OSHIWARA RIVER, MUMBAI

STRATEGIES TO REVITALIZE THE RIVER'S URBAN CORRIDOR

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CLIENT REPORT

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1. ABSTRACT

The city of Mumbai is built up of multiple layers of activities and organizations. Activities include interactions between the people who live, work, drift and travel here. Organizations include not only the administrative systems that plan for and attempt to keep the city's physical infrastructure functioning but also, the entrepreneurial systems that find ways to improve the city, and natural systems that still try to maintain balance in the city. Mumbai operates through various interactions of these activities and organizations, and depending on the form of interaction, the balance of the administrative apparatus gets shifted. Such a shift could affect the city adversely, but sometimes it also presents potential for improvement. The purpose of this report is to investigate and decipher one such potential along the Urban River Corridors in Mumbai.

Due to neglect and lack of Municipal interest the rivers have become open drains. Gated communities co-exist along with informal communities, dye making and other light industries and cattle sheds. This mixed land use is characteristic of Rivers' Urban Corridors of Mumbai. The waste from these land uses are disposed, directly and untreated, into the river. Developers of housing complexes have built high compound walls to block sight of these rivers. This causes the river edge to get neglected and subsequently, leads to further deterioration of the riverine eco-system.

This report aims to analyze and learn about the local conditions of one such urban river corridor – Oshiwara River, located in the North Western part of Mumbai. The following 3 symptoms were found as primary evidence of the larger issues – river bed and water pollution, regular floods in the watershed, and a general negative perception of the river. The root causes of these symptoms were found to be Government policies and ambiguous perceptions of urban rivers at national, state and local levels leading to general public apathy and neglect towards these urban natural systems.

These symptoms were further investigated and juxtaposed with the physical conditions of the river's urban corridor through a topographical and hydrological analysis of the river's watershed area. Subsequently, multiple intervention scenarios were tested against a fixed set of criteria to arrive at the best possible solutions to address the various issues.

Of the various alternatives tested it was found that improving the storm water infrastructure and making the watershed sea level rise resilient, along with spreading awareness among residents of ecological benefits of urban river corridors to influence their perception and gain their support, were found to have the best potential to revitalize Oshiwara River's urban corridor.

2. ACKNOWLEDGEMENT

I thank Vikram Pawar for including and involving me in his research on Urban Water Projects. Having been interested in how natural systems could be better integrated into a city's infrastructures, I am grateful to Vikram for providing me with the platform to perform this research. This report in no way is complete, or provides perfect solutions – it is merely a framework to which additional research and information could be plugged in to test possible approaches.

Professor Peter Bosselmann, for his wisdom, guidance, patience and support. Learning under his guidance was an honor and privilege. He has helped me gain a new perspective towards urban space and cities, in general.

Professor John Radke, for his technical guidance and willingness to help answer my questions at any time. Also, I have never enjoyed learning a new subject in my life, as I have enjoyed learning GIS.

Miriam Zuk, for reviewing early drafts of my CR and providing me with detailed comments and suggestions. If not for her encouragement and suggestions this CR would still have been hidden deep inside some folder in my computer!

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A lot of information present in this report would have been hard to procure without the help of my friends in Mumbai – Apurva Parikh, for updating me on various political and regulatory changes going on around mangrove forests in Mumbai. Tapan Maharishi for taking all the panoramic photographs that I have used in this report. Saachi Mishra for promptly telephoning real estate agents and collecting sale prices of apartments in buildings facing Oshiwara River.

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My parents, for providing me this opportunity and always encouraging me to keep exploring.

Thank you!

3. INTRODUCTION

Research background

As the city of Mumbai grew northwards, along with the density of suburbs the types of activities increased. Together with housing complexes, employment centres were set up and this in turn attracted informal settlements. Parallel to this growth, Government organizations set up infrastructure and created spatial strategies for development to streamline the way for entrepreneurial agencies to populate the market. In search of this market oriented goal, naturally existing systems were ignored, and at many places erased. In so doing, there was a shift in balance – urban development replaced nature. The mangrove forests, rivers, and wetland systems that protected the coastal suburbs from high monsoon tides, and floods, started being compromised. Initially, this shift was not noticed, but the last decade and half through flash floods, erosion causing landslides, and spread of water-borne diseases has made the city's vulnerability evident. Deeper examination suggests that it is the seasonal river corridors that emerge as one of the greatest potentials to not only address issues of flooding, but also create a liveable and symbiotic urban environment.

I am studying the 4km long urban corridor along Oshiwara River - a seasonal river of Mumbai. Due to neglect and lack of Municipal interest the river has become an open drain. Gated communities co-exist with informal communities and industries such as dye making and cattle sheds. The waste from these land uses are disposed directly into the river. Developers of housing complexes have built high compound walls to block sight of these rivers. This causes the river edge to get neglected and subsequently, lead to further deterioration of the riverine eco-system.

The client I am working for is an architect and a professor at the Kamla Raheja Vidyanidhi Institute for Architecture in Mumbai, Vikram Pawar. He is independently researching policy and advocacy of urban water systems and has been in talks with the Mumbai Metropolitan Region Development Authority (MMRDA) to investigate potentials for new policy interventions and begin analysing local perceptions using outreach methods.

a. Context

In the mid-17th Century, Mumbai was an archipelago of 7 islands. Back then, the city was called Bombay and the islands were – Isle of Bombay, Colaba, Old Woman's Island (Little Colaba), Mazagaon, Worli, Parel and Mahim. The Portuguese had set up trading posts here, and handed them over to the British as part of the dowry of Catherine of Braganza when she married Charles II in 1661[1].

Over time, the British set up cotton textile mills and developed the city's physical infrastructure. The Arabian Sea started getting reclaimed. So much so that by the early 1900s the 7 islands came together to form 2 major islands – Salsette and Bombay. And now, they are comprehensively referred to as Greater Mumbai.

When the islands were consolidated, most of the wetlands were sacrificed.

The wetlands protected the city against brutal monsoon tides and helped maintain a pleasant micro-climate during summer. Seasonal river streams flowed into the Arabian Sea, and some still do - Dahisar in the north, Oshiwara towards the west, Poisar in the center and Mithi in the southern part of Mumbai. These rivers collect all surface runoffs and drain untreated into the sea. The rivers begin from the catchment areas in the hills of Borivali national park (now known as Sanjay Gandhi National Park) and flow westwards towards the Arabian Sea.

[1] (Dwivedi 2001)

Mumbai, with its port, cotton textile mills and stock market, quickly became the financial capital of the country. This coupled with the burgeoning film industry made Mumbai an attractive city for the younger demography of the country. The population grew rapidly and housing colonies and complexes started developing along the coast. The city grew from south to north. Trains, trams and roads made this South- North commute possible.

In 1947, India gained independence, and Mumbai continued growing. Reclamation went on, the wetlands- further trampled over. A new business district - Bandra Kurla Complex was developed on what was the Mithi river greenbelt. Many more housing colonies extended to edges of other rivers. The rivers were channelized and diverted by real estate developers. Floods started becoming commonplace, especially in some low lying areas that were earlier protected by the wetlands.

The Municipality constructed concrete roads to withstand heavy rains and built storm water drains along the sides (below the sidewalk). However, due to lack of maintenance, unchecked growth of squatter settlements and informal communities, these drains started getting blocked with solid waste. To add to this, cutting down of wetlands reduced its capacity to defend the city from tidal surge and therefore led to backflow of the rivers. During high tide hours, the storm water drains overflow back into the city.

On 26th July, 2005 the entire city's drainage infrastructure collapsed. A heavy cloudburst coupled with high tide resulted in a flood that created destruction on a tremendous scale killing 435 people, and damaging 55 suburban trains, 900 buses, 4500 taxis, and 37000 rickshaws[2]. The rainfall measured 994 mm (Committee 2006)[3] (39.1 inches) on that day. This one event exposed everything that is wrong with Mumbai's drainage infrastructure.

Geomorphic transformation of Mumbai

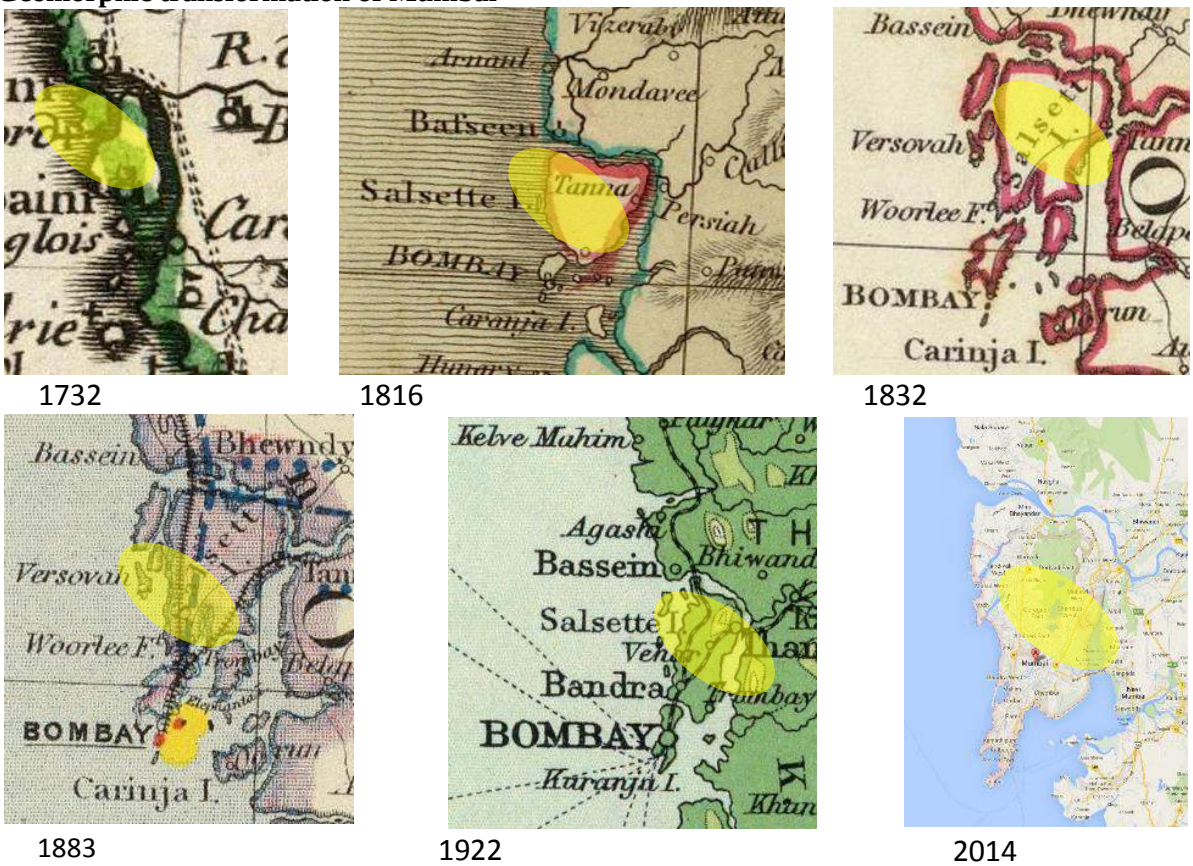

Image 1. Geomorphic transformation of Mumbai from 1700s to present.

[2] (Koppikar 2005)
[3] (FFC 2006)

According to these maps from David Rumsey records, much of Oshiwara River did not really exist, it was the Arabian Sea until land was reclaimed and the suburbs of north Mumbai started getting developed.

The yellow oval in the above maps shows where Oshiwara River would have been once, and is located at today. Under the British governance the 7 islands had already started getting consolidated, while the north did not get much attention. After independence, as Bombay started growing, Versova was connected to Salsette and the city started getting shaped to what it is today. Much of the area between the islands were wetlands and mangrove forests. Some part of Oshiwara River must have existed as a channel flowing from the hills of the Borivali forest, with wetlands and mangrove forests all along. However, these were trampled over for housing complexes to get built and development to expand.

Today, thanks to public protests and floods, the remaining mangroves and wetlands have been placed under control of the forest department and strict regulations have been set against deforestation of mangroves. Most or all the mangrove forests are now located along the coastal edge of the city. As can be seen from satellite images, tremendous building construction has taken place along the rivers and coastal edges. The mangrove forests have been pushed out, and rivers have been squeezed in, leaving the city vulnerable to tidal waves, floods, erosions and sea level rise.

b. General site conditions

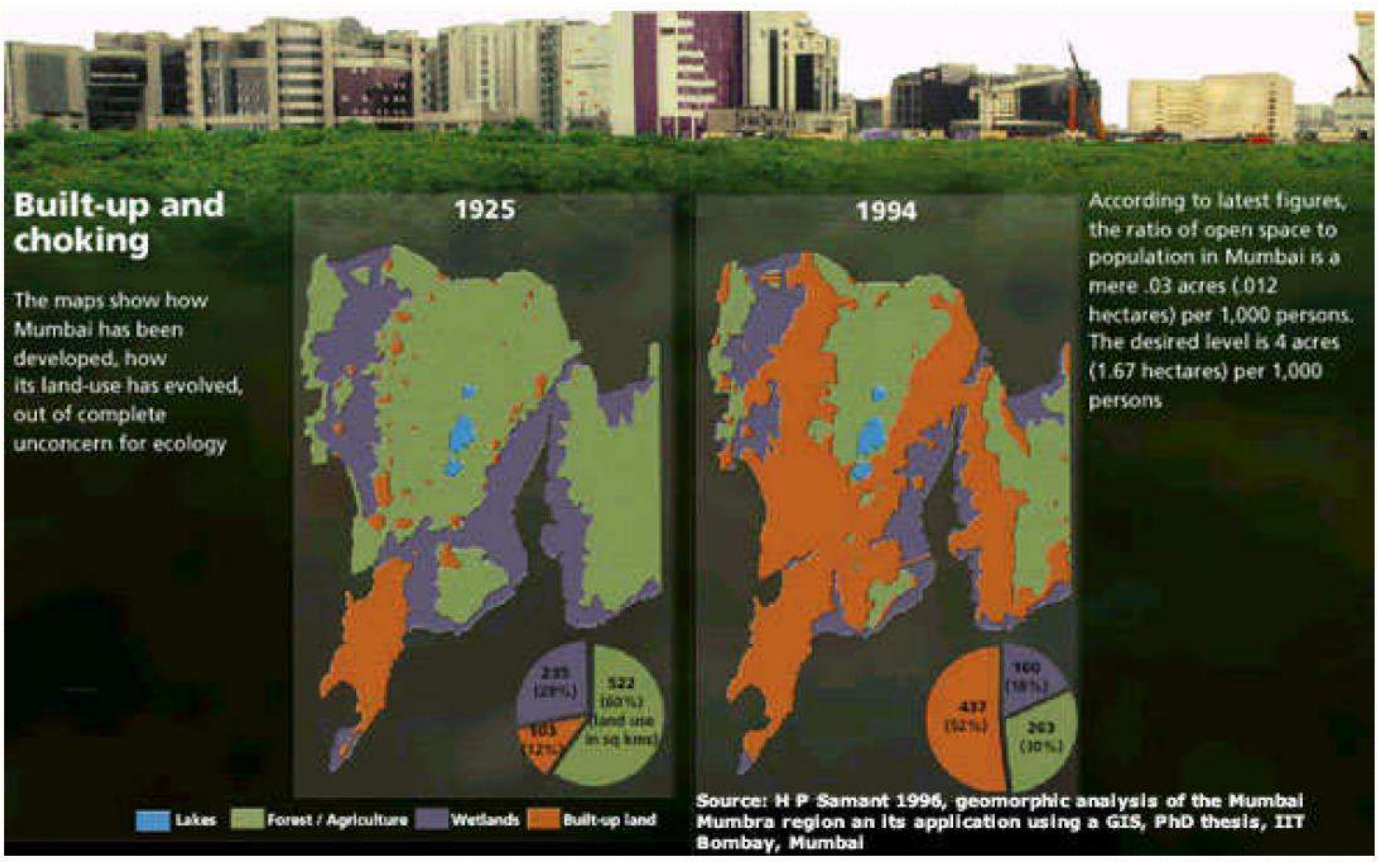

Image 2.
Green- Forest; Purple – wetlands; Red – built up.
This map[4] shows the decrease in area of the wetlands from 1925 and 1994. [Please note, this is a consolidated map of Mumbai created for comparison, it does not show the separate islands as they were in 1925.]

[4] (Samant 1996)

Image 3 Oshiwara River corridor today.
A strict boundary has been marked to prevent buildings from encroaching on to mangrove territory. The river width varies along its path. The upstream region is industrial and the river appears to flow underground, while the land use is residential as it flows downstream, and as it nears its mouth in the mangrove forest, the width increases.

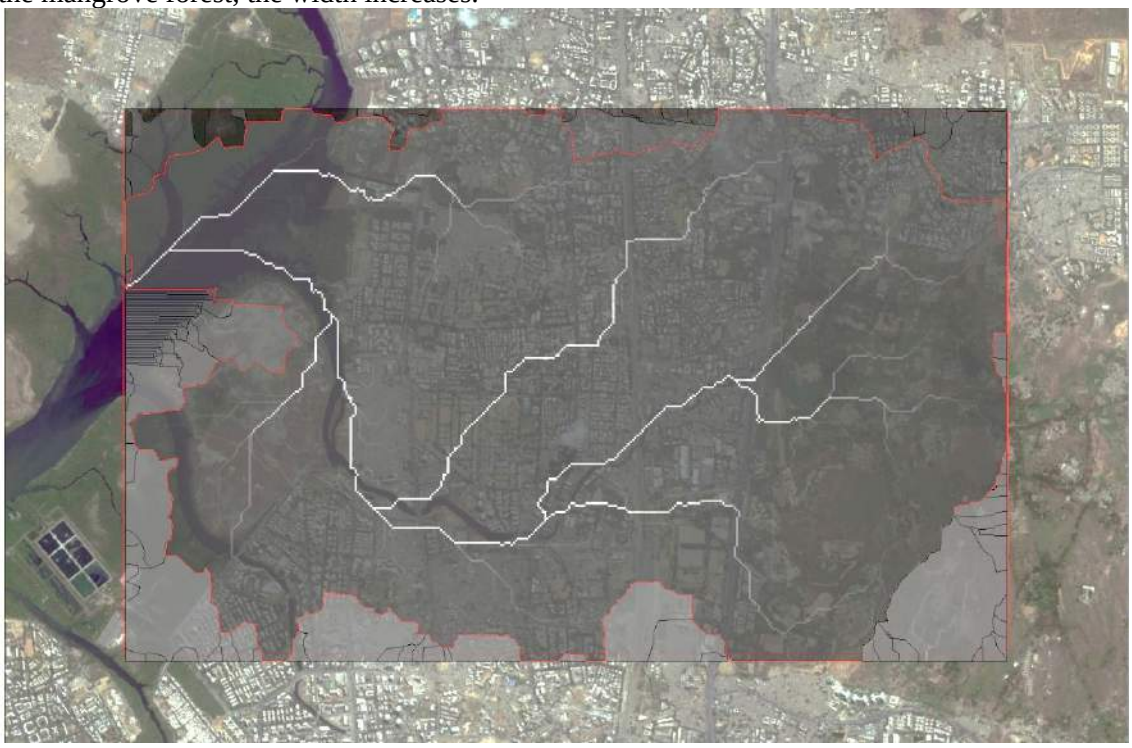

Image 4 – Oshiwara river watershed. Most of the watershed lies upstream, in the Sanjay Gandhi National Park. The moment it enters the urbanized territory it starts getting polluted. It travels 3.5km (2.19 miles) in the urban environment before flowing into the Arabian Sea.

Pink – Residential, Orange –commercial, Brown-industrial, Red- Municipal
Image 5 Oshiwara River is lined by a shopping mall, many informal settlements, residential tower complexes and informal light industries.

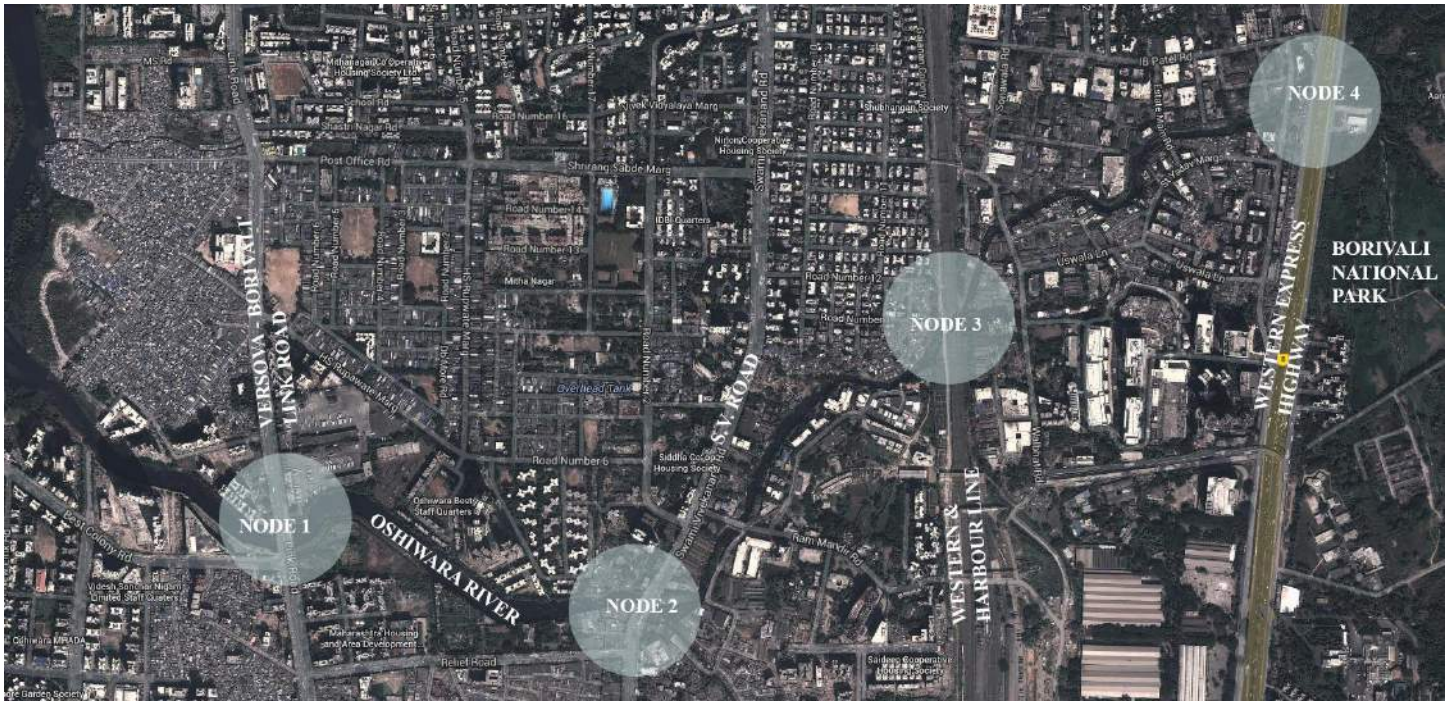

Image 6

The major transportation lines that cross the river are – from west to east – Versova Borivali Link Road (**Node 1**), SV Road (**Node 2**), Western and Harbour Line railway tracks (**Node 3**), and Western Express Highway (**Node 4**).

Image 7

- **NODE 1** - At the node where Oshiwara River and Versova Borivali Link Road intersect there is a shopping mall, a cemetery, BEST bus depot, and a housing complex.
    - The stretch between Link Road and SV Road consists of multiple housing complexes, a BEST employees' housing colony, an Islamic cemetery and a Hindu cemetery.

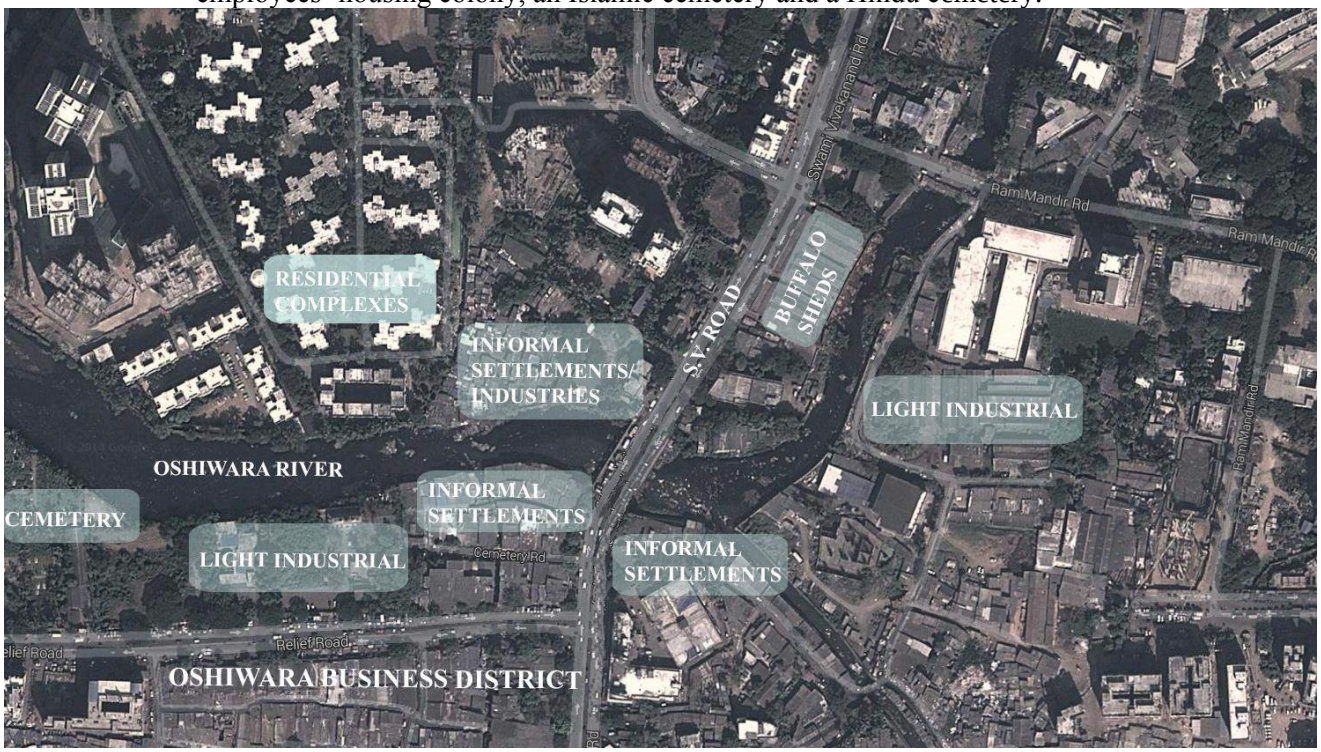

Image 8

- **NODE 2** - At the node where Oshiwara River and SV Road intersect there are informal settlements and buffalo sheds.
    - The stretch between SV Road and Railway tracks consists of buffalo sheds, informal settlements, dye making and other informal industries.
    - The area south of the river has been marked in the Development Plan as a Special Planned Area, under ownership of the MMRDA (regional planning body). They plan to create an Oshiwara Business District here.

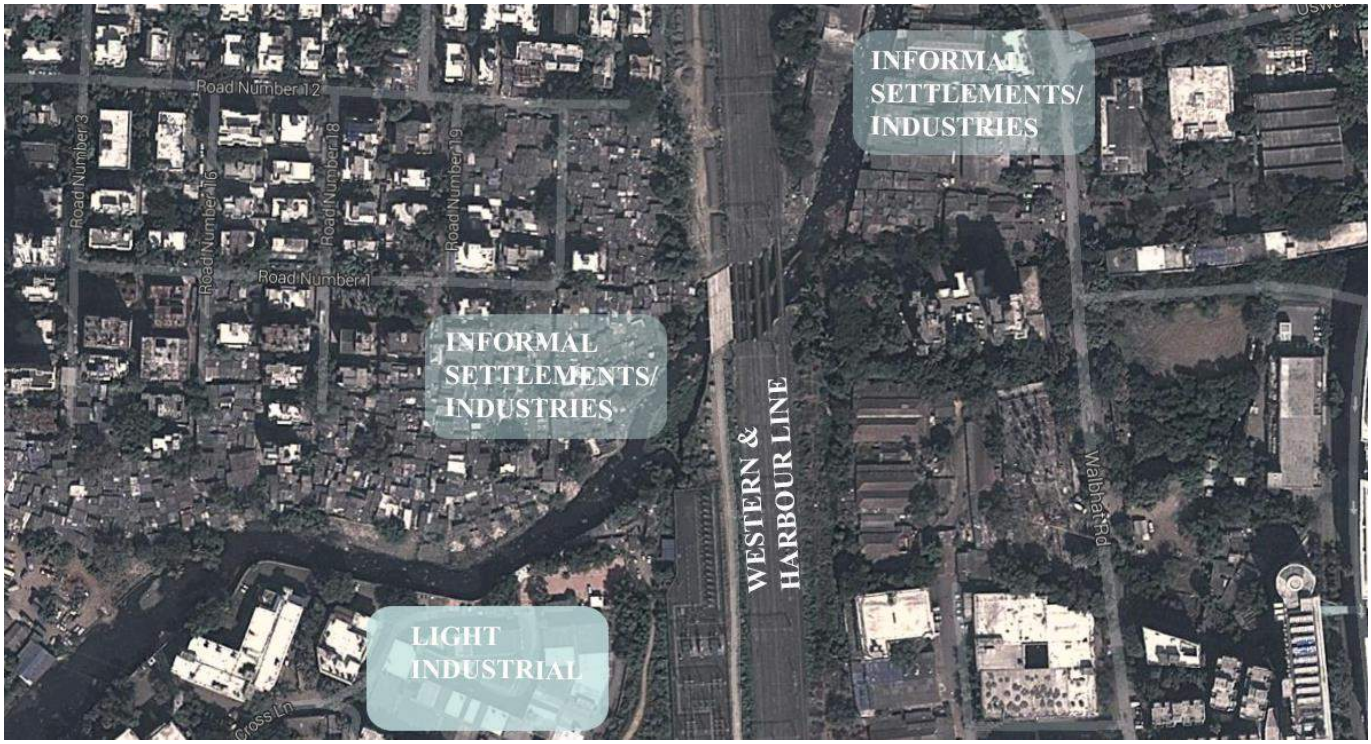

Image 9

- **NODE 3** - At the node where Oshiwara River and the tracks intersect there are many informal settlements.

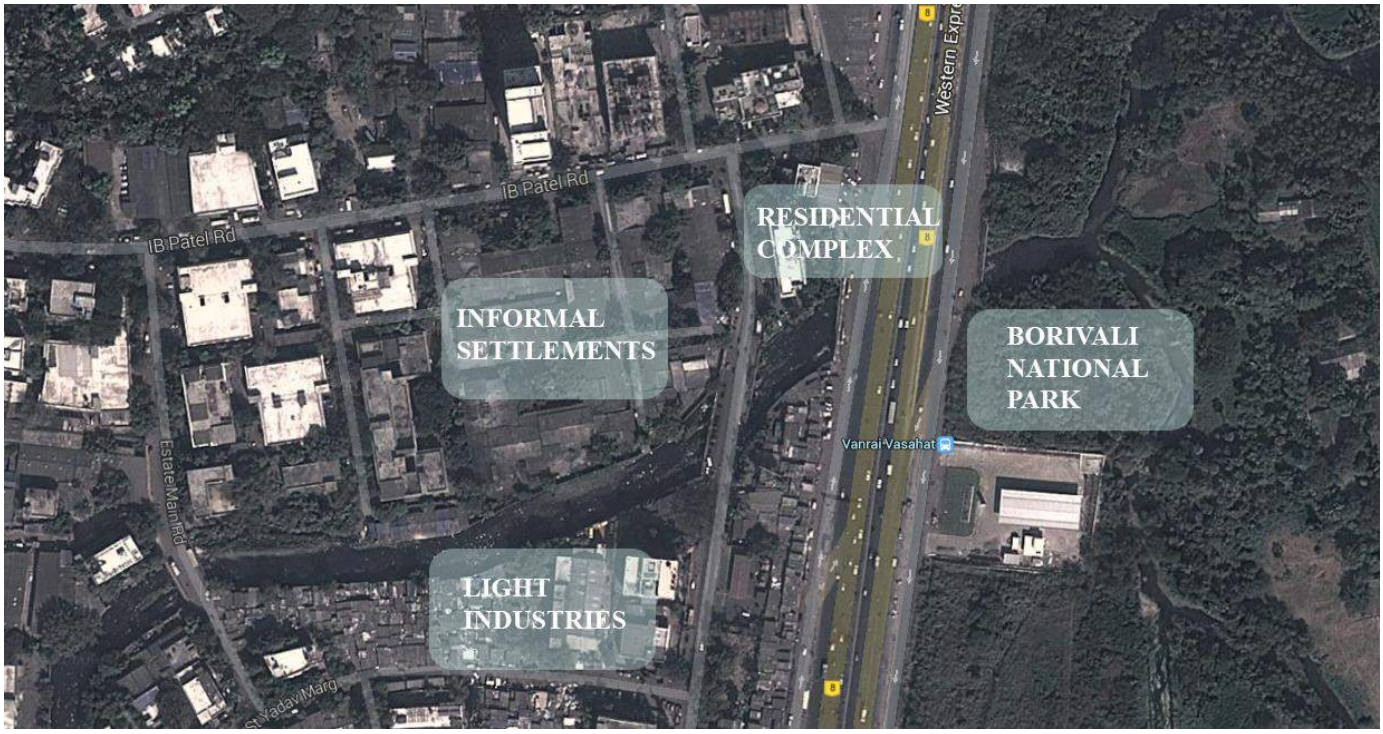

Image 10

- **NODE 4** - At the node where Oshiwara River and Western Express Highway is a combination of informal settlements and a housing complex facing the highway.
    - East of the highway the River enters Aarey Milk Colony. Here the river is amidst its natural environment and faces minimal human disturbance.
    - Further eastwards are the hills of the national park where Oshiwara River has its source.

Image 11 Informal settlements have come up along the corridor. These settlements lack sewer and drainage infrastructure and hence, release it untreated directly into the river.

Image 12 Residences set back sufficiently or build tall compound walls to avoid direct view. I had to climb onto the compound wall of one of them to take this photograph.

Image 13 The untreated waste accumulates and settles down as a form of sedimentation. This affects natural flow of the river and adversely impacts the stream's water carrying capacity causing overflow and flooding during heavy rains and high tides.

Image 14 Untreated Surface runoff and storm water is released directly into the river.

Image 15 Bridges going across the river lack any pedestrian infrastructure and are not properly maintained by the Municipality.

Image 16 Artificial channels are created to provide space for large luxury residential development projects.

Image 17 Solid waste from buffalo stables nearby release their waste directly into the river.

Image 18

All photographs above illustrate existing edge conditions along the River. The entire corridor came into being less than 50 years ago and has now, so easily disconnected itself from one of the few native features of the area. Analysing between the lines makes it quite evident that the deteriorating edge condition of the river is a product of public neglect and lack of state vision.

The following are some key observations along the Oshiwara River corridor:

i. The River edge is lined with R.C.C. retaining wall instead of a natural bank.

ii. There are no publicly accessible spots along the urban corridor from where the River can be seen, except the 4 nodes where roads and railway tracks cross.

iii. All residential complexes have high opaque perimeter walls blocking visibility of the River. Only apartments above 30 feet (or 4th floor upwards) can see the river.

iv. The informal settlements lack sewer and storm water drainage and all their waste is released unfiltered into the river.

v. Informal industries release their chemical waste directly into the river.

vi. Random channelization and unregulated development show that Municipal regulations are modified to suit real estate developers while being insensitive to the river's natural hydrology.

c. Proposed Development Plans

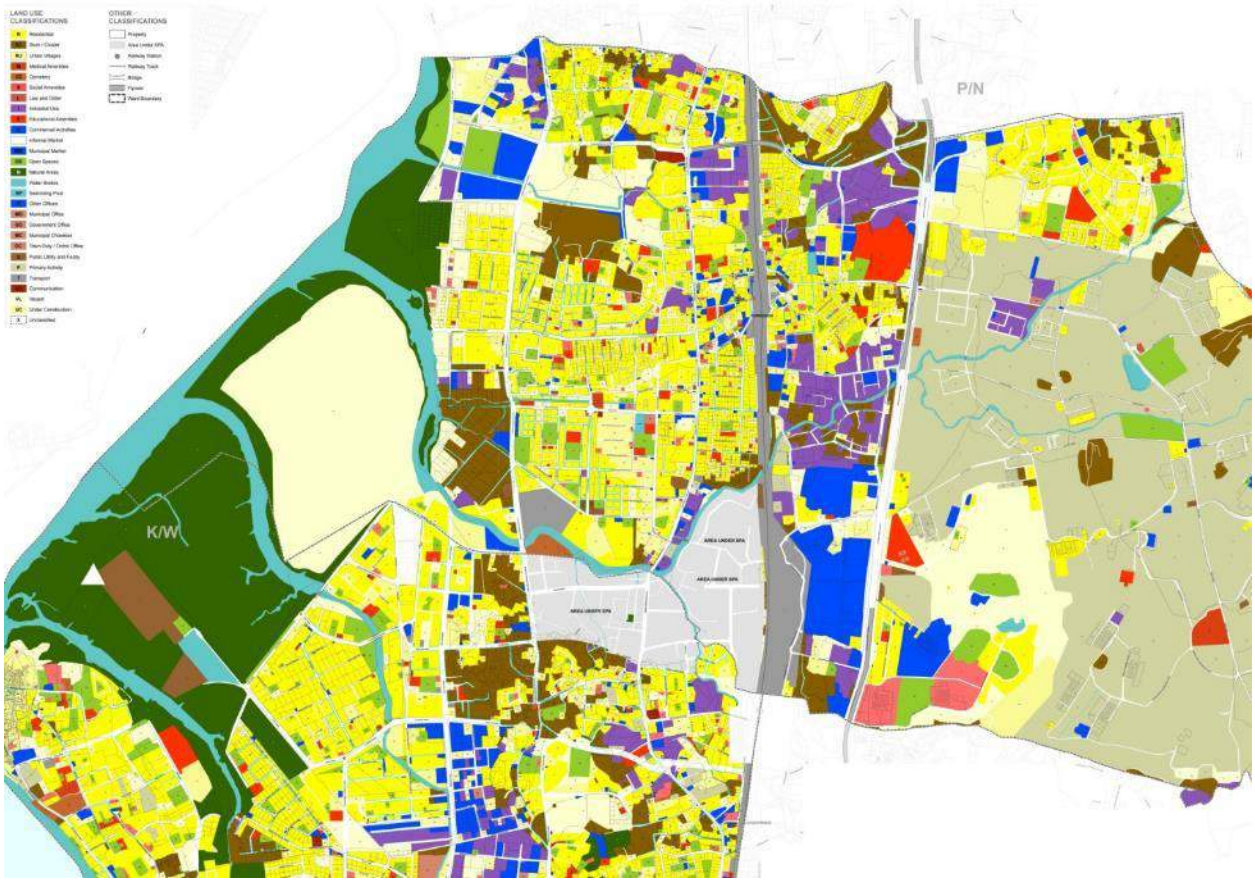

Image 19
P North and K west ward Land Use map.
Yellow- Residential, Brown-Informal, Grey – Special Planned Area (owned by regional planning department-MMRDA), Purple- Industrial and Ochre- Forest.

The land use along Oshiwara River's Urban Corridor is predominantly informal – squatter settlements, informal industries, and gated residential complexes. The informal settlements are located right on the edge of the river while the gated residential complexes are set back a few hundred feet with tall opaque perimeter walls.
As we move upstream, the corridor is surrounded by light industries and further upstream the corridor enters the forest. The only open or publicly accessible space that exists is the cemetery and road crossings.

The proposed Development Plan also does nothing to include the river in the corridor's daily experiential realm. There is no connection between the river, the developments and potential developments in the corridor. The river may very well be absent and no one would care!

The State of Maharashtra has formed a Maharashtra Coastal Zone Management Authority (MCZMA) to create area specific management plans and take measures for protecting and improving the quality of coastal environment. This is in addition to the Coastal Regulation Zone regulations that are already in order. The downstream part of Oshiwara River is part of CRZ I, while the built up part would be under CRZ II.

The recent revisions (2011) show that there are measures to combat pollution, and in order to protect and preserve the 'green lung' of the Greater Mumbai area, all open spaces, parks, gardens, playgrounds indicated in development plans within CRZ-II shall be categorized as CRZ-III, that is, 'no development zone'. Only construction of civic amenities and facilities for recreational sports shall be permitted if the floor space index is

upto 15%. Residential and commercial use of such spaces is prohibited[5].However, none of these regulations seem to have any teeth as the condition of the urban river corridor remains dilapidated even today in 2014.
Mumbai has 2 types of drains – sewage and storm water. The Sewer system is looked after by the Mumbai Sewage Disposal Project (MSDP) department of the Municipal Corporation of Greater Mumbai (MCGM) and storm water by Brihanmumbai Storm Water Disposal System (BRIMSTOWAD) department. The Sewage for Mumbai is treated at 7 Waste water treatment facilities while storm water, despite being collected in separate pipes, is let out untreated into the sea. The department's primary goal was to determine storm water pipe diameters, inlet points and outlets. Despite these discrepancies and ambiguities present in the various Governmental departments and their regulatory frameworks, these observations can also be viewed as untapped opportunities:

d. Potentials

1. The Government seems to be on the right track by setting up management and monitoring bodies that would ensure, at least in theory, that the damage or harm caused to nature due to building construction is minimized or removed completely.

2. The framework laid down by these bodies, allows opportunity for more localized measures to be recommended.

3. The new DP has marked the area between Link Road and SV Road as Special Planned Area under the MMRDA. This area is intended to be developed as a business district, and can still be, but using river sensitive sustainable strategies. If the regional body (MMRDA) could implement such a project, it would set a precedent not only for other regional planning departments, but also, the community at large.

4. Regulations against tall opaque perimeter walls could help make the river visible to residents along the corridor and just by that fact, potentially, spark a stir to create momentum to clean the river and improve edge conditions.

5. The River itself allows the potential to be treated as a value capture instrument thereby influencing public perception of itself.

6. Many states in India have published a Climate Action Plan. This document lays out the various climate related (especially sea level rise) issues in their states, and provides a set of evaluation measures to keep track of the kind of development and its impacts on the environment. This shows that the Government at state and national level has taken a step in the right direction.

e. Overall approach

In the context of these potentials, the report attempts to address the various issues associated with Oshiwara River urban corridor using the following approach:

- Analyse the visible symptoms evident in the River's urban corridor.
    - Based on observations and site analyses lay out all the symptoms that point towards larger issues.

- Locate and explore root causes behind these symptoms.
    - List down the various people and agencies involved and affected by these symptoms and issues.

- Lay out the issues and propose various diagnostic interventions to address them.
    - Enumerate all possible ways to address as many of the issues as possible.
    - Narrow down into the most probably interventions and begin exploring them.

[5] (MOEF 2011): CRZ-FAQ.

- Explore each intervention using case studies and best practices carried out in similar contexts and conditions.
    - Investigate case studies and best practices from the context of Oshiwara River's Urban Corridor.
    - In addition to picking the best possible solutions, their limitations and problems will also be analysed.

- Set up criteria to evaluate the various interventions.
    - Define the criteria based on Oshiwara River urban corridor's context.
    - Additionally, define and provide reasons for allocating points per criterion.

- Evaluate interventions against the fixed set of criteria.
    - Compare each intervention against another under consistent set of criteria.

- Based on the evaluation, strategize avenues where policies could be modified or recommended.
    - Relate the results with the questions asked above.
    - Based on these results and potentials for recommendations, suggest next steps that the various people and agencies (Governmental, non-profit, for-profit, informal) involved could take toward revitalizing Oshiwara River's Urban Corridor.

4. SYMPTOMS AND CAUSES

Oshiwara River's deteriorating physical conditions is adversely affecting the development corridor through which it flows– evident in solid waste and non-point source pollution, floods and a general negative perception of the River.

Symptoms

The tell-tale signs illustrating Oshiwara River's deterioration and its adverse impact on the development corridor are:

a) <u>The River water and bed are polluted.</u>
   - Non-point source pollution - Solid and liquid waste is released untreated from informal settlements and buffalo sheds, and surface runoff from residential developments along the River.
   - Petroleum and oil based runoff from vehicles travelling on bridges that go across the River.
   - The accumulation of this waste, when the River is dry, results in foul stench and forms a breeding ground for disease carrying insects and rodents.

b) <u>The development corridor along the River floods regularly during the monsoons.</u>
   - When it rains during high tide times, water backs up from storm drains in adjacent development corridor because pipe outlets are located at the wrong depth and the River is at capacity.
   - Excess sedimentation due to untreated waste discharged into the River has raised the level of the riverbed, thus disturbing the hydraulic and hydrologic infrastructure.

c) <u>Negative impact on the surrounding environment.</u>
   - In addition to causing a foul stench, the pollution has been harsh on the soil conditions at the edges, causing erosion leading to landslides and damaging property. These landslides affect informal settlements because unlike the residential developments they are not built on piles nor do they construct concrete retaining walls.
   - The lack of maintenance of the River or its edge has resulted in it becoming an eye-sore for the residents and passersby, thus impacting their inclination to access it.
   - The diversity of flora and fauna of the mangrove forests, at the mouth of Oshiwara River, is decreasing and scavenging birds are replacing flamingoes and egrets.

d) <u>Decrease in real estate prices of houses facing the River.</u>
   - This knowledge is based on anecdotal evidence and interviewing 4 real estate agents in the locality. The apartments in the development corridor along the River facing the River are priced at approximately $300/sq. feet less than those away from the river. However, there are other factors that could be causing this difference – this has been discussed in greater details in another section.

Root Causes

Before diagnosing the visible symptoms it is essential to locate the root cause behind the symptoms. This could be arrived at by analyzing the policies and regulations laid down by various agencies that look after infrastructure around urban natural systems and what their perception entails.

Government

Physical Infrastructure in Mumbai is operated and maintained by the Municipal Corporation of Greater Mumbai (MCGM). Within this Municipality it is the Storm Water Department that overlooks the river and storm water drainage, operations and management. At the State level it is the Maharashtra Coastal Zone Management Authority that lays down measures for protecting and improving the quality of coastal environment and preventing, abating and controlling environmental pollution in the coastal areas. And at the national level it is the Ministry of Environment and Forests that sets out general guidelines for conserving the nation's natural systems.

Presently, the State Government has delineated Coastal Regulation Zones (CRZ) to protect the state's coastline and ecological habitats, based on directives from the Central Government. Rivers and creeks also fall under this rubric and specific zones where no development can be allowed have been demarcated. One of these regulations states that "no construction allowed within 500 meters from the high tide line[6] of the river." This has affected all housing developments – existing and newly built, along the corridor. The developers, in order to regularize their developments had to charge residents an extra fee of Rs.6/sq.ft[7]. However, despite the fee, the condition of the river and its environment was not improved and value of homes declined.

The developers try getting around this problem using a design change by constructing taller perimeter walls (12 to 15 feet) to block the river's view, thus trying to create a positive perception of the development. However, this allowed informal settlements to encroach on the other side of the walls (within the 500 meter buffer zone), garbage to be thrown there and effectively, cause further deterioration of the River's ecology. Thus, inflexible state regulation imposing a blanket ban of no development within 500 meters, lack of enforcement of solid waste management and illegal settlement within CRZ buffer along with insensitive design did not succeed in preserving the River's ecology. A review of the various regulations laid down by these agencies is detailed in the appendix.

In the context of this report, following are some of the main critiques of these agencies and their regulations:

a) There is lack of public participation and absence of public opinion in the planning process.

b) Making the Central Government in charge creates multiple layers of red tape.

c) All regulations and codes appear to be written by engineers for engineers, without considering local contexts. This allows many discrepancies in interpretations by developers, bureaucrats, politicians and local citizens.

d) Terminologies used are ambiguous-

- The Fact Finding Committee's report on Mumbai floods refers to the Oshiwara River both as River and a major *nalla*, in different sections, depending on its utility. While listing places for improving storm water drains, it becomes a *nalla*, and while describing the areas that got flooded during the rains it becomes a river.
- The MCGM on its website lists 3 major *nallas* for P South ward (where Oshiwara River flows), however, there are no rivers present here.
- Even the Chief Engineer of the storm water department has designated Oshiwara River as a Storm water drain or major n*alla*[8].

[6] Ministry of Environment and Forests, CRZ – FAQs (2011)

[7] Times News Network, Forest Land: Maha considers review plea against SC verdict (2014)

[8] Chief Engineer's budget estimate 2001-12, Storm Water Department, MCGM, RTI report.

Public

Residents and passers-by refer to the River as a *nalla*, suggesting an open drain (sewer). This perception is generated by the River's physical conditions and Government's ambiguous terminology[9] in its zoning documents.

Residents whose houses face the river willingly drop their house's sale price merely based on the river's visibility[10]. In recent times, with the river's condition worsening, it has been noticed that housing units (apartments) closer to the river are being listed at lower prices than apartments further away. This could be attributed to the river being an eye sore and source for foul stench, among other factors.

a. Issue Analysis

Based on the above analysis it could be surmised that the visible symptoms of deteriorating River ecology could be due to ineffective Government regulations with general public apathy as a bi-product. The key issues could thus be summarized as:

- Poor physical (storm water and waste) infrastructure along the corridor.
- Unchecked dumping of waste and flow of untreated surface runoff in the river.
- Negative perception of the river among the residents.
- Existing regulations are top-down and don't consider local conditions.
- Ambiguous terminologies and definitions used by Government.
- Lack of incentive and inclination for residents and developers to maintain the River's ecology.

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So, according to the above listed issues the following questions attempt to situate them along the Oshiwara River's urban corridor:

- To what extent does public and Municipal perception of Oshiwara River affect the urban corridor's ecology?

  The rivers of Mumbai are referred to as nallahs (open storm drains) both, by the Municipality and the locals.
  - In what way can awareness drives using informative leaflets and survey questionnaires influence public perceptions?
  - How can the Municipal Government design regulations that are sensitive to the residents and local physical conditions around Oshiwara River's urban corridor?

- Can there be a correlation between hydrology and land-use along Oshiwara River urban corridor?
  - After unchecked development encroached and destroyed most of the ecology of Mumbai, is it time now to create policies and design guidelines that are more sensitive towards preserving and rejuvenating the physical features?
  - If so, then how will these regulations blend in with Oshiwara River urban corridor's existing built fabric?
  - As sea level rises and floods become more frequent, developments lining the river corridors in Mumbai become most vulnerable to damage. What measures can be adopted to make these corridors attractive for more ecologically sensitive real estate development?
  - How can the river corridor be made more liveable?

[9] Ibid

[10] 99acres.com, http://www.skyscrapercity.com/showthread.php?t=1188317, http://www.indianrealestateforum.com/real-estate-mumbai/t-nalla-flowing-near-property-should-i-buy-32404.html

Intervention ideas

To address these questions and their symptoms, the following interventions could be tested:

i. Improving storm water drainage infrastructure along the development corridor and sea level rise resilient strategies along the development corridor using decentralized approach.
ii. River and riverfront restoration through public participation modelled after Bandra Waterfront revitalization project, & modification of (presently) top-down CRZ norms.
iii. Spreading awareness and influencing perceptions of space about river ecosystems and their benefits.
iv. Status Quo

The alternative interventions that have been suggested are based on potentials observed from case studies of similar types of projects in Mumbai and elsewhere (sharing similar physical and social context). Both quantitative and qualitative analyses have been performed to describe these approaches.

b. Alternatives and testing criteria

The alternatives will be tested against 3 criteria – Effectiveness, Feasibility and Equity. Each alternative will be evaluated as LOW, MEDIUM or HIGH.

Effectiveness will determine the degree of impact each of the proposed interventions would have on the ecology of the river and its development corridor. Ecology of the River can be defined as an interaction between organisms and their environment. Thus, the intervention could be tested for its impact on the following: Water quality, Edge condition between River and development, accessibility to river, natural disaster prevention (flood, erosion, or landslide), Flora and Fauna of the neighborhood, and general vitality[11] of the space.

Feasibility will determine how viable the approaches would be practically (financially or organizationally). This would be tested by analyzing the ease with which it can be carried out – timeline, organizational hurdles, and externalities, versus the response it receives from the client/ users/ audience.

Equity will determine the depth to which each alternative approach would benefit its context. Listing down all the people or stakeholders who would benefit from these approaches would illustrate how equitable the proposed alternative is.

[11] Vitality is best defined by Jane Jacobs as vibrant places where people can easily interact with one another and benefit from social networks. Human interaction on public streets could be viewed as an agent of safety, diverse housing stock as an agent of social stability and economic vitality, and diversity of business types as a preventive measure against economic downturns. This can be deduced by analyzing the physical features of the corridor- Location and number of shops, retail and work places, restaurants, cafes and nightclubs, and the types of residences along the corridor.

Below, is the matrix that summarizes the alternatives and their testing criteria:

Alternatives	Effectiveness	Feasibility	Equity
1. Improving storm water drainage infrastructure and sea level rise resilient strategies along the development corridor using decentralized approach.			
2. River and riverfront restoration through 'bottom-up' approach – public participation modelled after Bandra Waterfront revitalization project, & modification of (presently) top-down CRZ norms.			
3. Spreading awareness and influencing perceptions of space about river ecosystems and their benefits.			
4. Status Quo			

c. Interventions

I. Improving storm water drainage infrastructure and sea level rise resilient strategies along Oshiwara River urban corridor using decentralized approach.

This proposal entails designing a system based on best management practices (BMPs) for storm water drainage design and management from across the world. In contrast to the present centralized system where storm water from all over the city is collected and then released untreated into the Arabian Sea, this intervention proposes a decentralized approach. The image below illustrates how this proposal would function at the neighborhood block scale.

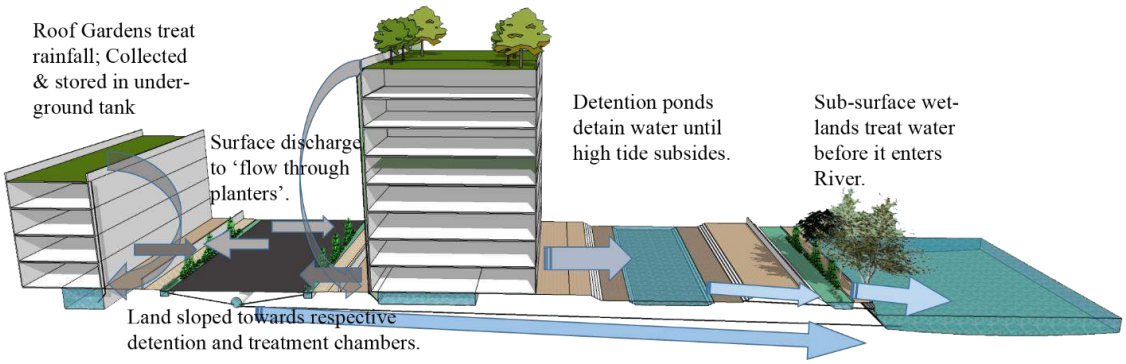


Image 20

Here the water gets treated through multiple ways:

a. Rain falling on terraces can be captured via vegetated roofing strategy. This will not only reduce the volume of rainwater coming down, but also treat it. Water from here will be collected in rainwater storing tanks located near the buildings underground water supply tank.
b. Combined flow through planters (bio-retention planters) along sidewalks will help capture and treat surface runoffs.
c. Detention ponds in residential blocks will help capture, treat and store temporarily water from surface runoff within the demarcated neighborhood block (proposed sub-watersheds).

d. Sub-surface flow wetland systems are proposed along edge of the river to collect surface runoff in addition to the treated water from detention ponds of neighborhood blocks abutting it. This will prevent effluents and harmful pollutants from entering the river.

In order to convert this concept into a realistic proposal, the site was divided into 28 sub-watersheds defined by neighborhood blocks.

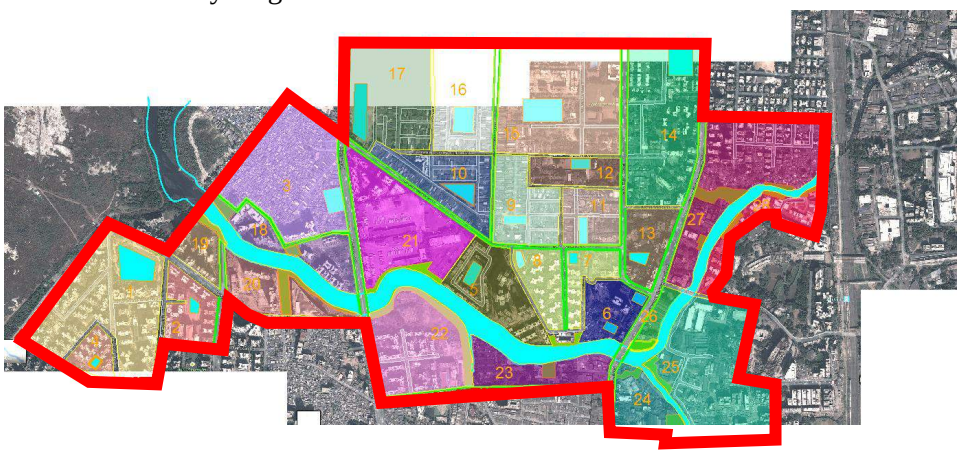


Image 21.

Each sub-watershed is demarcated in a different color and numbered. The following pages show the various calculations undertaken for the proposed interventions.

This decentralized approach will not only help detain and treat surface runoff water until the tide subsides and thus prevent overloading the river, but also help recycle water for non-potable purposes, thus, easing the load on water supply infrastructure as well. Additionally, sensitively designing the detention basins, treatment planters, and wetland swales could potentially create a livable environment in the development corridor.

Such an intervention is inspired from projects undertaken in San Francisco Bay Area and Bangkok. (Please see Chapter 5 for details and appendix for summaries of these projects).

II. River and riverfront restoration through 'inclusionary' approach – public participation modelled after Bandra Waterfront revitalization project & modification of top-down CRZ norms.

Bandra Waterfront revitalization project.

This intervention emphasizes a bottom-up approach through public-private partnership based on a waterfront revitalization project undertaken in 2001 in Bandra, a locality 6km south of Versova (locality of Oshiwara River downstream). It helps describe:

- Public outreach measures undertaken during the process, and how opinions of locals, experts, and developers can be accommodated.
- How collaborations between various stakeholders take place.

The Bandra promenade, before construction, was a stretch of wetland covered with garbage, dirt and solid waste. However, after it was cleared and converted into a public promenade with parks, and activity centers, it changed the perception of the locality completely. Now, it has some of the most expensive real estate in the city, and is arguably one of the most pleasant public promenades in the country.

The Bandra waterfronts stretch for approximately 3km along Mumbai's western edge. From being used as a dumping ground it was restored and revitalized into the vibrant publicly accessible waterfront it is today. The process began early in 2001 when various local area residents' association groups came together to draw out a strategy to restore the waterfront. They were supported by a Bollywood actress turned activist Shabana Azmi and master planner of the project, P.K. Das.

During the design process there were design charrettes held with residents. These were organized by landscape architects and planners, who, along with P.K. Das, were in charge of designing and implementing the project.

The design for both Bandstand and Carter Road waterfronts (collectively forming Bandra waterfront promenade) came as much from the local residents as from the designers. Most of the waterfront was restored to its historic glory

- The Bandra fort was renovated and restored,
- The band-stand was brought back,
- Mangroves were protected and allowed to grow,
- The two hotels along the coastline were disallowed from expanding onto the waterfront

According to P.K. Das this project and its implementation led to new and meaningful relationship between the neighborhood community and local Government. The apathetic Municipal administration, uncaring about city's public-space and coastline, in particular, became more responsive and supported the citizens' movement. The Police too co-operated with local citizens forming a more meaningful and effective monitoring group to not only execute this project but also maintain discipline, and prevent informal encroachments. Additionally, this led to discouragement of various informal activities that used to take place there, like drug peddling, boot-legging. Land grab, illegal land-fill, illegal constructions, attempts to colonizing space by private developers against larger public interest has been checked. This movement, for the residents, was not merely a beautification program but part of a larger struggle for reclaiming public-space and establishment of public-space rights, space where people meet, share with others, and come to care about each other[12].

The project was financed by private sponsor (Marico industries) appointed by the citizens' association. The association approved plans and activities of the sponsor. The citizens' association formed a trust and entered into a legal agreement with the local administration for their rights and control of the waterfront development. P.K.Das states that this project is a unique demonstration in the city of how dignity and respectability of a public space reclaimed by a public movement and sustained by a collective effort of the citizens.

In his paper about the development of Mumbai's waterfronts, P.K.Das includes a cautionary note stating that during implementation of the Bandra waterfront projects a number of issues relating to equity came up. The citizens' associations have been led by the elite – drawn largely from the middle and upper classes along with professional representing similar class interests. Such groups colonized and divided spaces on class-basis under the guise of beautification programs. Das emphasizes the need for putting people's needs before such commodification, and thus, focusing on the human/ humane dimensions.

On similar lines, residential buildings line the Oshiwara Riverfront. If awareness of the benefits of river and riverfront restoration can be spread among the residents then it could catalyze the formation of Bandra-like citizens' association.
However, approximately 20% of land fronting the River has informal settlements living and working on it. Hence, if the Bandra model is followed outright, it would entail displacement of both homes and work

[12] http://www.pkdas.com/pdfs/cont-shift-south-africa.pdf

places of many families along the River. Additionally, there are cattle sheds and industries located upstream. Hence, certain Municipal action would be required to set regulations not only to treat effluents, but also to only allow environmentally sensitive land uses along the River. According to the Bandra model, this too could be achieved through pressure exerted by citizen associations.

Modification of 'top-down' CRZ norms

Making the CRZ norms flexible according to local conditions would perhaps be more beneficial to residents, developers and the natural systems itself. The blanket of 500m offset from high tide line along river and coastal edges could be modified depending on elevation levels, and natural levees (vertical and horizontal), bio-swales, etc, can be proposed to both allow development and preserve the river's ecology. As already discussed in the introduction of this paper, the existing regulatory measures outlined by the Government have created discontentment among the residents and developers alike.

This approach emphasizes the need to undertake a hydrology analysis, flood analysis and propose a fresh approach. In order for this to happen the Municipality needs to hire hydrology and river restoration consultants, followed by urban designers and planners to come up with designs that are specific to local conditions.

III. Spreading awareness and influencing perceptions of space around river ecosystems and their benefits.

In order to better understand the relationships and interactions between people who live and traverse this corridor and the corridor itself, it is important to learn about the perception that Oshiwara River corridor implies. Both, people's and Municipality's perception of the corridor.

People's perception can be looked at in the following ways:

- Perception of neighborhood.

What part of the corridor do the residents consider as their neighborhood? Does this include the river? If yes, until what extent?

- Daily exposure to the River.

How often do the residents and passersby cross the river? How often do they see the river in their daily outdoor routines?

- Awareness of ecological benefits of the River.

How do the residents and passersby interact with the river? Have they experienced floods in their neighborhood? What measures according to them would mitigate future floods? Is there any awareness or worry about climate change and sea level rise?

- Sense of community

How familiar are the residents with people living in the neighborhood they demarcate? Do their friends or family live in their demarcated neighborhood?

Responses to these questions would help reveal the extent to which the residents and passersby are aware of the river and its benefits. Additionally, information about vulnerability of the corridor to floods and sea level rise could be distributed to spread awareness.

Municipal perception can be looked at in the following ways:

- Terminology used to define Oshiwara River.

Why is it referred to as a nallah in some documents and river in others? What effect does this definition have on their maintenance of the river?

- Existing regulations along the corridor.

To what extent is the river affected by building construction, waste disposal and drainage infrastructure?

- Proposed regulations for the corridor.

What are they? Do any of them include a participatory approach to dealing with the river edges?

Information for this has been obtained from CRZ regulations, BRIMSTOWAD report of 2006, and announcements of future projects made in newspapers by the Municipality.

Spreading awareness

i. Public Perception

Environmental behavior has been argued to be deeply grounded in environmental perception- a process that is complex, dynamic and active (Holahan, 1982). Holanah, Gifford, Gibson et al, define this concept through the field of environmental psychology. This field studies the relationship between environment and how that environment affects its inhabitants. Specific aspects of this field work by identifying a problem and through this identification, discovering a solution. The solutions can aid in making society function better as a whole and create a wealth of knowledge about inner workings of societies (Proshansky, 1987). 'Place studies' is another field that analyzes the ways in which people feel, use and interact with their surroundings (Moudon, 1992). Furthermore, with respect to human perception of the natural environment surrounding them, 'nature-ecology studies; from the 1980s explored perceptions of natural forces in relation to the built environment (George & McKinley, Hughes, Van der Ryn and Calthorpe).

Kevin Lynch ascribes performance dimensions based on a city's ability to provide biological, psychological, social and cultural requirements to its inhabitants. Once these requirements have been specified, an estimation could be made determining how good the city is. The performance dimensions are Vitality, Sense, Fit, Accessibility and Control.

Peter Bosselmann takes this further by specifying measurement techniques for vitality, livability and sense of place. He defines the vitality of urban space by examining three qualities – mixture of activities, density, and public life. For livability he includes personal safety, well managed traffic, ease of walking, centrality and the presence of nature in cities. He adds 'sense of belonging' as the dimension for sense of place and sense of time.

These performance dimensions would help understand the Oshiwara River corridor better, and provide avenues of opportunities for interventions. (Moudon 1992) (C.J.Holahan 1982) (Bosselmann 2008) (Lynch 1981) (Van der Ryn 1986) (Whyte 1988) (Southworth 1983) (K. T. Lynch 1995).

- Vitality

Vitality is best defined by Jane Jacobs as vibrant places where people can easily interact with one another and benefit from social networks. Human interaction on public streets could be viewed as an agent of safety, diverse housing stock as an agent of social stability and economic vitality, and diversity of business types as a preventive measure against economic downturns.

This can be deduced by analyzing the physical features of the corridor- Location and number of shops, retail and work places, restaurants, cafes and nightclubs, and the types of residences along the corridor. In addition to observations, certain specific questions in the survey could help reveal what affects the residents' perceptions.

- Livability

Livability, according to Peter Bosselmann is measured through a process of inquiry that focusses on individual perception and cognition. Livability helps understand environments where people feel most comfortable. In order to understand this, one must first analyze how people use and interact with the corridor- where do they gather, recreate, sit, walk, which streets do they use the most; and all of these during different times of the day and night.

Analyzing these aspects and comparing it with the existing physical environment will reveal clues about what causes such responses, why the residents prefer certain streets over the other, why do they ignore the Oshiwara River, or why do they like walking or jogging alongside it.

- Sense of Place

Kevin Lynch defines it as the degree of fit between the physical city and the way people recognize and organize it in their minds. It reflects the ease by which people perceive space, to what extent they connect with their community, and how they relation to time is affected by their perception of the place.

To measure this, specific questions will have to be asked to the residents in the survey. Questions requiring them to demarcate what they consider as their neighborhood, how familiar they area with their neighbors, how much time do they spend in their neighborhood, which part of the city do they like spending time in the most.

In addition to sense of community, the residents' sense of biodiversity can also be determined by testing their daily exposure to the Oshiwara River, their awareness of the ecological benefits of having a river in their backyards, and their awareness of the impacts of sea level rise, encroachment onto city's natural systems like mangroves and wetlands.

To analyze public perception, the following is hypothesized:

The residents' awareness and valuation of benefits of the Oshiwara River is affected by their:

a) Past experience of floods

b) Daily use of areas along the river

c) Socio-economic characteristics

d) Familiarity with neighbors and other residents living along the corridor.

To verify the hypothesis posed above, a survey must be undertaken. The survey would include questions about the respondents' socioeconomic status, daily exposure and visits to the river or areas by which it

flows, perceptions of its surrounding community, and perceptions and awareness of the ecological characteristics of the river corridor.

The survey questionnaire is provided in Appendix I. Answers to questions such as - 'How long have you lived in this neighbourhood? ; How many people (approximately) in your neighborhood do you know well enough to say 'hello' when you see them?' would suggest clues towards sense of place. While questions like 'Please select the statement that best characterizes your feelings about your neighborhood. And, If you walk or drive to work for at least a portion of the trip, and if that portion falls within the area indicated on the map, please mark using an arrow", are aimed at revealing sense of vitality. Questions about 'observations of flora and fauna in the neighbourhood and areas visited for recreation help learn about the respondent's sense of livability. The rest of the questions were to gauge a general demographic sense of the urban corridor.

ii. Municipal Perceptions

In order to better understand perception of the corridor, locating how the Municipal and administrative bodies refer to and treat the River Corridor, would help.

In 1986 an act to provide the protection and improvement of environment and related matters was passed by the Indian Parliament. This Act came about as a result of the United Nations' Conference on Human Environment held 14 years ago (1972) in Stockholm (MoEF 1986). As a result of this act, a Maharashtra Coastal Zone Management Authority (MCZMA) was constituted to take necessary measures for protecting and improving the quality of the coastal environment and preventing, abating and controlling environmental pollution in the coastal areas.

And finally, in 1991, the Coastal Regulation Zone notification (CRZ) was issued with the purpose to maintain a balance between development needs and protection of natural resources, protecting the coast against harmful activities and managing coastal ecosystem sustainably (EQUATIONS 2008).

The CRZ notification divided zones based on their location in the city –

CRZ-I – ecological sensitive, CRZ-II- built-up area, CRZ-III- rural area, and CRZ-IV- water area (MOEF 2011).

However, there are no maps available to precisely locate which zone is where, and hence, one can only make an educated guess based on the existing literature.

The FAQ section on CRZ notification, 2011 specifies for Mumbai –

in order to protect and preserve the 'green lung' of the Greater Mumbai area, all open spaces, parks, gardens, playgrounds indicated in development plans within CRZ –II shall be categorized as CRZ-III, that is 'no development zone', only construction of civic amenities and facilities for recreational sports shall be permitted if the floor index is upto 15%. Residential and commercial use of such spaces is prohibited.

Hence, we shall assume the Oshiwara River corridor to be part of CRZ-III.

Now, it must be noted that amendments or modifications to these regulations are not periodic or regular.

- ➔ The last time CRZ was reviewed, was soon after the 2004 tsunami in Southern Coast of India, in 2005 (UN 2005).
- ➔ In 2005, after the 26th July deluge in Mumbai, a Brihanmumbai Storm Water Disposal System project was planned by the Municipal Corporation of Greater Mumbai. A Fact Finding

Committee was set up to analyze and present a report detailing out all the problem areas of Mumbai that the floods revealed (FFC 2006).

➔ In 2011 during the upgrading of Mumbai's Development Plan (DP). The DP stakeholder group on environment outlined specific requirements to be added for environmental preservation and enhancement. (UDRI 2011) –

Water systems and Flood Mitigation in the Development Plan: Rivers, streams, lakes and creeks should be clearly identified and included as reservations in the new Development Plan with their appropriate names. Rivers, Streams and Nalas: These should be revived as clean natural rivers and stream.

Additionally, in terms of updating the maps-

The storm water department in 2011 had begun the process of mapping and generating GIS contour and hydrology maps of Mumbai. However, due to unknown reasons, these maps are not available for public use.

Further exploration revealed that as part of the DP update, the Urban Design Research Institute compiled comments on the existing land use from expert planners, architects, landscape architects, and engineers wherein it was stated that the GIS layers of forests, CRZ, heritage sites have been separately recorded and will be examined while preparing the proposed Land Use maps (MCGM, Existing Land Use Survey Comments - Ward A to T, Mumbai 2013).

Reviewing all these documents and amendments shows that bodies of the Government have right intention, but their regulations lack teeth. This is due to the following reasons –

a) Lack of public participation and absence of public opinion in the planning process, and

b) Making the Central Government in charge, thus creating multiple layers of red tape.

c) All the regulations and codes appear to be written by engineers for engineers, without considering local contexts. This allows for many discrepancies in interpretations by developers, bureaucrats, politicians and local citizens.

d) Terminology are used ambiguously-

   i. The Fact Finding Committee's report on Mumbai floods refers to the Oshiwara River both as River and a major Nalla, in different sections, depending on its utility. While listing places for improving storm water drains, it becomes a nalla, and while describing the areas that got flooded during the rains it becomes a river.

   ii. The MCGM on its website lists 3 major nallas for P South ward (where Oshiwara river flows), however, there are no rivers present here.

   iii. Even the Chief Engineer of the storm water department has designated Oshiwara River as a Storm water drain or Major Nalla[13].

Impact of Government perception on the public

Until the 26th July, 2005 floods, the rivers of Mumbai were never given a second look. The City would only concern itself with the edges where pipes would flow out from. What came out of the pipes was beyond their scope of work- they would concern themselves with pipe maintenance, repair, design and construction, but the quality of water flowing in them is never measured. The Municipality has a Mumbai

[13] (Engineer 2011-'12).

Pollution Control Board that lays down impurity levels; however it tests only treated sewage before it is released into the Sea.

Mumbai has 2 types of drains – sewage and storm water. The Sewer system is looked after by the Mumbai Sewage Disposal Project (MSDP) department of the Municipal Corporation of Greater Mumbai (MCGM) and storm water by Brihanmumbai Storm Water Disposal System (BRIMSTOWAD) department.
The Sewage for Mumbai is treated at 7 Waste water treatment facilities while storm water, despite being collected in separate pipes, is let out untreated into the sea. Best practices from Scandinavian cities tell us that both sewer and surface drainage must be treated before releasing into the sea. The department's primary goal was to determine storm water pipe diameters, inlet points and outlets.

The Municipality permits new development to encroach onto river if they channelized it and continued its flow. The developers built strong concrete retaining walls to protect their development from forces of the river, while at the same time, disturbing the river's natural hydrology.

Some of these mentioned problems and more, combined and led to the complete collapse of this storm water infrastructure on 26th July, 2005. Following this debacle, the Municipality increased its budget for BRIMSTOWAD for a complete overhaul of the storm water disposal system.
However, most of the changes were for upgrading the storm water pipes and clearing their outlets. There was no mention of river restoration and storm water treatment. The only change now is that before monsoons, the outlets are unclogged. This Government apathy towards the natural system furthers the *nalla* perception of such urban rivers.
Even the residents in development complexes alongside, and the developers themselves refer to the river as a nalla. This colloquial term used to describe an open drain immediately brings to mind a filthy and stinky channel of water. This perception is reason enough to shut it out of one's mind and think, look, walk as far away from it as possible.
Real estate value drops if the *nalla* is visible[14]. Hence, developers build tall compound walls to block its view.

On the other hand, the informal settlements see the river as a water source as well as a drainage channel for their bio and non-biodegradable waste. They use the water to wash clothes and at times, even utensils, and lacking any sewer connections, their waste flows directly into the river. Whereas, the sewer connections of development complexes are connected to the Municipal sewer lines, it is their surface drainage that flows directly into the river.

In recent weeks, rapid changes have been proposed along other ecological areas in Mumbai. This appears to be a political move in light of the General Elections coming up in May 2014.

Listed below are some of these proposals[15]:

- Bandra Versova sea link tender to be proposed. The Sea Link would be an extension of the Bandra Worli Sea Link and it would connect at Versova joggers' park, thereby affecting massive swathes of wetlands.
- Supreme Court deleted the private protected tag for forests and wetland areas in the city allowing developers to encroach, reclaim and develop residential and commercial buildings on land presently covered with mangrove forests and wetlands.

The Maharashtra state Government is considering a review plea against the Supreme Court ruling and bring the forests back into protection. Presently, they are facing a lot of flak from residents and

[14] 99acres.com, http://www.skyscrapercity.com/showthread.php?t=1188317, http://www.indianrealestateforum.com/real-estate-mumbai/t-nalla-flowing-near-property-should-i-buy-32404.html
[15] (TNN 2014), (TNN, Bandra-Versova sea link tender in next few days 2014)

developers because most of the residential buildings are violating CRZ regulations, and hence have paid hefty fines. Reverting the Supreme Court ruling would work against them and hence are vehemently lobbying against it.

Influencing public perception

In the recent past, there have been exhibitions held in Mumbai pointing at these rivers, mangrove forests and wetlands as the city's last remaining public spaces. A deeper understanding of public space and how it relates to making a space liveable could help create a positive perception, thereby impacting how residents value their properties, and citizens value the city's natural assets.

- Analysing public perception (vitality, liveability, and sense of place), Government perceptions and their impact on public perceptions will help locate loopholes and areas where future policies could be aimed towards.
- Studying the different kind of exhibitions and their impact (the length for which they lasted, the number of people they attracted, their impacts on the city) could also help determine the kind of outreach measures that could be adopted to spread awareness of ecological benefits.

Mumbai's natural systems in popular media

After the floods in 2005 people started realizing how extreme natural events can wreak havoc when not planned for. Bollywood responded with 2 film releases (26 July at Barista -2008 and Tum Mile- 2009), the National Geographic produced a documentary film, scientists, engineers and architects published research papers and articles (in journals not freely accessible), and, two exhibitions were held at the National Gallery of Modern Art, Mumbai (entry fee Rs.10).

None of these were freely available to the public. The movies were released in multiplexes, articles and research papers in journals and publications for a niche audience, and exhibitions in an art gallery which is visited primarily by the middle and upper class. This already narrows down the scope of these awareness spreading mechanisms from all public in general to a selective audience. Although this selective audience forms the majority of Mumbai's population and holds the key to potentially influencing Municipal decisions (through sheer strength of numbers), as P.K. Das so eloquently puts it - such groups colonize and divide spaces on class-basis under the guise of beautification programs.

Public exhibitions

For the scope of this report, to analyze how effective public awareness creating programs have been, it would be worthwhile to focus on the two exhibitions at NGMA. This is because this was the only form of documentary that was easiest to read, relate to, and more importantly, presented an in depth visual analysis of the city's physical features.

The two exhibitions were: (i) Soak[16] by Anuradha Mathur & Dilip da Cunha, June 2009, and
(ii) Open Mumbai[17] by P.K.Das, June 2012.

Soak

In this exhibition, Mumbai was perceived as an estuary and analyzed through topographical and morphological history. The city was drawn through section, plans and photographs. Various interfaces between the urban realm and natural realm were detailed and potential sites for design interventions were

[16] http://timesofindia.indiatimes.com/city/mumbai/Mumbai-a-water-body-in-denial/articleshow/4713630.cms

[17] http://timesofindia.indiatimes.com/city/mumbai/Open-Mumbai-exhibition-Nine-zones-have-oases-of-comfort/articleshow/14381969.cms
http://www.timeoutmumbai.net/around-town/features/network-open-spaces

located. The form of the exhibits were very artistic almost to the level of esoteric abstraction. However, it was one of the first times in recent past when historic maps of Mumbai were on display for the public. It brought to light the fact that Mumbai was originally 7 islands and the newly reclaimed terrains were the first to get flooded and devastated.
The exhibition was on for 4 months (June to September, 2009). There are no official figures to show how many people visited the exhibition but the fact that it was extended by 1 month proves that it attracted quite an audience. The exhibition was compressed into a publication with a foreword by renowned urbanist Arjun Appadurai. The book is well used and referred in many design schools (I know of KRVIA, Mumbai, UC Berkeley, U.Penn).

One of the greatest impacts of the exhibition was that it set a perfect foundation for P.K.Das's exhibition in 2012 on Mumbai's ignored open spaces.

Architects and planners like Neera Adarkar, Rahul Mehrotra, Sharda Dwivedi and P.K.Das had been writing about the need for additional open spaces in Mumbai for quite some time by then. Various books and articles were published on this issue, but P.K. Das took the initiative to hold a full-fledged public exhibition in 2012.

Open Mumbai
It was titled Open Mumbai and focused on space types in Mumbai. The exhibition had historic maps illustrating the morphological progression of the city, many photographs – aerial and ground, showing different parts of the city and how they exist presently, and drawings from the projects his form has worked on and some diagrammatic proposals. The exhibition displayed Mumbai's western coast and the rivers leading to it as having tremendous potential to be converted into publicly accessible open space. While this exhibition was on, the Government decided to fast track[18] the Irla *nalla* restoration and revitalization project. Additionally, the exhibition was extended by a further 2 months (From March 15-April 7 to May 15th, 2012).

However, in order to create a pleasant public space around the *nalla*, all informal hutments had to be demolished and removed. There is no available data stating where they have been displaced to. This goes back to the reasoning that such an undertaking is supported by citizens from the middle and upper class, who equate slums with the open drain and believe in cleansing the city of both.

Additional interventions

These set of 4 interventions describe various ways by which the Oshiwara River urban corridor could be revitalized. However, it must be noted that these are not the be all and end all of all possible interventions. There are merely suggestive in the context of the framework of this report. Many more could be added to the list based on which issues are prioritized or who would be funding the proposal, or other more practical reasons.

Additionally, two other interventions that can be proposed are:

i. Providing live-work facilities nearby for residents of informal houses along the urban corridor.

Or,

[18] http://www.mumbaimirror.com/mumbai/others/No-new-projects-but-BMC-to-complete-earlier-ones/articleshow/15989313.cms, http://timesofindia.indiatimes.com/city/mumbai/HC-refuses-to-stay-widening-of-Irla-Nalla/articleshow/18528978.cms, retrieved on February, 2014.

ii. Use the River for water transportation. This could give rise to many associated industries and lead to surge in employment opportunities.

NOTE: These interventions, like the ones proposed in this report would be subject to many local and external factors. One of the primary reasons for not considering them in this analysis is that this report aims at finding best possible ways to deal with existing land use without disturbing the present fabric, and at the same time, locating opportunities for new additions within the same context, but in the future.

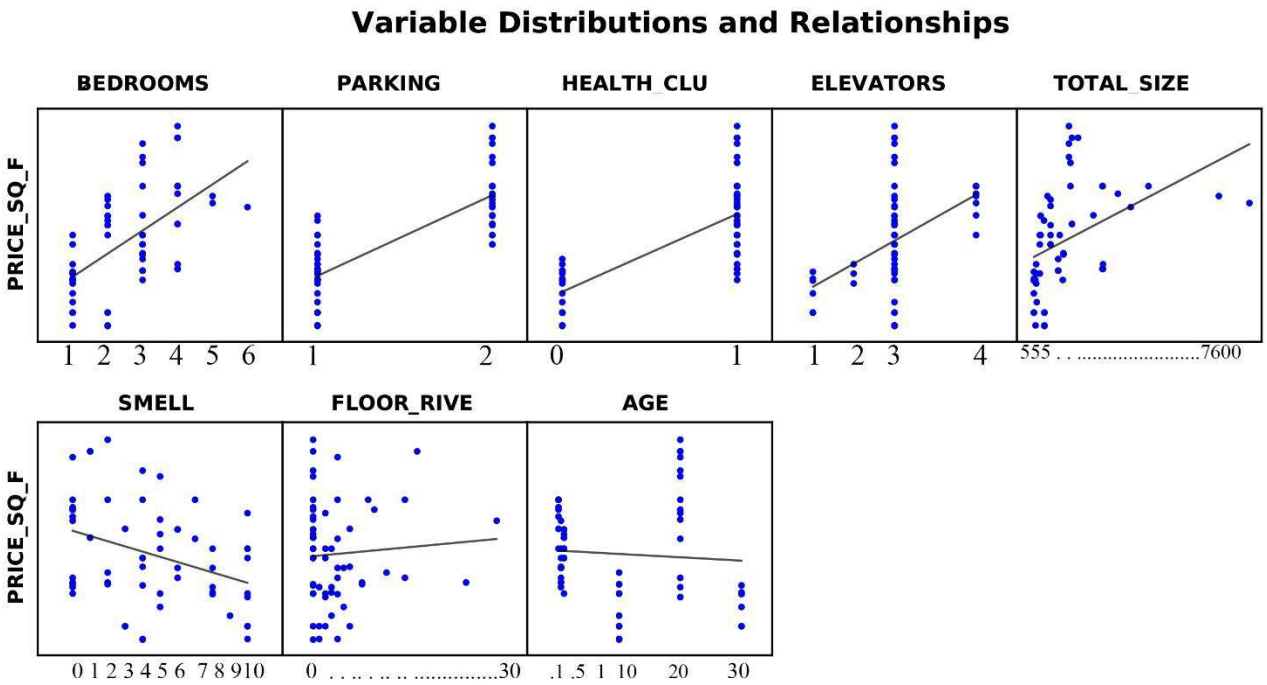
IV. Status Quo

The development corridor along Oshiwara River consists primarily of residential building complexes. The aim of this intervention is to leave the river infrastructure at status quo, while improve condition of residential developments lining the River. To arrive at this proposal a multi-criteria regression was performed to test the degrees of impact the various site amenities had on per square foot sale price of apartments in the building developments.

This regression was performed on a sample size of 59 apartments spread across 7 residential development complexes along the River. This forms approximately 15% of total number of apartments in all the buildings that front Oshiwara River.

The table below shows results of the multi-criteria analysis:

Variable	Coefficient [a]	StdError	t-Statistic	Probability [b]	Robust_SE	Robust_t	Robust_Pr [b]	VIF [c]
Intercept	73.857612	29.698092	2.486948	0.016266*	27.802709	2.656490	0.010569*	--------
BEDROOMS	17.888891	10.019990	1.785320	0.080278	9.730612	1.838414	0.071947	6.348485
PARKING	16.419846	20.526089	0.799950	0.427522	18.264824	0.898987	0.372966	4.103741
HEALTH_CLU	126.732636	18.191264	6.966676	0.000000*	18.264933	6.938576	0.000000*	2.930223
ELEVATORS	35.348013	11.004416	3.212166	0.002307*	8.696264	4.064735	0.000171*	4.784026
TOTAL_SIZE	-0.010606	0.007042	-1.506195	0.138311	0.004947	-2.144100	0.036911*	3.525386
SMELL	-2.398757	1.989812	-1.205519	0.233677	1.786013	-1.343079	0.185312	1.878981
FLOOR_RIVE	-0.822328	0.991904	-0.829040	0.411020	0.899941	-0.913757	0.365227	1.408717
AGE	5.655062	1.012833	5.583410	0.000001*	0.868043	6.514725	0.000000*	4.326055



This regression analysis was undertaken with price/sq. feet as the dependent variable to which the following aspects of the developments were compared:

(i) Number of bedrooms, (ii) Number of parking spaces, (iii) Presence of health club is the development, (iv) Number of elevators, (v) Total size of the apartment, (vi) Smell of the River (here, higher the number, higher the smell), (vii) Combination of the floor on which the apartment is located on and whether it has a view of river or not, and (viii) Age of the building.

These particular elements were chosen because this was the most comprehensive list of amenities that were available, and on which price of an apartment is assumed to depend on. The graphs above illustrate degrees to which each chosen variable of the building development is related to the price per square feet of the apartment.

According to the graph and table above, where price per square foot is a function of each of these variables, it was found that the presence of a health club in the residential development increased its price per square foot by $126.73. Similarly, the smellier it got, the price per square footage dropped by $2.39. Additionally, it also shows that despite floor level rising, if it has a view of the River, the price per square footage drops.

In addition to this, an exploratory regression was performed to test the comparative significance of each variable on the other. The table on the following page reveals the extent of significance of each variable on price per square foot of the apartment.

Summary of Variable Significance

Variable	% Significant	% Negative	% Positive
HEALTH_CLU	100.00	0.00	100.00
PARKING	97.98	0.00	100.00
AGE	65.66	2.02	97.98
BEDROOMS	48.48	4.04	95.96
ELEVATORS	37.37	28.28	71.72
SMELL	16.16	84.85	15.15
TOTAL_SIZE	13.13	40.40	59.60
FLOOR_RIVE	2.02	60.61	39.39

According to this table, the presence of health club is found to have the most positive significance on price per square foot of each apartment than any of the other variables. Smell, on the other hand, has the highest negative impact on the price per square foot suggesting that as foul stench increases, the price drops. However, in comparison to the rest of the variables it has one of the lowest significance on price per square foot of each apartment.

Finally, a spatial autocorrelation was performed on price per square foot, to measure and analyze whether the pattern of price per square foot is clustered, dispersed or random among observations in geographic space. To perform this, a distance threshold of 15m was used as apartments in the same building were to be tested.

The image on the following page is the Moran's Index curve. The z-score is 3.35 which illustrates that there is less than 1% likelihood that this clustered pattern could be the result of random chance.

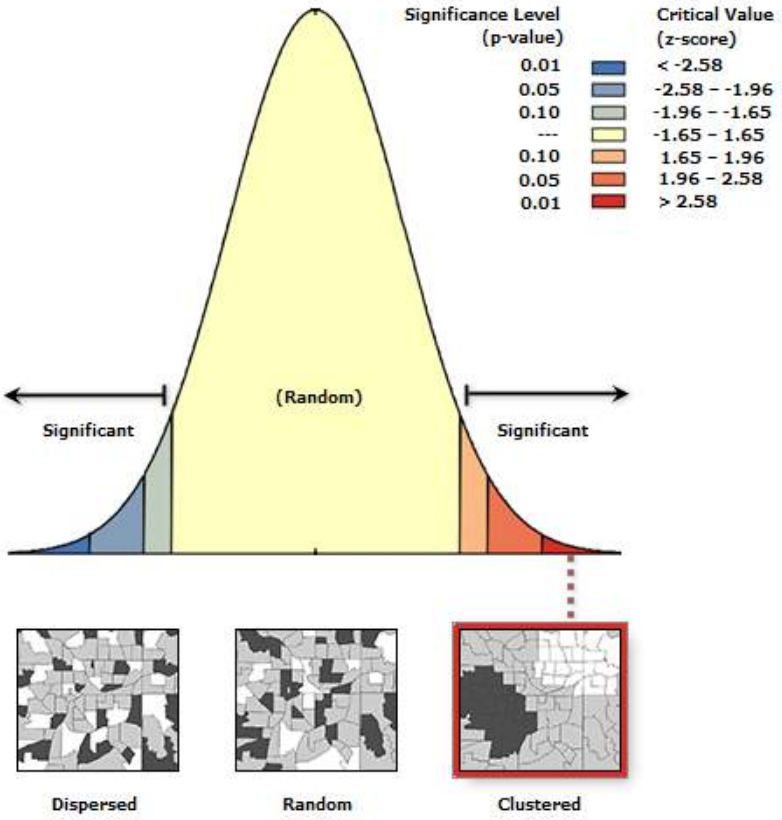
This means that all apartments within 15m of each other share a 99% likelihood of having an almost similar price. Thus, it could be surmised that apartments within 15m of each other share many similar qualities, especially in terms of amenities.

Spatial Autocorrelation Report

Moran's Index: 1.721260

z-score: 3.345490

p-value: 0.000821



Now, although the results reflect these relationships with price per square footage of apartments there are several limitations to the regression:

a) Since this data is not freely nor easily available, local real estate agents had to be telephoned to obtain it. They provided information of units that are for sale and those that were valuated recently. No specific reasoning was provided about affected specific price for the apartment.

b) There is a significant amount of noise in both analyses. This is because there could be other factors such as, age of building, affecting price of apartments. There are two new building complexes that have just been completed and are ready for possession. Apartment prices here are substantially higher than apartments in older buildings despite being closer to the river. For one of the newly constructed buildings, the real estate agent stated that the building was intentionally located near the river, and in the publicity illustrations the river was shown as a clean stream with a lot of green space around it.

c) The sample size used forms approximately 15% of the total number of apartments. This may not be enough to be a true representative of the total housing stock along Oshiwara River corridor.

d) Many other factors that influence apartment prices have not been considered – proximity to public transit, size of unit, quality of interior design, integrity of building, and several others.

e) Wind direction, wind speed, general climatic conditions, could affect the extent of spread of the stench.

In light of these limitations and the regression, it could be surmised, albeit with some caution, that providing additional amenities would increase price per square foot of apartments in the development corridor along the River, despite the River's deteriorating condition.

d. Evaluation of Interventions

The interventions are tested against 3 criteria – Effectiveness, Feasibility and Equity.

GREEN : HIGH **YELLOW – MEDIUM** **RED - LOW**

Effectiveness

Alternatives	Water quality	Edge condition	Accessibility to River	Disaster prevention	Flora & Fauna	Vitality	Total
1. Improving storm water drainage infrastructure and sea level rise resilient strategies along the development corridor using decentralized approach.	Treated & usable for non-potable purposes.	Sub-surface wetland swales – pleasant environment.	Detention basins, wetland swales lining the edge make it very accessible to everyone.	Detention basins prevent loading the River excessively. At case study sites, floods, erosion and landslides have become a thing of the past.	Presence of natural treatment systems create conducive environment for migratory birds and dissuade scavengers.	Detention basins could double up as playgrounds during dry months attracting residents. Wetlands, and planters along sidewalk will create a comfortable micro climate for residents and passersby to pause and talk.	6/6 - HIGH
2. River and riverfront restoration through 'bottom-up' approach – public participation modelled after Bandra Waterfront revitalization project, & modification of (presently) top-down CRZ norms.	Treated and discharged into the sea, instead of re-cycling.	Walking paths, children's playground, festival and event spaces activate the edge.	The waterfront is opened up and made more accessible to residents, passersby and the entire city.	Ripraps and wetlands would break waves and prevent a tsunami in addition to holding on firmly to the soil, thus preventing erosions and landslides.	'Cleaning up' of the edge discouraged scavenging birds and instead migratory and other sea birds are seen there now.	People start using the promenades and waterfronts right from 5 AM up to 2 AM. Most of these are residents, but many are visitors from different parts of the city. It has also attracted a variety of informal businesses - fruit vendors, juice stalls line the promenade during the day, after dusk tea and coffee stalls are set up.	5/6 – MEDIUM HIGH
3. Status Quo.	Ignored, remains the same.	Ignored, remains same, deteriorating.	Ignored, river blocked from view from lower floors.	None. Developments will continue facing floods.	No change from existing condition.	Development complexes will be filled with residents and their visitors, but none at the Riverfront.	0/6 – LOW
4. Spreading awareness and influencing perceptions of space around river ecosystems and their benefits.	No direct impact.	No direct immediate impact.	No direct impact, but expeditions and nature walks might be organized.	No direct immediate impact, but authorities might be pressurized to provide information and disaster management plan.	No direct impact.	No direct impact.	1/6 – LOW

The table above illustrates that Intervention 1 would be most effective while Intervention 3 would be the least. However, a combination of Interventions 1 and 2 might result in a more effective approach.

Feasibility/ Practicality

Alternatives	Timeline	Organizational hurdles	Externalities	Response from users/ residents	Total
1. Improving storm water drainage infrastructure and sea level rise resilient strategies along the development corridor using decentralized approach.	Projects elsewhere have been implemented rapidly. In Mumbai, due to presence of so many stakeholders, it is unpredictable.	MCGM, SWD, Central Housing Societies and its members, individual home owners, informal settlements, MSRTC, MMRDA.	Extensive hydrological, topological, hydraulic research would be required initially before laying the first stone. Cost of procuring plants and other materials.	Might require high initial maintenance and operating costs until the plants grow and become self-sustaining. This might invite push-back from residents. Saving and storing water might relieve them from relying on Municipality's erratic supply, hence positive.	0.5/4 - LOW
2. River and riverfront restoration through 'bottom-up' approach – public participation modelled after Bandra Waterfront revitalization project, & modification of (presently) top-down CRZ norms.	3 years.	MCGM, Bandra residents association, police, private funding agency. All worked in unison since this was a resident-initiated program supported by Municipality.	Led to displacement of informal communities.	Since it was a resident-initiated program it was received very positively. Additionally, the residents created a maintenance fund which is used for operating and maintaining the promenades and its various amenities.	3/4 - HIGH
3. Status Quo	Depending on money available with developers, additional amenities could be provided very easily and rapidly.	None – project undertaken completely by the private developer.	Residents might refuse due to increasing maintenance and operating costs. Gentrification.	It could go either way – residents may accept the additions in lieu of their house values rising, but increased maintenance or operating costs might discourage them.	2.5/4 – MEDIUM HIGH
4. Spreading awareness and influencing perceptions of space around river ecosystems and their benefits.	Both took 2-3 years to develop.	Funding agency, organization/ institution/ individual undertaking the awareness drive.	Could have run short of funds. Shortage of staff to undertake the program. Criticism from architects and planners.	Very positive response as both exhibitions were extended for a significant amount of time.	3/4 - HIGH

Interventions 2 and 4 rank highest in terms of feasibility. However, Intervention 1 appears to be the least feasible. Hence, using parts of interventions 2 and 4 might help creating the impetus needed to kick-start storm water drainage improvement and work towards a more effective solution.

Equity

Alternatives	Residents	Informal Communities	Government	Private agencies/ businesses	River	Flora & Fauna	Passersby	Total
1. Improving storm water drainage infrastructure and sea level rise resilient strategies along the development corridor using decentralized approach.	★	★	★	★	` ★	★	★	7/7 - HIGH
2. River and riverfront restoration through 'bottom-up' approach – public participation modelled after Bandra Waterfront revitalization project, & modification of (presently) top-down CRZ norms.	★	✗	★	★	★	★	★	6/7 - HIGH
3. Status Quo	★	✗	✗	✗	✗	✗	✗	1/7 - LOW
4. Spreading awareness and influencing perceptions of space around river ecosystems and their benefits.	★	✗	★	✗	★	★	★	3.5/7 - MEDIUM

Intervention 1 appears to be the most equitable alternative. Intervention 4, however, appears to be extremely positive except that none of its impact directly benefits anyone, except probably, the person who holds the exhibition.

Intervention 2 is a close second, however, it does nothing to take care of displaced informal communities. Herein lies one of the greatest discrepancies of this evaluation. The impact on informal communities is deduced as negative because of the elitist attitude of the public wherein under the pretext of 'beautification' informal settlements and encroachments are bulldozed away from the waterfront. In the context of this evaluation it could be argued that this impact is significantly greater than the impact on passersby or the private agencies or businesses – for instance, 3,000 *slum dwellers* could be evicted and rendered homeless overnight, while 20 people passing by would find the new waterfront attractive and decide to hang out there every day. Would this mean that evicting *3,000 slum dwellers* would be same as losing 20 new visitors to the waterfront? Probably not. Hence, due to the absence of an unbiased rationale for designating a hierarchy to the people / agents affected by these interventions, they have all been assumed to be the same, for the purposes of empirical evaluation. However, close attention must and will be paid to who is and who is not affected while recommending policies and implementing interventions.

Finally,

Alternatives	Effectiveness	Feasibility	Equity	Total
1. Improving storm water drainage infrastructure and sea level rise resilient strategies along the development corridor using decentralized approach.	HIGH (6/6)	LOW (0.5/4)	HIGH (7/7)	13.5/17
2. River and riverfront restoration through 'bottom-up' approach – public participation modelled after Bandra Waterfront revitalization project, & modification of (presently) top-down CRZ norms.	MEDIUM – HIGH (5/6)	HIGH (3/4)	HIGH (6/7)	14/17
3. Status Quo	LOW (0/6)	MEDIUM – HIGH (2.5/4)	LOW (1/7)	3.5/17
4. Spreading awareness and influencing perceptions of space around river ecosystems and their benefits.	LOW (1/6)	HIGH (3/4)	MEDIUM (3.5/7)	7.5/17

Overall, Intervention 2 appears to be the strongest alternative, closely followed by intervention 1. While, the no intervention alternative scored the lowest. Intervention 4 appears to be the most feasible alternative of the lot.

Thus, a combination of alternatives 1,2 and 4 would help achieve a positive approach towards addressing the issues of Oshiwara River.

e. Conclusion

After analyzing the symptoms of Oshiwara River, scrutinizing its issues and proposing various interventions, these are some of the many aspects where new or modified policies could be recommended to achieve the most effective, feasible and equitable result for the River itself, and the development corridor along it:

1. Strategies and designs to improve storm water drainage infrastructure along the development corridor require to be laid out soon before the entire system collapses leading to large scale disaster.

2. Decentralized approaches to storm water drainage treatment and management should be undertaken to ease load from existing deteriorating drainage and water supply infrastructures.

3. Strategies and designs for making the urban corridor sea level rise resilient must be prioritized.

4. Participation of residents and experts is essential during the design development stage to not only create awareness of the proposal's benefits, but also provide them with a sense of ownership.

5. Promote transparency in the planning stages by encouraging cross-departmental collaboration (storm water management, road transport, sewerage, and housing) and public participation.

6. Modify existing norms of the Coastal Regulation Zones and make them more flexible according to topography and hydrology of the site. This could be used as an incentive to interested developers to use Best Management Practices for storm water treatment and management.

7. Set up strict urban river water quality standards and perform regular maintenance and inspections.

8. Adopt revenue generating mechanisms along the River instead of charging special fee to the residents.

9. Encourage and subsidize public awareness programs via art and architecture exhibitions.

10. Distribute survey questionnaires and informational leaflets in areas vulnerable to floods, sea level rise and other natural calamities.

11. Revitalizing Oshiwara River into a natural amenity like an ecological corridor, to prevent it from getting neglected and instead, benefit residents and communities along the corridor.

Relating this analysis back to questions asked initially –

- To what extent does public and Municipal perception of the Oshiwara River affect the urban corridor's ecology?
- Can there be a correlation between hydrology and land-use along Oshiwara River urban corridor?

The analysis revealed that the need to spread public awareness and the need to involve local populations during the decision making phase appears to be the most essential intervention. Additionally, the importance of improving storm water drainage infrastructure and proposing sea level rise resilient strategies along the urban corridor, illustrates the need to integrate the site's physiology with land use. Thus, a two pronged approach of upgrading infrastructure sensitively, and utilizing local knowledge appear to be most relevant to maximize the various potentials provided by the Oshiwara River urban corridor.

5. Intervention Details: HYDROLOGY AND LAND USE

Resilient Oshiwara River Watershed – Decentralized approach to storm water management and strategies to mitigate impact of sea level rise.

The lack of permeable surfaces puts tremendous load on the city's infrastructure resulting in devastating floods. Additionally, with climate change imminent and sea levels rising, more hydrologically sensitive approaches need to be adopted to make the city resilient. The proposed strategies include Low Impact Development urban design tools effecting a decentralized approach to address storm water treatment and drainage, and sea level rise proofing the corridor using wetland restoration techniques, combination of horizontal and vertical levee systems, and strategically surrendering some low lying areas to create detention basins.

Outline

To propose a resilient watershed for Oshiwara River, the author proposes the following approach –

1. An improved storm water drainage system based on best management practices after understanding of the existing system.
2. Propose strategies to protect and strengthen the vulnerable mangrove forests and wetlands, thereby protecting the coast.

To support the proposals, relevant case studies at similar contexts have been looked at, and Government policies and regulations with respect to these issues are listed. Finally, strategies to encourage public involvement will be proposed.

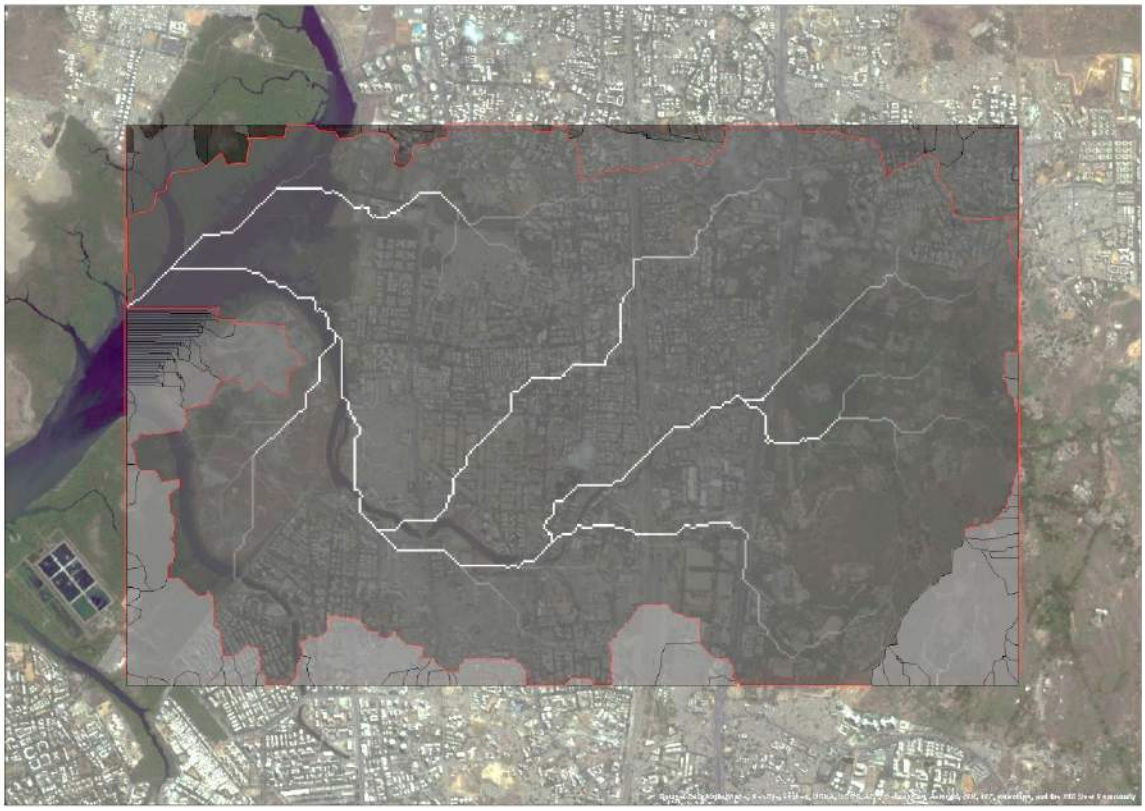


Image 22. Oshiwara river watershed. Most of the watershed lies upstream, in the Sanjay Gandhi National Park. The moment it enters the urbanized territory it starts getting polluted. It travels 3.5km (2.19 miles) in the urban environment before flowing into the Arabian Sea. Area of the entire watershed is approximately 4,500 acres or 7.1 sq.miles.

Failure to address such issues has resulted in many devastating floods, the most recent one was in July 26th 2005 - 39 inches of rain fell in 1 day destroying infrastructure and killing 435 people (Mumbai Fact finding committee, 2006).

Image 23.
The existing storm drains were unable to deal with rains and the high tide simultaneously. This caused back flow of water from the drains and flooded the city.

In addition to issues of flooding, climate change is causing sea levels to rise globally. Mumbai is one of the most vulnerable cities globally[19]. By turn of the century sea level around Mumbai is projected to rise by approximately 48cm[20], which along with tidal and storm surge could have devastating impact along the coast. There has been very little to no studies carried out on this issue. A google search reveals a couple of newspaper articles mentioning the possibility of sea level rise and the need for planners to consider it while preparing future plans[21] and a report from the National Institute of Oceanography in Goa[22]. There is need for a lot more research in this field.

The following are maps showing the areas that would be impacted by rising sea levels.

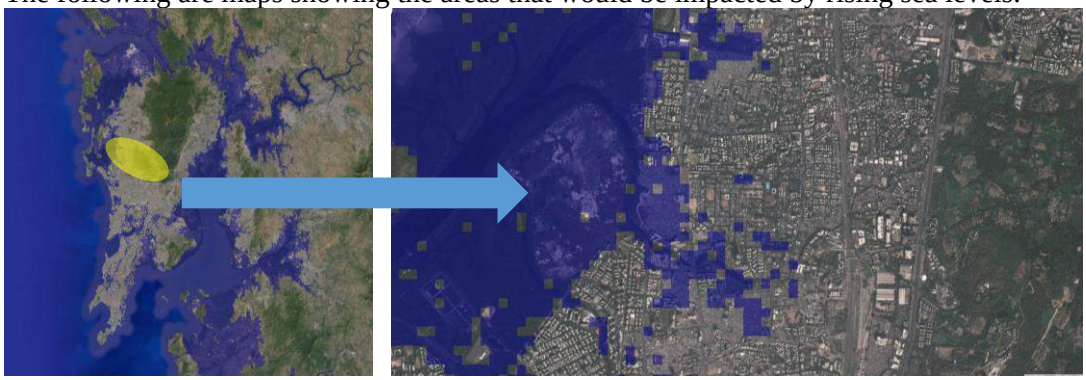


Image 24. *Source – Global Sea Level Rise Map (Global Sea Level Rise Map)*

[19] http://www.livescience.com/38956-most-vulnerable-cities-to-flooding.html , Tia Ghose – August 18, 2013.
[20] http://www.ipcc.ch/pdf/unfccc/cop19/3_gregory13sbsta.pdf , 2013 (IPCC 5th Assessment Report, 2013)
http://www.moef.nic.in/sites/default/files/Unni%20-%20Coastal%20India_0.pdf , 2013
[21] http://timesofindia.indiatimes.com/city/mumbai/Keep-room-for-sea-level-rise-in-city-planning-Environment/articleshow/28607640.cms (January 10th, 2014),
[22] http://www.moef.nic.in/sites/default/files/Unni%20-%20Coastal%20India_0.pdf

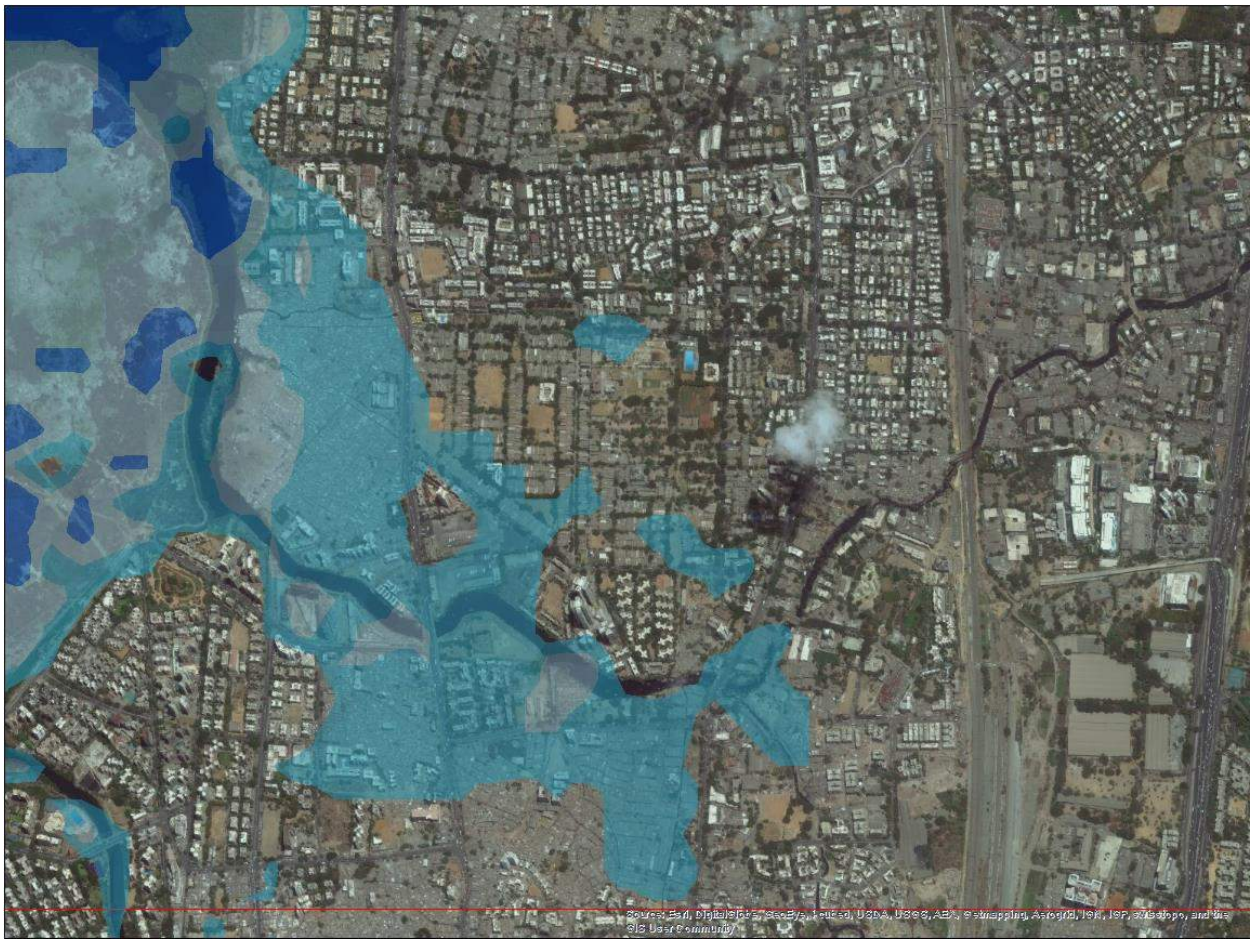


Image 25.
Inundation map – all areas in light blue will be inundated by 2050. These calculations take the high tide level (4.5m) into account.

Issues

Analysing the context reveals the following main issues:

Storm water management and design

- Effluents and solid waste is entering city's rivers and polluting them.
- Existing storm water drains are at maximum capacity resulting in back-flow of storm water during high tides.
- All storm water collected is drained, untreated, directly into the Sea.
- Despite the city being an island, and receiving average annual rainfall of 85in, it suffers from shortage of water.

Mangrove forests and vulnerable coast

- Rising sea levels due to climate change could have devastating impact on existing development and the mangroves, wetlands and other riparian habitat along the River corridor.
- Lack of awareness of these issues among residents of the corridor.

Goals

To address the various issues present in Mumbai's storm water system today, the Oshiwara River corridor is used as a test site to set these goals for the proposal:

- Protect water quality through primary treatment of storm water.
- Slow and reduce storm water entering the rivers thereby prevent floods.
- Promote use of storm water for non-potable purposes.
- Revitalize natural watershed functions.
- Transform the water way into a public amenity.
- Strengthen coastal edges using combination of horizontal and vertical levees.
- Protect mangroves and wetlands along the coast from drowning due to rising sea levels through adaptive strategies.

Site analysis and design conceptualization

Two aspects of the site will be analyzed in order to design the proposal.

1. The mangrove foroests along the coast
2. The Oshiwara River corridor.

Mangrove forests

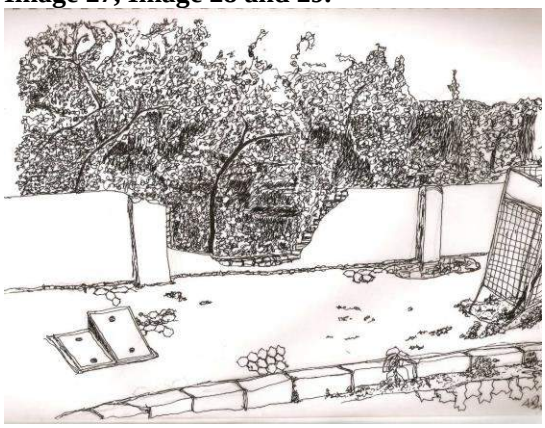
Image 26.

Mangrove forests are said to be the lungs of Mumbai. They form a buffer around the city protecting it from tidal surges, soil erosion in addition to purifying storm water before it is released into the sea. They also form a natural habitat for many species of flora and fauna.

The most common types of mangrove tree species are – Avicennia marina, Rhizophora apiculata, and water hyacinths.

The Oshiwara River's mouth is in the Versova Mangrove forest. These mangroves extended deep into the mainland until much of it was deforested and built on by developers. Only in the last two decades, thanks to constant protests, the Government has set regulations (Coastal Regulation Zones) to protect the remaining mangrove forests. However, recently, the state high court freed mangrove forest land for developers to build on. The Mumbai high court has filed an appeal against this ruling to the dismay of many developers and residents[23].

Image 27, Image 28 and 29.



These were drawn by the author on site showing the present state of the mangroves. The mangrove forests are now bounded by a perimeter wall and residential developments. While within the mangroves there exists a serene calmness removing one from the hustle and bustle of city life.

This blocking of the mangrove forests from the public realm hampers spread of awareness and knowledge of the various benefits these natural systems have for the city. This creates a sense of apathy among the public resulting in dumping of garbage and urinating behind the perimeter wall. Such mis-treatment results in destruction of the forests edge, foul stench and gradual destruction of the entire system.

[23] The present rule charges Rs.6/sq.ft from every resident whose building is within the coastal regulation zone boundary.

Presently, the mangroves forest are looked after by the ministry of environment and forest. No development is allowed with it. The Versova Waste Water Treatment Facility (WWTF) is present there. Its 6 aeration tanks can be seen in the satellite image.

Image 30.

Sea Level Rise is anticipated to engulf almost all of the mangrove forests and start penetrating parts of the urbanized blocks via the existing rivers and channels. Thus, making those the most vulnerable areas that need to be addressed through climate change adaptation strategies.
The following are the most extreme vulnerabilities of the mangroves:

i. Entire mangrove forest will be engulfed by rising sea levels by 2100.
ii. Levels of all rivers and channels that drain into the sea via the mangroves will also rise thus risking all development alongside it.
iii. All of Mumbai's waste water treatment facilities will be at major risk because they all lie in the mangroves. Thus not only causing massive physical and financial damage, but also, contamination of the sea, thereby risking aquatic lives.
iv. Loss of habitat for flora and fauna.
v. If the mangroves are destroyed Mumbai city will become extremely vulnerable to floods, and coastal erosion, leading to greater economic and physical loss.

In order to address these vulnerabilities various adaptation designs will be proposed referring to case studies and best practices.

PROPOSALS

a. Sea Level Rise

Oro Loma Ecotone Project[24]
This is a project proposed by the Oro Loma Sanitary District, San Lorenzo, to build climate change resiliency along the bay shoreline with green infrastructure and treated wastewater.
The goals of the project are:

- To use treated wastewater as a resource in marsh restoration and create historic upland habitat.
- To lower nutrient and emerging contaminant discharges to the Bay by using Green Infrastructure model.

[24] Oro Loma Ecotone Project, Jeremy Lowe, ESA

- To protect vulnerable wastewater treatment plants and adjacent improvements from rising sea levels and remove aging outfall infrastructure from the hazard zone.

The proposal aims to construct a vegetated ecotone slope, bayward of the flood risk management levee and landward of the tidal marsh to emulate a natural upland.

The ecotone slope will:

➔ Create an upland/transitional ecotone and restoring elevation and salinity gradients that are missing in many parts of the Bay due to diking and provide endangered species habitat more resilient to sea level rise.

➔ Create gently sloping upland to act as buffers to waves and sea level rise, with greater productivity to increase accretion rates, with the ability to treat stormwater, and at costs significantly lower than traditional levee designs.

➔ Act as treatment wetlands to polish wastewater discharge as an effective low cost low energy, and environmentally sustainable method to nearly eliminate nutrient loadings and impurities from receiving waters.

Image 31.

The following shows the progression of the horizontal levee from highest to lowest:
Land >> Grassland >> Tidal Marsh >> Tidal Mud Flat >> Shallow Bay

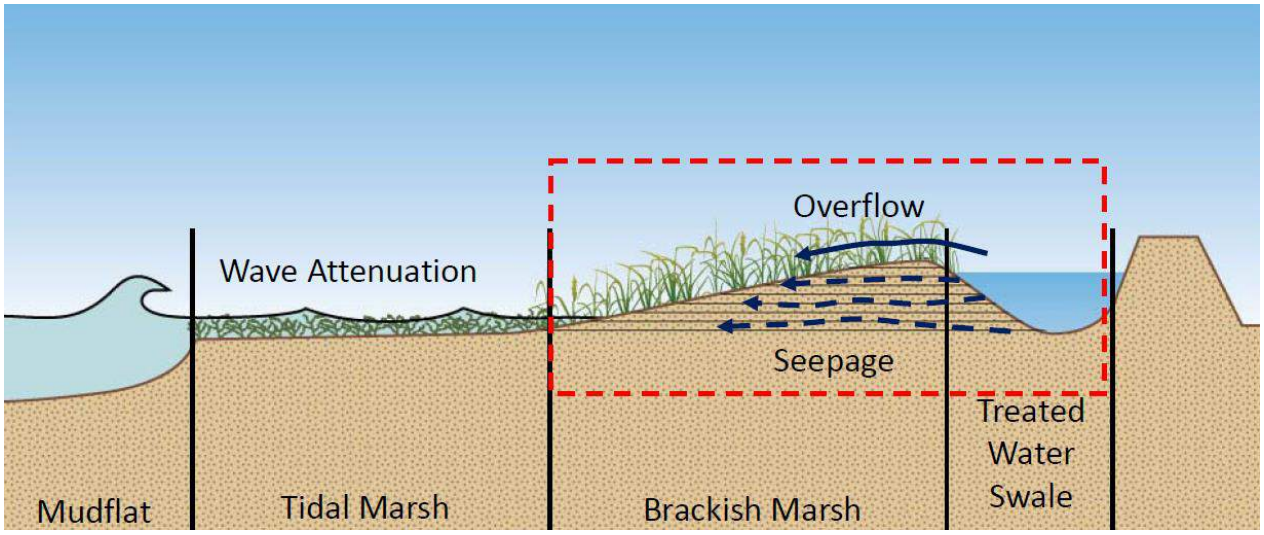


Image 32.

The berm surrounding the facility will be constructed as a short section of seepage slope allowing the treated wastewater to seep into the moist grasslands/ bayland ecotone. Native species will be planted on the ecotone slope to emulate a natural alluvial fan substrate, topography, and subsurface discharge patterns. Water that passes through the slope will be returned for treatment and discharge through the main Municipal outfall.

The co-benefits of the intervention would be:

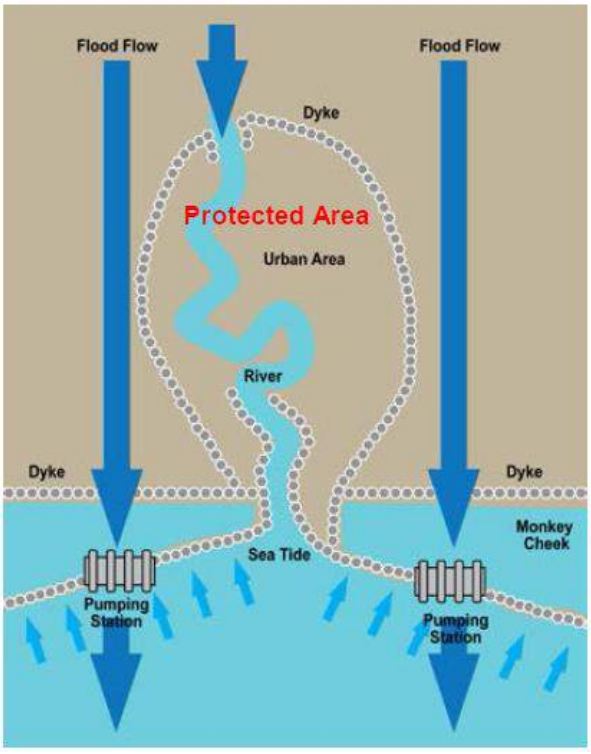
- Wastewater:
  - Wet weather equalization
  - Denitrification
- Ecological
  - Creates historic ecotone
  - High tide refuge
  - Allows continual growth of marshes
- Flood Risk Management
  - Increases wave attenuation
  - Reduction in levee size and maintenance
  - Removal of infrastructure from hazard zone.

This project would be a pilot intended to act as a laboratory for increasing understanding of seepage flows, vegetation establishment and water quality processes on ecotone slopes.

His Majesty the King of Thailand's Monkey Cheeks Project

This project was proposed by His Majesty the King of Thailand in 1995. The inspiration for the project originated from the King's observation of monkeys – when they were given bananas they would store up all the bananas in their mouths until their cheeks filled up and then they would chew and swallow the bananas. Accordingly, the project promoted water detention systems for solving the flood problems of Bangkok and also other areas of Thailand.

The proposal was to be a drainage system from the upper areas through a regulator by gravity flow and pumps. In a contrary manner, if the sea level is higher than the water level in the canal, the regulator is closed in order to prevent back flow of water. Thus, from this idea, there are three main components to the project: dikes, Monkey Cheeks or water detention basins and regulators and pumping stations. These components work in relation with sea tide.



His Majesty also suggested the construction project of the dug-canal and the sluice. It is because the Chao Phraya River is meandering the floodwater has to flow longer in order to drain to the south – or to the sea.

This dug-canal sluice project was built as a shortcut to quickly sluice water out of the river to the sea in large volume; the flood water from the north will flow through the canal, not through the meandering river and drain to the sea.

Image 33.

Bay Arc – San Francisco

Bay Arc is a Tidal Responsive Barrier designed by Skidmore Owings and Merill.
It is a minimal, lightweight and environmentally sensitive system designed to protect the San Francisco Bay Area from periodic high water levels associated with net membranes and tension. It has been touted as a concept that has the potential of buoyancy and the structural efficiency associated with net membranes and tension. It is a concept that has the potential to eliminate billions of dollars in permanent levees and localized Bay Area flood protection without compromising the Bay's system of ecology and commerce.

Among the alternatives, this one appears the most fantasy-like. However, with rapidly advancing technology and scientific progress, projects like these might become commonplace by end of the century. Hence, it may not be wise to dismiss it instantly.

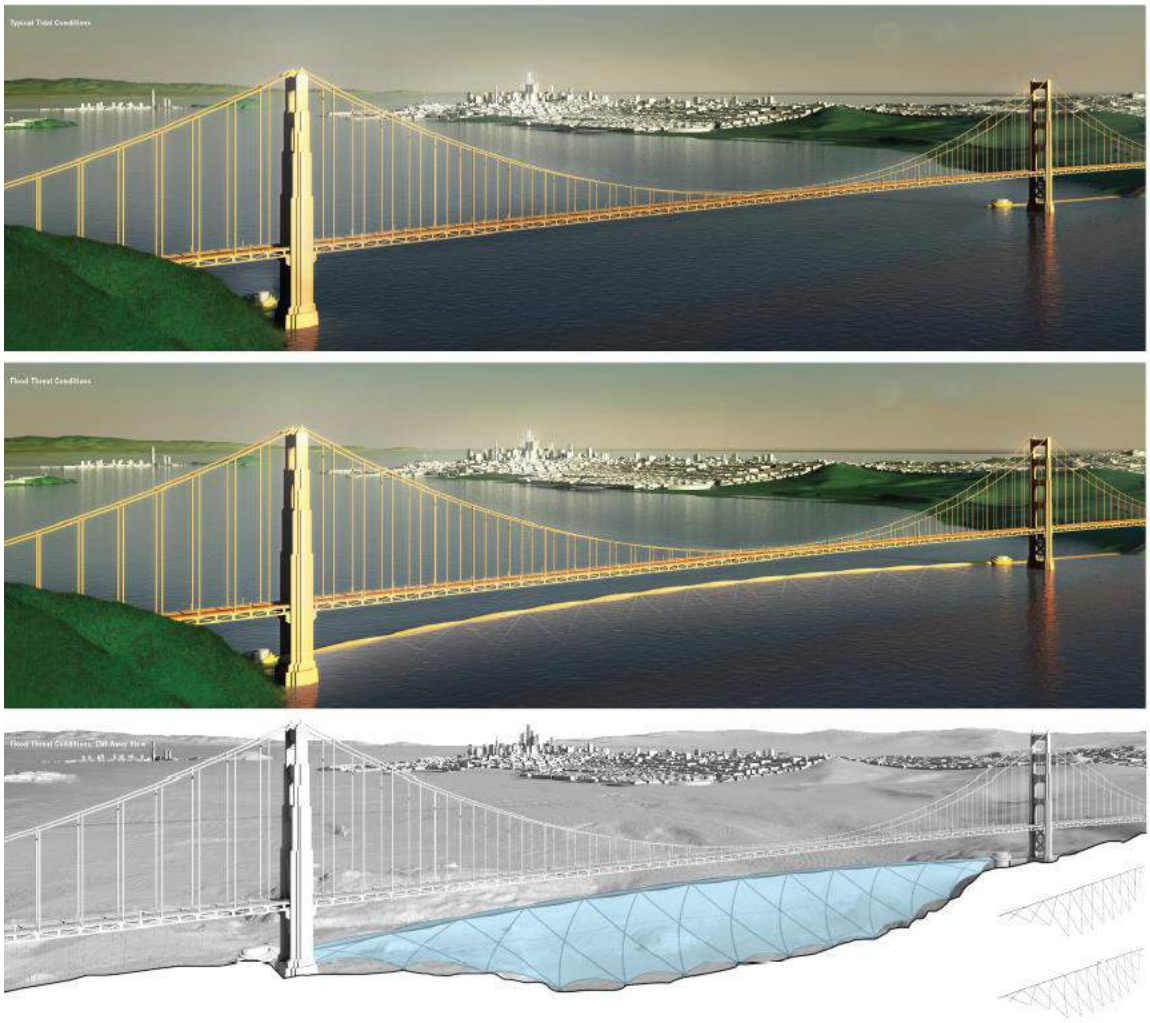


Image 34.

Relevant lessons:
These are the lessons that could be learnt from the two case studies:

1. A transitional ecotone slope could be constructed along the bayward side of the mangrove forest.
2. Monkey cheeks or detention basins could be proposed along the river corridors to detain the storm water before it is released back into the sea during low tide.
3. A sea curtain could be built at the edge of Arabian Sea and Versova lagoon to control the amount of water entering and leaving the Versova lagoon.

Intervention
Based on the above mentioned case studies and site analysis, the following measures can be proposed:

a. Manage the mangrove forest ecosystem to prevent or reduce further impacts.

b. Moderate intervention – recreate some of the historical site characteristics – grade channels, remove exotic vegetation.
c. Large scare intervention – re-grade much of a site, replant native vegetation.
d. Construct a transitional ecotone slope using tidal marshes (native) along the bayward side of the mangrove forests.
e. Monkey cheeks constructed in residential neighborhood blocks.
f. Oshiwara River and other streams and channels could works as sloughs controlled by gates that would release the water only during low tide times.
g. Propose a fantasy vision for a sea curtain at the mouth where Versova lagoon meets Arabian Sea.
h. Strategically surrender some parts of the Oshiwara River corridor to the rising sea levels. The area on the Development Plan (designed by Mumbai Metropolitan Regional Development Authority) has been marked as 250 acre property for building a business district. However, if part of this area was surrendered to the sea and a detention basin created, then, not only would the regional Government could set a precedent for rest of the city to follow, but also minimize flood risks due to rising sea levels.

Image 35.

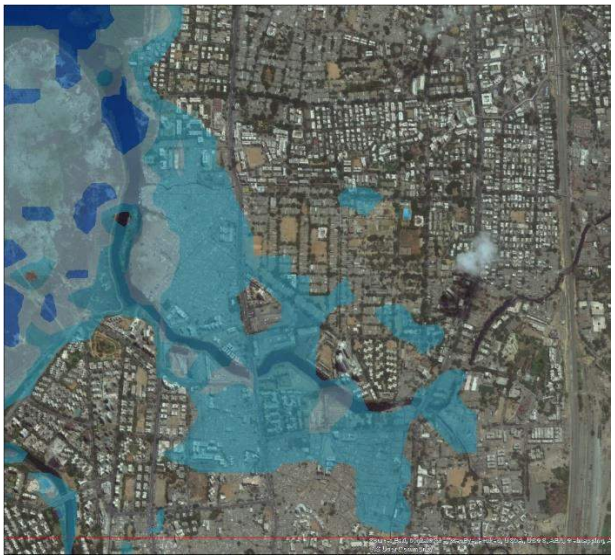


Image 36 and Image 37.

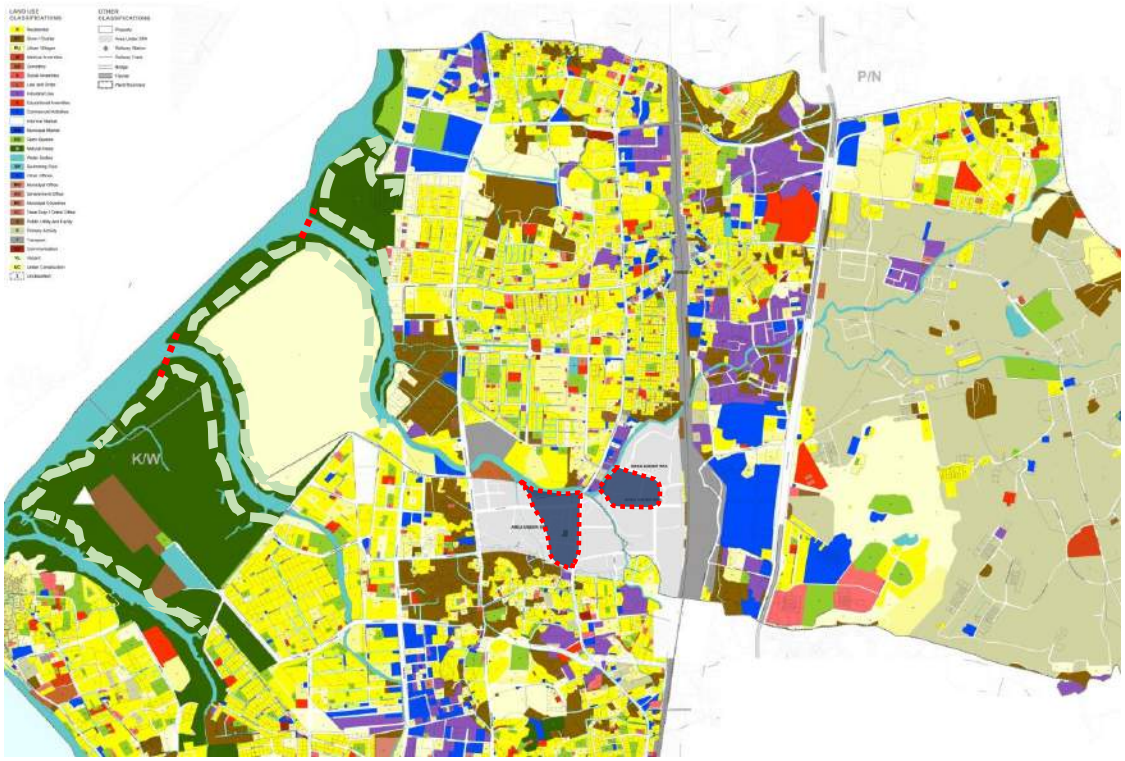


Image 38.

Surrendered Areas

Ecotone Slope

Regulatory Gates

Image 39.
Existing conditions.

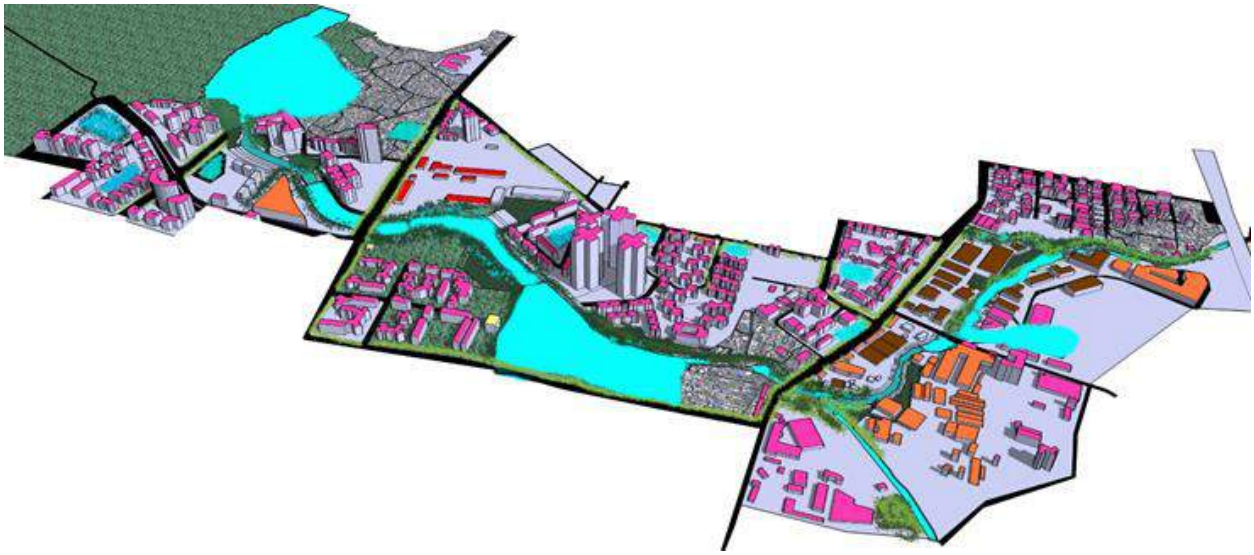


Image 40.
Proposed conditions.

This manner of reinforcing and protecting the mangrove forest could be one of the strategies by which not only will Mumbai's coastal edge will be preserved, but also it will help maintain consistent levels of water in the city throughout the year.

In order for the city to be able to drain into and feed from these strategies efficiently, the storm water drainage and management systems would have to be revised. The next section elaborates on various best management practices for storm water drainage and management along Oshiwara River corridor.

b. Storm water drainage management and design strategies

Image 41.

The site selected is downstream of the Oshiwara River watershed.

This particular stretch has been chosen because it is the most urban (highest density of buildings) part of the entire corridor.
Also, along with multiple residential complexes, a large plot of land owned by the Municipality faces the river. This presents an opportunity to propose strategic adaptive measures to address flooding and sea level rise related issues.

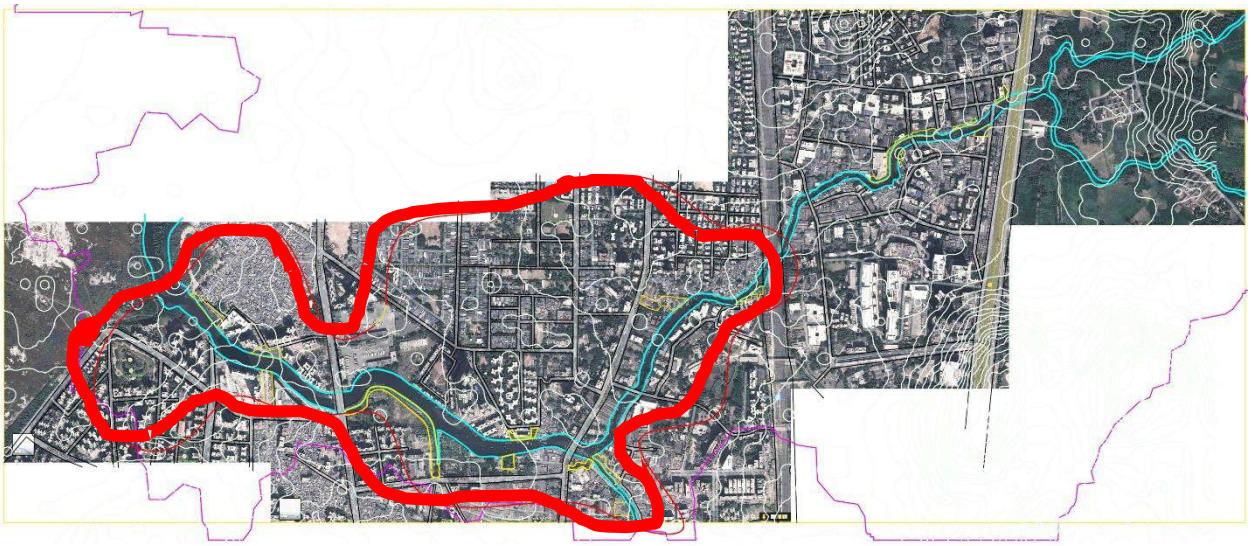


Image 42.
The thick outline in red is my area of interest for the proposal. The thin outline in magenta is the entire river's watershed boundary. The area of this sub-watershed is 936 acres.

Next, I analyzed the site for sink points. A sink is a point or cell on a digital map that represents a sudden drop in elevation. These could be due to error in data, or sudden depressions on ground. Generally, while creating a depressionless DEM all sinks are filled in and a uniform watershed map is formed. For the purposes of this paper, locations of sink points are used as depressions on site representing areas most prone to flooding.

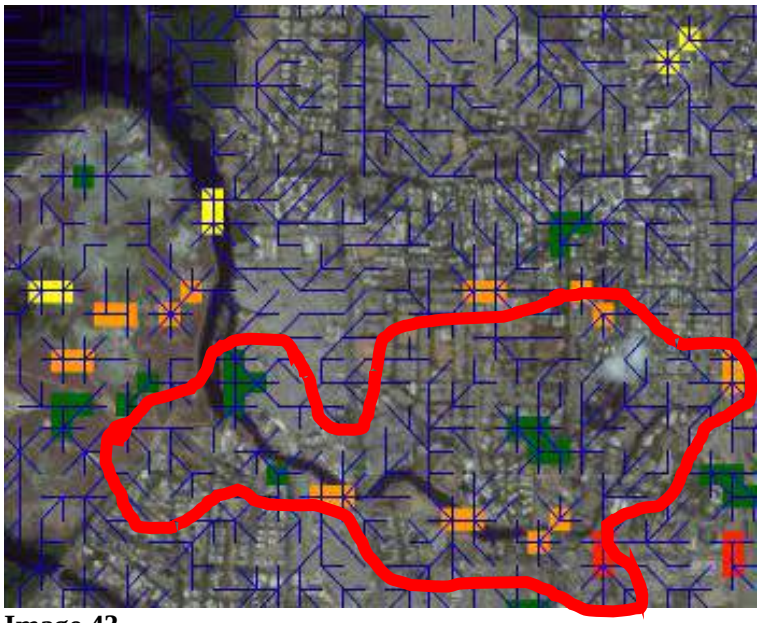


Image 43.
The map above shows all sink points in the area of interest. Red being the deepest and green being closest to ground level. This shows that the sink points are spread evenly throughout the site.

These are used as opportunity to propose decentralizing the storm water collection points. Instead of collecting water from surface drainage, building terraces into one big pipe and taking that to the Sea, each neighborhood could collect, detail and treat the water before letting it out to the Sea. Thereby, not only reducing load on the system, but also, improving the water quality. Some of this water could also be re-used by the residents for non-potable purposes. This could potentially reduce load on the city's water supply infrastructure as well.

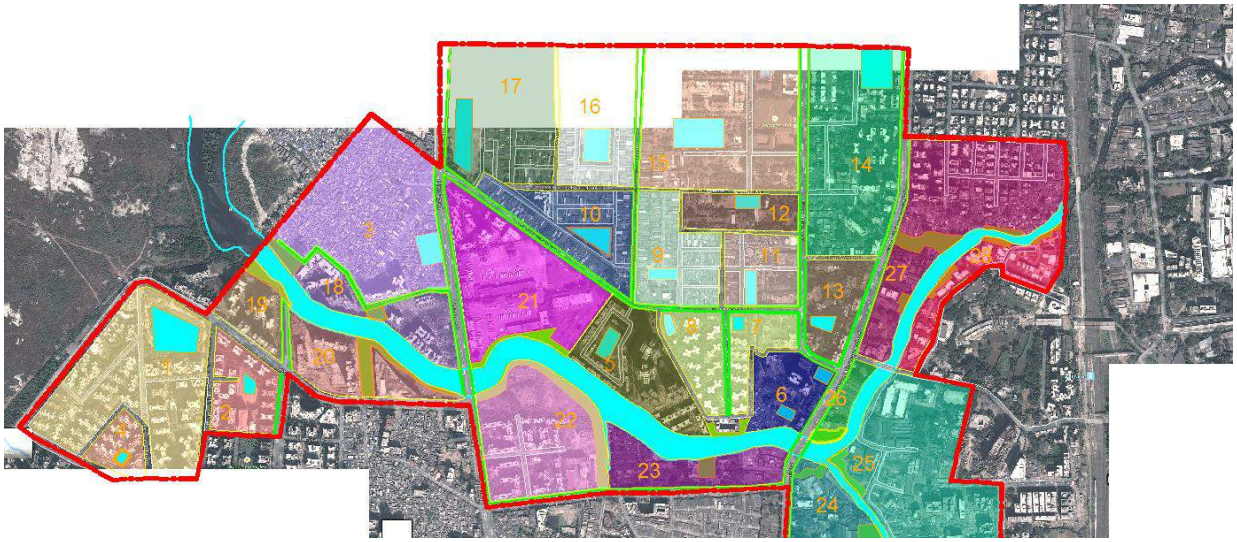


Image 44.

In keeping with this idea, the site boundaries are redrawn according to neighborhood blocks. The outline in red traces boundaries of various neighborhoods. There is immense potential on these opportunities already present on the site. Instead of creating a new separate system to address the issues, I propose a decentralized approach of storm water management.

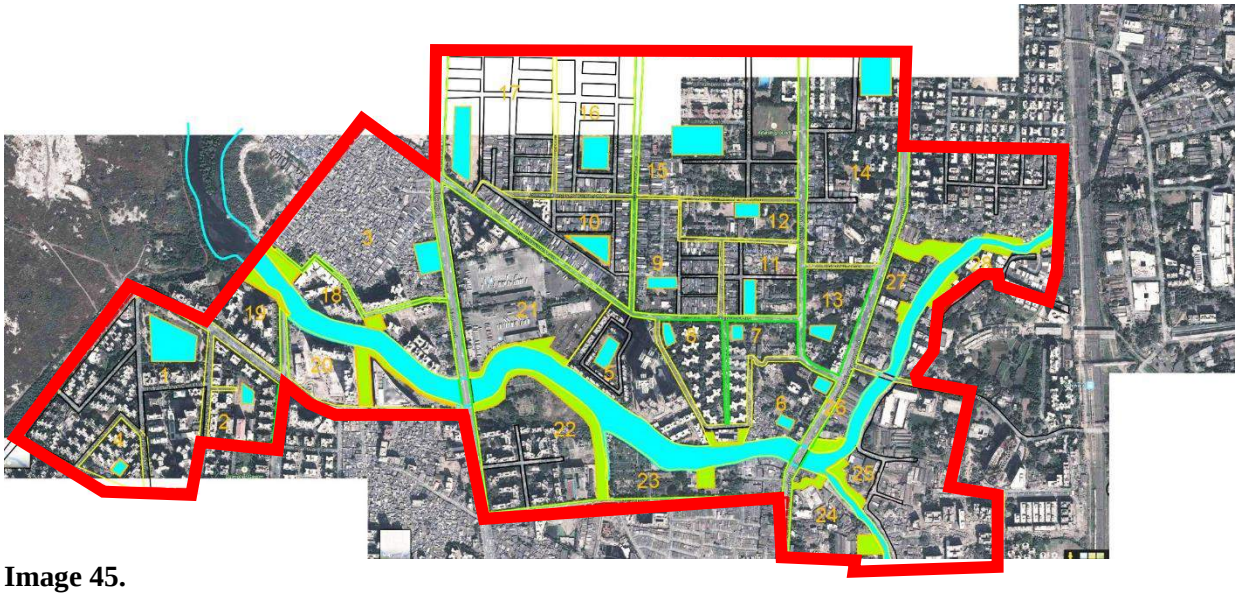


Image 45.

The blue and green polygons are locations where the storm water collection and treatment is proposed. These are based on locations of sink points in the site. Additionally, bio-retention chambers are proposed below sidewalks – shown as twin lines in green on the major roads.

Intervention

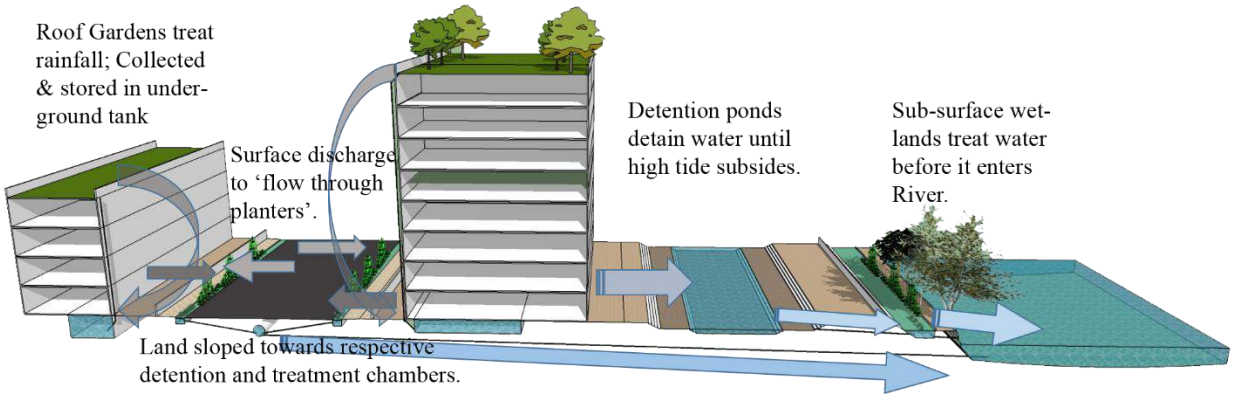


Image 46.

Here the water gets treated through multiple ways:

1. Rain falling on terraces can be captured via vegetated roofing strategy. This will not only reduce the volume of rainwater coming down, but also treat it. Water from here will be collected in rainwater storing tanks located near the buildings underground water supply tank.
2. Combined flow through planters (bio-retention planters) along sidewalks will help capture and treat surface runoff. Sizes for these are designed using flow-based method.
3. Detention ponds in residential blocks will help capture, treat and store temporarily water from surface runoff within the demarcated neighborhood block (proposed sub-watersheds). The sizes of these are calculated using volume-based method.
4. Sub-surface flow wetland systems are proposed along edge of the river to collect surface runoff in addition to the treated water from detention ponds of neighborhood blocks abutting it. This will prevent effluents and harmful pollutants from entering the river. The sizes of these are calculated using volume-based method.

In order to convert this concept into a realistic proposal, the site was divided into 28 sub-watersheds defined by neighborhood blocks.

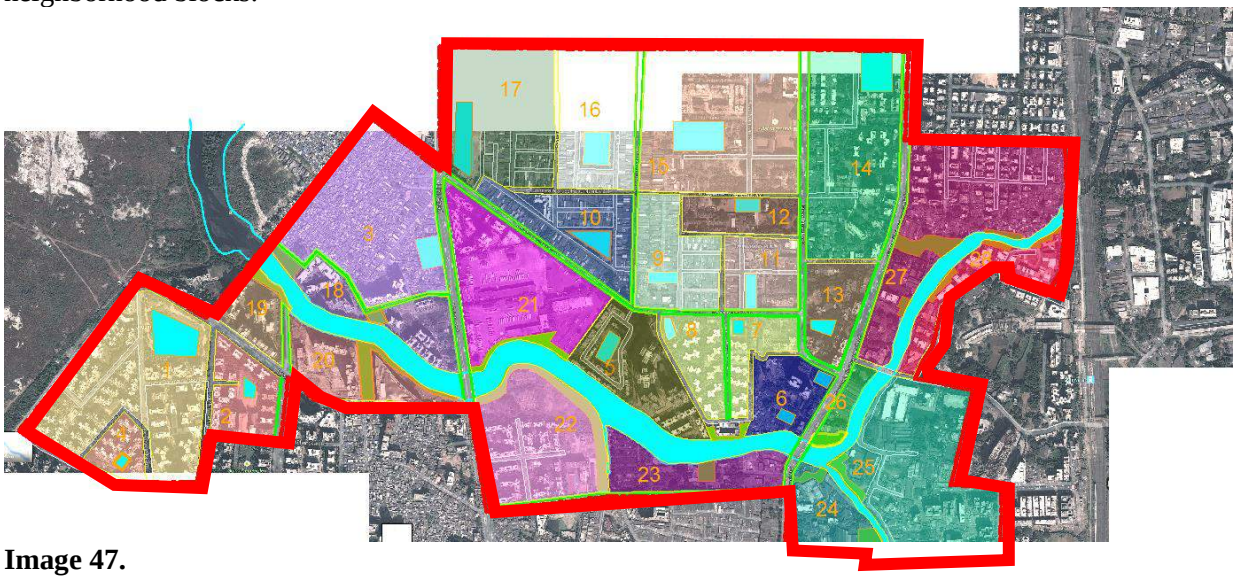


Image 47.

Each sub-watershed is demarcated in a different color and numbered. The following pages show the various calculations undertaken for the proposed interventions.

Calculations

Total area of site: 3,788,006 sq.m => 936 acres.
Total area of Oshiwara River: 1,057 sq.m = 0.1 acres
Total built-up area (impermeable): 929,866.8 sq.m = 229 acres
Total open space (permeable): 2,857,082 sq.m = 707acres

➔ To find the required areas for Bio-retention intervention (planters along sidewalks)
a = CiA/r

a= required area of bio-retention planters
C = runoff coefficient (for asphalt C=0.95)
i= rainfall intensity = 0.2 inches/ hour
r= infiltration rate = 5 inches/hour
A= Area of watershed under consideration (all public right of ways where bio-retention planters will be proposed) = 61 acres

a= (0.95 X 0.2 X 61) / 5
a= 2.32 acres.

Hence, Area of bio-retention planters along sidewalk should be equal to or more than 2.32 Acres.

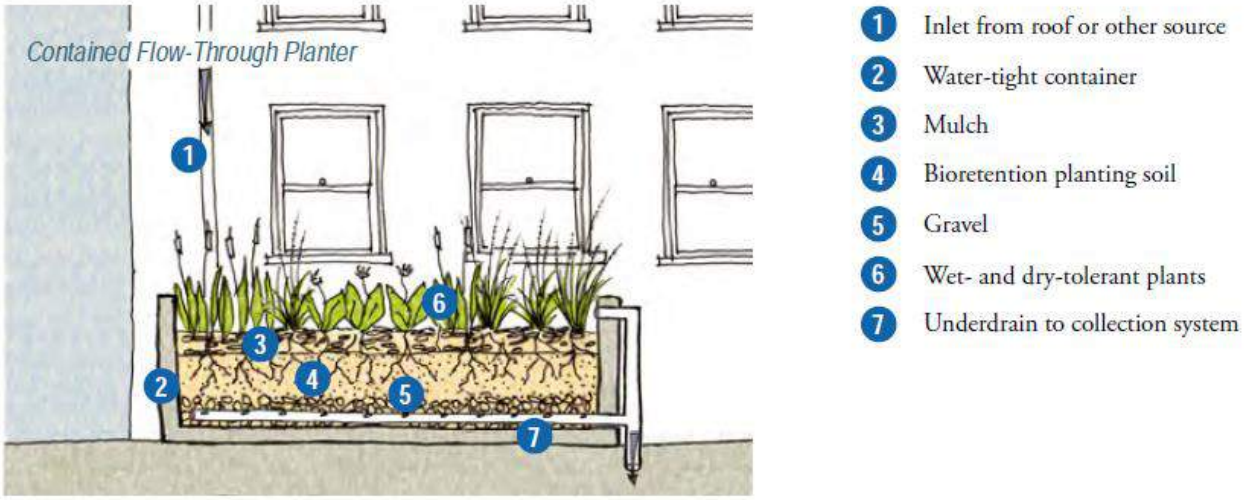


Image 48.
This figure above, shows the various elements of this system.[25]

The only limitation of this system is that it will require irrigation and maintenance during non-monsoon months (November to May). One way this issue could be addressed is through Government incentives for neighborhoods to recycle their grey water and use it here.

Calculation for the 28 sub-watersheds:
1-17 sub-watersheds use the detention pond system to treat and detain storm water. Calculations for sizing these detention ponds are carried out using the Volume-based method.

18-28 sub-watersheds use the sub-surface wetland system. Calculations for sizing these are carried out using the Volume-based method.

[25] SFPUC BMP Facts Sheet, July 2010.

➔ To find required sizes for storm water detention ponds and sub-surface wetland systems.
Volume based calculation is used.

Water quality volume = Area X Unit Volume

Here,
Area = area of sub-watershed
Unit volume = unit volume for storing rainfall runoff based on the need to detain 80% of annual runoff for 48 hours.

For Mumbai, India the composite runoff coefficient is set at 1.
Using the percent rainfall runoff capture curve graph[26], I fixed the unit basin storage volume at 0.8inches or 0.07feet.

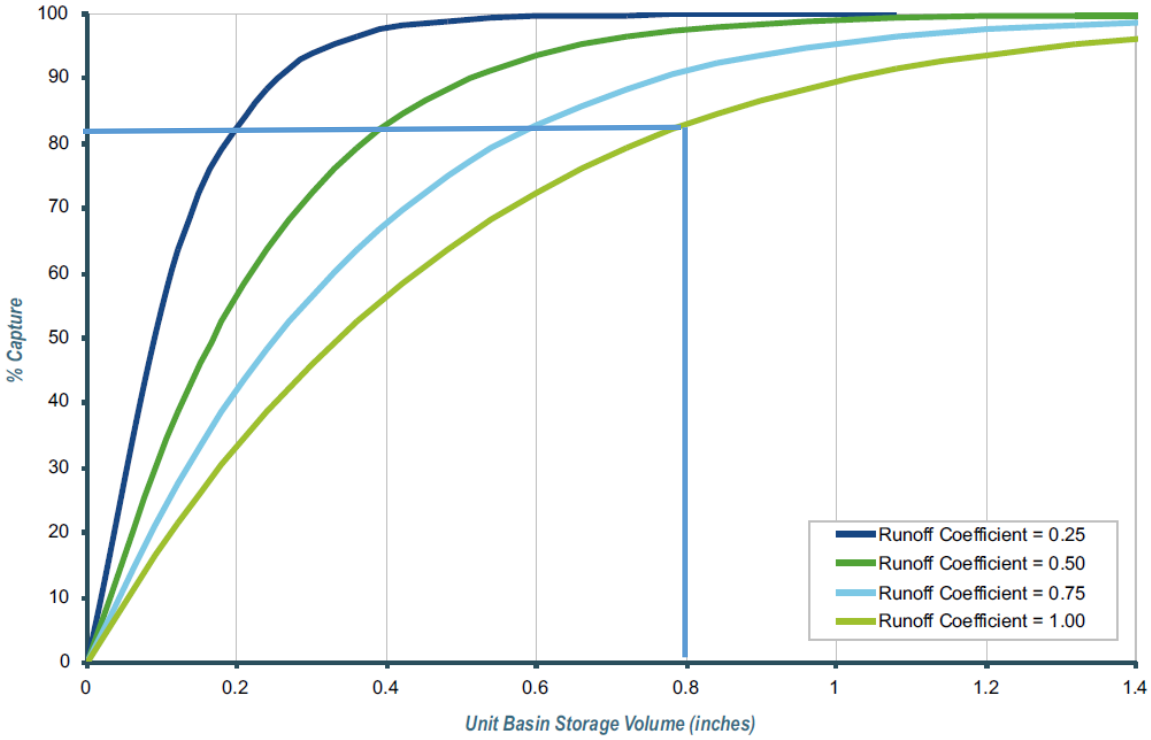


Image 49.
The graph on the following page shows sizes for all the sub-watersheds.

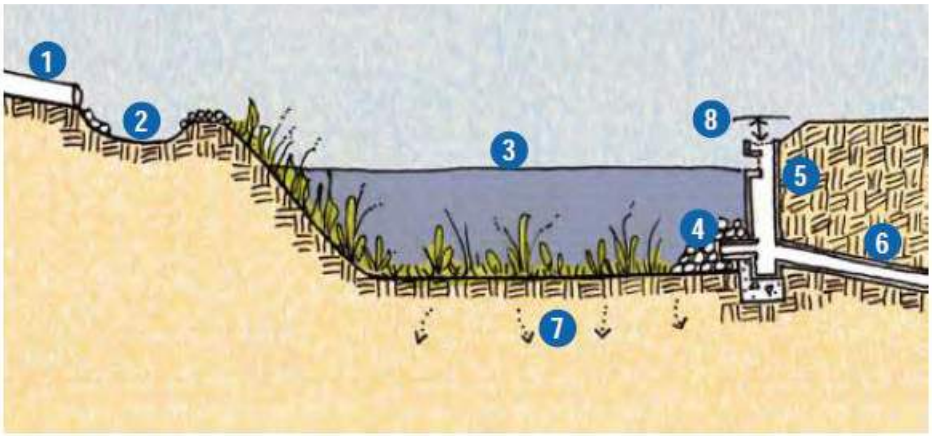
[26] SFPUC Storm water design guidelines, 2010

Sub - watershed	Area	Unit Volume (feet)	Water quantity volume (acre feet)	Depth -as per calculation (feet)
1	55	0.07	3.85	0.9
2	15	0.07	1.05	1.6
3	55	0.07	3.85	2
4	7	0.07	0.49	1.3
5	26	0.07	1.82	1.5
6	14	0.07	0.98	1
7	10.3	0.07	0.72	1.7
8	13	0.07	0.91	1.5
9	1.56	0.07	1.56	1.6
10	25	0.07	1.75	1
11	15	0.07	1.05	1
12	12.1	0.07	0.85	1
13	15	0.07	1.05	1
14	53	0.07	3.71	1
15	64	0.07	4.48	1
16	30	0.07	2.1	1
17	41	0.07	2.87	1
18	20	0.07	1.4	1
19	12	0.07	0.84	1
20	21	0.07	1.47	0.8
21	46.2	0.07	3.2	1.7
22	41.6	0.07	2.42	1.7
23	19.1	0.07	1.33	2.1
24	17.9	0.07	1.25	1.7
25	58.3	0.07	4.08	2.9
26	5.3	0.07	0.37	0.7
27	55	0.07	3.85	1.5
28	17	0.07	1.19	0.9

The depth is kept below 3 feet for safety as these would be in publicly accessible places.

The two storm water treatment and management systems used are – Detention Ponds and Sub-surface wetlands.

Detention Pond:



1. Inlet
2. Fore-bay
3. Water quality volume level
4. Primary outlet
5. Overflow structure with screened inlets
6. Outlet collection system
7. Infiltration where feasible
8. Minimum 1 foot freeboard

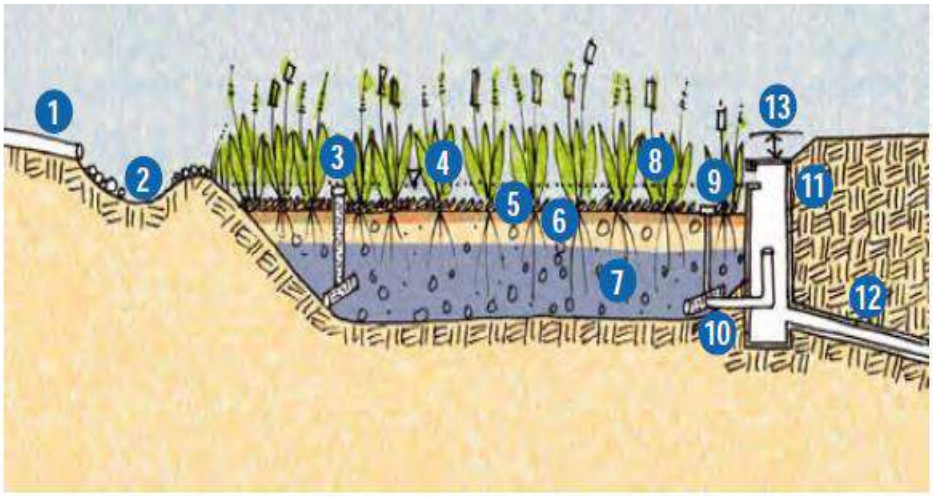
Image 50.
This figure above, shows the various elements of the detention pond system.[27]
During non-monsoon months this basin can be used for recreational activities, hence here, the planters need not be irrigated constantly.

A dry detention pond sited within a Children's play space in Augustenborg, Malmö/Sweden tests different methods of reducing and detaining peak stormwater flows while enhancing the neighborhood.

Image 51.

Sub-surface wetlands

[27] SFPUC BMP Facts Sheet, July 2010.



1. Inlet
2. Fore-bay
3. Perforated riser and inlet pipe
4. Water quality volume level
5. Mulch
6. Low permeability wetland soil
7. Medium coarse gravel
8. Wetland vegetation
9. Observation well and cleanout
10. Primary outlet
11. Overflow structure with screened inlets
12. Outflow to collection system
13. Minimum 1 foot freeboard.

Image 52.
The main reason for using a sub-surface wetland in Mumbai is to prevent mosquito infestation. Additionally, it creates a pleasant path for walking, jogging or biking. The design locates these wetlands along the river hence encouraging residents to not only access the river, but also develop a more sensitive perception towards the city's natural systems.

Using these techniques and designs, the proposal aims at creating a resilient and a more livable environment.

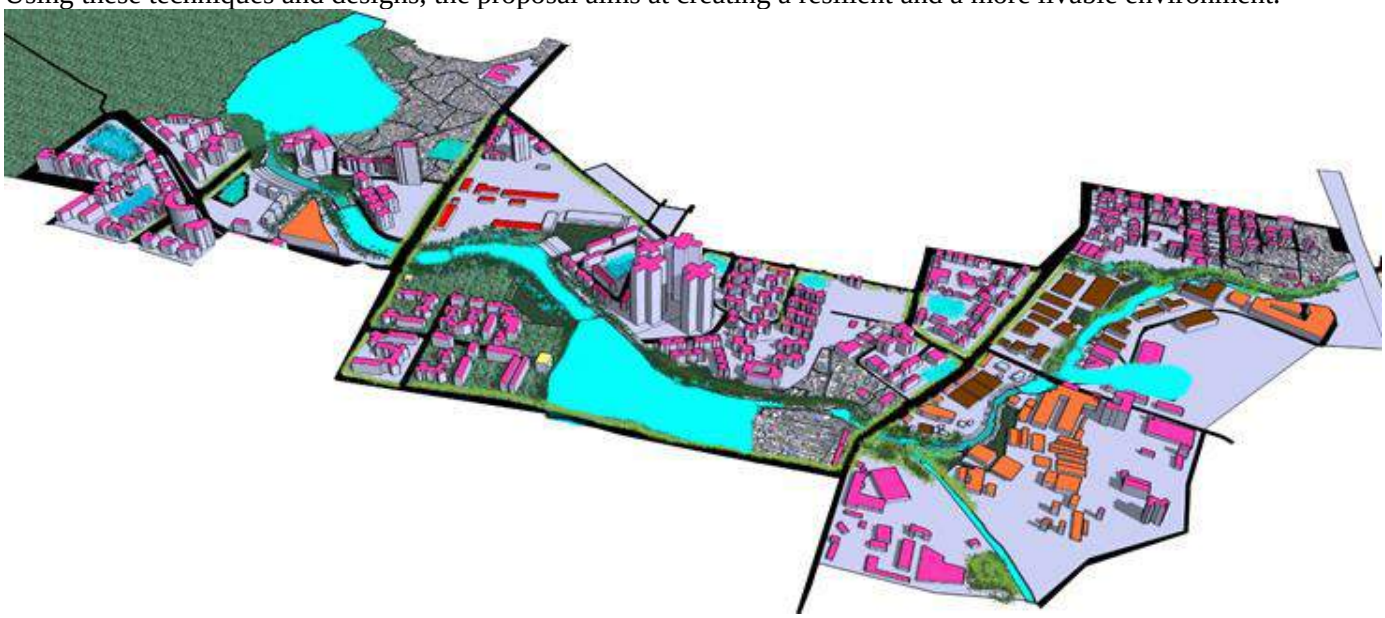


Image 53.
Greener, friendlier roads and streets, pleasant edge conditions along Oshiwara River, and hydrologically sensitive neighbourhood blocks.

Limitations

During the analysis and design process, I came across numerous limitations that would affect the proposals outcome:

- Lack of space on public right of ways to intervene.
- Lack of inclination of Municipal authorities to encourage treatment and re-use of storm water.

- No free access to technical hydrological data.

The Municipality, despite having the technical expertise shows no inclination to implement contemporary design concepts. Their plans involve enlarging sizes of storm water drain pipes and dredging sediments out of rivers before the monsoons. Both these, although potentially effective, do nothing to treat the polluted water, nor create a pleasant environment.

Additionally, the Municipality does not make technical data easily accessible to the public. A lot of the data is classified due to security reasons! Thus, hampering public awareness of the importance of natural systems and their participation altogether.

Lack of space has been cited as the primary reason for not proposing storm water treatment facilities by the Municipality. This, is more of an excuse than a reason because other cities in the world have managed to make themselves more resilient. New York City's PlANYC is one such example that the city can learn from. Many Dutch cities also have started implementing designs and plans for protecting them from sea level rise, let alone floods.

c. Potentials

Conclusion and future steps

The Oshiwara River corridor has been used as a testing site to analyze and learn the issues affecting urban water systems in dense metropolitan cities like Mumbai. As cities rapidly modernize and compete with cities around the world for attracting businesses and providing better living conditions, they tend to ignore the environmental needs of a city under the pretext that there are other more pressing issues – like providing basic food, water and shelter. However, with increasing rates of natural calamities globally, it is becoming evident that by designing for issues related to climate change, the city can very easily and rapidly start reaping benefits in almost every other aspect necessary for its functioning. For example, efficient storm water drainage management will help conserve water and thus reduce load on the Municipality for transporting large quantities of water from hundreds of kilometers away.

Many of these design strategies could help create more liveable and pleasant public spaces. Presently the city's open space to people ratio is 1.1sq.m, which is the lowest amongst all major metropolitan cities in the world. Detention basins have the potential to create a more pleasant micro-climate and attract people to gather and meet.

Additionally, by addressing these issues the city becomes more resilient and would be able to emerge out of extreme climate events without much, if not, any loss of property, life or resources. The strategies proposed in this report are based on best management practices. However, for any of them to be implemented, first, a corridor-wide outreach method would have to be undertaken to spread awareness of the various issues around natural urban systems and climate change. Survey questionnaires could be used as an important tool to learn about residents' perceptions. This would help policy makers and urban planners design appropriate strategies and approaches to begin dealing with the issues.

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7. APPENDICES

I. Survey

To verify the hypothesis posed above, a survey must be undertaken. The survey would include questions about the respondents' socioeconomic status, daily exposure and visits to the river or areas by which it flows, perceptions of its surrounding community, and perceptions and awareness of the ecological characteristics of the river corridor.

1. How long have you lived in this neighbourhood?

2. How long do you think most people in this housing society have lived here? (Circle one)

- Less than 3 years
- 3-5 years
- 5-10 years
- More than 10 years

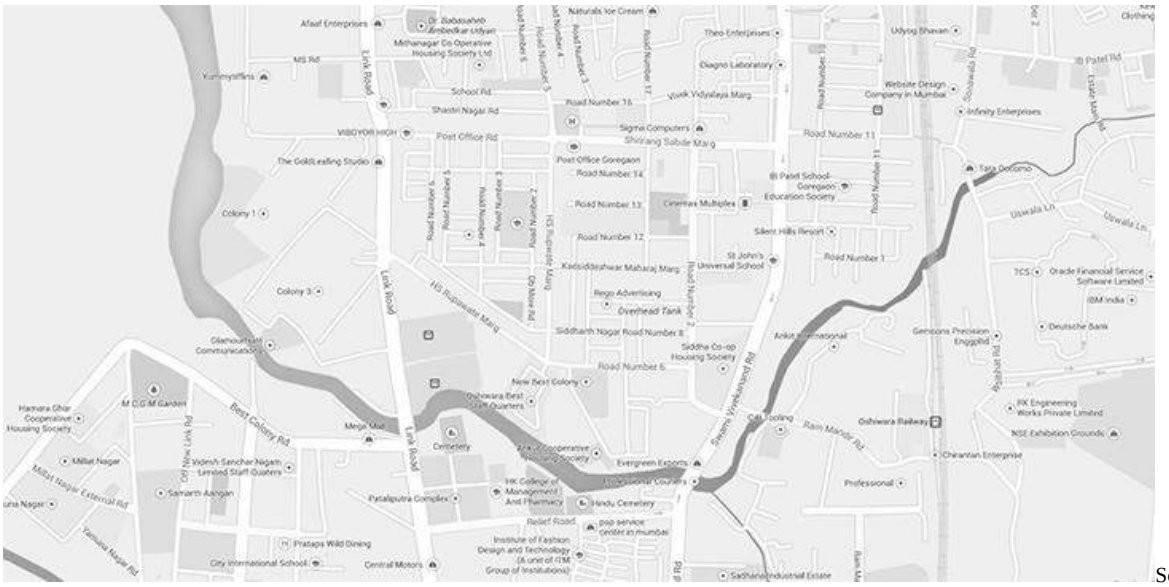
3. In the map below, please circle the area that you consider to be your neighborhood.

4. How many people (approximately) in your neighborhood do you know well enough to say 'hello' when you see them?

5. Of the activities listed below, circle the one that you most frequently engage in with the people that you know in your neighborhood:

- Talk/socialize
- Play recreational sports
- Other (please name)
- Meet during festivals
- Go on walks

6. In the map below, please indicate any localities where you have friends/ acquaintances:



Source: Google

7. Please select the statement that best characterizes your feelings about your neighborhood:
I feel safe in my neighbourhood

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

I feel that my neighbourhood is composed of individuals that contribute to the community:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Thinking about your street/ neighbourhood, which one of these statements best describes how much this area feels like home to you:

- Most definitely feels like home
- Usually feels like home
- Rarely feels like home
- Somewhat, it could feel like home
- It doesn't feel like home

8. Based on your observation, would you say that your neighbourhood has a large diversity of birds and other fauna?

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

9. Please name a bird or an animal that you most frequently see in your neighbourhood

10. Do you see Oshiwara River from your house? (Circle all that apply)

- See
- Hear
- Smell
- None

11. Did you know that it is a River and not a nalla?

- Yes
- No
- I didn't know

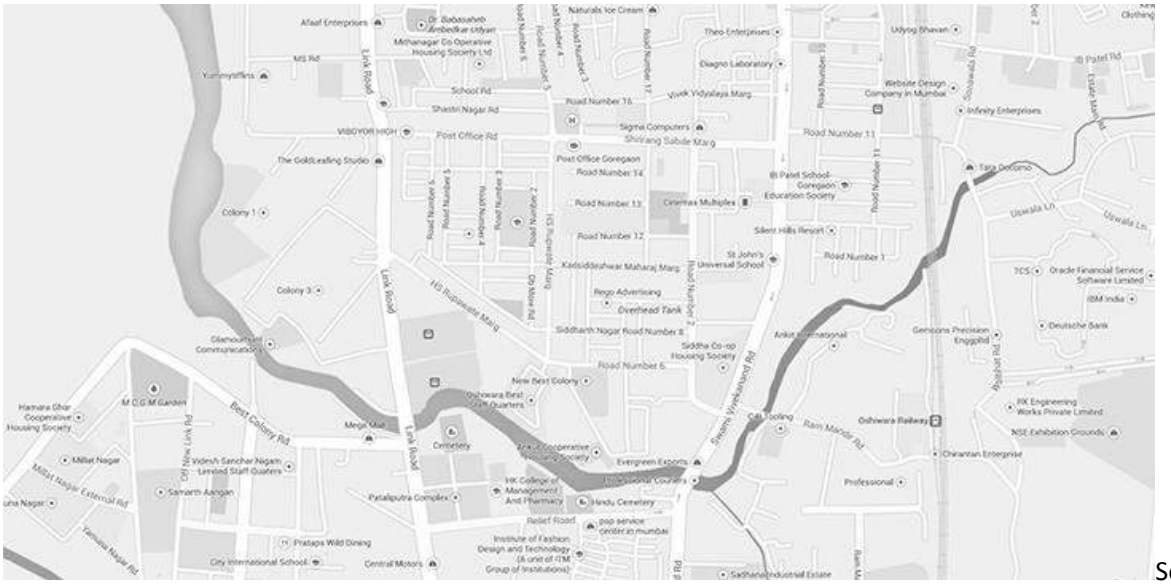
12. How often do you visit areas from where Oshiwara River is accessible for recreational purpose?

- Once a day
- At least once a week
- Occasionally
- Never

13. Do you cross the Oshiwara River in your daily commute to/ from work or other trips?

- Yes
- No
- I don't know

14. If you walk or drive to get to work for at least a portion of the trip, and if that portion falls within the area indicated on the map, please mark using an arrow:



Source: Google

15. Do you own the apartment you live in?

- Yes
- No

16. Are you aware that climate change is causing sea level to rise?

- Yes
- No

17. Are you aware that the rising sea levels will affect Oshiwara River and cause it to overflow its banks very frequently?

- Yes
- No

18. Have you participated in any of the following activities? (Circle any that apply)

- Tree planting
- Implementation of stormwater and other 'green' infrastructure
- Outdoor classroom
- Rain water harvesting
- Other (Please specify)

19. Have your friends or neighbours been involved in any of the above activities? (which one)

20. Circle the statement that best characterizes your view:

- Oshiwara River is important for stormwater management in my neighbourhood
- The River is NOT important for stormwater management in my neighbourhood
- Improving, cleaning and making the river a public amenity will increase the value of my house
- The presence of the river does not affect my or my family's life
- I am not familiar with how the River contributes to stormwater management

21. What is your gender?
22. Which housing complex do you live in?

23. Does your household include children?

24. What is your educational background?

- 12th Standard
- Bachelor's degree
- Master's degree
- PhD
- Other

25. Please indicate your family's annual income range. (Circle one)

- Less than Rs.50,000
- Rs.51,000-Rs.1Lac
- Rs.1Lac-Rs.10Lacs
- Rs.10Lacs-Rs.50Lacs
- Rs.50 Lacs- Rs.1 Crore
- Above Rs.1 Crore

26. Do you have flood insurance?

- Yes
- No

27. Quickly scan the list below and circle any adjectives that in your view are characteristic of your street/ neighbourhood:

active	bare	bleak	boring	calm	clean	colourfull
dangerous	dead	dense	dirty	exciting	filthy	fresh
friendly	gloomy	greasy	green	happy	harsh	inspiring
inviting	isolated	lifeless	lively	moist	monotonous	muddy
natural	nice	noisy	pleasant	polluted	rainy	stinky
swampy	ugly	unfriendly	wealthy	slum-like	safe	

Questions – 1,2,3,4,5,6,10,15 & 20 – Sense of Place

7 & 14 – Vitality

8, 9, 12, 13 – Livability

11,16,17,21,22,23,24,25,26,27- Informative.

II. Government perception

Municipal Corporation of Greater Mumbai's description of various "particulars" of Oshiwara River urban corridor.

No.	Particulars	Description
1.	Name of River	Oshiwara
2.	Point of Origin	Aarey Milk Colony, Goregaon (East)
3.	Length in km (approximate)	7 km
4.	Areas (locations) through which the River flows	Aarey Colony, Pahadi Area, Western Express Highway,Walbhat Road, Jawahar Nagar Slums, Ram Mandir Road , Oshiwara, Bohri Compound, Areas between Motilal Nagar and Hindu Cemetery, area behind BEST Depot, region along the "K" West and "P" South Ward boundaries, Link Road, Malad Creek.
5.	Major Nallas associated with the River within the catchment area	Majas Nalla (originates in Jogeshwari (East), also meets the Oshiwara River at Goregaon - East), Excel Nalla, Gogatewadi Nalla, Prem Nagar Nalla,

No.	Particulars	Description
		Shastri Nagar Nalla, Bimbisar Nagar Nalla.
6.	Meeting point	Malad Creek.
7.	Total Catchment area	2,938 ha (catchment number 217 as described in the BRIMSTOWAD report Table A7.1, page ES-14)
8.	Potential Risk Zones (maps)	"Slums" which are prone to flooding: Locations are (a) Slums near Walbhat Road(Goregaon - East); (b) Slums near Jawahar Nagar(Goregaon - West); (c) Slums of Bhagat Singh Nagar(Goregaon- West, on Link Road).
		"Low-lying areas" prone to monsoon flooding: Locations are (a) Siddhartha Nagar;(b) Motilal Nagar; (c) Bhagat Singh Nagar Slums; (d)BEST Colony; (e) Ram Mandir Road industrial area. All these locations are in Goregaon (West).
		"Chronic drainage choking sites": Locations are Ram Mandir Road and Siddhartha Nagar in Goregaon (West).
		"Prone to cyclones/ strong wave action in monsoon": Locations are (a) Shaheed Bhagat Singh Nagar, on Link Road opposite BEST Bus Depot;(b) Indira Nagar Goregaon (West) and (c) Lakshmi Nagar, Goregaon (West).
9.	Urban Practices and Activities Responsible for Environmental Degradation	Narrowing of the banks for housing: Locations are (a) Jawahar Nagar, Goregaon (West); (b) Bhagat Singh Nagar, Goregaon (West); (c) BEST Colony, Link Road, Goregaon (West).
		Encroachment of River bed for industrial units: Locations are (a) Industrial establishments (small scale) located along the I.B. Patel Road and Walbhat Road (Goregaon-East); (b) Ram Mandir Industrial Estate, Goregaon(West).
		Obstructions of River flow due to dumping of construction debris/ solid waste/ industrial waste: Locations are (a) S.V. Road Bridge at Oshiwara; (b) Ram Mandir Road, Goregaon (West).
		Dumping of solid waste generated at Stables: Locations are (a) Walbhat Road, Goregaon (East); (b) Ram Mandir Road, Goregaon (West).
10.	Major impact of July 26 incidence	
	(i) Ecological Changes	Loss of extensive mangrove stands in the down stream region of the River behind Bhagat Singh Nagar, Goregaon (West).

No.	Particulars	Description
	(i) Economic Losses	The catchment areas of the River is conspicuous with establishment of various housing colonies of middle income groups, particularly Jawahar Nagar, Siddhartha Nagar, BEST Colony, Motilal Nagar and Bhagat Singh Nagar. The water of high intensity floods that occurred on July 26 entered all these areas and submerged the residents. Moreover, the small-scale entrepreneurs in the Walbhat Road region (Goregaon - East) and Ram Mandir Road (Goregaon - West) suffered heavy losses.
	(iii) Social Impact	The Stable-based economy of the local area (Walbhat Road and Ram Mandir Road areas) collapsed due to the deluge. Most of the buffalos (almost 1400) drowned in the floods due to which the people suffered heavy capital losses. The indirect impact of this calamity also affected most of the residents in the Goregaon region due to paucity of milk and milk based products.

Land use / land cover area for Oshiwara River Catchment estimated from IRS data of February-April, 2005 [Adapted from Table 4.6 on page 4-8 reported by WAPCOS, 2005]

Sr. No.	Class	Area in ha	% of total area
1	Slum (Dense Built-up Land)	793	23
2	Built-up (Spare)	1054	30
3	Dense Vegetation / Forest Cover	96	3
4	Spare Vegetation	549	16
5	Barren Land	136	4
6	Land with Grass / Rough Pasture	699	20
7	Mangrove Forest	96	3
8	Marshy Vegetation	0	0
9	Exposed Rock	0	0
10	Water Body	51	1
	Total =	**3474**	**100**

4. Oshiwara River: BRIMSTOWAD catchment number 217	Shaheed Bhagat Singh Nagar, Motilal Nagar (bothlocated in oregaon - West).	These are residential areas that fall in the low-lying catchment.
	Walbhat Road egion (Goregaon-East) and Ram Mandir Road Region (Goregaon -West)	These are industrial areas and also stable areas
	Siddhartha Nagar, BEST Colony, both located in Goregaon (West).	These residential areas have externalwater drainage systems through narrow Nallas that pose a greater threat offlooding the region in heavy rains.
	Jawahar Nagar Slums, Goregaon (West).	The Slums located right on the Riverbanks pose a risk of getting affected by the floodwaters. The untreated discharge of sewerage also threatens the areas with health hazards.

III. Government interventions for carrying out river restorations – Case Studies

Buriganga River Restoration Program, Dhaka, Bangladesh

A review of the benefit cost analysis of Buriganga River restoration program by Professor Khorshed Alam (faculty of business at University of Southern Queensland, Toowomha, Queensland, Australia) published in the International Journal of Water Resources Development by Routledge, will help learn about potential benefits of undertaking a similar project in a similar context versus the costs incurred.

The Buriganga River flows in southwest Dhaka in Bangladesh. The spatial context of Dhaka is very similar to that of Mumbai. Both cities experience heavy floods, are densely populated, on the verge of imploding, and urgently need their infrastructural systems to be overhauled. The Buroganga River although is much larger in scale compared to Oshiwara River, it is part of a dense urban environment with residential complexes lining it, massive amounts of solid waste is dumped here and the edge condition has become source of disease for the nearby communities. Thus, in line with these similarities it is worthwhile considering Buriganga River restoration program as an example to see what could happen if Oshiwara River is restored and renovated.

The Buriganga River restoration program included removal of illegal structures and construction of access roads and walkways, establishment of wastewater treatment plant, improvement of sewerage facilities, river-bed dredging. The total economic cost incurred over the 10-year duration of the program was approximately $36.64 million. The total investment cost is estimated at $22.6 million and the rest would be the operating and maintenance costs. The total cost is estimated at 74% of total benefit in first year, declining to 4.3% of total benefit in year 10. Thus, providing an incremental net benefit of $1.74 million and rising to $39 million by end of the program in year 10. This indicates that the restoration program will generate more benefits in later years of the implementation period. The report suggests that the BCR for Buroganga River restoration program is approximately 4.35, thus proving that the river restoration program can be economically viable.

Now, in this project, the willingness to contribute money as a percentage of total household income was found to be less than 1%. In fact, as a percentage of stated median household income is only 0.07%, while respondents' total willingness to contribute money as a percent of per capita GDP is 0.64. The report also tests how realistic the estimated value of non-market benefits of the river restoration program can be raised. For this, first a comparison of the willingness to contribute money estimate can be made is the average payments of utility bulls for other public and publicly provided goods and services in Dhaka city. In comparison to charges for utility services of residents in Dhaka City, the amount respondents expressed as their willingness to contribute is not too high (between 7.7 and 50%) and therefore seems to be realistic. Furthermore, a World Bank assisted study stated that poor people in slum areas not connected to utility services such as gas, water or electricity actually pay 50-100% more than the official rate in Dhaka City.

This study, thus reveals that the whole range of benefits both market and non-market is relevant to the economic analysis. The use of direct benefits alone to determine investment worth is in fact a purely commercial criterion.

Sabarmati Riverfront Restoration Project, Ahmedabad, India.

The total project cost of $190 million for Phase I has been divided into three stages. First stage financed through equity contributions from (AMC) Ahmedabad Municipal Corporation (20%) and a (HUDCO) Housing and Urban Development Corporation loan (18%). Stage II of Phase I (30%) would be financed through equity contributions from AMC and HUDCO. Financing of Stage III of Phase I and Phase II would be tied up through a mix of AMC contributions, revenue proceeds and a term loan as required.

If properly managed, the proceeds from sale of land created by project will easily cover the full cost of the project including the cost of interest paid on construction periods even 14% of the land available for development would be sufficient to recover the investment made in the project.

Apart from direct monetary benefits, these are some benefits that are predicted – environmental improvement, creating network of public open spaces, providing adequate public access to the river, rehabilitating the slums and informal markets, creating vibrant urban neighborhoods, boating and recreational activities. Additionally, benefits to other cities such as recharges ground water, thus reducing load on city's water infrastructure, and relocation and rehabilitation of slums, strengthening of transportation network of the city.

These projects reveal that an investment in environmental improvement would stimulate renovation of adjacent areas, including residential, industrial and public spaces, massive improvement in public health and safety, natural disaster management – creation of a resilient flood and storm water management infrastructure, increasing the spread of local flora and fauna in the area, and impacting public opinion and mood by creating liveable and pleasant urban spaces. Each of these benefits would be hard to quantify precisely without the area's census and employment data. However, for the scope of this paper, it is worthwhile to note that restoring and renovating Oshiwara River in Mumbai could catalyse so many benefits not just for the vicinity, but also for the entire city and its metropolitan region.

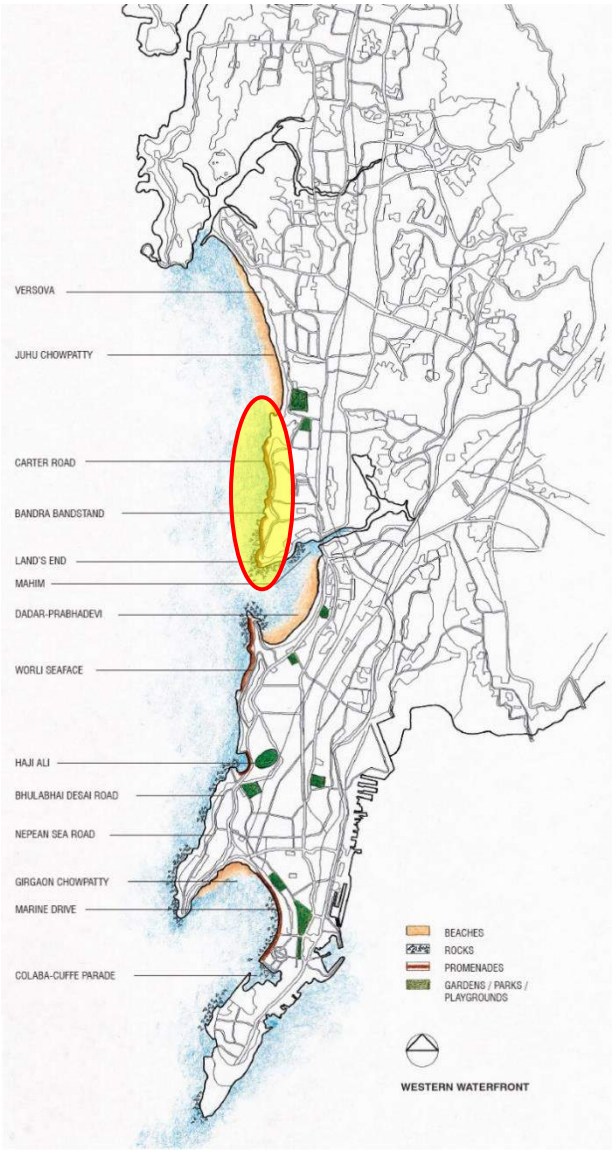
IV. River restoration through public participation

Bandra promenades – case study

Not far from Oshiwara River is the Bandra promenade. Before construction of the promenade, it was a stretch of wetlands covered with garbage, dirt and solid waste. However, after it was cleared and converted into a public promenade with parks, and activity centers, it changed the perception of the locality completely. Now, it has some of the most expensive real estate in the city, and is arguably one of the most pleasant public promenades in the country.

There were design charrettes held with residents. These were organized by landscape architects and planners, who were in charge of designing and implementing the project.

The Bandra waterfronts stretch for approximately 3km along Mumbai's western edge. From being used as a dumping ground it was restored and revitalized into the vibrant publicly accessible waterfront it is today. The process began early in 2001 when various local area residents' association groups came together to draw out a strategy to restore the waterfront. They were supported by a Bollywood actress turned activist Shabana Azmi and architect P.K. Das.



From "Restoration of Mumbai's Waterfronts" by P.K.Das[28]

I am using Bandra promenades' restoration and revitalization as a comparative for Oshiwara River corridor because of the potential they hold in inviting residents' opinion and participation in the design process.

Additionally, the lengths of both waterfronts is very similar at approximately 3km. This would allow a comparable scale for analyzing project costs.

[28] http://pkdas.com/article.php?id=76

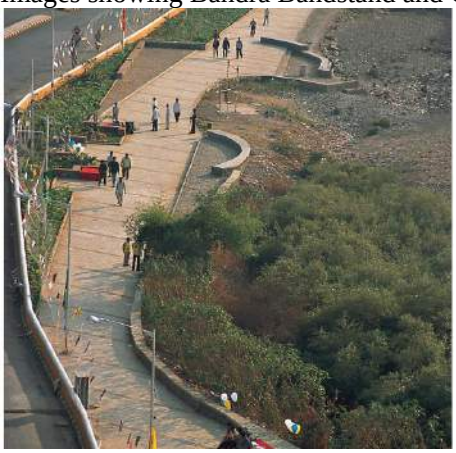
The design for both Bandstand and Carter Road waterfronts (collectively forming Bandra waterfront promenade) came as much from the local residents as from the architect. Most of the waterfront was restored to its historic glory

- The Bandra fort was renovated and restored,
- The band-stand was brought back,
- Mangroves were protected and allowed to grow,
- The two hotels along the coastline were disallowed from expanding onto the waterfront

According to P.K. Das this project and its implementation led to new and meaningful relationship between the neighborhood community and local Government. The apathetic Municipal administration, uncaring about city's public-space and coastline, in particular, became more responsive and supported the citizen's movement. The Police too co-operated with local citizens forming a more meaningful and effective monitoring group to not only execute this project but to maintain discipline, confront dubious interests and challenge encroachments. With this development various anti-social elements and boot-leggers left the place. Land grab illegal land-fill, illegal constructions, attempts to colonizing space against larger public interest has been checked. This movement was not merely a beautification program but part of a larger democratic struggle for reclaiming public-space and establishment of public-space rights, space where people meet, share with others, and come to care about each other[29].

The project was financed by private sponsor (Marico industries) appointed by the citizens' association. The association approved plans and activities of the sponsor. The citizens' association has formed a trust and entered into a legal agreement with the local administration for their rights and control of the waterfront development. P.K.Das states that this project is a unique demonstration in the city of how dignity and respectability of a public space reclaimed by a public movement and sustained by a collective effort of the citizens.


Images showing Bandra Bandstand and Carter road waterfronts being used for dumping waste and scrap.




[29] http://www.pkdas.com/pdfs/cont-shift-south-africa.pdf

Bandra waterfront after restoration. It has become an actively used public space not only for residents, but also the entire city.

In his paper about the development of Mumbai's waterfronts, architect P.K.Das ends on cautionary note stating that during implementation of the Bandra waterfront projects a number of issues relating to equity came up. Evidently, the citizens' associations have been led by the elite – drawn largely from the middle and upper classes along with professional representing similar class interests. Such groups colonized and divided spaces on class-basis under the guise of beautification programs. Das emphasizes the need for putting people's needs before such commodification, and thus, focusing on the human/ humane dimensions.

On similar lines, residential buildings line the Oshiwara Riverfront. If awareness of the benefits of river and riverfront restoration can be spread among the residents then it could catalyze the formation of Bandra-like citizens' association. However, due to the presence of cattle sheds and industries upstream, certain Municipal action would be required. This too, can be achieved through pressure exerted by citizen associations. Using the precedent set by citizen associations at Bandra bandstand to prevent five star hotels from expanding onto the waterfront.

V. Data collected from Real Estate websites

Building	Distance from river	Age	floor	bedrooms	toilets	parking	Lifts	gym	gas line	Nala wt	weightage (proximity determining smell)	sq ft	rate per sq ft	Floor X View	total rate
Imperial heights	75	0.5	25	4	5	1	2	1	1	1	10	2815	16500	25	46447500
			8	4	5	1	2	1	1	1	8	2795	16529	8	46198555
			6	3	2	1	2	1	1	1	6	1520	18092	6	27499840
			3	1	2	don't know	2	1	1	1	0	750	20000	3	15000000
			30	6	6	2	2	1	1	1	10	3720	22849	30	84998280
			5	3	2	1	2	1	1	1	4	1520	18000	5	27360000
			2	1	2	1	2	1	1	1	0	750	19000	2	14250000
			1	1	2	1	2	1	1	1	0	750	16000	1	12000000
			15	4	5	1	2	1	1	1	9	2815	17000	15	47855000
			4	3	2	1	2	1	1	1	2	1520	18000	4	27360000
														0	
Ankur Co-operative housing society	50	30	2	1	1	1	0	0	1	0	6	555	16216	0	8999880
			3	1	1	1	0	0	1	1	2	555	15500	3	8602500
			5	1	1	1	0	0	1	1	5	555	14000	5	7770000
			4	1	1	1	0	0	1	1	2	555	15316	4	8500380
			1	1	1	1	0	0	1	1	0	555	12000	1	6660000
			2	1	1	1	0	0	1	1	0	555	12000	2	6660000
														0	
Sai Baba Galaxy	20	20	2	1	2	1	1	0	1	1	0	630	15000	2	9450000
			3	1	2	1	1	0	1	1	2	630	16000	3	10080000
			4	1	2	1	1	0	1	1	4	630	17000	4	10710000
Dheeraj Residency	240	10	10	3	3	1	2	0	1	0	10	1350	16296	0	21999600
			2	1	2	1	2	0	1	0	4	600	15333	0	9199800
			4	2	2	1	2	0	1	1	6	900	10650	4	9585000
			1	1	1	don't know	2	0	1	1	0	610	10650	1	6496500
			3	1	1	don't know	2	0	1	1	1	650	13077	3	8500050
			2	1	2	1	2	0	1	1	0	600	15333	2	9199800
			8	3	3	1	2	0	1	1	8	1350	16296	8	21999600
			12	3	3	1	2	0	1	1	8	1350	17500	12	23625000
			6	2	2	1	2	0	1	1	7	900	12000	6	10800000
			4	2	2	1	2	0	1	0	6	900	10600	0	9540000
			5	2	2	1	2	0	1	0	7	900	12000	0	10800000

Building	Distance from river	Age	floor	bedrooms	toilets	parking	Lifts	gym	gas line	Nala wt	weightage (proximity determining smell)	sq ft	rate per sq ft	Floor X View	total rate
vasant galaxy - Pluto	30	1	2	2	2	1	2	1	1		4	775	21963	0	17021325
			6	3	3	2	2	1	1		5	1100	20000	0	22000000
			3	2	2	1	2	1	1		5	885	21469	0	19000065
			8	4	4	don't know	2	1	1		9	1800	21111	0	38000000
			4	3	3	2	2	1	1		6	1100	19000	0	20900000
			5	3	4	don't know	2	1	1		2	1500	15333	0	23000000
			1	2	2	1	2	1	1		2	775	20000	0	15500000
			2	2	2	1	2	1	1		4	775	21963	0	17021325
			7	4	4	2	2	1	1		9	1800	21111	0	37999800
			4	3	3	2	2	1	1		6	1100	19000	0	20900000
Windsor Grande residences (under construction)	300	0.1	8	4	5	2	4	1	1		10	3300	24242	0	79998600
			10	4	5	2	4	1	1		10	4300	25000	0	107500000
			13	5	5	2	4	1	1		10	6600	24000	0	158400000
			14	5	6	2	4	1	1		10	7600	23289	0	177000000
			2	3	4	2	4	1	1	1	0	1400	20000	2	28000000
			4	4	5	2	4	1	1	1	6	2800	25000	4	70000000
			9	4	5	2	4	1	1	1	8	4300	25000	9	107500000
			6	3	4	2	4	1	1	1	7	2500	22000	6	55000000
Windermere	100	20	2	2	2	2	2	1	don't know	1	0	1100	23636	2	25999600
			6	3	3	2	2	1	don't know	0	5	1750	27429	0	48000000
			8	4	4	2	2	1	don't know	0	8	1700	31176	0	53000000
			10	2	2	don't know	2	1	don't know	1	10	1000	24000	10	24000000
			15	4	4	don't know	2	1	don't know	1	10	1700	29412	15	50000000
			4	3	3	2	2	1		1	3	1750	25000	4	43750000
			5	4	4	2	2	1		0	6	1700	28000	0	47600000
			7	4	4	2	2	1		0	9	1800	30000	0	54000000
			4	2	2	2	2	1	don't know	1	3	1100	21000	4	23100000
			3	2	2	2	2	1		0	5	1100	23000	0	25300000
			17	4	4	2	2	1		1	9	2000	30000	17	60000000