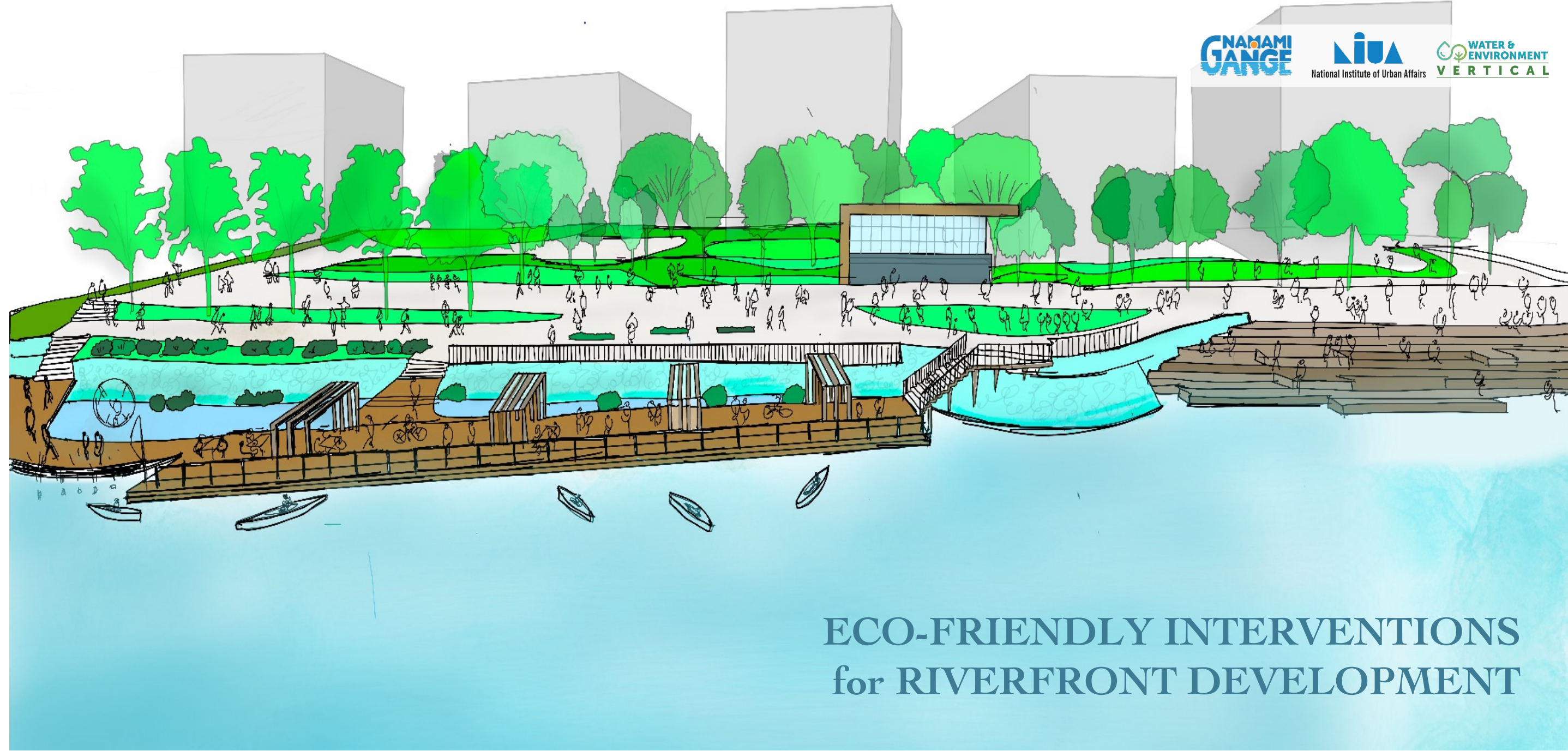




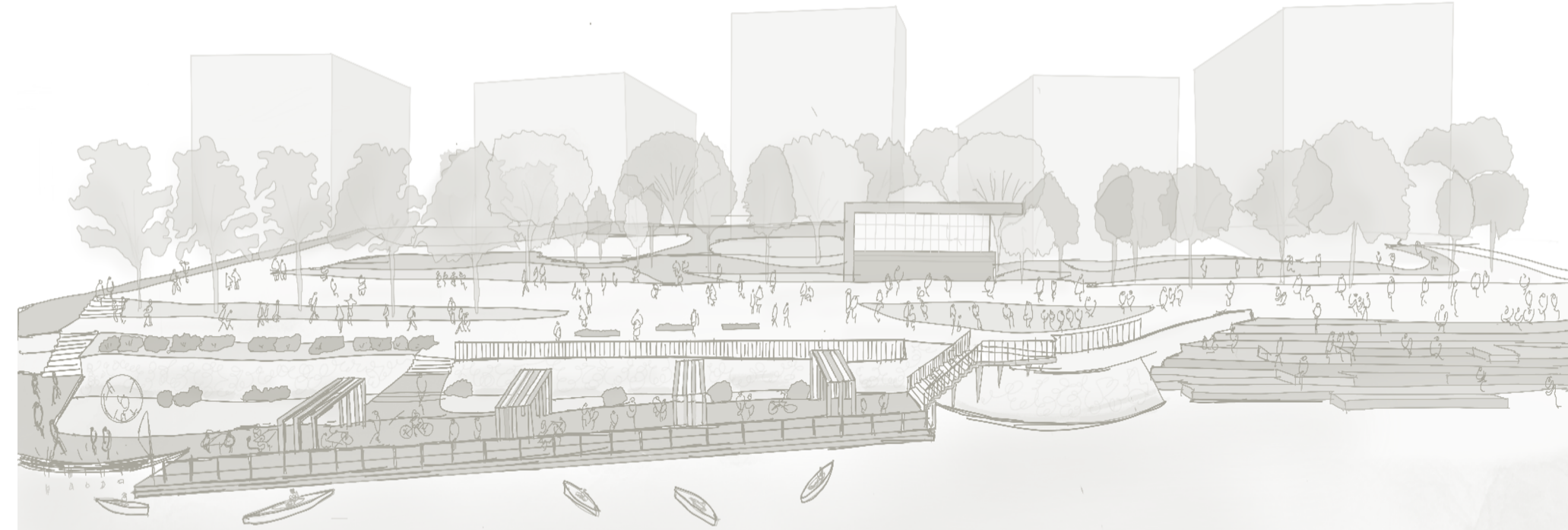
Water and Environment Vertical
National Institute of Urban Affairs
1st Floor, Core 4B,
India Habitat Centre,
Lodhi Road, New Delhi - 110003, India
(+91-11) 24643284/ 24617517 (ext. 214)
urvers@niu.org



National Mission for Clean Ganga
Ministry of Jal Shakti, Government of India
1st Floor, Major Dhyan Chand National Stadium
India Gate, New Delhi – 110002, India
(+91-11) 23072900-901
admn.nmcg@nic.in



ECO-FRIENDLY INTERVENTIONS
for RIVERFRONT DEVELOPMENT



FOREWORD

Rivers play an intrinsic role in community engagement. They have vast potential for activating a city's social, economic as well as cultural life. However in the past few decades, the connect of the citizens with the rivers has been suffering due to the poor state of urban riverfronts.

Moreover, the exponential growth of cities has left minimal land parcels for recreational needs, making it essential to explore the use of special areas for this purpose. River edges, owing to their natural character and landscape, are ideal locations for exploring the potential of ecologically developed recreational areas within the city.

There is a promising future for urban riverfronts, with the provision of necessary infrastructure facilities and improvement of aesthetics, for restoring the lost citizen-river connect. While doing so, it needs to be ensured that the ecological character of the area is not disturbed.

This knowledge product showcases a set of best practices, with eco-friendly interventions and specific elements, that can be adopted for environmentally sensitive, economically viable and socially cohesive development of the urban riverfronts. A mix of practices can be adopted together as per the local needs, to achieve the desired goal of developing eco-sensitive riverfronts, which also improve the social connect while maximising the economic potential of the river.



Title

Eco-friendly Interventions for Riverfront Development

Publisher

National Institute of Urban Affairs (NIUA), Ministry of Housing & Urban Affairs (MoHUA), GoI
National Mission for Clean Ganga (NMCG), Ministry of Jal Shakti, GoI

Acknowledgements

Aishwarya Khadse, Banibrata Choudhury, Nikita Madan,
Ishleen Kaur, Jyoti Verma, Lovlesh Sharma, Rahul Sachdeva, Sahil Bhardwaj, Uday Bhonde,
Victor R. Shinde, Vishakha Jha(NIUA team)

Disclaimer

This document is a compilation of various works. Original references may be studied along with this document.

Neither the authors nor NIUA or NMCG accept any legal liability for the accuracy of inferences drawn from the material contained herein or for any consequences arising from the use of this material.

Material from this publication may be reproduced with due acknowledgement to NIUA and NMCG

Graphics, Illustrations and Images

The illustrations within the document have been picked from the original citations.

Year of Publication

2022



CONTENTS



INTRODUCTION

- Understanding Riverfronts13
- Need for Riverfront[Re]Development15
- Potential Benefits17

ENVIRONMENTALLY SUSTAINABLE INTERVENTIONS

- Biodiversity Parks21
- Natural River-Edge25
- Recharge Zones29

ECONOMICALLY VIABLE INTERVENTIONS

- River Markets35
- Theme Parks39
- River Museums and Galleries43
- River Adventure and Recreational Activities47

SOCIALLY COHESIVE INTERVENTIONS

- Riverfront Promenades / Walks/ Walkways.....53
- Religious Developments.....57

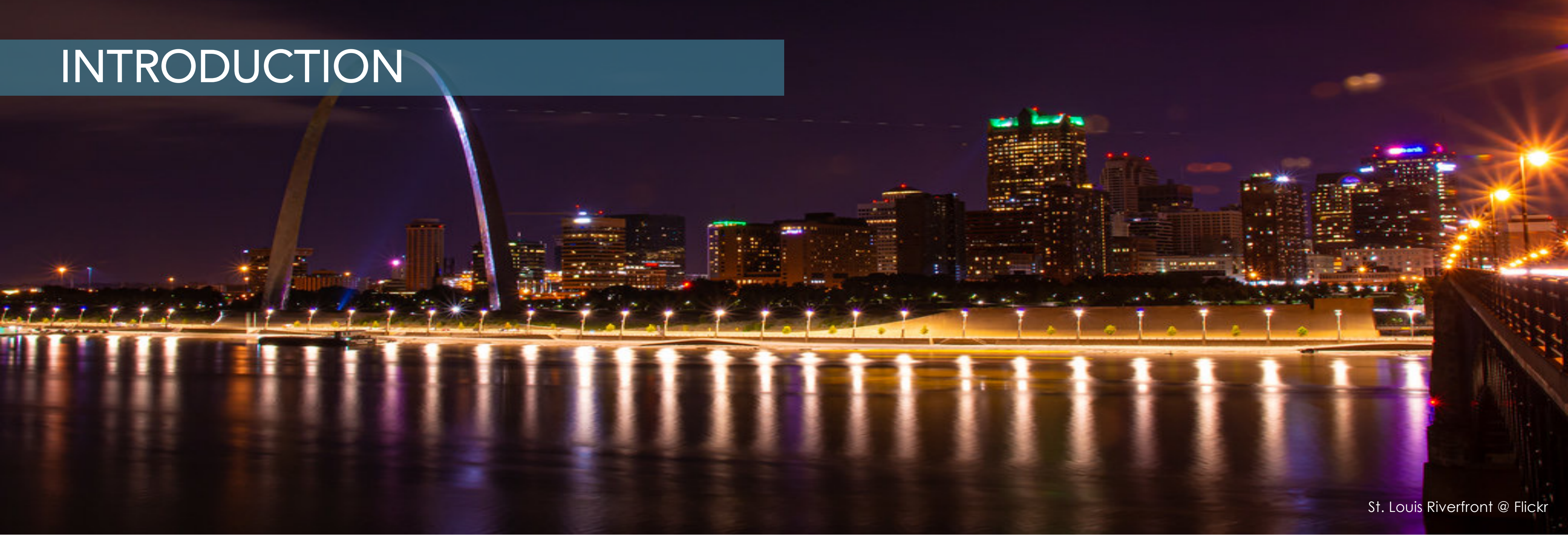
COMMON AMENITIES for Riverfronts.....61

OVERVIEW - Eco-friendly Interventions for Riverfront Development.....67



River Jumna @ Snappy Goat

INTRODUCTION



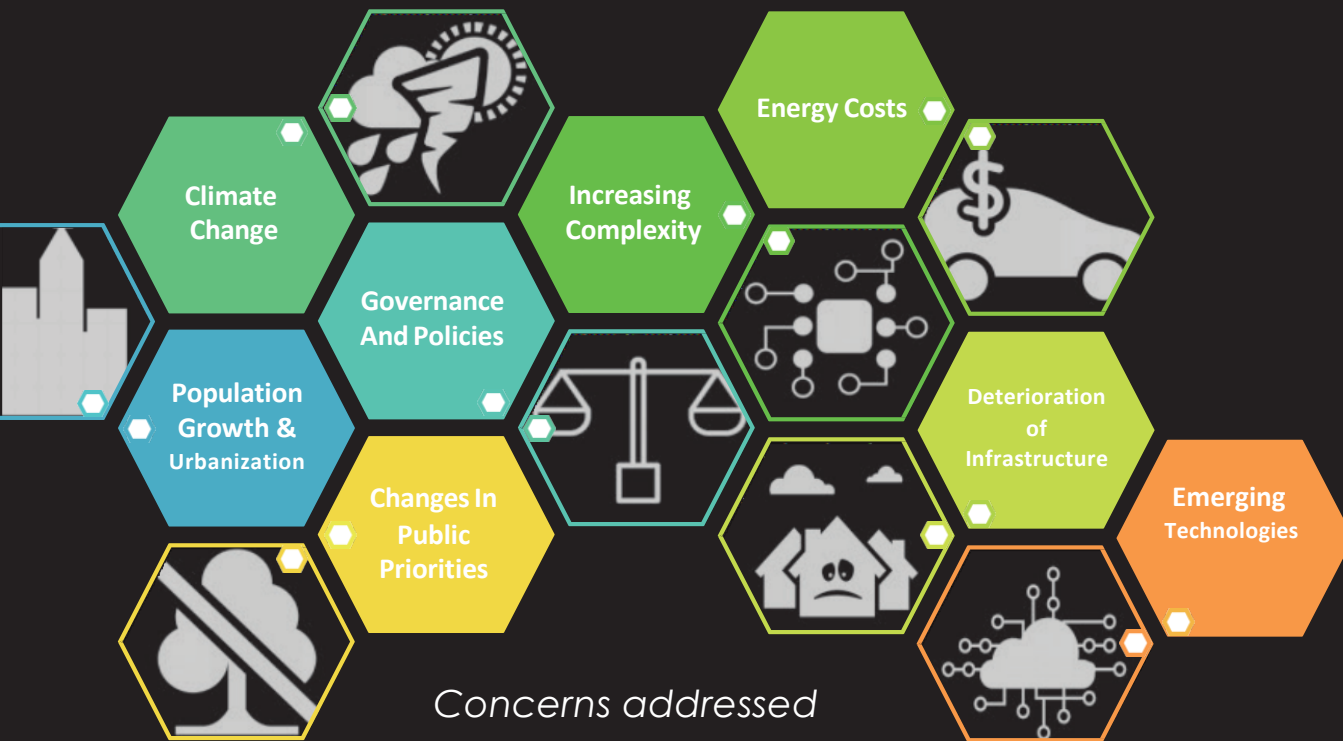
Understanding Riverfronts

An aerial photograph of the Sabarmati Riverfront in Ahmedabad, India. The image shows the wide Sabarmati River flowing through the city. A long bridge with multiple spans crosses the river. On the left bank, there are several tall apartment buildings and other urban structures. On the right bank, there is a large open area with some greenery and a few buildings. The sky is clear and blue.

Oxford dictionary defines Urban Waterfront as '*the part of a town or city adjoining a water body such as a river, lake, harbour, sea etc*'. These are usually seen in the form of river-front, lake-front, canal-front or sea-front in most of the cities.

Riverfronts can be seen as the origin of human culture and economy. In fact, most of the earliest settlements developed on the banks of rivers. They serve as an excellent opportunity for recreational spaces within a city, intra and inter-city navigation along the water channels, livelihood generation in the form of fishing/ agriculture/ and other activities, spaces for religious/ cultural/ historical connect with the city, generating avenues for promoting tourism, and most importantly saving open areas to serve as a lung-space within the city's built-up fabric.

Need for Riverfront [Re]Development



- Ecological Restoration
- Flood Prevention
- Historic Restoration
- Economic Development
- Recreation and Leisure
- Citizen Connect with Nature
- Livelihood Generation
- Cleanliness

Over the years, riverfronts have been in a state of neglect. They are undergoing rapid changes due to transformation of their use, increasing pressure of urbanisation, flooding instances and other impacts associated with climate change, deteriorating public infrastructure, and degrading health of the river systems. More importantly, they have taken a back seat in the city development and management processes.

Presently many of the riverfronts have reached an unpleasant state, due to over-exploitation and lack of planned development. There is thus, an alarming need for robust planning and development of the urban riverfronts.

Strategies for Sustainable Riverfront Development

- Showcase the river's history
- Feature riverfront as the front yard
- Expand leisure and recreational use of the river, and develop an art/entertainment/ cultural district
- Re-establish the lost citizen-river connect, to attract people and investment to the riverfront
- Repair and enhance the environment
- Use high-quality sustainable architectural materials and engineering practices
- Create visually pleasing order to the river's edge
- Strengthen river access by establishing riverfront walkway, trails, parks
- Provide outdoor activities for the people.

Potential Benefits



Economic Benefits

- Generates additional livelihood opportunities for local population
- Benefits the national and state economy
- Increases the market value for properties in the vicinity
- Supports restoration and enhancement of urban waterways



Environmental Benefits

- Ensures prevention of flood, if developed in a sustainable fashion
- Maintains the hydrological balance by restoration of the natural environment
- Minimizes any negative impact of encroachment or urban development on the natural environment
- Builds potential to enhance the bio-diversity of natural habitats/ landscapes
- Aids groundwater recharge
- Ameliorating urban heat island effect



Social Benefits

- Enhances the citizen connect with nature
- Provides community engagement spaces
- Provides for the community recreational needs
- Opportunity to re-instate the lost religious, cultural and historical values associated with the river

Riverfront Development Projects have a huge potential to renew the ecological landscape of Indian cities. There are various environmental, economic and social benefits associated with such projects. These help in maintaining the natural environment, providing quality public recreational opportunities, adding value to the cultural connects and boosting the local economy.

All riverfronts should be

Environmentally Sustainable



Economically Viable



Socially Responsive



ENVIRONMENTALLY SUSTAINABLE INTERVENTIONS



Biodiversity Parks

In order to rescue and restore the lost native biodiversity in urban areas, the creation of biodiversity parks is an innovative and novel approach. Biodiversity parks, which are assemblages of species in the form of biotic communities that belong to a particular ecological range, help promote urban biodiversity conservation as they serve as nature reserves within the urban areas.

Riverfronts are ideal sites for locating biodiversity parks, especially to foster aquatic flora and fauna.

Processes Involved

- Restoration of degraded ecosystems
- Awareness and capacity building
- Creation of ecological network and development of riparian habitat
- Management of native species, and conservation of rare and invasive species
- Development of alternative livelihood opportunities
- Incorporating ecological perspectives in development projects

Elements

- » Miyawaki Tree Plantation
- » Bird Park
- » Sustainable Construction
- Techniques
 - » Nature Pools
 - » Nature Sanctuaries
 - » Conservatory

Sabarmati Biodiversity Park, Sabarmati Riverfront, Ahmedabad

- Designed as a wild forest over 2ha. of land on the Sabarmati riverfront
- Houses around 7,000 trees of over 120 rare species brought from different parts of the country. Trees such as sea grape, mulberry, betel, seven-sons, khaya and date palm, which were not seen in Ahmedabad can be spotted here.
- The park also houses 35 species of native and migratory birds, including boot-headed eagle, egrets, ibis, white-throated kingfisher, purple swamp-hen and sparrows, along with different species of butterflies and snakes
- Usage of organic material to provide a natural habitat to these species.

Elements adopted

- Miyawaki tree plantation - planted around 91000 trees along the bank of the river to ensure green areas around the waterfront (Japanese method allowing saplings to grow 10 times faster, with forests 10 times more dense)
- Use of organic and sustainable material to provide natural habitat, such as nature trails with seating made of bamboo and tree trunks

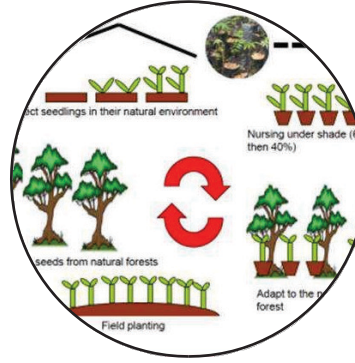
Chicago Wilderness, Chicago

- 2 lakh acres of protected conservation land, housing some of the largest and best surviving woodlands, wetlands and prairies in the Midwest
- Boundaries of the watersheds were demarcated with natural communities that helped in defining the region as did the large concentration of natural preserves in the Metropolitan area.

Elements adopted

- Alfred Caldwell lily pool - maintained even after restoration
- North Pond Nature Sanctuary - revitalization of the sanctuary
- Lincoln Park Conservatory & gardens - restored a rusty, leaking conservatory while adding green technologies, additional display and education spaces
- Adopt a monument - matches individual donors, foundations and corporations to take care of public art pieces

ELEMENTS



Miyawaki Technique

Invented by and named after Japanese botanist Akira Miyawaki, the 'Miyawaki Method' is a unique technique to grow forests. Under the approach, dozens of native species are planted in the same area, close to each other, which ensures that the plants receive sunlight only from the top, and grow upwards than sideways



Nature Pool

Natural pools or ponds are natural water bodies which are filtered organically rather than by chemicals. A regeneration zone is built near these, where the water enters either a gravel filter or a constructed wetland made out of plants that clean the water



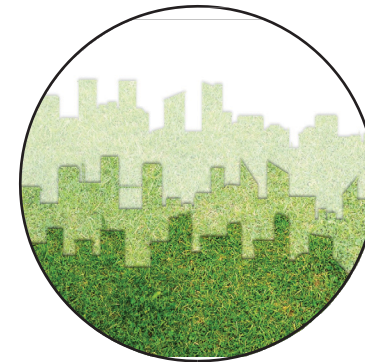
Nature Sanctuary

A protected area of importance for flora, fauna, or features of geological or other special interest, which is reserved and managed for the purpose of conservation and to provide special research opportunities



Bird Park

For a riverfront where the avifauna thrives. This is an interactive engagement space with a variety of bird species, that promotes observation and bird watching. The habitat is harvested as per the needs of the avifauna species



Use of Sustainable Materials

A sustainable building material is one that generates less waste, uses renewable raw materials and is more durable



Conservatory

A conservatory is a building or a room having glass or tarpaulin roofs and walls, which is used as a greenhouse or a sunroof.

Natural River-Edge

Riverbanks, shorelines and riparian buffers are critically important components of riverfront development. The river edges can be developed in various natural ways for integrated regenerative design, storm-water management, habitat restoration, public access, etc., in order to manage and maintain the natural ecology.

Buffer Typology 1

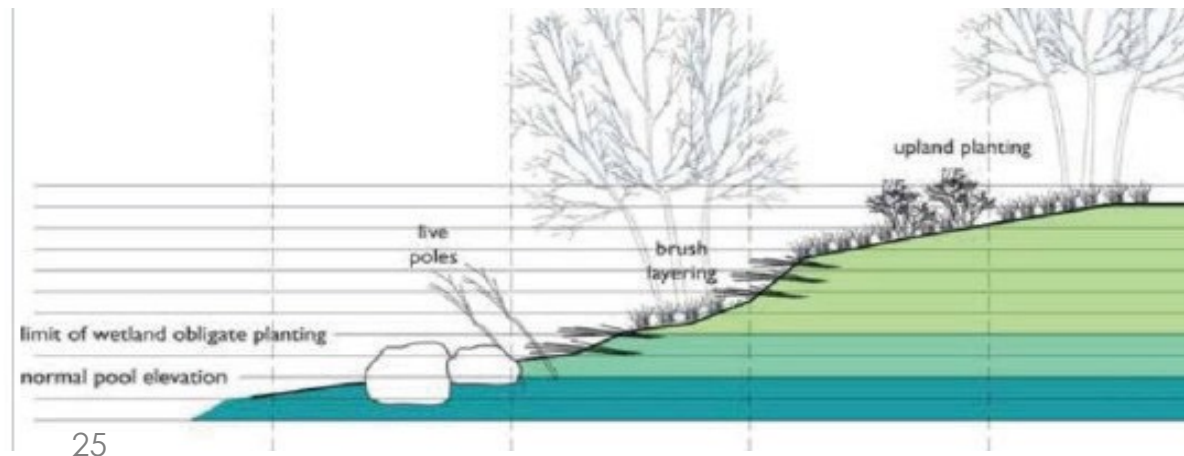
(Buffers in dense urban development)
Design and development techniques that will provide and enhance integrated green infrastructure, storm-water management practices, improved trail access, improved habitat corridor with increased vegetative types as well as increased tree canopy, open space amenities, and integrated design of waterfront access & hardscape elements.

Buffer Typology 3

(Buffer for ecological conservation and open-space)
Design and development techniques that will provide and enhance provision of ecosystem services, ecological restoration, conservation and improvement of biodiversity, increased habitat corridor potential, improved public trail access, open-space amenities and environmental education

Buffer Typology 2

(Buffers in mixed industrial & residential)
Design and development techniques that will provide and enhance provision of ecosystem services, integrated green infrastructure, ecological restoration, storm-water management practices improved public trail access, improved & widened habitat corridors, and open-space/ recreational amenities



Elements

- » Riparian Buffer
- » Conserving natural hydrology
- » Perma-culture
- » Slope bank treatment
- » Seawall treatment
- » Local construction technique

Patna Riverfront

Currently the river banks are prone to erosion and used for garbage dumping

Elements adopted

Riparian edge restoration

- Restoration proposed between the ghats to protect erosion and retain the local flora & fauna
- Presence of promenade & appropriate solid waste disposal system to discourage discard of garbage in the river
- Riparian plantation along river edge, with loose boulders, gabions with grass, plants with native shrubs to control soil erosion
- Only the existing flora & fauna are encouraged to remain and grow in the area between the ghats
- Local construction techniques using locally sourced eco-friendly material and finishes with natural stones for durability and aesthetics

Chicago Riverfront

Elements adopted

River Edge Treatment

- To address riverbank or waterline erosion at the toe of the slope caused by flowing river water & wave action.
- Armouring the toe of the bank with rip rap or other material
- Generally address the toe of the bank up to approximately two (2) feet above

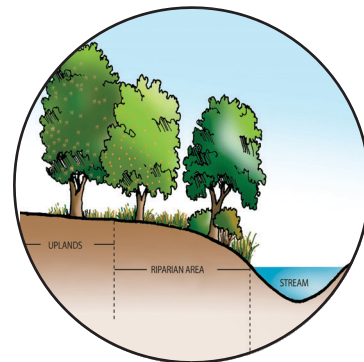
Sloped Bank Treatment

- Used for a sloped or “natural” bank, to create an environmental buffer and to preserve, restore, or create a naturalistic appearance

Vertical Bulkhead or Seawall Treatment

- Used where there is a vertical bulkhead or seawall or other engineered structure
- The “top of the bank” is defined as the point at the top of the bulkhead on the riverside

ELEMENTS



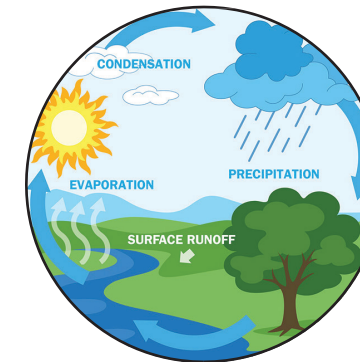
Riparian Buffer

A permanent naturally vegetated area located adjacent to a stream, river, lake, pond or wetland



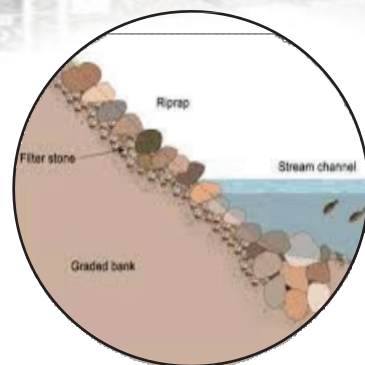
Seawall Treatments

Seawalls are hard engineered structures with a primary function to prevent further erosion of the shoreline. They are built parallel to the shore and aim to hold or prevent sliding of the soil, while providing protection from wave action



Conserving Natural Hydrology

This advocates the adaptive management of watershed lands to optimize re-hydration. Ensured by implementing and enforcing land use patterns that enhance the receptive capacity of watersheds in times of excess as well as scarcity



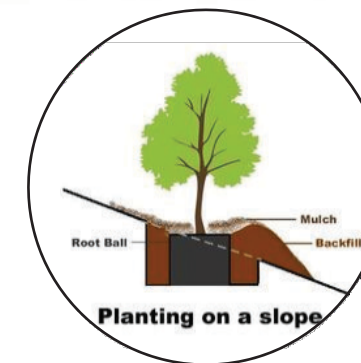
Slope Bank Treatment

Slopes can be stabilized by adding a surface cover to the slope, excavating and changing (or regrading) the slope geometry, adding support structures to reinforce the slope or using drainage to control the groundwater in slope material



Local Construction Techniques

This resorts to the procedures and techniques that are used during the building process. Use of local techniques helps in cost effectiveness of construction as well as promotes environmental sustainability



Perma-Culture Design

It is essentially a multi-faceted, integrated and ecologically harmonious method of designing human-centered landscapes.

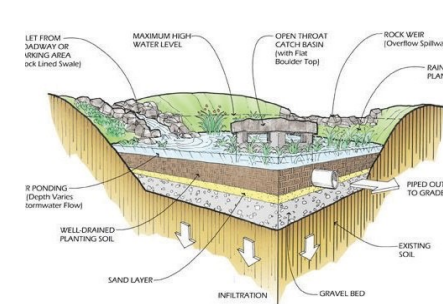
Recharge Zones

Groundwater is the water stored in the pores of the soil strata by infiltration, i.e., water present below the earth surface. Groundwater recharge denotes the entry of water from the unsaturated zone into the saturated zone below the water table surface.

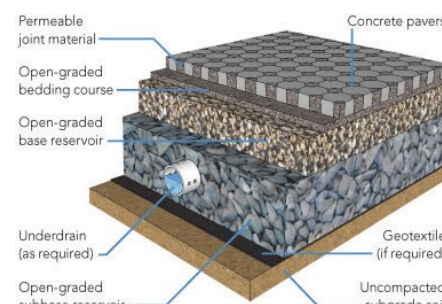
Artificial recharge is the process by which ground water is increased at a rate much higher than that under the natural conditions for percolation.

Identification of areas for recharge –

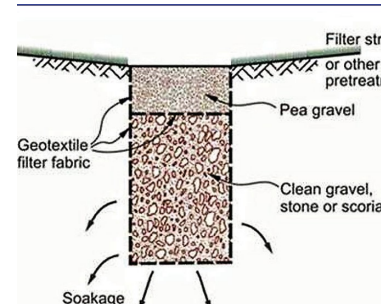
- where ground water levels are declining due to over-exploitation
- where aquifer has already been de-saturated, i.e. regeneration of water in wells and hand pumps is slow after drawing some water
- where availability of water from wells and hand pumps is inadequate during the lean months



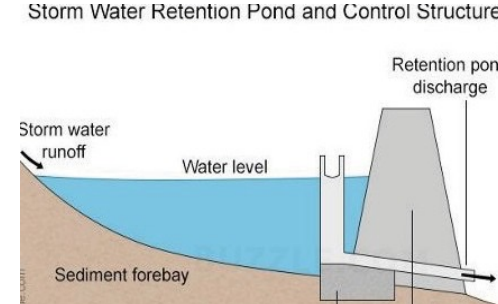
Bio-retention



Permeable pavement



Infiltration zone



Detention pond

Elements

- » Bio-retention
- » Permeable paving
- » Infiltration zone and trenches
- » Detention pond
- » Infiltration
- » Sand filters
- » Plantation management

Gomti Riverfront Development Project

Use of different embankment and construction techniques to promote recharge zones with technological advancements, through an environment monitoring program which includes water quality monitoring and management.

Elements adopted

Water quality management by introducing sand filters

- River edge serves as a ground water recharging bed. Hence sand filters along the edge will filtrate water before recharging the ground.

Plantation management

- Plantation management programs which add value to the environment, and at the same time the landscape acts as an infiltration zone. A pond of filtered water through plantation, acts as a retention basin for the fresh water.

Brooklyn Waterfront Greenway

Elements adopted

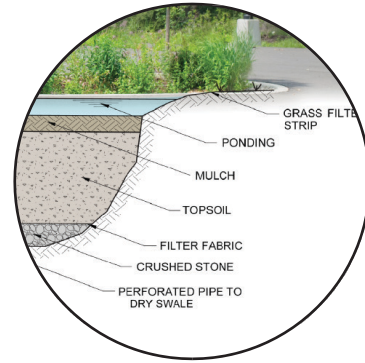
Creating an ecologically sustainable green way

- Native tolerant planting at the riverside - Native trees and vegetation help in sustaining green infrastructure in a tolerant way and in an environmentally friendly manner
- Vegetated buffer at Gantry State Park - Acts as a natural infiltration zone promoting ground water recharge and helps in reducing the water and soil runoff

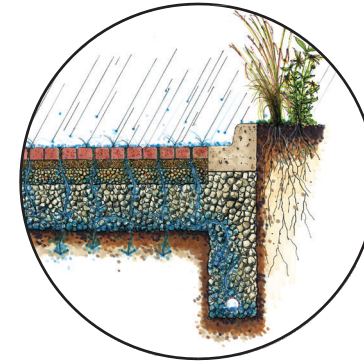
Permeable pathways

- To help in infiltration of water and reduction in runoff, while providing a hard surface for commute.

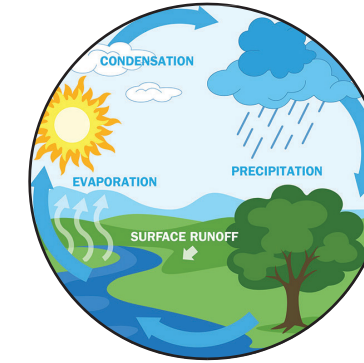
ELEMENTS



Bio Retention
Shallow landscaped depressions, which rely on engineered soils and enhanced vegetation for filtration



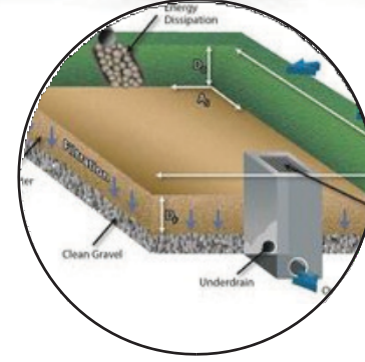
Permeable Pavement
Dual usage allows for both water retention and hard surfaces to coexist in the same area



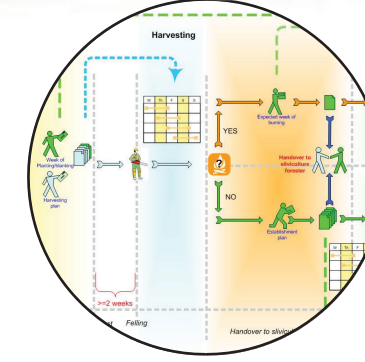
Detention/ Retention Trench
Stores and holds rainwater. These are dry or wet, depending on their consistency to hold water



Infiltration Pond
Concentrated planted spaces for rapid infiltration of surface water



Sand Filters
Sand filters are used as a step in the water treatment process. These are of three different types - rapid (gravity) sand filters, upward flow sand filters and slow sand filters



Plantation Management
Plantation management depends foremost on the main production objective (like conservation, fuel wood, fiber, or saw-log production)

ECONOMICALLY VIABLE INTERVENTIONS



River Markets

River markets involve a specific type of commercial development along the rivers, without harming the ecological significance of the area. These are becoming increasingly popular, with the growing interest for development of nature reserves in an economically viable fashion. Such markets enliven the riverfronts, by drastically increasing the footfall and enhancing the citizen-connect with the river spaces.

Floating river markets

- A floating market is a market where goods are sold from boats.
- Most floating markets operating today mainly serve as tourist attractions.
- They help to promote and preserve the cultural characteristic and heritage of floating markets that have existed for centuries.
- Requires development of infrastructure and public utilities such as electricity and water supply, due to increased footfall
- Economically, floating markets help to improve the standard of living by increasing employment opportunities for locals.



Markets along the riverfront

- These help in improving the riverside infrastructure, providing a healthy environment for the nearby communities.
- Creation of engaging public spaces along the river for people to experience. They help in bringing river closer to people.
- Provide economic and social benefits.

Elements

- » Seating areas
- » Permeable paving
- » Vendor platforms / Kiosks
- » Infiltration
- » Market cultural tours
- » Boat ride in floating markets
- » Cultural experiences
- » Plantation management

Ravivari Market, Sabarmati Riverfront, Ahmedabad

- An informal sunday market
- Designed as an open air market with a functional arrangement of platforms and zones, where vendors can display and sell their goods.
- Provided with seating areas for visitors, public wash-rooms, multi-functional plazas, vehicular access and parking facilities.

Elements adopted

- Vendor Platforms - 1,641 vendor platforms provided to the sellers
- Seating areas - Shaded sitting areas at regular intervals
- Food courts - Food zones selling local delicacies
- Vehicular access - Access provided to the open-air market

Damnoen Saduak Floating Market , Thailand

- Largest and oldest floating market in Bangkok, established in 1866. A perfect blend of antiquity, history and chaos
- Canal bustling with vendors in their narrow wooden boats, selling a variety of local produce - from delicious delicacies to tropical fruits, regional agricultural produce and even Thai handicrafts.

Elements adopted

- Boat Ride - Shopping on a boat ride taking you through different floating shops
- Cultural experiences - Local food and product stores introduced for international tourists
- Safety facilities - safety boats are available throughout the market for monitoring
- Tour guides - A tour guide facility centre is provided at the entrance where tourists can get guided tours of the market

ELEMENTS



Seating Areas

Areas dedicated to sitting in-front or along the riverfront, which act as passive recreational spaces



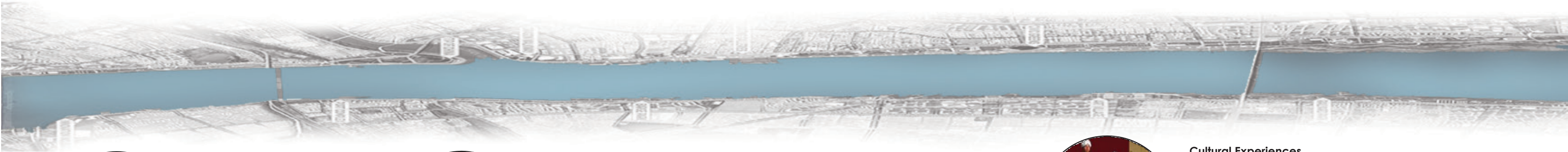
Permeable Pavement

The dual usage allows for both water retention and hard surfaces to coexist in the same area.



Vendor Platforms/ Kiosks

Spaces for vendors where they can have their temporary market stalls or set up their kiosks, within the designated/ allocated area.



Market Tours

A specially designed market stroll tour, where tourists or people can be provided with the cultural experience of the space.



Boat Rides in Floating Markets

The floating markets have this unique feature to have boats as a navigation tool through the market.



Cultural Experiences

The market can provide with unique cultural experiences through various spaces. It helps visitors strengthen the socio-cultural element of the place.

Theme Parks

Waterfronts have the potential to serve as active as well as passive recreational spaces. While most common along rivers, waterfront theme parks can be developed along other water edges as well.

Riverfront theme parks are communal recreational spaces that are intentionally designed to be flooded during storm or flood events. They reduce the impacts of flooding by creating a space that can capture and store floodwaters with minimal damage to the infrastructure.

Riverfront Theme parks must be avoided in:

- Sites where flooding is currently a recurring problem
- Sites with potential to most effectively store floodwaters
- Sites where drainage allows floodwaters to easily enter and recede in a controlled way, to effectively help in flood reduction
- Sites where any park infrastructure may be submerged by floodwaters for extended stretches of time.

Co-Benefits of Riverfront Theme Parks

- Creates opportunities for community engagement and improved public health & wellbeing, through exercise & community interaction.
- Increased traffic and sales for the surrounding businesses
- Increase in value of adjacent properties
- Restoring floodplain and wetland habitat, as breeding ground for local wildlife and the potential for more human-wildlife interactions

Elements

- » Seating Areas
- » Permeable paving
 - » Landscape
 - » Art Installations
 - » Sustainable Construction Techniques
- » Use of Sustainable Materials

Flower Park, Sabarmati Riverfront

- A city level theme park spread in approx 45000 Sq mt. area along the river, with more than 330 native and exotic flower species
- Strengthens green space network of the city

Elements adopted

- Seating Areas - provided at regular intervals
- Art Installations - depicting the theme of the park, installed at various places
- Thematic Landscaping - done in a view to appreciate the theme of the flowers, where the flower beds itself form a decorative feature



Brooklyn Bridge Park

- A 34-hectare sustainable waterfront park on Brooklyn's East River shoreline.
- It revitalizes 2.1km of Brooklyn's post-industrial waterfront

Elements adopted

- Sustainable practices - in planning, design, construction and operation to minimize environmental impacts with extensive reuse of on-site structures
- Construction techniques - design based on the structural capacity of the piers with heavier infrastructure-dependent elements located on the uplands and lighter landscapes on the pile supported
- Financial Sustainability - financially self-sustaining. Leverages on community & business groups to finance & maintain public spaces. Like approximately 10% site set aside for development of residential and hotel building to generate revenue

ELEMENTS



Sitting Areas

The theme parks can have sitting areas representing the visual and thematic experience through them.



Permeable Pathways

Permeable pathways are trails with porous surfaces, permitting ground water seepage. These are made by natural techniques or naturally formed after a prolonged time.



Landscape

Unique landscaping features which can reinstate the flora & fauna and add aesthetic value to the space



Art Installation

Art installations for use or just aesthetics, depicting components related to the theme of the area. These are used to make the spaces vibrant and lively.



Construction Techniques

Eco friendly or green construction techniques could be adapted while developing a theme park, which do not affect the natural river habitat and have negligible impact on nature.



Sustainable Practices

Sustainable practices are the processes or services employed to maintain the qualities that are valued in the physical environment. It means adopting natural systems (environment) and ensuring that the lifecycle doesn't harm others (society and culture).

River Museums and Galleries

Riverfronts can also be used for educational purposes. Museums/galleries are spaces for the display of art, usually intended to educate the community about a certain aspect.

These areas promote social interactions as well as a feeling of belonging to the space, forming a social fabric of the given area. They have the capability to connect people with the social and historical context of the river. Such museums and galleries also contribute to a healthy economic, social and ecological environment.



Elements

- » Seating Areas
- » Exhibition Centers
- » Event Centers
- » Sound and Light Shows
- » Art Kiosks
- » Information Center

The Socio-Cultural Infrastructure, Sabarmati Riverfront

- Infrastructure provided to boost the cities social, cultural and economic fabric.

Elements adopted

- Exhibition Centre - as a multifaceted convention venue proposed on the river bank, with adaptable spaces equipped with state-of-the-art facilities.
- Event center - planned to offer venues for local/ international events, specially those of a historical and national significance. Infrastructural facilities (like stage, VIP Lounge, designated parking, zones for event halls, lawn area, lighting) provided for events along the river in an organized manner.



Cheonggyecheon Museum, Korea

- This museum symbolizes the Cheonggyecheon stream. It spans 6 floors, with exhibition halls, education facilities and an auditorium for cultural events.
- Visitors can learn about the river restoration project, which changed the face of the city forever.

Elements adopted

- Permanent exhibition hall - The history of Cheonggyecheon stream, which has run alongside the history of the city is on display
- Design intervention - its long glass exterior symbolize the flowing waters
- Historic representations - offers educational classes for children on the history and ecology of the stream



ELEMENTS



Seating Areas

Areas dedicated to sitting in-front or along the riverfront, which act as passive recreational spaces



Exhibition Centers

A large building that is designed to hold conventions or exhibits, where individuals or groups can gather to promote and display common interests.



Event Centers

The dual usage allows for a complex, consisting of an arena for any kind of social gatherings. The events can be hosted in the backdrop of the serene environment, ensuring appropriate measures to preserve the natural ecology.



Sound and Light Galleries

Areas for visual entertainment with the help of technology. These visual aids are effective tools for citizen engagement



Art Kiosks

Indoor & outdoor kiosks that display nature are well suited for such natural settings.



Information center

Information center, for addressing visitor queries regarding area's attractions, lodgings, maps, and other items relevant to promoting tourism. These might also showcase other details and updated information regarding the area

River Adventure & Recreational Activities

By making water accessible, we not only get social and economic benefits but also enhance the environmental wellbeing by instilling a sense of belonging in the minds of the people. River activities help in connecting the river to the people by associating individuals with the river. Such areas bring people to recreate, eat, shop, and play. It also attracts entrepreneurs, new businesses, and new residents who desire to live in a community that values health, wellness and outdoor physical activity. On the water the tourists can participate in activities such as sailing in speedboats, kayaking and fishing in fishing boats. In the water the tourists can enjoy a swim in the sea, diving under the surface or rafting/ boating.

River is one of the recreational resource potential of water-sports in many countries. The growing trend of sports tourism in water-based recreation, is emerging in rivers and rapids with unique morphology, being developed by the local community as a tourism destination. Furthermore, comprehensive planning and meticulous study, is the key to develop sustainable sports tourism.

Recreational water activities also have substantial benefits to human health and well-being. Lakes, rivers and water bodies provide environment for rest and relaxation, physical activity, exercise, pleasure and fun.

Elements

- » Water Craft
- » Leisure Fishing
 - » Para sailing
 - » Short Cruising
- » Water Sound and Light Shows
 - » Peddle Boat
 - » Speed Boat
- » Zorbing water bubbles
 - » River rafting
 - » Art Kiosks
- » Information Center

Sabarmati Riverfront

- Different water related activities easily accessible to public
- These practices have been proven to generate employment for the locals in Ahmedabad.

Elements adopted

- Speed boat – speed boat rides generating employment for local people.
- Water craft – facility available on rent. Infrastructure like sheds, etc. are provided on the riverfront.
- Jet Ski water scooter - available for public with provision of supporting infrastructure, like ticketing counter, etc.
- Pedal/ motor boat – Infrastructure like parking areas for these boats are clearly specified in the plan
- Zorbing water bubbles - available at specific periods of time in specific months, with supporting infrastructure like sheds, deck -ticketing counter, etc.

Hudson Riverfront

- The park's four-miles of piers, esplanades and landscapes boast sunset views, scores of recreational and play spaces, stunning gardens and much more.

Elements adopted

- Boat Building - a variety of opportunities to learn about and engage in the art of seamanship
- Circle Line Sightseeing Cruises - completely circles Manhattan, showing all of NYC's iconic landmarks
- Downtown Boathouse - provides free public access to the New York Harbor through kayaking programs
- Kayaking – a great sport for novice or pro adventurers
- Outrigger Canoe Paddling - an ancient sport with deep roots in Polynesian culture
- World Yacht – luxury yacht rentals, departing from Hudson River Park

ELEMENTS



Water Craft



Leisure Fishing areas



Para Sailing



Short Cruising



Water Show



Peddle Boat



Speed Boat



Zorbing Water Bubbles



River Rafting

SOCIALLY COHESIVE INTERVENTIONS



Riverfront Promenades/ Walks/ Walkways

Riverfront Trails

These are riverfront connections that place emphasis on moving along the river. Ideally designed for pedestrians, runner, cyclist or rollerblades, these provide riverfront connections for recreational uses.

Riverfront Promenades

Promenades are generally more pedestrian in character, rather than recreational. They provide opportunities to experience the river from a different vantage point. Promenades are places to see and to be seen. They can open up the views of the river and integrate the character of the community with the pastoral nature of a park. Ideally placed where landings intersect connections along the riverfront park and where urban districts are adjacent to the riverfront.

Riverfront Streets

Streets along a riverfront have the potential to be an exciting and different way to experience riverfront parks, and to create new opportunities for development adjacent to them. They can make the riverfront more accessible and open up all areas of the park. Designing and locating of riverfront streets should ensure that access to the riverfront is not restricted by the presence of vehicular streets, and with pedestrians as a primary consideration.

Elements

- » Biking Trails
- » Permeable pathways
- » Promenades
- » Riverfront streets
- » Walking trails
- » Scenic Drives

Sabarmati Riverfront

Different trails are spotted at the Sabarmati Riverfront, developed as riverfront interventions or a part of an activity in the biodiversity or flower park.

Elements adopted

- Riverfront Trails - made of paved surfaces, these are also used for jogging or bicycling when the footfall is less in the morning.
- Riverfront Promenades - form scenic walkways and vistas. These are provided with infrastructure like sitting spaces, toilets, and mostly made of sustainable materials.
- Scenic drives - 4 vehicular bridges over the river creating a visual connection between the people and the riverfront.



Manhattan Greenway, Hudson Riverfront

- Located on Manhattan’s western waterfront, it splits into two sections - Hudson river green way (car-free portion) and the east river green way (with several road links currently)

Elements adopted

- Riverfront trails as sight seeing trails - interspersed with landmarks like riverside parks, the Chelsea piers, and the world trade center
- Riverfront promenades riverside park south – contains various curving pathways amid the greenery, connected to riverside drive and waterfront level via staircases/ ramps, crossing with bicycle lanes at few nodal locations.
- Scenic drives – connecting museums, grand estates, west point, and an aerodrome



ELEMENTS



Biking Trails

These are paths with their own right of way dedicated to cycling, though in many cases shared with pedestrians and other non-motorized traffic. Dedicated bike trails along the river banks can serve as an engaging community activity space



Permeable Pathways

A permeable paver walkway allows water to pass through it and seep into the ground. There are far less flooding and water-displacement concerns using these, than faced with impermeable material. Thus the riverfront surfaces should be kept permeable, as much as possible.



Promenade

These are paved public walks, typically the ones along a riverfront, designed in a way to provide with an experience of a leisure walk from one place to another. These are usually accompanied by viewing and accessing decks to the river.



Riverfront Streets

These streets along the rivers are viewed as a part of the river, framing scenic views and making the river a part of the daily activities in these areas.



Walking Trails

A green way is a long, narrow stretch of land, often used for recreation or pedestrian and bicycle users, and sometimes for streetcars, light rail or retail uses. Such shared use paths supports multiple modes, such as walking, bicycling, in-line skating and people in wheelchairs, for connecting rivers with the citizens.



Scenic Drives

Driveways along or crossing the river provide a great combination of the required city infrastructure with aesthetics. The concept of bringing river as a part of the daily route, by proposing interventions such as promenades, boulevards and bridges, is being widely adopted by river cities.

Religious Developments

Water has been of utmost significance to the communities, specially in India, within their daily life, traditions and festivities. Indian rivers have a huge religious significance. Over time, riverbanks attracted temple complexes, pilgrimage sites, ghats, palaces, forts and capital cities through successive reigns and periods in history.

Ghat, a term used in the Indian subcontinent, refers (in the river context) to a series of steps leading down to a body of water or wharf, such as bathing or cremation place along the banks of a river or pond, Dhoby Ghat or religious Varanasi Ghats.

Usually ghats of the river are exposed to a load of religious offerings and activities associated with the river, namely, offerings of flowers and lamps, bathing, washing, cremation, etc. These activities add to the pollutant content in the river, which requires regular cleaning. Religious activities like cremation, bathing performed on the banks of the river contribute to the high pollution of the river.



Elements

- » Boat ride
- » Heritage walk
- » Market
- » Dhobi Ghat
- » Electric Cremation
- » Cultural drives

Varanasi Ghat Development, Uttar Pradesh

Harishchandra ghat is the oldest Kashi cremation ground. Significant number of cremations take place here, hence it currently faces many issues like cleanliness, pollution, silt deposits, encroachment, deterioration of hard scape, unorganized wood stocks and funeral activities, missing street scape elements, dilapidated building facades, etc.

The proposal for ghat revitalization is a three step process as described below.

- Electric cremation - Electric cremation centers are provided at the ghat to avoid water pollution
- Boat Ride - Evening boat rides are available to people for scenic drives and cultural experiences.
- Market - A dedicated market place has been approved where local vendors could set up their stalls, increasing the local economy

Activities performed on the ghats

The Ghats continue to perform complex religious, environmental and social functions in the given space:

- Evening Aarti Ceremony
- Morning Boat Ride
- Holy Bath
- Heritage walk
- Market
- Laundry



ELEMENTS



Boat Ride

Boat ride along the ghat offering cultural and heritage experiences. Many Indian rivers offer such activities to promote religious tourism.



Heritage Walk

Heritage walk through the scenic places along the ghat, showcasing different activities with the help of supporting infrastructure like information boards/ centres or a local tour guide.



Market

Different markets supporting Religious and cultural activities associated with the river could be provided, serving as an additional livelihood opportunity for the local population.



Dhobi Ghat (Laundry Places)

The traditional Indian *Dhobi Ghat* could be re-imagined in a more organized manner, by allocating a dedicated space and providing the required infrastructure with semi-permanent or permanent structures.



Electric Cremation

Electric cremation centers can support in controlling river pollution, specially in areas where the furnace or incinerator is a high powered one. This will drastically help in pollution control, within rivers in such areas.



Cultural Drives

A planned cultural drive can be developed to promote religion based tourism, highlighting different cultural activities associated with the area.

COMMON AMENITIES for Riverfronts



ELEMENTS



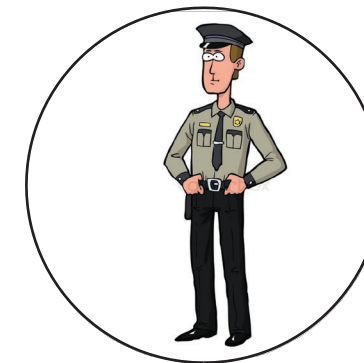
Lockers

Public lockers should be provided for people (on rent) to hold their valuables while engaging with recreational and other river activities.



Motion Sensor Lights

Motion sensor lights increase visibility during night to enhance the safety and security of the space, and at the same time save electricity.



On-site Security

Riverfronts can turn into inactive spaces at night. On-site security personal could assist people and enhance a safe experience during day and night. They also assist to be an over-looker for any malpractices carried out by taking necessary actions.



Wireless Cameras

These can cover more ground than a security guard. They also help in the off-site monitoring from an allocated space and provide immediate attention, if needed.



Emergency Monitoring

The idea is to have a one-button-away system for seeking help. These can separately be provided on street lights or poles as well.



Public Toilets

Mobile or E-toilets which are self-contained, self-cleaning, unisex, user-friendly, unmanned, automated and remotely monitored toilet pods, shall be adequately installed in appropriate public places.



Street Furniture/ Signages

Adequate signage and furniture are to be provided in a public space, where ever required. The street furniture could be multi-functional to enhance the usability of the space.

ELEMENTS



Universal Design

The design of a riverfront area has to be accessible to people with different needs and abilities. All the design elements should be in coherence with the accessibility measures for the disabled.



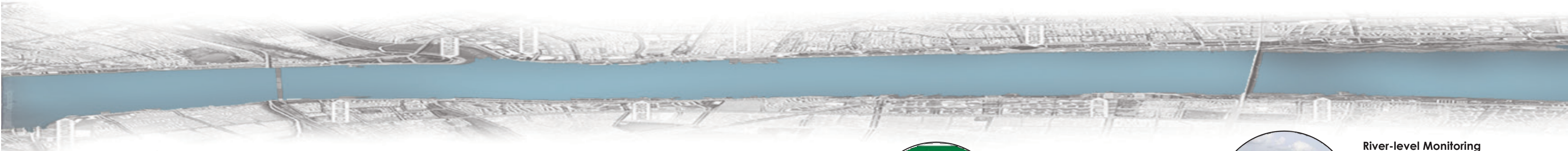
Shaded Plazas

These can be provided at regular intervals along the riverfront, making the experience more comfortable. Such plazas can be used for sitting as well as walking along the place, specially in summers.



Evacuation Map

An evacuation map should be provided at regular intervals for public access in case of emergencies. Evacuation drills should be conducted from time-to-time, to avoid extreme events in case of hazards.



Speakers and Alarm Systems

Sound systems should be installed at appropriate locations along the riverfront, for making the necessary announcements.



River Safety Infrastructure

All the necessary infrastructure for safety, such as safety docks, lifeboats, patrolling boats, etc. should be available on the riverfront.



Medical Aid Rooms

A medical assistance room should be provided with all the necessary infrastructure the nursing staff needed, and with all the medical facilities.



River-level Monitoring

A monitoring system should be installed with monitoring units at appropriately identified locations and the public should be intimidated for any early-warning signals.

OVERVIEW

Eco-friendly Interventions for Riverfront Development



National Case Studies

Case Study	Environmentally Sustainable	Economically Viable	Socially Cohesive
Sabarmati Riverfront	Biodiversity Park	Riverfront Market	Riverfront Promenades/ Walks/ Walkways
	Bird Sanctuary	Flower Theme Park	Social and Cultural gathering place
		Exhibition Centre/ Event Centre	
		Water Sports/ Water Recreational areas	
Patna Riverfront	Patna Natural River edge	Riverfront Market	Riverfront Promenades/ Walks/ Walkways
	Sustainable Construction Technology	Riverfront Park	Social & Cultural gathering place
			Ghat Development
Gomti Riverfront	Recharge Zones	Riverfront Market	Riverfront Promenades/ Walks/ Walkways
	Water treatment plants		Social & cultural gathering place
	Wetlands		
Varanasi Ghat Development, Uttar Pradesh	Water Pollution Regulation	Riverfront Market	Varanasi Ghat Development
	Sustainable Planning Systems	Cultural & Heritage Tourism	Social & Cultural gathering place

International Case Studies

Case Study	Environmentally Sustainable	Economically Viable	Socially Cohesive
Chicago	Chicago wilderness (biodiversity park and bird sanctuary)	Mccormick bridge house & Chicago river museum outdoor art gallery	Riverfront Promenades/ Walks/ Walkways
	Chicago natural river edge Pollution and restoration	Water sports water recreational areas Chicago Riverwalk restaurants and bars	Moveable bridge
Brooklyn waterfront Greenway	Natural river edge (Brooklyn waterfront green way)	Brooklyn bridge park, theme park	Riverfront Promenades/ Walks/ Walkways
		Brooklyn crab (food and market place)	Emmons avenue
		Empire Fulton ferry	
Damnoen Saduak, Thailand	Bang Kachao wilderness park	Floating market	Riverfront Promenades/ Walks/ Walkways
		Food and cultural exploration	Social and cultural gathering places
Cheonggyecheon river, Korea	Use of green energy	Cheonggyecheon museum, Korea	Creation of pedestrian amenities recreational spaces.
	Sustainable construction technology	Creation of two plazas, eight thematic places	
Hudson Riverfront	Preserved ecologically sensitive area	Water sports water recreational areas	Riverfront Promenades/ Walks/ Walkways
	Infill development as greenfield development	Linear riverfront parks	Social and cultural gathering places
		Community parks (water sports and recreational activities)	

REFERENCES

- Jacqueline Hoyer, W. D. (2011). Water Sensitive Urban Design. Sustainable Water Management in the City of the Future , 1-118.
- Leopold, L. B. (1968). Hydrology for- Urban Land Planning . Washington : GEOLOGICAL SURVEY CIRCULAR .
- Peter M. Bach, D. T. (2013). A planning algorithm for quantifying decentralised water. Australia: IWA Publishin.
- Sara Maria Lerer, K. A.-N. (2015). A Mapping of Tools for Informing Water Sensitive Urban Development. water , 1-20.
- Sharma, D. N. (2016). Participatory Approach of Water Resource Management: A Case Study of Marathwada. IOSR Journal of Business and Management (IOSR-JBM).
- SWITCH. (2012). For eva Solutions. Retrieved 04 10, 2017, from <http://www.forevasolutions.com/Integrated-Water-Management.html>
- Thneibat, M. M. (2016). POLICY DESIGN TOOL FOR MANAGING INDOOR RESIDENTIAL WATER. West Lafayette, Indiana.
- Tim D. Fletcher, W. S. (2014). SUDS, LID, BMPs, WSUD and more . Urban Water Journal , 1-19.
- Tiwari, B. V. (2009). Place-Making through Water Sensitive Urban Design. sustainability , 1-26.
- Brown, Tony H. F. Wong and Rebekah R. 2011. "Water sensitive urban design." Water Resources Planning and Management
- Miller et al. 2006;
- Naturally Resilient Communities, Waterfront Parks, <http://nrcsolutions.org/waterfront-parks/>

- Martin Prominski, Antje Stokman, n.d.; Design and Space, n.d.;
- Engineering 2008; BUIDCO (Bihar Urban Infrastructure Development Corporation Limited) 2013)
- "Alleghenys-Riverfronts.Pdf," n.d.; A. B. Park 2012;
- Schaefer 2014;
- Amelar 2011; S. Park, State, and Quality 1899;
- Greenway 2008; Buckman 2016; Mission and Clean 2019;
- Farbstein, J., Lubenau, A.M., Sherman, D., Shibley, R., Wener 2017;
- City of Chicago 2019; City of Chicago Department of Planning and Development 2019;
- Aman and Tarush 2017; Department 2018; Coastal and Working 2016;
- Woo et al. 2017; A. B. M. Yassin, Bond, and McDonagh 2011;
- Riverlife Pittsburgh 2014; Dong 2004;
- NABILAH REDZUAN and NURUL SYALA ABDUL LATIP 2016;
- Kalita 2017; Rathore and Jadon 2019;
- Commons 2008; A. B. Yassin 2011; Andini 2011; Hussein 2006; Rasal 2012; Zhang 2002;
- Addy et al. 2016;
- Kapoor 2016;
- Chen 2013;
- A. B. Yassin, Eves, and Mcdonagh 2010;
- Paneria, Mehta, and Bhatt 2017;
- Patel 2011; Balakrishnan 2018;
- Vimawala 2018;
- (EPC) 1998; Improvement and Revitalization 2011; Mahadevia and Lathia 2019; Lee 2006; Seoul Institute
- Green 2008; Quay 2010; Nurul 2013;