and foreign investments to the heart of the city*

*a. Development of Special Economic Zones in India*

After the protectionist phase of the India economy until the liberalization of the 90's, it has now become necessary to attract foreign capital without damaging the national economy since many sectors are still weak. After the old free ports and the more recent export processing zones, the Special Economic Zones have proven that they can be successful concepts provided the right conditions are observed. SEZs have first been implemented on a large scale in China by Deng Xiaoping and his epigones. They have been a huge success: even if they are limited to the outer fringe of China and even if many Chinese peasants are still plunged into poverty, a new middle class has been created and in some places like Shanghai, the living conditions have improved to a point that was unimaginable just twenty years ago. India is now following this model since April 2000 with the creation of dozens of Special Economic Zones all over the country[1] and the conversion of older Export Processing Zones into SEZs. In these zones, tax incentives[2] have been created and bureaucratic hassle has been suppressed as well as the restrictions that were hindering the growth of foreign investments. Today, India comes second in the world after China in terms of foreign direct investments (FDI) and Delhi should take better advantage of this situation.

*b. A SEZ for Delhi?*

Should a special economic zone be installed along the Yamuna, a little bit like Pudong in Shanghai? The current structure of SEZ in India is not well adapted to our situation since it is turned towards the production of industrial goods rather than the production of services. Besides, the Indian SEZ are designed for foreign companies and if we want to create a new waterfront in Delhi, we want that big Indian companies move there as well. Moreover, the SEZ idea is that fiscal incentives are given to the companies locating there.

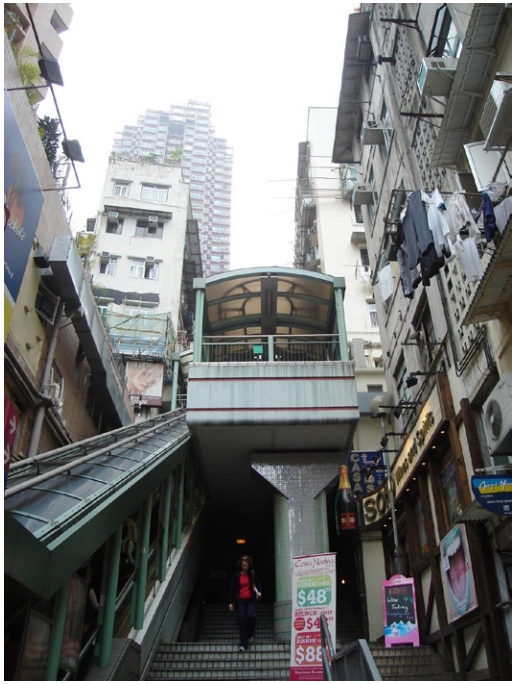
1 See www.sezindia.nic.in. However, the SEZ Act was only enacted in June 2005, and the SEZ Rules announced in February 2006.

2 However, goods from the SEZ which are sold in India (i.e. Domestic Tariff Area) are considered to be imported and are subject to custom duty and import policy in force.


Picture 18 Extraordinarily dense urban fabric on the eastern bank, Delhi


Picture 19 Karol Bagh, a retail center in Delhi, with typical small shops and four story buildings


Picture 20 High rises and an even higher density than Delhi in Kowloon, Hong Kong



Picture 21 Street and escalator in a multi-layered urban landscape on Hong Kong island.

However, experience has proven throughout the world that fiscal incentives often play a small part in a firm's decision to move to one place or to another. Elements like the location, the general economic situation of the country, the size of the market, the characteristics of the labour market and the future prospects of benefits are in fact more important than the fiscal incentives by themselves. Foreign companies would have come to China anyway as soon as the Chinese market opened, eager to tap into a cheap Chinese labour force and to gain access to 1 billion potential customers. On the contrary, many developing countries, often in Africa, have created SEZ with little success because of the lack of surrounding infrastructure, a heavy bureaucracy, political instability, etc. In the case of Delhi, we could say that the prime location of the Yamuna banks at the heart of the capital of India, with the possibility to have access both to a cheap workforce for lower jobs and to highly educated individuals for white collar work, as well as the presence of a potential customer base of 14 million people, is enough of an incentive so as to make any fiscal incentives unnecessary. However, limited incentives for just a few years could be interesting as a signal towards entrepreneurs, just to kick off the project. Another interest of establishing a SEZ would be that it could be a special zone in the city in respect to zoning regulations and it could escape the authority of the DDA and be placed under the aegis of another, more efficient development authority.

A SEZ-Services Delhi (SEZSD) could be created with the following characteristics:

- Foreign companies, joint-ventures and national companies would be authorized in the SEZSD
- Only services (including research and education) would be allowed in the SEZSD. SEZ for industries would be created around the city.
- Research and education would benefit from further fiscal advantages. Job-training institutes for low-skill workers, teaching them jobs, English lessons, etc. so as to allow them to move upward, mid- and higher level research and educational institutions should be created in the new development so as to create synergies with new businesses and make the project benefit Delhi's workforce: the Yamuna waterfront must not be an enclave for foreign companies with no connections to the citizens.
- Companies may benefit from fiscal incentives for just a few years (between 1 and 5 maximum), but this would have to be discussed further
- The SEZ would have its own regulations and would be governed by a new development authority - or a renovated DDA (see chapter V on Institutions)
- Retail and entertainment facilities, along with parks - also necessary for environmental reasons, see Chapter I, would serve to attract residents in the new development and prevent it from becoming a CBD deserted at night and separated from the rest of the city and from the Delhiites.

*c. Improvement of infrastructure*

Several key points need to be improved in order to create a business friendly environment. One of them is to be able to rely with confidence on the architecture of systems which allows modern business to function. If this architecture gets disrupted, business gets disrupted. Electrical shortages for instance create a risk for air conditioning systems, for private electrical pump-operated water systems - themselves a consequence of an inadequate water supply network, and, last but not least, for computers and other communication systems, which are at the core of modern global business. Sanitation problems in the water supply hinder the creation of a world class city as local people and non-immunized foreign businessmen are more subject to water borne diseases. Poor urban design leads to a devalued image of the city in the world, which will curb down tourism and business investments just as a good urban design can be a showcase for a city. Traffic hazards, harassment by beggars, dilapidated façades, all of this can lead to a lesser attractive power of the city. All things that contribute to insecurity and lack of safety create a business-hostile environment (see next chapter, ch. IV "Deficient Infrastructure" for more details).

## B. Where

*1. Out of the city vs. in the city*

We can see that there is a major difference between the Chinese SEZs and the Indian ones. The Indian SEZs are turned towards the export of goods only and are often located outside of cities, whereas the Chinese SEZs are also located within big cities like Shanghai (Pudong District) or Shenzhen. Thanks to that location, the industries and offices located in the Chinese SEZ are able to easily recruit employees from the pool of workers living nearby and can use existing infrastructures in addition to the new ones built for the SEZ. Transportation costs are also reduced, as commuting time is short. At the same time, the benefits reaped from the SEZs can be more easily conveyed to the city thanks to the infrastructures needed for the SEZ which can be also used by city's inhabitants and other businesses; the money earned by the workers is also used to improve their living conditions and spend more, thus contributing to the city's economic growth.

Even if the SEZ enjoys special advantages not given to the rest of the city and the region, these non-SEZ territories should also have a more business friendly environment so that positive spill-overs can ensue from the SEZ to

the city and the region. In the longer term, the definitive moment of success happens when the SEZ itself becomes useless as the distinction between SEZ and non-SEZ zones becomes irrelevant.

Delhi should create more SEZs within the State of Delhi, some in the core of the city of today - first of all by creating a new international business district on the bank of the Yamuna River, some in the close neighbourhood of the city. Other States are already showing the path to follow: an IT (Information Technology) specialized SEZ has been created in Noida, and the Haryana State is creating a giant SEZ near Gurgaon with Reliance as a private partner. The fact that one of the most important high tech companies in the country spends so much money in this project shows that private investors are ready to go ahead in attracting global investment. Time has come for Delhi to seize this kind of opportunities as well.

Here is an article available online at indiaenews.com on India's largest SEZ project:

"India's largest SEZ that will also have an entertainment centre and a golf course, will be set up by Reliance Industries Ltd. in a 25,000 acre area in Gurgaon in Haryana, about 35 km from the national capital.

"The project will catapult India on the world stage in terms of attracting global investment and we intend to compete with China, Singapore, Malaysia, Indonesia and other nations", Reliance chairman Mukesh Ambani said after signing the pact with the Haryana government here Monday to set up the Rs. 400 billion (9 billion dollars) project.

Reliance Industries on its own has committed to invest Rs. 250 billion in the project over a period of five to 10 years", Ambani told a press conference. The SEZ is going to come up near the National Highway 8 in Gurgaon – a satellite township of the capital – and would extend to Jhajar district adjacent to the proposed Kundli-Manesar-Palwal expressway.

About five percent of the area is being earmarked for leisure and recreation. " A possible tie-up with Disney, Time Warner or Universal could be undertaken", said Ambani, who controls India's largest private sector company.

A golf course as per the standards prescribed by the Professional Golfer's Association (PGA) will also be set up in this special zone. The pact calls for a new holding company – Reliance Haryana SEZ Ltd – to be set up to commission the project that will facilitate 100 percent foreign investments with special tax rebates, cargo airport and a metro link to New Delhi.

"This company will also be listed on major stock exchanges', Ambani added.

"This project would benefit the whole country, especially Haryana, as it would attract an investment of Rs. 1,000 billion ($22 billion) over the next decade", Haryana Chief Minister B. S. Hooda said.

Reliance officials said the project was expected to generate over 200,000 jobs and will be a fully sustained township with its own power plant, schools, colleges, banks, and one of India's biggest medical institutes.

They say the focus of the zone is on environmentally friendly medium and large industries; export houses, business and knowledge process outsourcing companies and research laboratories and institutions.

Apart from this, hospitality and leisure destinations, educational institutions, offshore banking and insurance and medical tourism also figure high on the priority list of the special zone, officials added.

Industrial units would account for the bulk of the land and would be allotted up to 25% of the total area. Commercial establishments would be set up on 20% of the land, while 15% of the area is for residential units.

The cost of acquiring the land is pegged at Rs. 30 billion ($665 million) and about Rs. 220 billion will be invested in the development of the zone, the officials said. "We will also sell developed land to the industries and different units"."

Other projects are starting inside Delhi itself, they should be encouraged and developed even further in a comprehensive and systematic way: for example,

the Economic Times of Delhi announced in September 2005 a new SEZ in Delhi, specialized in gems and jewellery:

"Delhi State Industrial Development Corporation has tied up with the Delhi Trade and Tourism Department [DDA never mentions this department!] in order to set up a gems and jewellery SEZ in the capital with an investment of around Rs. 250 crore[3], excluding the cost of land. They want to sport global mega brands like Donna Karan and Gucci and to create a world class business hub, so that these brands can exploit domestic strengths and manufacture at low cost. We want to ensure that India citizens no longer need to visit Dubai and Malaysia to shop for jewellery. On the contrary, we are looking to capturing the markets in Sri Lanka and Burma. This would also promote the 7000 unorganized jewellers across Delhi. 18 acres identified in West Delhi with two hotels, one habitat centre and the gems and jewellery business centres. Apart from that, we are looking at another 80 acres of land at Najafgarh for the back end operations."

To the extent of my knowledge, this SEZ is still waiting clearance from the Municipal Council of Delhi. The time you need to create your business or invest in a country is critical for investors: in Singapore, it takes on average 4 hours for foreigners to start a medium or large size business, in some other countries it can take up to one year. The government of Delhi should ensure that making business in Delhi is easy and not plagued by bureaucratic excesses.

*2. Location along the Yamuna*

Economically, it makes perfect sense to locate along the Yamuna River:

- Available land at the heart of the city, mostly controlled by the State of Delhi
- A few minutes away from the Indian political center as well as cultural and entertainment facilities
- Gorgeous view onto a clean Yamuna river and the adjacent parks, and formation of an identifiable skyline giving companies a unique visibility
- Proximity to metro lines at the north and south ends of the available parcels, which could be extended to include the center of the site

3 1 crore = 10 millions Rupees ; 1 lakh = 100.000 Rupees ; 1US$ ≈ 50 Rupees

**IV. Be financially viable**

One of the most important conditions for success is the fact that the whole project is financially sound and profitable for the city. This empty land in the middle of the city is a unique opportunity for Delhi, and only development with the highest rate of return should be allowed here. If the profit from the development is only limited, other uses, such as keeping the banks as open space in the form of a big park, should be preferred.

**V. Having a competent planning authority**

Last but not least, a competent planning authority should be in charge of the implementation of the project. This authority should have enough powers to be able to control land property and land use, should have the will and manpower to move things forward, and should have enough independance in order not to be stopped by political contingencies and pressures from any group. At the same time, it should have a clear mandate and should fulfill all of it, but not more than it.

# Part III. Are these conditions present? And if not, what can we do?

**Summary**

We have defined the challenges (I), the conditions to overcome these challenges (II); now, how can we fulfill these conditions? It appears that certain conditions can be easily done for a reasonable cost, such as the land improvement part. The improvement of infrastructure in the city, which has been planned in the Delhi Master Plan 2021, should also be completed to a certain extent. Financial viability is also assured due to the fact that the government owns the major part of the land and that real estate prices are currently very high in Delhi. Two conditions remain difficult to fulfill: create a business friendly climate in Delhi in order to attract business in the new development; have a competent planning authority able to carry on the project. Two solutions could help find a solution to these conditions: first, encourage lobbying from business groups; second, push for the creation of an independent Delhi Yamuna Development Corporation (DYDC) modelled after the Docklands Development Corporation in London.

# I. Conditions which are present

## A. In the Delhi Master Plan

The Delhi Master Plan 2021focuses largely on problems of water, electricity and transportation, which are in effect among the biggest issues in Delhi. Many recommendations are given in the Master Plan, some of which have been talked about in part II already. Implementation of these measures might be difficult, but with the democratic pressure from the population as well as the urgency of some issues in front of an ever growing population, we may reasonably assume that at least 66% of the Master Plan most practical goals (such as the ones concerning water, electricity and transportation) will have ben achieved.

**B. Real Estate analysis**

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**Summary**

Land reclamation techniques must be used on such a challenging site as the Yamuna banks and this will makes the project more costly. At the same time, a hot real estate market as well as the locational advantages inherent to the site will ensure that the sales price for this land will be much higher than the cost to develop it, thus making the project realistic financially. Finally, the best solution regarding property rights that would guarantee long-term benefits for the city seem to be the leasehold one.

**Conditions and thresholds**

- Minimum price estimate for sale at 100$/m2 (break-even point for development if the whole site is developed)
- At current market rates for commercial land, 50% of the site left as open space would still make the project a financial success.

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Land reclamation projects can be the opportunity to make a huge profit when located at the right place and under the right market conditions. In Singapore, land reclaimed at US$ 10/m3 of Malaysian sand has then been sold at 600 US$/m2. In 1998, the DDA's project for Delhi was planning on a cost of development of $16/m2 and a sales price ranging from $53 to $319 for commercial property. This development cost is in fact a gross underestimation of the actual cost induced by land reclamation along the Yamuna River because of the difficult site conditions that I mentioned earlier, even if labor costs are lower in India. However, the real estate market in India and in and around Delhi is experiencing a huge boom and the sales price today is much higher than what it was in 1998. We should first calculate cost estimates for making the land ready for construction, then determine what the market prices are today, and finally devise the best strategy for the city so that they can maximize their profits and use them wisely.

*1. Cost estimates for land reclamation*

These estimates are based on costs for different techniques found in several sources: US Army Corps of Engineers[1], Federal Highway Administration Report[2] and other technical articles and reports. Since I only know about the general composition of the soils of my site, these are estimates that of course should be supplemented by in situ expert studies.

1 Ch. 7, Technical Manual 5-818-1/AIR FORCE AFM 88-3, Soils and Geology Procedures for Foundation Design of Buildings and Other Structures (Except Hydraulic Structures), US Army Corps of Engineers, 1983

2 Elias, V., Welsh, J., Warren, J. and R. Lukas, Ground Improvement Technical Summaries, Federal Highway Administration Report No. FHWA-SA-98-086, 1998

Soils on the site are mostly composed of sand and, in a smaller percentage, of silt. Chemical grout is extremely expensive so that alternatives should be sought. Vibro-compaction and jet grouting (mixing cement and soil to produce soilcrete) are two valuable alternatives for our site, as well as stone columns.

Estimates for different techniques follow:

- Deep vibrocompaction (up to 100 feet): 1-5$/m3.

With a depth of 90 feet, the cost is $150/m2

- Jet-grouting: $100-300/m3 (superjet technique is advised here because of the depth of subsurface soil)

- Stone column: $45-60/m + an equal cost for the transportation of stones: $90-120/m.

- Earth fill: $3/m3 for earth fill

- Fly-ash fill: 15-20$/m3

Our site extends from Wazirabad bridge to the north to Noida toll bridge to the south and covers on the left bank an area of around 9.2 million m2 and on the right bank 21.3 million m2, for a total of 30.5 million m2 (35 km2, 3500 ha).

The vibrocompaction method is the most effective for sandy soils, even if it can be supplemented at certain places by jetgrouting, stone columns and other techniques. With the hypothesis that 1m2 size vibrocompaction columns fill 15% of the total site area, hence 4.6 million m2, cost a value of 5$/m3 and go at a depth of 30 meters, we obtain a cost of 690 million $. If we add 2m of fill at a price of 10$/m3 for fill to compensate for compaction and to elevate the site compared to the river, accounting for an additional price of 610 million, we reach 1,3 billion $ for the site, which puts a development price per square meter at 43$/m2.

Estimates for site development before any further study and assessment by contractors usually vary between half and double of price. Once thorough

site studies have been conducted and methods and construction materials and other variables have been decided, there is usually still a 30% variation margin of the final cost of the project. If we double the price, including additional costs for land improvement as well as roads, parks, canal embankments, dredging and channelizing of the river and additional costs, we reach a reasonable development cost estimate of 100$/m2.

*2. Real estate demand*

Our site is at a prime location in the center of Delhi and could become one of the major destinations in the capital of India, for business, shopping, tourism and leisure. With an expanding middle class (one third of the country's population) and a shortage of available land and construction stock, prices are soaring. Here is an excerpt from a January 2007 article in the Tribune of India[3]:

· India's real estate market is currently estimated at $16 billion and is forecast to reach $60 billion by 2010. The real estate sector could attract a quarter of an estimated $8 billion in long-term foreign investment bound for India in 2006-2007, according to a study by industry lobby Assocham.

· In the last two years, the value of commercial office space has increased by 40 per cent. It is expected that the demand for office spaces alone will grow to over 19 million square feet in 2006 to 2007. The outsourcing sector would account for approximately 75 per cent of the demand and by 2010 would need 200 million square feet of office space in major metropolitan cities.

· The number of shopping malls in Kolkata, Mumbai, Bangalore, New Delhi, Hyderabad and Pune is expected to grow to 300 by 2010 from the current 50. The total mall space currently available in these cities is around 12.4 million square feet.

· In 2005-06, the real estate sector tapped 16 per cent of the $5.54 billion of foreign investment attracted to India, compared to 10.6 percent of the $3.75 billion foreign investment in India in 2004-05.

In Delhi, the real estate boom is particularly impressive: the price of residen-

3 http://www.tribuneindia.com/2007/20070113/real1.htm

tial housing has gone up by 60 to 120% between 2005 and 2007.[4] Because of the scarcity of exisiting housing and, for offices, because of thedifficulty of having new office/commercial space in Delhi until now – and until this new waterfront project is created, residential housing and offices have experienced a huge boom around Delhi in cities like Noida and Gurgaon. Residential property fetch 250 to 500$/m2 in Gurgaon[5], and sometimes much more, and commercial property and land zoned for commercial use reach even higher prices. However, this is little compared to Delhi. Prices of commercial land have increased more than six-fold in South Delhi and more than double in Dwarka since 2004-05. Prices of residential plots have surged by almost 150 per cent in South Delhi over the past two years (2005-2007)[6]. The DDA has recently auctioned off land for commercial use at 4000$/m2 in South Delhi.

Of course, this real estate pressure makes it difficult for low income people to find a decent housing in Delhi. At the same time, it may contribute to slow down migrations to the capital region and encourage people to move to smaller satellite cities. It also makes for a hefty profit for the National Capital Territory if the land around the Yamuna was to be developed and rented or sold.

If prices in South and West Delhi reach 4000$/m2 for commercial use, in such a prime location such as the new Yamuna waterfront, prices could easily reach 10 000$/m2. Even unexpected additional costs due to jet grouting or other techniques would be offset by such a high land value. It means that profits from the development of the site could range from 40 to 100 times the initial investment. It also means that *theoretically*, if one chooses to do so, the vast majority of the site (98-99%) could be developed as open space and the project would still be viable, even if economic and social benefits from a large business district would then be absent, which could in effect lead to a decrease in the value of the site and then in less profits. In fact, new infrastructure and the anticipated clustering of businesses associated with large projects is an important factor in the added value of the site, in addition to its sheer locational advantages. We can however estimate that developing even half of the site, i.e. 1750ha, as business district, and developing the rest of it as parks, would still make the project move beyond the critical size necessary to attract businesses.

4 http://timesofindia.indiatimes.com/articleshow/1024894.cms
5 http://www.anandproperties.com
6 http://www.tribuneindia.com/2007/20070312/delhi.htm#3

## II. Conditions which are not present

**A. Lack of strategy for attracting business**

The Master Plan does not mention a real business strategy to attract business in Delhi; in fact, the DDA does not plan business districts as such, even if it sells from time to time some parcels for commercial use. However, a coherent business strategy for Delhi is essential if Delhi wants to retain or attract companies and jobs which move to neighbouring cities of other states, such as Noida or Gurgaon.

**B. Institutions and Institutional changes**

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**Summary**

Delhi, being at the same time capital of India, part of the the National Capital Region regrouping Delhi and a piece of Haryana, Uttar Pradesh and Rajasthan, State and city divided into Delhi, New Delhi and the Delhi Cantonment Board, is subordinated to complicated bureaucratic logics. In this context, the Delhi Development Authority has proved unable to play a significant role in an effective management of Delhi's urban growth. The development of the Yamuna bank should thus be devolved to either a renovated new development authority that would replace the DDA, or, more realistically, on the model of the Delhi metro and of the Docklands in London, to an independant development corporation.

**Conditions and thresholds**

- creation of a Delhi Yamuna Development Corporation with land ownership, planning powers and the power to broker deals.

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*1. Institutions*

In order to create a successful redevelopment along the Yamuna River, it is essential to see who the main stakeholders in Delhi are. Perhaps because of the status of Delhi as the capital of India and of the heavy control exerted by a host of bureaucratic levels over the city, it does not seem that we can consider businessmen as stakeholders, even if they surely exert an indirect influence through elected officials, especially at the national level. There are two major stakeholders in Delhi: the various public institutions that are involved in the governance and planning of Delhi on one hand, and on the other, all the Delhiites who form the constituency of Delhi. In this last group, two


Fig. 12 National Capital Region and counter-magnets around it

sub-groups appear to be especially important: the new middle class (and the would-be middle class) and the slum-dwellers, often supported by NGO's. There is a third sub-group made out of all the Federal and State civil servants living in Delhi, their interest is likely to hang between those of the institutions they are working for and those of the middle class at large. The slum dwellers problem should be addressed adequately, for instance by choosing to redevelop neighbourhoods that are not too far from downtown so that one could increase their density, relocate slum-dwellers there and provide adequate education, training, transportation and employment for them.

I choose here to specifically focus on the functioning of the institutions because they are the ones who have the most power in the planning of the capital.

The institutional system in Delhi is a complicated one, many levels of governance overlapping in the national capital and for historical reasons.

- On the regional level, a National Capital Region was created to allow interstate cooperation for policies concerning the whole region, such as growth control or transportation. It groups together the State of Delhi and a portion of three other states: Haryana, Uttar Pradesh, Rajasthan. However, it is not an administrative level as such but rather an entity created for regional planning purposes. A National Capital Region board, composed of State chief ministers and planners, is in charge of initiating regional programs. This board is also advocating for the "counter-magnet" strategy to try to prevent the growth of Delhi by developing cities sufficiently far away from the capital city, lest they too become eventually absorbed in the urban sprawl of Delhi.

- On the State level, Delhi was a special entity known as a Union Territory, administered directly at the federal level in association with the local institutions; in 1991, it became "National Capital Territory", which gave it a quasi-State status, albeit with limited powers. As a special Union Territory, the National Capital Territory of Delhi has its own Legislative Assembly, Lieutenant Governor, Council of Ministers and Chief Minister. The legislative assembly seats are filled by direct election from territorial constituencies in the NCT. However, the Union Government of India and the Government of National Capital Territory of Delhi jointly administer New Delhi. The legislative assembly was re-established in 1993 for the first time since 1956, with direct federal rule in the span. Delhi was a traditional stronghold of the Congress Party, but in the 1990's the BJP came into power, only to lose it again to Congress in 1998, with Sheila Dikshit as current Chief Minister.

- At the local level, three institutions handle civic administration over the city: the Municipal Corporation of Delhi (MCD) cares for the major part

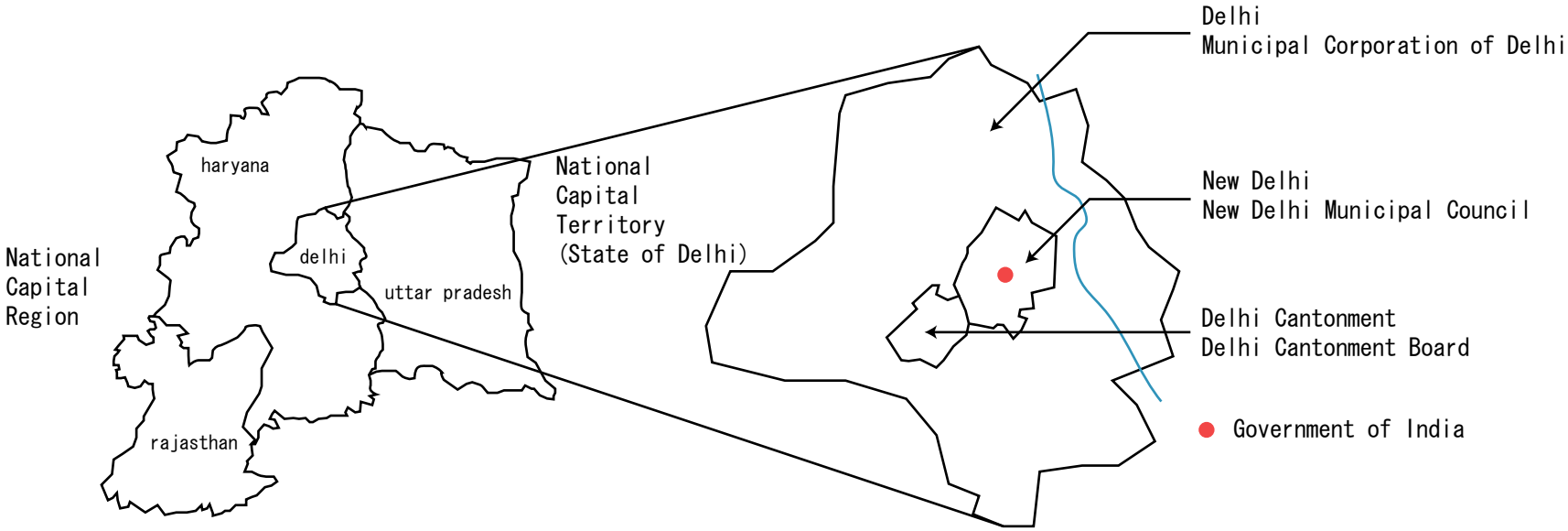



Fig. 13 Administrative structure of Delhi

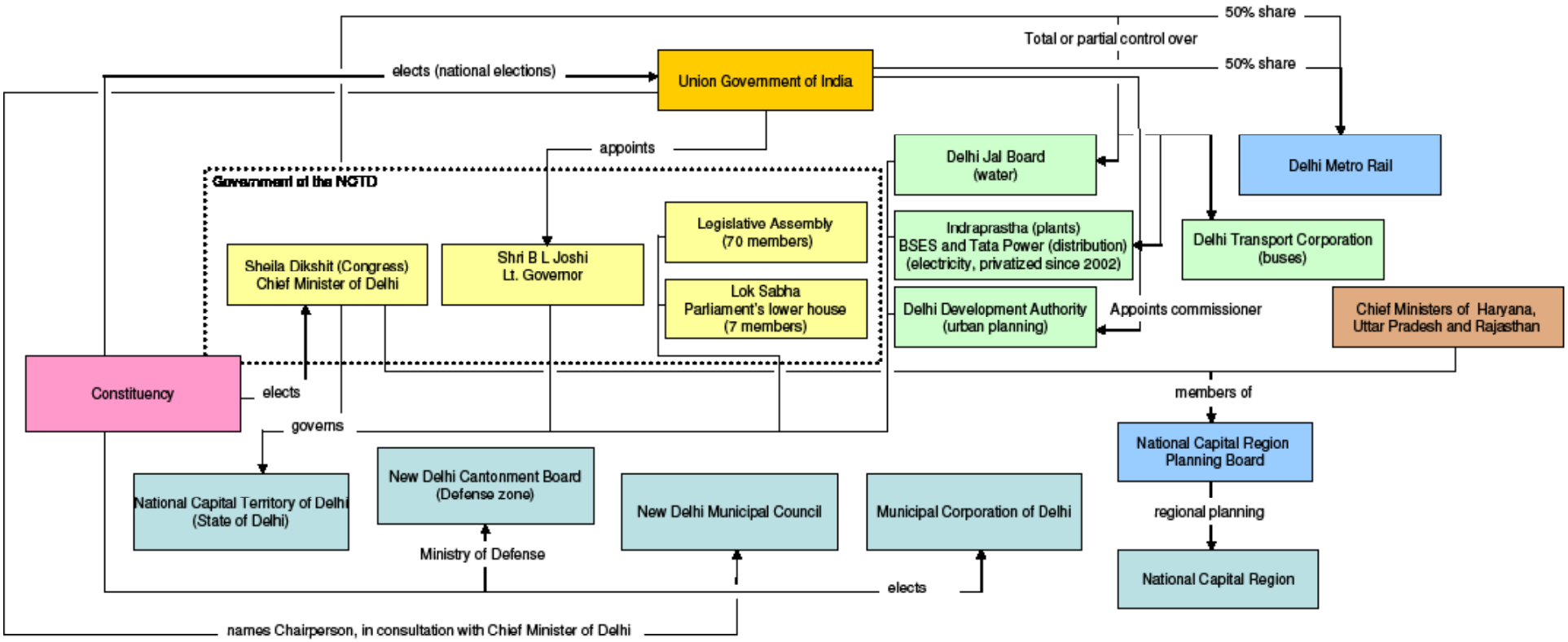



Fig. 14 Organization chart of Delhi institutions

of the capital, while the Delhi Cantonment Board cares for the cantonment zone where military headquarters and barracks are installed, a heritage of the British era. Another historical heritage explains the fact that New Delhi, the British part of Delhi, designed by Sir Edwards Lutyens, is also governed by a distinct board, the New Delhi Municipal Council. This area is the seat of both the State Government of Delhi and the Government of India. The Parliament of India, the Presidential Palace and the palace of the Prime Minister are all in New Delhi, as well as foreign embassies, major ministries and institutions. Here too, in the low density "bungalow area", reside the rich and powerful, high civil servants or businessmen.

## III. What to do when the conditions are not present?

### A. Pro-business lobbying

Business people should create interest groups to push bureaucrats for the creation of a business district on the Yamuna river. They should also push for the inclusion of a business strategy in the Master Plan and in particular in a city development plan. Economic factors in general should become a priority for planners. Businessmen could also use their political connections to try to make the infrastructure problem move forward towards a solution. The Commonwealth Games of 2010, with the Games Village located on the banks of the Yamuna River, as well as the new metro stations being built near the river, should also be used to give another impetus for the development of the site.

### B. Institutional changes

The existing institutions are not efficient enough. There is no point designing a waterfront for Delhi if the institutional system would doom it from the very beginning. I will focus here on the Delhi Development Authority in particular as it is in charge of the planning of the city.

While some of them were sticking to the Master Plan recommendations, many planners in national and local planning institutions said "off-record" that the anti-growth strategy of the DDA had not been working and that new solutions should be found, like increasing the density in the city by authorizing higher buildings for instance. The problem is that many reports are being published but not many things seem to change for the Delhiites. A simple thing to ask in order to know whether an institution is actually useful or not is to ask ourselves: if this institution was suppressed, would the city fare worse? Equal? Or perhaps even better? In this case, even if the DDA does implement useful structural programs like housing programs and slum upgrading, its strategic and prospective wing appears weak. Its disappearing would probably not be such a big tragedy. Sidewalks would still remain either non-existing or in poor condition, traffic on the road would still be hectic, the poor condition of the roads would still create water-logging areas during

monsoon time, shortages of water and electricity would still occur…

These institutions seem to have transformed themselves into bureaucratic monsters providing little help for Delhi's future. They should be leaner, quicker, centralized, proactive and even aggressive in pushing forward to achieve their goals.

Of course, the DDA and other governmental institutions should not be the only ones to bear the brunt of the blame. The politicians who are supposed to rule over Delhi should also push forward to implement clear goals. In this case however, the DDA's fuzziness is also sending the wrong message to the politicians and to the population of Delhi, especially to newcomers: "we don't have any ideas, we don't want Delhi to grow anyway, we don't want you to come to our city, we don't have specific advice to give to politicians, and even if they have their own ideas, we will make sure that these get drowned into bureaucracy". That the DMP advocates discouraging new businesses from coming to Delhi is for instance simply appalling. In fact, and this is a point which has put the DDA under much criticism in India, the DDA is not even planning commercial and business areas. Apart from existing commercial zones such as Connaught Place, where new buildings are scarce and old ones are crumbling down, it does not encourage new commercial areas and even if it does sell some of the land it owns for commercial use, on the strategic side, it has only been planning for housing, and not for organized

commercial and business developments. The main counter-argument used to justify DDA's inefficiency is that contrary to China, India is a democracy and that means that things cannot go as fast as with a dictatorial government. Should it means that democracy can only rhyme with inefficiency?

The DDA needs to be reformed. Ideally, it would need to transform into an organization which would focus on *growth management*, centralizing all the major institutions of Delhi in terms of water, electricity, transportation, business investment, etc., to mix them into different cross-disciplinary task specific teams with clear goals and deadlines[1].

This is however a difficult task, and we may want to try to go around the DDA rather than trying to reform it, an endeavour which could slow down our project to a halt before it has even started. This has already been done with the Delhi metro, a great success achieved by bypassing completely the DDA, relying instead on a new company called Delhi Metro Rail Corporation, which obeyed to a private sector management style, half of which is owned by the State of Delhi, and half by the Government of India.

At the same time, we don't want to alienate the DDA by ignoring it totally. A more realistic option would then be to create a Delhi Yamuna Development Corporation (DYDC), where DDA would be represented but would

Picture 22 Delhi Development Authority headquarters

1 Morgan de Rivery Philippe, *Appraisal Study of the Delhi Master Plan 2021,* Delhi, August 2006 (not published)

**C. Financial strategy**

The State of Delhi has two options: either to develop the land and then sell it to developers, or to develop the land and rent it to gain sustainable revenues from it over the longer term. Of course, a third option would be to sell the land directly to developers who would be then in charge of improving it, but this would not be a good idea in this case as this is likely to lead to piecemeal improvement effort without any large scale coordinated effort between developers. Improving the land before selling it would on the contrary allow for an integrated development strategy and would also show to potential investors that the city is committed to this new major project at the heart of Delhi. At the same time, developers would have to abide by earthquake prevention regulations, build the new constructions with anti-seismic techniques and would be the ones bearing the additional cost incurred by these measures.

Renting the land would assure long-term revenues to the city but at the same time Delhi might want to benefit from the current hot real estate market to reap maximum profits from this project.

The most interesting strategy is probably the one of the leasehold, often signed for a period ranging from 30 to 99 years. The owner can get foreseeable revenues over the long term and at the same time it allows him not to have to create new zoning by-laws, since he can include whatever regulations he wants into the leasehold agreement, thus giving him the possibility to overcome bureaucratic hurdles and to adapt regulations to fit its own specific needs.

In any case, the State of Delhi should reinvest the benefits in education, infrastructure and housing so as to redistribute the benefits from this project and create the conditions of a shared prosperity and increased economic growth.

# Conclusion on the optimal use for the Yamuna River

**I. Uses**

What kind of uses should be developed in the new land available along the Yamuna River? We have seen that due to geotechnical reasons, the cost of development is high. It means that only high value activities should be allowed on the new land, which would allow the state to amortize the price of development.

We have seen that Delhi is in acute need of affordable housing. However, I advocate against the construction of any housing on the new available land. Because the city has done nothing to develop a real City Business District, there is also an acute shortage of office and commercial space, and this is why companies relocate elsewhere, in business friendly cities close to Delhi, such as Noida and Gurgaon. Due to its prime real estate location within the city and along the river, this land should be reserved for the highest income generating activities and the city should be densified elsewhere to accommodate new housing. High income generating activities that would take full advantage of a location at the center of the city are front-door offices such as company headquarters and high-end retail, hotels and restaurants. I would also allow activities directly associated with the business activities, such as research and educational centers useful for supplying medium to highly qualified workers for the new businesses. Concerning the physical form of the new district, since land value would be the highest in the capital, high-rises should be the norm. Strict regulations would allow the new district to organize street hawkers and prevent them from encroaching on the new streets. At the same time, good connections with the rest of the city and a promenade along the river as well as diverse entertainment facilities would guarantee an easy public access to this part of Delhi and ensure that it does not become another enclave for rich people as it already is the case in the bungalow area and other places in Delhi.

**II. Conditions and thresholds**

This waterfront can only be created on the Yamuna if the following conditions are respected:

Physical conditions

- soil improvement
- earthquake engineering
- channelization of the Yamuna and construction of a bypass canal
- creation of parks serving as collectors for rainwater

## Infrastructure

- sufficient water (1840 millions gallons per day in 2021) and water treatment
- sufficient electricity (11 200 MW in 2021)

These are the goals according to the DMP 2021. According to previous experiences in Delhi, two thirds of these goals are likely to get implemented, which should be enough for the Yamuna project to function in 2021.

- proper roads and access: traffic segregation, quality of road surface, access from city and ring roads, proximity of public transportation (metro, tramway)
- enough parking spaces (see requirements in Chapter IV)

## Real estate

- Minimum price estimate for sale at 100$/m2 (break-even point for development if the whole site is developed)
- At current market rates for commercial land, 50% of the site left as open space would still make the project a financial success.

## Economic development

This would require a pro-business group in Delhi, made out of powerful Indian businessmen, to counterbalance the bureaucratic group in Delhi

- Creation of a new central business district for the capital, with no or little new housing being built
- Creation of a service-oriented SEZ without or with little tax incentives but with special zoning bylaws, providing jobs to citizens of Delhi
- Educational and research facilities working in synergy with businesses in order to connect businesses and workforce at all qualification levels
- Retail and entertainment facilities to avoid the classic "empty CBD" effect after office hours and to add up to the new parks and promenade along the waterfront in order to attract Delhi residents in the new development and along the water

## Institutions

- creation of a Delhi Yamuna Development Corporation with land ownership, planning powers and the power to broker deals.

Some of the liabilities identified in the introduction might then become assets (in green), while some of them would need to be at least partially solved for the sucess of the project (in orange).

| Liabilities | Assets |
|---|---|
| Poor soil conditions, floods and earthquake hazard | River in the middle of the city |
| | Competent engineers and cheap manual workforce |
| Poor water supply and treatment, sewerage and electricity | - |
| Poor traffic conditions and degraded roads | Extensive bus system and new Delhi metro |
| 46% of the city made out of illegal settlements and slums | Highly % of educated, English speaking workforce in the country |
| Low efficiency bureaucratic institutions | Capital city of India |
| Lack of modern CBD | Possible leverage of capital ($$$) if it has a better strategy |
| Lack of housing | Hot real estate market |

# Part IV. A new downtown

## I. Site analysis

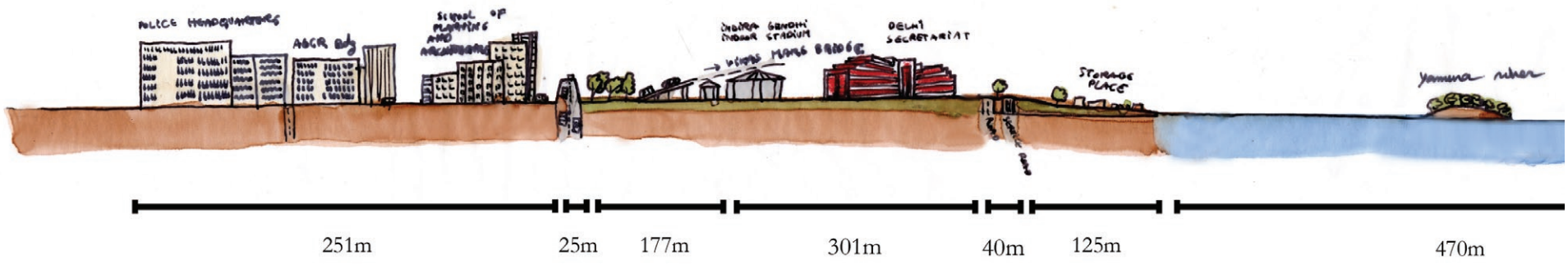
### A. Context and existing conditions

*1. Description of the site*

The Yamuna River currently separates West and East Delhi on a North-South axis. The river itself is separated from the rest of the city by the ring road that surrounds Delhi and by a string of marshy land, meadows, fields and forest. More inland, a second major artery, successively called Mathura Road, Bahadur Shah Zafar Marg, Shamnath Marg and Mahatma Ghandi Marg, runs parallel to the ring road and separates the city and the river as well. In addition, several treatment plants block the view to the water and several slums stretch along the bank, although some have already been forcibly removed by the authorities. Besides, the Yamuna was seen more as a liability rather than an asset, something that one didn't want to see, and a string of parks were developed along the water to provide a green buffer between the city and a polluted river; at the same time, the development of these parks were consistent with the policy of leaving the land as open space along the Yamuna, due to the difficult nature of soils and for environmental protection reasons. There are two main parks along the river: one in the north, with several memorials such as the Raj Ghat, where Mahatma Gandhi's tomb is, Shanti Vana, where Jawaharlal Nehru lays; in this park too rest Indira and Rajiv Gandhi; farther to the south, another park, the Rajiv Ghandi Smriti Van, built in memory of the eponymous politician. In addition, we must mention the National Zoological Park that flanks the Old Fort as well as Humayun's Tomb, since these two open spaces also create a barrier between the city and the river. The Red Fort (Lal Qila) is another major feature along the Yamuna; it is worth noticing that it was not built along the water but about one kilometre inland, so as to be in a higher position, better protected from floods. South of the Red Fort, the ramparts of the Old Fort (Purana Qila) also separate the river from the city.

West of the river, going North to South, we first have the organic structure of Old Delhi, organized around a few main arteries such as Chandni Chowk (main bazaar) running perpendicular to the Red Fort and the river. Then, we find New Delhi, with a radio-concentric structure organized around rotaries, the biggest ones being Connaught Place and the India Gate. South of impe-

rial Delhi stretch post-war developments such as Green Park or Haus Khaz, made of medium density colonies regrouping four or five story buildings. For all the aforementioned reasons, the river is de facto invisible from the Western part of the city. The situation is not much better on the Eastern side. On the East bank of the river, separated from the Yamuna by a marshy stretch of grass and by a levee on which a main road, called from south to north, Noida Link Road, Geeta Colony Road, Yamuna Marginal Bandh Marg, runs parallel to the river, the lowlands of East Delhi stretch with colonies all along belonging to Delhi till the city of Noida is reached south of Lakshmi Nagar. On the river side of the levee, two major encroachments: the Akshardham temple, a Hindu temple complex achieved in 2005, with later regularization from DDA, and the Commonwealth Games Village built for the 2010 Commonwealth Games. Ten road bridges and two railway bridges also span over the Yamuna in Delhi.



Section of Yamuna waterfront, along Vikas Marg bridge axis, facing north

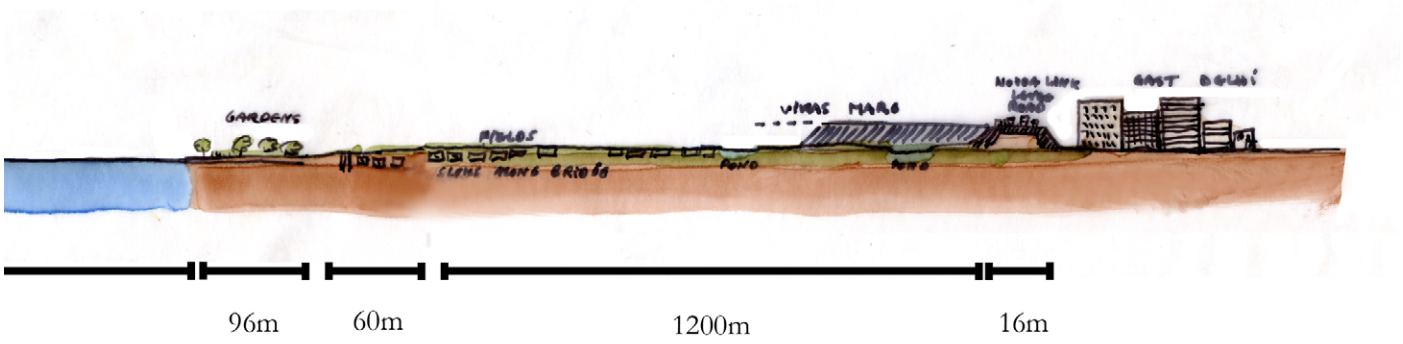



Fig. 15 Section of Yamuna waterfront along Vikas Marg bridge axis, facing north

Fig. 16 Historical and cultural map of Delhi

*2. History and culture*

Along the Yamuna stretch many monuments, witnesses of Delhi's glorious past: the old Fort, built in the 16th century by the Lion King Sher Shah Suri in a unique Mughal-Hind-Afghan style, which is now deemed by certain archeologists to be the place where the great city of Indraprastha, mentioned in the great epic of Mahabharata, once stood; the Red Fort, palace built for Mughal Emperor Shah Jahan's new capital, Shahjahanabad, the seventh Muslim city in the Delhi site. More modern parks and monuments, such as the Raj Ghat, Mahatma Gandhi's tomb, the Delhi Zoo or the Indira Gandhi Indoor Stadium, as well as, on the other bank, the Akhshardam temple complex and, soon, the Commonwealth Games Village, also stretch from the north to the south along the river. These attractions, now turned inland, could be also connected to the riverside so as to form an already existing layer of activities ncreasing the value of the new development.

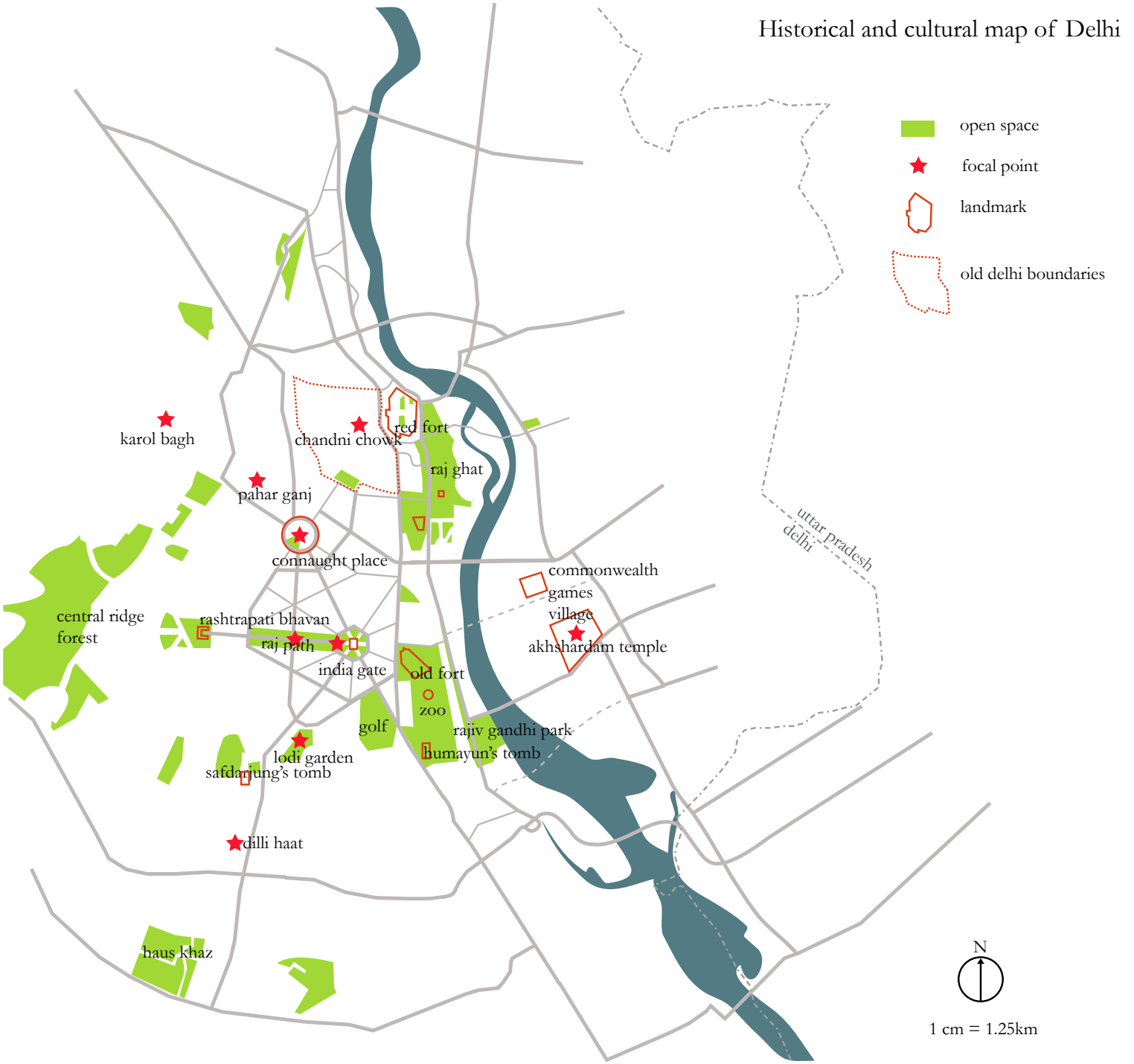

Historical and cultural map of Delhi
open space
focal point
landmark
old delhi boundaries
karol bagh
chandni chowk
red fort
raj ghat
pahar ganj
connaught place
commonwealth
games
village
akhshardam temple
central ridge
forest
rashtrapati bhavan
raj path
india gate
old fort
zoo
golf
rajiv gandhi park
humayun's tomb
lodi garden
safdarjung's tomb
dilli haat
haus khaz
uttar pradesh
delhi
N
1 cm = 1.25km

Fig. 17 Transportation map of Delhi

*3. Transportation*

Automobile access is good thanks to the two ring roads running along the river. Creating two other roads flanking the river more narrowly should be avoided as it would act as a divider between the river and the development. In order to avoid excessive traffic inside the development, parking lots should be created along the ring roads as well as along transversal access roads inside the site on both banks; public transportation should be enhanced with additional bus lines and the creation of another metro or tramway line. Due to the soil conditions, a surface line should be preferred to an underground one. A tramway line might be visually less intrusive than a metro line. Existing metro stations and new lines being currently built, such as the extension which will pass along the Commonwealth Games Village, should be also used. Ring roads could prove a problem for direct pedestrian access from the rest of the city; at the same time, pedestrian crossings should not impinge the traffic flow on the ring road. On the left bank, the ring road could be buried underground at places to allow pedestrian crossing; where it is elevated, attractive pedestrian crossings could be created underneath.

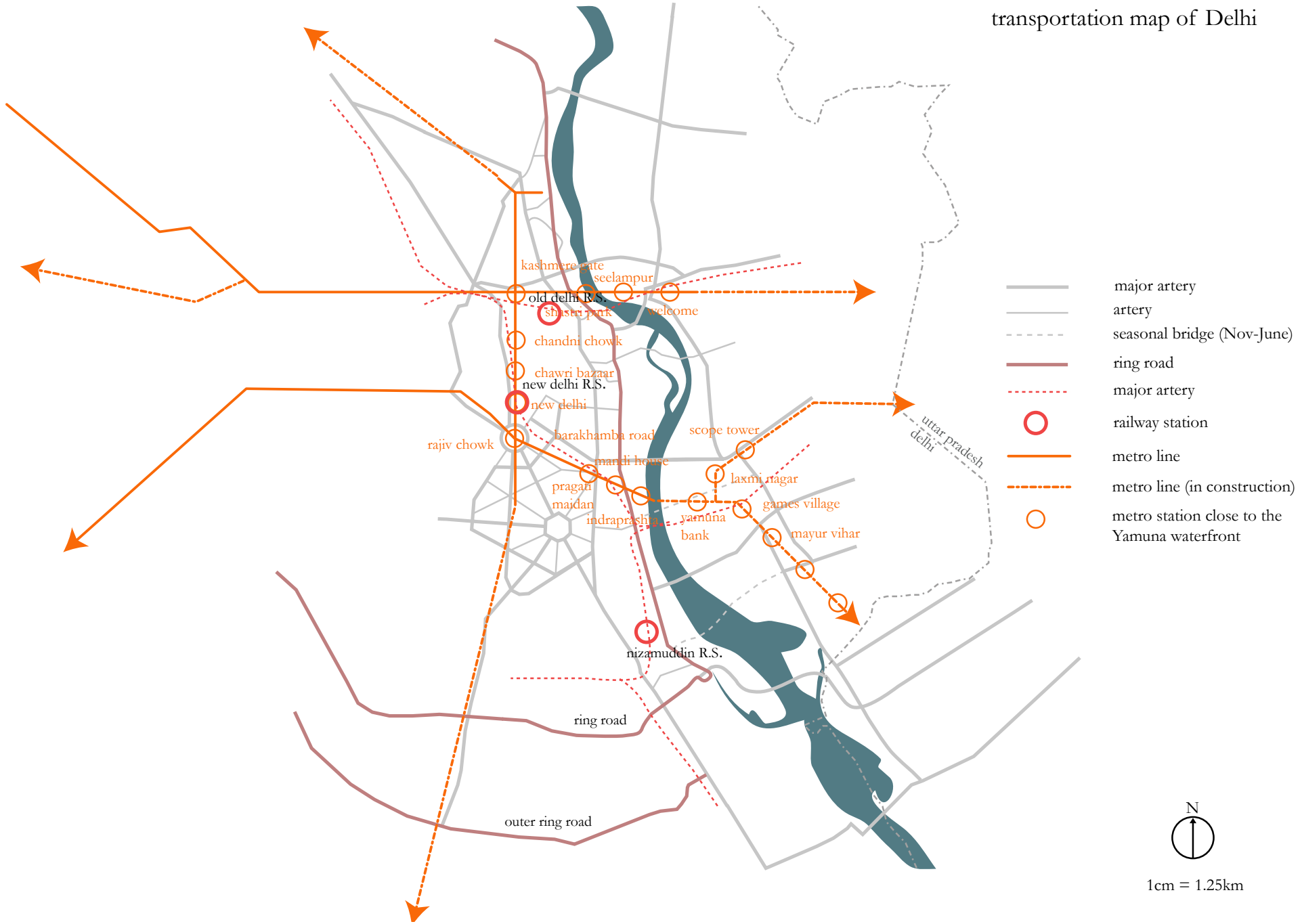
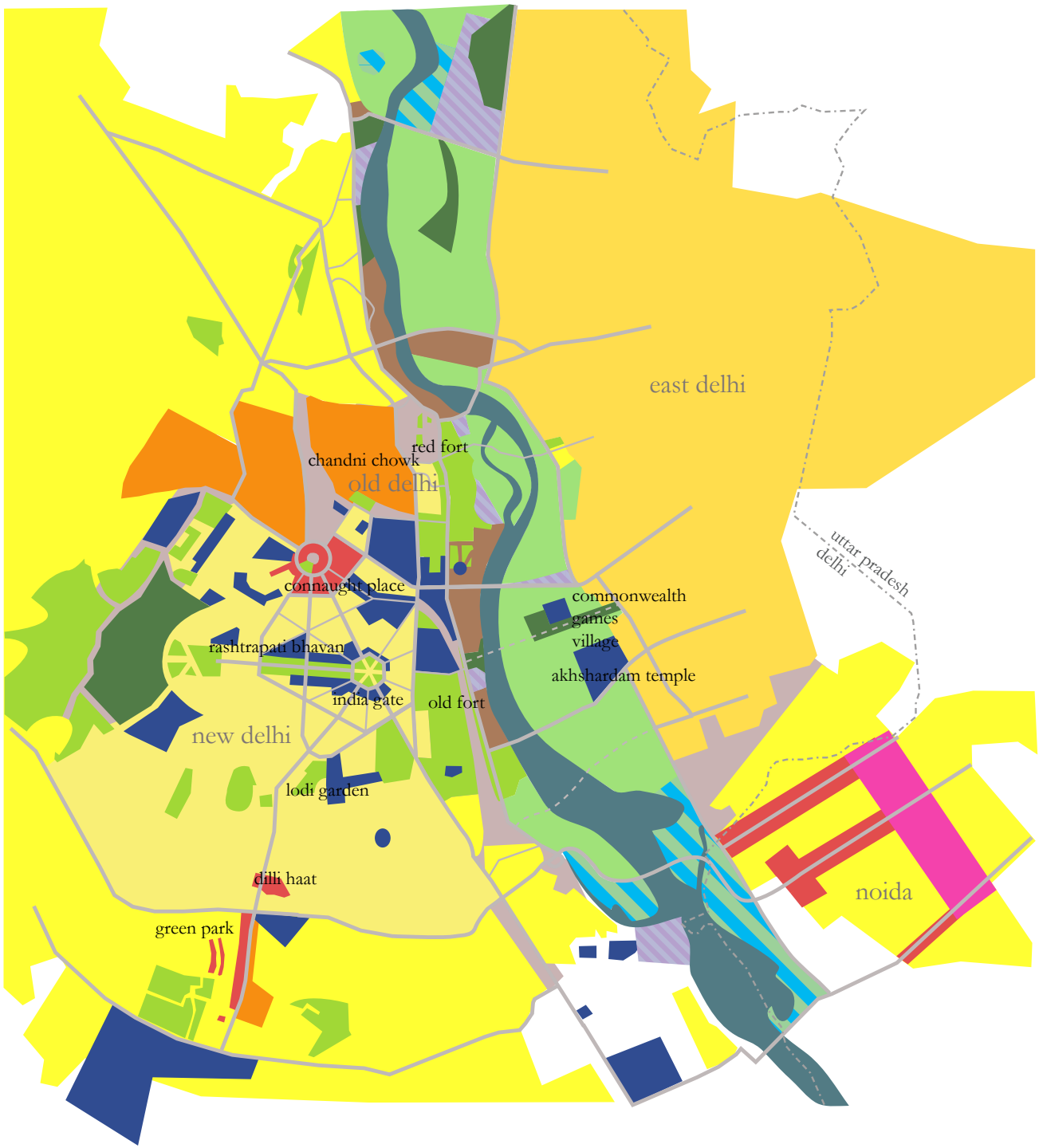

transportation map of Delhi
kashmere gate
seelampur
old delhi R.S.
shastri park
welcome
chandni chowk
chawri bazaar
new delhi R.S.
new delhi
rajiv chowk
barakhamba road
scope tower
mandi house
laxmi nagar
pragati maidan
indraprashta
yamuna bank
games village
mayur vihar
nizamuddin R.S.
ring road
outer ring road
uttar pradesh
delhi
major artery
artery
seasonal bridge (Nov-June)
ring road
major artery
railway station
metro line
metro line (in construction)
metro station close to the Yamuna waterfront
N
1cm = 1.25km

Fig. 18 Existing land use map in Delhi

*4. Land use*

Delhi is a growing megacity and has an evermore need for space. Two areas stand out in this respect: low-density New Delhi, and the open space around the Yamuna river. Some have proposed to densify the first one, but this seems difficult to do politically speaking, as Lutyens' Delhi is the place where most of the high civil servants and rich businessmen representing the political and economic power in Delhi reside. Provided that all conditions are respected to make it a place both sustainable and attractive, the Yamuna river appears like a good alternative, and a high density spine running along would also have the merit of unifying both sides of Delhi, West and East. A second interesting point on this map is that commercial districts are almost entirely absent from the map, except along Connaught Place and the adjacent avenues, though often in a dilapidated state. The only commercial and business district of importance standing out here are located in Noida, which belongs to the State of Uttar Pradesh.




existing land uses in delhi

- commercial
- office parks
- very dense mixed-use (old delhi)
- very high density residential
- high density residential
- low density residential
- institutional
- parks
- forest
- agriculture
- wetlands
- riverside slums
- other riverside encroachments
- easements (railways, canals...)

N

1 cm = 1.25km

Fig. 19 Existing land uses along the Yamuna river in Delhi

*5. Uses along the river*

Many encroachments along the river, and yet only a few of them would really be a problem for a new development: the slums that are now being cleared by the DDA - which would necessitate appropriate relocation measures, the Indraprastha Thermal Plant, which could also be relocated, and the parking yard for the Delhi metro on the right bank, which separates two important parcels on the eastern bank. This problem could probably be solved by creating a new path along the river, using Shashtri Park as another connection and putting flyovers over the marshalling yard.

# Uses along the Yamuna River in Delhi

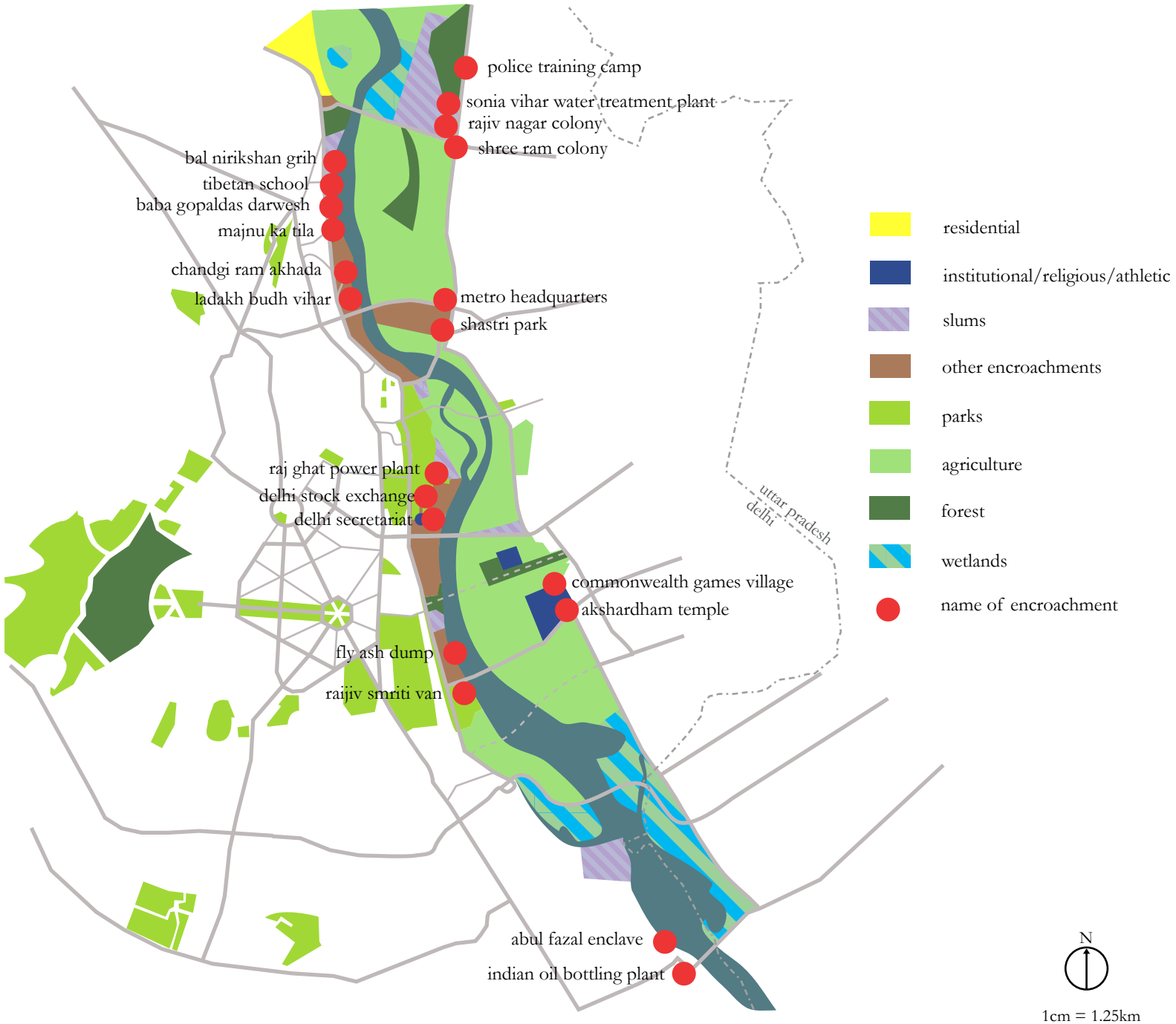


Fig. 20 Future development parcels along the Yamuna river, Delhi

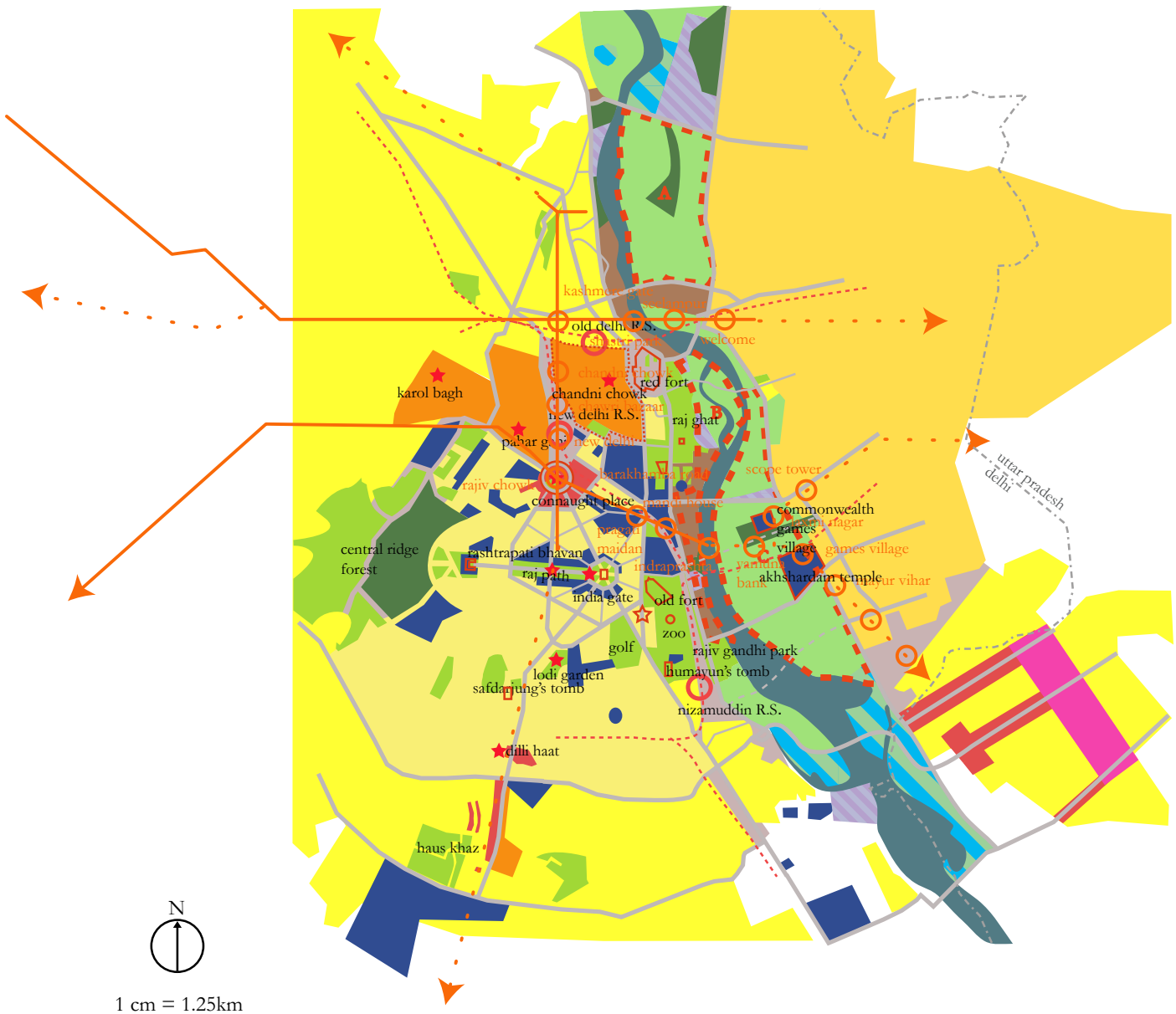
*6. Development parcels*

Three parcels stand out along the river, because of their size and of their location. Development should start here before eventually stretching upstream and downstream. It could first begin on parcels B and C, directly in the axis of the Raj Path and the India Gate.


Map of future development parcels
open space
major road
A
future development parcel
A
B
C
uttar pradesh
delhi
N
1 cm = 1.25km

Fig. 21 Composite map of Delhi

# composite map of Delhi




- commercial
- office parks
- very dense mixed-use (old delhi)
- very high density residential
- high density residential
- low density residential
- institutional
- parks
- forest
- agriculture
- wetlands
- riverside slums
- other riverside encroachments
- easements (railways, canals...)
- major artery
- artery
- seasonal bridge (Nov-June)
- ring road
- major artery
- railway station
- metro line
- metro line (in construction)
- metro station close to the Yamuna waterfront
- A — proposed development parcel

## B. Opportunities and constraints

The following opportunities and constraints can be stressed:

· *Opportunities*

- Proximity to downtown: Connaught Place is 3km away from the river, India Gate is 2km away, and the Yamuna is also not far from the political center: 5km from Rashtrapati Bhavan, house of the president of India, and from the office of the Prime Minister.
- Numerous bridges linking the Western bank with the Eastern bank
- Three quarters of the land belong to the State of Delhi or other governmental entities
- Existing park system could be used for collecting run-off water to recharge aquifers
- View on the river, once the Yamuna will be cleaned and restored
- Good access by car with the Ring road running along the West bank and the levee road running along East Delhi and Noida
- Good public transportation with an extensive bus network and a bus line along the Ring Road, as well as line 2 of the Delhi metro which runs parallel to the river

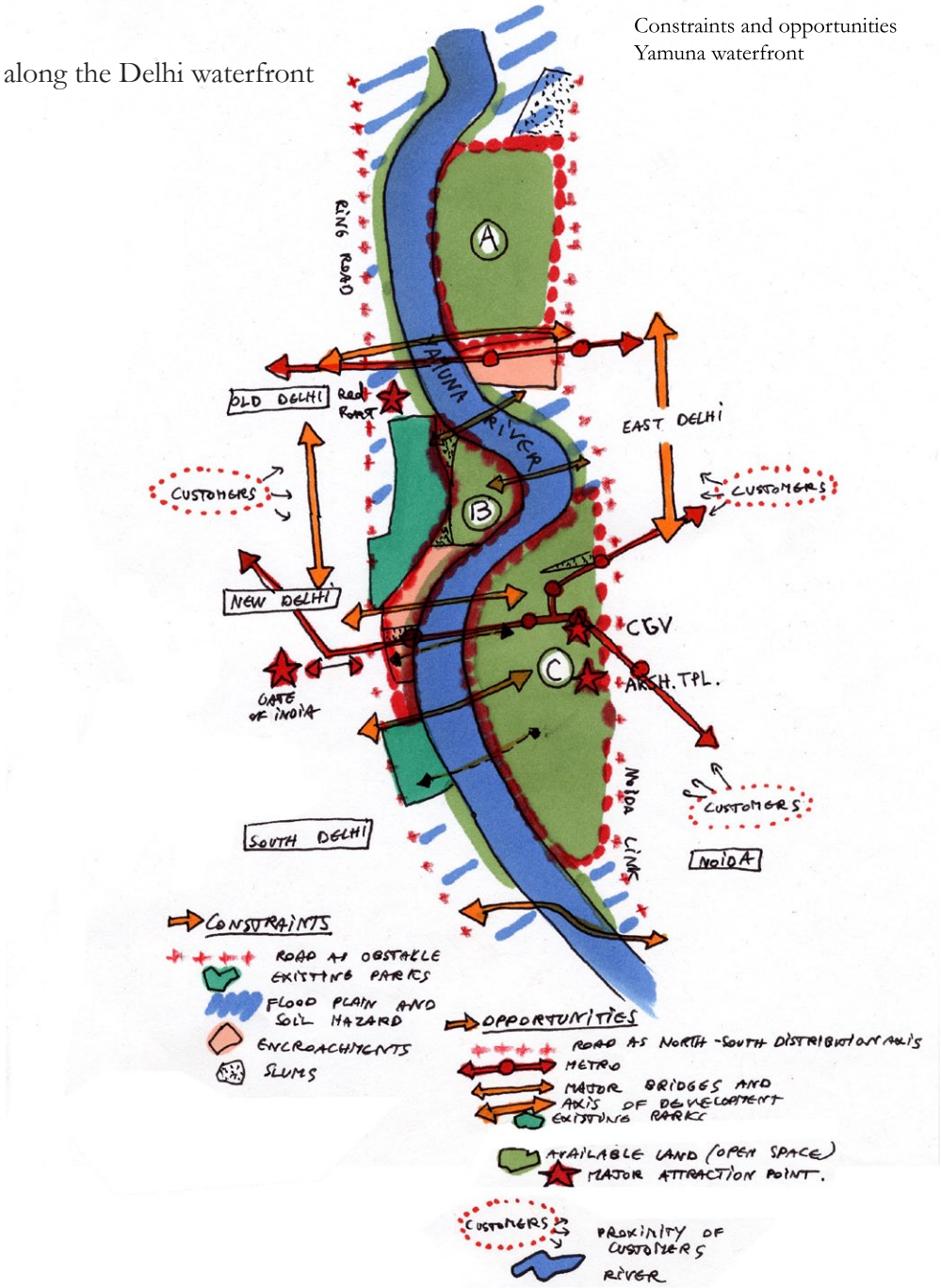
· *Constraints*

- Geotechnical characteristics of site (see chapter 1)
- Slum-dwellers
- Ring Road as an obstacle to public access and a road frequently clogged by traffic jams
- Parks as obstacles blocking views and access to the river
- Inefficiency of certain institutions
- The metro line is too far away from the river in the middle of our development on the West bank in particular: a new metro line or some other means of transportation, like a tramway line, should be envisioned

## C. Site boundaries

Three parcels stand out in the center of the city, where there is a maximum of available place for development: the first one is the most upnorth, on the East bank, between Wazirabad bridge and Sahai Marg bridge; the second one is on the West bank, East of the Raj Ghat Park, and stretches until the Rajiv

Fig. 22 Constraints and opportunities along the Delhi waterfront



Ghandi Smriti Van; the third parcel is on the East bank, where Akshardam temple already stands. These parcels are the biggest ones and are in the heart of the city, they will help me delimitate the northern and southern boundaries of my site: on the north, the Wazirabad bridge, and on the south, the Noida Toll bridge.

## II. Concept

### A. Waterfront development

Creating a waterfront, as in many urban design projects, means creating a destination. A study of various waterfront developments or redevelopments around the world allows us to see that some elements are always found in every major successful case:

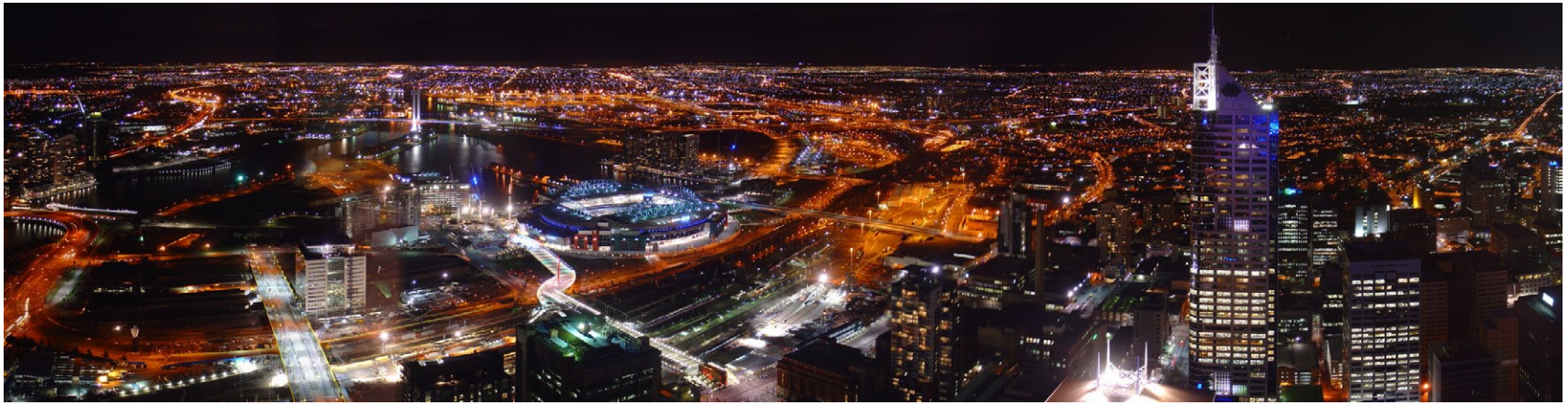
- cleaning up of water and site
- mixing of complimentary uses such as shopping, restaurants, hotels, offices, entertainment and education
- creating a specific, unique identity to the waterfront, often using themes associated with its history and enhancing these themes through urban design, the creation of a museum, the keeping of a working harbour nearby, etc.
- using water and natural elements associated with it, which are unique amenities in a city and often contribute to give it its character. What would Paris be without the Seine, London without the Thames, Saint-Petersburg without the Neva or New York without the Manhattan peninsula, lying between the Hudson and East Rivers, without Ellis and Liberty Islands, in the bay discovered by Verrazzano?
- allowing easy public access along as well as to and from the waterfront

These elements must be implemented with respect of the local conditions that I detailed in the first part of my work. They nevertheless form what we could call the grammar for a successful waterfront development. Hundreds of examples of successful waterfront redevelopments following these concepts can be found throughout the world. A good case can be found for instance with the redevelopment of the Yarra Southgate riverfront in Melbourne. Completed in 1994, this project opened downtown Melbourne on the Yarra River, which used to be inaccessible as buildings and railyards were blocking view and access all along it. Waste was also piling up along and in the river, and the Yarra acted as a real divider between the southern part of the city, made of industry, marshes and suburbs, and Melbourne's classic Victorian central business district just north of the river. The Yarra redevelopment managed to transform the river from being a dividing element to being a unifying feature of the city. It also sparked some major redevelopments up

Picture 23 (right) Waterfront redevelopment projects in Melbourne: Southgate on the Yarra River

Picture 24 (first below) Waterfront redevelopment projects in Melbourne: Docklands

Picture 25 (second below) Waterfront redevelopment projects in Melbourne: Docklands, night time view of the waterfront



and down the river. After a river clean-up, an essential preliminary step for waterfront regeneration, the plan followed all the steps enumerated above. Cultural features are present as Southgate adjoins the Victorian Arts Centre and work in conjunction with restaurants and shops along a multi-level, artfully landscaped promenade to attract tourists and residents alike. Ferries and tour boats also dock at the lower level of the promenade. In addition to the retail uses, Southgate features a four-hundred room hotel, two office towers, parking space, a small church as well as offices.

The Docklands are an even bigger waterfront development, also along the Yarra in Melbourne, featuring a mix of offices, high-end residential condos and shopping places. The Docklands precinct was originally used for docks but fell out of use following the containerisation of shipping traffic. The space remained vacant during the 1980's and was only used for "special events" during the 1990's, becoming notable for a number of dance and rave parties. When completed in 2015, the redeveloped area is expected to almost double the size of the city's central business district. Its population primarily lives in high-density highrise apartments and is expected to reach 20,000 people in 2015. By this time, it should also become the workplace of 25,000 office workers. It has become a major tourist destination and Melbourne's tourist authorities anticipate over 20 million visitors per year in future years.

**B. Concept for Delhi**

The New Delhi area could be firmly connected with the other side of the river and the growth directed along the eastern bank of the river and on the Ghaziabad road axis. There could be two development axis: one West-East axis connecting Connaught Place with Nehru Place on the other side of the river[1], one North-South axis along the river. A new central business district could be created along the Yamuna with skyscrapers creating a nice skyline, which means height limitations would have to be reviewed. At the same time, shopping centres, entertainment businesses (cinemas, theatres, opera…) could also be created. Existing small businesses could work in joint ventures with bigger size investors and be given incentives to develop businesses there as well, so as not to damage the existing craftsmen's fabric. The developments could also integrate the Akshardham temple complex as well

1. Delhi authorities have announced that a new 4.8 km tunnel will be built from Baghwan Dan Marg to the banks of the Yamuna, the road crossing the river on a new bridge, in order to decrease the traffic flow on Bhairon Road ad Vikas Marg and to connect Connaught Place with Mayur Vikar and Akshardham temple. If it is really built, this project will be a positive step in the process of connecting more firmly the West side and the East side of the city.

as the Commonwealth Games Village (CGV), which are now in the middle of nowhere. A park could be created along the water and become one of the major meeting places in the city.

**C. Three scenarios**

The conditions and thresholds that have been defined in the first part of my thesis leave large possibilities for design variations according to the intensity of each use - for if architectural design itself was considered, an infinite quantity of designs could be drawn, and we shall not, for this discussion, reach to such a level.

Variations of design within the boundaries of the conditions enounced before can be regrouped and conceptualized into three designs[2]:

- Lutyens

Characterized by an important part given to open space, with medium-sized parks and tree-lined avenues, and to residential use

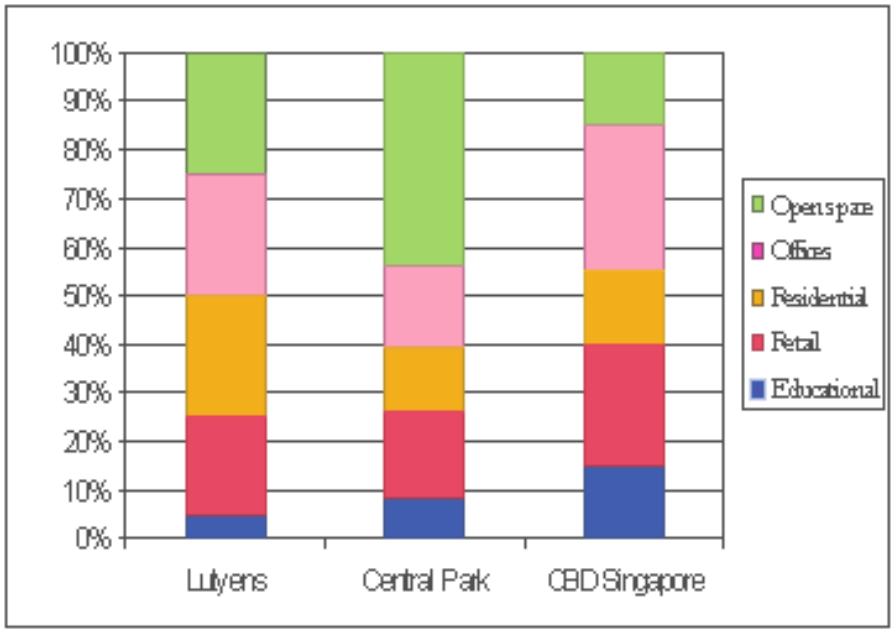
- Central Park

Characterized by the presence of a single giant park in the development.

- CBD Singapore

Characterized by a rather limited though artfully managed open space and a great importance of offices, retail as well as educational facilities.

I will describe the implications of these scenarii through the design of a representative part of my site, in this case, I will design the southern part of parcel C, on the eastern bank of the Yamuna, near the cultural center of Akshardham temple.




Gr. 9 Land use scenarios for the Yamuna waterfront

2 These designs have been named after famous places, not because they are the exact duplication of these places' characteristics, which would not be possible for the mere reason that these designs must fall within the boundaries of the conditions and thresholds determined for this specific site only, but because they share some resemblance and take some inspiration from these fundamentally different paradigms of urban design

## III. Design scenarios

### A. "Lutyens"

In this configuration, open space and upper and middle class housing dominate. However, even if this project would already generate profits, it does not take full advantage of the available space in terms of use and density.

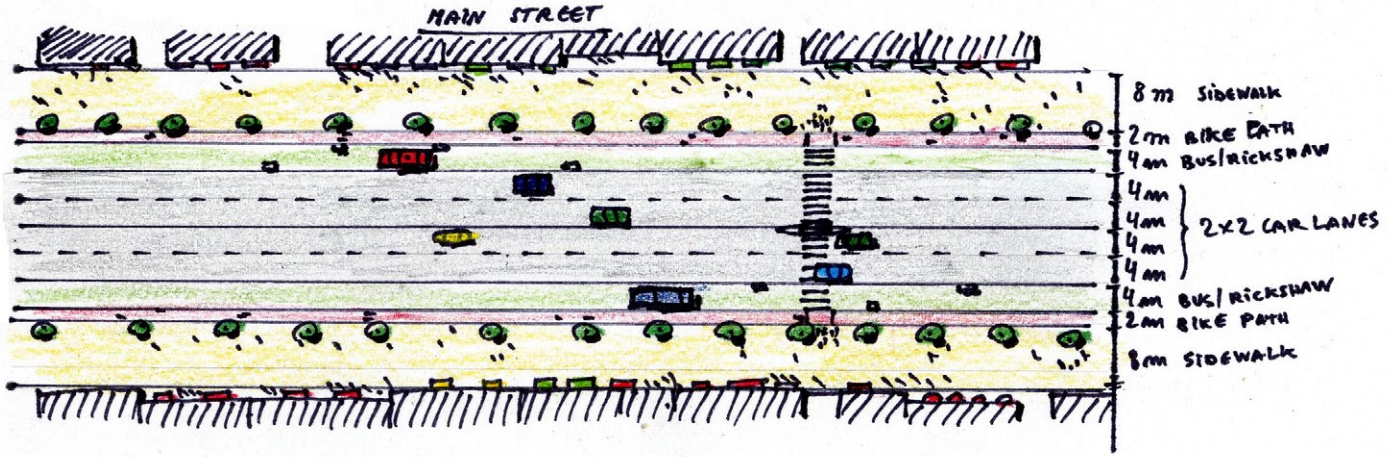



Fig. 23 Main street transect and segregation of modes of transportation

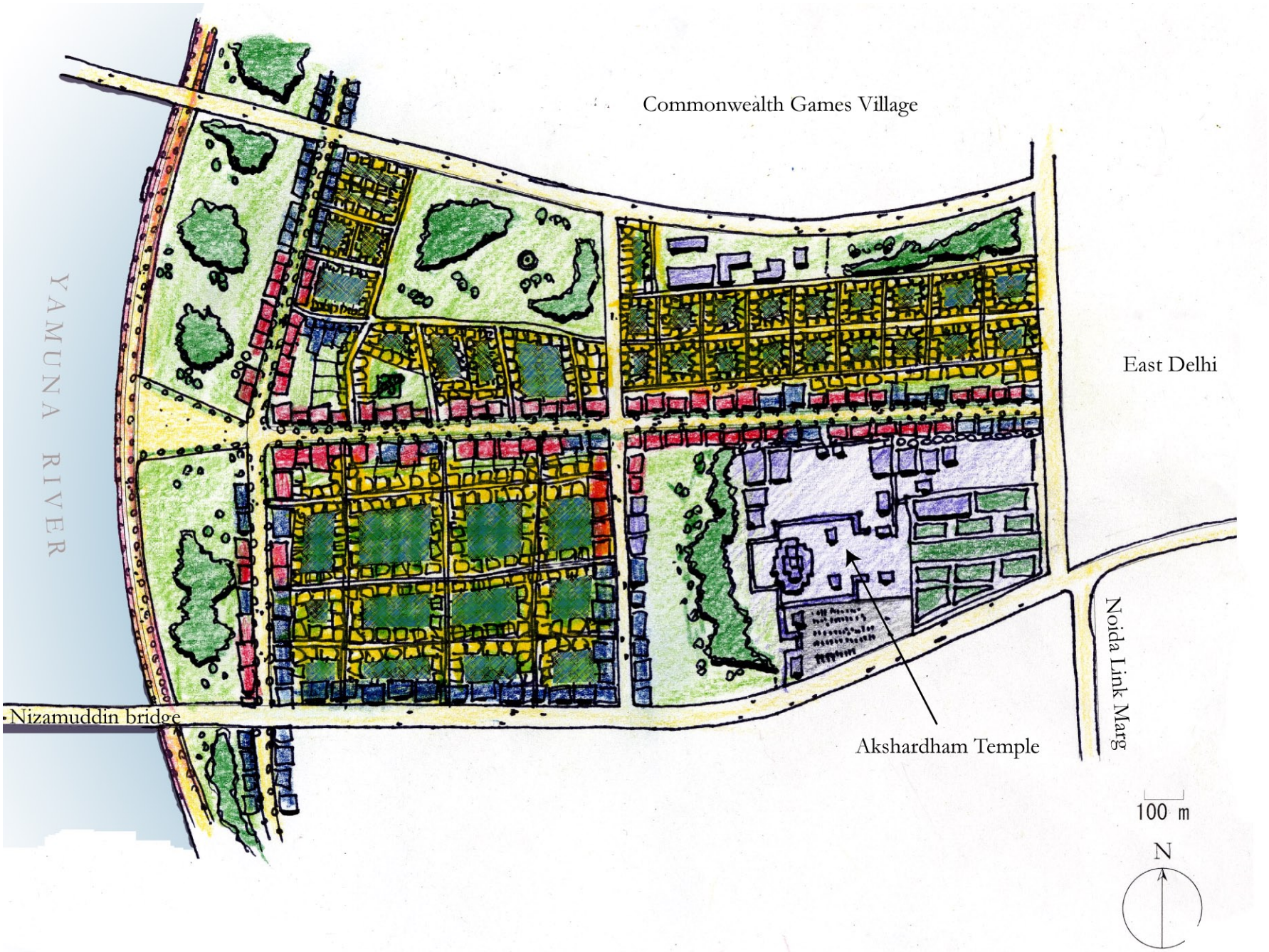



Fig. 24 "Lutyens" scenario land use plan **(red = retail and offices, blue = offices only, yellow = residential, purple = educational/cultural/religious)**

**B. “Central Park”**

This project keeps an important part of the site as open space or for campus activities (see upper left corner, along the water). However, even if water permeability is favored on the western side of the site, the eastern part is characterized by a lack of permeable surfaces. Besides, it could also be argued that such a solution would, like in the Lutyens case, be a waste of available space and that such a prominent place reserved to parks would prevent the business district from expanding more and reaching the size critical for its success.

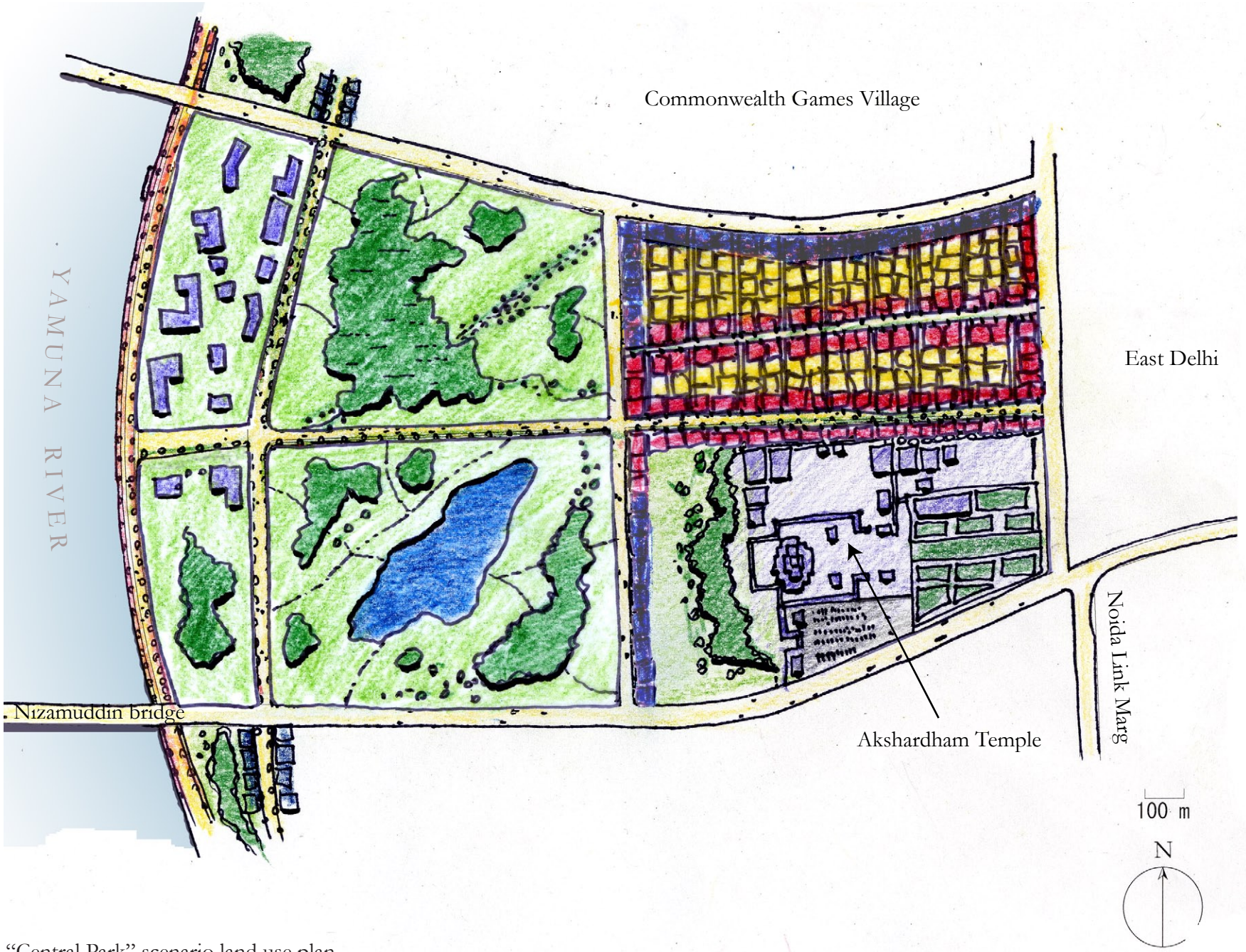



Fig. 25 “Central Park” scenario land use plan

**C. "CBD Singapore"**

This is, I think, the most promising of all plans. Like the other possibilities, it has two main commercial axis, one east-west main street leading from East Delhi and Akshardham temple to the river, and another retail avenue stretching from north to south, in addition to the promenade itself. Residential housing is limited to student housing on campus and to luxury condominiums. Retail and office space is maximized. Education i also valued with two campuses on the site. At the same time, natural features are not neglected, but they are artfully incorporated into the city instead of being separated from it as in the "Central Park" case: water runoff is directed to small inner courtyard parks which allow water infiltration within each block, and on the eastern side of the site, a small creek has been uncovered and is the central feature of a diagonal promenade with shopping and restaurants.

Fig. 26 Waterfront Promenade. Note the difference of level between the channelized Yamuna and the eastern bank, the water sports, the green slope, the promenade, the bike path, the tramway and high rises.

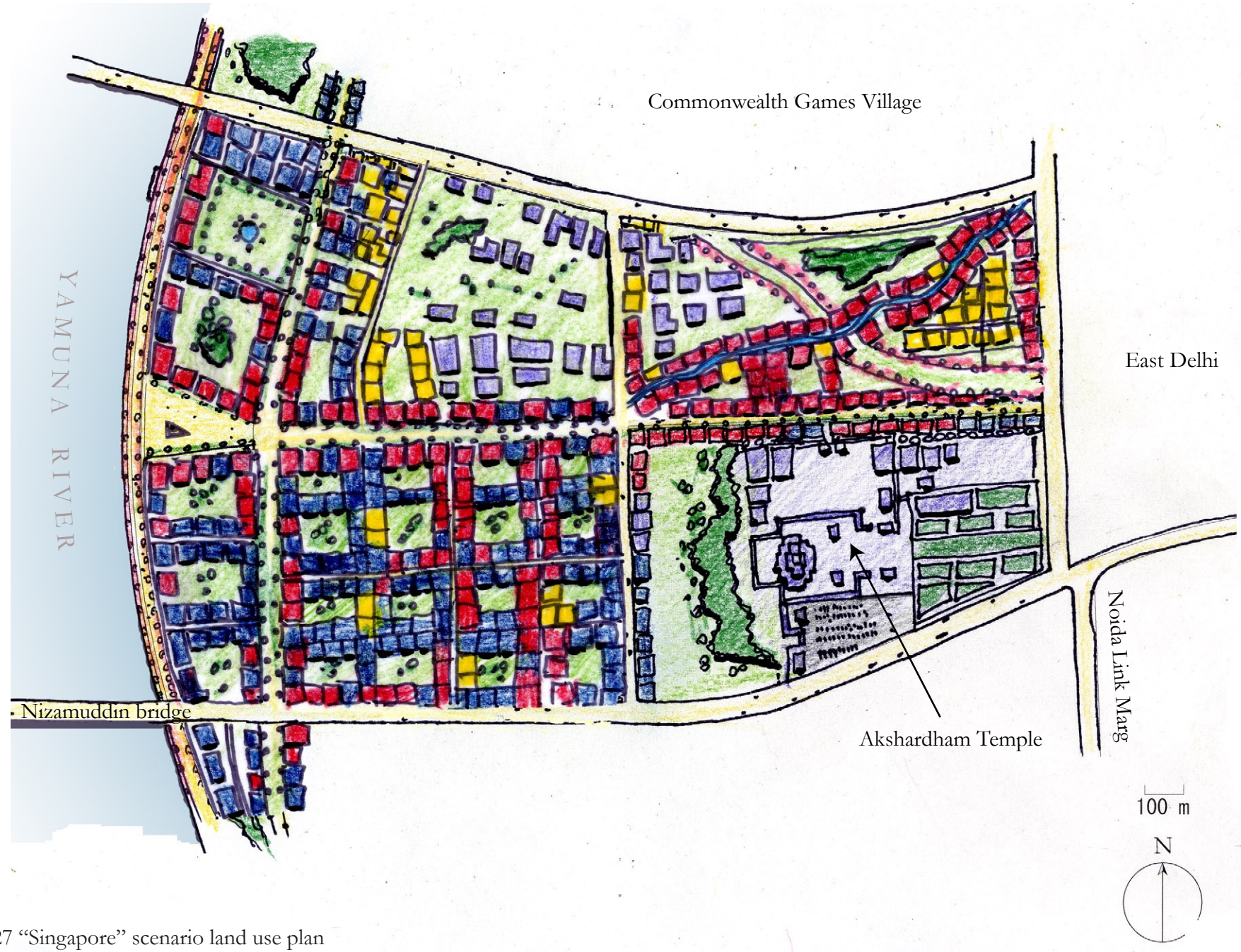
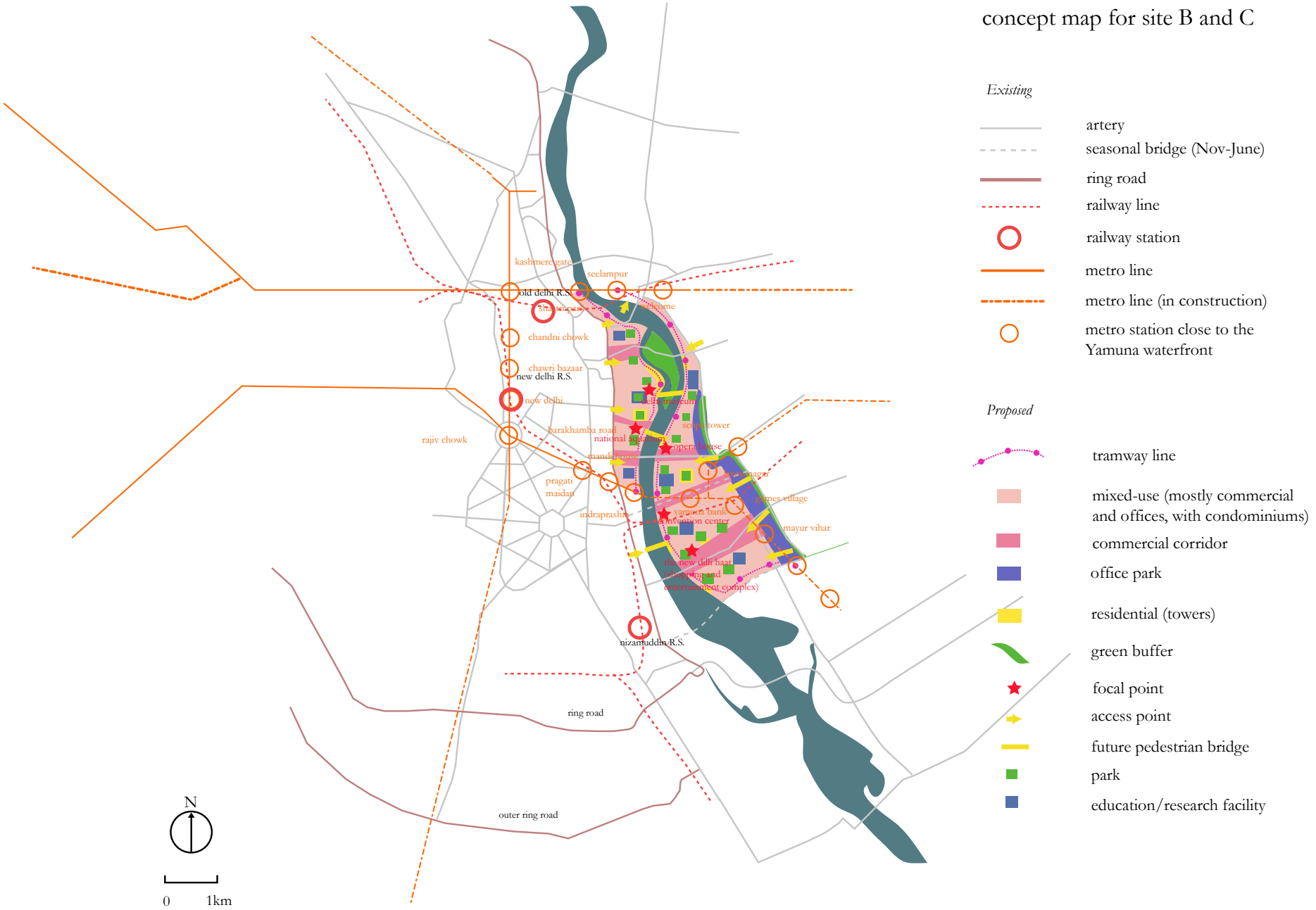



Fig. 27 “Singapore” scenario land use plan

This concept plan shows the main features of the development on the most central parcels, B and C, where the development is likely to begin. The waterfront can be accessed both from the ring roads, from metro stations and from one tramway line running along the river on each bank and linking the new development with the metro stations. New pedestrian bridges are also built to allow a better connectivity between the two sides of the river. The waterfront comprises mostly mixed-use buildings, with retail on the first floors and residential or offices above. Several commercia corridors lead to the river. On the East bank, the part of the development which is near the levee road is isolated from the distrubances of traffic by a green buffer. Parks are also interspersed in the development and serve as amenities and as water collectors. Eudcational and research facilities find here a good place to develop, where the quietness of the river and the open space joins the proximity of companies to create a unique atmosphere. Finally, alongwith the parks, retail options and promenade along the river, attractions like an aquarium, a museum or a shopping and entertainment complex draw the public to the site.

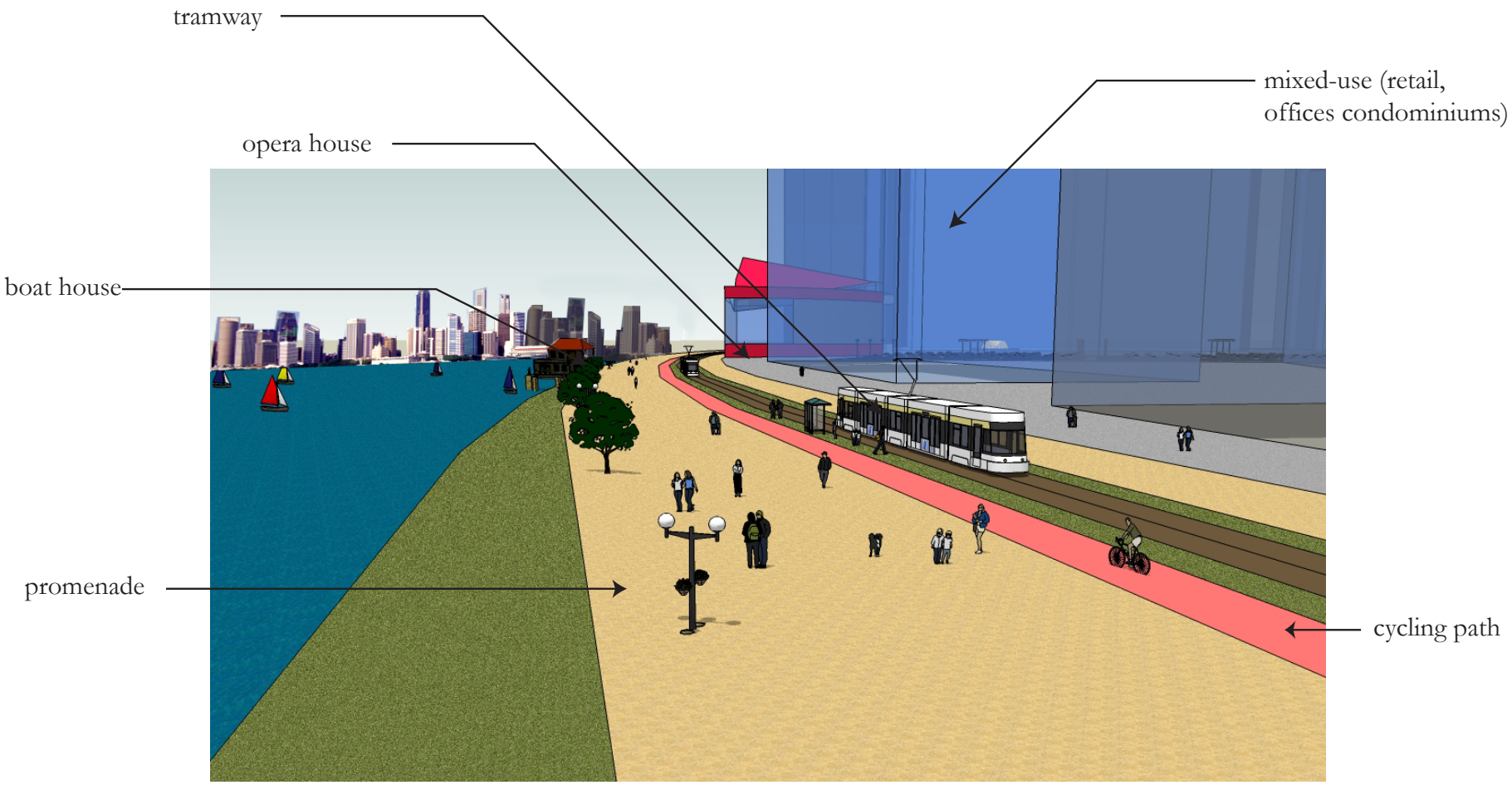
Fig. 28 Concept map for parcels B and C


concept map for site B and C
Existing
artery
seasonal bridge (Nov-June)
ring road
railway line
railway station
metro line
metro line (in construction)
metro station close to the Yamuna waterfront
Proposed
tramway line
mixed-use (mostly commercial and offices, with condominiums)
commercial corridor
office park
residential (towers)
green buffer
focal point
access point
future pedestrian bridge
park
education/research facility
kashmere gate
seelampur
old delhi R.S.
chandni chowk
chawri bazaar
new delhi R.S.
new delhi
rajiv chowk
barakhamba road
pragati maidan
indraprashta
mayur vihar
nizamuddin R.S.
ring road
outer ring road
N
0
1km

The Singapore model is an interesting one, with the highest density in the world after Hong Kong and Macau, resulting in tall, mixed-use buildings and land reclamation efforts; at the same time, British era villas, old Chinese houses and shops have also been preserved and renovated, such as the ones along the Singapore river, now a major attraction in the city. It is an interesting, if undemocratic, model for Delhi, because of the high density issues and the way it was resolved there, the waterfront reclamation of the river, and the emphasis on education and research.

Picture 26 Singapore business district and the Singapore river


Picture 27 Close-up on land use on a the northern part of site C (opera house district)




Picture 28 Perspective of the promenade on the northern part of site C (opera house district)

# Conclusion

Can we build a waterfront on the Yamuna that would be both sustainable and attractive? This thesis brings the demonstration that it is technically, financially and politically feasible, under the conditions described in the first part of the thesis: land improvement, upgrading of water, electricity and transportation supply, creation of a development corporation, etc. The conditions concerning the land improvement and the financial viability of the project are relatively easy to fulfill because of the good situation of the real estate market; the infrastructure of the city should also see enough improvement in the next twenty years to make the project possible. The creation of an independent development corporation and of a real business strategy for Delhi might prove more difficult, but not impossible.

A striking lesson from this study is that in the case of Delhi, and, we could argue, in the case of many developing countries, transformations that need to be done in the city matter as much as the ones to be done on the site itself. The geographic context of the site needs not only to be studied in a preliminary analysis, it needs to be transformed as an essential condition for success. Studying the context has proved not only to be helpful in understanding what kind of use there should be on the site, but also in understanding that the context itself should be changed. Thus, creating a waterfront in Delhi is as much as reforming the whole city as reforming the Yamuna banks. The waterfront is an engine to make 21st century Delhi. But it can only do so once the conditions for Delhi to transform into a full global city have been at least already partially implemented in the rest of the city. The waterfront works by itself as an instrument for the rejuvenation of the city, but it cannot perform miracles and will only work to its full potential under certain conditions. Attractiveness and sustainability on the banks are linked with the general attractiveness and sustainability of the city: no good roads will lead to bad access to the site, no good public transportation will have the same consequences, no clean water will prevent the waterfront from being attractive, not enough water supply and electricity will prevent it from being sustainable.

But *should* we build a waterfront there? I have brought several arguments which strongly support this endeavour. I have also shown that big change could be positive, and that it is possible to be at the same time economically, socially and environmentally dynamic. Today, Delhi is at the crossroads, and the fate of its own river appears singularly tied to the fate of the city itself.

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# Glossary

CWGA : Central Ground Water Authority

DCB: Delhi Cantonment Board

DDA : Delhi Development Authority

DJB : Delhi Jal Board (water)

DMP: Delhi Master Plan

DMRC : Delhi Metro Rail Corporation

DTC : Delhi Transport Corporation

DVB : Delhi Vidyut Board (electricity, now privatized)

GPCD: gallon per capita per day

GoI : Government of India

HUDCO : Housing and Urban Develoment Corporation

ITPI : Institute of Town Planners India

MCD: Municipal Corporation of Delhi

MGD: million gallon per day (British gallon)

NCRPB : National Capital Region Planning Board

NCT : National Capital Territory

NDMC : New Delhi Municipal Council

SPA : School of Planning and Architecture

TCPO : Town and Country Planning Organization

UP : Uttar Pradesh

YAP: Yamuna Action Plan

YSL Yamuna Sutlej Link

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