VISHWAMITRI: A River and its Reign

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ASP Foundation, Smita Pradhan

Location

Vadodara, Gujarat, India

Project Period

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*See Appendix 4 for Student, Advisor, and Client Profiles

A project submitted in partial fulfillment of the requirement for the degree of
Master of Science and Master of Landscape Architecture
University of Michigan
School of Natural Resources and the Environment
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An Alternative Design Concept for the Vishwamitri River in Vadodara, India

A project submitted in partial fulfillment of the requirement for the degree of Master of Science and Master of Landscape Architecture

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We also extend our appreciation to our client, the ASP Foundation, which supported us with feedback throughout the project, in addition to connecting us to local officials and city residents to gather the data we needed to develop our conceptual design alternative.

We are thankful to the many people and institutions in Vadodara that made our trip successful. These include Vadodara Municipal Seva Sadan (VMSS), The Maharaja Sayajirao University of Vadodara (MSU), Community Science Center (CSS) , Ministry of Environment and Forests, Gujarat (MoEF) and Vadodara Regenerative Action Team (VRAT) .We are thankful to the many residents of Vadodara, from our landlord, to laughing clubs, to residents of informal settlements, who shared stories, thoughts, and visions of the River Vishwamitri. We hope that our design reflects those visions.

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List of acronyms & organizations

ASP:	Amrut Sitaram Pradhan Foundation, our client
Bhuvan:	Online geoportal for data from the Indian Space and Research Organization (ISRO)
DEM:	Digital elevation model
EIA:	Environmental Impact Assessment
GERI:	Gujarat Engineering Research Institute
GI:	Green infrastructure
GIDC:	Gujarat Industrial Development Corporation
HCP:	HCP Design, Planning, and Management, the firm behind SRDP and VRDP
HFL:	High flood level
ISRO:	Indian Space and Research Organization
MSU:	Maharaja Sayajirao University (located in Vadodara)
NGO:	Non-governmental Organization
NGT:	National Green Tribunal
NIH:	National Institute of Hydrology
SIA:	Social Impact Assessment
SNRE:	School of Natural Resources and the Environment
SRDP:	Sabarmati Riverfront Development Plan
STP:	Sewage Treatment Plant
RIRA:	Rackham International Research Award
U-M:	University of Michigan
VMC:	Vadodara Municipal Corporation (municipal government)
VRDP:	Vishwamitri Riverfront Development Project

INTRODUCTION

Perhaps the only thing more dynamic than a city is a river. As cultural, social, and technological advancements serve people in an increasingly urbanized environment, rivers remain a novel feature of human and environmental systems, In India, a country of over 1.2 billion people, the mounting concerns related to water are numerous: water quality, shortage and supply, wastewater treatment, the recognition of ecosystem services, the protection of species, habitat, and ecological processes, and the impact of water management on the local communities. Watershed and broader landscape issues in India contend with an increasingly urbanizing population, causing national, state, and municipal governments to undertake infrastructural megaprojects to adapt (Follman 2014)[1]. Development across the country attempts to address complex environmental management issues, with varying degrees of attention to ecology, landscape processes, and long-term sustainability for the environment and local people. Actions over the course of the last century will shape the next, with complicated questions of how people, cities, and landscapes coexist shaping the future of how India's natural resources can thrive for years to come.

Within this context, we turn to the city of Vadodara, Gujarat, the site of our Master's Project. Vadodara, a bustling city of roughly two million people, was founded on the banks of the Vishwamitri River. Like many urban rivers, Vishwamitri exhibits symptoms of the "urban stream syndrome"[2], a condition defined by challenges such as floodplain encroachment, poor water quality, habitat degradation, increase of tolerant species, and bank erosion. In addition to these common issues, the Vishwamitri River also faces a unique challenge, as it is home to the legally protected, but dangerous, Mugger crocodile[3] (Crocodylus palustris), a species that thrives in the lush blooms of this degraded, nutrient-rich environment. In response to the challenges of the Vishwamitri, the Vadodara Municipal Corporation (VMC) commissioned HCP Design, Planning, and Management, Pvt. Ltd. (HCP) of the neighboring city of Ahmedabad to develop a riverfront development plan. This proposal, the Vishwamitri Riverfront Development Project (VRDP), introduced in 2014, was met with concern and controversy locally. Many stakeholders are concerned about the negative ecological and social impacts of the intended land use changes, which includes replacing the natural riparian edge of the entire urban river corridor with a concretized pedestrian riverfront.

Our team was commissioned by one of the stakeholder organizations, the ASP Foundation, to formally critique the VRDP and develop a corresponding alternative design concept for Vishwamitri. Our work in this report is preceded by the public critiques and opposition of numerous NGOs, community activists, and academics in Vadodara, Gujarat, and across India. We are indebted to and respect these investigators for their commitment to the health of the river and

[1] Dr. Follmann's (Geographisches Institut - Universität zu Köln) case study explores the "environmental dimensions, discourses, and legal conflicts" in the format of a case study "contrast[ing] the slum demolitions and development of two intertwined mega-projects," ultimately arguing that the intentionally created spaces create zones of "calculated" urban informality.

[2] The urban stream syndrome describes the consistently observed ecological degradation of streams draining to urban land, including flashier flows, elevated concentrations of nutrients and contaminants, altered channel morphology and stability, and reduced biodiversity, all of which are noticeable in the Vishwamitri River (Walsh et al., 2005).

[3] The Mugger is listed as a vulnerable (VU) species on the IUCN Red List since 1982, as the population has declined 30% over the past 75 years. The species is native to India, Iran, Sri Lanka, Pakistan, Nepal and possibly extinct in Bangladesh. According to the IUCN, the current population is "stable" with a severely fragmented population.

those who share space with it. Our work responds to their requests for a nuanced, holistic vision for Vishwamitri that acknowledges the potential for complementary dynamism between Vadodara and the river system.

This project offered our interdisciplinary team an excellent case study in multifunctional design for urban stormwater management, ecosystem health, and human well-being. Our work is presented in direct response to the VRDP, responding specifically to the issues inherent to the design's conceptual framework. We offer a new framework altogether. The VRDP intends to control monsoon flooding through a highly-engineered restructuring of the river corridor. Following in the footsteps of HCP's award-winning work on the Sabarmati River in Ahmedabad (the SRDP), the VRDP is accepted by many as the only plausible solution to the challenges at hand. However, we believe complex issues demand an equally dynamic and complex approach. Our approach looks beyond the SRDP, making a compelling case for innovative, Vishwamitri-specific ecological design over conventional engineering solutions. We believe an ecologically-designed riverfront would allow the City of Vadodara to capitalize on Vishwamitri as a unique regional asset, attracting visitors and new residents alike. In light of the growing body of knowledge in urban ecology, urban stormwater management, and watershed dynamics in India and beyond, in addition to local sentiments on the river's identity and importance, our work articulates an alternative vision of Vishwamitri.

VRDP PROJECT HISTORY AND OVERVIEW

History

The Vishwamitri River was key to the settlement of Vadodara, which was founded on its banks in 1721. Historic images and paintings show people in close connection to the river in daily life, filling earthen pots with its water and washing clothes on ghats (steps) leading down to the water's edge. However, rapid growth in population, industrialization, and urbanization have degraded the river to such an extent that, like many urban rivers, the Vishwamitri is now considered a drain. In our interactions with residents, we found that people often refer to the river with a sense of disappointment about its potential or hope that one day it will be "clean". Broadly speaking, the major causes of the degradation are improper sewage management, increased impervious surface and deforestation throughout the watershed, encroachment within the floodplain[4], lack of concern for ecological processes, invasive species (such as *Prosopis juliflora*)[5], open dumping of solid waste[6] and lack of sensitivity for historical context in development (Kothari & Thomas 2015).

These issues have lead a number of organizations to develop visions for an improved Vishwamitri, eventually leading to the VRDP. There have been numerous attempts at reviving Vishwamitri in the past, with varying techniques to achieve a similar goal. As early as 1998, the VDA (Vadodara

[4]Conversations with our client and other stakeholders suggest that some of the major buildings in the city have been constructed on wetlands and natural floodplains of the river. Estimated floodplain maps provided by the National Institute of Hydrology confirm these suggestions.

[5]The riverine ecosystem is incredibly biodiverse. However, invasive species have prevented the regeneration of native trees (such as banyan, from which Vadodara gets its name, and the protected Ravantad palm).

[6]Dumping along the river occurs at multiple scales. There are some designated municipal dumping sites that include construction debris or refuse, while in some places residents, butchers, and zookeepers dump food waste or domestic waste into the river to attract crocodiles, for example.

Design Academy) conducted a month-long study with the aim of inspiring professional bodies, architects and consultants to initiate a development project by sharing information about Vishwamitri's landscape, ecology, topography, hydrology and water quality by setting up an information bank (Kothari & Thomas). Then in 2008, there was the Vishwamitri "Re-sectioning and Rejuvenation Project," which aimed at increasing the flood-carrying capacity, strengthening bridges, rehabilitating slum dwellings along the river, and proposing check-dams for development and solid waste management (Kothari & Thomas).

Several years later, the VMC initiated the Re-sectioning and Rejuvenation Project which did marginally improve the flood mitigation potential of certain portions of the river by creating diversion channels and check-dams, but long-term goals of improved water quality were not met (Kothari & Thomas). The regrading of the riverbanks lead to destruction of vegetation and crocodile nests (which were soon reclaimed by the territorial species). In 2012, a river revitalization campaign was brought forth, known as the Vaho Vishwamitri Abhiyaan (literal translation: "campaign for the flow of Vishwamitri"). The campaign has a large-scale vision, including the creation of a "bioshield", or a native plant buffer along approximately 135 km of Vishwamitri, starting at the source in Pavagadh. The plan received widespread support due to its promising combination of environmental engineering and botanical knowledge. However, the lack of funds and governmental support halted the project.

Then, in 2012, the Sabarmati Riverfront Development Project (SRDP) by HCP Design in the neighboring city of Ahmedabad, became an award-winning riverfront development project. The reverberations of this project in Vadodara are clear, as the SRDP is the foundational model for the VRDP. The clear inspiration is seen in the reuse of images from the SRDP in the VRDP feasibility report without appropriate contextualization.

Government Project Overview

In response to increasing demands from the residents of Vadodara to manage the flooding, the Vadodara Municipal Corporation (VMC), or the municipal government, collaborated with HCP Design to develop a solution for Vishwamitri. In 2014, the Interim Feasibility Report for the Vishwamitri Riverfront Development Project (VRDP) was released. The report defines the overarching goals of the project to be river clean-up, increasing its flood carrying capacity, groundwater recharge, creating a "safer" habitat for crocodiles, and integrating economic development into the river corridor. On the surface, the goals of the VRDP are timely and encouraging. However, a closer look at the design reveals a number of serious concerns about the environmental and social implications of the actual design. A variety of local stakeholders have expressed their concerns to the government, resulting in superficial changes to the feasibility report documents and graphics, such as the addition of a few clumps of grass into visualizations to demonstrate attention to biodiversity. However, few instances of meaningful, course-correcting changes to the design have occurred since it was announced.

Legal status of the VRDP and illegal construction

As of April 2017, the VRDP has not received the proper environmental and social impact clearances (Times of India, 5 May 2016). In May 2016, a case was filed in this regard with the National Green Tribunal (NGT), the federal environmental policy force in India. Additionally, illegal

encroachment on the river and government land for commercial development led to the filing of multiple petitions and Public Interest Litigations with the Gujarat High Court (*The Times of India*, 14 May 2016). To date, these cases have been successful at holding back the main thrust of the VRDP, with the exception of some illegal construction and project preparation, which our client has documented through photographs[7]. Entire riverfront settlements have been demolished in the name of the project, even as our team was in Vadodara in May-June of 2016[8]. Stakeholders in opposition to the VRDP are incredibly active in the opposition process, using every channel available to engage with the VMC. It is apparent from conversations with our client that there are discussions behind the scenes about how the project can be changed to avoid controversy. We view this as fertile ground for our proposal.

Our role in the project

Dhara Mittal, a SNRE student from the Master of Landscape Architecture track and resident of Vadodara, sourced this project in collaboration with a professor from her alma mater, Maharaja Sayajirao University in Vadodara. Our client requested our team to develop an alternative conceptual framework on which to base the future of the Vishwamitri. This alternative will be presented to the VMC by the client, although it, like the VRDP proposal itself, will require additional site-specific design development before implementation.

PROJECT OBJECTIVES

This Master's Project had two primary objectives:

1) To evaluate and critique the VRDP based on current peer-reviewed literature, regional and national trends, and previous criticisms presented by local stakeholders.

2) To develop a plausible, visionary alternative design framework for the Vishwamitri River that responds critically, creatively, and specifically to both the VRDP and Vadodara's wider watershed context.

DELIVERABLES

To meet these objectives, we supplied our client with the following deliverables:

1. Critique (Appendix 1): This document builds upon criticism provided by local environmental activists and opponents of the VRDP. The critique identifies key deficiencies of the VRDP from a variety of angles. The critique is not intended to demean the VMC or HCP Design, but to provide a well-researched analysis of the impacts of their proposal based on a growing body of scientific knowledge. The critique is also a starting point from which to approach our second deliverable, the alternative design.

[7] A Times of India article discusses the VRDP being put on "fast track", and the development of a 1000 day detailed plan for making the city smarter (Times of India, 25 June 2016). Our client also has photographs of illegal construction that has begun in the river corridor in spite construction stays ordered by the National Green Tribunal.

[8] The proposal outlined the restructuring of slums in three ways: "relocation", "redevelopment", "upgrading" the existing slums.

2. Alternative design report (Appendix 2): Our conceptual design framework will be used by our client, the ASP Foundation, to present to the VMC a more holistic future for the Vishwamitri River. Responding directly to our overarching criticisms of the VRDP, our alternative design is presented at three scales: the watershed scale, the city scale, and at the scale of the VRDP's Influence Zone itself. Our report also recommends policy and organizational solutions to sustain and support both the design and future efforts to monitor and protect the river and those who depend on it.

METHODS

To develop our critique and alternative design framework, we used the following methods:

Developing a sense of place: Field Visits

With funding from SNRE and the Rackham International Research Award (RIRA), our team travelled to Vadodara for several weeks (May-June 2016, just before the monsoon). During this trip, we gathered information from our client, VMC officials, MSU professors, and members of the Forest Department. In addition, we did a "watershed tour", in which we travelled the entire length of the the Vishwamitri from Pavagadh to the Gulf of Khambat, in an effort to understand the range of landscapes in the watershed. We spent a great deal of time observing the role of the river in the fabric of the city, spending time on its banks, watching crocodiles from bridges, and engaging with citizens.

Field visits along the banks of Vishwamitri provided a better picture of the issues and put the VRDP's goals in context. We saw the downstream effects of nutrient-rich sewage from outfalls, riverbanks composed entirely of compacted trash, and saw the impacts of erosion and invasive species on native vegetation and biodiversity. In our field visits, we were accompanied either by our client or personnel from the state Forest Department to ensure maximum safety in crocodile habitat. Throughout our travels, we had the opportunity to discuss our project and gather perspectives from those we met along the way, whether in a homestead, a public park, or a salt flat. Many of the photographs from these adventures are included in this report.

Gathering Data: Assistance from the VMC and MSU professors

The main purpose of our visit to Vadodara was to gather information. Unlike the U.S., where there are comprehensive databases on soils, topography, land cover, and historic land use changes are readily available online, fine-grained data related to the Vishwamitri is scattered within the VMC and throughout various departments at Maharaja Sayajirao University. Ensuring high quality deliverables was dependent on the amount and quality of the information we could collect from the VMC, MSU, local experts and by conducting surveys. We were strongly advised against collecting first-hand data, especially within the riparian zone, as the presence of Mugger in the river is hard to detect from the riverbank. We recognize this data will be important moving forward if our conceptual design is to be fleshed out in meaningful, site-specific ways.

A majority of our time in Vadodara was spent in discussions with officials from the VMC including the mayor, municipal commissioner, and city engineer; professors in MSU (zoology, geography, architecture, urban planning, and environmental studies departments.), and local experts from the Forest Department to gather all available information related to the river's ecology, hydrology, geology, and cultural importance. While we did manage to get more data than we expected in some areas (such as sewer system maps), there are many areas where fine-grained data limits our ability to design. It is important to note the conceptual nature of our design concept is due to the lack of fine-grained data regarding infrastructure, vegetation, topography, and other key information.

Gathering Perspectives: Public surveys and informal interviews[9]

During the latter portion of our visit, we conducted public surveys to gather perspectives on the river and its future. In a preliminary critique of the Interim VRDP Feasibility Report which was sent to the VMC, the NGT, and the Ministry of Forests, Environment and Climate Change, our clients called out the lack of public participation in the development of the VRDP. Our clients felt that the citizens of Vadodara have a valuable perspective to offer the design process. This survey was a first attempt at gathering those perspectives.

The survey questions were developed collaboratively between the client and our team, consisting of both open-ended and multiple choice questions (see Appendix 3 for the survey in both Gujarati and English). We disseminated this survey in person and online. The paper surveys were in Gujarati and English, in order to gain the opinions of people with varying educational backgrounds. These surveys were conducted in public places such as Sayaji Baug (the largest public park in Vadodara), public commons, and on bridges throughout the city, where residents often gather to relax with friends or watch crocodiles in the Vishwamitri. The online surveys were only in English and were circulated through familiar networks. In total, we had 200 responses to the survey, some of which were incomplete. We also conducted informal interviews with individuals, mostly with none or very little formal education, especially those who used to interact with the river on a regular basis. We met some of the respondents both during our travel throughout the watershed and through personal contacts.

It is important to note that these surveys were not intended to be statistically analyzed or to make definitive design decisions, but were conducted as an exercise in gathering perspectives. The information we gained from this process was folded into our understanding of the Vishwamitri. We hope that any future design projects at the scale of the VRDP and Vadodara would include a more systematic approach to gathering truly representative public input.

Building the Argument: Critiquing the VRDP (Appendix 1)

While both our client and other concerned stakeholders have submitted formal criticisms of the VRDP Interim Feasibility Report, there was a need for a more comprehensive critique backed by current peer-reviewed literature. Building on these preliminary critiques, we developed a report describing 24 interrelated criticisms in detail. The critique builds the argument for our alternative design framework, making a case for a more holistic approach to the design of the Vishwamitri

[9] We received an IRB (Institutional Review Board) exemption through the University of Michigan to conduct our survey.

River. Wherever possible, the critique calls out the positive aspects of the VRDP, but is unashamed and direct in its criticism of the project's environmental and social shortcomings. Each statement in the critique is linked directly to a statement or graphic in a VRDP document.

To arrive at these final 24 critique topics, we first individually examined multiple publicly-available versions of the VRDP Interim Feasibility Report.[10] After individually critiquing the documents, we consolidated similar veins of thought into topics, and further organized those topics into four themes: River Flow Regulation & Infrastructure, Ecosystem Health and Wildlife, Community Preference and Social Concerns, and Proposal Development and Design. An extensive literature review informed our discussion of each criticism.

Designing the Alternative: Vishwamitri as a common thread (Appendix 2)

The final step of the project is the development of an alternative design framework. We considered the Vishwamitri River at three scales: the watershed scale, the city scale, and at the scale of the VRDP itself (the "Influence Zone"). Developing this framework was an iterative, collaborative process which required multiple team charrettes[11] and input from our knowledgeable clients and advisors. Our design responds directly to our critique of the VRDP, making use of available maps, satellite images, original photographs of sites along Vishwamitri, and our understanding of local culture and values (as indicated by our client, teammates from the area, and gathered perspectives) to develop a cohesive framework. Our alternative design framework will be used by our client to advocate for a different future for the Vishwamitri.

CONCLUSION

The Vishwamitri, though in many ways degraded and forgotten in Vadodara, has an extensive cultural and natural history that cannot be paved over. It is our firm belief that degradation cannot be remedied with further degradation. As students of ecology, environmental policy, and ecological design in landscape architecture, we believe Vishwamitri can be an economic, cultural, and ecological asset to the city, by setting a new precedent for urban river development in India and beyond. We hope to offer a glimpse of that alternative vision in the following pages.

[10] The VMC has released multiple iterations of the Feasibility Report. Within these documents, it is clear that HCP attempted to respond to criticisms from stakeholders, including our client. However, no fundamental changes to the design have occurred. Our critique calls out these superficial changes directly.

[11] A charrette is a group design exercise. Over a limited period of time, the group quickly iterates through ideas together, with each participant bringing their unique skills, perspectives, and creativity to the table, regardless of design background or experience.

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APPENDIX 1
VRDP CRITIQUE

Vishwamitri River Development Project (VRDP)

CRITIQUE

1806: A bridge over Vishwamitri River presently Kala Ghoda

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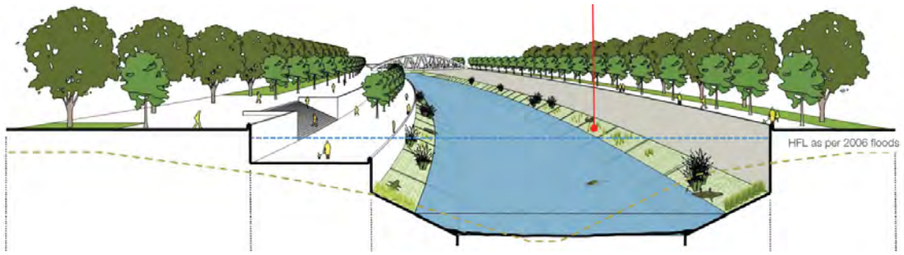
EXECUTIVE SUMMARY

The Vishwamitri Riverfront Development Project (VRDP) describes the ongoing planning vision for the Vishwamitri River and its surrounding area in Vadodara, India. The VRDP was developed by Vadodara Municipal Corporation (VMC) in collaboration with HCP Design, Planning and Management of Ahmedabad. The VRDP describes a vision for the Vishwamitri River, which includes:

- Flood mitigation plans and landscape design solutions;
- Seeks to enhance the cultural importance of the city;
- Restore the connection of the river with the people;
- Address the future needs of the city (VRDP Feasibility Study, October 2015).

Following our research trip to Vadodara, India (May 2016), interactions with our client and the VMC and an extensive literature review led us to an informed critique of the VRDP containing four distinct sections. These sections represent fundamental areas in the VRDP, which as our research reveals, lack sufficient support and rationale to define the Vishwamitri's future.



Proposed cross-section of the river with concretized banks. "Riparian edge" added to visualization after stakeholder criticism.

CRITIQUE HIGHLIGHTS: 4 TOPICS

RIVERFLOW, WATER QUALITY & INFRASTRUCTURE

Rapid urbanization of the city and its upstream regions has altered the hydrological network of the Vishwamitri River watershed profoundly. These changes have lead to increased flooding, in addition to conflict between human communities and an introduced population of Mugger crocodiles. Without recognizing the catchment-scale causes of flooding, such as vegetation loss and increases in impervious surface cover, the VRDP addresses the issue by further altering the hydrology of the river and modifying the ecological structure of the floodplain. The proposed riparian vegetation removal, river channel streamlining, acceleration of runoff, and diversion of water from other rivers to permanently fill the engineered channel will very likely increase flooding issues downstream and lead to a false sense of protection from flooding within the city. We believe the VRDP actually creates a more vulnerable system by basing its entire channel design on 2005 and 2006 flood levels alone and engineering its design to handle floods of mere 50-year recurrence interval. In combination with the promotion of floodplain development and little consideration for disaster management or floodplain policy protections, we believe the VRDP inadequately addresses flood hazard and causes of stream degradation.

Vishwamitri Riverfront Development Project (VRDP) Critique
University of Michigan School of Natural Resources and Environment

ECOSYSTEM HEALTH & WILDLIFE

The VRDP's oversimplification of the ecological and hydrologic structure of the Vishwamitri river system is apparent throughout the proposal. In this section, we critique the fundamental ecological illiteracy exhibited by HCP design and the VMC. In spite of surface attempts to appear concerned with ecology to assuage critics, there have been no fundamental changes in the design since it was first proposed. The VRDP fails to acknowledge the complexities of the system in which it works by mandating the destruction of habitat for a variety of organisms, the relocation of protected crocodiles into a park designed without scientific basis, and the inadequate consideration of catchment-scale causes of stream degradation, such as increase in impervious surface. Based on a wide body of knowledge from both local and global expertise, the ecological ramifications of this failure are not hard to imagine. The proposal focuses on engineering the river and its aesthetics, rather than allowing the river's ecology drive the design. The narrow spatial extent of this project ignores opportunities to enhance other parts of the city in a more widespread approach that could decentralize stormwater management. The narrow temporal extent allow regional fads to determine the design rather than the river's ability to provide ecosystem services in the future. Although the VRDP has, in a sense, effectively addressed issues such as flooding and beautification, it does so in a way that ignores more creative possibilities with less detrimental outcomes to the natural environment.

PROJECT DEVELOPMENT & DESIGN

Although the VRDP's urban development proposal claims to comprehensively address a variety of urban issues, we believe the design does not respond to the context of Vadodara or Vishwamitri river system. The process of landscape design is usually informed by an analysis, which leads to a design process, which eventually leads to an informed design. However, we believe that the VRDP proposal does the opposite; the analysis presented in proposal documents appears to rationalize a preconceived design that is a near replica to HCP's work in other cities. We contend that the VRDP fails to demonstrate significant contextual understanding, and is inspired by inappropriate precedents that are not critically evaluated in their own contexts before being applied by HCP. In addition, it is nearly impossible to anticipate the actual ecological impact and social acceptance of this design because of knowledge gaps about the system itself. We believe it is possible for a design to address the issues raised by the VRDP in a more comprehensive manner.

COMMUNITY PREFERENCE & SOCIAL CONCERNS

Our critique touches on social concerns including the displacement of informal settlements, lack of community engagement in the design process, and failure to critically engage with cultural heritage in the design's form. The VRDP also fails to gauge perception of the project, responding to criticism only when forced, and never responding with meaningful changes. Furthermore, because the spatial extent of this river project inherently creates a cross-section of the city, we believe more input is needed if the design is to respond to the unique needs of different neighbourhoods and social groups. While some might argue that the VRDP is an improvement from current condition of the river and surrounding community, we believe it is an incomplete, utilitarian design that misses out on opportunities to address social, ecological, and economic needs in a multifunctional and holistic manner. Overall, the VRDP may result in further inequity, increased distrust of government, and largely irreversible changes to landscapes that once held deep cultural meaning.

INTRODUCTION

Snapshots of the Vishwamitri River. (Photo: Rubin Sagar)

This document presents a comprehensive critique of the Vishwamitri Riverfront Development Project (VRDP) as proposed by the HCP Design, Planning and Management (HCP), project consultants to the Vadodara Municipal Corporation (VMC) in Gujarat, India, in 2014. Broadly, the proposal aims to "rejuvenate the ecology of the Vishwamitri River, enhance the cultural importance of the city, restore the connection of the river with the people, and address the future needs of the city" (VRDP Feasibility Report, 7 May 2016, pg 23) while focusing on flood mitigation, land development, and public amenities along the riverfront.

The VMC's interest in development arrives at a significant time for Vadodara. Relative to other Indian states, Gujarat is home to only 5% of India's population and 6% of the landmass, yet represents a higher GDP (10% increase per year, on average) than the entire country as a whole (The Gujarat Model 2015). The larger development rate in Gujarat represents an opportunity to develop new infrastructure and industrial projects. The path to development has been influenced by regional trends in governance, policies, and attitudes reflecting market economies based on large-scale physical development projects. One example includes the Sabarmati Riverfront Development Project (SRDP) in Ahmedabad, only 110 kilometers away from Vadodara. This project was also completed by HCP Design, and bears striking similarity to HCP's proposal for the Vishwamitri, in spite of clear differences between the river systems. The award-winning SRDP has, in many ways, become a new standard for riverfront development and land reclamation in the region (Follmann 2015). The majority of the construction for the SRDP is complete, providing a glimpse of the radically altered landscape and the social impacts the VRDP proposes. In spite of many awards, the SRDP also faced a large amount of criticism (Rao 2012, Follmann 2015, Bhagwat 2013, Desai 2012, Mathur 2012). In the wake of this development, the VRDP is an opportunity to either follow suit, or change the precedent entirely. It is in this spirit of offering an alternative framework for development that we offer this critique--the first step in our design process.

Development and informal settlements on the banks of the Vishwamitri River. (Photo: Rubin Sagar)

The following pages present a well-researched compilation of both stakeholder criticisms and our team's concerns on a variety of issues. It is built upon criticisms from the SOCLEEN VRDP Petition, individual stakeholder critiques, and concerns of our client the ASP Foundation with reference to specific VRDP documents such including feasibility reports, an environmental impact "checklist" by Kadam Environmental Consultants (appointed by the VMC), and presentations that have been made available to us both online and from the VMC itself. In addition, our team relied on our collective expertise in ecology, landscape architecture, stormwater management, and policy to further develop this critique on firm foundation of current scientific research, news articles and editorials by regional stakeholders, and policy analysis. After examining these resources, we divided our critique into four main sections: River Flow Regulation & Infrastructure, Ecosystem Health & Wildlife, Community Preferences & Social Concerns, and Proposal Development and Design Presentation.

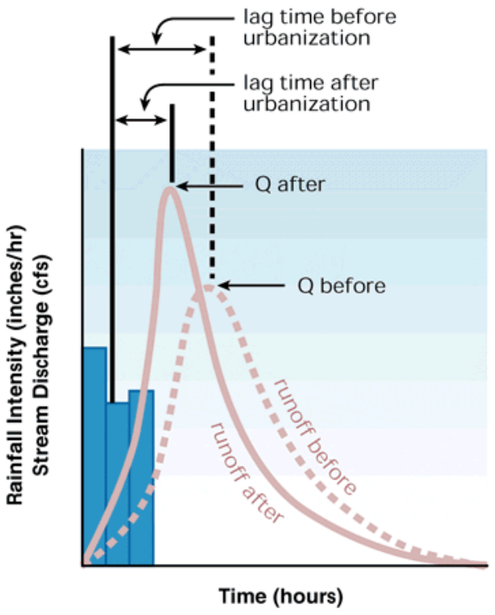
Finally, we would like to acknowledge that the way in which the VRDP has framed the problems of Vishwamitri is fundamentally flawed. If an outsider to the situation were to read the goals of the proposal, they would find a number of worthwhile goals, such as flood mitigation, increasing the safety and well-being of city residents, and development of a masterplan to guide land use along the Vishwamitri River. However, these should not be taken at face-value. Our critique suggests that the methods and outworking of even those goals which seem most appropriate within the VRDP are insufficient and detrimental to the well-being of the river and the city's future. The purpose of this critique is not yet to provide solutions, but to further develop the issues at stake in the design. For further information on our alternative design framework developed in response to this critique, see the Design Report in Appendix 2.

RIVERFLOW, WATER QUALITY & INFRASTRUCTURE

The mitigation of flooding and the associated human-wildlife conflict in Vadodara are key goals of the VRDP. While the VRDP seeks to address these challenges -- flooding, in particular-- the following section of the critique explains the conceptual inadequacies of the VRDP's approach. We believe the VRDP, as developed by HCP design, lacks fundamental foresight and contextual understanding in its handling of the Vishwamitri River system. Attempts by HCP to replicate design and engineering solutions from the Sabarmati River to overlook opportunities to work with the system in an innovative way that could better promote long-term sustainability, ecological health, and multifunctional design. The following points delve into this overarching criticism, breaking down the false assumptions and design issues apparent in the VRDP.

1 CONTRIBUTION OF URBAN DEVELOPMENT TO FLOODING

Current research on watershed dynamics reveals that flooding occurs in urban areas due to loss and disrepair of its hydrological network (Sengupta 2016, Walsh 2005, Hill 2009). In India specifically, some experts point to the lack of legal protection for water bodies and the destruction of wetlands due to urban development. Flooding, which is a natural process in a river system, affects society as a direct consequence of unplanned development and poor governance in a watershed. Gujarat specifically is 42.58% urbanized and has experienced 15 major floods between its 3 major cities in the last 10 years (4 of which occurred in the city of Vadodara, Sengupta 2016).

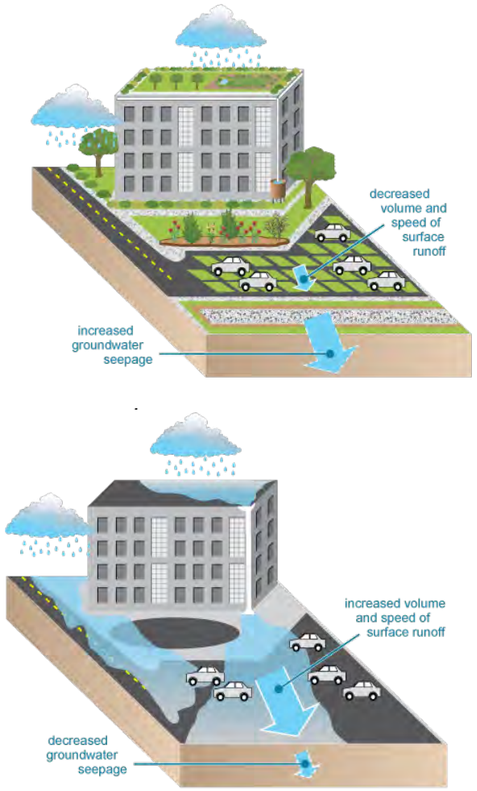


A comparison of hydrographs before and after urbanization. Urban streams have a higher and steeper discharge curve than non-urbanized streams due to greater and faster runoff. (Source: USEPA Watershed Academy Web)

As the VRDP takes aim at the flooding issue, it sets its sights on the river channel itself. By modifying the stream channel to cope with the volume of water entering the system during the monsoon season, they hope to create enough extra capacity to handle the largest of most recent monsoons (VRDP Feasibility Report, 21 October 2014, pg 11,14, 37-41). However, we contend that their focus on the channel as the source of flooding is misplaced. Without widening the scope of the project to examine the catchment-scale causes of the degradation of Vishwamitri, the VRDP cannot be successful (Vietz et al. 2016, Hill 2009).

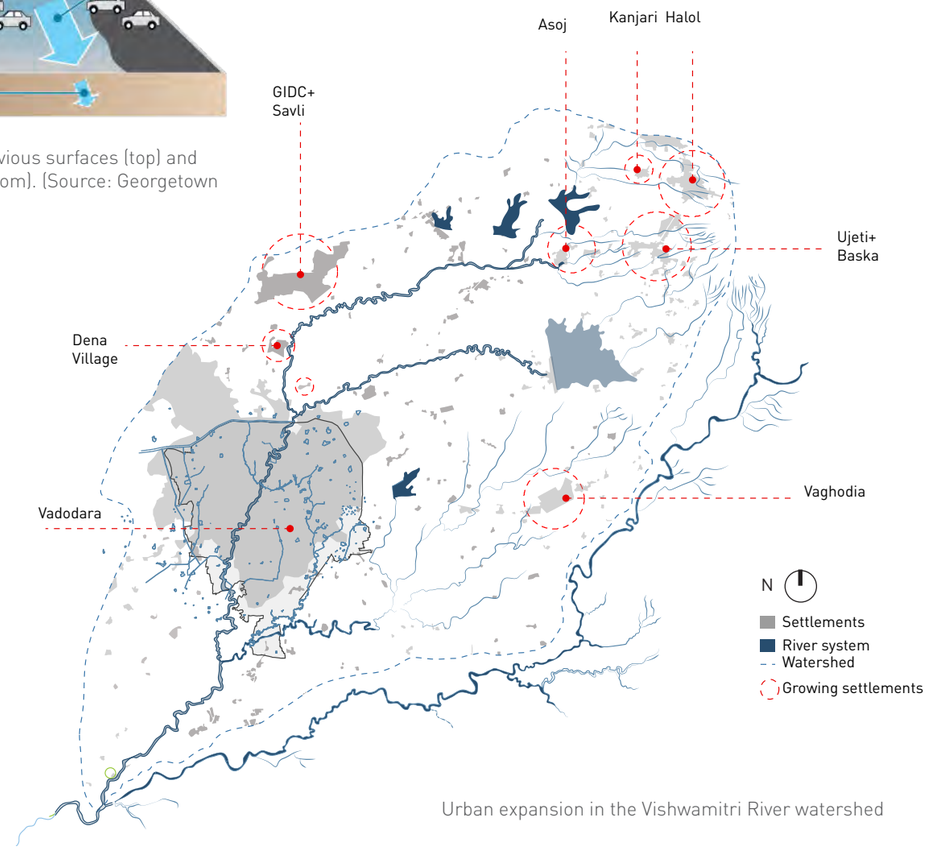
Within the city of Vadodara, increasing urbanization alters the landscape's ability to function hydrologically. Impervious surface reduces infiltration of water into the ground and speeds up the rate at which water collects in the river channel through the creation of efficiently drained urban landscapes, or grey infrastructure (Forman 2014, pg 167). The consequences of these changes affect the morphology of stream by "increasing [volume and rate of] runoff [into the stream], altering sediment regimes, and limiting space for channel change" (Vietz et al. 2016, pg. 2).

Urbanization in the Vishwamitri watershed is not limited to Vadodara. The upper reaches of the watershed, in the Panchmahal and Vadodara Districts, has also experienced rapid growth due to industrial development (Gujarat Industrial Development Corporation (GIDC) - District Wise Area Statement of Estates). Other land use changes in the upper watershed, including agriculture, damming, and deforestation cumulatively contribute to the issue of flooding within the city. The Panchmahal District has seen a 5 square kilometres decrease in forest cover compared to the area in 2005. A significant decrease in vegetation in the western part has been noticed through geospatial analysis (Kumari et al. , 2015). With government giving clearances, towns like Halol and Jarod in the upstream region have turned into industrial regions and the area is undergoing fast paced urbanization (Kiran et al. 2015). Within the Vadodara district, the southern and southwestern regions are seeing increased urbanization.



Comparison between pervious surfaces (top) and impervious surfaces (bottom). (Source: Georgetown Climate Center)

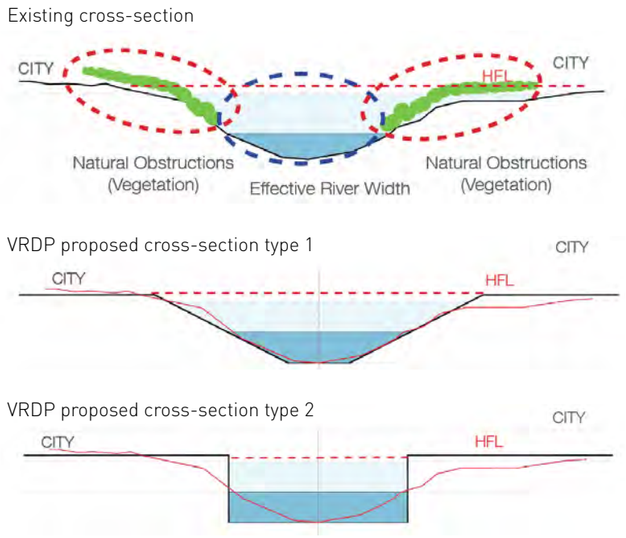
All of these changes impact how water moves through the watershed, and, thus, impact flooding of cities downstream, including Vadodara. For this reason, the VRDP's laser-beam focus on the river channel is misplaced (VRDP Feasibility Report, 21 October 2014, pg 26, 37-41). Vishwamitri within Vadodara cannot be seen in isolation from the wider extent of the river and its tributaries. The watershed scale processes contributing to flooding within the city must be further examined.



Urban expansion in the Vishwamitri River watershed

2 RIPARIAN VEGETATION & FLOODING

The VRDP views riparian vegetation along the river as excessive and incorrectly states that wild plant species obstruct water flow during monsoon (VRDP Feasibility Report, 21 October 2014, p. 84). Based on that, the VRDP believes removing these "natural obstructions" and streamlining the entire river stretch will be beneficial for reducing the high flood level (HFL) and thus mitigating the flood risks (VRDP Feasibility Report, 21 October 2014, p. 84). This perspective ignores the ecological value of riparian vegetation in detaining and filtering surface runoff and the public health benefits associated with urban greenness. Removal of riparian plant species can lead to loss of these values (also see section: Water velocity).

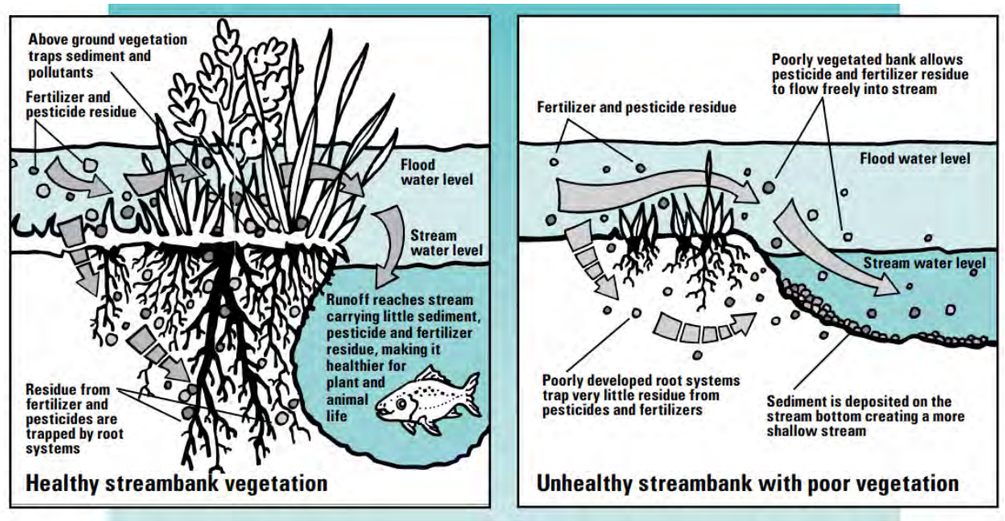


Vegetation seen as natural obstructions to flow by VRDP. (Source: VRDP Feasibility Report 2014)

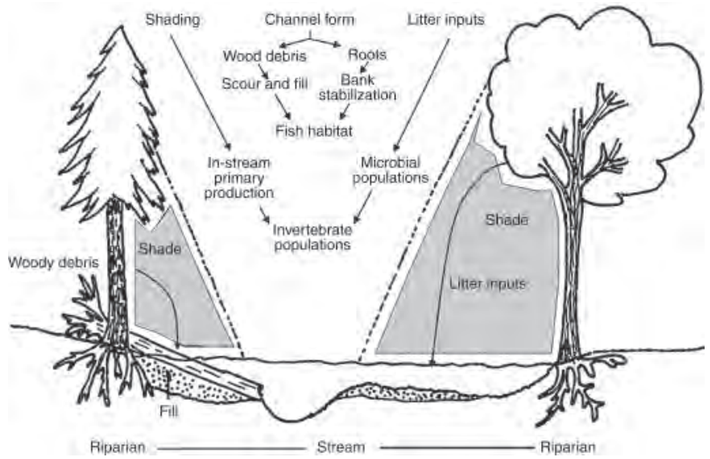
During monsoon season, a large volume of water is released from Ajwa Dam upstream of the Vishwamitri, roaring down the corridor toward Vadodara, which, together with heavy precipitation, results in flooding in the city. Natural vegetation along this corridor greatly reduces and slows water runoff. While a flood will subside more rapidly if the floodplain upstream is bare than if it is covered with natural vegetation, the flood level is ultimately higher if the floodplain is bare (Forman 1995). Converting the vegetated surface to developed land uses often results in the most severe flooding (Forman 2014). Therefore, removing riparian vegetation and streamlining the river may not mitigate flooding to the extent that the VRDP imagines, leading to damaged embankments and infrastructure close to the river. It does, however, rapidly funnel a greater amount of floodwater downstream, creating devastating consequences to Vadodara's downstream neighbors (see section: Regional impact ignored).

In addition to providing friction that slows floodwater, riparian vegetation effectively traps sediment as water passes. In this way, the flooded area is ecologically rejuvenated (Forman 1995). The fertilization benefit is provided free by riparian vegetation and will be washed away once the plants are removed.

Riparian plants also play a crucial role in supporting a healthy riverbed and aquatic species community. The vegetation provides dead organic matter in both particulate and dissolved forms (Forman 2014). Shade from riverside vegetation helps maintain cool water temperature and decreases excessive growth of plankton and aquatic vegetation,



Sediment and pollutant trapping function provided by healthy streambank vegetation. (Source: Streambank Stewardship: A Saskatchewan Riparian Project 1998)



Influence of riparian vegetation on fish and benthic populations and their habitats. (Source: Cummins and Wilzbach 2008)

whose presence has been observed in many segments of the Vishwamitri, adding another layer to the existing water quality issues.

In addition, the health benefits of vegetation in urban settings have also been well-documented, including promoting physical activity and social contact, decreasing stress, and mitigating air pollution, noise and heat exposure. The level of positive impact increases with greenness area and tree density (James et al. 2015).

While there is no doubt that riparian vegetation of the Vishwamitri should be preserved in light of its values, the plant species present in the area need to be further investigated to distinguish the native species from the invasives. Instead of removing all "excessive" plants, efforts should be targeted to enhance habitat quality for the native plant community.

3 WATER VELOCITY

The flood mitigation strategy of the VRDP consists of two main parts: 1) streamlining the river and 2) developing embankments. By streamlining the river, the VRDP intends to reduce friction along the waterway, thus increasing the velocity of flowing water in the channel during monsoon in an effort to get water out of the city as soon as possible. Eventually, HCP claims, this will improve the river's flood carrying capacity (VRDP Feasibility Report, 21 October 2014, p138). Despite the good wish, though, it is unlikely that accelerating water movement will effectively reduce flood risks in Vadodara or the broader Vishwamitri River watershed.

The key to mitigating the negative impacts of flooding is to reduce flow velocity. Flash floods, which are characterized to have short-duration, high peak flows and most severe consequences, frequent highly-impervious and vegetation-poor urban areas (Forman 2014), like what Vadodara might turn into if the VRDP got implemented. At high velocities during the peak flow, water has tremendous erosive force and damage potential. A study modeling flood damage confirmed that high flow velocity has a significant influence on structural damage of roads and residential buildings (Kreibich et al. 2009). Because of the destructive nature of high velocity water flow, floodplain friction provided by vegetation that slows water down and reduces peak flow is considered a valuable benefit for flood mitigation (Forman 2014, see section: Riparian vegetation and flooding), instead of a burden as depicted by the VRDP. A serious question arises whether the river lining and riverfront structures proposed by the VRDP can withstand the high pressure imposed by the fast-flowing floodwaters in extreme high flow events (see section: Flood carrying capacity/ design flood).

Structural damage caused by erosion. (Source: US Department of Transportation Federal Highway Administration)

Increasing the velocity of water flows does not alleviate flood risks. It only reduces the time that floods persist in Vadodara, but at the cost of forming a larger, faster flood downstream due to removal of riparian vegetation and conversion of natural landscape into impervious surfaces (Forman 1995). In the meantime, accelerating water movement drys out wetlands upstream and lowers water levels in the soils (Forman 1995), threatening agricultural activities in the floodplain. Another side effect is that with water rushing downstream the river also drains faster during dry seasons, which ironically goes against the VRDP's goal of retaining water in the river all year round.

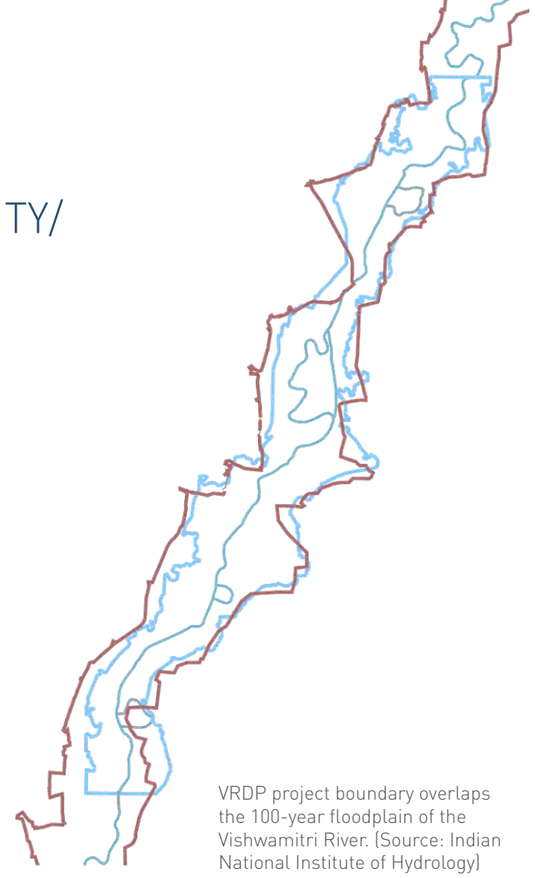
The flood mitigation strategy proposed by HCP contradicts scientific evidence and standard practice around the world, which may later on reveal the long-lasting detrimental effects of channelization on the ecosystem. Despite the enormous efforts to remedy the repercussions of channelization, the VRDP intends to streamline the river and regulates the flow, an approach that resembles channelization, hoping that this will address the flooding issue in Vadodara. On the other hand, there exists a range of alternative solutions that depend on natural vegetation and retention ponds to manage stormwater and deal with the river beyond itself but as a component of a complex ecosystem characterized by spatial and temporal variations. These options are further explored and illustrated in the Combined Sewer System and Green Infrastructure sections.

Efforts to restore the meanders of the previously channelized Kissimme River. (Source: South Florida Water Management District)

4 FLOOD CARRYING CAPACITY/ DESIGN FLOOD

Design of the embankment walls of the VRDP was based on two of the highest recorded floods in Vadodara in the recent past. The 2006 flood level was analyzed for determining the hydraulic parameters for the river and estimating the surface water levels once the VRDP is in place, thus a Design Flood. The 2005 flood event, during which uncontrolled water passed from a breach in the embankment of the Ajwa Dam causing an abnormal flood even higher than the 2006 level, was used to the represent the peak values and as a Check Flood (VRDP Feasibility Report, 21 October 2014, pg 39).

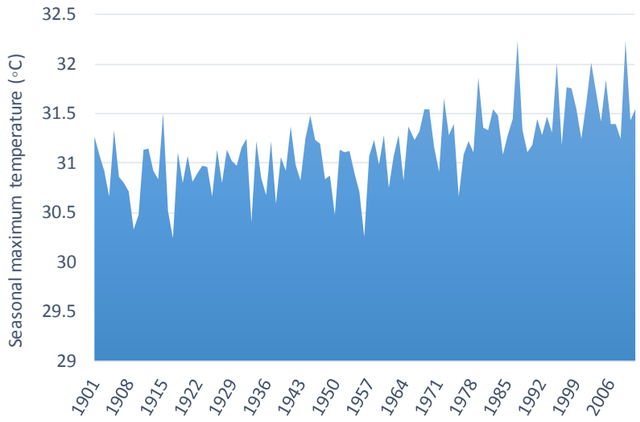
Surprisingly, the VRDP did not design for contingency in flood level or HCP was confident enough to bet the entire project on the 2015 event alone, believing that nothing will cause comparable or more severe damage than that one event. This can be destructive to the city both in terms of the unpredictable consequences that people may suffer and the money and resources needed to deal with the aftermath, let alone the up-front investment in the riverfront project going into the water. A flood with HFL higher than the Design Flood can possibly destroy the embankments and other VRDP works along the river, will fill the riverfront with sediment that need an immense amount of cleaning, and crocodiles will be able to reach higher levels of the riverfront, endangering people's lives. The proposed vegetation removal and property development in close vicinity of the river are only going to worsen the situation; meanwhile, climate change can make extreme storm events more likely to happen in Vadodara, which all point to the inadequacy of the flood carrying capacity



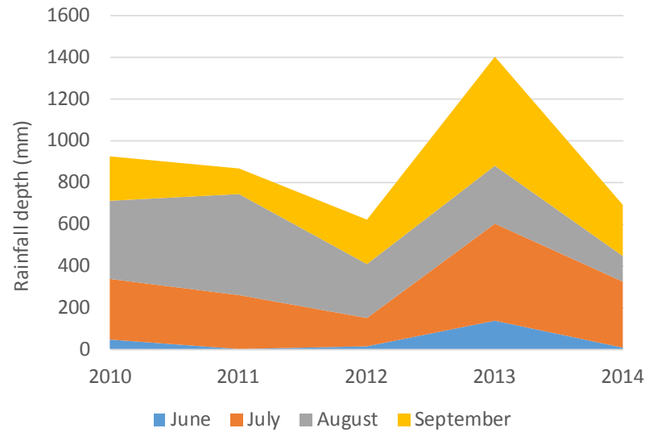
VRDP project boundary overlaps the 100-year floodplain of the Vishwamitri River. (Source: Indian National Institute of Hydrology)

achievable by the VRDP to withstand the potential high flood levels in the future.

Another major defect of the flood protection design is that the VRDP works were planned for floods of 50-year recurrence interval. This is deemed acceptable by HCP because existing bridges in the reach are normally being designed for the 50-year flood (VRDP Feasibility Report, 21 October 2014, pg 39). In contrast, the US Army Corps of Engineer typically used flood recurrence interval that ranges between 200 to 500 years as the protection level when they built dams and levees. As this design frequency has been considered too stringent for communities building their own stormwater systems due to the high costs associated with the high level of protection, the 100-year flood frequency was adopted by the National Flood Insurance Program as a standard in mapping the flood hazard areas and establishing regulations



Maximum temperature in the monsoon season (June-September) in India from 1901 to 2011. (Source: Open Government Data Platform India)



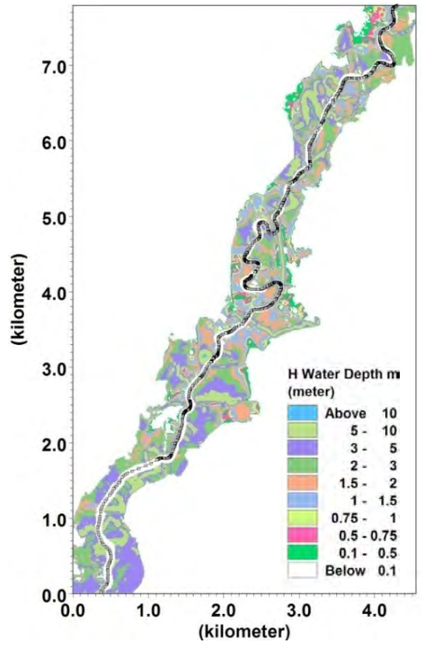
Total rainfall depth in the monsoon season (June-September) in Vadodara from 2010 to 2014. (Source: India Meteorological Department)

for development standards in those flood-prone areas. Recognized as a reasonable flood protection level, the 100-year standard is now used throughout the US and in many other countries. Vadodara should not be an exception, especially when the existing bridges and other infrastructure in the city have already been under pressure.

In the VRDP, flood carrying capacity of the Vishwamitri is determined by the river channel's ability to confine floodwaters. While building embankments may be necessary for flood protection in some cases, it also creates a series of new problems at the watershed scale, as illustrated in many sections of this critique. On the contrary, a study examined four case studies on the lowland area of Rio de Janeiro State in Brazil and composed a central point that refers to the need of respecting watershed limits and giving space to rivers. Essentially, the study found the Flood Control Master Plan relying on traditional levee systems unable to resolve flood issues in the four urban settlements. Instead, it highlighted an alternative solution that employs proper zoning to define higher minimum terrain elevations for urban development and use riparian zones as multifunctional parks combining the aims of river bank preservation and introduction of storage volumes in the system (Miguez et al. 2015) . Studies like this can provide helpful insights to Vadodara as the city searches for the appropriate flood protection and mitigation strategy that mostly suits its environmental and socioeconomic context.

5 ZONING/BUILDING CODES IGNORE FLOOD HAZARD

It is unclear from the VRDP proposal documents how, or if, policies such as zoning and building codes fit into a cohesive flood management strategy for the city. Although the proposal recommends a hard-engineering approach that hopes to stem flooding, it would be reckless of the government to promote development in an area that could flood, should a monsoon season exceed the engineered capacity of the new channel, particularly in light of the uncertainty of climate change (see section: Consideration of climate change) and the apparent inadequacy of the design storm used to engineer the system (see section: Flood carrying capacity/ design storm). Without a cohesive flood management strategy that links policy, design, and disaster management, we believe the city runs the risk of wasting money, time, and potential on a system that will only partially and temporarily address the problems at hand.



Inundation map of the estimated 100-year flood. (Source: Indian National Institute of Hydrology)

Flood-prone areas inherently face different challenges than other areas of the city. The effects of flooding, regardless of the confidence in an engineered system, should always be taken into consideration in any riverfront development. However, the VRDP lacks the policy "teeth" to enforce protection of those citizens which it encourages to live in the floodplain from flood hazard. For example, there are no proposed zoning codes that prevent residents or businesses from building within the natural or altered floodplain of the Vishwamitri River. In fact, at no point in the VRDP is the size or extent of either the current or altered floodplain mapped or even mentioned in any meaningful way. This alone illustrates the recklessness and lack of contextual understanding with which this plan has been developed. In addition, there are no apparent efforts to enforce flood adaptation measures, such as building codes, that regulate the way buildings in the floodplain are designed. This means that if a monsoon season exceeds the engineered capacity of the Vishwamitri system, there is nothing to protect renters or businesses from builders that do not properly design for the hazard in which they choose to construct the building.

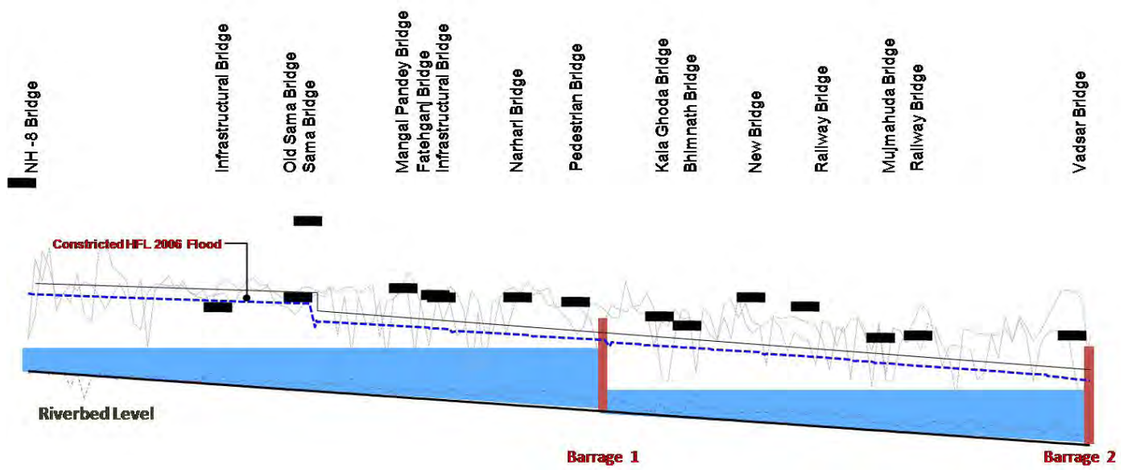
Recent studies suggest that "flood-zoning policies, flood insurance, and building codes are powerful tools for controlling changing future land use, and hence the potential vulnerability of land use to flood risks", especially in areas where climate change is increasing flooding vulnerability (Aerts & Botzen 2011, p. 1). With a variety of international precedents for flood management through zoning, flood insurance, and building code regulation, the lack of a cohesive flood management strategy that unites policy and design is a large deficiency in the VRDP.

6 RIVER REPLENISHMENT & WATER RETENTION

The Vishwamitri river is an ephemeral river, only flowing during monsoon seasons. The VRDP aims to retain rainwater in the river throughout the year by constructing two barrages and replenish the river using treated wastewater from sewage treatment plants (STPs) nearby. The result is described by HCP as an environmentally sustainable cycle (VRDP Feasibility Report, 21 October 2014, p85). However, labelling this approach as environmentally sustainable is yet another sign of scientific illiteracy of the VRDP.

Replenishing the river and retaining water in it year round will substantially change the hydrology of the Vishwamitri, converting it into a perennial river and greatly reducing flow heterogeneity. Variable flows might not be appealing to the VMC, but they are crucial for various benthic and aquatic species living in the river with different flow requirements for their desired habitats. On the other hand, a relatively static and constantly flowing river might bring about more water recreation opportunities and related tourism revenues, but in the meantime, that will dramatically change the habitat structures in the river and result in different but much less diverse species communities and thus greatly diminished ecological values. Apparently, those forgone values were not accounted for in HCP's definition of environmental sustainability.

According to the VRDP, water used to replenish the river will come from 3 STPs, which as of now only have two basic treatment processes and do not have the capacity to treat all effluents generated within the city (GERI 2014). Although the VRDP has proposed upgradation of existing STPs and implementation of advanced water treatment, given the enormous water quality challenge currently facing the city, clean river water which is safe for human contact cannot be promised easily. The following Water Quality



VRDP proposed barrages to retain water in the river channel. (Source: VRDP Feasibility Report 2014)

Assessment section scrutinizes the VRDP in terms of its projects on improving water quality of the river and other water bodies in the city. The other external source of water to replenish the river will be the Narmada River that currently transfers water to the Sabarmati River in Ahmedabad. Adding another transfer scheme to supply water to the Vishwamitri can aggravate the already existing impacts on both the ecological and socioeconomic conditions in the Narmada River watershed. However, not surprisingly, none of the impacts outside of the VRDP's "project influence zone" were assessed (see section: Regional impact ignored).

Similarly, the impacts of putting barrages on the river on upstream and downstream regions of the Vishwamitri watershed were never mentioned. Impoundments in the context of the VRDP might not have the same severe consequences like floodplain and morphological changes as dams can cause to free-flowing waters. Nonetheless, that is simply because the river itself will already be disconnected from its floodplain and the natural process of energy flow and material exchange between the river and its surroundings will be heavily impaired by streamlining the river and building concrete embankments. Much sediment moving downstream may be trapped behind the barrages, though, and as water velocity increases, more sediments can be carried away by the high energy water flows and fill up the volume behind the barrages (Forman 1995). During monsoon, the barrages are kept open to allow unobstructed flow of water, which also brings the accumulated sediments downstream or even spreads out the sediments over the riverfront when a flood higher than

Top: Pink salmon, blocked from migrating further upstream, wait below the now removed Elwha Dam, Washington, USA.
Middle: Exposed sediments after removal of Elwha Dam.
Bottom: Sediment accumulation behind dam.

the 2006 level, or the system's Design Flood level, strikes the city. Clearly, there is much to ponder and revise before HCP can call its approach to replenish the river as environmentally concerned or sustainable.

7 WATER QUALITY ASSESSMENT

A river, along with its tributaries acts as a one-way conveyance system for all dissolved and particulate matter of natural and anthropogenic origin. Thus, the river water quality is a reflection of influential factors such as riverbed sediments, industrial effluents, agricultural runoff, climatic conditions, etc. (Bricker and Jones 1995). Thus, the effective, long-term management of rivers, especially in river restoration projects requires a fundamental understanding of hydro-morphological, chemical and biological characteristics (Shrestha and Kazama 2007).

In India, several policies and regulations such as the Water (Prevention and Control of Pollution) Act, 1974 regulate the pollution discharges and restore water quality of aquatic resources, both at the State and the National level. One of the important provisions of the Act is to maintain and restore the wholesomeness of the aquatic resources, for which a system of water use classification was developed that defines the level of wholesomeness to be maintained or restored (see appendix). The waterbody is then designated a 'best use' water quality. Regular monitoring of the existing water quality as compared to the desired quality aid in defining quality gaps in the water body, and thereby establish the extent of pollution (CPCB Delhi 2007-08).

While the VRDP proposal establishes the need for 'cleaning the river', there is no definition of the existing water quality, or the projected use for the river's waters (whether for drinking, aesthetic appeal, recreation, fishing or other such uses). Further, the physical, chemical, biological or hydrological extent to which the clean-up is proposed is unclear.

Signs of water pollution in Vadodara from various sources (top: industrial effluent; middle: urban stormwater; bottom: garbage dumping). (Photo: Rubin Sagar)

Effective pollution control and water resource management requires the identification of pollution sources and their quantitative contributions (Singh et al. 2005). The VRDP proposal identifies the point sources of pollution to the river. However, the consideration of non-point sources of pollution from urban stormwater and littering and dumping along the river, needs to be taken into consideration to ensure effective remediation of the system. Additionally, the removal of obstruction to flow (which has supposedly been singled out to only certain sections of the river) is not enough to ameliorate the water quality. Cleaning up of the river as a whole, with provisions for regular water quality assessments needs to be addressed.

The lack of a clear baseline for the restoration of water quality and intended use and of clear management plans for mitigating non-point source pollution seems to overlook the main purpose of the project- to better the Vishwamitri river waters.

Excessive algae growth in the Vishwamitri River due to high levels of nutrients in the water. (Photo: Rubin Sagar)

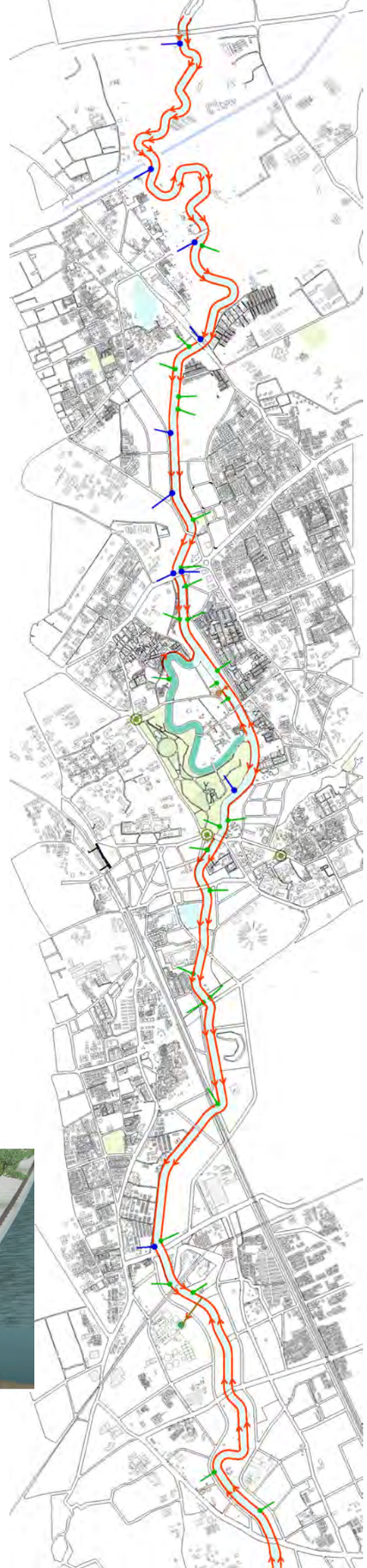
8 COMBINED SEWER INTERCEPTOR

While our team commends the VRDP's efforts to remove sources of pollution, such as sewage and stormwater outfalls from the river channel, we believe the proposed alternative does not adequately prevent these sources from entering the river. The VRDP proposes a combined sewer interceptor running along the river channel (VRDP Feasibility Report, 7 May 2016, pg 41), presenting multiple issues in terms of water quality, regional impact, and stability of vital infrastructure.

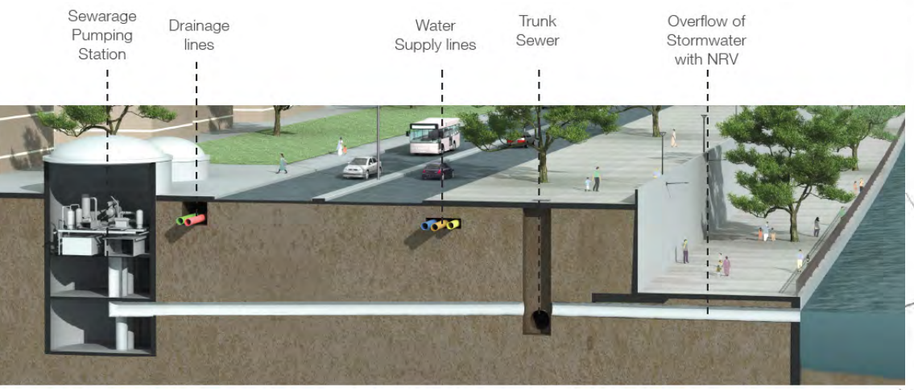
First, it is well-understood that overflows of combined sewer systems can lead to both ecological damage and public health issues (Burton & Pitt 2001). Combined sewer systems carry stormwater runoff and municipal sewage into one pipe for treatment at treatment plants (STPs). In theory, combined systems are intended to treat all wastewater, which is a worthwhile objective. However, unless the city is actively working to manage the volume of wastewater, large storm events or long periods of rainfall (such as the monsoon season) can exceed the infrastructure's capacity, allowing untreated sewage to overflow into the river. Combined sewer overflows (CSOs) affect water quality by introducing high amounts of urban pollutants, E. coli bacteria, and excess nutrients into water bodies. This has negative effects on both the ecological and human systems associated with the river (Burton & Pitt 2001). While there are many cities worldwide with similar systems, urban development trends internationally suggest that cities are either moving away from combined systems or actively working to manage the risk of CSOs to better protect water quality in receiving water bodies (Burton & Pitt 2001, PlaNYC 2008). Of course, the risk of a CSO is dependent on how the system is engineered. In response to this point, please note that our team also questions the design storm chosen for this development of the VRDP, in addition to its increases in flood carrying capacity (see section: Flood carrying capacity/design storm), which would affect the engineered capacity of the system and, thus, increase the risk of CSOs.

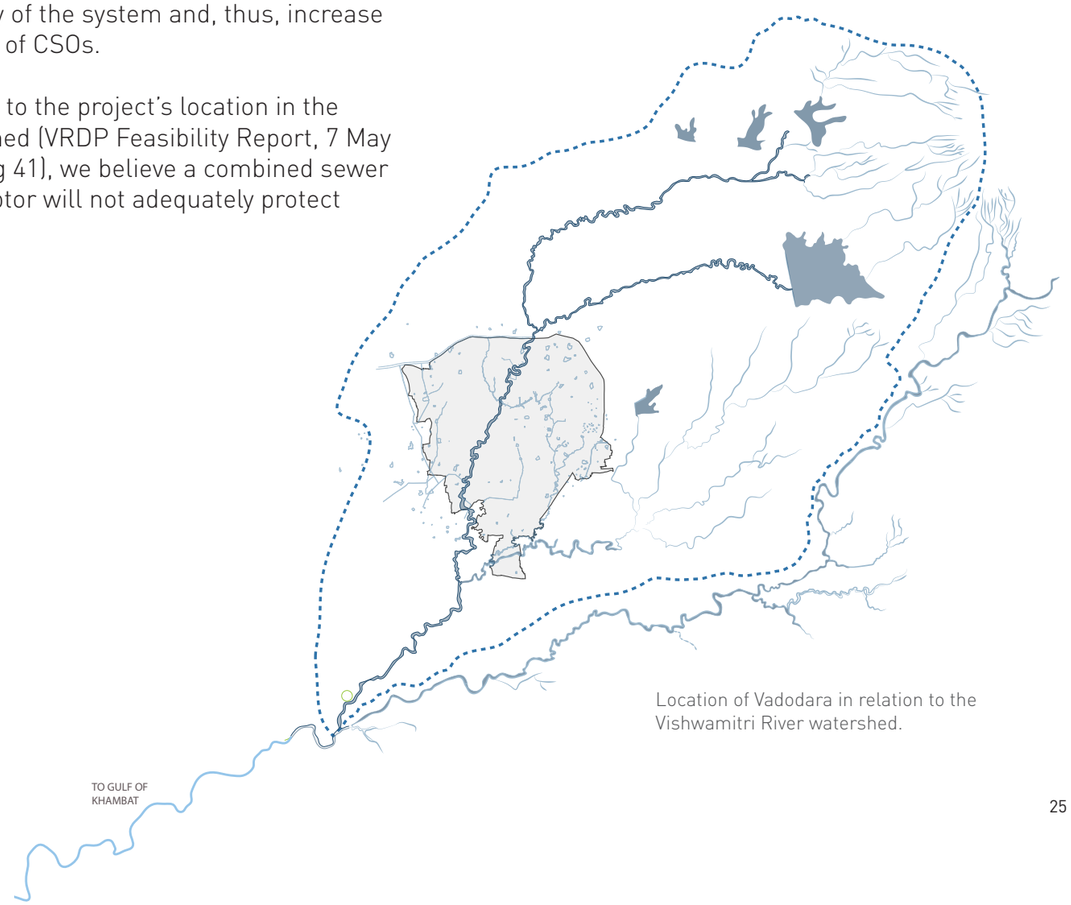
Related to the project's location in the watershed (VRDP Feasibility Report, 7 May 2016, pg 41), we believe a combined sewer interceptor will not adequately protect water quality in downstream communities. This is yet another example of the authors of the VRDP ignoring the regional impact of Vadodara's development decisions (see section: Regional Impact Ignored). Although the Vishwamitri is not the main drinking water source within the city of Vadodara, many use the river to water cattle and perform domestic tasks, such as laundry. Downstream of Vadodara, farmers use the river to irrigate their fields. Frequent combined sewer overflows in monsoon season would do nothing to stem water quality issues downstream.

Finally, the placement of such a vital piece of infrastructure in a dynamic environment (VRDP Feasibility Report, 7 May 2016, pg 41) is problematic. While the VRDP represents an attempt to control the river, the city may be in for a surprise in the future if the river proves difficult to control (Resh et al. 1988).



VRDP proposed combined sewer interceptor network (right: parallel sewer interceptor lines shown in red; bottom: cross-section). (Source: VRDP Feasibility Report 2014)





Location of Vadodara in relation to the Vishwamitri River watershed.

ECOSYSTEM HEALTH & WILDLIFE

A core criticism of the VRDP, voiced by multiple local stakeholders, is the ecological illiteracy permeating every aspect of the proposal. While the latest version of the proposal pays lip-service to ecology, these attempts to assuage the opposition by adjusting project language seem shallow and uninformed. Since receiving criticism about the project's ecological impact, there have been no fundamental changes to the VRDP's approach to development or flood mitigation.

Changes to the language in the VRDP can be seen in adjustments to VRDP documents since it was first announced (see specifically reports dated 4 June 2014 and 7 May 2016). There have also been superficial changes to project graphics without any meaningful changes to fundamental structure and function. The following sections of this critique explain the primary manifestations and related impacts of this ecological illiteracy in more detail. These criticisms deal with the most glaring ecological issues associated with the VRDP, or stated misconceptions about the ecological benefits of the proposal (VRDP Feasibility Report, 7 May 2016, pg 70, for example), relying on established literature to illustrate our concerns.

It is important to note that although we would prefer to illustrate these concerns in a more site-specific way, there has not been enough research to date to inform that level of detail. This, also, is a serious flaw with the VRDP. There is not enough research on the Vishwamitri River system itself to understand the site-specific ecological impact this project will have. In spite of poor attempts to address ecological concerns (see Kadam Environmental Consultants Environmental Impact Checklist of 2015), the truth is that much of the ecological analysis that is being done now to save face, should have been conducted before any design was developed to begin with. Our critiques, then, are inherently conceptual in nature, relating to the ecological processes and structures that should be considered in any proposal relating to the Vishwamitri River.

9 RIVER AS A SYSTEM OF INTEGRATED PROCESSES

The primary manifestation of ecological illiteracy in the VRDP is its failure to treat the river as a system of integrated natural processes rather than simply as a drainage channel for water. This attitude permeates the proposal, becoming evident in the spatial extent of the project's influence area (VRDP Feasibility Report, 7 May 2016, pg 29-30), alteration to the river's channel size and habitat types (VRDP Feasibility Report, 7 May 2016, pg 49-63, 70), and removal of any opportunity for the river to change over time (VRDP Feasibility Report, 7 May 2016, pg 55). As a fundamentally structural approach to "restoration" (VRDP Feasibility Report, 7 May 2016, pg 55-63), the proposal ignores the ecological, hydrologic, and biological processes that both formed and continue to shape the Vishwamitri River through time and space. The changes also prevent the city from taking advantage of the ecosystem services that the river can provide. In terms of design, we challenge HCP's lack of creativity in dealing with the many complex, Vishwamitri-specific ecological and infrastructural challenges.

In terms of "restoration of the river's ecology", a stated goal of the VRDP (VRDP Feasibility Report, 7 May 2016, pg 36), the proposal represents a widely criticized, non-process-based approach to restoration. It addresses symptoms of degradation, such as poor water quality, rather than their catchment-scale causes, such as contamination from urban runoff (Vietz et al. 2016). A process-based approach would look at the restoration of watershed processes and function before considering widespread structural changes.

Top: VRDP visualization. Bottom: HCP's earlier work of Sabarmati Riverfront Development Project in Ahmedabad, India.

(Source: VRDP Feasibility Report 2014; Sabarmati Riverfront official website)

In other words, it would both consider and stem the causes of degradation before treating the symptoms (Vietz et al. 2016). It would acknowledge processes that operate at larger spatial and temporal scales. Examples of these processes include nutrient exchange, channel migration, and watershed flow dynamics that have been altered due to urban development, among others. For this project specifically, a process-based approach would inherently expand the project boundary to address stormwater management in the city as a whole. In addition to respecting the ecology of the river, process-based restoration and management can increase the ability of the river to handle flooding disturbances, thus enhancing its natural ability to provide ecosystem services to the city at large (Palmer 2009).

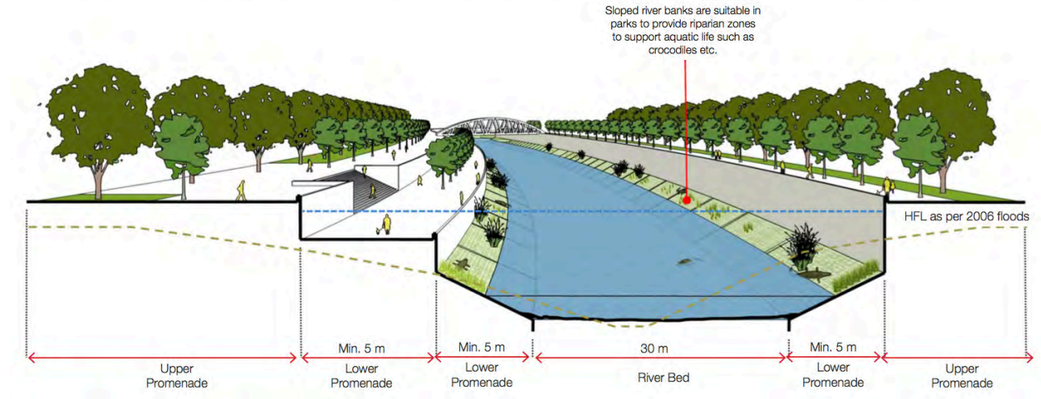
Further examples evidencing this criticism include:

1. The proposal has a narrow temporal and spatial extent for "restoration". It fundamentally limits the city by relying on regional fads in urban development while ignoring the wider context of stream restoration globally. Spatially speaking, it fails to address issues at the scale of the watershed from which the river is formed. Temporally, it fails to address the ecological impacts of past development choices (see section: Contribution of Urban Development to Flooding)

2. The proposal mentioned groundwater recharge as an important need (VRDP Feasibility Report, 21 October 2014, pg 11, 93, 188, 199-200), but fails to address it by creating concrete-lined channels that will prevent infiltration along the channel. In addition, it ignores the fact that to truly address this issue, reducing impervious surface area in upland areas of the watershed is a more strategic priority (Hill 2009).

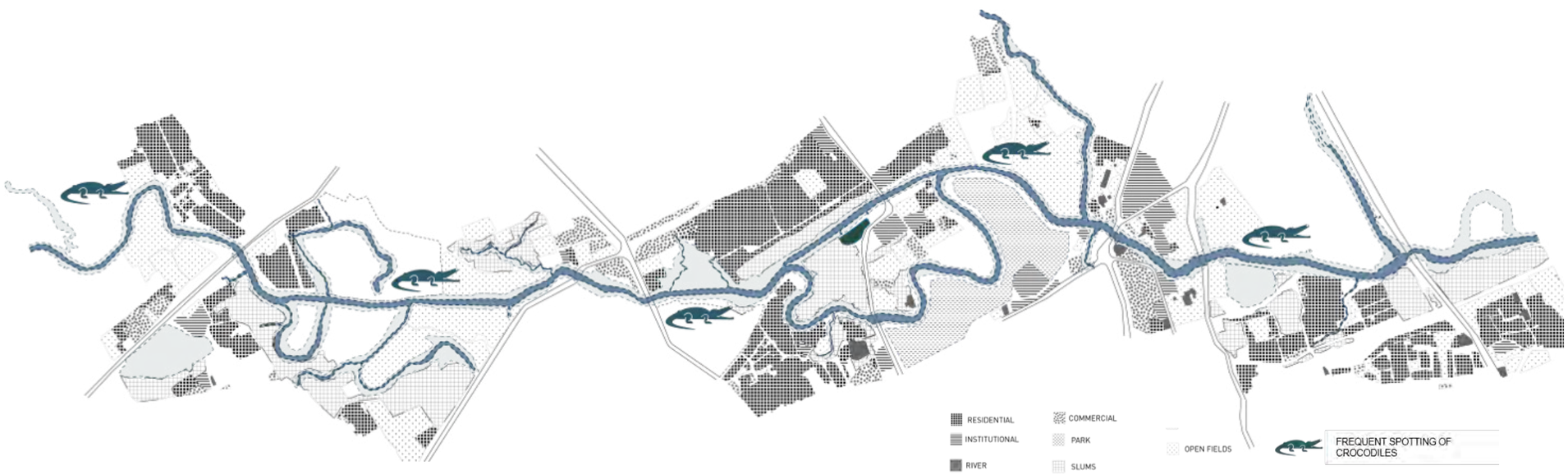
3. Lack of clarity on the spatial extent of crocodile relocation. If they will only be removed from within the city, the plan ignores the large population of crocodiles upstream (Ajwa Lake, Vadodara's water source) and downstream of Vadodara. These crocodiles could find their way into the city while migrating, or simply passing through, the altered corridor. This presents multiple problems, especially for a design that hopes to promote safe recreational opportunities for city-dwellers.

Extent of the VRDP's proposed crocodile park (green).



Top: VRDP proposed relocating all mugger crocodiles in the Vishwamitri River to a crocodile park.
Bottom: River edge design for the proposed crocodile park. (Source: VRDP Feasibility Report 2014)

Before undertaking largely irreversible structural changes to the river channel and surrounding floodplain, the city could draw on scientific understanding of ecological, process-based restoration strategies. While it is widely recognized that this approach is significantly more challenging for a variety of reasons (Palmer 2009), we also contend that it provides more opportunities to meet other goals of the project, such as flood management and recreation (VRDP Feasibility Report, 7 May 2016, pg 36), while increasing the overall health of the river. These benefits will create economic benefits. By increasing the functionality of the design, we can both increase and spread out the benefits of natural spaces throughout the city (see section: Green Infrastructure).



Mugger crocodile nesting sites along the Vishwamitri River within Vadodara.

10 LOW HABITAT VALUE

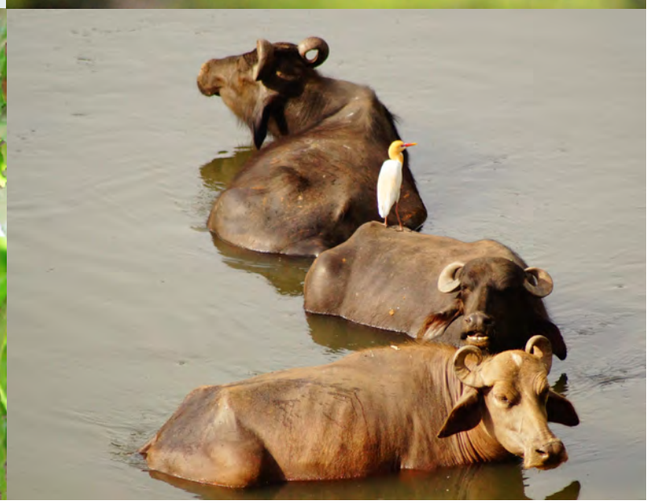
Riparian zones are usually characterized by a high species richness due to a variety of factors such as disturbance (in Vishwamitri, the major natural form of disturbance is due to periodic flooding) (Pollock et al. 1998) and high productivity (Pollock et al. 1998). Plant species richness varies considerably in space and time along stream margins as a result of varying floods and debris flows. These variations in plant species have important influences on the in-stream biota and processes, while maintaining biodiversity by providing an unusually diverse array of habitat and ecological services (Naiman and Decamps 1990). In addition, rivers and their adjoining riparian zones are important corridors of movement, not only for water, but for plants and animals (Hanson et al. 1990, Forman 2014).

Riparian corridors are most sensitive to environmental change (Naiman et al. 1988, 1989), and the dynamics of delivery and routing of water, sediment and woody debris as altered by changes to the landscape can affect the ecological characteristics of these corridors (Naiman et al. 1993).

The VRDP proposal suggests the creation of concrete promenades along the entire urban stretch of Vishwamitri, eliminating opportunities for natural plant growth. Instead, they will plant a row of trees along the promenade in a deep oversimplification of the habitat pattern and process of the riparian edge. This oversimplification is will result in extreme fragmentation of the riparian corridor, inclusion of exotic/invasive species as a result of 'aesthetic' landscaping along the promenades, and an overall reduction in the habitat quality for existing wildlife.

The modelling of seed dispersal in fragmented riparian landscapes projects lower diversity, which may be amplified in the face of increased environmental stress- such as flooding (Hanson et al. 1990), and cause dire problems for the regeneration of the plant species dotting the riparian edge. Relatively low vagilities of amphibians, narrow habitat tolerances and high vulnerability to pathogens, invasive species, climate change and pollution make amphibians vulnerable to habitat loss and fragmentation (Cushman 2006), causing concerns for the different amphibian species that call the Vishwamitri home. The altered dynamics of riparian ecosystems trigger the establishment and spread of invasive alien plants due to their ability to thrive in low competition environments created by disturbance (Richardson et al. 2007). Invasion along the riparian corridor, especially by plants such as *P. juliflora* (vernacular: Gando Baval) is associated with habitat degradation and a negative impact on

Invasive plant species along the Vishwamitri River. (Photo: Rubin Sagar)



Diverse animal and plant species observed in the urban ecosystem in Vadodara, whose vital existence depends on a healthy river system and high quality habitats within and beyond the riparian area. (Photo: Rubin Sagar)

associated native vegetation (El-Keblawy and Al-Rawai 2007). The survival of these species also hints at inhospitable environments and dry, sandy soils (El-Keblawy and Al-Rawai 2005), and as a result, at degrading environments.

The creation and development of eco-sensitive areas and biodiversity hotspots have been proposed by the VDRP to combat the issues of habitat connectivity, and species loss. The proposal however lacks proper understanding of the importance and functions of biodiversity hotspots and habitat connectivity, and needs to address the critical concerns of fragmentation and species loss. Overall, the oversimplification of complex ecosystems, the lack of understanding of key ecosystem processes and the dire need for addressing ecological concerns of implementing the elements of the proposal indicate at low habitat value in the face of implementation of the VRDP proposal sans modification.

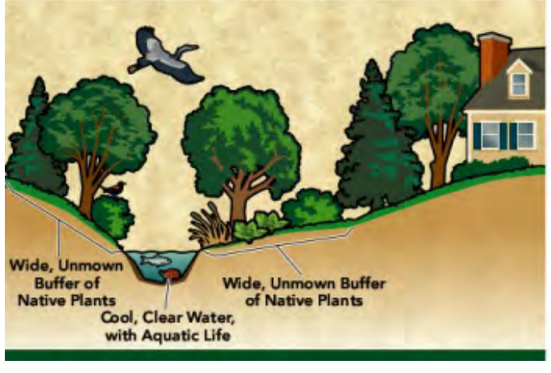
11 ECOLOGICAL PROCESSES & STRUCTURES

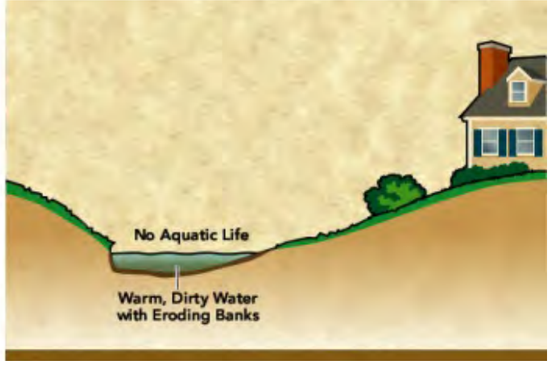
It is possible for river restoration to combine improved flood protection measures with ecological rehabilitation of river corridors (Boon et al. 2000, European Union 2000, BWG 2001). However, public perception and acceptance of ecologically-based river revitalization projects may vary (Junker & Buchecker 2006).

Although a stated goal of the VRDP is to "restore the river's ecology", the actual design proposal indicates the exact opposite. In truth, the VRDP only aims to improve the visual and recreational of the river. While some may perceive benefits to concrete banks, manicured promenades, seating areas and water-based recreational opportunities, those. However, photographic simulation surveys have shown that aesthetic preferences relate more positively to eco-morphological quality (Junker & Buchecker 2006), and the look of a well-cared-for landscape may evoke immediate aesthetic response, which can influence behavior to maintain and protect the landscape appearance (Nassauer 2011). When a similar preference survey was conducted in the city of Vadodara to gain an understanding of people's perception regarding the river in general and the restoration project, a striking observation was that people actually preferred a manicured structure - an opinion that was influenced by the poor state of the river and the lack of alternatives.

The VRDP's proposal to jacket the river and build concrete promenades as an aesthetic incentive is flawed in the face of other ecosystem services that rivers in general offer. The proposal seems to mirror a channelization project more than that of a river restoration effort - without acknowledging that channelization of the river will forever change the natural processes that have led to its current dynamic form- and that undoing this in the future would be incredibly challenging and expensive. The suggested modifications to the river severely undermine the complex structure of the ecosystem which plays host to the biodiversity of Vadodara, and does not consider the ramifications of the potential loss to the ecosystem. Alternative approaches to design and restoration efforts, with an enhanced understanding of sensitive ecological structures and processes need to be the new line of thought.

Healthy (left) and unhealthy (right) streams and their ecological structure. (Source: Philadelphia Water Department)





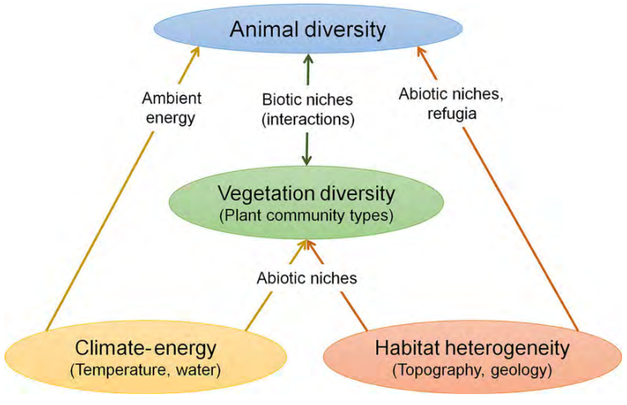
12 HABITAT HETEROGENEITY

Habitat heterogeneity, also called spatial heterogeneity, is the basis of the habitat heterogeneity hypothesis, which states that structurally complex habitats may provide more niches and diverse ways of utilizing the environmental resources and as a result, increases species diversity (Bazzaz 1975).

Although habitat heterogeneity and biodiversity are generally understood to be positively correlated, it is not always the case. A study done by Tews et al. showed that a majority of the studies they reviewed showed a positive correlation between habitat heterogeneity and animal diversity, and also a positive relation between plant diversity and animal diversity (Murdoch et al. 1972), but not always. This is because the structural attributes of the habitat may vary considerably depending on what is perceived as habitat by different species groups (Tews et al. 2004). Moreover, changes in biodiversity due to changes in habitat heterogeneity seem to depend on the region and anthropogenic influence (Palmer et al. 2010). Hence, understanding the relationship between species groups and the ecology of the Vishwamitri River is important and should be incorporated in the design.

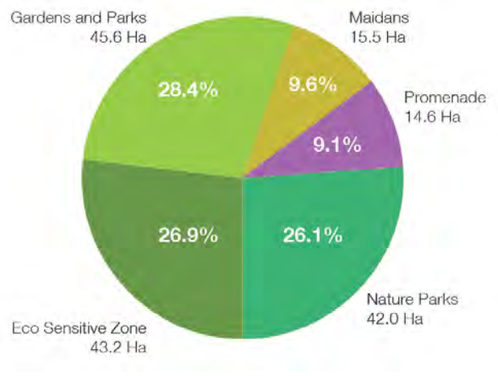
Channelization of some portions of the river is also a part of the VRDP, by concretizing the banks for constructing promenades (VRDP Feasibility Report, 21 October 2014, p39, pg 88, pg 121). Projects as such require dredging of sediments and can cause irreversible disturbance to habitats on the river bed and banks. Habitat values of the river are also likely to degrade since the modified channels will have much less structural heterogeneity compared to the river in its natural state. There have been a number of cases in other countries, especially in the west, where river channelization has had negative effects on the biodiversity and the associated restoration projects involved some form of channel reconfiguration and enhancement of structural complexity, however, only a few of these projects resulted in a significant increase in species richness (Palmer et al. 2010).

A major component of the VRDP is to create large public open spaces along the river (VRDP Feasibility Report, 21 October 2014, p87, p121, p147-p150) and modifying the river edge (VRDP Feasibility Report, 21 October 2014, p129-p135). All these activities will involve modifications to the existing river bank either partially or completely, based on the purpose, resulting in loss of heterogeneity. VRDP's proposal seems to be similar to SRDP, as the designs for both the projects have been made by HCP Design, as mentioned above. A major issue with the Sabarmati Riverfront is that throughout the entire stretch, there are very few species of trees, planted in a single line, that were observed during our visit. If that is what the Vishwamitri Riverfront as per HCP Design's design will end up being, there will be a significant reduction in the habitat heterogeneity, possibly a complete loss of habitat in certain portions. As a result, the biodiversity could significantly reduce along the entire stretch of the river.



Interactions between climate, habitat heterogeneity, and biodiversity.
(Source: Jimenez-Alfaro et al. 2016)

Although VRDP includes green spaces – eco-sensitive zones, gardens, parks and maidans (meaning large open lawns), these amount to only 146.3 ha (VRDP Feasibility Report, 21 October 2014, p147) of the total project area which is 1093 ha (VRDP Feasibility Report, 21 October 2014, p93). Moreover, the planned green spaces are not continuous and are meant for people, hence have little purpose as habitat for diverse animal species.



VRDP proposed public spaces along the river.
(Source: VRDP Feasibility Report 2014)

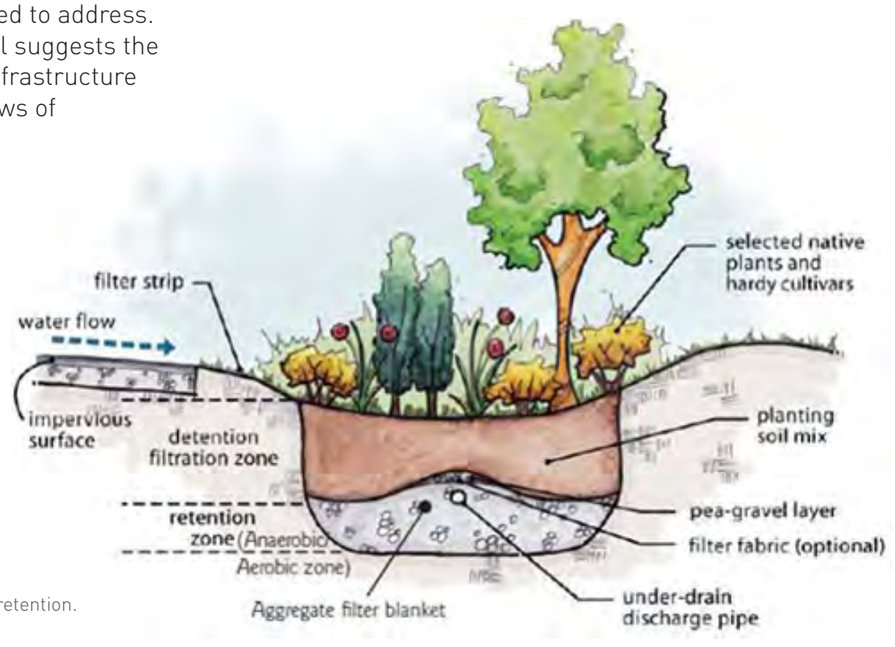
13 GREEN INFRASTRUCTURE

It is evident that the innumerable issues the proposal attributes to the river itself are actually a result of lack of systems understanding and dealing with problems at the larger catchment level (see section: River as an integrated system of processes). The proposal comes across as a lost design opportunity because of its piecemeal approach and lack of integrative framework for analysis and application to address and reveal the functioning of the overall stream system and its innumerable associated benefits.

As indicated in (see section: Consideration of climate change) the high probability of climate change will most likely produce new rainfall patterns that civic infrastructure will need to address. Although the proposal suggests the need of an updated infrastructure to deal with urban flows of sanitation and stormwater (VRDP Feasibility Report, 21 October 2014, pg 84-85), it fails to recognize that this infrastructure can and should be multifunctional to serve multiple purposes of both ecological and social importance (Hill 2009, pg12). In its design, the proposal focuses on addressing the channel rather than the drivers of channel degradation. It is important to understand that mimicking channelization to meet the problems of flooding, inundation and waterlogging will result in the loss of ecological value (see section: Habitat Heterogeneity) and will increase the problem downstream(Hill 2009). A better solution would be to adopt a catchment scale strategy to address the causes at the source.

New and evolving approaches like source control, green infrastructure, low impact development have been adopted world-over to deal with stormwater related issues."Retention, bioretention and biofiltration source control techniques have the potential to provide non-stormwater benefits. They include cleaning and cleansing the air, reducing energy demand, sequestering and reducing emissions of greenhouse gases, beautifying neighbourhoods and potentially raising property value, providing habitat for wildlife, stream health benefits, and developing new local markets that can stimulate job growth." (PlaNYC 2008, pg44).

The proposal fails to recognize these new approaches . It does not tap into the potential infrastructure has of creating an ecologically positive way of thinking that allows for civic expression (Poole 2005).



An illustrative example of bioretention.

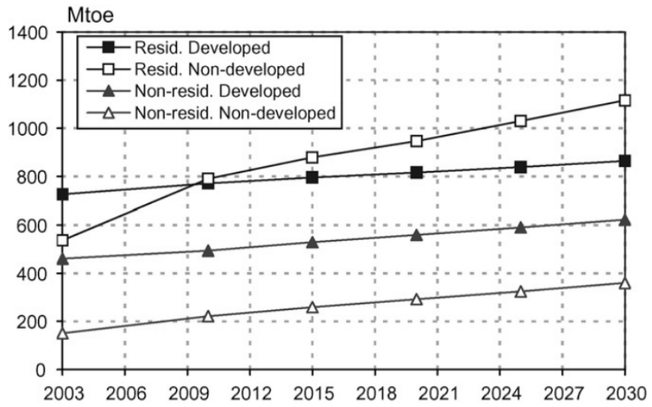
Examples of Low Impact Development.

14 CONSIDERATION OF CLIMATE CHANGE

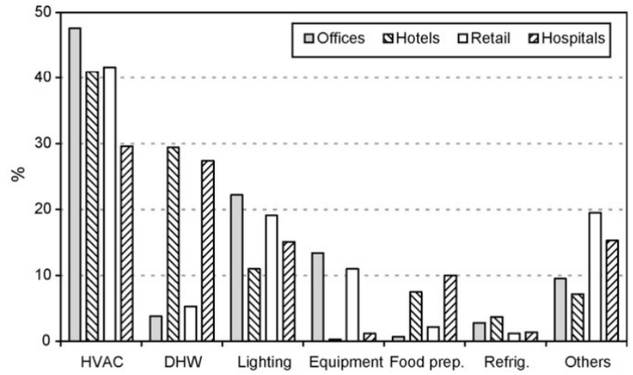
One of the biggest problems that the world is currently facing is climate change. It is being regarded as a major threat to extant biodiversity. Effects of climate change which can have major impacts in Vadodara are – weather extremes (hotter and drier summers, wetter monsoons) (IPCC 2001) and intensification of hydrological cycle (Milly et al. 2002). During our visit to Vadodara, we experienced temperatures as high as 47 C (116.6 F); it is likely to increase in the coming years.

Based on occurrences in the past, intensification of the hydrological cycle can result in extreme floods within the city of Vadodara, as well as a change in the course of the river (Mall et al. 2006). The effects of climate change on channel changes have not been studied much (Gregory 2006). However, climate change can be a major cause for changes in a river system (Church 2002).

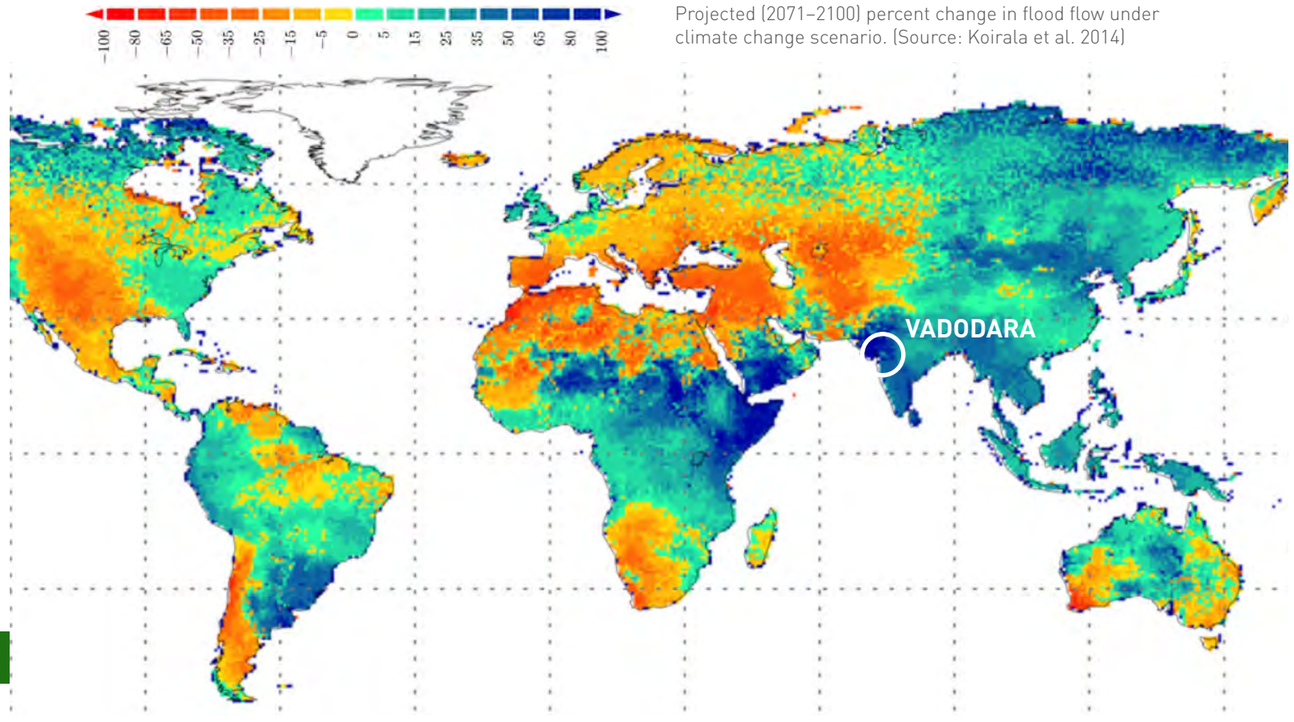
Constructing promenades (VRDP Feasibility Report, 21 October 2014, p117, p129, p149) along the river will result in two major changes to the current state of the riverbanks – clearing the vegetation and concretizing the surface. These can worsen the effects of climate change by exacerbating the microclimate of the region (see section: Microclimate) . The VRDP involves developing a Central Business District (CBD) along the river (VRDP Feasibility Report, 21 October 2014, p96). Commercial buildings, especially office buildings consume maximum energy (Perez-Lombard et al. 2008); the possibility of being in a UHI (coupled with the intensification



Building energy consumption outlook. (Source: US Energy Information Administration)



Consumption by end use for different building types. (Source: US Energy Information Administration)



Projected (2071–2100) percent change in flood flow under climate change scenario. (Source: Koirala et al. 2014)

of summers) can result in a higher energy consumption, especially in the CBD. However, having vegetation (green areas) can result in a significant reduction in temperature (Han et al. 2007). Moreover, the energy consumption of buildings, specifically for cooling can reduce too (Han et al. 2007).

VRDP has little consideration of climate change. Being inevitable, more research needs to be done regarding the possible effects of climate change, which can have major impacts on the city, most importantly, changes in the river and climatic changes. Moreover, considering impacts of development in regions downstream are necessary. Establishing feedback mechanisms and mitigation practices should also be a part of the plan.

15 MICROCLIMATE

Recent research on the land surface temperature in Vadodara shows a significant increase in overall temperature from 1990 to 2009. Increased impervious cover due to urbanization has been amongst the biggest contributors to the accumulation of heat that has led to heat island formation in several areas of the city. Vegetation and water bodies in the city act as heat sinks. Encroached lakes and filled up ravines show an increase in temperature due to the developments on them (Bhatt and Joshi 2012).

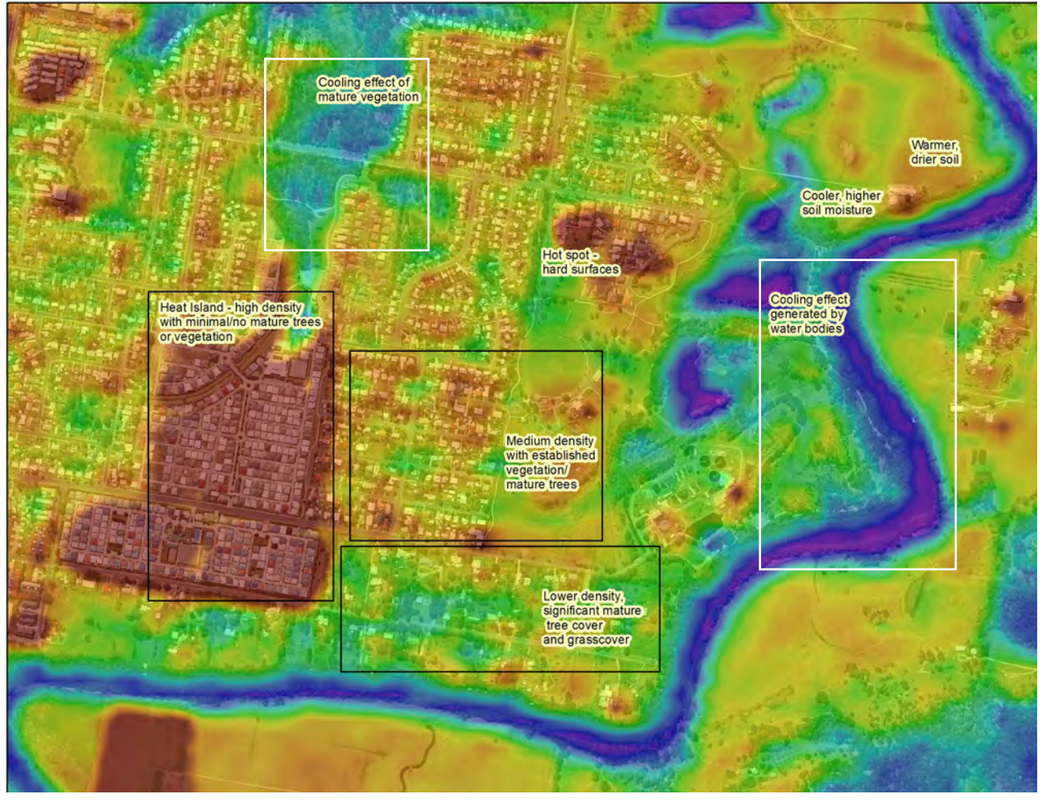
In light of the above coupled with the advent of climate change, it is important to analyse the microclimatic impacts of the VRDP on both (1) the stream and (2) the project influence zone.

1.Stream: Stream temperature is a function of many variables, some of which are directly or indirectly affected by urbanization. It is a major regulator of life in systems regardless of other physicochemical changes. Temperature changes may cause shifts in structure of aquatic communities (Karr et al. 1978).

According to the study on effects of landuse change on water temperature in unregulated urban streams by LeBlanc et al., it has been stated that "three main urban factors responsible for altering the thermal environment of streams are: (1) changes to the composition of vegetation in the watershed (more specifically, the clearing of riparian vegetation along stream banks), (2) changes to the low flow regime, and (3) changes to the stream's hydraulic geometry" (LeBlanc et al. 1997, pg 446).

The government proposal aims at (1) jacketing of the river, (2) streamlining of the flow, removal of natural obstructions and promenade development along the banks,(3) diversion and retention of water from another river and (4) proposal of large scaled development along the river banks. (VRDP Feasibility Report, 21 October 2014) These design intentions are likely to cause changes in all three factors contributing to alteration of the thermal environment of streams. This alteration of temperature regimes may lead to digression of the stream to a highly unstable state. The stream is home to diverse flora and fauna and the proposal that mimics stream channelization may cause irreversible damage to the stream ecosystem by altering historical temperature regimes, since stream temperature is a major regulator of life systems.

Riparian vegetation shading the stream helps maintain water temperature. (Source: Tennessee Valley Authority)



Surface temperature mapping shows cooling effects of water bodies and mature vegetation. (Source: SEQ Catchments)

2. The project influence zone: The stream corridor of the city is an important heat sink that mitigates the urban heat island effect now profound in several parts of the city. The proposal intends to modify the entire project influence zone essentially the entire stream corridor within the city into several land uses that will comprise of the following: (1) development projects along the riverfront (105.7 ha), (2) a public promenade along the river that comes across as impervious and concretized (29.2 km), (3) cultural interventions public buildings and infrastructural development (22.9 Ha), (4) street infrastructure proposals (161.0 Ha) and (5) services and utilities infrastructure 19.9 Ha. As stated earlier, only a small portion of the area has been allotted to green spaces (eco-sensitive zones, gardens, parks and maidans that could be seen as heat sinks), these amount to about 13% of the total project area which is 1093 ha (VRDP Feasibility Report, 21 October 2014, p93).

The intended material usage for the project area is also important in light of microclimatic effects of building materials used. The renderings show usage of concrete and asphalt as the primary materials for the project its associated development. It has been found during calculation of material radiation using the Stephen Boltzmann Law , that the high emissivity value and substantial usage of concrete and asphalt in surfaces contribute a significant amount of radiation throughout the day (Kannama and Sundaram 2014). Therefore, it can be predicted that the design will influence the microclimate of the river corridor and most likely cause an increased temperature due to significant radiation.

"Thermal comfort is one of the determinant conditions of desirable space's criterion." (Tahbaz et al. 2011, pg 1) Based on the given argument, the project's design of promenades and public spaces and their projected use throughout the day and through all seasons are questionable and need further analysis.

16 HABITAT STRUCTURE & SIZE FOR CROCODILES

The mugger (*Crocodylus palustris*) is found in the Indian subcontinent only. Their habitat ranges from southwestern Iran to Myanmar. Over the years, there has been a decline in the wild population of the mugger; now they are mostly found in protected areas (Santiapillai and Silva 2001). The Vishwamitri River basin is one of India's few areas where the mugger has been thriving in the wild since decades (personal communication with Dr. Raju Vyas). Not only is the entire stretch of the river natural, but it is one of the world's few urban rivers with such a large crocodile population. The VRDP aims at converting a small stretch of the river into a protected crocodile park (VRDP Feasibility Report, 21 October 2014, p154) which disregards the uniqueness of this river, and the city of Vadodara.

The mugger is one of 23 species in the order *Crocodylia* (IUCN Crocodile Specialist Group) and each of these species have different requirements (Lang 1987). A picture of St. Augustine Alligator Park in Florida has been shown in VMC's report (VRDP Feasibility Report, 21 October 2014, p86) suggesting that a crocodile park emulating that could be created. Two important characteristics that the muggers require are: still or slow flowing water (Whitaker and Whitaker 1989, Andrews and Mceachern 1994) and space for burrowing as well as creating holes for their nests, as the mugger is a hole-nesting species (Santiapillai and Silva 2001, Mobaraki et al. 2015), which could be a limiting factor in habitat preference (Mobaraki et al. 2015). A study conducted by Behrouzi et al. determined three characteristics of a suitable crocodile habitat – (a) cover (vegetation cover, depth and slope), (b) food and (c) chemical characteristics of water (Behrouzi et al. 2010). In general, muggers prefer habitats with 2-4 m water depth, vegetation cover of 35%, mean slope of 25-35% and an abundance of fish and amphibians (Behrouzi et al. 2010)

Mugger range in the world. (Source: IUCN)

The mugger crocodile has been found in a wide range of freshwater ponds, lakes, rivers and has even been found to flourish in man-made water bodies such as reservoirs and water tanks (Mobaraki et al. 2015, Whitaker and Whitaker 1989). Being a seasonal river, the amount of water in the Vishwamitri varies considerably throughout the year, however many stretches of the river are slow flowing, especially during the non-monsoon months. The VMC proposes to separate the oxbow lakes from the main river and create public spaces (VRDP Feasibility Report, 21 October 2014, p153), however these could be important habitats for the crocodiles.

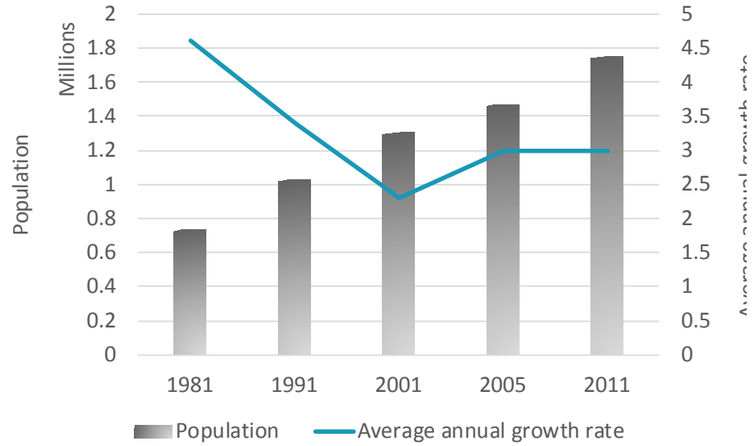
Another very important characteristic of the mugger is burrowing which is a characteristic of other crocodile species as well (Mobaraki et al. 2015). Burrowing has been observed in muggers of varying ages, from yearlings to adults (Whitaker and Whitaker 1984). Being social in nature, muggers often share burrows, but there is not enough data as to how many crocodiles can or do share a single burrow (Mobaraki et al. 2015). Burrows can be as much as 6 m in length, and are extremely important during the summer for thermoregulation of the crocodiles (Da Silva and Lenin 2010).

VRDP mentions the creation of a separate crocodile habitat as an extension of Kamati Baug (VRDP Feasibility Report, 21 October 2014, pg 154). Treated water from a nearby STP will be used to replenish the stretch of river within the crocodile park, which will have check gates at both ends. This can prevent the inflow (completely or partially) of fish and other organisms which forms an integral part of the crocodile's diet. Although the proposal mentions a land area of 25-40%, there is no mention of vegetation cover. With a large number of crocodiles present in the park, the amount of land required might not be enough, considering enough vegetation cover as well as open spaces for basking. Moreover, there should also be enough land for the crocodiles to create their burrows.

A historical crocodile sculpture in Kala Ghoda suggests the long existance of Mugger in Vadodara. (Source: VRDP Feasibility Report 2014)

Similar to many other animals, crocodiles also occupy specific areas, known as home ranges. Crocodiles are known to have a high site fidelity, meaning that they stick to their home ranges (Lang 1987). The mugger crocodile is one of those species (personal communication with personnel involved in mugger relocation). There have been cases in which muggers which were relocated to Ajwa Talav from certain portions of the river, returned back to their home range within days, and this is a typical behavior (Lang 1987). The proposal for a crocodile park will involve a massive amount of relocation; from their home ranges to the park. This could cause stress in the crocodiles since the creation of barrages will prevent them from leaving the park and returning to their home ranges. Secondly, observations of Nile crocodiles (Crocodylus niloticus) have shown that the area of home ranges using radiolocation range from 0.064 sq. km to 0.799 sq. km for a single crocodile (smaller home ranges for smaller crocodiles). The entire area for the proposed park by VMC (in collaboration with HCP Design) is 0.063 sq. km, which is not enough.

COMMUNITY PREFERENCE & SOCIAL CONCERNS



The population of Vadodara has grown significantly over the past 30-years, from 734,000 (1981) to over 1.7 million (2011) (Government of India, Census Data 2011) and continues to expand. Given the growth and consideration of the ecological systems, development of public space can be an opportunity to refine how the city develops. The VRDP proposal, however, overlooks many of the important concerns and needs of the city's population (including the informal settlements) and avoids consideration of local stakeholders outside of the small advisory council. The following section details some of the concerns outlined by stakeholders in critiquing the VRDP proposal.

17 DISPLACEMENT OF INFORMAL SETTLEMENTS

The VRDP Master Plan calls for re-organization of present land use (VRDP Feasibility Report, 21 October 2014, p.36) to achieve intended benefits of the development along the Vishwamitri. These intended benefits are framed as principles to: "rejuvenate the ecology," "enhance the cultural importance of the city," and restore the "connection of the river with the people" (VRDP Feasibility Report, 21 October 2014, p.23). Given meaningful consideration in a future proposal, we believe these principles are achievable in the project area. Furthermore, we allow the likelihood that any attempt to enhance the Vishwamitri will invariably result in adjustments to policies, plans, and updates for efficient use of land resources. It is our hope that by illuminating the flaws of the VRDP proposal, the city can develop more holistically beneficial solutions for the its inhabitants. From our standpoint, as currently proposed, the degree to which the VRDP proposal will result in harm to citizens by displacing people living along the Vishwamitri remains both a significant and unanswered question.

Information about informal settlements in Vadodara. (Source: VMC)

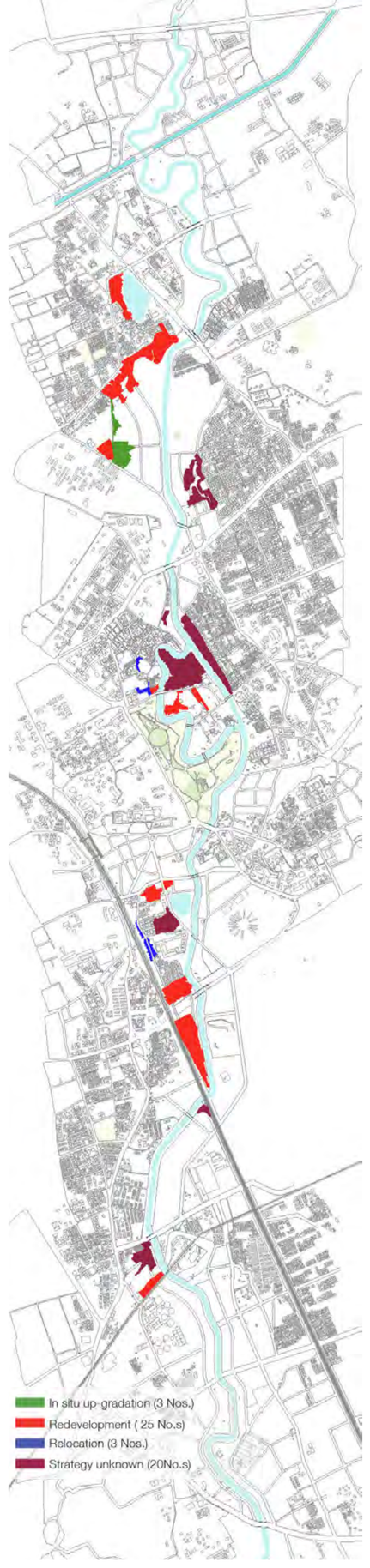
Year	Population	Access to Municipal Services		
		Water Supply	Sewage	Waste Collection
1991	226100	-	-	-
2001	257195	88	46	80
2005	270299	88	46	80

An informal settlement located on the river bank near development. (Photo: Rubin Sagar)

Broadly, our concern stems from the VRDP's lack of attention to describe how the proposal will address the demands of the city's inhabitants and growing population. The lack of meaningful engagement may be a result of how existing environmental laws and policies in India, which the VRDP is bound to, are challenging to enforce broadly. The inability to enforce environmental laws in India has been challenging policymakers over the past decade or so (Agrawal 2005). Whether the VRDP proposal fits with the spirit of enforcing environmental law remains an open debate ("The Indian Express" 2015). But in instances like this, where adhering to environmental law is aspirational in light of challenging enforcement measures, the fundamental concern is how the project will meet the city's inhabitants. This is particularly important in light of Vadodara's underserved populations. According to the VMC's past studies on informal settlements in the last two decades, the majority of individuals living in informal settlements limit their access (and may depend on) the water supply in the area proposed for development. Our empirical observations in Vadodara witness that the situation has not changed. How can the VRDP's more strongly consider the realities and livelihoods of over a quarter-million residents in Vadodara (and growing)?

The lack of consideration given to the underserved segment of the population is one of our fundamental concerns, which has been guiding the critique and future policy recommendations. One practical objective of ecological landscape design is to protect and enhance ecological resources while mitigating negative impacts on the greater public. In our view, adhering to these principles of design should make revising the VRDP substantially to address questions a priority. For example, does the proposal provide support or information concerning the preferences or interests of individuals currently inhabiting the area along the riverfront? Does the proposal cause future stresses of urbanization for residents along the river? The VRDP proposal may create more problems than it solves without answering these questions thoroughly.

VRDP proposed strategies for informal settlement improvement. 20 out of 51 settlements have not been designated any improvement strategy but relocation has been reported underway. (Source: VRDP Feasibility Report 2014)



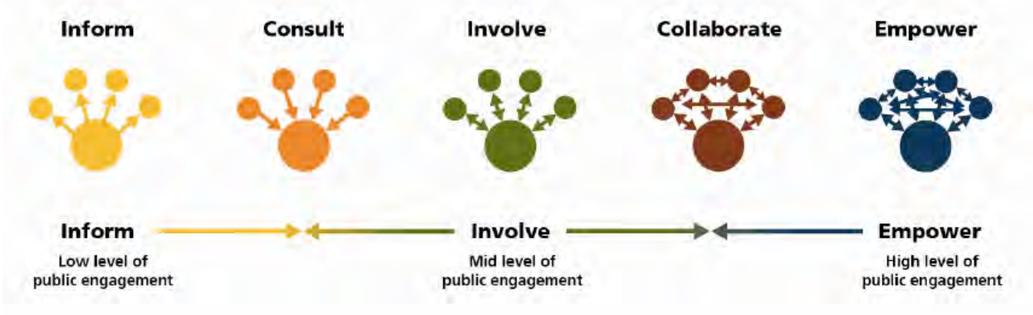
18 LACK OF COMMUNITY ENGAGEMENT DURING DESIGN PROCESS

One concern is the lack of a role the general public has to participate in the design process (i.e garnering public approval, sharing findings, obtaining consent). Although the proposal does include a function for public outreach, there is no evidence that this process will be carried out. In addition, the proposal does have an advisory council of experts, but it is unclear how their input reflects the broader community of Baroda. In Gujarat, environmental policies require a permitting approval process and the High Court has had some success with enforcing regulations. However, the VRDP stipulates that the development " be implemented without obstruction or delay" which, in some sense implies development without public input. The VRDP may be seeking to avoid confrontation with the public, given the accounts of outcry in local media outlets reporting wide opposition from stakeholders (VRDP Feasibility Report, 21 October 2014, p.195). Another explanation may take into account how VRDP will be funded. According to the Organisation for Economic Co-operation and Development (OECD), 10 percent of the total investment for controlling pollution (e.g. wastewater) in Gujarat historically has come through a public-private partnerships. In this case, the VRDP may rely on private partnership to accelerate permitting processes and obtain funds otherwise unavailable.

In our own group consultation conducted with several local experts at the ASP Foundation, concerns were raised that the ongoing dialogue with the VRDP to work with the community and simply share the minutes of the design process has been secretive. In the current proposal, the only opportunities for public involvement (VRDP Feasibility Report, 21 October 2014, p.193) are simply to view what the project. We were unable to find evidence of interaction with the public in any substantive manner, nor any opportunity for the public to address grievances meaningfully.

It should be noted that the citizens have voiced their concerns to the VRDP directly in a letter: "We are especially concerned about the "Vishwamitri Riverfront Development Project" (VRDP) and the "Sursagar ('Lake') Development Project" (SDP) in Vadodara. In addition, as concerned citizens of Vadodara, we also want to ensure our active and legitimate participation in the longer term development decisions and efforts (such as, the town planning schemes and various other development infrastructure projects) related to Vadodara city and its eco-region" (Citizens Petition 2016).

Public engagement spectrum. (Source: Burlington Gazette)



19 PERCEPTION OF OPEN SPACE

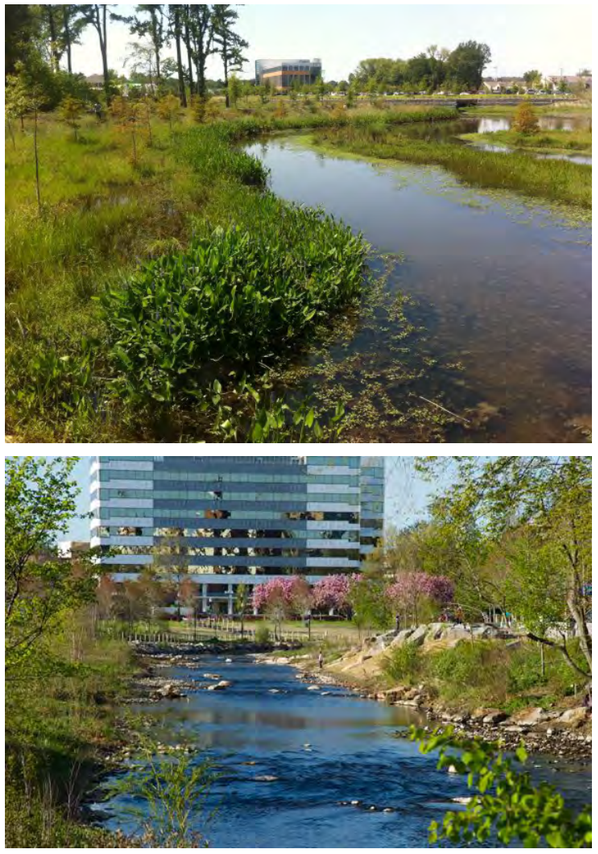
Urban green spaces (UGS), such as parks and gardens, form a very important part of an urban area as they serve a number of functions such as air purification, noise and wind breaks, and microclimate stabilization, as well as providing psychological benefits to people (Ulrich 1981). Vadodara's largest (46 ha) and most popular UGS is Kamati Baug. It has various attractions such as a zoo, architecturally significant buildings, toy train, walking/jogging paths, gardens and a view of the Vishwamitri bank in a relatively natural state. VMC proposes the development of 36 new smaller green spaces (average size 3.64 ha, VRDP Feasibility Report, 21 October 2014, p149). We believe the VRDP lacks a meaningful, community-focused basis for this number or the layout. If the city better understood community preferences for green spaces, they may find it would be easier to incorporate efforts to "rejuvenate the ecology of the river" with socio-cultural needs.

Some important issues, which the VRDP fails to consider, are impervious surfaces from the promenade, inter-site connection and that smaller sized UGSs result in greater fragmentation, which have resulted in the degradation of UGSs in certain Chinese cities (Chen 2006).

A study done by Chen regarding the perception of the public towards Guangzhou's UGSs gives a good idea of what people in a large city in a developing country think. Some major findings of the study are:

- The most preferred design of UGSs was the naturalistic-ecological style. The most popular/desirable green spaces in Guangzhou have been left in their natural state with only essential facilities for visitors.
- Ecosystem services provided by UGSs that were the most important according to the public were regulating microclimate, controlling noise and air pollution and aesthetic enhancement. Guangzhou also has hot and humid summers, similar to Vadodara.

Benefits of urban greenness. (Source: Plant Your Trees)



Examples of stream restoration projects that incorporate urban green spaces. (Source: City of Conway, AR; Rosslyn, VA)

Similarly, in Bari, a city in Italy, people opine that the most important function of green spaces is that of improving climatic conditions (Sanesi and Chiarello 2006). In Sheffield, UK, people's perception towards a naturally landscaped green space versus a more formally designed green space were compared. Different attributes associated with each park were valued differently. However, the naturally landscaped park received more appreciation for values and benefits such as contact with nature, social contact, benefits to wildlife, excitement, and a sense of naturalness and freedom (Ozguner and Kendle 2004). Moreover, the most valued feature of the naturally landscaped parks were the streams and water bodies within the park.

While, of course, people's perception of open and urban green spaces is highly dependent on the location and culture, we believe these studies can be a starting benchmark in considering preferences.

The people of Vadodara may have a variety of preferences, but the VMC and HCP have yet to gauge what those preferences are or how strongly they are felt by different stakeholder groups. Hence, some form of community engagement, whether a public survey or a series of focus groups, to understand people's views on UGSs should be carried out before developing more green spaces in the city. From the surveys we conducted, 64% (online) participants indicated the desire to visit a park or public garden more often than they do. This could mean more UGSs could get a very warm reception from the public. Although the public desire more green spaces, their location and arrangement could take a multitude of forms, each with their own set of ecological and social impacts. We recommend that the VMC reconsider the design of the green spaces with less fragmentation (larger and intact parks), leaving parks near the river as natural as possible, and considering them as ecosystem enhancers or opportunities for stormwater management rather than public attractions.

20 HERITAGE

Over the years rivers have been seen as conveyance systems to serve human needs, in spite of historic cultural importance. This shift in perspective is evident in the way the "proposal questions the nature of and reason for the river's existence in the city rather than the original reason for the city's coming into existence" (Rao 2012, pg 2).

In its approach for a solution to the issues of the city, the proposal fails to emphasize that the biggest inheritance the city has: the river and its interconnected ecological system. The basis of the establishment of the entire city rests on the existence of the river. The VRDP and associated development projects further separate the city from its heritage, forgetting that traditional societies in the city of Vadodara related to elements of nature in a manner that was beyond the utilitarian and mundane. These practices led to the establishment of cultural interventions that celebrated the idea of an essential connectedness with nature. We contend that the VRDP does not celebrate the river, rather it limits its health and potential.

Although the proposal mentions the architectural heritage in the form of historical temples, ghats, vavs and other river/ water related interventions along the river (pg 46 - 48) , it fails to recognize, understand, learn from and incorporate into the design these hydraulic civilization traditions that are more often than not, low-tech/ low cost systems rich in their understanding of ecological landscapes. It fails to see that historically the selected and few points of connecting to the river were inherent to the idea of sacredness of the river and that over these selected few built edges, majority of the river comprised of gentler edges where the earth met water and it was here that another world existed (Bhagwat 2013).

Such as the case of Sabarmati, it is unfortunate to see that even for the Vishwamitri River the large scale proposal "pays scant regard to the entire river system and limits the vision of to a stretch of frontage as seen relevant to the immediacy of the city" (Rao 2012, pg 4). In an effort to demonstrate human domination of the river, overriding cultural heritage, the proposal fails to "be very gentle in the act of intervention, to the point of leaving no trace of having touched the space at all. The real value in many cases lies in being nuanced or silent" (Bhagwat 2016).

Top: Kamati Baug in 1890, now the most frequented public garden in Vadodara.
Bottom: Kala Ghoda Bridge over the Vishwamitri River in 1890.
(Source: History of Baroda)

Sabarmti Riverfront Development Project, Ahmedabad, India. (Source: The Economics Times)

21 CONCERNS ON LAND OWNERSHIP & EQUITY

Our concerns about land ownership (VRDP Feasibility Report, 21 October 2014, p. 144-148) stem from analyzing the VRDP's plans to significantly alter the riverfront. The basis of our concern is about how equity will play a role in the future of Vadodara, specifically for existing land owners. Increased development may push certain groups out of their homes to make way for new businesses and then reorganize of land ownership rights. New development will promote economic benefits for the city, but to do so requires replacing what currently exists, and given the vision of the VRDP, will not necessarily the benefit current residents The impact of sustainable development often fails to address impacts on the livelihood and the rights of the low-income residents (UNFCCC, 2006). By essentially withholding the opportunity for current landowners to maintain ownership (in some cases), or missing opportunities for generating wealth in situ , the result will setback lower-income segments of the population The VRDP's relocation of those currently inhabiting the riverfront ignores cultural patterns of development in favor of amenities.

One of the VRDP's principle goals of the proposal is to address the stress of urbanization. As Vadodara grows, the question of how the city intends to assist the low-income population will continue to be an issue related to urbanization. The quality of life experienced by Vadodara's vulnerable populations will impact the quality of life for all Vadodara's citizens and it should be recognized that the greater social value Vadodara achieves will have ripple effects to the entire city. Therefore, the VRDP's lack of consideration given to the low-income population contradicts their stated goal of addressing urbanization, because certain stressors, such as adapting to new livelihoods, would increase instability for those populations. The current social and economic stressors will increase as a byproduct of developing commercial business parks where Vadodara's poorest residents currently live. Socio-economic-systems (SES) still contain negative feedback loops despite progress (Lemos et al. 2013) and continue to be present in the community as a whole, though perhaps not as readily visible to the extent that Vadodara's informal settlement areas are now.

By anticipating rapid urbanization, it appears that the VRDP looks upon existing community's informal land ownership as an obstacle, instead of an opportunity to engage in equitable development. For example, VRDP suggests that land parcels have already been selected alongside the riverfront despite the fact that, in some cases, ownership of land parcels still needs to be verified (VRDP Feasibility Report, 21 October 2014). Development along the riverfront is alarming because these areas could directly result in commercial zones mandating that the current inhabitants relocate. Instead of increasing urban density, the VRDP should favor solutions benefitting residents currently living along the river, instead of displacing them.

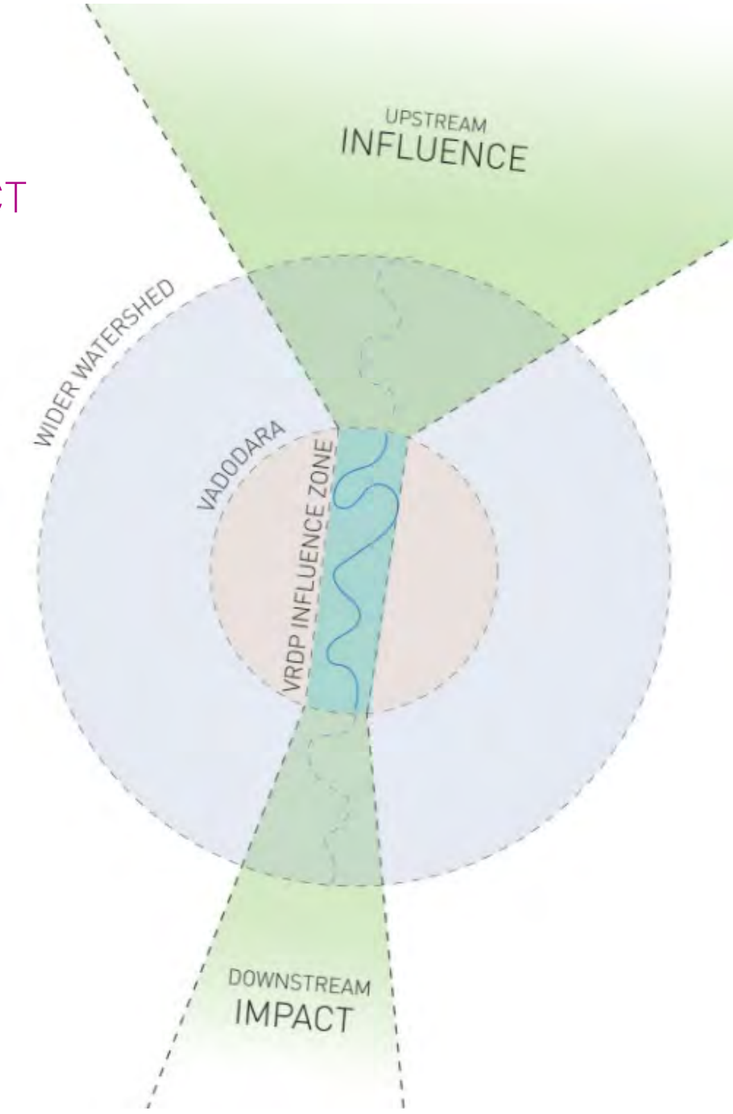
PROPOSAL DEVELOPMENT & DESIGN

The VRDP is a comprehensive overview of the development plan aiming the existing problem. Yet it still neglects crucial views from experts and depends on inappropriate precedents. Each city has its own role and it orientates the development of the infrastructure like all the item mentioned in the VRDP. The proper approach, what we propose here, is to take cultural and natural context into consideration seriously, and to guarantee its viability, before and after the project. The purpose of analysis is to substantiate design. The VRDP does not utilize analysis to inform their design, but rather rationalizes the proposal by selecting evidence that supports the design.

22 REGIONAL IMPACT IGNORED

We call into question the VRDP's consideration of the regional impact of this project. As an overarching criticism of the VRDP, we believe the project ignores the downstream impacts of Vadodara's development decisions and lacks a regional strategy for a regional river system. We have already addressed our concern about the VRDP's lack of knowledge and neglect of the natural systems that both form and support the river within the city (see section: River as a system). Now, we would like to consider the implications of the VRDP on its regional hydrologic and social context. Manifestations of this critique include:

1. Flood risk to downstream communities in light of increased capacity of the engineered river channel. We doubt the practical viability of a plan that requires a gate to be opened to release water in anticipation of the monsoon in order to prevent flooding of downstream villages (VRDP Feasibility Report, 21 October 2014, pg 41). This seems like an unnecessary risk. In addition, we see this as a grave injustice when communities could be harmed on behalf of the enjoyment and recreation of wealthier neighbors.
2. Risk of combined stormwater/ sewage interceptor overflows impacting water quality in downstream communities and ecosystems (see section: Combined sewer interceptor).



The VRDP lacks a regional view, ignoring upstream influence on the city and downstream impact of the proposed development.

3. Social impacts of rerouting rivers on neighboring communities and ecosystems not explored.
4. Lack of a cohesive flood management strategy for the region or city in general (VRDP Feasibility Report, 7 May 2016, pg 67).

" As disturbing is the shift in one's perception and relationships to natural systems in our cities, equally so is our response to such systems" (Rao 2012).

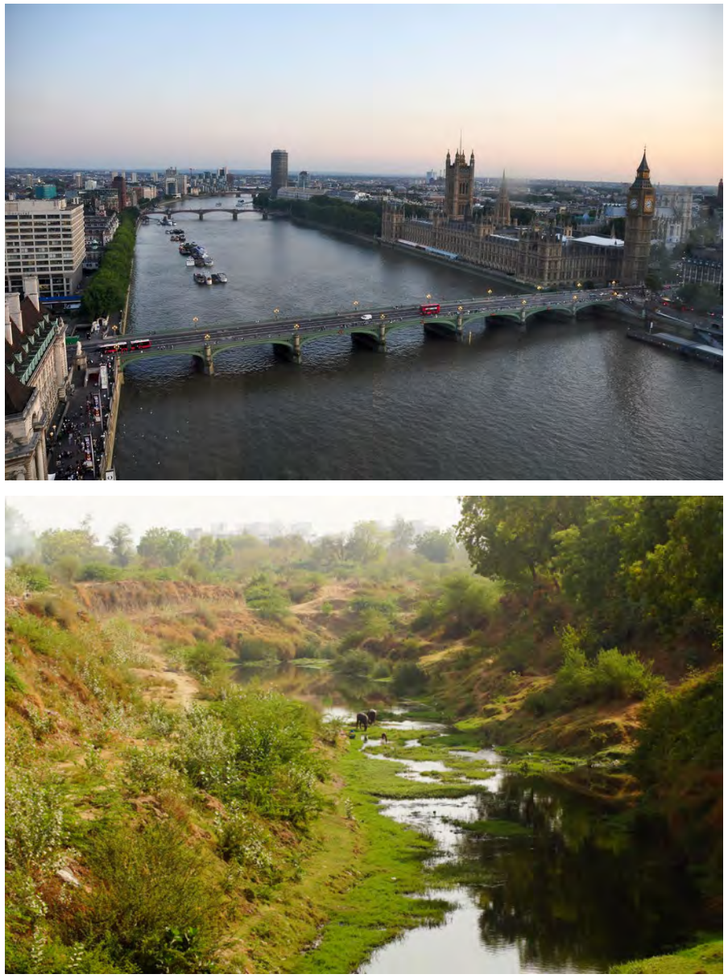
23 INAPPROPRIATE PRECEDENTS FOR THE CONTEXT

Riverfront project attracts development. (Photo: Rubin Sagar)

We feel that the Vishwamitri Riverfront Development Project is an offshoot the regional trend in India, of economizing landscapes. Similar to SRDP, it is an effort to create an investment friendly image for Vadodara by portraying it as a "world -class" city (Follmann 2015). The riverfront project is promoted as a proposal that will improve the quality and life of the city. (VRDP Feasibility Report, 21 October 2014, pg 03). To achieve this, primary goals of the VRDP are to increase the flood carrying capacity of the river, make the river clean and pollution free, enhance the river's natural and ecological assets, retain and replenish water, generate revenue through commercial development and improve connectivity and accessibility to the river, (VRDP Feasibility Report, 21 October 2014, pg 11) Unfortunately, the conceptualized designs to meet these goals are rooted in and drawn from distant cultures and climates. They impose on the river an aesthetic that is not contextual both in terms of time and space.

In each detailed section that elaborates the mechanisms to achieve the goals, the proposal refers to a number of precedents that the design idea is inspired from. Though these precedents are exemplary in terms of their functioning in their relevant contexts, the intent to use them to base interventions in the context of the Vishwamitri river is questionable and in certain cases detrimental to the health of the river ecosystem. For instance, in the river hydrology and hydraulics section of the feasibility report, a number of precedents showing barrages that retain water in river systems like the Thames barrier in London, the Marina barrage in Singapore, the Gomti in Lucknow, are shown. While we criticize the idea of water retention in a seasonal river like Vishwamitri (see section 6: River Replenishment and Water Retention), it is important to note the size scale and nature of the river systems that have been used as precedents in this section. The precedents are river systems that have much larger river sections and lengths than the Vishwamitri river. Unlike the sinuous meandering channel of the Vishwamitri, these river systems have fairly linear profiles or broader meanders. River systems like the Thames are snow fed rivers unlike the Vishwamitri, which is a monsoon river that remains partially dry for most of the year. It is disturbing to see this idea of an aesthetic that alters the river's very being.

In the objectives section of the feasibility report for the VRDP (VRDP Feasibility Report, 21 October 2014, pg 83 - 90) a number of precedents have been cited to set examples of ways to achieve the set objectives. To achieve increased flood carrying capacity, precedents of vegetation removal and streamlining of the channel have been shown. (VRDP Feasibility Report, 21 October 2014, pg 84). The destruction of the river system ecology through implementation of these methods has been discussed in detail in the section (see section 2: Riparian Vegetation and Flooding). The precedents shown for creating a safe habitat for crocodiles are designs where the crocodiles have been confined to zoos or parks like in Chennai and St Augustine in Florida. Instead of celebrating the uniqueness of coexistence the ecological setting of Vishwamitri offers, most of these design ideas destroy this characteristic and promote the creation of a completely new landscape by redrawing the entire geography of the river system.



Thames River in London, UK (top) and Vishwamitri (bottom), two charming rivers with distinctively different characteristics. (Photo: Rubin Sagar)

CONCLUSION

If the VRDP seeks to "rejuvenate the ecology of the Vishwamitri River, enhance the cultural importance of the city, restore the connection of the river with the people, and address the future needs of the city" (VRDP Feasibility Report, 7 May 2016, pg 23), it must take a wider perspective of Vishwamitri. The VRDP's promotion of development does not promote the well-being of the river system as understood by widely researched ecological understanding or global experience with urban rivers. If the VRDP were to be implemented, it would not only be disastrous for the river's future, but a true loss of an opportunity for Vadodara to form a unique, innovative identity among cities in the region. That said, It is our hope that our critique both acknowledges and reveals that, at the heart of the VRDP, lie a number of worthwhile goals, such as flood mitigation, increasing the safety and well-being of city residents. These goals cannot and may not be achieved by the VRDP as currently designed.

This critique is a starting point for alternative design. To see what our team has come up with, please see the Design Report in Appendix 2.

Bird eye view of Vadodara and the Vishwamitri River. (Source: Vishwamitri River Project Website)

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A River and its Reign

APPENDIX 2
DESIGN REPORT

TABLE OF CONTENT

INTRODUCTION

Life-giving, complex, dynamic--rivers have long been the impetus for settlement and growth of cities. Embedded into the social fabric of many communities, rivers are often focal points of cultural celebrations, daily needs, stories, and legends (Rao 2012). Historically, issues such as flooding, water quality degradation, and human-wildlife conflict related to urban growth have lead cities to restructure the hydrology of urban watersheds. This restructuring occurs through channelization, development of efficiently-drained impervious surfaces, and construction of gray infrastructure[1] that directs runoff from the wider urban catchment into urban rivers (Walsh et al 2005). These conventional engineering approaches exchange infiltration and vegetated riverbanks for efficient underground drainage systems and concretized channels, fundamentally ignoring the complex watershed dynamics, ecology, and heritage.

This pattern holds true for the relationship between the City of Vadodara and the Vishwamitri River. As the city and the river fight for space, identity, and health, the river's edge becomes disputed territory. While the need for a solution to the problems of Vishwamitri is clear, the solution is not. The Vishwamitri Riverfront Development Project (VRDP) proposed by the Vadodara Municipal Corporation (VMC) in 2014 takes a conventional approach to symptoms of the "urban stream syndrome"[2] evident along the river corridor. However, it neglects opportunities for complementary dynamism that allows the river and city to thrive simultaneously. With Vadodara's uncommon cultural and natural heritage, we believe the VMC should not accept a common approach to riverfront development. It is time to imagine a more dynamic approach.

Our detailed examination of the Vishwamitri Riverfront Development Plan (VRDP) reveals the ecological and cultural inadequacies of the government's proposed future for Vishwamitri (see Appendix I: Critique). The foundation of the alternative design concept presented in this report was one of our overarching criticisms: the inadequacy of the VRDP's project boundary, called the "Influence Zone". Indeed, it is impossible for the VRDP to meet its flood mitigation and water quality goals within this narrow corridor alone. Therefore, to offer a compelling alternative for the Influence Zone, we first made recommendations for the wider watershed.

Our alternative concept relies on the use of multifunctional green infrastructure (GI)[3] throughout the watershed to address the causes, rather than the symptoms, of the urban stream syndrome. Focusing on green infrastructure allows us to design for the health and wellbeing of people and the river ecosystem in the same space. Rather than claiming the disputed territory of the

[1] Gray infrastructure refers to the city drainage system, both for sewage and stormwater runoff. In Vadodara, stormwater and sewage enter the river via several outfalls along the river channel, though some sewage does enter the river after being treated at sewage treatment plants (STPs). This increases the volume of water in the channel compared to a pre-development landscape which would retain and infiltrate water naturally.

[2] The urban stream syndrome describes the consistently observed ecological degradation of streams draining to urban land, including flashier flows, elevated concentrations of nutrients and contaminants, altered channel morphology and stability, and reduced biodiversity, all of which are noticeable in the Vishwamitri River (Walsh et al., 2005).

[3] According to the U.S. EPA "Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits. While single-purpose gray stormwater infrastructure—conventional piped drainage and water treatment systems—is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits." (United States Environmental Protection Agency 2016)

riverbank for the city, we envision a riverfront where the city and river mutually protect, support, and celebrate each other. In this vision, the unique cultural and natural heritage of the City of Vadodara and Vishwamitri are on display, attracting visitors and new residents to this unique hub of ecological design, place-making, and regionally rare urban wildlife experiences. To accomplish this, we propose green infrastructure-based interventions at three scales:

1. The Watershed Scale, where we respond to the hydrological and ecological impacts of land use changes in the upper watershed on Vadodara. Interventions at this scale aim to reduce the volume and velocity of water and sediment flowing into the city.

2. The City Scale, where we propose an urban stormwater management framework that prioritizes multifunctional green infrastructure projects citywide. Adopting this framework will reduce the impact of urban development on the river channel and expand the benefits of public greenspace creation throughout the city.

3. Influence Zone takes advantage of the cumulative impacts of interventions at the previous two scales to create a truly unique regional asset in the riverfront. Our approach is inherently river-centric, using that focus as a platform to increase safety, ecological health, well-being, and place-making. Our green infrastructure approach here fits into our city-scale stormwater management framework.

Our alternative design concept is reinforced by our collective expertise in ecology, conservation, and landscape architecture. We further cement this with policy recommendations to enhance and support the broader objectives. Through this cohesive alternative design concept, we offer a vision for Vishwamitri beyond anything the VRDP has to offer.

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UPPER WATERSHED:
Expanding boundaries of understanding

View Upstream at Source
Pavagadh Hills, 2016

Origin of the Vishwamitri River at
Dudhia Talav - Pavagadh Hills, 2016

Vishwamitri, like most urban rivers, is impaired. The cumulative impacts of land use changes in the wider, especially the upper watershed and the city disrupt the integrated structure defining the river system. From agriculture to urban development, altered flow dynamics and vegetation patterns disrupt the complex ecological and social dynamism of the Vishwamitri, both within Vadodara and beyond. While the VRDP lists goals such as mitigating flooding, increasing groundwater recharge and preserving the biodiversity of the river, we recognize that the effectiveness of any project along the Vishwamitri within Vadodara is constrained by the future of the upper watershed. Therefore, to promote the integrity of the Vishwamitri River effectively, we must widen both the VRDP's physical boundary as well as its conceptual boundaries of understanding. In an attempt to respond to the Vishwamitri's "urban stream syndrome" (Walsh 2005), the VRDP works to treat symptoms of stream degradation in the river channel itself, rather than the drivers of degradation in the wider watershed (Vietz 2016).

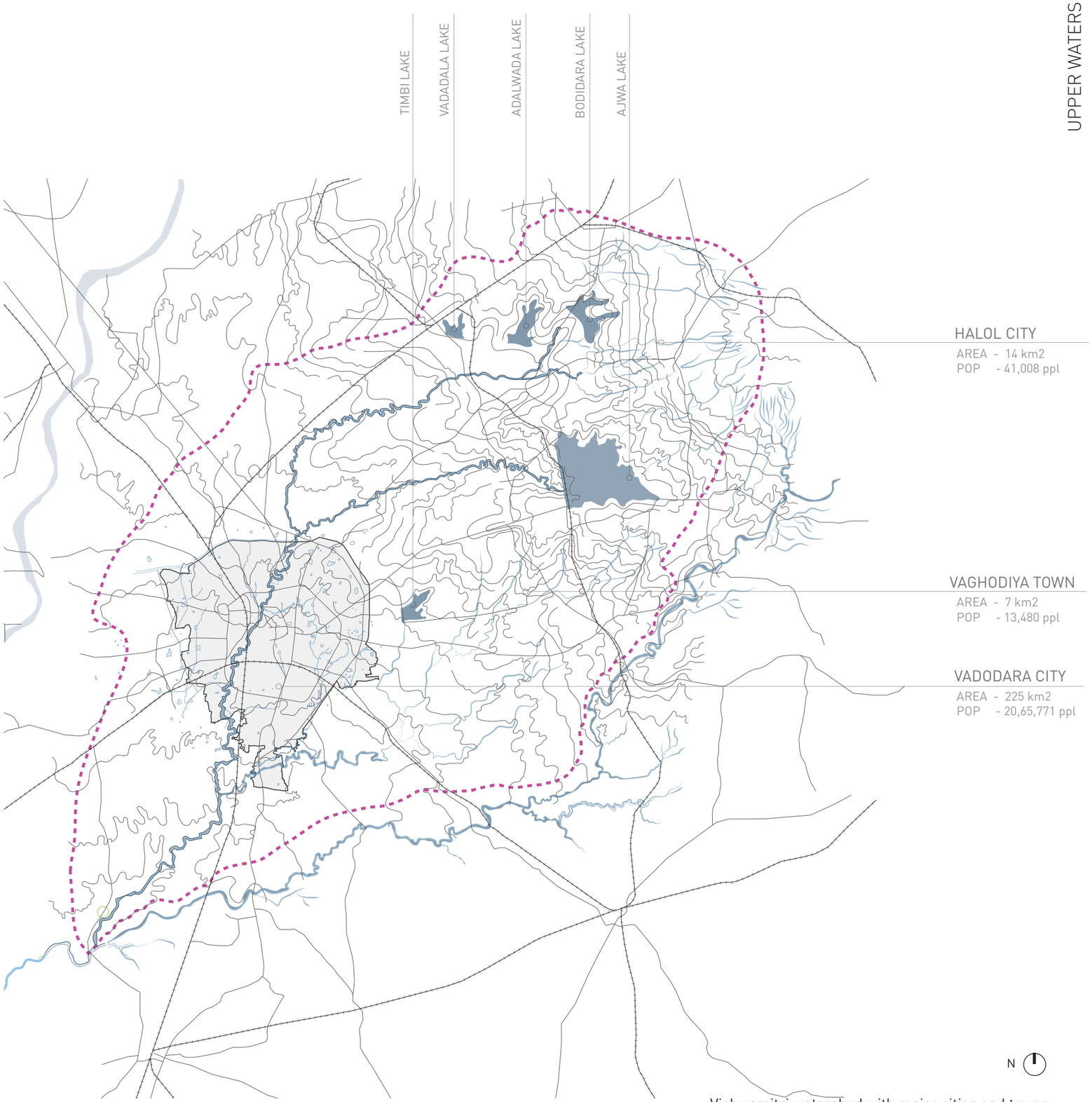
[1] All of these publications describe the benefits of a watershed approach to urban river issues. See critique for more details.

While the VRDP takes a conventional approach to these issues (Vietz 2016, Walsh 2005, Forman 2014), current knowledge of river systems offers a compelling opportunity for more complex, ecologically-sensitive design that more effectively addresses the original goals set out by the VRDP. By recognizing the urban river corridor as part of a wider catchment system with a focus on the hydrological processes and associated structure operating across scales, it is possible to address the root causes of degradation within the city (Vietz 2016, Walsh 2005, Hill 2009, France 2006)[1]. The upper watershed is a crucial component of strategic management and protection of the Vishwamitri Watershed.

This section of the Design Report offers a cohesive set of design interventions for the upper watershed. First, we establish the interdependence of Vadodara and the upper watershed region. Next, we outline land-use changes and practices in the upper watershed that have influenced the Vishwamitri River over time. Then, we suggest how these changes outside of city limits impact the city of Vadodara based on scientific understanding of watershed dynamics.

Our conceptual design strategy and policy recommendations respond to these specific land-use changes, making a case for the city's investment in precautionary design and collaborative stewardship of the upper watershed. Our recommendations focus on green infrastructure (described in the introduction to this report) rather than hard engineering, an approach that will require interdisciplinary collaboration and site-specific detail to be successful. The conceptual nature of our proposal is directly related to the quality of our data. We are limited to satellite imagery and low-resolution digital elevation models (DEMs) obtained from Google Earth and Bhuvan[1], on-site visits, and discussions with stakeholders. The content presented here needs site-specific understanding and further research on watershed dynamics before it is implemented, further emphasizing another critique of the VRDP, that there has not been enough analysis of the river system to make such widespread, largely irreversible changes to its structure and function.

Finally, we address the broader setbacks in the existing framework that limit effective implementation and monitoring of our design goals. As part of a comprehensive watershed management strategy, we suggest policy additions to the government's framework. We strongly recommend the chartering of a Vishwamitri River Watershed Council, an independent, collaborative hub organization that can advise the government, developers, and city residents on issues related to the river. We use these interventions as a starting point for discussion of Vishwamitri's future.



Vishwamitri watershed with major cities and towns

[1] These publications describe the benefits of a watershed-based approach to urban river issues. See critique for a more detailed discussion.
[2] Bhuvan is the geoportal of the Indian Space Research Organization (ISRO) from which we obtained spatial data for the region.

View Upstream at Source
Pavagadh Hills, 2016 as seen while
driving along road to Champaner

View Upstream at Source
Pavagadh Hills, 2016

LOCATION OF UPPER WATERSHED

The upper watershed stretches from the Pavagadh Hills to National Highway 8, located on the edge of the VMC administrative boundary of Vadodara. The region holds villages, agricultural lands, and the protected Pavagadh Hills, an important recreation and pilgrimage site for residents of Vadodara and the wider region.

P1


Historical Painting Pavagadh 18808 AD


Pavagadh hills and the fields

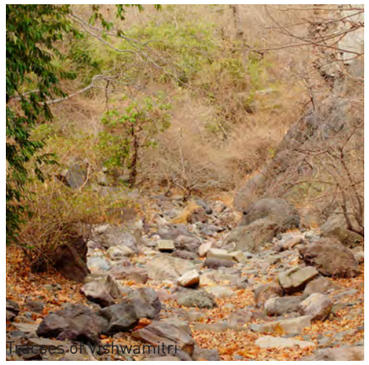

Scars of the flow of water


Where Vishwamitri descends


The abode of leopards


Protected forests


Forests in the summer


Terraces of Vishwamitri


Vishwamitri and its depositions of rocks


Forested buffer


Agriculture


Fishing amongst crocodiles at Ajwa

ECOLOGICAL AND HYDTOLOGIC CONTEXT

The Vishwamitri begins in the Pavagadh Hills approximately 820 meters (2690 feet) above sea level.The dry, deciduous forest of Pavagadh oscillates between drought and inundation, as the seasonal monsoon transforms the ecosystem from June to September[3]. The hills are home to a variety of flora and fauna including the Indian leopard (*Panthera pardus fusca*), sloth bear (*Melursus ursinus*), Indian python (*Python molurus)*, nilgai (*Boselaphus tragocamelus*), black eagle (*Ictinaetus malayensis*)(Trivedi and Soni 2006).The absence of intensive domestic usage of the river (such as bathing, open defecation, washing clothes and waste dumping) as well as the absence of untreated sewage, suggests higher water quality in this area of the watershed (Deshkar et al. 2014).

From the Pavagadh Hills, the main branch of the Vishwamitri River funnels into Ajwa Lake, Vadodara's water supply. The man-made dam at Ajwa regulates flow into Vadodara. To the northwest of Ajwa, the Surya River flows from Pavagadh, meeting in confluence with the main branch of the Vishwamitri River in Dena village, a few kilometers north of Vadodara. Therefore, while the volume of water entering Vadodara from the upper watershed is regulated in part by Ajwa Dam, a great volume bypasses this engineered control. For this reason, any flood mitigation efforts must take a comprehensive approach which recognizes the complexity of the watershed.

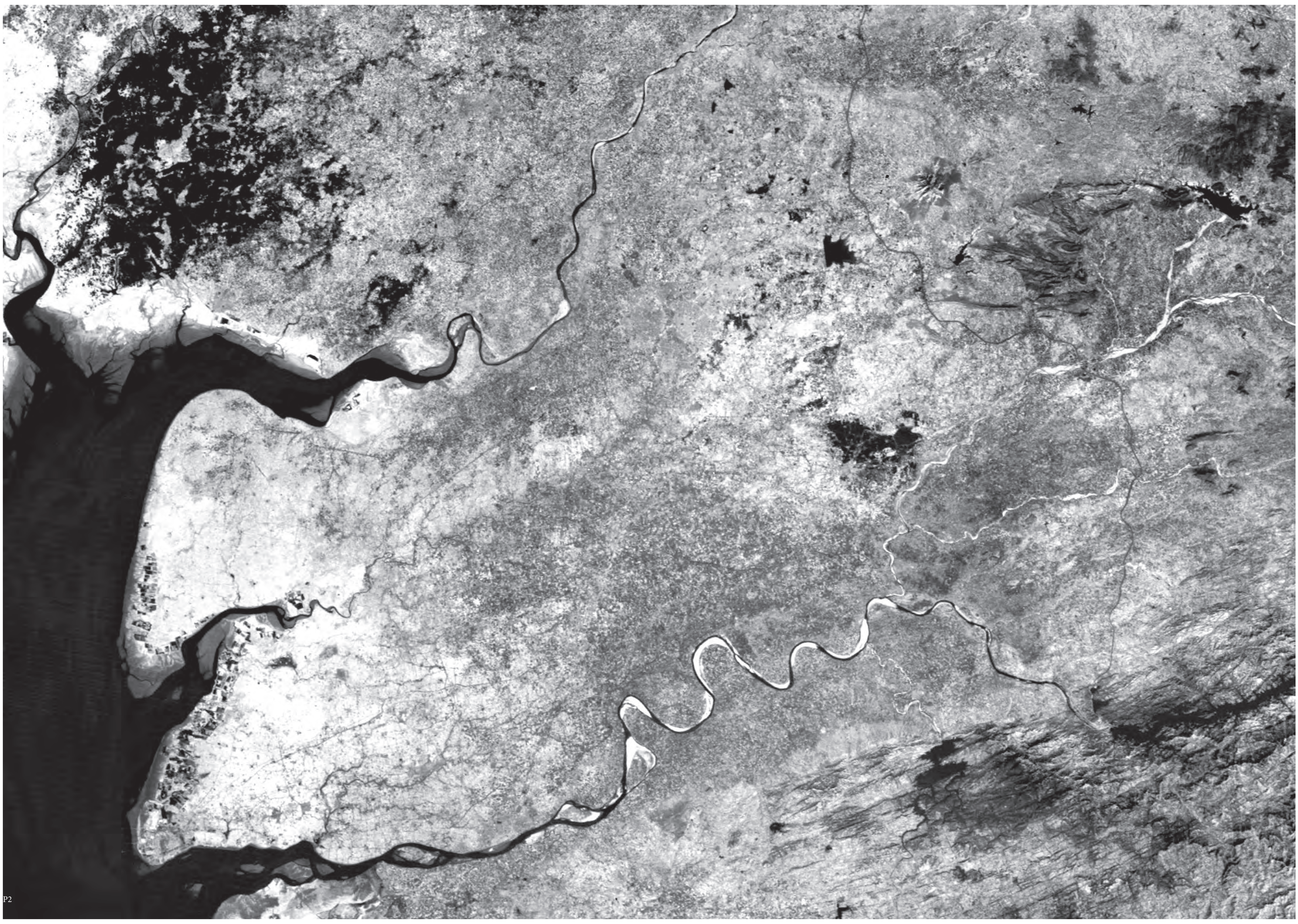
[3] The average annual rainfall from 2000-2012 was 29.69cm (World Weather Online).

[4] Grey infrastructure refers to the city drainage system, both for sewage and stormwater runoff. In Vadodara, stormwater and sewage enter the river via several outfalls along the river channel, though some sewage does enter the river after being treated at sewage treatment plants (STPs).

[3] Personal communications with Dr. Raju Vyas and the dam management personnel revealed the presence of a dense population of crocodiles in the Ajwa reservoir. According to them, the crocodiles were first brought in a few decades ago by the then Maharaja of Baroda as pets, who then released them into the reservoir. Each monsoon, the floodgates are opened to release the excess water along with some crocodiles which enter city limits.

INTERCONNECTED: The upper watershed and Vadodara

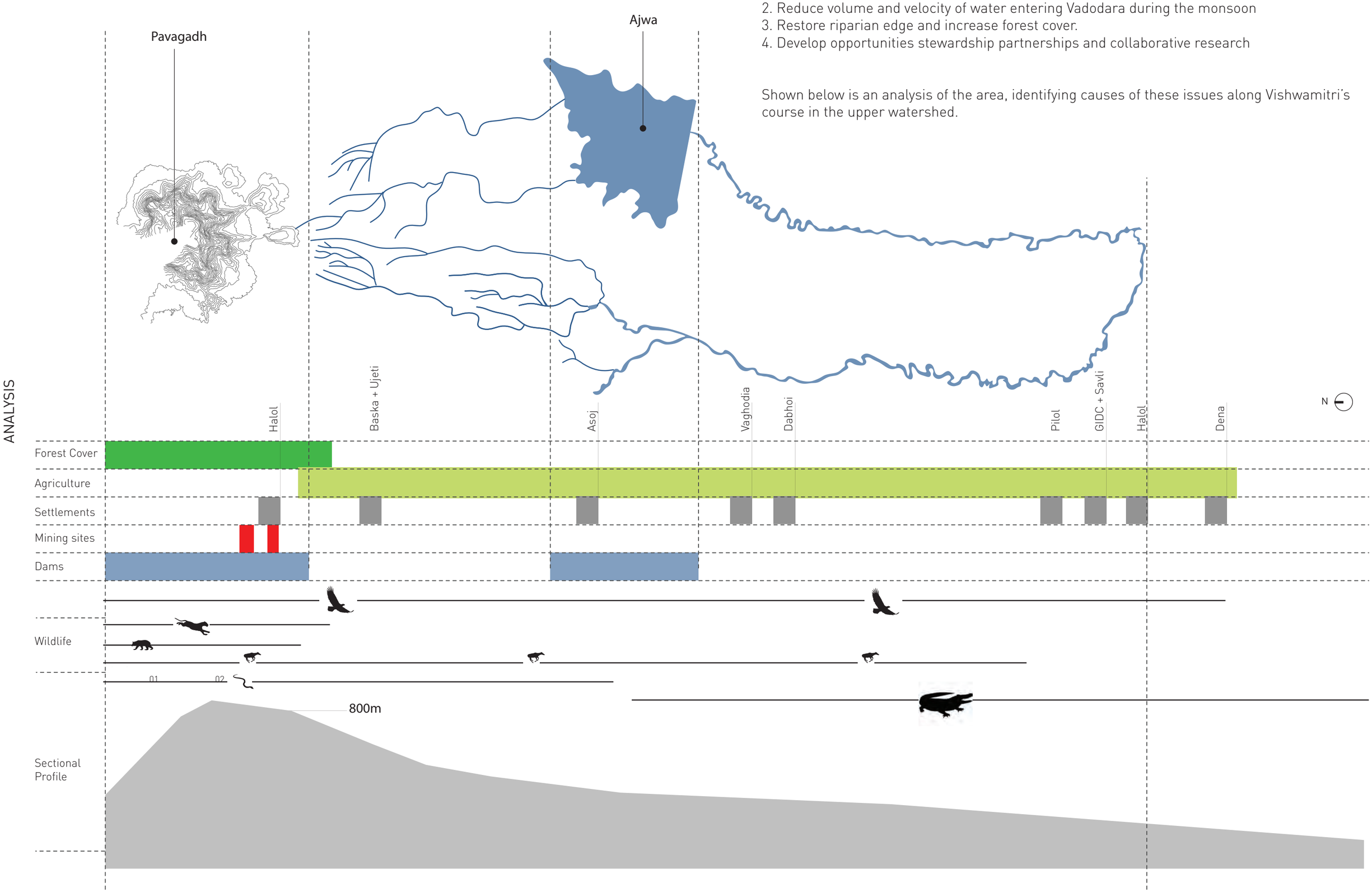
The city of Vadodara experiences frequent flooding during the monsoon season, poor water quality, and occasionally deadly human-wildlife conflict. While these issues can be largely attributed to urban impervious development, the encroachment of the floodplain, and the introduction of urban runoff into the river channel through gray infrastructure[4] within the city (Walsh 2005, Vietz 2016, Hill 2009). However, land use changes in the upper watershed can also alter the hydrologic functions of the watershed as a whole. For example, the conversion of forest land for agriculture in the upper watershed decreases evapotranspiration and groundwater recharge, as there are fewer large trees and plants do not have time to dig deep into the soil to promote infiltration. The heavy seasonal rainfall and reduced forest cover likely increases erosion along the course of the river above Ajwa, leading to sedimentation within the reservoir that reduces its capacity for storing runoff and drinking water. In addition to a loss of forest cover due to agriculture, deforestation in the Pavagadh Hills, mining operations near Pavagadh, increased urbanization in the upper watershed, and the high-velocity pulse of water overflowing Ajwa Dam in the monsoon contribute to water quality, flooding issues, and human-wildlife conflict in Vadodara. It is thus apparent that consumption patterns in the upper watershed are directly linked to the issues downstream, and cannot be ignored. However, the VRDP misses out on key opportunities to reduce the volume of water entering the city by failing to prioritize interventions in the upper reaches of the Vishwamitri watershed. As a first step toward flood mitigation, the VRDP should recognize that the city is not isolated, but interconnected, to the wider watershed.



GOALS OF UPPER WATERSHED INTERVENTIONS

1. Reduce sediment load entering Vadodara
2. Reduce volume and velocity of water entering Vadodara during the monsoon
3. Restore riparian edge and increase forest cover.
4. Develop opportunities stewardship partnerships and collaborative research

Shown below is an analysis of the area, identifying causes of these issues along Vishwamitri's course in the upper watershed.



LANDCOVER CHANGES AND PRACTICES IN THE UPPERWATERSHED

LOSS OF FOREST COVER

AGRICULTURE

URBANIZATION

AJWA DAM

UPPER WATERSHED

FOREST COVER

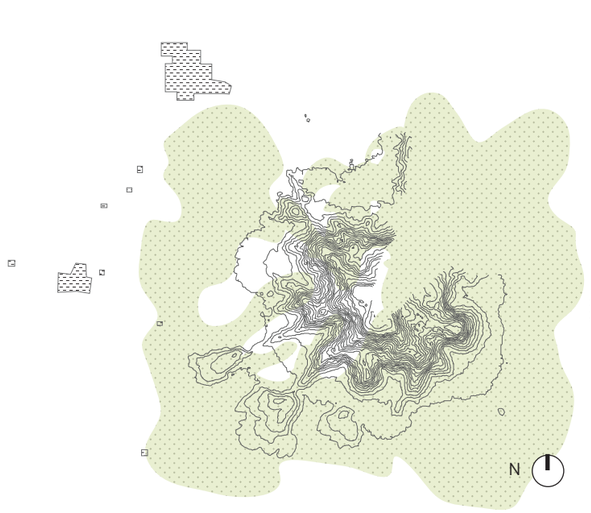
Forest cover in the upper watershed is majorly confined to the Pavagadh Hills. Within Pavagadh, comparisons between historical and current imagery (right) show an incredible reduction in forest cover, perhaps due to mining and fuelwood and building pole harvesting. Deforestation significantly increases erosion within Pavagadh, and in the river channel itself, due to increased volume and velocity of water moving through the landscape. This is evident particularly in the steep slopes of Pavagadh.

Moreover, the Pavagadh Hills are frequently visited by nature enthusiasts, and by the inhabitants of the Vadodara city in search for a weekend getaway. The hills are also situated close to the historic town of Champaner. The Champaner-Pavagadh archaeological park (a UNESCO heritage site) and the Champaner fort, which are of cultural and recreational importance attract the architecture students as well as tourists

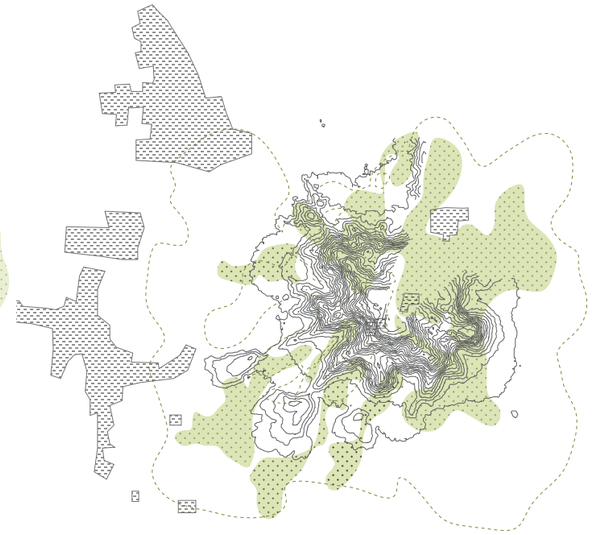
To address the above issues, we suggest strategic restoration and reforestation initiatives within Pavagadh. Reforestation initiatives will focus on naturally stabilizing steep slopes to reduce the velocity of runoff, thus reducing sedimentation downstream. There may be opportunities for collaborative projects, such as pre and post-monitoring of restoration sites in collaboration with the Forest Department and professors of botany from Maharaja Sayajirao University in Vadodara (MSU). Collaboration with the university brings forth a win-win situation since the scientific approach of monitoring the vegetation is beneficial for students as well as for the Additionally, projects that creatively consider how to stabilize the hills and provide for the needs of residents gathering fuelwood or building poles should be prioritized.

All restoration initiatives should include only species native to Pavagadh. Native species are better adapted to their native habitat and promote biodiversity in other aspects of the ecosystem (Butterfield 1995). While some reforestation initiatives default to fast-growing exotics such as eucalyptus, one study in a similar forest type with the same invasive species (*Prosopis spp.*) suggests that native species provide a greater variety of ecosystem services to those who rely on them for livelihoods (Shackleton et al 2015). Additionally, native species tend to be embedded in local culture in meaningful ways (*Tamarindus indica*, for example, is a common kitchen ingredient in most households). Some species which thrive in Pavagadh include Kadamb (*Mitragyna parviflora*), Aakdo (*Asclepias gigantea*), Shimlo (*Bombax malabaricum*) and Imli (*Tamarindus indica*) (Chavan & Oza 1966). Many native tree species are grown at the Forest Department managed nurseries in Vadodara, and local experts well-versed in botany and plant ecology make this goal feasible. For reducing erosion specifically, traditional methods of earthen check dams at suitable locations could slow down water moving downstream. Gulley plugs for water gathering slopes, jute lining, and seeding for water spreading slopes could be efficient methods of stabilization

The benefits of restoring the vegetation in Pavagadh are: slowing and storing runoff, increased infiltration and groundwater recharge, creating terrestrial habitats, storage of water, climate change mitigation, storage of carbon, recreational opportunities and flood risk reduction [nwrm.eu].
In addition to reforestation in Pavagadh, reforestation in the agricultural areas can add additional benefits for water retention in the upper watershed.



Settlements and Forest Cover - 1984
(as estimated from Google satellite images)



Settlements and Forest Cover 2016
(as estimated from Google satellite images)

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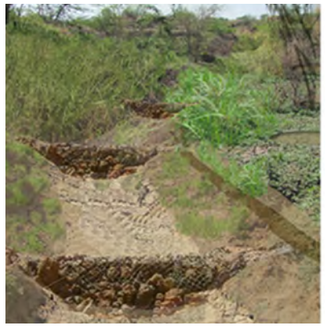
INVASIVE SPECIES

WATER GATHERING SLOPES



GULLEY PLUGS

TOP OF THE HILLS

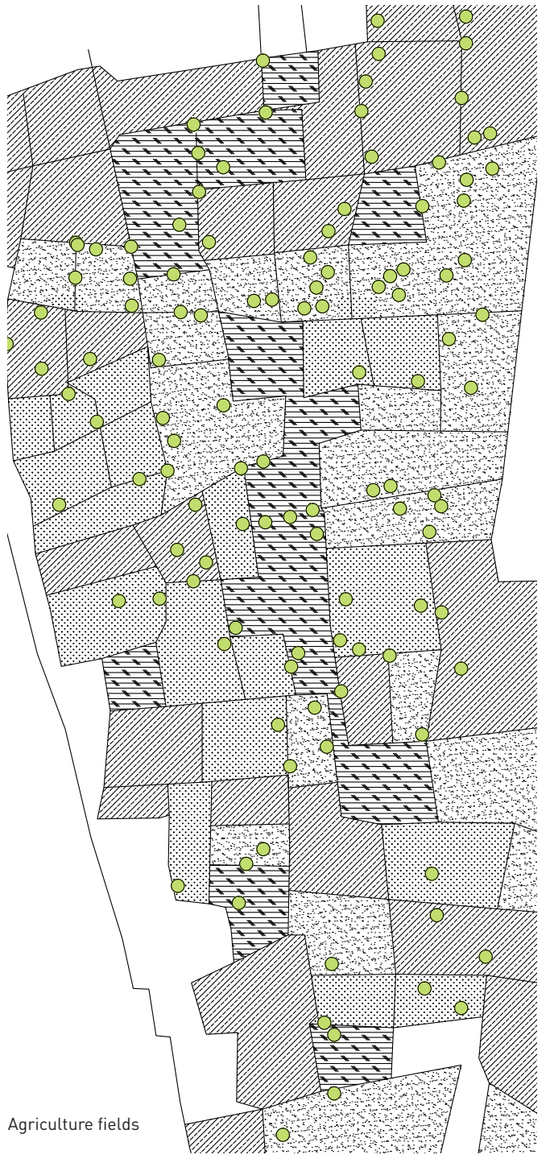
WATER SPREADING SLOPES

JUTE LINING AND SEEDING

AGRICULTURE

As an economic driver, the agriculture in Vadodara is a key concern related to water management of the Vishwamitri River. The presence of the Narmada Canal and the tributaries of Vishwamitri provide ample sources of irrigation for agriculture in the upper watershed. With an area of 526,100 hectares sown in 2007-2008, Vadodara district stands third in terms of agricultural area in Gujarat. This area has gradually increased from 509,200 hectares in 2003-2004 (Directorate of Economics and Statistics, Government of Gujarat, Irrigation in Gujarat 2008-2009 and 2011-2012). However, leading agricultural economists and water management experts suggest that improved agricultural yields in Gujarat, have little to do with irrigation provided by the canals but rather to the Sardar Patel Sahakari Jal Sanchaya Yojana. This program is a water conservation scheme through which more than 500,000 rainwater harvesting structures like percolation ponds and check dams were built in Gujarat (unclear how many were constructed in the Vishwamitri River Watershed). Studies suggest that the success of agriculture in Gujarat is founded on these groundwater irrigation techniques (Sharma 2014).

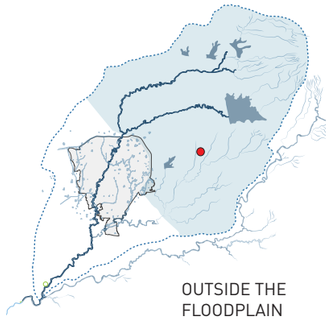
Regarding irrigation, the Indian government determined that the power to manage water operations is possible through both Article 48[5] of the Constitution and the Water (Prevention and Control of Pollution) Act, 1974 (Agarwal 2005). The law mandates broad "central" and "state" control boards, which establish governing provisions for water quality standards, research, planning and investigations. Given the studied condition in Gujarat of agricultural water management, the possibility to create a rainwater harvesting program similar to Sardar Patel Sahakari Jal Sanchaya Yojana is in the power of control board. Decisions about how water management cases actually operate occur through the board's power to regulate.
Amendments to the Water Act further empowered states to issue "directions," which empower regulators to rule on the operations and processes the management of water supplies (Pant, 2003). If the water management

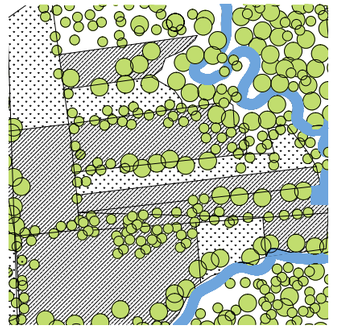


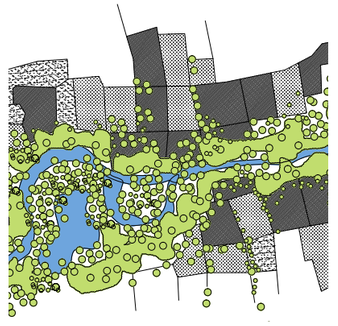
Agriculture fields

of canals does not improve agricultural yields, as demonstrated through study of rainfall harvesting structures, both citizens and the state control board can raise this issue under the Water Act's provisions to facilitate newer management practices.[6]

Such water retention and temporary detention practices, if strategically expanded in the Vishwamitri watershed, could not only help the farmers increase their agricultural yield, but also increase retention in the upper watershed, again reducing the volume of water entering the Vishwamitri and its







tributaries during the monsoon. Building off of this idea, our proposal recommends expansion of traditional rainwater harvesting measures to retain, detain, or infiltrate water based on the location of the fields near the river and its tributaries.

OUTSIDE THE FLOODPLAIN: RETENTION + INFILTRATION

1. Khet talavadis
Historically, in the absence of canals and modern techniques of irrigation, farmers used in-field practices such as surface storage of water to maximize the use of rainwater. This technique is locally known as khet talavdi (literal translation: "field ponds").

This technique can have multiple benefits. The retention of rainwater within the upper reaches of the water reduces the peak flow of the river, while serving to irrigate fields without major infrastructural investments. In terms of wildlife, khet talavdis provide breeding habitat for the Sarus crane (Antigone antigone) (Mukherjee et al. 2002). This species is native to Gujarat and is classified vulnerable by the IUCN.

Agriculture fields at the foothills of Pavagadh

P12

Season - Monsoon

2. Hedges and tree rows along field margins:
Trees, shrubs, and grasses along field margins can help to slow runoff and increase infiltration by breaking up the soil and taking up water. Vegetation increases the habitat value of the agricultural matrix for birds and insects. This vegetation also provides shade on hot days.

INSIDE THE FLOODPLAIN: CHANNEL ENHANCEMENT + TEMPORARY STORAGE

1. Canopied riparian buffers:
Dense, diverse vegetation along the stream edge along the course of the river would increase the habitat value of the river as an important travel corridor for wildlife throughout the region. Additionally, the trees help stabilize the banks of the river from unnatural rates of erosion caused by increased water volume and its associated velocity (Trivedi & Soni 2006). Particularly in agricultural landscapes where fertilizer may be used, "well-designed, located and managed forestry can reduce the volume of sediment, nutrients and salt volumes transported into river systems" (van Dijk et al. 2007), thus increasing the overall water quality of the Vishwamitri.
2. Preservation of ox-bow lakes:
Throughout the upper watershed, prioritizing the preservation of oxbow lakes in agricultural fields near the river channel increases the off-channel storage capacity of the floodplain, reducing the peak flow in the river channel and, through time, within the city.

The above measures are conceptual examples of the measures that can be used to retain as much water in the agricultural areas of the watershed as possible. These have been recommended based on their success in watershed management programs within the country and their traditional use in the region, especially in arid and semi-arid regions.The main strategy was to detain and exploit all available sources of water, especially rainfall, and maximise the availability of moisture for the soil (Smyle et al 2014). The implementation of these practices should be based on community engagement and detailed site analysis. It is also important to note that current development rates (as mentioned in the next section) suggest that these areas will not remain agricultural forever.

[5]Article 48: "The State shall endeavour to organize agriculture and animal husbandry on modern and scientific lines..."; and Article 48-A: "Protection and improvement of environment and safeguarding of forests and wildlife: The State shall endeavour to protect and improve

[6]A subsequent provision empowers citizens, not just agriculture or water management experts, to take management actions (through legal cases).

INCREASED URBANIZATION

Looking beyond currently visible land use changes, our strategic look at the upper watershed keeps an eye on the future. As villages and cities in the upper watershed expand, landcover will change, altering flow dynamics and causing more widespread symptoms of the urban stream syndrome and further fragmentation of the river corridor habitat. With a preemptive look toward growth, a regional watershed plan can anticipate and respond to these issues in advance.

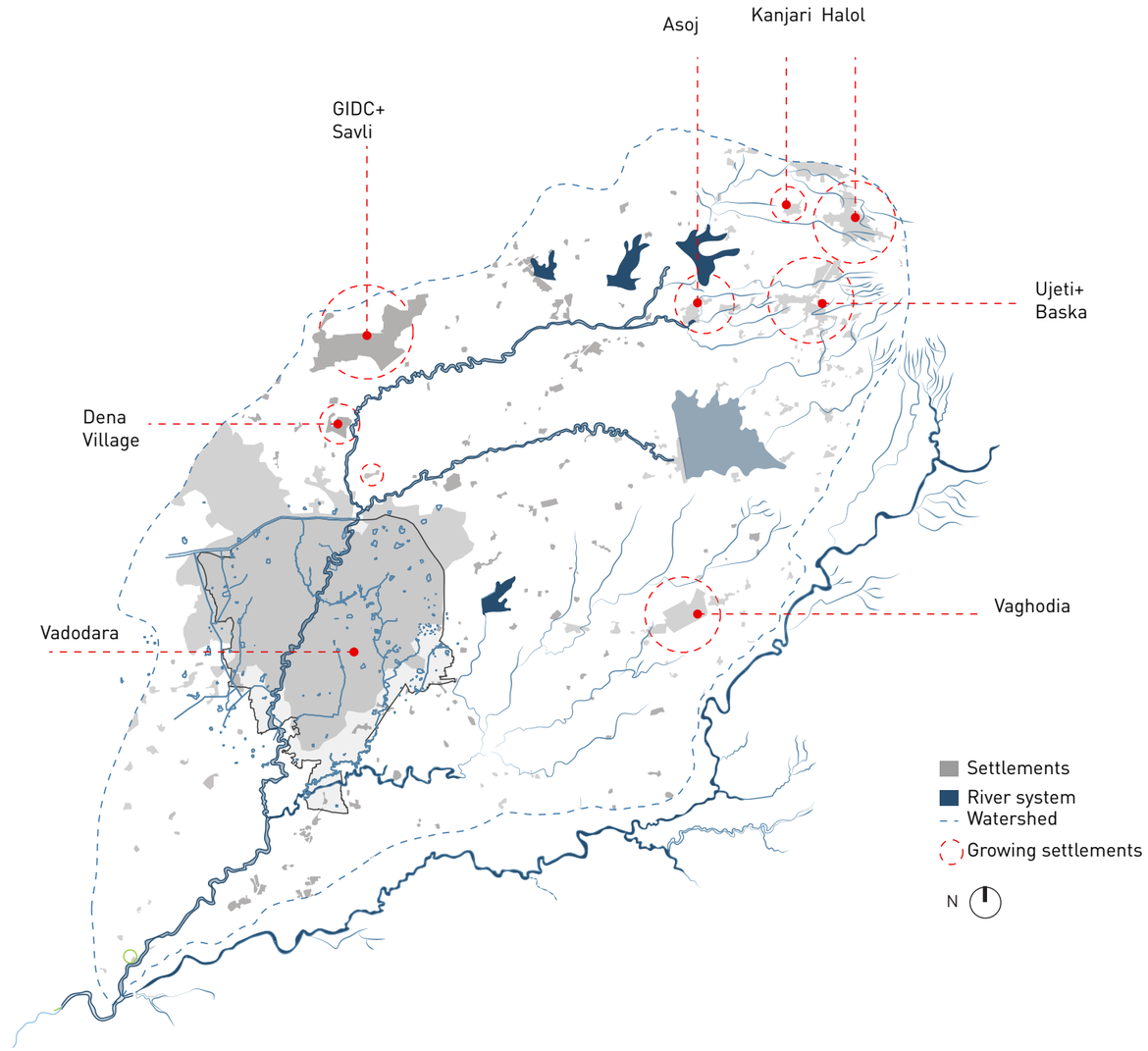
Urban growth in the upper watershed is clearly visible from Google Earth imagery. Dena village, for example, located about 4 km from Harni, has grown substantially in the past decade. Savli, a major taluka (district) located immediately north of Vadodara covering an area of 820 ha (GIDC), is one of Gujarat's primary industrial districts due to the establishment of Gujarat Industrial Development Corporation (GIDC) in 1962. Similarly, Asoj, a small town upstream Vishwamitri has also seen a boom in industries.

In the future, it is likely for an expansion in industrial land use as well as a growth in the population of the towns mainly due to the migration of people from rural areas in search of employment opportunities. In a statement by a GIDC official, the GIDC grounds are destined to expand to over a 1000 ha in the near future. Moreover, Savli has also been recognized as a location for a Special Economic Zone (SEZ), and a 280 ha "Biotechnology Park" (business center) which has already received clearance from the Ministry of Environment and Forests (GIDC, Estate Details Districtwise).

The increase in industries is accompanied with an increase in population as well. Per official government reports, the two most important towns in the upper watershed region of Vishwamitri, Savli and Halol, have increased in population by 7% and 22%, respectively, in the last ten years (Directorate of Economics and Statistics, Irrigation in Gujarat 2008-2009). In addition to housing schemes, educational institutions have been established (such as the Delhi Public School and a Management Institute), further adding to the complexity of the urban mosaic.

Under the assumption that the upper regions of the Vishwamitri watershed will urbanize in the coming decades, it is important to make preemptive moves to protect the river, both as a natural resource and a cultural space. Urbanization has and will continue to lead to more complicated networks of gray infrastructure and impervious surface unless someone with an eye to the future takes advantage of the opportunity for a different model of development (Hill 2009, Walsh 2005).

It is with this in mind that we direct you to the City Scale section of the Design Report, where we describe a framework for urban stormwater management that prioritizes specific hydrologic functions in specific areas of the watershed through the installation of green infrastructure. If Vadodara picks of the banner of green infrastructure and sets an example for other cities in the watershed, it is possible that cities in the upper watershed will see the benefits and prioritize development through green infrastructure. In this way, development in Vadodara sets a precedent for future development in the watershed. Additionally, Vadodara will be directly impacted by the development pattern of upstream communities. If those cities develop with the same level of impervious as Vadodara currently has, it is hard to imagine that any of the VRDP's engineering calculations will be sufficient to manage the runoff generated upstream.
communities, including Vadodara.



AJWA DAM

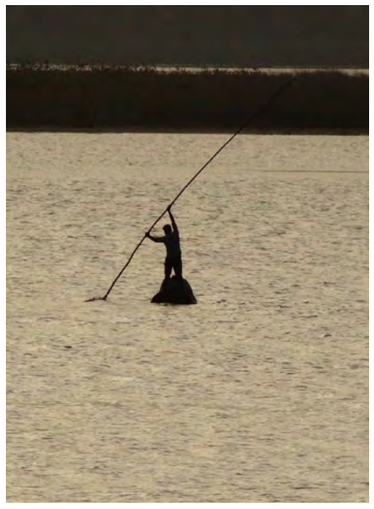
Before reaching Vadodara, much of the water from Pavagadh passes through Ajwa Lake, the drinking supply for Vadodara. Each monsoon season, water overflows the dam from Ajwa Lake toward Vadodara, destabilizing the banks adjacent to the dam and flushing sediment downstream. Sediment is a key concern because contaminants bind to sediment, decreasing water quality and leading to embeddedness--a reduction of microhabitats for microfauna due to sedimentation in spaces between rocks in the river.

The effects of erosion are clear in satellite imagery. On the top right, water overflowing the dam during the monsoon leaves a clear pattern of erosion. On the ground (below aerial image), the bare earth is scoured and clear of vegetation.

It is also important to note that the reservoir is a habitat for crocodiles, which move into Vishwamitri when Ajwa overflows, adding to the already booming population within city limits[7]. Chances for human-wildlife conflict increase during floods, as crocodiles rise to higher terraces to bask, only to find themselves in the middle of a city. Although the VRDP proposes removing crocodiles from the river channel and opening the river for recreation, a watershed scale understanding of the river reveals that the solution is not that simple. The issues of flooding and human-wildlife conflict require ameliorative actions that cannot be accomplished within city limits alone.

While we do not want to inhibit migration of crocodiles or other animals in the river corridor, we do propose a simple solution to stabilize the banks at the dam gate. First, we propose that the first 45 meters after the dam gate are stabilized with rip-rap. For the first 15 meters of each riverbank, we propose a buffer of native trees that will increase the habitat quality, aesthetic quality, and stability of the riverbank. Additionally, the construction of off-channel storage within 100 meters of the dam gate will continue to alleviate the initial pressure caused by the overflow or release of water from Ajwa Lake.

P13



Erosion at Ajwa's outlet

On the Ajwa side of the dam, wetlands provide habitat during tte dry season.

[7]Personal communications with Dr. Raju Vyas and the dam management personnel revealed the presence of a dense population of crocodiles in the Ajwa reservoir. According to them, the crocodiles were first brought in a few decades ago by the then Maharaja of Baroda as pets, who then released them into the reservoir. Each monsoon, the floodgates are opened to release the excess water along with some crocodiles which enter city limits.

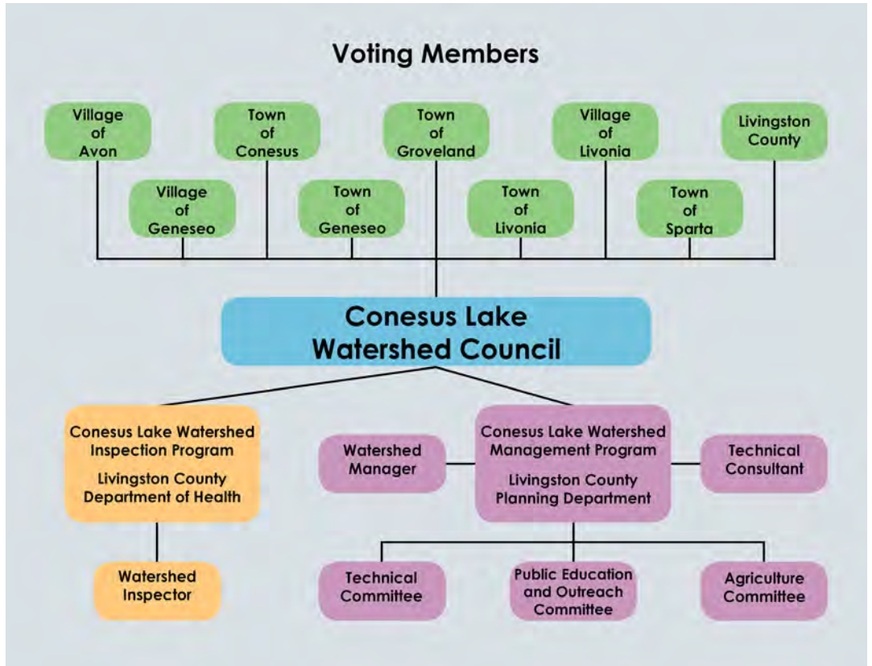
POLICY RECOMMENDATIONS TO SUPPORT THE FRAMEWORK

Our policy and organizational changes are intended to support the health of the upper watershed, and by association, Vadodara. Environmental policies designed specifically for the upper watershed will help to shape the future of human and ecological systems along the entire Vishwamitri River.

Therefore, we suggest the formation of an independent collaborative watershed council for Vishwamitri to facilitate a gradual shift away from an engineered solution. This non-governmental Watershed Council will represent both informal and formal organizations, interests groups, or local constituencies, allowing the majority of local citizens represent their own individual private and public interests (see Quesada 1999). An Upper Watershed River Council to integrate site-specific goals with local stakeholders in the Pavagadh Hills, which includes a protected area, villages, and agricultural areas. A broader, inclusive decisionmaking processes would serve to shape the future of Vishwamitri River management.

Restoring the upper watershed has several goals which, along with changes at the city scale and inside the Influence Zone, work to protect Vadodara and the health of the Vishwamitri River itself. Policies integrating goals throughout the Vishwamitri begin in the upper watershed and the implementation of policies originating here will increase the likelihood that solutions proposed downriver[8] will be successful. The goal of collaboration of the watershed council in the upper watershed is to increase forested area along the river by decreasing wasteland (e.g. restoration) and reducing soil erosion. In India, environmental legal frameworks exist which seek to improve environmental conditions, as described by Agrawal (2005), but have been delayed due to lack of technical expertise.

We continue to propose a community-based watershed council throughout our various scales. Watershed councils are present in communities attempting to negotiate with complex management issues. The format of a watershed council offers a variety of stakeholders the ability to plan and interconnect initiatives with one another. Below, is a diagram depicting a watershed council on Conesus Lake in Livingston County, New York (for more examples, see the City Scale section).



P14

As one example, the Conesus Lake Watershed Council (USA) is an "an inter-municipal organization established" with a purpose "to govern the implementation of the Conesus Lake Watershed Management Plan." Similar to the Vishwamtiri upper watershed, the Conesus Lake council membership is "comprised of towns and villages with land within the watershed boundaries and water purveyors who use Conesus Lake as a public water supply". Furthermore, the Council oversees the Conesus Lake Watershed Management Program, as well as the Conesus Lake Watershed Inspection Program," which establishes the roles by the program, which include "manager," "technical committee," "inspector," as well as "agricultural committee".

A collaborative, non-governmental watershed council would be particularly effective to achieve the objectives set forth in our conceptual framework along the Vishwamitri at three scales. Within the upper watershed, in particular, we propose specific techniques that a watershed council would be well-equipped to both initiate and monitor over time. For example, studies have observed that water retention of rainwater to irrigate fields may lead to higher agricultural yields, as opposed to modern irrigation canals (see: Agriculture: "Khet Talvadis"). Rainwater detention, when carefully selected to increase water retention, can also reduce flooding issues downstream. With ample communication, a watershed council can collaborate with farmers toward mutual goals that benefit the river and agricultural communties.

In addition to practical management techniques, there is a broader need to address the upper watershed scale which arises from the lack of adequately defined language in the environmental laws governing water bodies. In the Indian constitution, two laws are worthy of consideration to amend or revise going forward for improved management techniques.

The Water (Pollution and Prevention) Act specifies standards for industrial effluents disposed into surface water bodies. The Interstate River Water Disputes Act (IRWDA), enacted under Article 262 of the Constitution, defines directives for inter-state river water conflicts that arise from the actions of one state affecting another state(s). Under the IRWDA, activities such as damming (downstream) and obstructing average river flows and quality (either through constructing water reservoirs or through consumptive uses upstream) are potential conflicts (IWRD from India Water Portal).

The IRWDA defines excessive silting/turbidity as a "man-made water quality alteration" arising from deforestation and mining activities, and using water from other river basins. The Act has an interest in resolving interstate river disputes such as the Godavari, Narmada and Kaveri water disputes. Our field visits and analysis reveal a contrasting picture which highlighted the gaps in both the Water Act and IRWDA frameworks:

1. Poor water quality arises from "non- point" sources

Agricultural runoff containing inorganic manure would be a significant non-point source of pollution. The Water Act, while assuring water quality by virtue of compliance with effluent standards, does not specify directives for non- point pollution sources.[9]

2. The major source of turbidity in the Vishwamitri river is the absence of adequate forest cover and sediment traps (in the form of off channel detention ponds).

While the IRWD Act could be interpreted to suggest turbidity results from man-made activities, such as deforestation and mining, the Act's limited definition to inter-state river, and not broader watersheds. However, turbidity is a widely observed phenomenon with seasonal rivers experiencing landcover changes throughout their watershed.

3. Our field visits observed that the reduced capacity of the Ajwa Reservoir results in increased flood flows during the monsoon.

Constructing water detention structures has been recognized as a potential conflict under the IWRDA, which limits this to inter-state rivers, and in certain cases, only to upstream or downstream section of rivers.

Concerning regulations, we offer the following policy recommendations:
1. Amending the Water Act

Adding provisions and standards for monitoring pollution levels. Specifically, concerning turbidity, nitrogen and phosphorus, arising from non-point sources, the Water Act could simply mandate standards. We also suggest expanding the current Bureau of Indian Standards (BIS) to reflect point and non-point non- industrial effluent pollution loads.

2. The scope of the language and directives of the IWRD Act needs expanding to include all rivers.

We also suggest redefining the definition of "altered flows of rivers" to include excessive flooding as a result of anthropogenic activity (in addition to the obstruction of normal river flow and water quality). An expanded definition will allow us to consider the impacts of engineered solutions.

3. While GPCB may serve as the enforcing authority for maintaining the overall quality of Vishwamitri, by definition the forum does not ensure adequate monitoring or protection of the entire stretch of the river and basin.
As discussed at various scales, we su
ggest the establishment of a Watershed Council which defines a river's boundaries based on its natural flow and hydrology, and not through limiting terminology that simply favor beneficiary use for humans. The Council will be autonomous and unified in its function throughout India, thereby reducing conflicts arising out of differences in the State and Union legislature. In particular, the Council will use scientific critique to address concerns of water quality and management at the watershed level.

[8] Our analysis of precedents including the Yangtze River's Sloping Lands Conversion Program and Natural Forest Conservation Program have also enhanced our vision of how policy can work hand in hand with local management.
[9]Surface water quality is purely determined on the basis of designated best use (see critique section on water quality assessment for more info). Effluent discharge standards are only specified for industries and not nonpoint sources of pollutants. See Environmental Standards on the CPCB website for more details.

CONCLUSION

Vadodara has the opportunity to take a forward-thinking approach to watershed management. By prioritizing retention and infiltration in the upper watershed, in addition to strategic opportunities to increase or protect off-channel storage, the interventions presented here mitigate flooding within Vadodara without yet venturing into city limits. They also provide a basis for collaborative partnerships and meaningful relationships with other municipalities within the watershed.

By expanding the boundaries of the issues that brought about the VRDP, we are able to more effectively address Vishwamitri in its watershed context. We are confident that our alternative strategy in the upper watershed will allow for more exciting, ecologically sound, multi-functional design solutions within the City of Vadodara.

SUMMARY OF DESIGN INTERVENTIONS

LANDCOVER CHANGE	DESIGN RESPONSE	EXPLANATION	WHY?				
			S	W	D	R	H
Loss of forest cover (especially at Vishwamitri's source, the Pavagadh Hills)	Forest cover regeneration	Plant more native trees (Kadamb, Shimlo, Imli, etc) and allow for natural succession of forest cover in protected areas	■	■	■	■	■
	Earthen check dams	Construct small dams using locally sourced material	■	■	■		■
	Gulley plugs, jute lining and seeding	Gulley plugs are constructed similar to check dams; jute lining can be 'stapled' onto banks; a seed mix of grasses, sedges and other natives etc. Can stabilize banks and promote plant growth	■	■	■		■
Agriculture	Khet talavadi (field ponds)	Dig in field storage ponds to capture rainwater	■	■	■		■
	Hedges and stream buffer in fields	Plant/ use existing dense vegetation (trees, shrubs, grass) along field margins					
Increased urbanization	300 m buffer strip along stream where possible	Prevent development within the floodplain of the Vishwamitri	■		■		■
	Urban stormwater management typologies (see *City Scale*)	Have a stormwater management plan as towns develop in the upper watershed					
	Preserve ox-bow lakes	Preserve existing, natural meanders along the course of the river for natural off-channel storage	■	■		■	■
Ajwa Dam	Rip rap treatment (with green buffer strip)	Use rubble or rock armor to prevent scour and water erosion near Ajwa Dam's outlet	■		■		■
	Preserve and/or construct wetlands for off-channel storage to delay water	Preserve and/ or create new wetlands in areas with water logging potential, using native plants that thrive in these dynamic environments	■	■	■	■	■

S- Trap sediment
W- Slow runoff volume (detention/infiltration)
D- Decrease runoff volume (retention/infiltration)
R- Recreation
H- Habitat quality improvement

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P1: http://www.bl.uk/onlinegallery/onlineex/kinggeorge/p/003ktop00000115u05500000.html
P2: USGS ,https://store.usgs.gov/b2c_usgs/b2c/start/(xcm=r3standardpitrex_prd)/.do
P3: Google Earth Pro (2016)
P4: Google Earth Pro (2016)
P5: Google Earth Pro (2016)
P6: Google Earth Pro (2016)
P7: saa synergies - concept for Raksha Shakti University
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CITY SCALE:
An ecological framework for urban stormwater management

"When I speak this standing on a bridge

Speaking in a way only Vishwamitri can hear

She pretends not to hear

And shutting her eyes tightly

Tucking her unclean sari a bit higher

She rushes away hastily

Hiding her face behind the pallu of rubbish drifting the water

Behind the bend."

-SHITANSHU YASHASHCHANDRA

Residents, domestic buffalos, and stray dogs share space on the riverbank.

Voew of Vishwamitri from a bridge, Vadodara 2016

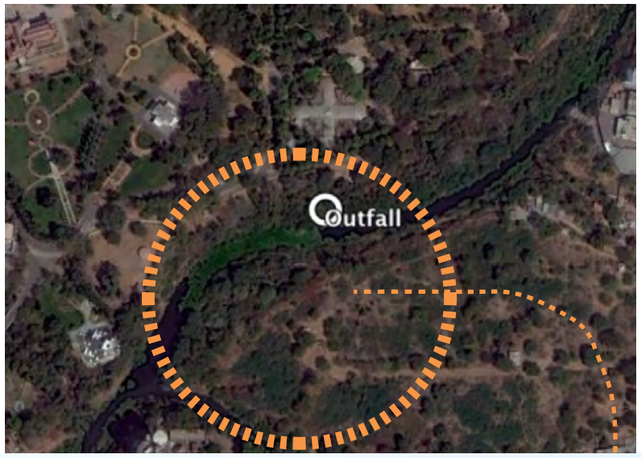
In our critique of the VRDP, we describe the inadequacy of the project boundary (the "Influence Zone") to address its stated goals. These goals include flood mitigation, groundwater recharge, biodiversity protection, creating a safer environment for humans and crocodiles, and increasing water quality in the Vishwamitri River. Many of these goals are responses to the symptoms of the urban stream syndrome[1] so evident along the Vishwamitri River. As described in our critique (Appendix 1), we do not believe that the VRDP can successfully address these concerns within this narrow corridor alone. It is clear that the VRDP's conventional channelization approach only addresses the symptoms of the urban stream syndrome (Vietz 2016). In contrast, we focus on its root causes, which must be addressed at a wider scale (Booth et al. 2004; Walsh et al. 2005). Impervious surface and engineered drainage systems, which increase the velocity and reduce the concentration time of runoff into urban streams, are the primary drivers of urban stream syndrome (Walsh et al. 2005, Vietz 2016). It is clear then, that the pattern of development in Vadodara is directly related to these issues in the Vishwamitri River.

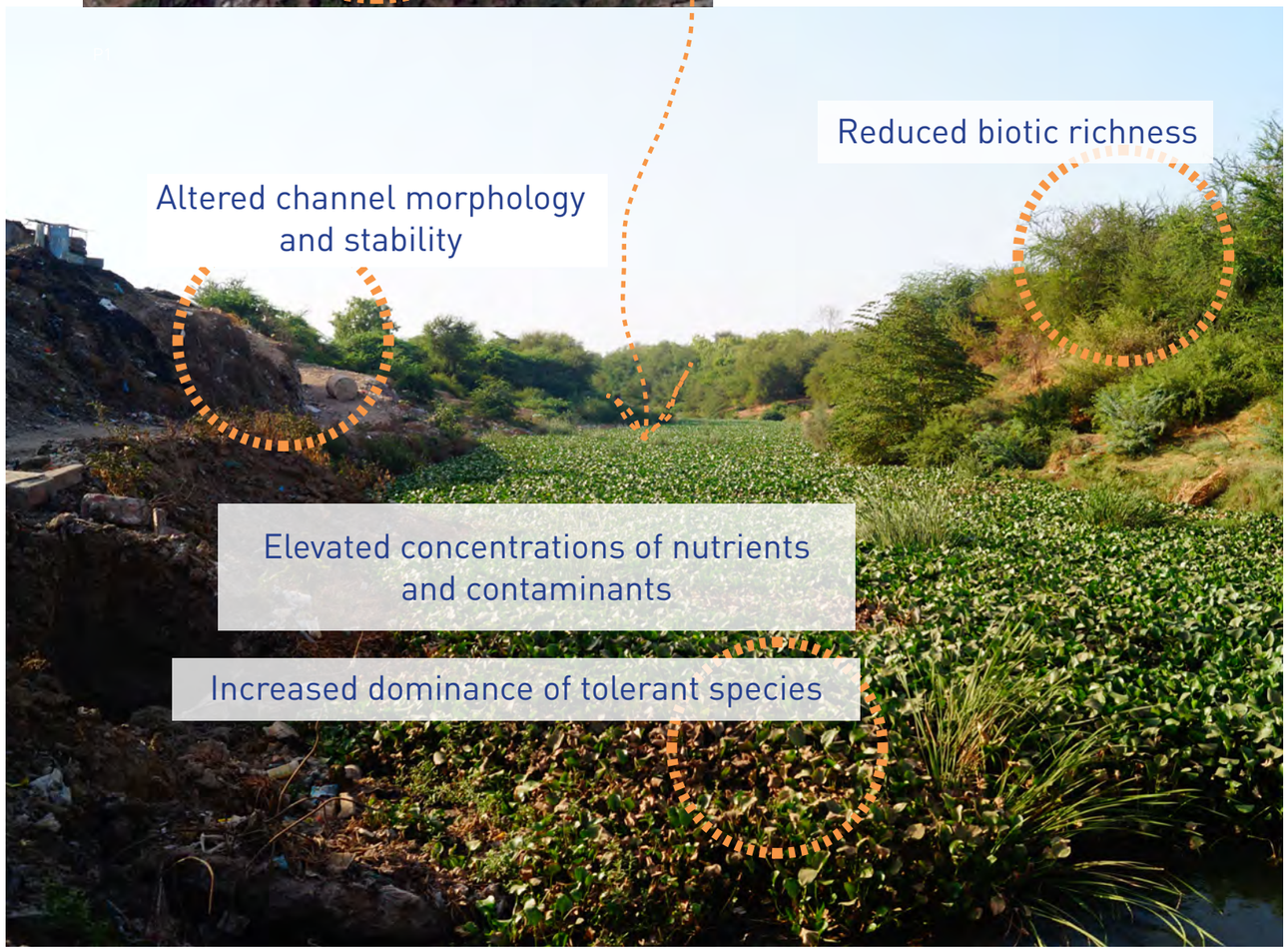
The alternative stormwater management framework presented in this report prioritizes the restoration of specific hydrologic functions (such as infiltration, retention, and off-channel storage) throughout Vadodara's urban watershed through the proposal of strategic green infrastructure projects.

First, we prioritize urban sewersheds[2] for the installation of green infrastructure based on their contribution to the main branch of the Vishwamitri River. Then, relying on the hydrologic function typology presented in Kristina Hill's work on urban watersheds (Hill 2009), we discuss strategic, functional design priorities for green infrastructure within each priority sewershed. To illustrate how this framework can be operationalized, we provide examples of prominent city sites that fit into each component of the Hill typology. Additionally, the use of this framework for "shoreline" sites[3] extends into the following design section, Inside the Influence Zone.

In addition to this management framework, we provide policy suggestions aimed to mitigate the impact of urban development on the river. These include the chartering of a non-governmental watershed organization that is a hub for research and protection of the Vishwamitri River watershed, the appointment of a Stormwater Management Deputy at the Vadodara Municipal Corporation (VMC), and stricter enforcement of India's Water Act within Vadodara. We offer these as alternative starting points for increased dialogue as the city decides how the river fits into its urban identity moving forward.

URBAN STREAM SYNDROME





[1] The urban stream syndrome describes the consistently observed ecological degradation of streams draining to urban land, including flashier flows, elevated concentrations of nutrients and contaminants, altered channel morphology and stability, and reduced biodiversity, all of which are noticeable in the Vishwamitri River (Walsh et al., 2005).
[2] The use of the term "sewersheds" in this report refers specifically to drainage catchments for urban surface runoff, not piped sewage generated from within household plumbing systems. It is, however, important to note that urban runoff in Vadodara likely includes human and/or animal waste, especially from urban livestock.
[3] According to the Kristina Hill's typologies for urban stormwater design and management (Hill 2009), a shoreline site is where water eventually concentrates, such as a lake, river, or ocean. As a general rule, urban sites that are within the floodplain are considered "shoreline" sites. See page X for more detail.

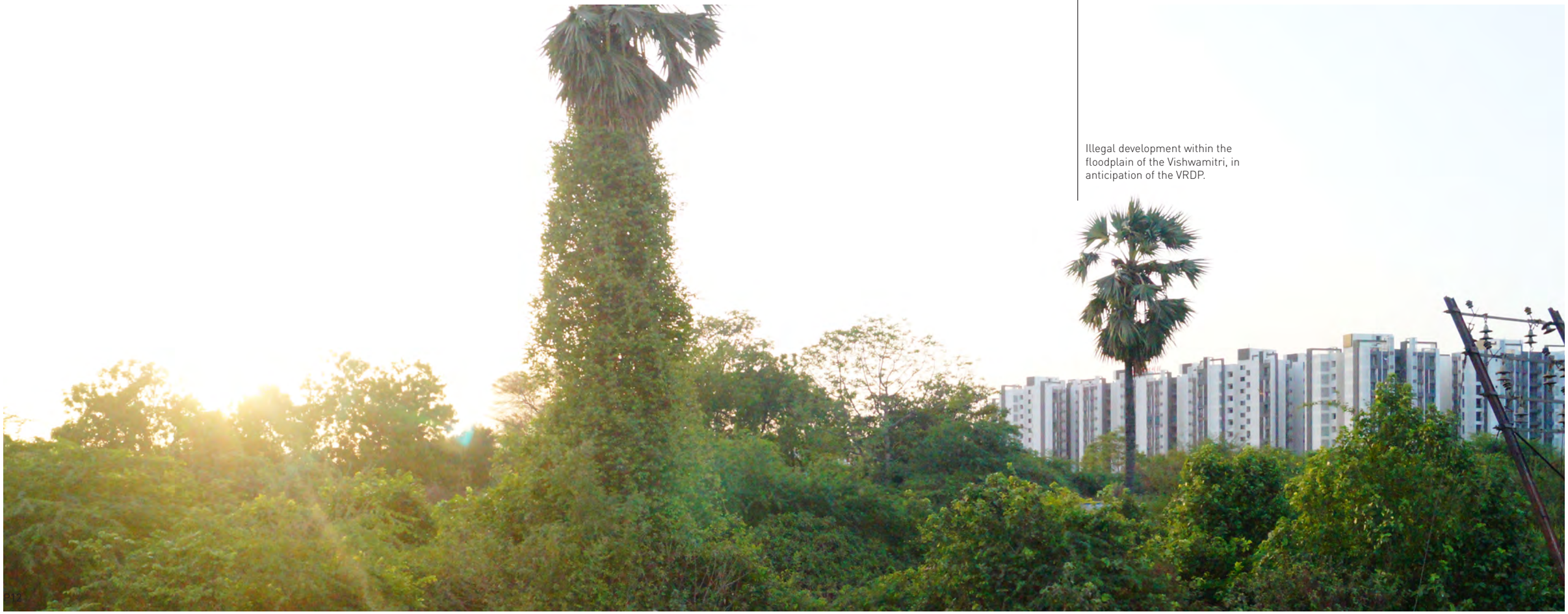
STORMWATER, GREEN INFRASTRUCTURE + MULTIFUNCTIONALITY

Although our alternative design concept to the VRDP is presented at three scales, interventions at each scale focus on the same thing--how can we build a healthier relationship between the City and the River? Our goal in this City Scale section of the report is not to create a design plan for the entire city, but to create new opportunities to deal with the urban stream syndrome within the Influence Zone--the heart of our design. To do so, we must first address issues of flooding and water quality at a wider scale. For this reason, stormwater management is a key priority (Vietz 2016).

However, we also recognize that a fundamentally worthwhile goal of the VRDP is to create new public spaces in Vadodara. Through our City Scale stormwater management, we expand on this desire through the promotion of multifunctional green infrastructure (hereafter referred to as GI) to manage runoff. At its heart, GI provides opportunities for placemaking, increasing ecological health and ecosystem services, and enhancing the restorative experiential potential of urban spaces. Engineered solutions tend to focus on one function, providing these key ecological and social needs in superficial ways (Booth, Hartley, & Jackson 2002). Through GI, the city can go deeper. It can prioritize new community greenspaces, urban ecosystem services, improvements to human well-being, and provide flood and water quality protections in a single design, with a single price tag. Our strategic GI framework for the entire urban area also allows us to spatially expand the benefits of public projects beyond the river corridor. We believe this approach will maximize the city's investment in these issues and create exciting design opportunities city-wide.

Focusing on function, rather than form, this framework offers endless opportunities for the creativity of local designers to shine through in the development of GI. In our search for more relevant GI precedents for the City of Vadodara, we did not find many examples of original design or research on the design, perception, or management of GI in monsoon climates. While we believe the functional approach of GI is appropriate across climates, we also see the need for more nuanced design solutions in form. The form of GI in Vadodara is the primary opportunity for innovation. Designers should consider how GI, which relies on plant material rather than hardscape, is perceived by residents in the dry season. They must consider how the capacity of the design accommodates heavy rains days in a row.

We are proposing this framework not only for its ecological benefits, but also because it is an opportunity for Vadodara to become a leading name in innovative GI design for monsoon climates. Large projects such as the VRDP are opportunities for cities to set themselves apart. The VRDP is a common solution and does nothing to set the city apart as a hub of design innovation. With a thriving local university, design talent, and plans for future growth, it would be silly for the VMC to ignore this opportunity to turn Vishwamitri into a unique regional asset that attracts visitors and new residents alike.



Illegal development within the floodplain of the Vishwamitri, in anticipation of the VRDP.

View from a bridge in Vadodara.

THE CONCEPTUAL FRAMEWORK

The stormwater management framework presented here allows prioritizing urban sewersheds for the installation of GI based on their contribution to the main branch of the Vishwamitri River. The strategic, functional design priorities within each priority sewershed can then be defined according to the typology for the restoration of hydrologic function to urban watersheds, presented in Kristina Hill's work on urban watersheds (Hill 2009). The three components of this typology are based on a site's relationship to sewer infrastructure and the river's floodplain.

SEWERSHED DELINEATION:
Prioritizing sewersheds for green infrastructure

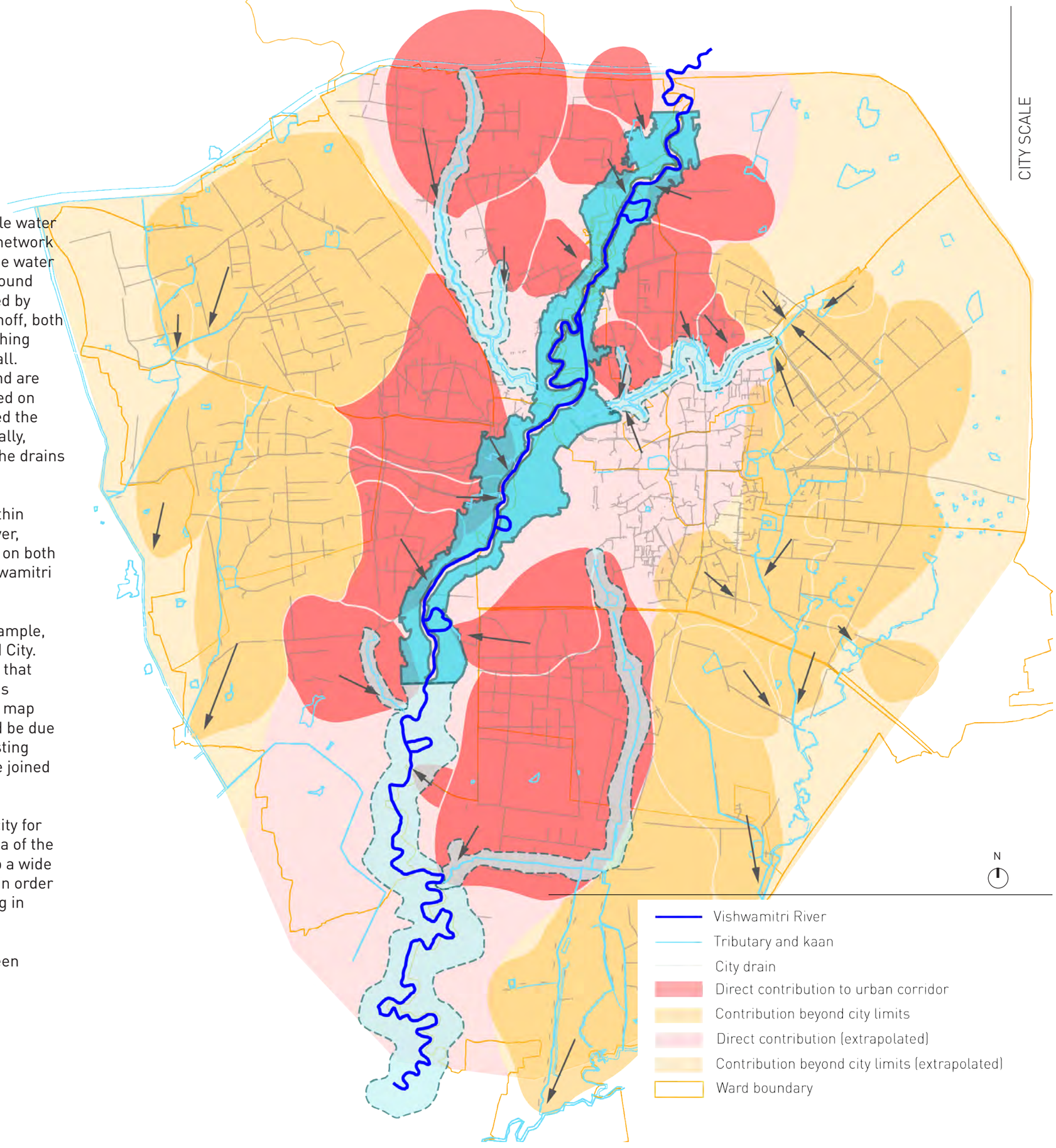
Unlike natural watersheds, which refer to an area draining to a single water body, such as a river, lake, or basin, sewersheds are defined by the network of storm drain infrastructure emptying to a common outfall. Because water flows in urban areas are altered by impervious surface and underground drainage networks (grey infrastructure), they can be better described by sewersheds rather than sub-watersheds. In a sewershed, urban runoff, both from the monsoon and daily activities (such as watering plants, washing cars, etc.) is collected into sewer pipes that drain to a common outfall. Outfalls are located along the Vishwamitri River or its tributaries, and are significant sources of pollution, as evidenced in aerial imagery. Based on the city drainage map provided to our team by the VMC, we estimated the approximate boundaries of sewersheds in Vadodara (right). Specifically, water flows were carefully traced by following the flow direction in the drains labeled on the map.

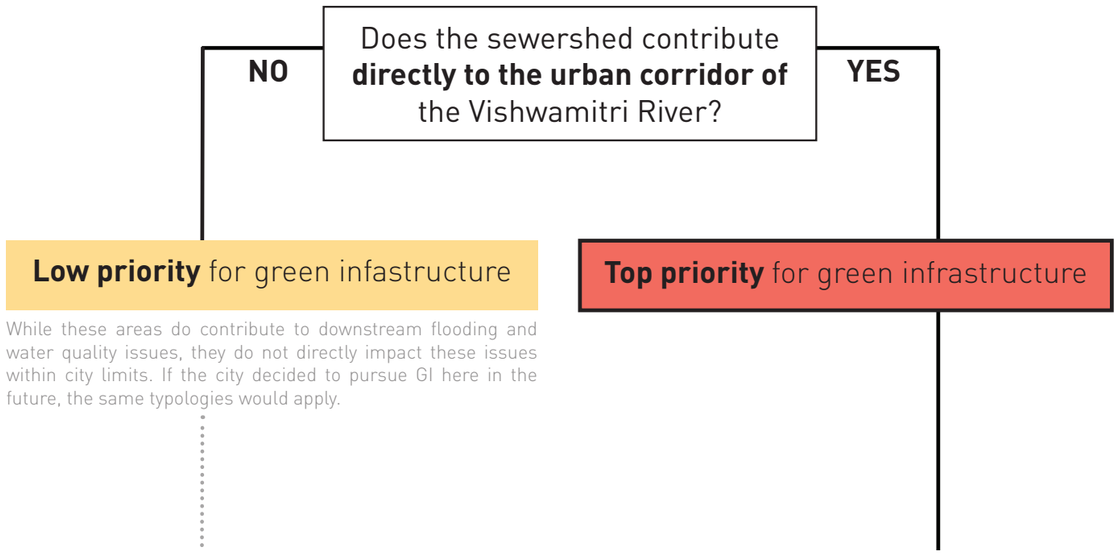
As shown in the map to the right, roughly half of the sewersheds within the city directly contribute to the main branch of the Vishwamitri River, indicated by the red areas along the river. The sewersheds in yellow on both sides drain either to a western tributary that connects with the Vishwamitri downstream of Vadodara or the Jambua River to the east.

Drainage maps received from the VMC may not be complete. For example, the city drainage map does not specify flow directions within the Old City. According to the drainage pattern of the adjacent areas, we inferred that the Old City contributes to urban corridor of the Vishwamitri River, as represented by the faint red area. The remaining blank areas on the map represent areas where drainage information is missing, which could be due to an undeveloped drainage network or an incomplete survey of existing drainage system. Areas where drainage information is missing were joined to their adjacent sewersheds using our team's best judgment.

The sewershed map provides the basis for prioritizing areas of the city for GI projects. Although it would be beneficial to pursue GI in every area of the city, we recognize that the VMC may have limited capacity to develop a wide variety of projects. For this reason, we suggest these priority areas in order to achieve the greatest impact on water quality, erosion, and flooding in Vishwamitri.

The red sewersheds on this map represent the priority areas for green infrastructure projects.

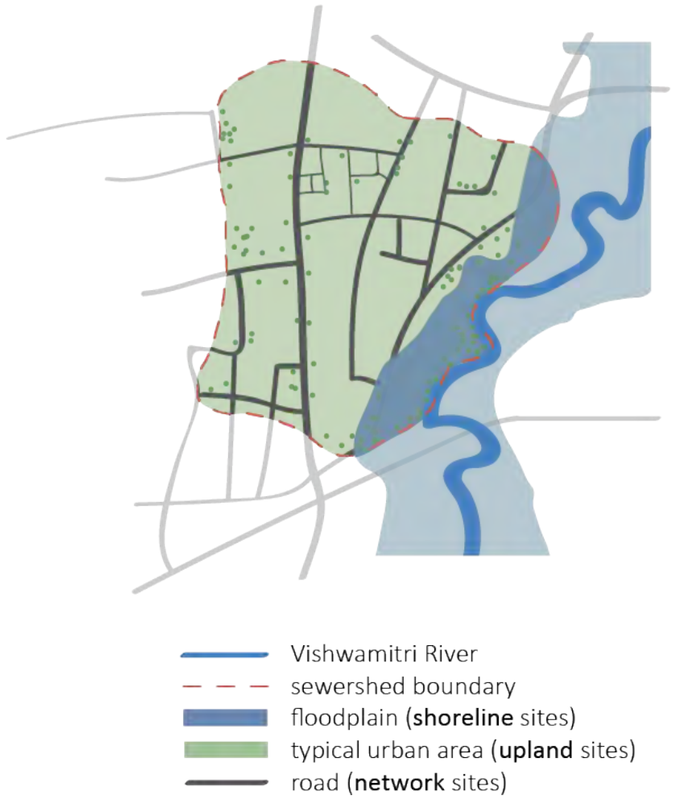


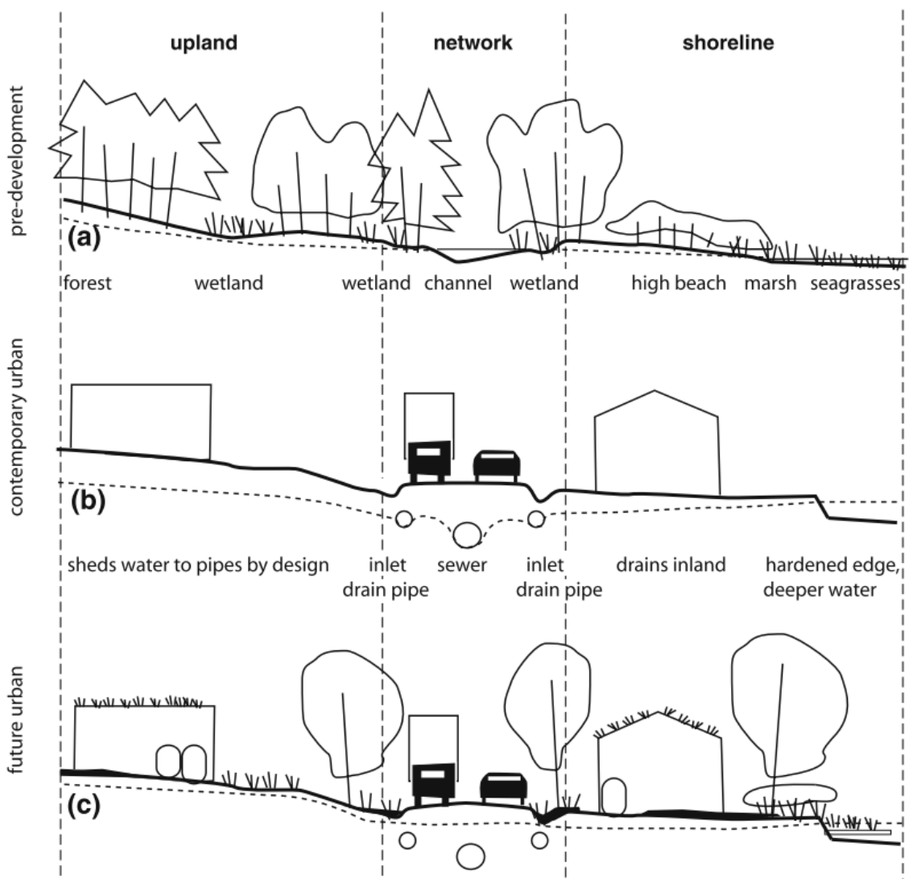


The first part of the framework focuses on location, but the second focuses on function.

After prioritizing locations for future GI projects, we prescribe the restoration of specific hydrologic functions to the urban watershed.

Zooming into one of these priority sewersheds as an example, we will illustrate how we use Kristina Hill's typology to do so.





A diagram from Kristina Hill's 2009 chapter on Urban Design and Urban Water Ecosystems expresses the impact of development on the function of landscapes hydrologically (Hill 2009, p. 154). To combat this degradation, she recommends a series of typologies to restore pre-development hydrologic functions to urban landscapes through green infrastructure.

MAPPING THE FLOODPLAIN

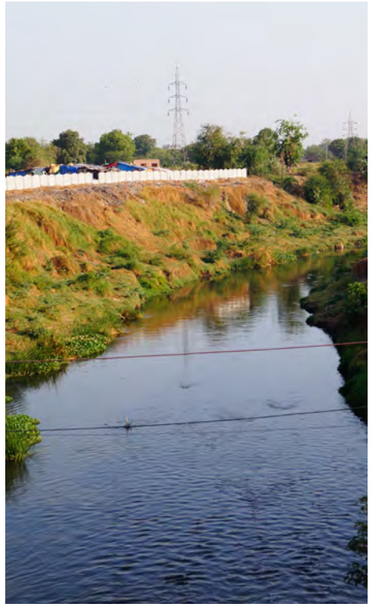
In order to specify the most strategic function of GI projects within these priority sewersheds, it is also important to understand how different areas within each sewershed function both in a pre-development, natural system and a contemporary urban environment like Vadodara today. One of the key elements in understanding these differences is knowing whether or not a site sites within the river's floodplain. Understanding the extent of the floodplain allows us to prioritize areas for expanded water storage during the monsoon. It also allows us to focus on keeping rainfall that falls outside of the floodplain where it falls.

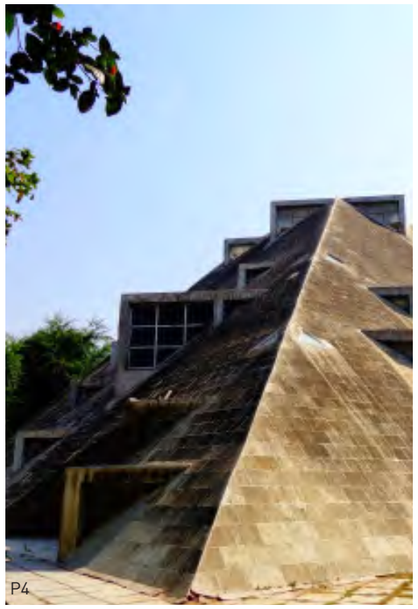
To estimate Vishwamitri's floodplain, we rely on a study from the Indian National Institute of Hydrology (NIH), which makes use of MIKE-FLOOD, a hydrodynamically coupled 1D-2D flow model, to estimate the inundation areas of the Vishwamitri River in its present condition (Kumar et al. 2016). The design flood simulation was carried out for a period of 3 days based on the daily annual maximum rainfall for 100-year return period (39.0 cm). After accounting for different peak floods of Vishwamitri's tributaries, the peak flood of Vishwamitri itself, also called the design flood, at Kalaghoda was estimated to be 2198.26 m3/s. Kumar et al. also include an inundation map corresponding to the design flood for the urban corridor proposed for embankment in the VRDP[4] (Kumar et al. 2016). We used the inundation areas produced by the model as an approximation for the floodplain of the Vishwamitri (Figure 2). The floodplain of the lower Vishwamitri River, which was not mapped in the NIH study, was approximated using a similar width as the known floodplain of the upper reach. Comparison between this estimated floodplain and the VRDP Influence Zone reveals that the majority of, if not the entire, Influence Zone falls within the floodplain. Based on the model results, constructing concrete embankments as high as 4 meters will not increase the "safe carrying capacity" of the river to meet its design flood level (Kumar et al. 2016, pg 110-113). According to the NIH, the VRDP alone is not sufficient to handle flooding.

It is for this reason that we must rely on our understanding watershed dynamics to suggest interventions at the wider scale. It is important to couple a floodplain management strategy with proper measures to reduce and retain stormwater city-wide.

[4]This area represents 11km out of the 26km that run through the The entire stretch of the Vishwamitri River is 52 km.


P3

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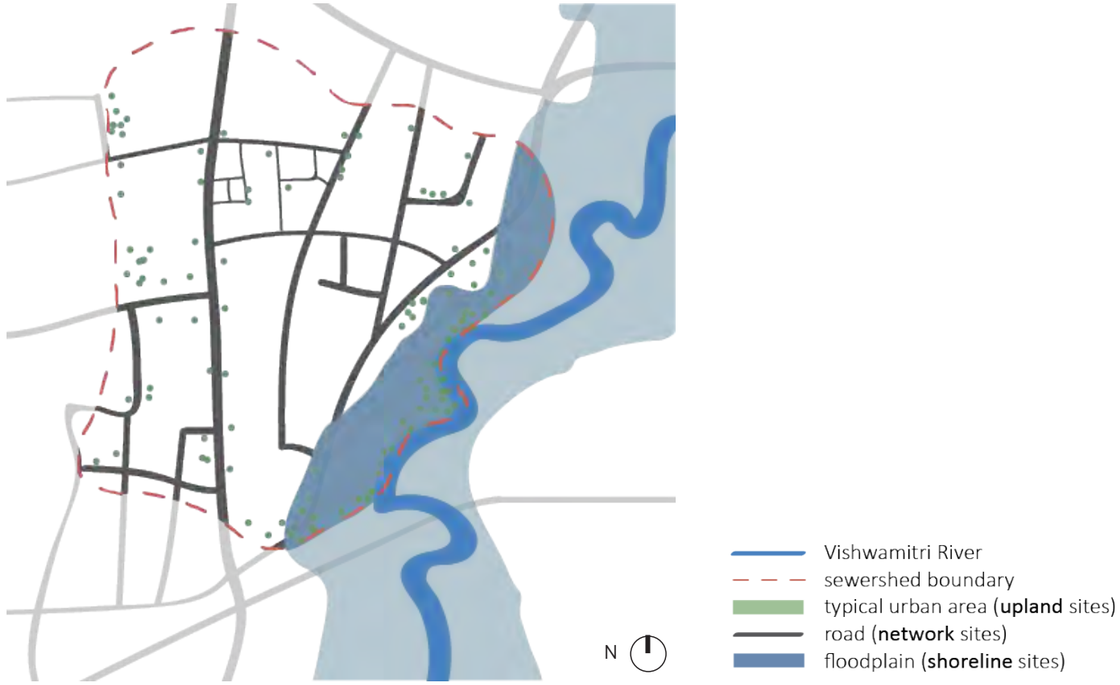


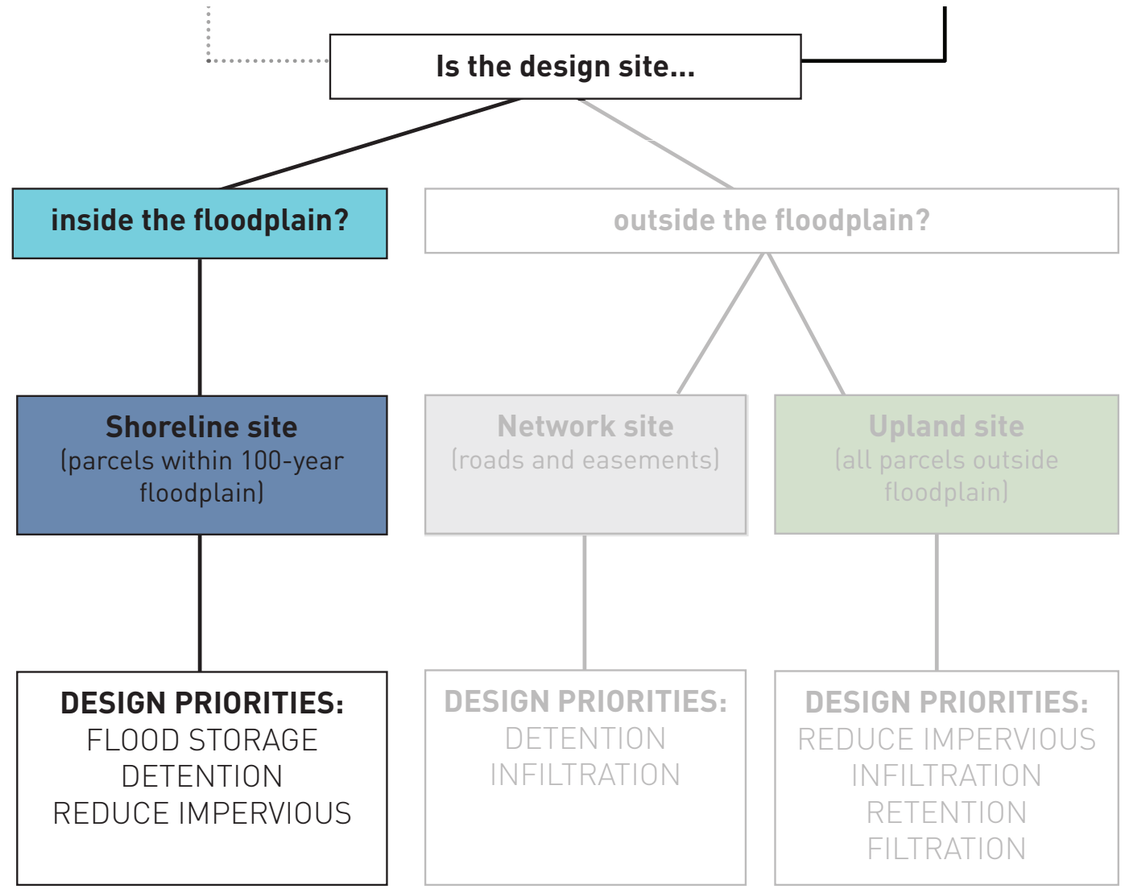
Shoreline sites:

Sites inside the floodplain of Vishwamitri or its tributaries

In terms of stormwater management, the floodplain of the Vishwamitri is considered a "shoreline" region due to its direct interaction with the river. In these areas, the main priority is to expand temporary storage of flood water during the monsoon using off-channel storage. Off-channel storage temporarily stores water outside of the main channel. To better illustrate, the best natural example of off-channel storage is an oxbow lake, which is separated from the channel but deep enough depressed enough to hold a significant volume of water. Shoreline areas are good places for short-term stormwater storage. In addition, vegetated buffers around off-channel storage and along the river can increase water retention while reducing the destructive forces carried by fast-traveling floodwater during monsoons.

High density development in the floodplain region should be avoided in order to minimize safety concerns and prevent property damage. Building in the floodplain reduces the capacity of the floodplain to do its job--hold water. In this same vein, it is important to minimize the amount of water piped into the floodplain, as it reduces the carrying capacity of the floodplain.

Examples of shoreline sites in Vadodara include Ratri Bazaar, the Sardar Patel Planetarium, and the Central Business District. and The best example of a shoreline site in Vadodara is the VRDP's Influence Zone itself. A more detailed discussion of interventions within shoreline areas of Vadodara can be found in the next section of this report (see *Inside the Influence Zone*).

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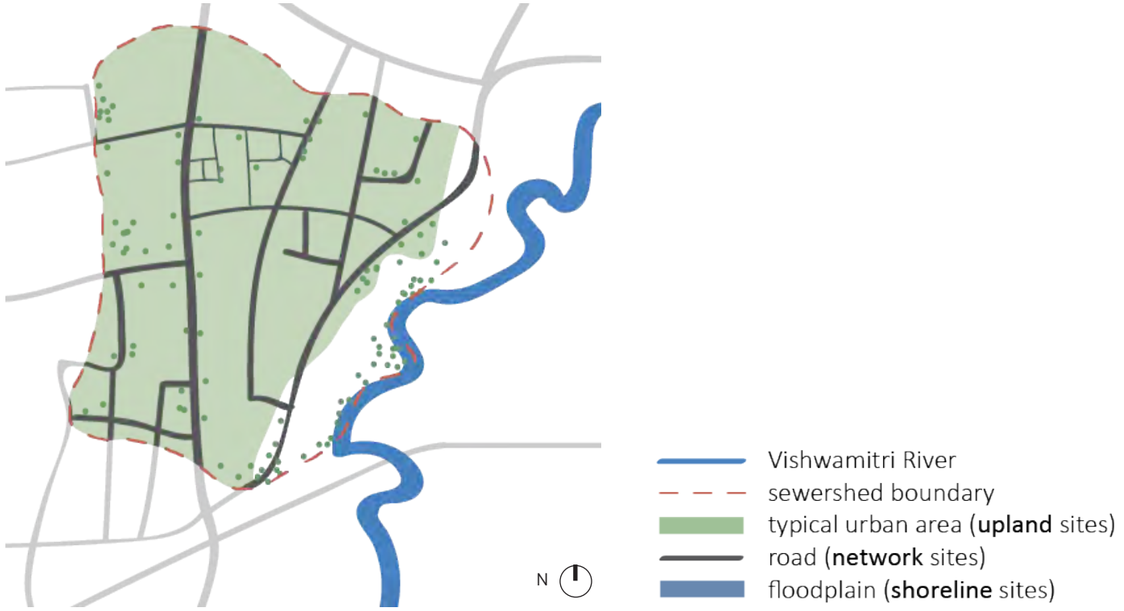


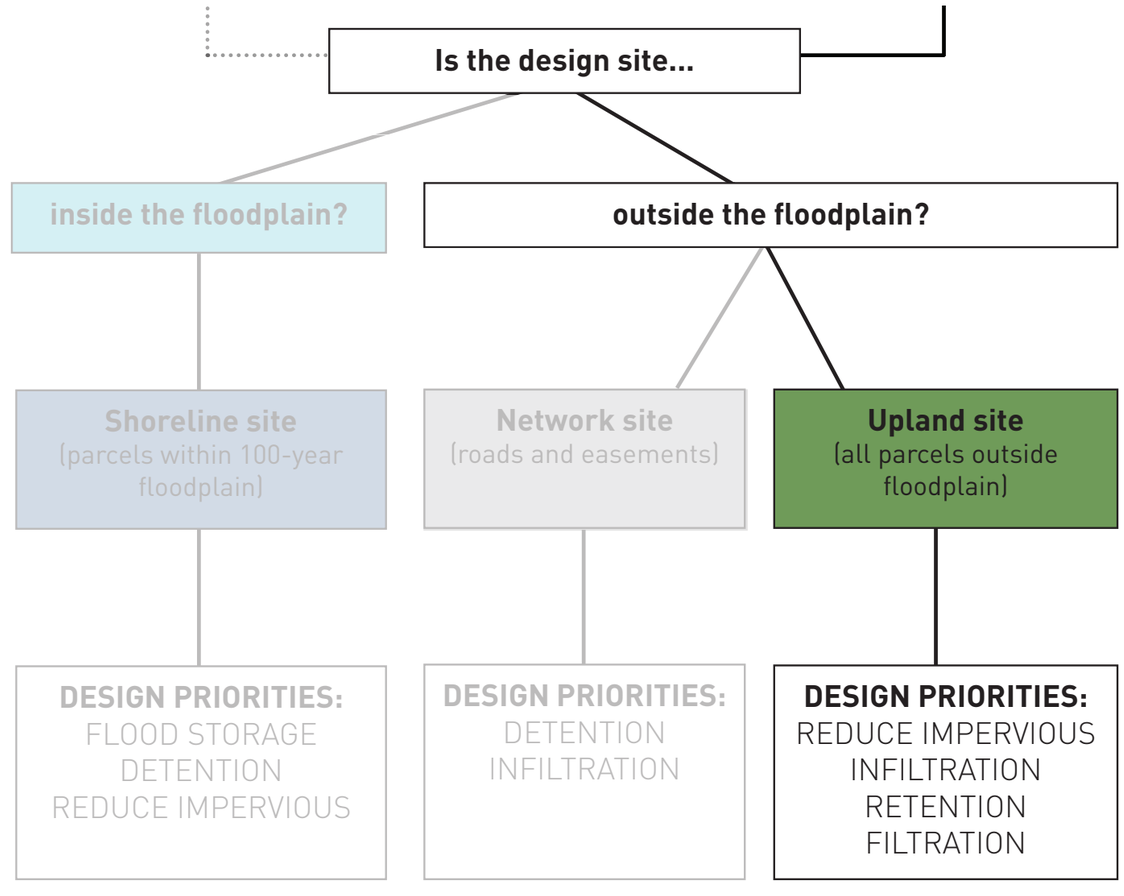
Upland sites:

Sites in outside of Vishwamitri's floodplain (most sites)

Upland areas generate runoff that, through conventional grey infrastructure connections, leads to the Vishwamitri River or one of its tributaries more directly than in a pre-development landscape. In these areas, it is important to prioritize GI that decreases impervious surface and increases both the retention and infiltration capacity of the urban landscape. In this way, the goal of GI on upland sites is to keep water where it falls, preventing it from moving into the river corridor faster than it would naturally.

Reducing water generated from the upland regions is key to managing stormwater in the city and water quality within the river. In addition to increased water velocity and peak flow of water to the river, water moving through urban landscapes carries contaminants that bind to sediment in erosion-prone rivers (Burton & Pitt 2005).

Prominent upland sites in Vadodara include the VMC buildings at Khanderao Market, Center Square Mall, and the Vadodara Central Bus Station.
Common practices adopted to reduce impervious surfaces include retrofitting the existing impervious surfaces by including gravel sublayers, underground storage systems, or reducing the surface area of a site covered with asphalt and concrete over more permeable materials.

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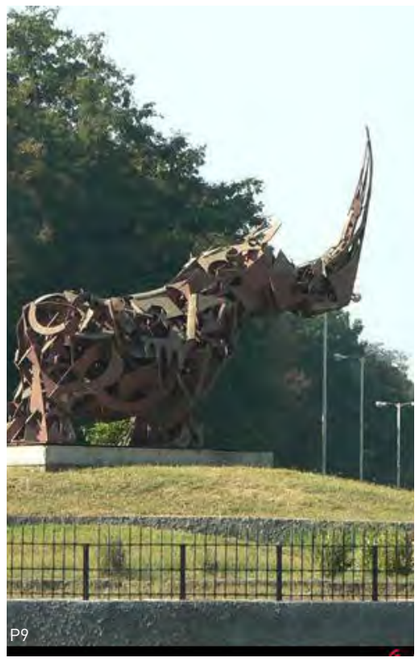
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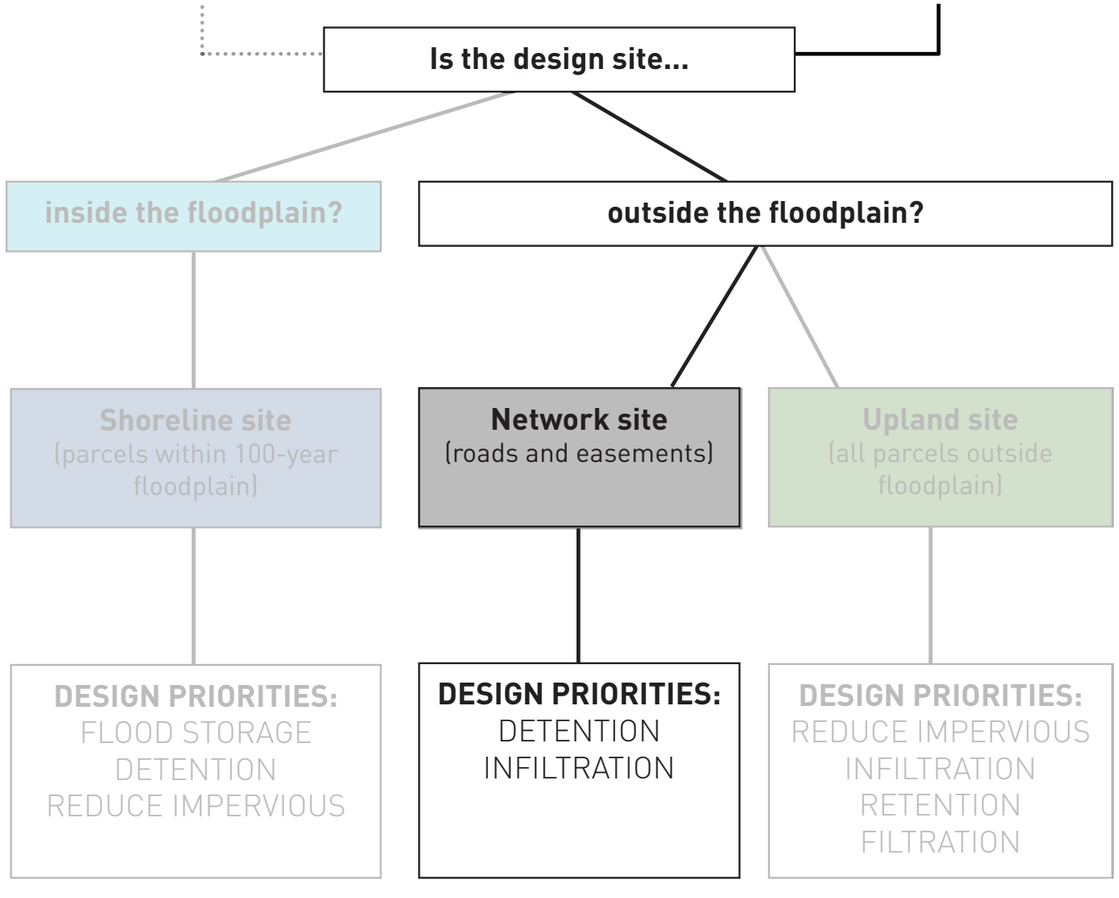
Network sites:

Sites along roads, especially roads with interceptor sewer pipes

Network sites include roads and nearby areas where water from upland sites is collected and conveyed to the river through conventional grey infrastructure. The sewer system conveys destructive pollutants in stormwater runoff, such as petroleum byproducts, heavy metals, and sediments (Hill 2009; Burton & Pitt 2005). These sites present important opportunities to improve the hydrological function of the urban watershed, both in terms of slowing down the stormwater runoff and preventing contaminants from entering the river system.

In an undeveloped system, a network site is the river channel itself, pointing us to the types of functions we want to promote: temporary storage, or detention. The deep ravines of the Vishwamitri act as extra storage capacity during the monsoon. In the same way, on network sites, we want to install GI that provides temporary storage to reduce both the volume of water flowing into the system as well increasing the lag time.

GI strategies for the network sites often utilize vegetation to promote runoff detention and infiltration. Network sites include Genda Circle and Chakli Circle. It is also possible to consider the edges of properties along roads. An example of this is the portion of Maganlal Agricultural University near Genda Circle. This brings up interesting opportunities for partnerships in GI design. Sites on or near universities hold exciting collaboration potential, and there may be other opportunities to explore.

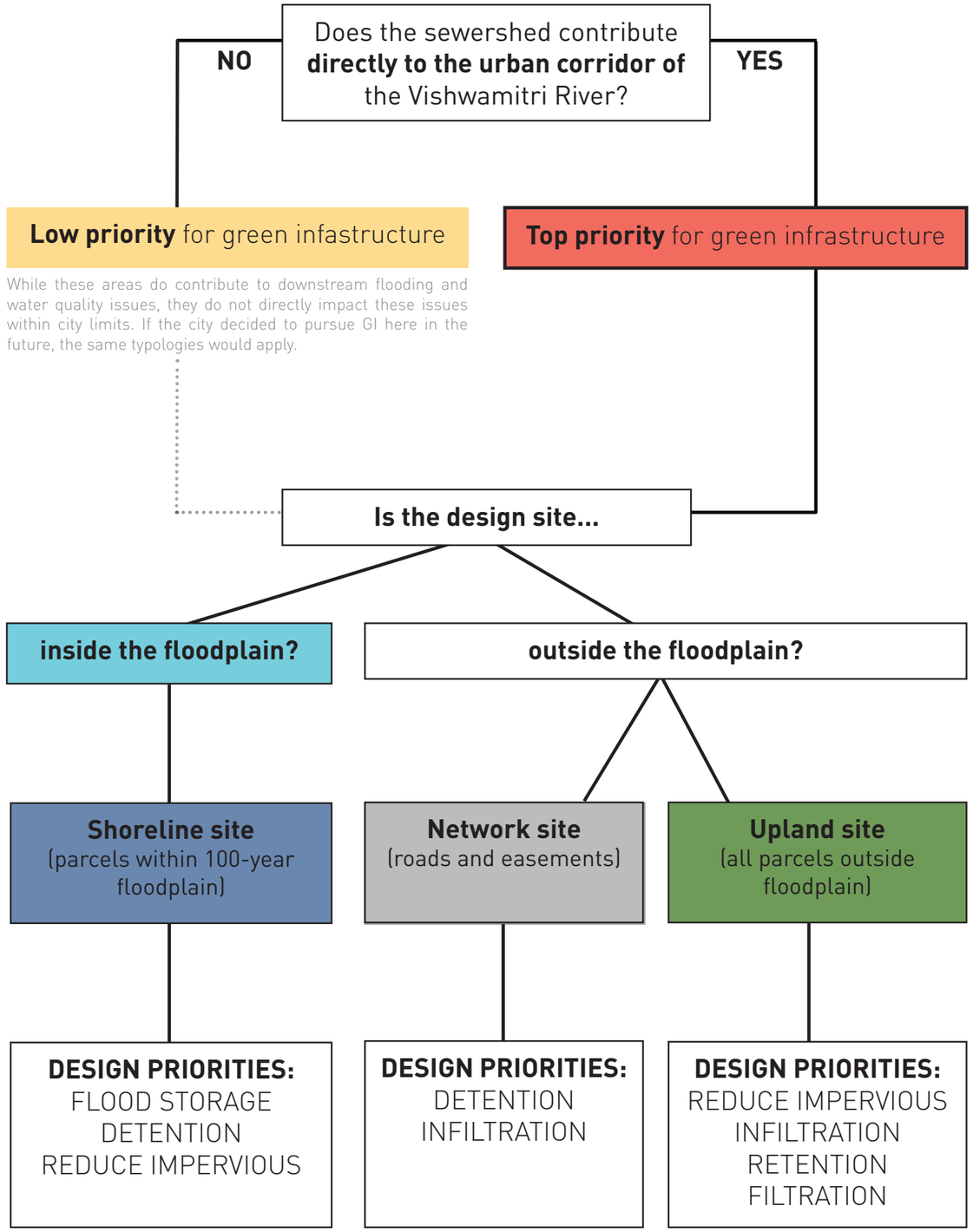


By combining layers of analysis and research on urban watershed management, we have developed a cohesive framework for stormwater management. If pursued collaboratively and comprehensively, the impact of this management framework will be felt city-wide. From new greenspaces to reduced flooding, the multifunctional benefits of this approach are clear.

WHY A CONCEPTUAL FRAMEWORK?

A sound stormwater management and flood control plan for the city should be based on a thorough understanding of both broad and localized flow dynamics, flood risks, and waterlogging within the city. In addition to detailed rainfall records and hydrologic modeling results, knowledge of the current stormwater system and flood risks can be gained through spatial analyses about current land use, impervious surfaces, floodplain delineation, catch basins associated sub-watersheds, population distribution, and building footprints in flood-prone areas. However, the lack of detailed spatial data and uneven data quality for the Vishwamitri River and Vadodara do not allow us to develop this comprehensive analysis. While we consider a detailed and scientific stormwater management plan to be necessary for successful, long-term flood control and water quality improvements in Vadodara, there are too many data gaps to develop such a plan at this time.

Nonetheless, strategic stormwater management is vital to the health and wellbeing of the river ecosystem and city residents. Our stormwater management framework is intended to be a strategic, guiding approach rather than a site-specific set of designs for new GI projects. We consider a detailed, site-specific stormwater management plan to be necessary for successful, long-term flood control in Vadodara. In this way, the framework presented here requires strategic, site-specific development to be effective.



POLICY RECOMMENDATIONS TO SUPPORT THE FRAMEWORK

To support our design framework, we also recommend key policies that will allow the city to monitor and mitigate the impact of urban development on the Vishwamitri River. Within the City Scale, engineered drainage systems and impervious surfaces are the foundational fabric on which the entire city expands. As far as policy is concerned, the fundamental issue is how to promote and enforce better development practices in a large city. To do this, we promote the following policies:

Establishment of a Vishwamitri River Watershed Council

In the past 20 years, there have been numerous attempts to create partnerships in an effort to enhance watersheds across Gujarat. For example, according to Groetschel et al. (2000), an estimated 1,200 watershed development projects were initiated under the Rural Development Department in Gujarat. Of those projects, seventy percent of the initiatives during that time period were guided by non-governmental organizations located in Gujarat. The diversity of stakeholders interested in watershed development signals that significant organizational and municipal partnerships can exist to address watershed management issues. Participation in management must include resources outside of the government to enhance collaboration. The purpose of our alternative design is to implement collaborative management strategies, such as natural water retention measures implemented on public and private land nearby the river. Relationships established between municipal, state, central, and non-governmental actors are crucial to make the plan happen.

Our stormwater management framework will increase water quality and ecosystem services, as well as enhance preexisting shared community spaces and flood flow detention areas. Data collection on sewersheds and stormwater sheds and frequent updates to ensure proper installation and maintenance of GI. The principal design interventions we seek to implement can be addressed in companion policy interventions. Forming a watershed council would facilitate an independent collaborative body specific to the Vishwamitri within the City Scale to assist the gradual shift away from an engineered solution to GI implementation. A broader, inclusive decisionmaking processes ultimately serves to shape the future of Vishwamitri River with participation from people across the watershed. The vision conceptualized for the City Scale is based on the underlying notion of collaboration. A non-governmental Watershed Council in Vadodara could represent both informal and formal organizations, interests groups, or local constituencies, which would allow the majority of citizens to voice their individual private and public interests within the City Scale (see Quesada 1999).

The existence of a collaborative watershed council also encourages representatives of public agencies, The Maharaja University of Baroda, water utilities, waste management, and labor unions, as well as major resources users, specifically water users, to join the membership. Broadly, a watershed council can be seen as a response to legal action in India, which remains one of the most important ways to take on environmental issues. Although the legal system is an effective mechanism for enforcement, taking a case to court is not necessarily a reasonable action for the general public living in Vadodara due the length of a trial, cost, and technical resources needed to prevail in most legal cases makes justice difficult to achieve (Agrawal 2005). However, a more collaborative, inclusive, decision-making body can be an equally effective forum. Legal cases remain an important avenue for action, whereas a watershed council functions as a cost-effective 'alternative' to going to court to settle disputes. The watershed council does not replace the need for legal action, but serves as a potential safeguard to prevent unnecessary litigation.

Across the world, there are plenty of examples (see Table below) of successfully operational watershed councils in contexts similar to the Vishwamitri River in both industrialized and developing scales. One component of any successful council is a formalized council charter, where the exact balance of interests governing land use can truly reflect all the players at the table. A successful watershed council establishes a "roadmap" to achieve a litany of goals benefiting participating stakeholders in Vadodara, including but not limited to: information sharing, water quality and stream health monitoring, coordination and cooperation, proposing and drafting water quality code, assisting in administering the permit system, and education about urban stormwater runoff best practices (Quesada 1999).

Example Watershed Council Name	Region	Notes
West Creek Preservation Committee	Ohio, Midwest, United States, North America	Citizen-centered group; highly-urbanized area.
African Network for River Basin Organizations (ANBO)	River/Lake Basins, Africa (entire continent)	Relationships established between governments, serves as advisory body to study and report on matters of water resources.
Red Thai Binh River Basin Planning Management Board	Hanoi, Vietnam, Asia	Manages basin-level water resources and planning; provincial people's committees, water resource ministries, coordinates with related agencies.
Azerbaijan Amelioration and Water Farm Joint Stock Company (OJSC)	Baku, Azerbaijan, Southwest Asia	Main institute responsible for watering, sanitization. President appointed by President of Azerbaijan.
Huron River Watershed Council (HRWC)	Ann Arbor, Michigan United States, North America	Coalition of governments, businesses, and volunteers dedicated to protecting, sustaining, and rehabilitating the Huron River system.

Table Sources:
AARC Corporation (1997). *Source Book on AWRB*. www.inbo-news.org/IMG/pdf/AWRB_Source_Book-2.pdf. Accessed 17 Apr. 2017.
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Appointment of a Stormwater Management Deputy at the Vadodara Municipal Corporation
Integrating a watershed council in VMC's decisionmaking process would greatly benefit by appointing an Official City Stormwater Management Deputy position to oversee these relationships described above and build upon the strategies formulated by the representation there.

Stronger, more regular enforcement of the Water Act.

Furthermore, we must require enforcing agencies to expand monitoring and evaluation procedures to reduce data gaps and maintain performance records in peak monsoon flows. The Water Act's amendments, which empower citizens, should be re-defined to promote stormwater and sewersheds, standards and directive principles for their maintenance, as well as penalties for non-compliance. Under the Water Act, the State Control Board maintains significant regulatory power. However, we suggest that a newly established Watershed Council work as a research arm of the State to prevent conflicts arising out of discrepancies in the State and Union legislative terminologies. Policies should work to mitigate the risks posed to residents through stormwater management.

Information could be provided to the central and state control board representatives, as well as the local government. This "top down" solution may provide a monitoring system to observe the quality and volume of water entering the system. The system might function like a yearly inspection, where the purpose would be to record stormwater activity city-wide to allow for better management practices at strategic shoreline sites. An indirect benefit of provide water quality testing could be to benefit "citizen science" initiatives. A city-wide educational program could simultaneously grow general awareness about the functioning ecology of the river.

CONCLUSION

The conceptual framework presented here offers an alternative approach to flood management than the VRDP. By engaging with the negative impacts of development in the wider catchment of the river, rather than focusing on flooding within the channel itself, the city can take a holistic approach to growth and development.

Vadodara has the opportunity to be on the cutting edge if it prioritizes green infrastructure in every current and future urban project. The variety of benefits of this approach, such as the creation of greenspace and unique design opportunities for local designers, offer an exciting vision of Vadodara's future.

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IMAGE REFERENCES

All images taken by team members May-June 2016 unless otherwise noted.

P1: Google Earth Pro (2016)

P2: Google Earth Pro (2016)

P3: Google Earth Pro (2016)

P4: http://68.media.tumblr.com/e0cfbdc073d4168c24025c249c68db03/tumblr_inline_ntsjuexKDH1r61yk6_500.jpg

P5: Google Earth Pro (2016)

P6: https://maps.mapmyindia.com/place/original-N0000180899.jpg

P7: Google Earth Pro (2016)

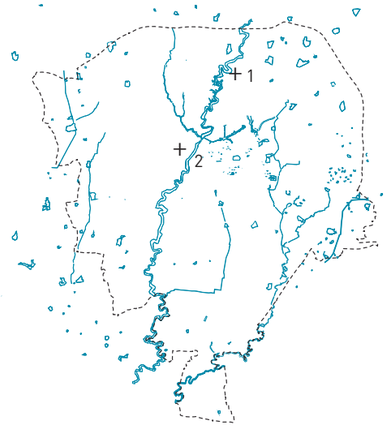
P8: http://s2.firstpost.in/wp-content/uploads/2014/09/floods-Surat-PTI2.jpg

P9: http://photos.wikimapia.org/p/00/03/15/27/76_big.jpg

INSIDE THE VRDP INFLUENCE ZONE

1 View within the Influence Zone,
Sama - Savali, Vadodara, 2016

2 View within the Influence Zone,
Sayajigunj Vadodara, 2016
Source - Dhrumil Kantharia



Addressing the urban stream syndrome, specifically stormwater impacts, would require wide application of interventions aimed at changing the hydraulically efficient drainage system in urban catchments (Walsh et al., 2005).

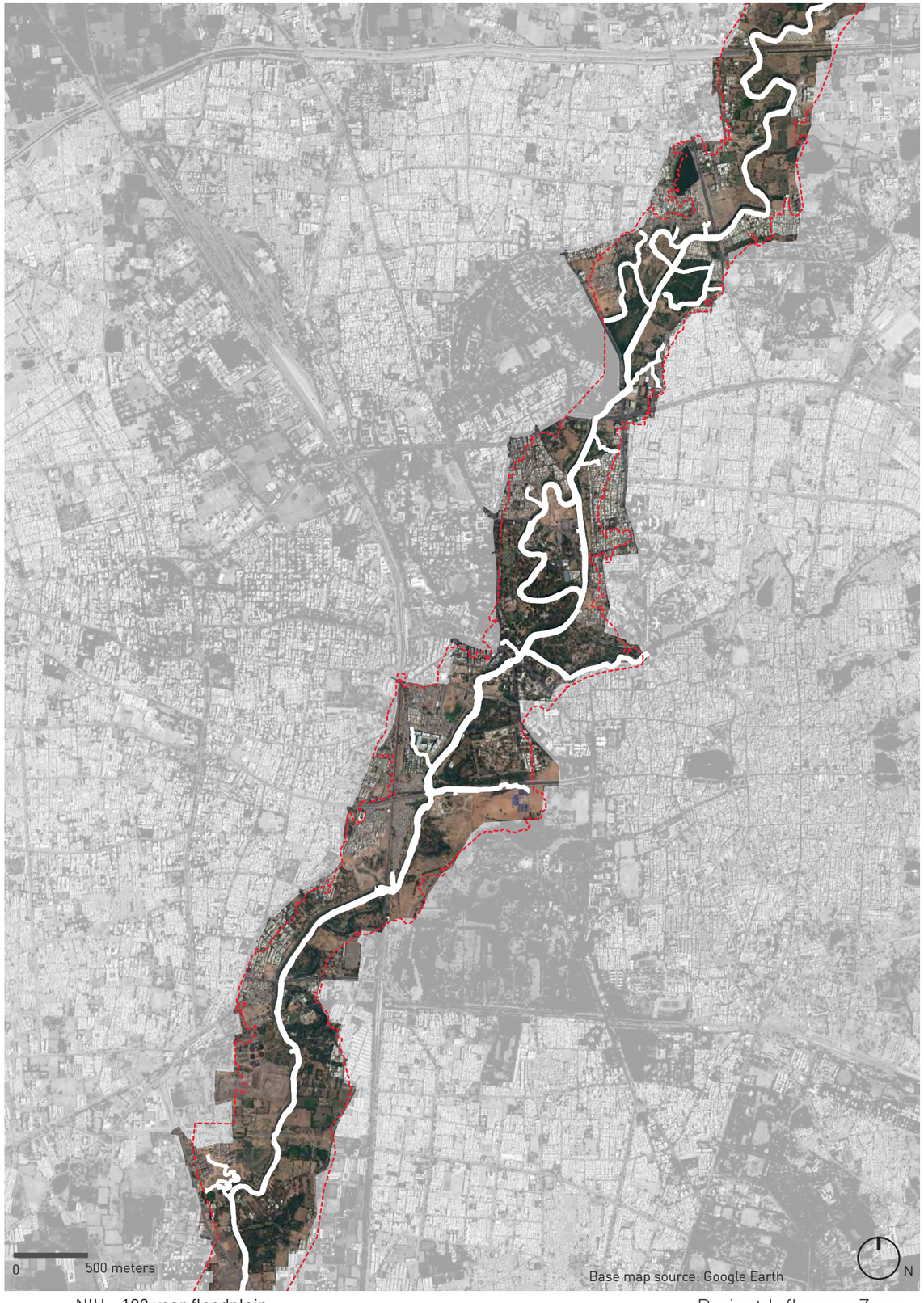
In an integrative manner, following the upper-watershed restoration and based on the city-scale stormwater management framework, we drill down to interventions at a finer scale that corresponds to the VRDP project extent, or what is referred to as the project influence zone.

The urban stretch of the river Vishwamitri lies within the Influence Zone. According to the project proposal, the Influence Zone was defined with an average width of 500m, or extending up to a major road along the river. Starting in the north from the national highway (NH8) to 500m beyond the Ring Road in the southern portion of the city, the entire Influence Zone covers approximately 1000 ha (VRDP Feasibility Report, 21 October 2014, pg 26), representing around 7% of the total area of the city (VMC, 2007). This area corresponds roughly to the estimated floodplain from the NIH making it a shoreline site within our City Scale urban stormwater management framework (see map to the right). Since the City Scale framework aims to prevent water beyond the floodplain from entering the river channel through gray infrastructure, we have more capacity within the floodplain to handle floodwater flowing through the channel itself. For this reason, the highest priority for flood mitigation in this area of the city is the preservation, restoration, and enhancement of temporary storage capacity (Hill 2009). Fundamentally, this is the opposite of the VRDP, which seeks to reclaim riverbank for development, fill the deep ravines of the kaans and nullahs which act as natural flood storage, disconnect the river from oxbow lakes, and permanently fill the river channel with water from STPs and other streams. In this section, we propose a series of green infrastructure interventions according to this shoreline typology. While our City Scale typologies tell us how to manage the site hydrologically, a good ecological designer knows that the best green infrastructure is multifunctional - providing ecological benefits, as well as benefits for the economy, wildlife, and human well-being.

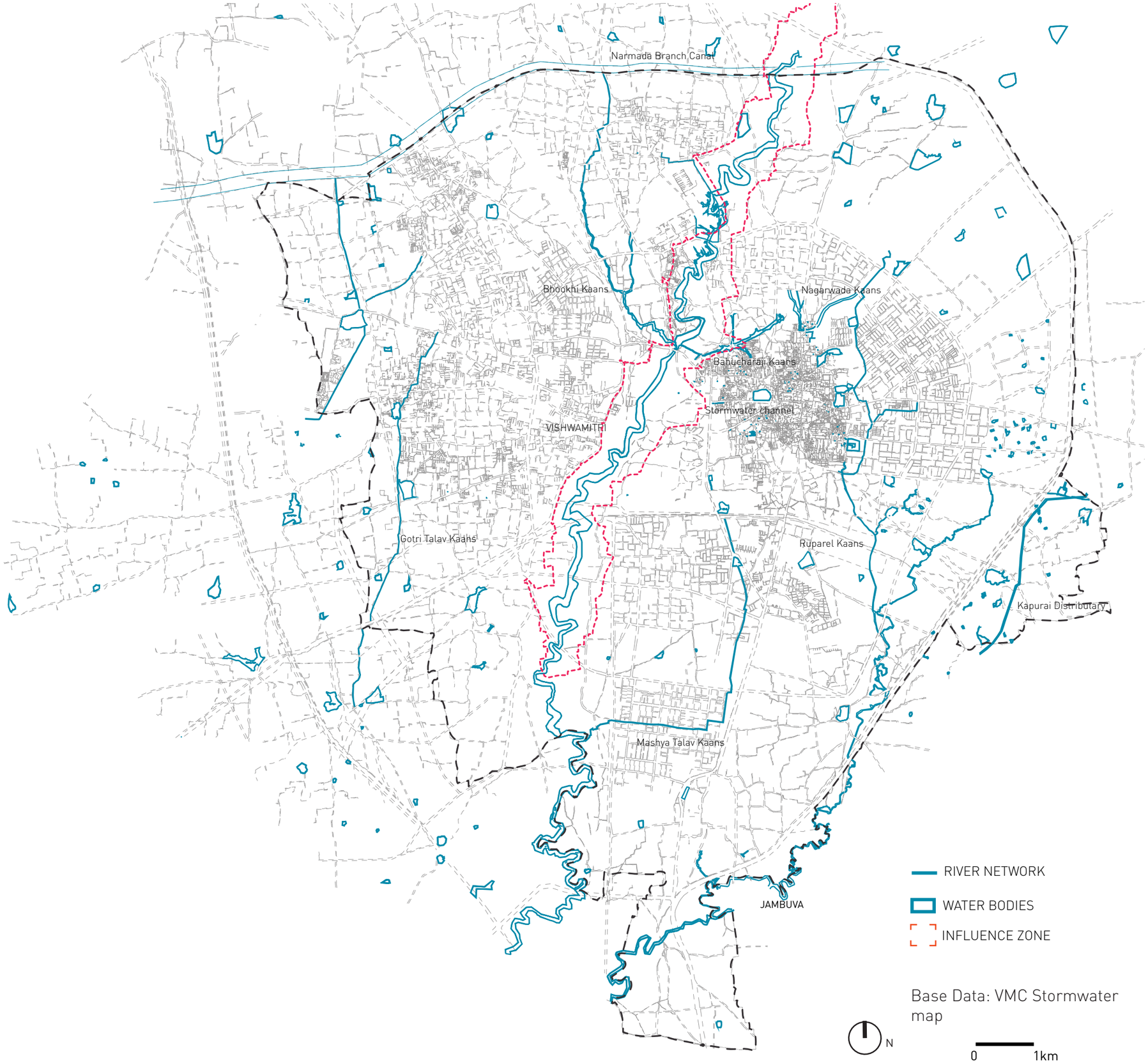
The VRDP's engineered approach prioritizes economic development in the Influence Zone with a design that is not unique to Vadodara. But we ask the question: why should Vadodara emulate when it can create? Our alternative relies on the spirit of the city to inform a multifunctional, Vishwamitri-specific design. The primary goal within the Influence Zone is to enhance the riverbank into a unique, multifunctional regional asset that will stay true to Vadodara's identity as the cultural capital of Gujarat. Many cities have concretized riverfronts, but few have lush, dynamic riverfronts offering wild urban adventures. Our design capitalizes on Vishwamitri as a unique asset that can attract new residents and tourists alike.

Despite our critique of the VRDP, government efforts facilitated the collection of a range of data for the Influence Zone, which allowed us to analyze the flooding issue in specific spatial contexts and propose place-based interventions.

The following section details our alternative design for the VRDP Influence Zone. We first present the overarching goals that underlie the entire design at this scale, building upon and echoing the proposed interventions of the Upper Watershed and the stormwater management framework of the City Scale. We then analyze the current conditions and existing challenges faced in the Influence Zone from three aspects: the river system, biological conditions, and land use. Following an illustrated description of our master plan, we dive into detailed discussions of three close-up designs representing three distinct existing land use scenarios. By side-by-side comparison with the VRDP, we dissect the concerns associated with the proposed development in VRDP, and explain how our alternative addresses those concerns and adds layers of multifunctional benefits.



Project Influence Zone
Base Data: VMC Survey



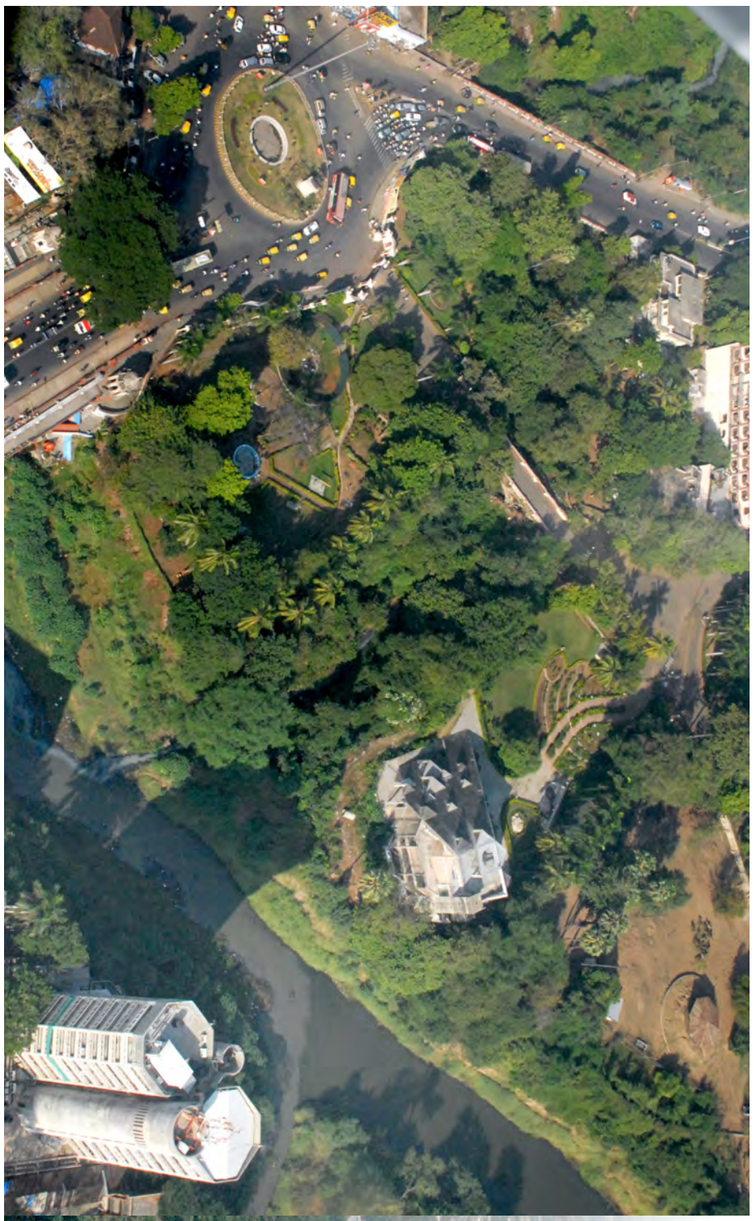
SITE CONTEXT AND ANALYSIS

Originating in the Pavagadh hills, the Vishwamitri river flows southwest through the city of Vadodara and meets the Dhadhar river at Pingalwada.

The major tributaries of Vishwamitri are the Surya river, which joins Vishwamitri north of the city, and the Jambua river, which flows in beyond the southern extent of the urban area.

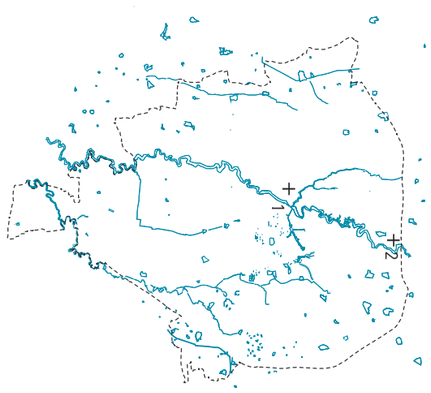
Within the project influence zone, the Vishwamitri river system includes the Narmada Branch Canal in the north, Sama Lake, Bhim talav and two tributaries, namely Bhookhi and Bhaucharji nallas (VRDP, pg 45 and 77)

ANALYSIS - RIVER SYSTEM

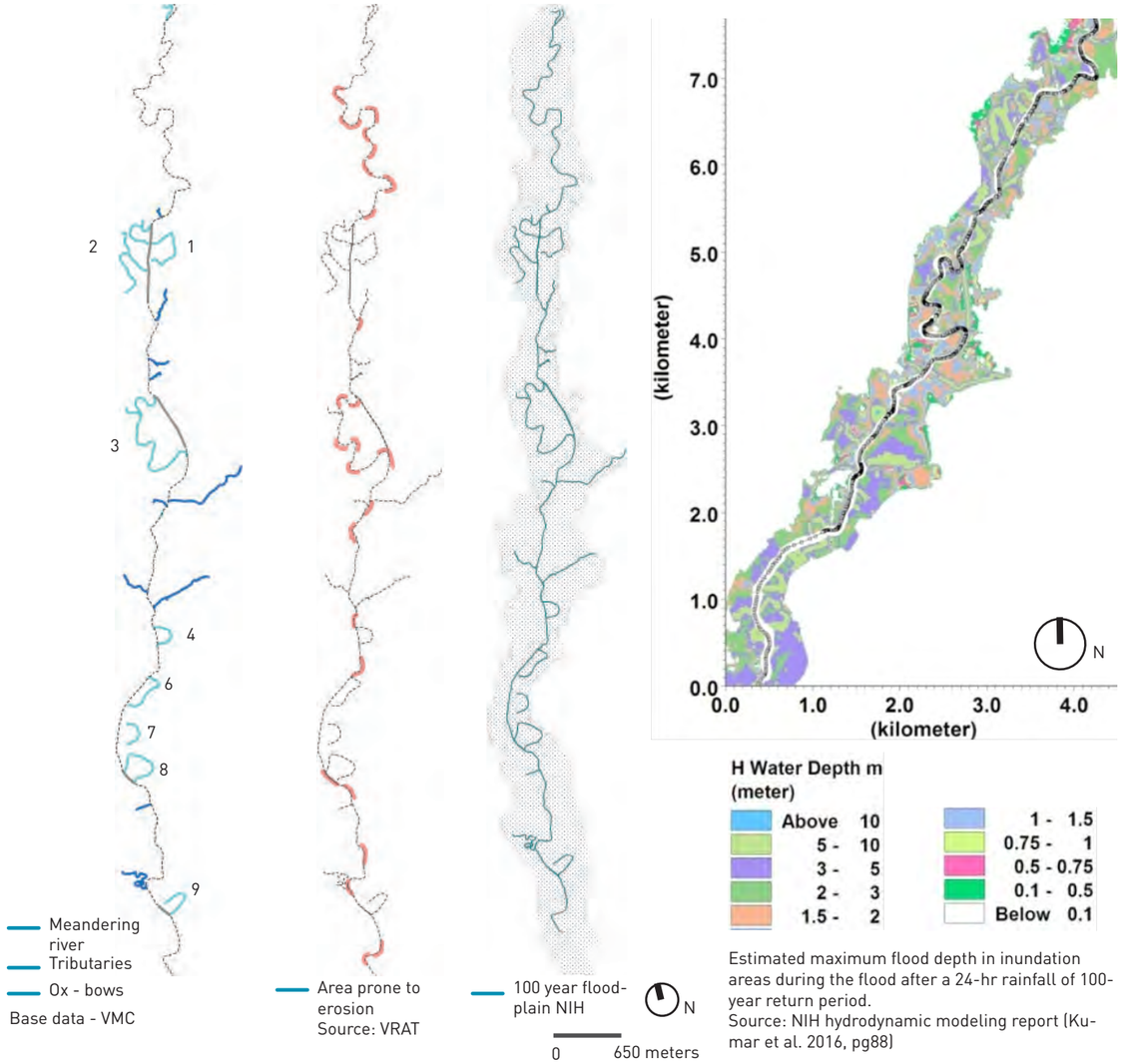


1

View within the Influence Zone,
Kalaghoda circle -2008
Source: VMC



2 View within the Influence Zone,
Sama Narmada canal area, 2008
Source : VMC



Estimated maximum flood depth in inundation areas during the flood after a 24-hr rainfall of 100-year return period.
Source: NIH hydrodynamic modeling report (Kumar et al. 2016, pg88)

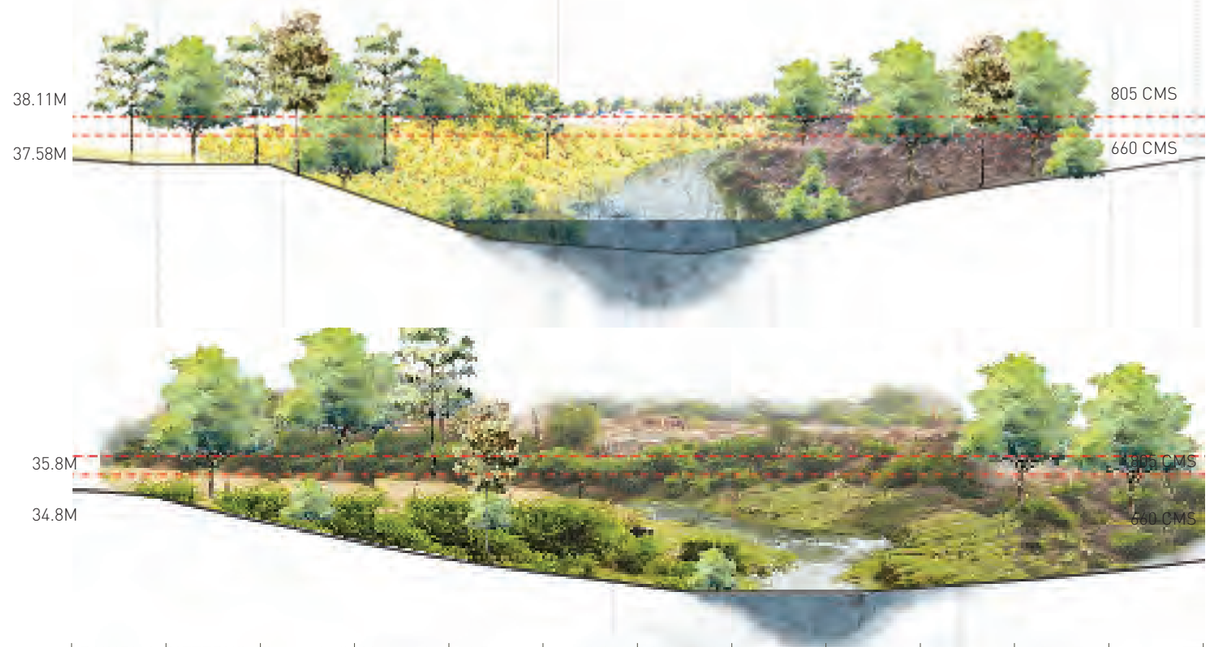
RIVER SYSTEM

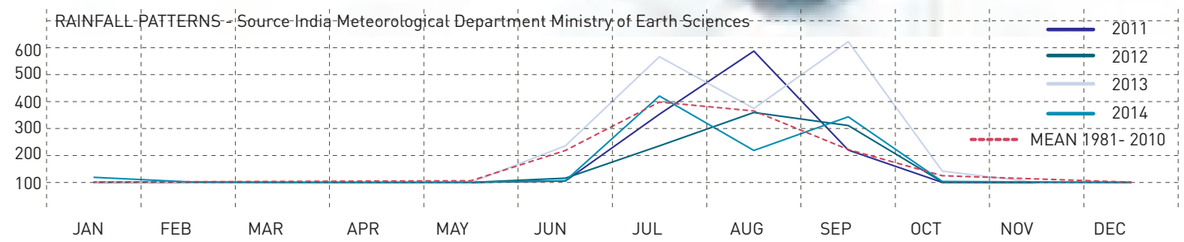
MORPHOLOGY AND BANK EROSION

The urban corridor of Vishwamitri features an array of tributaries, meanders, and oxbows that reveal its dynamism. Some segments of the river have been straightened for development and flood control. Diversion channels were built to bypass sections of the meandering corridor and expedite floodwater discharge. This, in addition to natural processes, has led to the creation of oxbow lakes. Additionally, meanders and oxbow lakes are lost due to poor management and garbage dumping in the channel (VRDP Feasibility Report, 21 October 2014, pg 77).

The Vishwamitri river channel is narrow and deeply incised. During the dry season, the river cross-section varies in width from 60 to 130m, while the channel only varies between 15 and 40m (VRDP Feasibility Report, 2014, pg 78). A 2004 survey found that in several places the ravines of Vishwamitri are up to 15 m deep (Raj et al. 2004). The ongoing development in the floodplain and an increase in impervious surfaces throughout the city could most likely aggravate bank erosion along the Vishwamitri (Map above). Currently, approximately 6.3 ton/ha of soil is eroded from the Vishwamitri watershed in Vadodara on an annual basis (Pancholi et al. 2015).

WATER LEVEL FLUCTUATIONS FOR RAINFALL CAUSING FLOODS IN 2005 AND 2006
Base data - NIH hydrodynamic modeling report (Kumar et al. 2016)



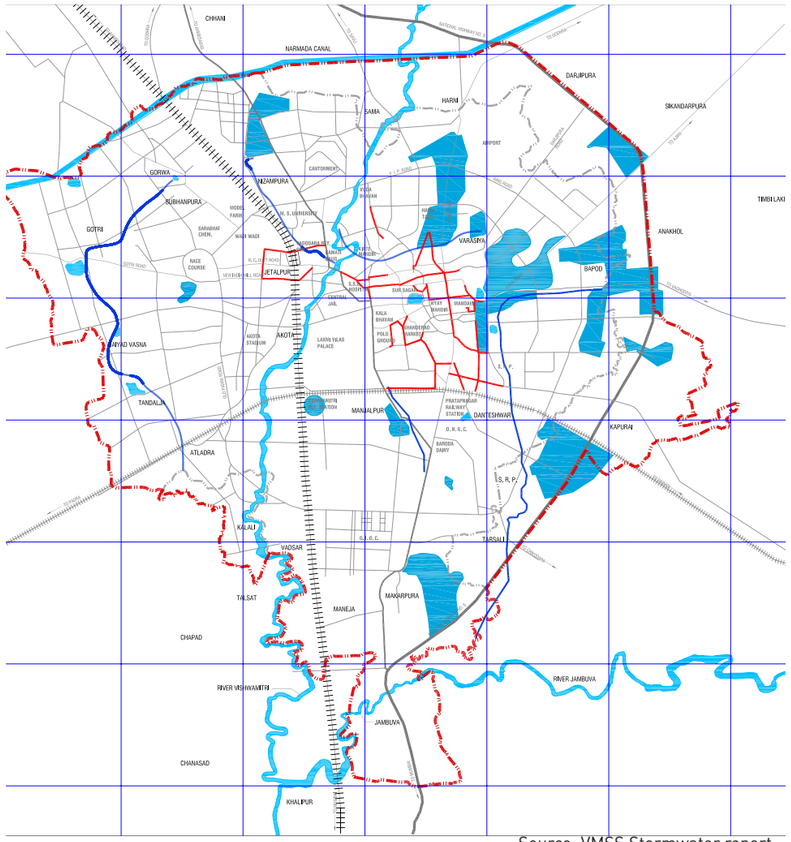


RIVER SYSTEM

HYDROLOGIC CONDITIONS

As a seasonal river, water levels in Vishwamitri fluctuate throughout the year. Baseflow ceases outside of the monsoon season, which spans from mid-June to mid-September (Rainfall patterns graph above). The daily maximum rainfall values in the Vadodara region for 25, 50, and 100 year return period were estimated as 284.20, 333.83, and 390.29 mm, respectively (Kumar et al. 2016, pg 51).Other than the monsoon season, water flowing in the channel is primarily discharge from sewage treatment plants (STPS), other stormwater, sewage or industrial effluents (VRDP Feasibility Report, 2014, pg 55).

During the dry period, the Vishwamitri river receives a baseflow of 10.95 m3/s from the Vadodara sub-basin in its direct adjacency (Kumar et al. 2016, pg 54). During the monsoon, the water level rises up after continuous rainfall and can overflow the banks during heavy storm events (Figure above), causing flooding in low-lying areas of the Influence zone (Figure left. While flooding is a natural process, encroachment in the floodplain leads to inundation, which is exacerbated by land use changes in the upper watershed and the volume of water efficiently funnelled into the channel by gray infrastructure within Vadodara. Based on hydrodynamic modelling performed by the Indian National Institute of Hydrology (Kumar et al. 2016, pg 85 and 88), under current conditions, a flood following a 24-hr rainfall event of a 100-year return interval (an event with 1% probability of occurrence in any given year), with a discharge of 2198.26 m3/s, can result in the inundation of a significant portion of the Influence zone by water deeper than 2 m. Inundation is more severe in the lower portion of the floodplain, where the water is deeper(NIH Map).

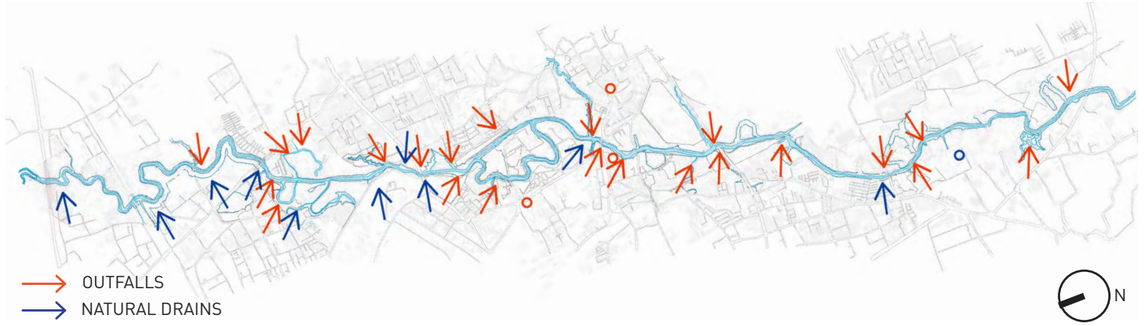


Source: VMSS Stormwater report

The highest recorded flood in Vadodara occurred in 2005, when more than 350 mm of rainfall occurred within 24 hours resulting in a discharge of 805 m3/s. Thirty thousand people had to be evacuated due to this flood (The Hindu, 2005; VRDP Feasibility Report, 2014, pg 39). Similar high flood levels were observed in the following years of 2006, 2013, and 2014. In 2014, a flood with an estimated discharge of 720 m3/s raised the river level to 34.37m, exceeding the bank heights for more than half of the entire stretch within Vadodara (Sections pg 12) (VRDP Feasibility Report, 2014, pg 38). As a result, over 20,000 residents of Vadodara had to be moved to safety (Times of India, 2014).

In our critique of the VRDP, we questioned their use of a 50-year return interval for the riverfront structure design and choice of the 2006 flood as their design flood level (see Appendix 2). This choice seems inadequate given the reality of climate change (see Appendix 1, section 14: Consideration of Climate Change). Due to increases in intensity of weather, it is likely that a flood of higher magnitude will occur in the future. In this way, designing management strategies that are "safe-to-fail" [1] are critical (Aherns 2011). To this effect, out alternative interventions are based on floodplain estimate corresponding to the 24-hr rainfall event of a 100-year return interval and would offer a greater level of protection to the city and its people.

1-A "safe-to-fail" system, versus a static "fail-safe" system, "anticipates failures and designs systems strategically that failure is contained and minimized" (Aherns 2011, pg. 2)



RIVER SYSTEM

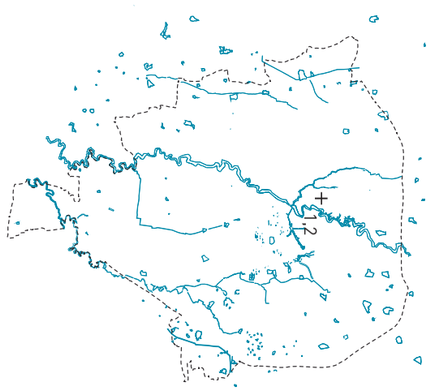
WATER QUALITY

The urban corridor of Vishwamitri is heavily polluted. As the river enters the city from the north, it encounters pollutants including raw and partially-treated sewage, urban stormwater runoff, and industrial effluent. In contrast, the water quality in the river is relatively clean upstream of Vadodara (Vyas et al. 2014). The city generates around 215 millions liters of domestic sewage per day (MLD), out of which only 180 MLD is treated at STPs (Vyas et al. 2014). As reported by the VMC, roughly 40% of the city is covered by the sanitary sewerage network, an underground drainage system in place since 1894. Many areas remain underserved, with the untreated wastewater flowing into depressions, open drains, and nallas in the city (Vyas et al. 2014). The VRDP proposes additional STPs and expanded tertiary treatment at existing STPs, something our proposal fully embraces as a necessary measure for improved water quality. In addition, insufficient treatment is given to the industrial sources, which are responsible for 20-25 MLD of discharge. Many small scale industries located in residential areas generate wastewater, releasing their effluent into the domestic sewerage system that is not capable of treating industrial pollutants (Vyas et al. 2014). Garbage and construction debris are also dumped along the river, leading to solid waste accumulation along the banks of the river, especially during the monsoon (VRDP Feasibility Report, 2014, pg 56).

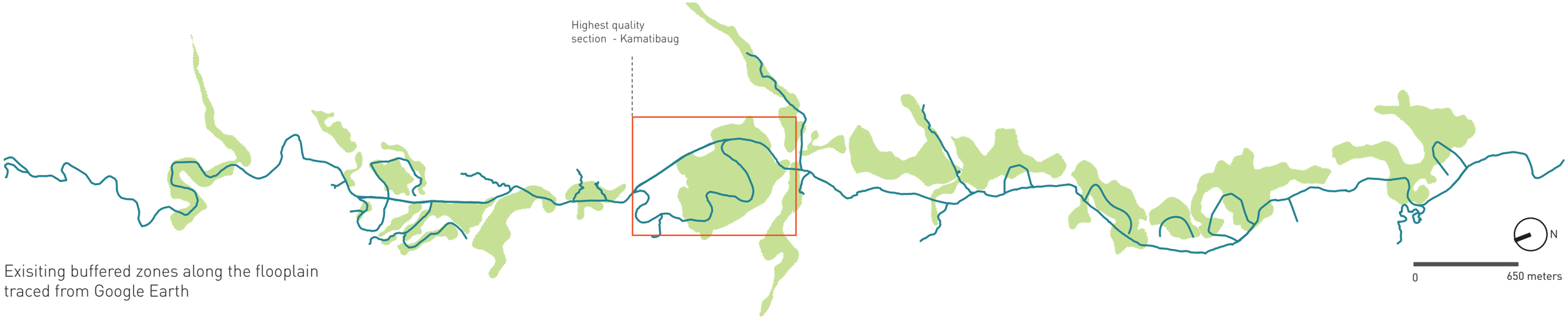
A water quality study done by Gujarat Engineering Research Institute in 2014 found that the Vishwamitri typically has water quality below desired level for designated best use (Vyas et al. 2014). The urban stretch of Vishwamitri is heavily polluted by domestic and industrial sources, is characterized by high bacterial populations, cloudy appearance, high biological oxygen demand, strong odor, and low dissolved oxygen. Masses of sludge have settled at the bottom of the river, and regularly rise up and float on the surface of the river. Furthermore, the trapped noxious gasses bubble up as crocodiles walk along the river bottom. The extremely high load of organic matter in the river depletes dissolved oxygen and lead to the low levels of aquatic life (Vyas et al. 2014). The level of contamination combined with high levels of sedimentation from erosion magnify each other's effects (Burton & Pitt 2005). Because contaminants bind to sediment, it is not feasible to remove pollution from the river entirely. However, we can work to reduce future inputs through water quality standards and the strategies presented in the Upper Watershed and City Scale sections of this Design Report.

ANALYSIS- BIOLOGICAL CONDITIONS

1 View within the Influence Zone,
Sayajibaug tiger and lion cage, 2008
Source : VMC



2 View within the Influence Zone.
Sayajibaug zoo bird section, 2008
Source : VMC



Exisiting buffered zones along the flooplain
traced from Google Earth

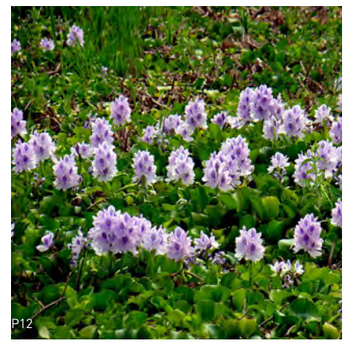
Hypaene dichotoma

Pithecellobium dulce

Pongamia glabra

Achyranthes aspera

Tridax procumbens



Eicchornia crassipes

Ipomea aquatica

BIOLOGICAL CONDITIONS

FLORA

The structure of the vegetation along the banks of the Vishwamitri River can be categorized into three classes: the canopy (upper storey), the understory (middle storey) and the lowermost vegetation (lower story) (Chavan and Sabnis, 1960). It is important to understand that the canopy and understory species are for the most part, perennial, whereas the lowermost vegetation is ephemeral, lasting for a few months of the year. This is due to the fact that the river floods very often, and the vegetation closest to the surface die during the floods.

According to a text published by Chavan and Sabris in 1960, there were 151 species in 45 families, along the banks of the river. Of these, 35 were woody perennial trees or shrubs which form the canopy. Some of the common species are ***Acacia arabica*** (Baval), ***Streblus asper*** (Dahia), ***Pithecellobium dulce*** (Gorasamli), ***Pongamia glabra*** (Karanja) and ***Borassus flabellifer*** (Tad) (Chavan and Sabnis, 1960). A study done in 2002 by S. Dhuru mentions 138 species in 44 families along the stretch of the river within the Influence Zone, and introduces an invasive species that has become a nuisance, ***Prosopis juliflora*** (Gando baval). A very valuable species, categorized as near threatened by the IUCN also exists, ***Hypaene dichotoma*** (Raavan tad). The vegetation in the understory consists of 40 species, which are not subject to a lot of changes and are edaphic. Some of the species which are present along the banks are ***Xanthium strumarium*** (Gadarium), ***Argemone mexicana*** (Darudi), ***Tridax procumbens*** (Pardesi Bhangro) and ***Achyranthes aspera*** (Safed aghedo). The lowermost vegetation is controlled almost entirely by the presence of water and the water currents.

During the winter and the dry months, when the water level is the minimum, some of the commonly found species are ***Alternanthera sessilis*** (Panini bhaji), ***Sphaeranthus indicus*** (Bodiyo Kalhar), ***Nicotiana plumbaginifolia*** (Jungli tumbaku), ***Ipomea aquatica*** (Kamli saag) and ***Eicchornia crassipes*** (Jal kumbhi).

The presence of certain species of vegetation can provide certain information about the condition and quality of the soil and water. For example, our team witnessed certain portions of the river, especially near outfalls and the open dumping sites which were eutrophic. The surface of the water was covered by ***Eicchornia crassipes***, an indication of excess nutrients. Recent activities on the banks by the government such as widening of the river and construction of embankments cause serious damage to the flora: not only do perennials and canopy species die, but it also makes the landscape susceptible to invasives such as Prosopis juliflora. Another threat to the vegetation is overgrazing, due to the presence of cattle. At some places only spiny plants like ***Argemone mexicana*** and ***Solanum xanthocarpum*** are present, which indicate overgrazing (Chavan and Sabnis 1960).

The highest quality section of the riverbank in terms of biodiversity and abundance (visually estimated due to the presence of crocodiles; least disturbance from human activities) is located along the Vishwamitri as it flows through Kamati Baug, the largest public park in Vadodara. This area was essentially preserved with the establishment of Kamati Baug as a park, a gift from the Maharaja Sayajirao to the city. This stretch of the urban corridor is ideal to use as a reference condition as we work to restore the riverbanks of Vishwamitri.

Areas where crocodiles are frequently spotted surrounded by city landuse

Crocodile nesting habitat - base data source: VRAT

Water buffaloes wading in the river

Crocodiles in the river

Crocodiles burrows

Crocodiles escaping flood waters

BIOLOGICAL CONDITIONS:

FAUNA

In spite of the poor water quality relative to other rivers in central Gujarat (Vyas 2013b), the riparian ecosystem within the city is habitat for numerous species of invertebrates, birds, mammals, and reptiles. The ecosystem supports 59 species of rotifers, 3 species of mollusks, 4 species of annelids, 63 species of arthropods, 14 species of arachnids, 2 species of fish, 5 species of amphibians, 9 reptilian species, 77 species of birds and 8 species of mammals (Dhuru 2002).

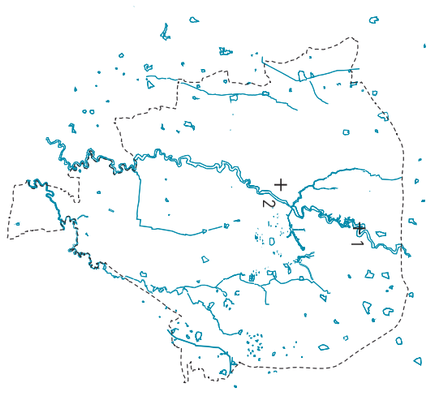
Certain species, such as leopards, sloth bears, and nilgai, which are present in the upper watershed, are absent in the urban corridor. However, the urban corridor is home to mugger crocodiles (***Crocodylus palustris***) and the Indian softshell Turtle (***Nilssonia gangetica***); both of these species have been classified as vulnerable by the IUCN (Choudhary and de Silva 2013; Asian Turtle Trade Working Group 2016). It is reasonable to assume that, with improved habitat quality, other species could be attracted to Vishwamitri. For example, the Sarus crane (***Antigone antigone***) has been spotted along the banks of Vatrak River near Kheda, a mere 85 km from Vadodara (Vyas 2013b).

Despite the low habitat quality that Vishwamitri offers, it is one of India's few rivers where the mugger crocodile has thrived in the wild for decades (personal communication with Dr. Raju Vyas, Vyas 2010). Muggers thrive in Vishwamitri precisely because the lack of concrete channelization allows them to dig dens. The latest count indicated over 250 individual muggers make their home in the VRDP Influence Zone alone (Vyas 2013a), let alone in upstream reaches of Vishwamitri. Certain portions of the river, such as within Kamati Baug, have a higher number of crocodiles. There are a couple of reasons for this: a) as mentioned, this stretch is relatively undisturbed, providing better nesting and breeding habitat b) there is often leftover meat and bones from the zoo, located in Kamati Baug, which is dropped into the river from a bridge in Kamati baug, which attracts the crocodiles (personal communication with Dr. Raju Vyas and staff inside Kamati Baug).

Some commonly found birds are ***Corvus splendens*** (House crow), ***Corvus macrorynchos*** (Jungle crow), ***Halcyon smyrnensis*** (White-breasted kingfisher), ***Centropus sinensis*** (Coucal), ***Pavo cristatus*** (Common indian peafowl) and ***Milvus migrans*** (Common kite). Commonly found mammals are ***Presbytes entellus*** (Hanuman langur) and domesticated species such as ***Bubalus bubalis*** (Water buffalo) and feral dogs.

1

View within the Influence Zone,
Sama - Savali, Vadodara, 2008
Source: VMC



2 View within the Influence Zone,
Bhimnath bridge, 2016
Source - Dhrumil Kantharia

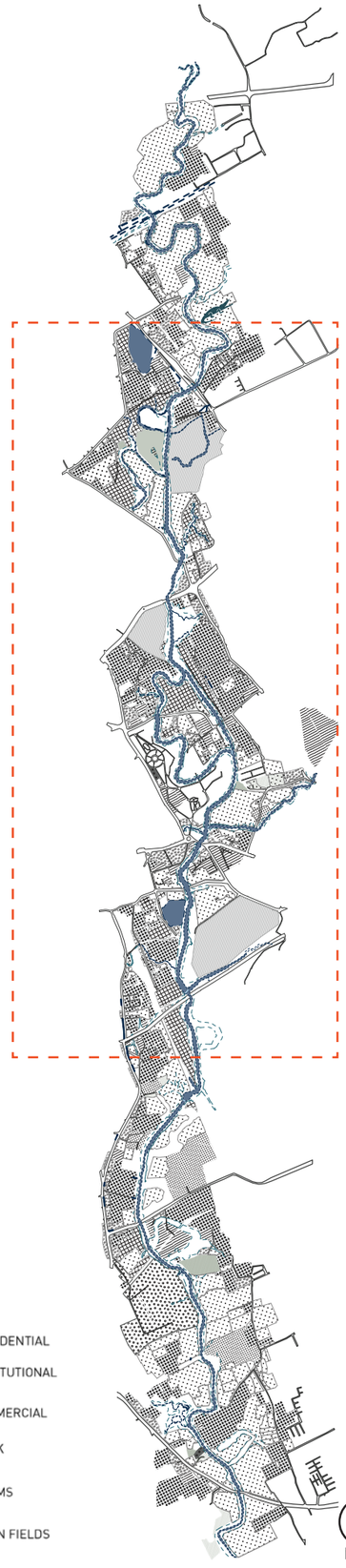
LAND USE

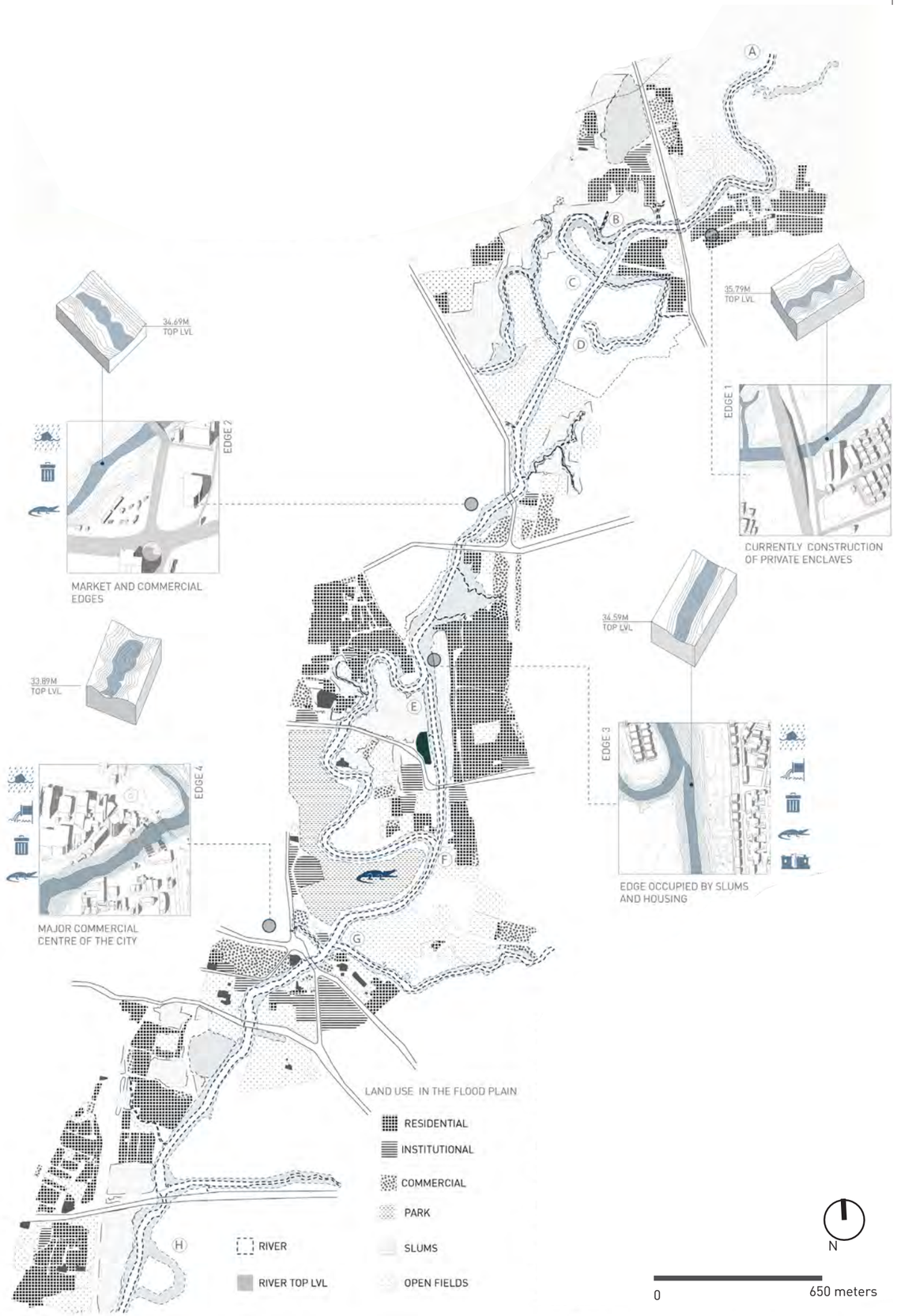
There are a variety of land uses along the Vishwamitri (see map for VRDP Feasibility Report below). Beyond Sama Lake to the north and Munjhmahuada Bridge to the south, agriculture dominates, though these areas are targeted for development as per the city's proposed land use map for 2031 (VRDP Feasibility Report, 21 October 2014, pg 48). Residential areas make up a significant portion of the existing land use in the Influence Zone. These are currently expanding, in spite of flooding issues, and are expected to expand if the city pursues a VRDP-like pathway. Commercial parcels can also be found along the river, concentrated in the central segment of the Influence Zone where diverse land uses coexist.

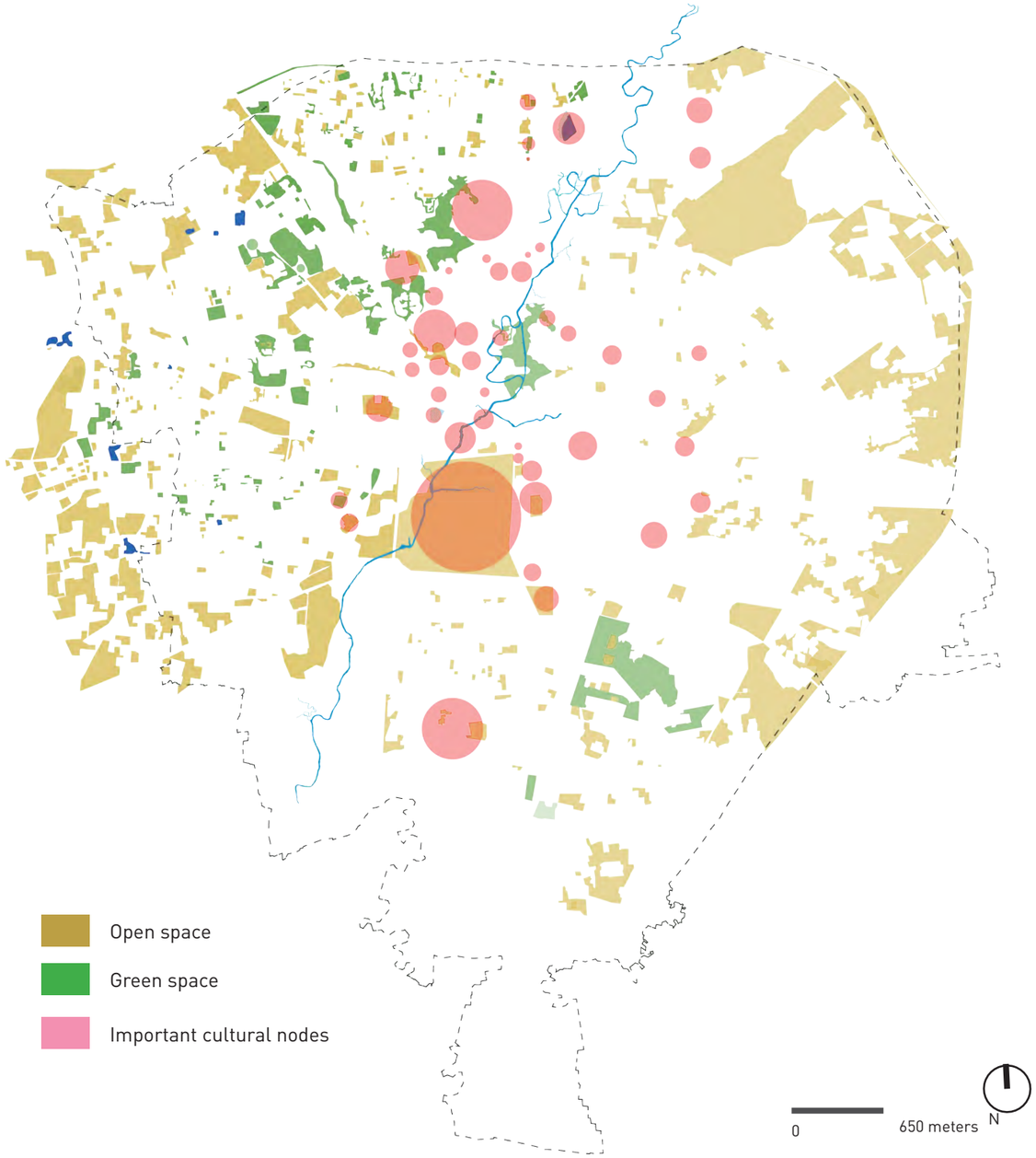
Areas in between have seen urban expansion with residential development coming up on both sides of the river. The central stretch from Sayaji Baug to Bhim Talav is the city's most busy area where a number of landuses come together. It houses the two main entry nodes to the city the railway station and the bus stop . Institutional and public uses like the university, city museum, city parks etc make it an area frequented by people from both within and outside the city. South of the Bhim Talav, the vast Palace grounds lie on the east bank of the river, recalling the city's history. Higher quality habitats and ecosystems are present in the EME army cantonment area and the oxbows directly to its north, as well as within Sayaji Baug, the oldest and most beloved green space in the city.

Other significant land uses along the river include two STPs, temples, cemeteries, and informal settlements. According to draft report of "Slum Free City Action Plan", about 58.8 hectares, or 32% of the total 185 hectares, of informal settlements exist in the Influence Zone with an approximate population of 100,000 (VRDP Feasibility Report, 21 October 2014, pg 58). However, many of these have been razed in anticipation of the VRDP.

At multiple locations, residential and/or commercial developments are situated extremely close to the main reach of Vishwamitri. Given that roughly the entire Influence Zone overlaps the 100-year floodplain, extreme monsoons pose a serious threat to both human safety and property within the Influence Zone. Anecdotally, our team learned that residential developments on the outskirts of the city, all of which are encroaching the floodplain in anticipation of the VRDP, experience serious flooding during the monsoon, often up to the level of countertops first floor.








Bhimnath bridge


Jubilee baug

Source:
Government feasibility report - HCP

GREENSPACE AND RECREATION

In a city of 2 million, every public space is used to capacity. From early morning laughing clubs to architecture students sketching for class, most public parks (often called gardens), are full to the brim for a majority of the day. The largest public space in the Influence Zone, and Vadodara in general, is Sayaji Baug. The garden is 25 hectares of programming (VRDP Feasibility Report, 21 October 2014, pg 76), including a train, walking paths, a planetarium, and a zoo. Even people from outside the city travel to Vadodara just to visit Sayaji Baug. Because it is directly along the river, Sayaji Baug experiences flooding. A walk into the planetarium, 20 meters from the water's edge, reveals high water marks taller than our tallest group member (over 6 feet).

While there are other, smaller public gardens scattered throughout the city, they are not evenly distributed. Another large patch of urban forest, is the army cantonment. Although access is restricted to monitor public access, it likely provides habitat for a variety of species within the urban matrix.

Physical access to the riverbanks of Vishwamitri is limited. Observations throughout our time in Vadodara indicate that the most common relationship between a citizen of Vadodara and the river is on a bridge. While these may seem like unlikely places to spend time in light of heavy traffic, we routinely saw people pull over on a busy bridge to look at the river, search for crocodiles, or chat with a friend.

Informal settlements at Kalyan Nagar in 2014

Existing landuse at Kalyan Nagar , 2016

Informal settlements at Sama in 2014

Existing landuse at Sama, 2016

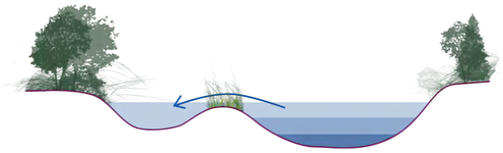
Satellite images source: Google Earth

INFORMAL SETTLEMENTS

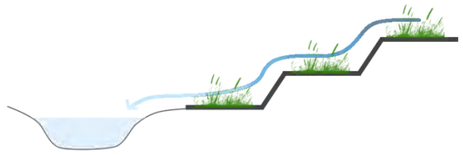
Vadodara has numerous informal settlements, referred to as slums by the VRDP (VRDP Feasibility Report, 21 October 2014, pg 58), which are spread throughout the city. A third, or about 58.8 ha fall within the project Influence Zone. As many as 100,000 people used to live in these areas. There are as many as 51 informal settlements, however most of them have been established close to each other forming slum pockets. Some of the largest pockets are situated to the south of Sama Lake and to the north of Sayaji Baug.

The VMC has also mentioned the Slum Free City Action Plan, which aims at either redeveloping, in-situ upgradation or relocation of these areas. Reports mention that the plan was initiated as early as 2011 (The Times of India, 2009) and residents expressed their disapproval through protests outside the VMC office (The Times of India, 2009). In certain locations, prominent builders hope to construct malls in cleared areas, along the river (The Indian Express, 2016) (insert map).

Informal interviews conducted with residents revealed how life along the Vishwamitri has changed over the years. Activities such as washing clothes, fetching water for livestock, etc. were daily activities. However, with the increase in pollution, these activities have virtually ceased. People have been living in these settlements for decades. While some areas have seen improvements in sanitation and access to utilities over the years, as these settlements are razed, people lose access to these basic amenities (The Indian Express, 2016). In some cases, people have not been provided alternative housing (NDTV, 2015). There is a need for affordable housing, but the challenge of where to incorporate it equitably has yet to be met. In the name of the Vishwamitri Riverfront Development Project the government has razed down a number of informal settlements along the area without a social impact study or suitable plans of rehabilitation.



1) To mitigate flood risks through sound stormwater management:



2) To improve water quality of the Vishwamitri river:

3) To improve habitat quality while minimizing human-animal conflict:

4) To maximize the potential for multifunctionality:

INFLUENCE ZONE DESIGN GOALS

In light of this understanding of context, in addition to our understanding of the goals of the VRDP, we developed the following goals and objectives:

GOAL: To establish the Vishwamitri as the common thread of Vadodara's past, present, and future through ecologically-sound design that promotes the economic and social well-being of Vadodara's residents.

OBJECTIVES:

1) To mitigate flood risks through sound stormwater management:

Within our proposed city-wide stormwater management framework, the Influence Zone overlaps the floodplain and features network and shoreline sites based on Hill's stormwater typology (Hill, 2009). Immediate flood control interventions in the Influence Zone would aim to reduce the volume of water entering the river and delay the peak of floods through reducing connected impervious surfaces, creating temporary flood storage and promoting stormwater infiltration by vegetated buffer zones along the river.

2) To improve water quality of the Vishwamitri river:

Water quality issues related to sewage effluent and stormwater runoff currently prevent the river from being an attraction to Vadodara residents and visitors. Building on the VRDP's proposed sewage treatment plant upgradation, our design seeks to maximize the potential for bioremediation and targets stormwater pollutant infiltration and removal through creating vegetated buffer zones along the river.

3) To improve habitat quality while minimizing human-animal conflict:

The Vishwamitri river system sustains a diverse range of animal and plant species. The endangered mugger crocodiles are a unique asset of the city but the current river and riparian conditions are of poor habitat quality and lead to concerns of dreadful human-crocodile interactions. Another major goal of our influence design is thus to promote biodiversity and enhance the overall habitat quality along the river corridor while creating opportunities for safe human-animal interactions.

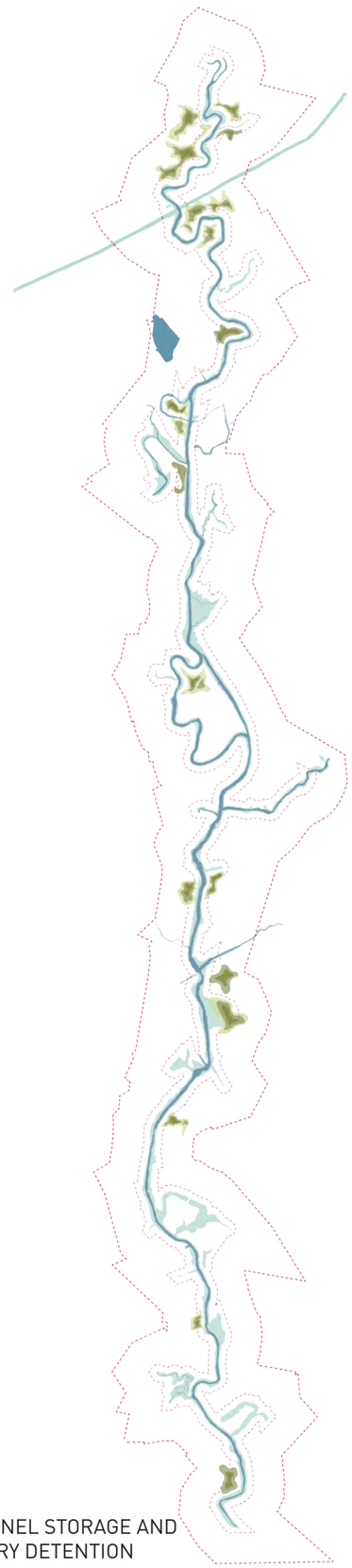
4) To maximize the potential for multifunctionality:

The Vishwamitri river is more than a water-conveying canal. It has, in a long history, nurtured the cultural development of the Vadodara city and will continue to shape the city's identify in the years to come. In the meantime, the river and its ever-changing state can influence the day-to-day life for city residents in one way or the other. With this complex fabric associated with the river in mind, we attempt to design our interventions in a way that creates additional benefits for the city and its people while achieving the above mentioned goals. These would include to enhance the cultural identify of the city, to create public health benefits, and to advance economic development that is both socially and environmentally sustainable.

BUFFER SYSTEM

0 650 meters

N



OFF CHANNEL STORAGE AND
TEMPORARY DETENTION

0 650 meters

N

OVERARCHING IDEAS

The Influence Zone has a diverse fabric made up of ever-changing river features (meanders, branches, and oxbows), in- and off-stream habitats, and various land uses along the river. A river restoration design for Vishwamitri will achieve the most effective and sustainable results by addressing the flooding and water quality issues

A. broadly, for the Influence Zone to realize its desired hydrologic and stormwater functions at the city and watershed scale, and

B. specifically responding to distinctive land uses that influence river processes at different locations along the river.

To do this, we propose two general measures to be implemented throughout the entire Influence Zone, which align with the floodplain management priorities based on our city-scale stormwater management framework.

1) OFF CHANNEL STORAGE AND TEMPORARY DETENTION

Due to the extent of the Influence Zone, overlapping the 100-year floodplain and extending temporary flood storage and increasing stormwater retention, the main priorities for flood control in the Influence Zone. As discussed in the City Scale framework for stormwater management and green infrastructure, simply addressing issues of flooding and water/habitat quality within the floodplain alone is not enough. Despite significant urban development across Vadodara, the city remains fortunate to have several large open spaces remaining along the river, which offer potentials for off-channel flood storage wetlands to be built. During high flows, water can be diverted from the main reach to be stored in those wetlands; in the following dry periods, stored water serves as a source to recharge groundwater and replenish the river.

At the same time, storage wetlands can improve water quality that has been adversely impacted by pollutants such as biochemical oxygen demand, metals, nutrients, organics, and sediments (Sanders, Pau, and Jaffe, 2006). Connected wetland and river system can substantially improve habitat quality and support various aquatic and terrestrial species. In an urban context, by creating moments of interaction in the form of trails, boardwalks, decks and etc., The off-channel storage wetlands can provide additional recreational and public health benefits. These structures are designed to be flooded, allowing the river to take its space during high flow events, and thus, the storage wetlands need to be closed in monsoon seasons to ensure the maximum level of human safety.

2) BUFFER SYSTEM

In most parts of the Influence Zone, though, existing development limits the possibility for building off-channel storage wetlands. In this case, we propose to maintain at least 50m of vegetative buffer wherever possible along the entire riparian corridor. The important role of riparian vegetation in controlling both stormwater quantity and quality has been well-documented. Vegetative buffers slow and spread incoming surface runoff, promote the infiltration and removal of soluble water pollutants, and trap sediment and sediment-bound pollutants (Lee et al., 2000). The vegetative buffers with those functions mentioned above are drastically different from the river edge types proposed by VRDP, which leave little space for plants to grow and inherently hinder nutrient and energy exchange between Vishwamitri and its riparian corridor by concretizing the entire river reach (see Critique). On the contrary, we propose to preserve the native vegetation currently in the riparian corridor and enhance the buffer zone by removing the invasive plant species.

Our two overarching measures for the influence zone form the basis of our context specfic masterplan. In addition we develop detailed designs for three distinct landuses to demonstrate our conceptual vision for the influence zone.

Existing satellite imagery, 2016 Google Earth

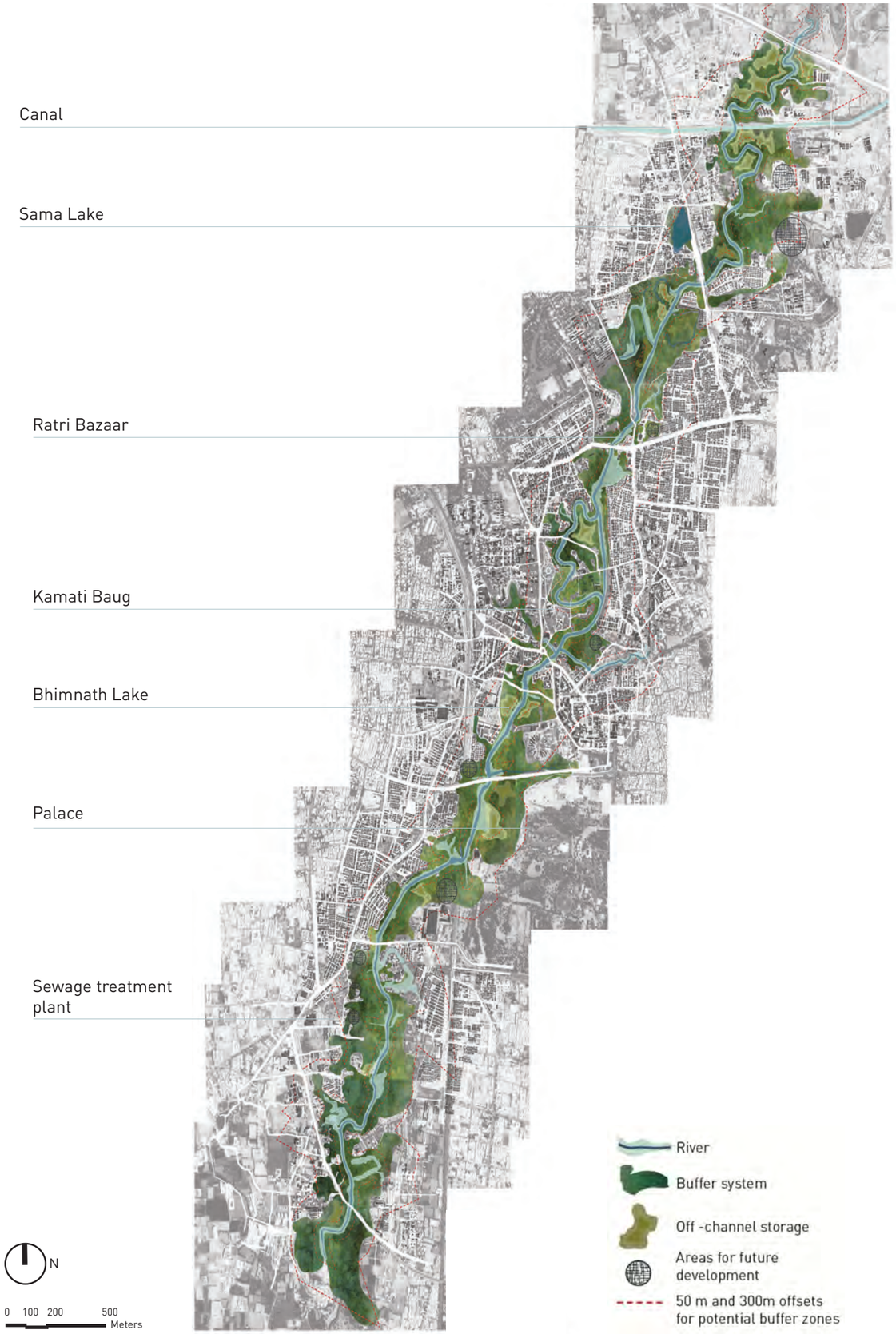
N Not to Scale

VRDP Master Plan- Government feasibility report, 2015

N Not to Scale

Proposed conceptual context specific masterplan

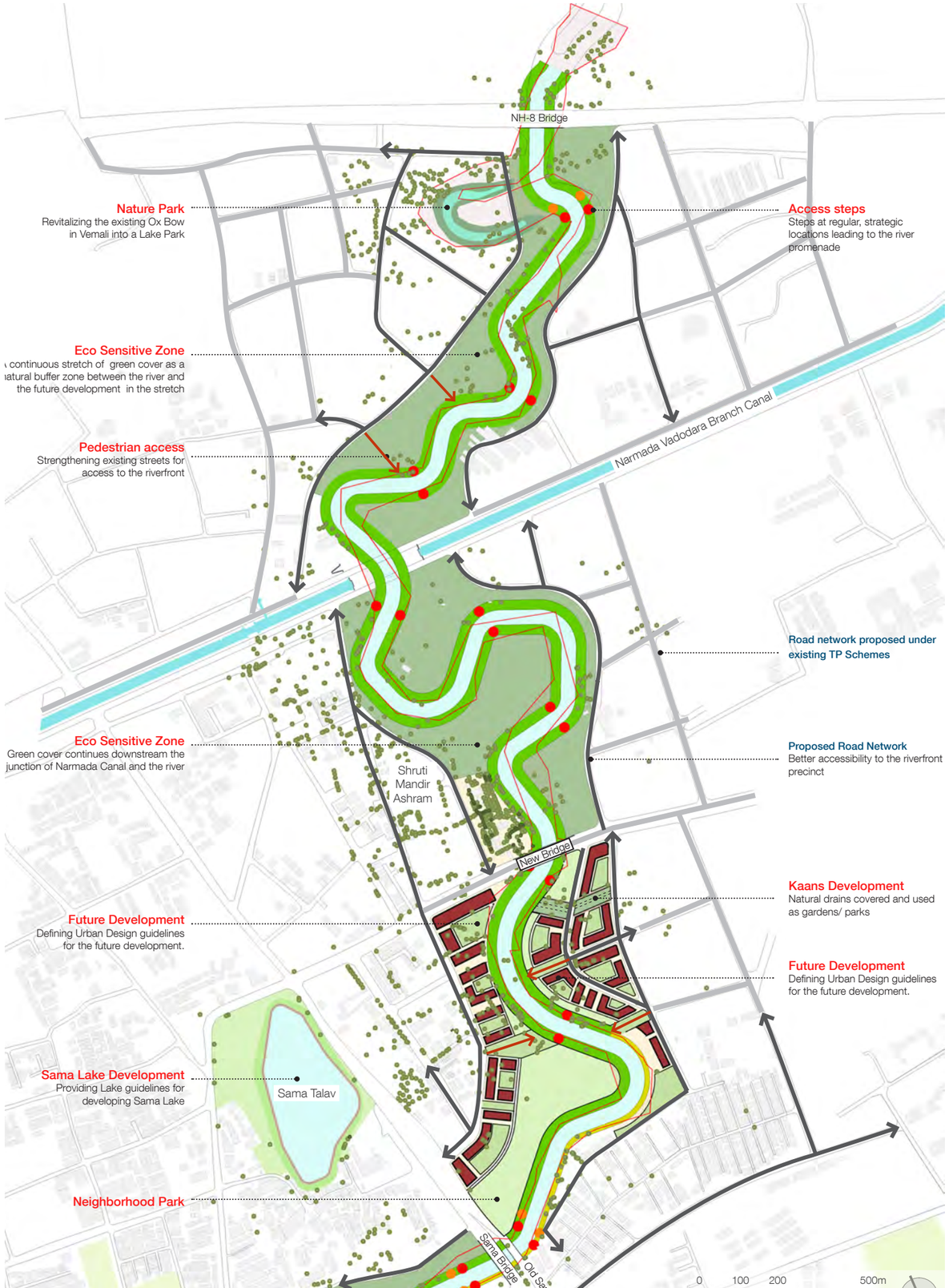
N Not to Scale



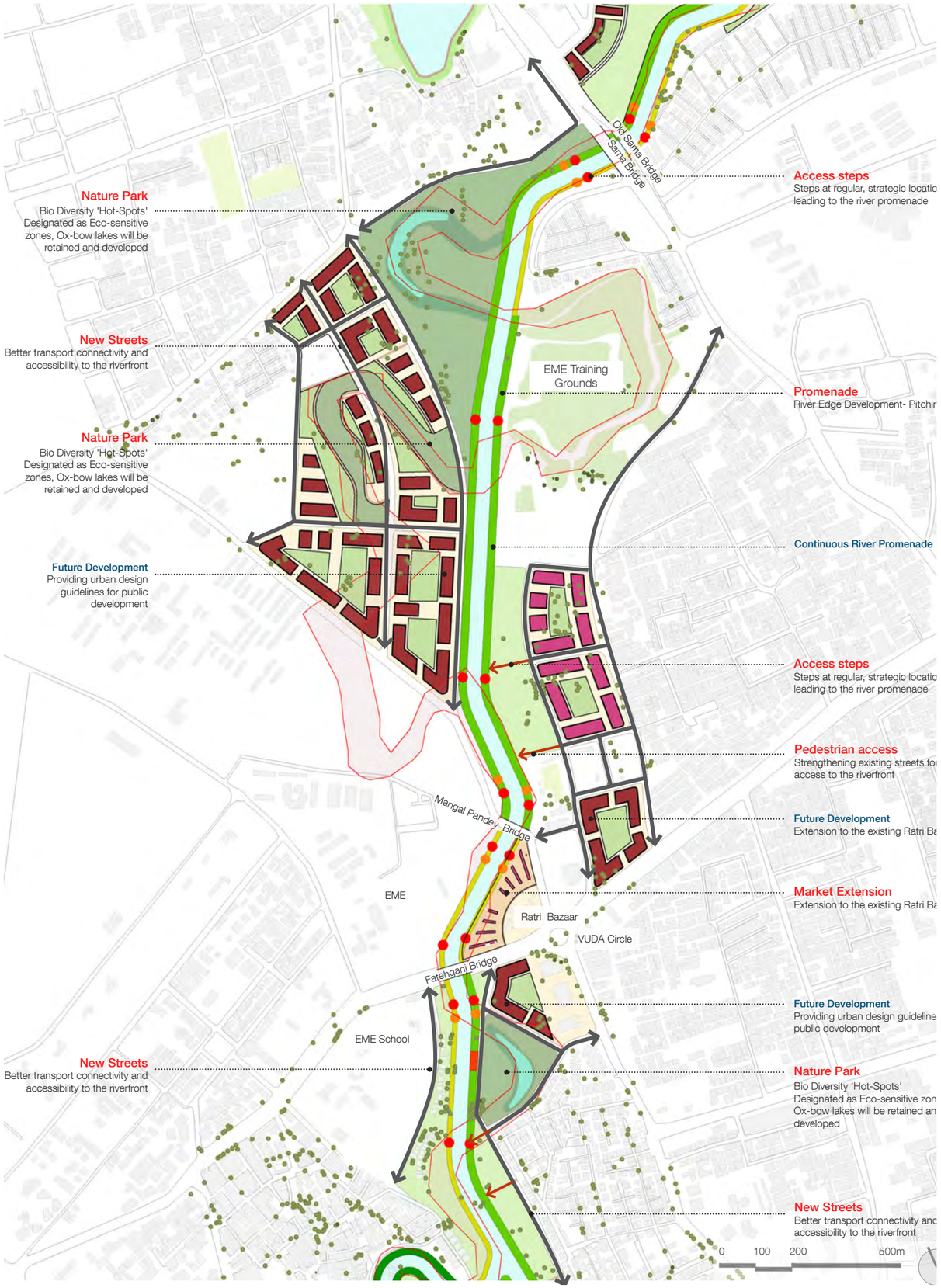
CONTEXT SPECIFIC MASTER PLAN

In our masterplan for Vishwamitri you can see these two overarching ideas undulate through the city along the river corridor. It is here that the multifunctionality of green infrastructure in Vadodara will truly shine. In contrast to the hard edge of the VRDP, our vision for Vishwamitri leaves room for dynamism. In the dry season, there is room along the river for recreation and excitement. Visitors and residents can stand on bridges and overlooks to watch crocodiles and turtles swim through the shallow water and bask on the shore. Boardwalks along wetland edges offer kilometers of urban trails for walking, environmental education, and wildlife viewing. Where piles of trash and eroded banks once stood, the dense buffer system will offer a sense of peace and wildness in the midst of a bustling city.

In the monsoon season, our design will earn its keep. The preservation, expansion, and restoration of the floodplain, including expanded capacity for off-channel storage of floodwater, will protect the city from flooding and buffer its associated human-wildlife conflict. As part of a comprehensive stormwater management framework, this shoreline green infrastructure is not only beautiful, but highly functional.



Stretch 1- Proposed Master Plan


Nature Park
Bio Diversity 'Hot-Spots' Designated as Eco-sensitive zones, Ox-bow lakes will be retained and developed
New Streets
Better transport connectivity and accessibility to the riverfront
Nature Park
Bio Diversity 'Hot-Spots' Designated as Eco-sensitive zones, Ox-bow lakes will be retained and developed
Future Development
Providing urban design guidelines for public development
New Streets
Better transport connectivity and accessibility to the riverfront
Old Sarna Bridge
Sarna Bridge
Access steps
Steps at regular, strategic locatic leading to the river promenade
EME Training Grounds
Promenade
River Edge Development- Pitchir
Continuous River Promenade
Access steps
Steps at regular, strategic locatic leading to the river promenade
Pedestrian access
Strengthening existing streets fo access to the riverfront
Mangal Pandey Bridge
Future Development
Extension to the existing Ratri Ba
EME
Ratri Bazaar
VUDA Circle
Market Extension
Extension to the existing Ratri Ba
Fatehganj Bridge
Future Development
Providing urban design guideline public development
EME School
Nature Park
Bio Diversity 'Hot-Spots' Designated as Eco-sensitive zon Ox-bow lakes will be retained an developed
New Streets
Better transport connectivity anc accessibility to the riverfront
0 100 200 500m


River
Buffer system
Off -channel storage
Areas for future development
50 m and 300m offsets for potential buffer zones
0 100 200 500
Meters
N

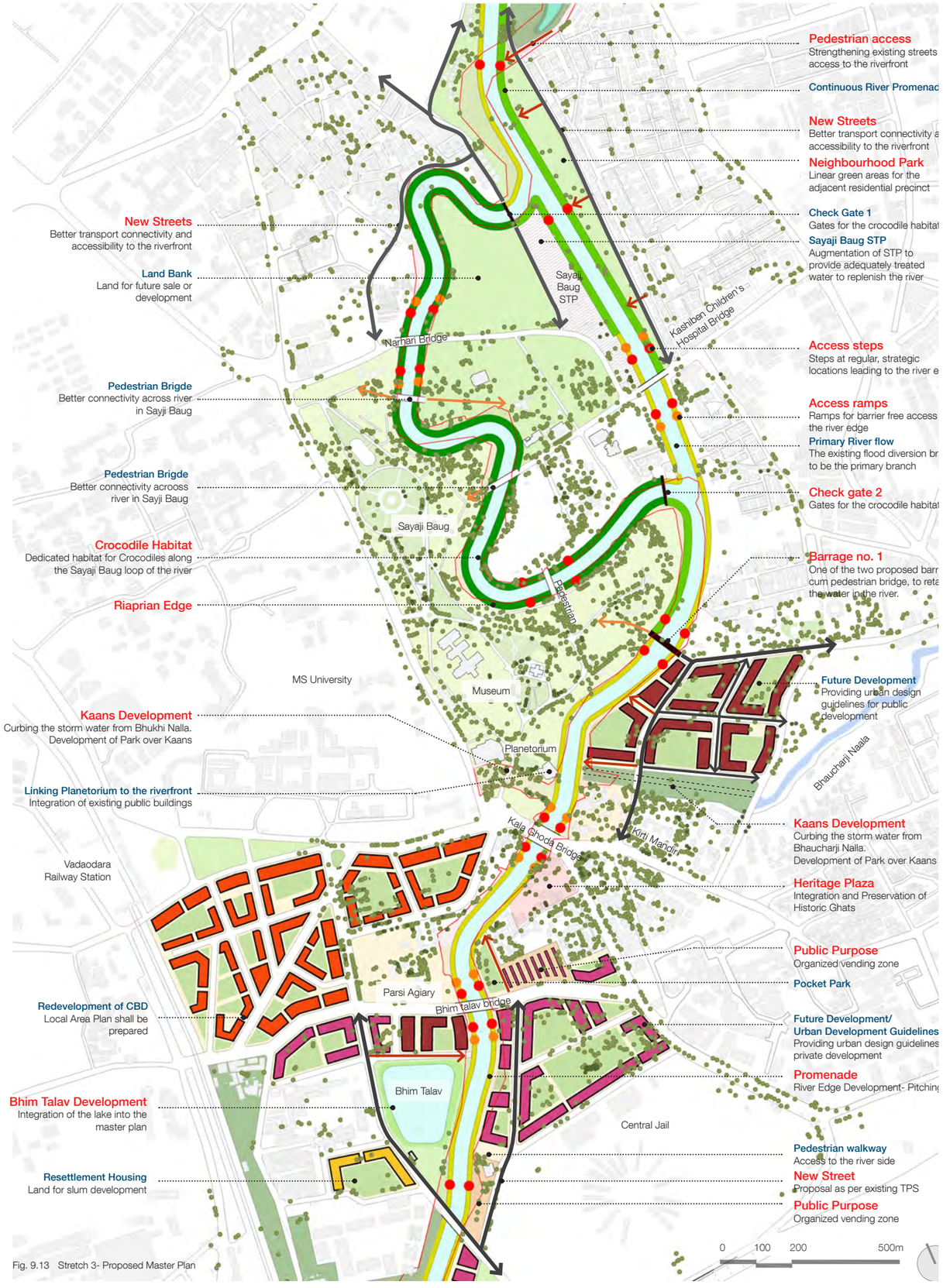


Fig. 9.13 Stretch 3- Proposed Master Plan

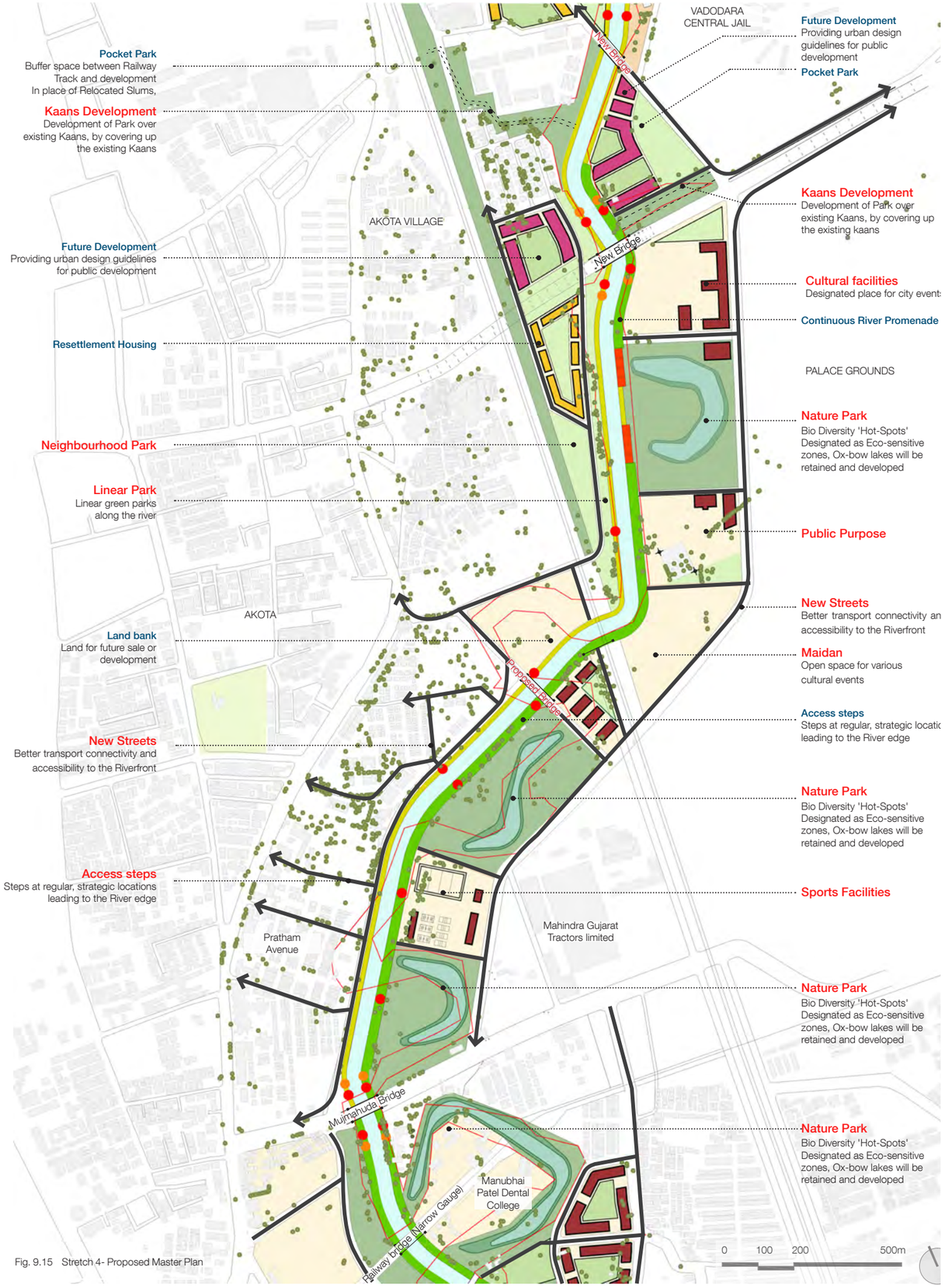
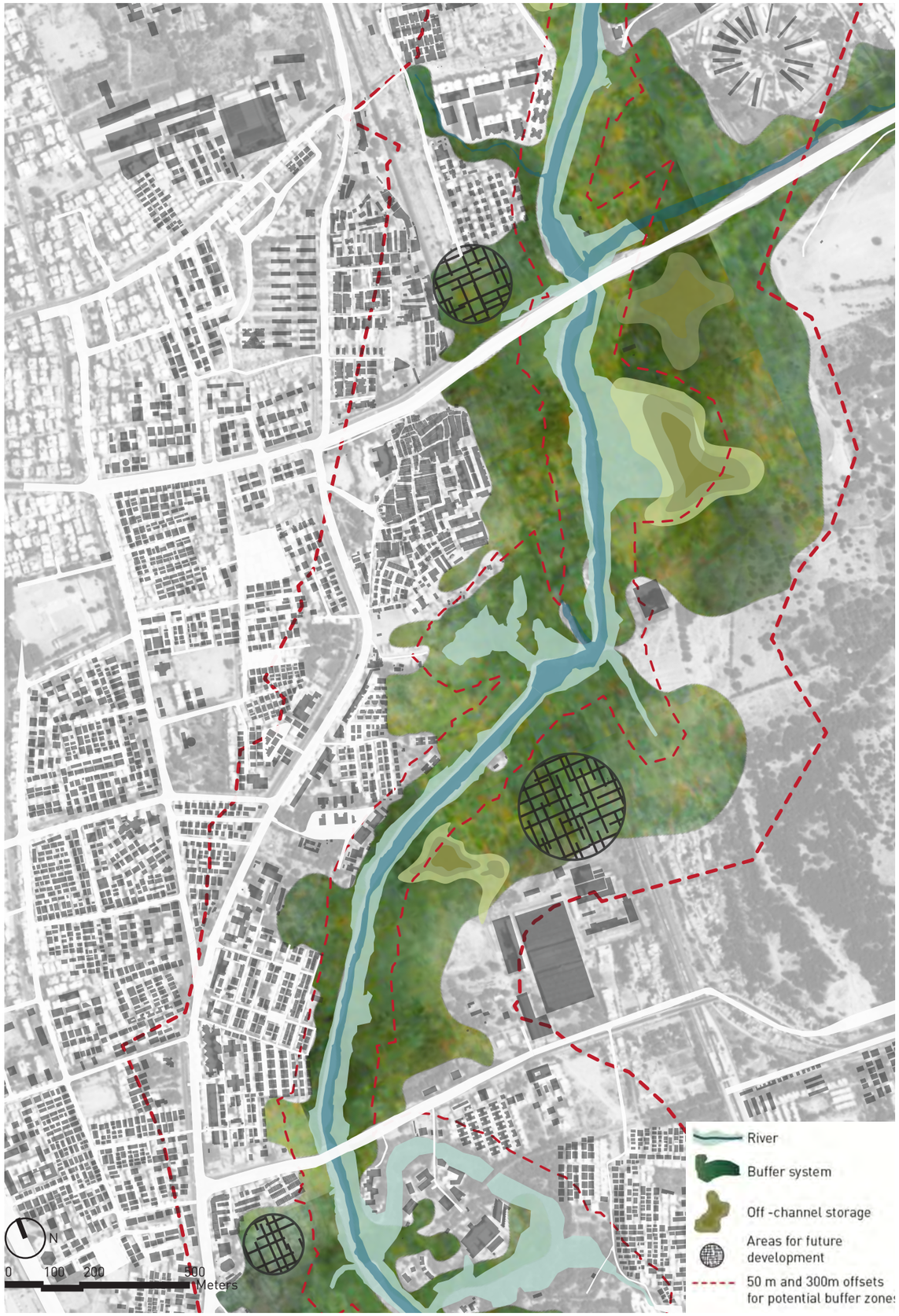


Fig. 9.15 Stretch 4- Proposed Master Plan



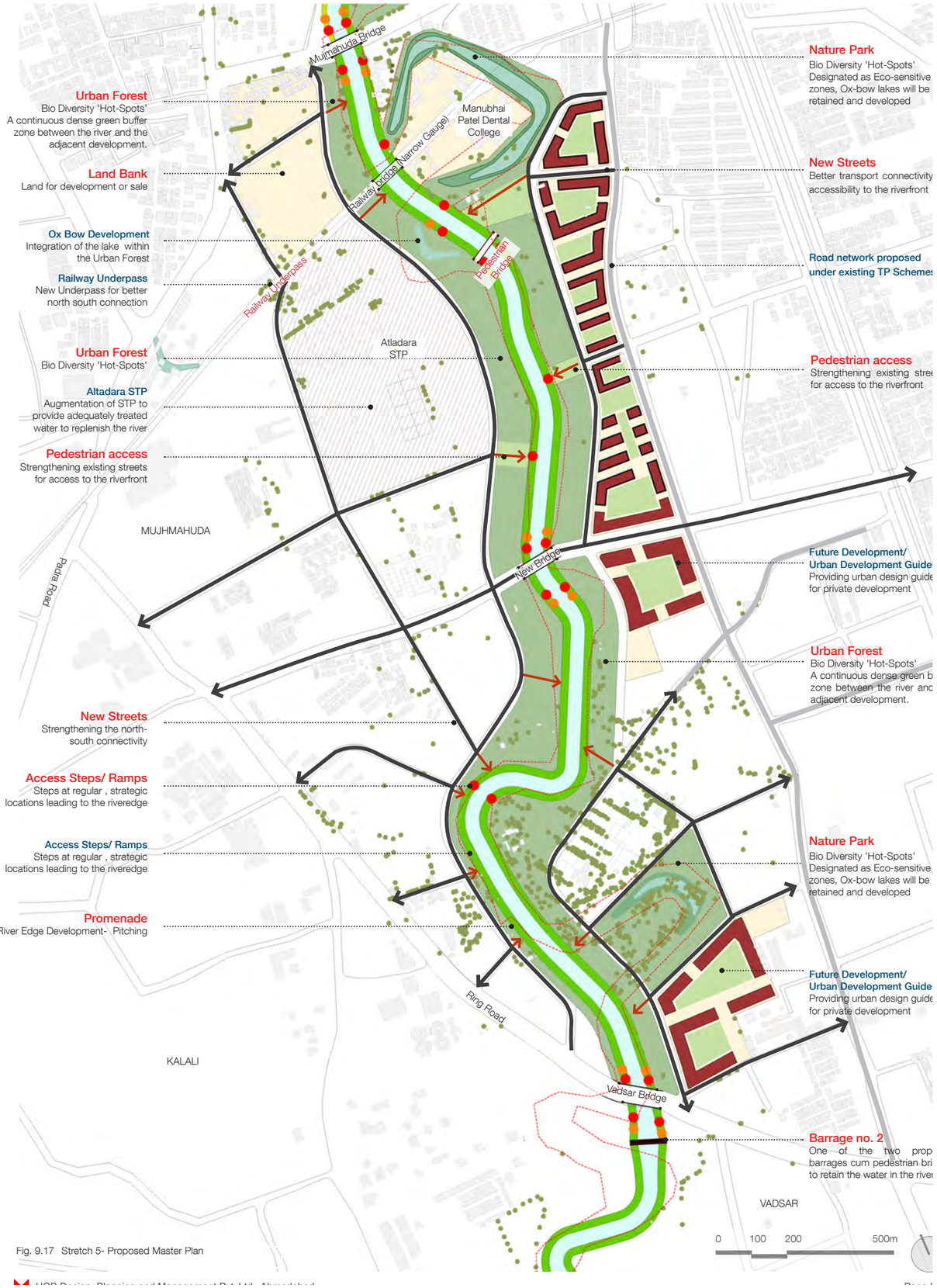
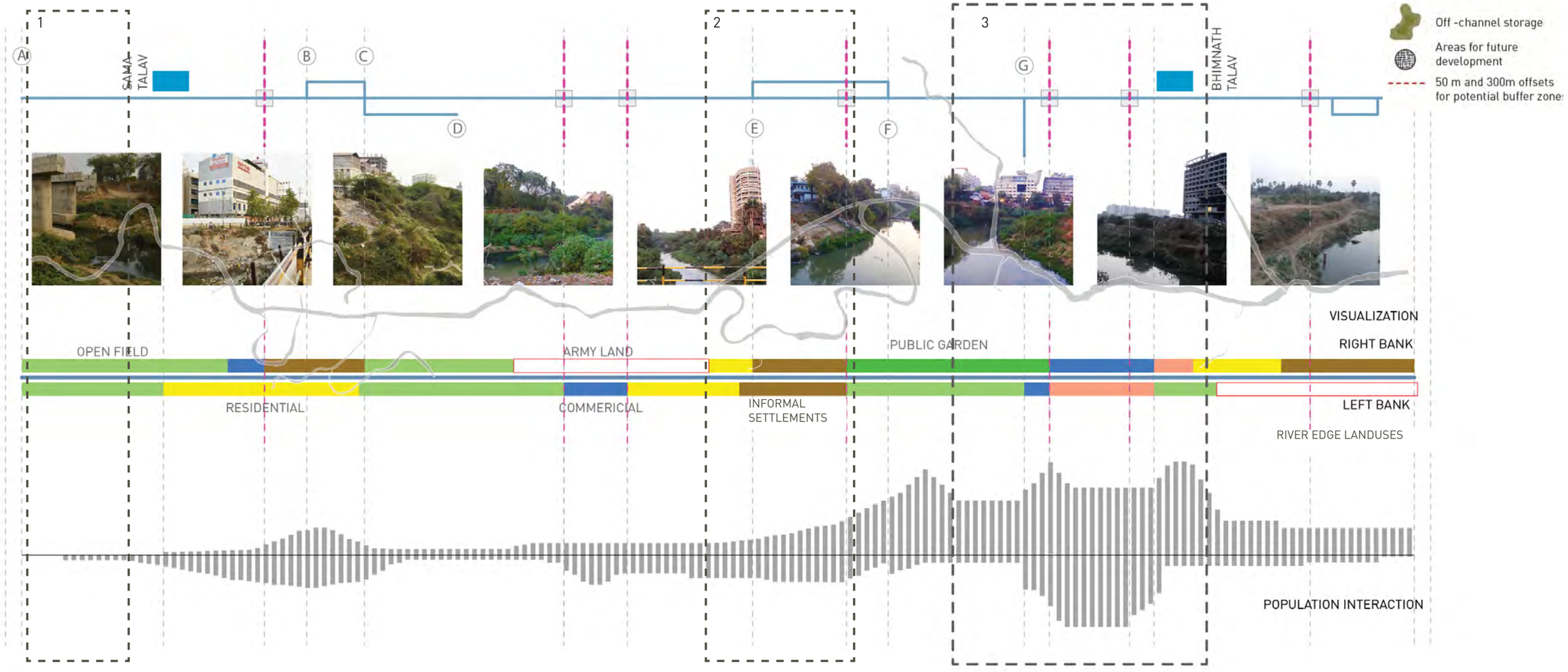


Fig. 9.17 Stretch 5- Proposed Master Plan



Detailed designs have been created for three locations along the river, featuring 1) Sama Savali area which has a dominant agricultural landuse in the north, 2) Kalayan nagar Area close to Sayajibaug with institutional and residential landuses and 3) Sayajigunj area which houses a number of landuses (commercial, institutional,residential, open space and parks, public).

These designs are aimed to demonstrate the concept of how our proposed approaches work in different contexts and to inspire further place-based interventions.

For the purpose of this report only the design for the Sayajigunj area has been explained in full detail. Other designs have been derived via the same process. We chose to elaborate the explanation for this area because it is here that the city's most populated and diverse landuse coexists with the river edge.

PLAN

AREA I : SAMA SAVALI AREA, NARMADA CANAL

Surrounded by lush vegetation, this area within the influence zone contains residential and agricultural land-uses in close proximity to one another. Nearby the river, a local ashram, free market place, and wetland park offer attractive public spaces to residents. The design program of these spaces can address the residents' current concerns regarding human-animal wildlife conflicts, which is a major source of anxiety for residents.

The proposal utilizes the existing topography to provide opportunities for safe, physical engagement for residents by creating a trail system that connects city-dwellers to the river at a reasonable distance. Relying on a simple path, which serves as an analog to the river's path, visitors can utilize "sensory pods" – opportunities for visual engagement – from which to observe crocodiles through "viewpoints," as well as bird-watching, and informal markets, which enhance the residents' perception of the Vishwamitri as a lively space.

Underlying the integration of human-wildlife connections are advanced mitigation techniques (e.g. off-channel storage), which are deceptively simple and aesthetically pleasing. The proposal consists of two (2) intervention types: 1.) Off-channel storage and 2.) Buffer zone.

These practical mechanisms of ecological design enhance the natural systems, increasing the quality of the landscape species residing within the city. Residents benefit from the landscape in a safe, meaningful manner. The intervention foregrounds natural elements, allowing residents traverse and experience the landscape worry-free.

VIEW ALONG SENSORY PODS ON THE TRAIL

PLAN

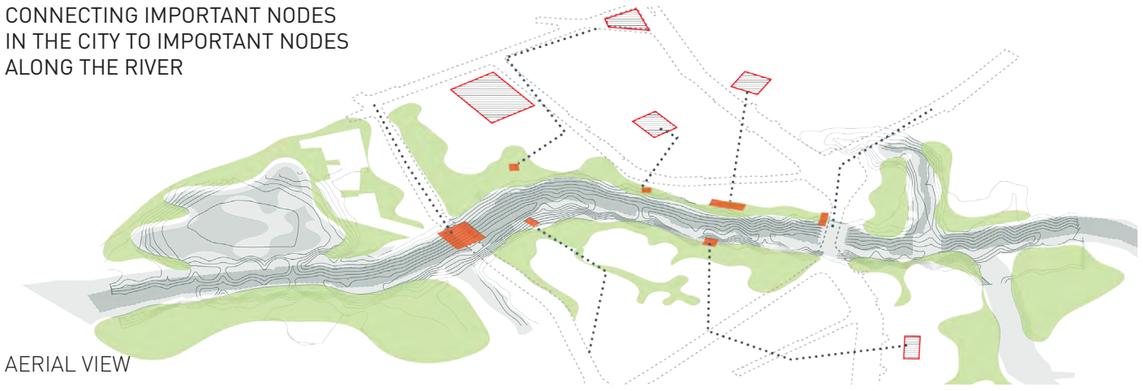
VIEW ALONG SENSORY PODS ON THE FORESTED TRAIL ALONG THE RESIDENTIAL AREA

AREA II : NARHARI , KALYAN NAGAR AREA

Within this quiet residential neighborhood, the Vishwamitiri is a main feature of the floodplain, running alongside the dense homes within walking distance of a nearby recreational zone. A path system allows residents to navigate to the city amidst a primitive forest along a path which creates a visual sight line to a tributary that runs to the river. Given the density, balancing the ecosystem and infrastructure of residents is one of the challenges of this site.

Forested recreational zones, in particular, create strong connections between natural and human systems. Through a trail system, residents will perceive the close proximity of nature and connectivity to the urban environment nearby. The primary ecological design components of the proposal within the site are off-channel storage and a forested buffer zone. Given the relationship between the residents and the ecosystem, the ecological design promotes ecosystem services that provide direct benefits to the residents, such as cleaner water and air.

CONNECTING IMPORTANT NODES
IN THE CITY TO IMPORTANT NODES
ALONG THE RIVER



AERIAL VIEW

AREA III: SAYAJIGUNJ AREA

Contained within this interwoven site are commercial, institutional, and residential land uses coalescing in a dense, multipurpose zone. The principal techniques for river restoration at the site include off-channel storage and riparian buffer. Most importantly, the site is connected to carefully selected least disruptive nodes on the river landscape via important public nodes in the city area including an exhibition space, university-area, social spaces, and informal markets.

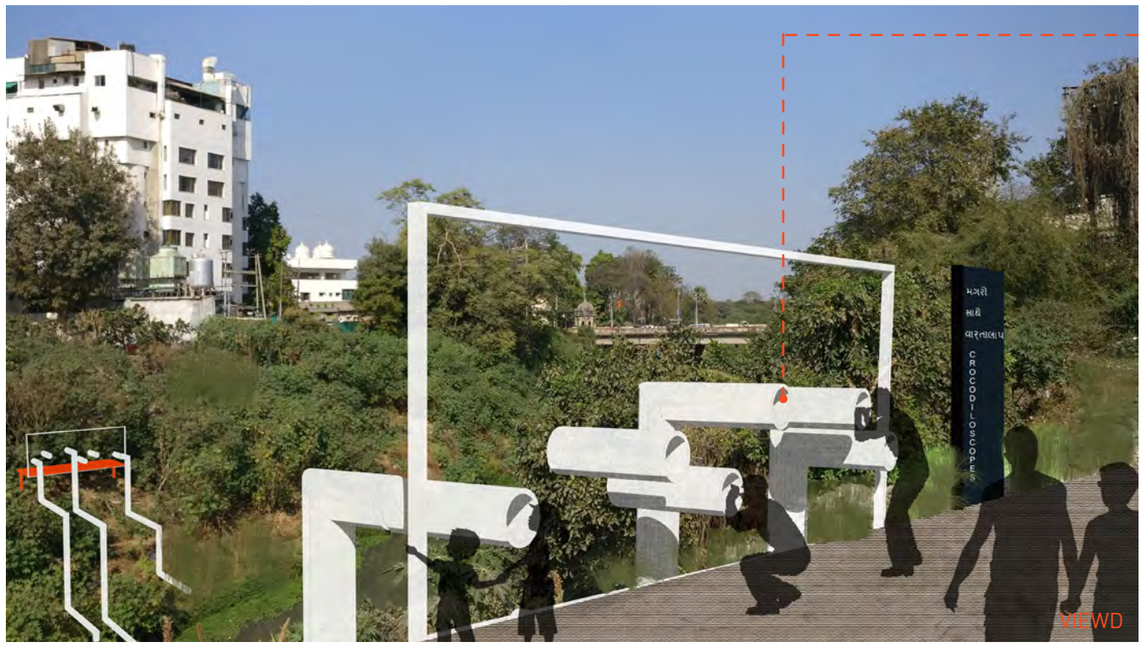
VIEW A

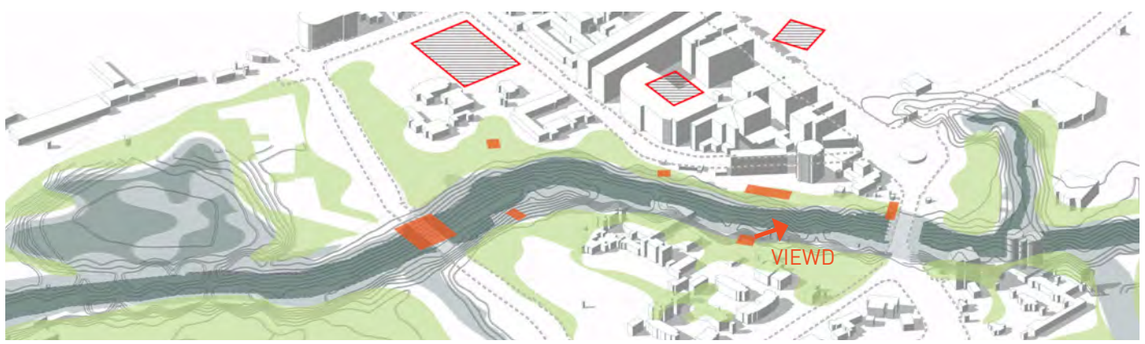
VIEW OF THE DESIGNED LANDSCAPE
AS SEEN IN THE SOUTHERN PART OF
SAYAJIGUNJ

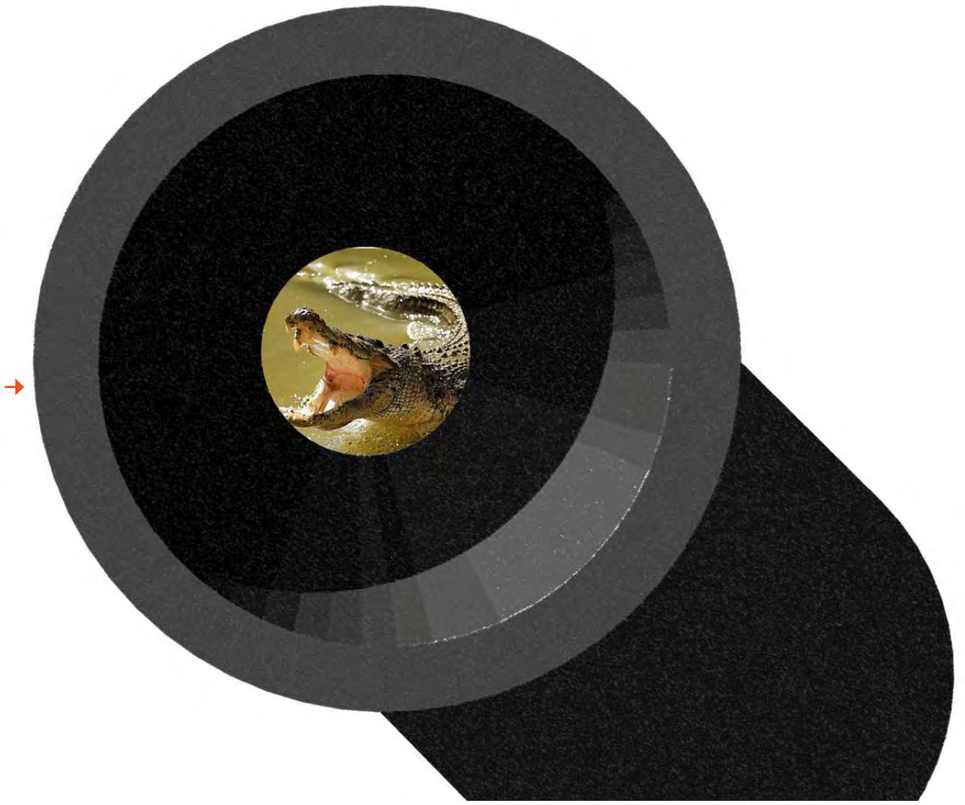
Interventions like “river-o-phones” render the functioning ecosystem apparent to viewers through auditory and visual sight lines. The benefits attract the public to the river space, while providing viewers with cues for sensory engagement. The interactions occur between the natural system and the social environment of the city.

Image Illustration: Dhrumil Kantharia

Sight lines enhance awareness of the functioning ecosystem, though their importance is highlighted by displayed information describing the river system. The definitions provide educational moments for viewers to gain knowledge beyond simple engagement, a passive form of interaction. The information may serve to further frame the interaction between the city fabric and the river. Periscopes shown in red facilitate an interaction of “being there” when the physical limits bar entry for safety reasons.





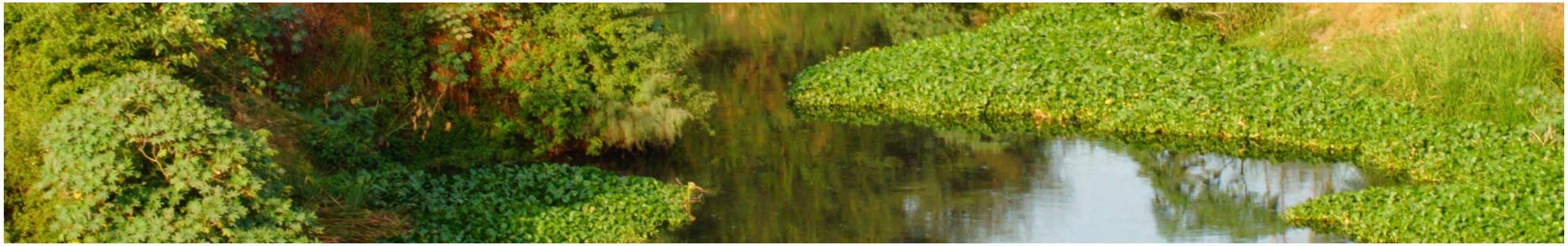


Another playful intervention, the “crocodil-o-scopes,” intend to celebrate the river and the city’s inhabitants. The ambition is to promote a positive interaction between human and wildlife. Whereas the city’s public spaces are often unusable, disregarded, or in a degraded state, these spaces have the possibility to become distinct and functional for residents. The simple gesture is intuitively understood through interaction. These implements are familiar and found in a wide-variety of public spaces. In many ways, mechanisms for incorporating public space and wildlife are quotations from other parts of the river. In its’ current proposal, the government foregoes the possibility for interactions in favor of engineered approaches, limiting interesting moments, in favor of a simple concretized riverbank.

Lastly, as a way to compare our alternative design concept with the VRDP, we revisited the issues identified in our critique for the VRDP and evaluated our design concept in terms of its ability to address the corresponding concerns. In the resulting comparison table, we assess each of the interventions proposed for the upper-watershed, city-scale, and influence zone against our detailed critiques.

Based on our best qualitative judgement, we then determine the interventions that directly or indirectly address the issues related with a given critique. Putting together the evaluation of individual interventions allows us to further assess how our integrative design concept across scales responds to the critiques (indicated by the "Overall design concept" columns). From the comparison table, the importance and effectiveness of expanding the project boundary and taking a multi-scale approach is self-explanatory.

			Upper-Watershed											City Extent									Influence Zone								
			Overall design concept	Forest cover regeneration	Khet talavadi (field ponds)	Hedges and stream buffer in fields	50 m buffer strip along stream	Preserve oxbow lakes	Vavs (underground wells)	Earthen check dams	Gulley plugs, jute lining and seeding	Rip rap treatment (with green buffer strip)	Wetlands	**Overall design concept**	Identify priorities based on stormwater typologies	Shorline: increase flood storage and detention	Shoreline and Upland: reduce imperviousness	Shorline and Network: increase stormwater detention	Upland: Increase infiltration, retention and filtration	Pollution permitting system	Establish a local watershed council	Volume-based stormwater mandate	**Overall design concept**	Off-channel flood storage wetlands	Vegetative buffer strips along the river	Trails, boardwalks, viewing decks and etc.	CBD designed around green infrastructure	Affordable housing outside of floodplain	STP tertiary treatment wetland	Public spaces and cultural nodes	Development encouraged outside of the floodplain
River Flow Regulation & Infrastructure	1,9	Watershed scale causes of river issues are not addressed	**V**	V	V			V					V	**V**	V		V														
	2,7	River edge design ignores various values of riparian vegetation	**V**			V	V																**V**		V				V		
	3,9	Accelerating water movement in the river does more harm than good												**V**		V		V	V				**V**	V	V						
	4	Flood management plan does not provide adequate protection against extreme events	**V**	V	V			V	V				V	**V**	V	V	V	V	V			V	**V**	V				V			V
	5	Zoning/building codes ignore flood hazard																					**V**					V			V
	6	Negative impacts of water replenishment and retention in river are not assessed																													
	7	Clear plan for managing non-point source water pollution is not available	**V**	V		V	V						V	**V**	V		V		V				**V**		V						
	8	Combined sewer interceptor system presents water quality issues and regional impacts												**V**					V	V			**V**	V	V		V		V		
Ecosystem Health & Wildlife	9	River is not treated as a system of integrated processes	**V**	V				V					V	**V**	V								**V**	V							
	10	Implementation of VRDP will result in reduction in habitat quality	**V**	V		V	V	V		V			V	**V**			V						**V**	V	V						
	11	So-called restoration seeks to improve visual appeal rather than ecosystem services	**V**	V		V	V	V		V			V	**V**		V	V	V	V	V			**V**	V	V						
	12	Modification of river banks ignores potential impacts on habitat heteorogeneity																					**V**		V						
	13	Proposal fails to recognize new and evolving approaches to infrastructure design												**V**	V	V	V	V	V				**V**	V	V	V	V		V	V	
	14	Proposal has little consideration of climate change and its impacts on river system	**V**	V				V					V	**V**	V	V	V	V	V			V	**V**	V							
	15	Increasing imperviousness and jacketing of river will negatively impact microclimate												**V**			V						**V**		V						
	16	Crocodile park falls short in size and habitat quality																													
Community Preference & Social Concerns	17,21	Displacement of informal settlement may create social problems																					**V**					V			V
	18	Lack of community engagement during design process												**V**							V										
	19	Proposed urban green spaces do not necessarily reflect residents' preferences												**V**							V		**V**			V			V		
	20	Proposal ignores the historic cultural importance of the river and its ecological system												**V**									**V**	V	V		V			V	
	21	New development does not provide equal benefits to the low-income residents												**V**							V		**V**					V			V
Proposal & Design	22	VRDP ignores downstream impacts of Vadodara's development decisions												**V**	V	V	V	V	V	V		V	**V**	V	V						
	23	Proposal uses inappropriate precedents that pertain to different contexts																													



POLICY RECOMMENDATIONS TO SUPPORT DESIGN

Integrating Solutions at the Influence Zone Scale

At the physical heart of our design is the Influence Zone. Due to the physical centrality of its' location, the Influence Zone significantly underlies economic, social, and sustainability in Vadodara and the Vishwamitiri River. Although the City Scale and Influence Zone physically overlap, as a prominent area with broad significance in the watershed, any changes to management of the Influence Zone may have a "triple-bottom line" effect, while achieving goals of multi-functionality. Therefore, enhancing the economy, wildlife, and human well-being within the Influence Zone are priorities of policy recommendations to support our design recommendations below.

The underlying principle our design for the Influence Zone shifts the notion of a river from a channel to a thriving ecosystem full of opportunities for the beneficial integration of man and wildlife. Policies supporting these initiatives require the legislature to reflect this ideology. For example, proposed "morphological" restructuring of the Vishwamitri River (such as channelization and concretization practices), referred to as "engineered" solutions, should be defined as "man-made alterations to rivers" within pre-existing laws and regulations like the Inter-State River Water Disputes Act (IWRDA). By redefining man-made alterations in the law, there could be a basis within the legal governance system to influence enforcement mechanisms, including economic considerations that concern industries (e.g. "polluter pays" principle).

In addition to revising the definitions within broader environmental laws, adjustments to the boundaries of rivers should expand. Along the Vishwamitri River, the physical boundary should lead to the floodplain within the Influence Zone. In terms of enforcement, an expanded floodplain would permit monitoring strategies to evaluate quality of riparian edges and wetlands with a greater degree of accuracy. The urban development along the riparian edges should also be reviewed for compliance with prescribed impervious/pervious surface standards in addition to other Environmental Impact Assessment (EIA) clearance requirements.

Concerning economic development, the Influence Zone plays an important role in Vadodara. Along the riparian edge, for example, the "Slum Free City Action Plan," an initiative to reduce sub-optimal living conditions, found that 32% of the 185 hectares nearby the river contained informal settlements. the Action Plan subsequently targeted this area for redevelopment, which in turn affects the economic potential and physical settlement of the river. There exists a need for "capacity building," which Influence Zone policy initiatives like the Slum Free City Action plan may impact. However, there are multiple ways to redevelop the physical landscape; over the course of the plan, some 1900 homes were reportedly demolished in Kalyannagar and another 350 in Kamatipura settlements along the Vishwamitri River (Raja 2015). In lieu of redeveloping large swaths of residential area, Vadodara should instead take advantage of broader economic initiatives like India's "Smart Cities" program,focusing on the "most pressing needs and the greatest opportunities to improve lives", including sustainable development. Instead of demolishing the city, similar funding initiatives provide opportunities to individuals by stimulating in an effort to monitor existing context and establish a common thread inside the Influence Zone.

Promoting economic and sustainable development policies has been studied by Porras et al. (2013) through initiatives "payment for ecosystem services". Payment for watershed services (PWS) are "schemes that use funds from water users (including governments) as an incentive for landholders to improve their land management practices". As an alternative to the "polluter pays principle," seen throughout India (Agrawal 2005), where industries "cover" the harm incurred on the environment, "payment for ecosystem services" initiates a collaborative relationship with citizens -- potential employers.

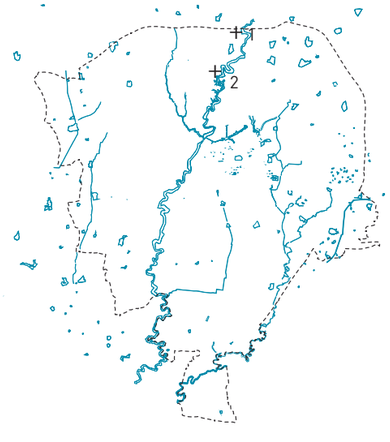
Porras et al. also argue that "viable policy alternative to watershed management issues," such as PWS offer "a means of addressing chronic problems such as declining water flows, deteriorating water quality and flooding." Indirect benefits of PWS can pay residents familiar with the Influence Zone to monitor and implement green infrastructure. Forms of PWS programs have already begun in India, for example, projects like the "Myrada project" (http://myrada.org/) which offers case studies of livelihoods of individuals living in micro-watersheds in India (Porras et al. 2008, Prakash Fernandez, 2003).

Our Influence Zone design offers a response to a landscape within the watershed which can serve as a shared community space; opportunities for interactions with the riparian ecosystem (similar to the existing Sayaji park at the heart of the city), provide for improved ecosystem services. Overall, policies should support these initiatives by requiring the legislature to reflect this ideology, such as those described above. Nevertheless, as is present in other scales of our design, the diversity of stakeholders interested in watershed development signals how significant partnerships must be to address watershed management issues. Therefore, strengthening participation at the Influence Zone scale, as at other scales, must include resources outside of the government to enhance collaboration. Throughout the Vishwamitri River, a watershed council could function successfully within the Influence Zone.

The participation will facilitate the work of an independent collaborative body specific to the Vishwamitri, functioning in the Influence Zone, and across the watershed. The broader, inclusive decisionmaking processes derived from the Watershed Council ultimately serves to shape the future of Vishwamitri River at various scales. A non-governmental Watershed Council in Vadodara would represent both informal and formal organizations, interests groups, or local constituencies, which would allow the majority of citizens to voice their individual private and public interests within the City Scale (see Quesada 1999).

1 View within the Influence Zone,
Sama Savali, 2016

2 View within the Influence Zone,
Sama, Parth School, 2016



CONCLUSION

It was a breezy evening in late May when our team headed to the Bhimnath bridge to search for crocodiles. Amidst the bustling sounds of a city returning from a hard day's work, we gripped the dusty railing in anticipation. In the wide gap between buildings, the lush views of Vishwamitri's meanders provided a sense of wild adventure and mystery that few cities in the world can offer. We watched for over an hour, surrounded by people from all walks of life pausing from their journeys to search alongside us. As a female buffalo waded into the water, we feared for her safety, the tell-tale ripples and bubbles on the surface of the water revealing what was hiding below. Two crocodiles made a beeline toward her, but she waded with confidence, bucking them off and continuing on her way across the channel. She was not afraid. Like the buffalo, Vadodara should take a risk on Vishwamitri.

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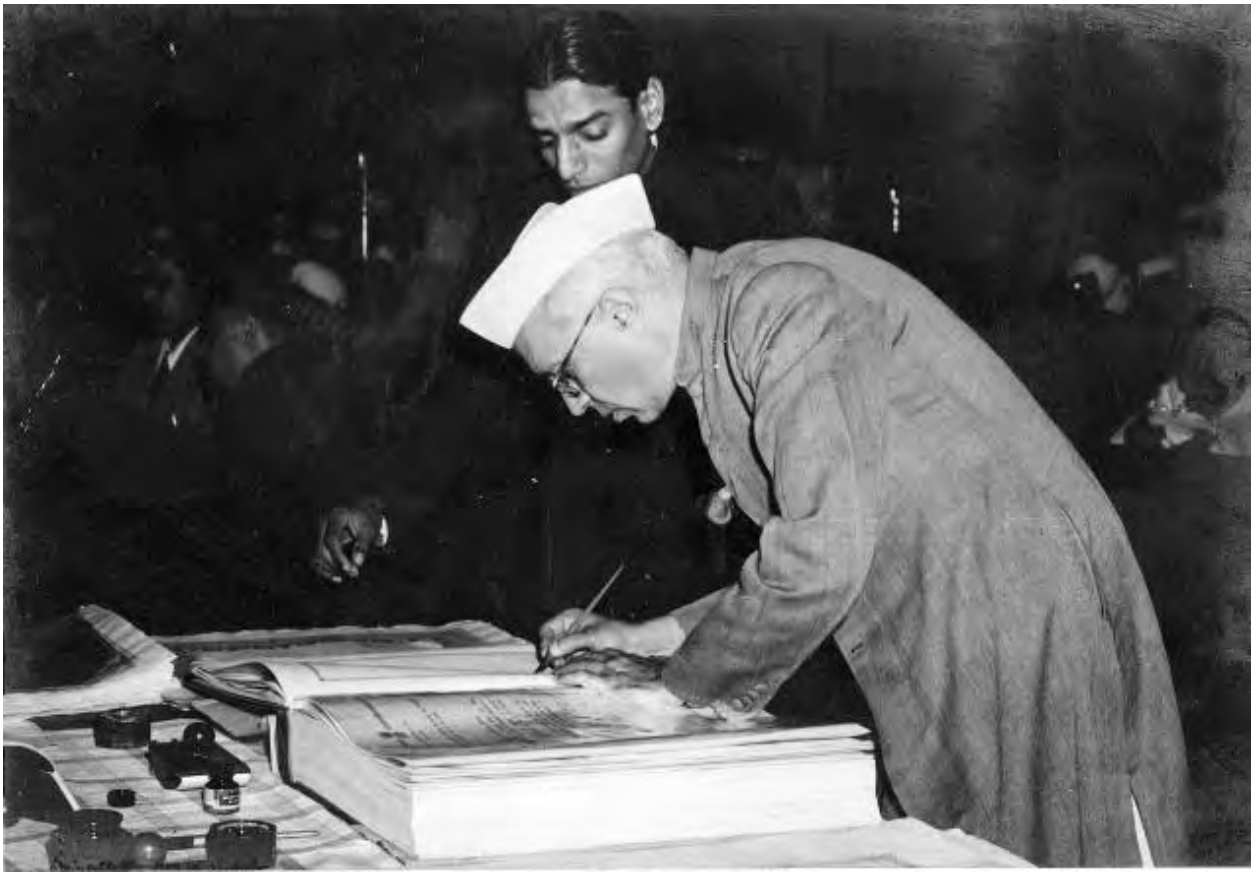
A River and its Reign

APPENDIX 3
POLICY ANALYSIS

INTRODUCTION TO POLICY ANALYSIS



The Constitution of India being signed into action by the Prime Minister Jawaharlal Nehru. (source: https://commons.wikimedia.org/wiki/File:Jawaharlal_Nehru_signing_Indian_Constitution.jpg)

Protection of the environment is a responsibility written into the provisions of India's constitution. Environmental laws stem from landmark legislation passed in the 1970s, beginning with the international Stockholm Declaration (Rustomjee 2008), almost two decades after the constitution was signed into action. In this section, we will summarize the efforts to protect the environment the context of the Vishwamitri River. In addition to constitutional provisions, India has passed substantial legislation that protects natural resources, such as the Water Act and the Air Act (Agrawal 2005). Despite these laws having been in effect for some time, enforcing environmental protection remains a sincere challenge across the country.

Environmental enforcement may suffer in part due to a lack of visibility of the laws themselves. During our May 2016 visit to Vadodara, public bans on cigarette

smoking in public where rarely adhered to, despite common knowledge of the law's existence. The voluntary nature of human health laws leads us to be skeptical about the enforcement of environmental laws. Our design proposal suggests that we shift away from "engineered solutions" will foster long-term safeguarding of ecology, however, when it comes to protecting the environment, especially complex river systems like the Vishwamitri, we argue that "urban stream syndrome" has taken effect due to years of neglect (Walsh 2005).

Though enforcement is clearly challenging, sheer growth also plays an important role in enforcement. Within the State of Gujarat, home to the Vishwamitiri, the past decade has seen a marked increase in urbanization. Roughly 71% of the State is water deficient, with more people seeking the State's autonomy in utilizing its groundwater resources. Furthermore, the City of Vadodara has also been listed as one of the critical locations where waste water used for irrigation has resulted in heavy metals accumulated in agriculture fields close to urban areas (Gujarat Ecology Commission Report, 2014-2019). With such pressing needs, environmental laws must address critical growth in a swift manner.

With these perspectives in mind, we observe the Vishwamitri River, a unique habitat for an array of flora and fauna. Gaining a better understanding of the functioning of the enforcement agencies led us analyze the current framework's impact on the Vishwamitiri River. While not intended to be comprehensive, we comment on the gaps we see that have been causal to the current degraded state of the Vishwamitri, and provide suggestions through policy changes that would support the river system in its revival. We first give a broad overview of how environmental consciousness first developed in the Indian Judicial system, and understand the hierarchical functioning and division of legislative powers (specific to our project boundaries) within the system. We then summarize the system as specific to the State of Gujarat and highlight the issues within each of our three design scales.

Our rationale for this hierarchy is to target flood flow reduction by allowing for localized water detention in the entire watershed, thereby reducing the stress on the river stream to carry excess monsoon precipitation. This is followed by additional measures at preventing stormwater from flowing into the river channel by allowing for more infiltration and percolation in the city. Our interventions in the two broader scales therefore allows us to retain (and where possible, expand) on the existing river channel floodplain, giving the river room to breathe during peak monsoon. We finally use our analysis of the legal framework and our understanding of the setbacks in implementing our project, to deliver a policy analysis of the Vishwamitri watershed.

Enforcement Mechanisms for Environmental Law

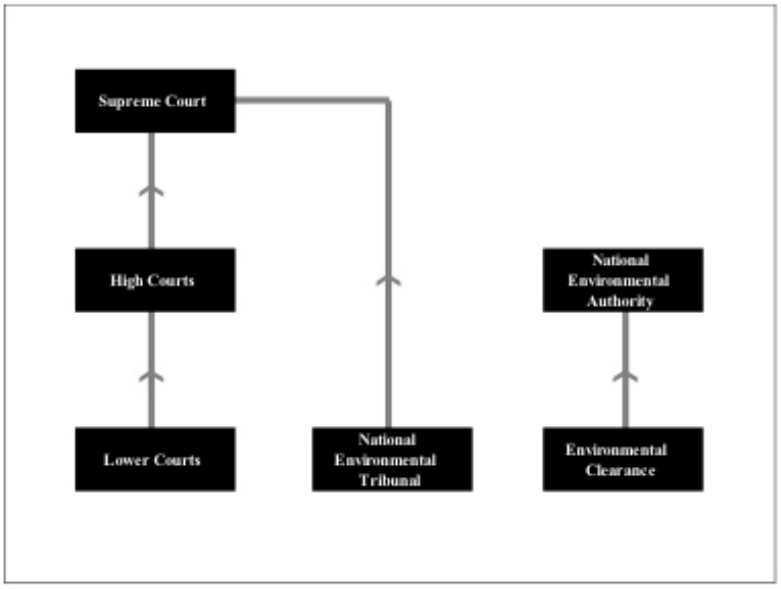
Judges, public litigation, and landmark cases in India have begun to influence the enforcement mechanisms and increase the positive results pertaining to environmental disputes. However, due to the length of court cases, the lack of financial resources available to pursue investigations, a general lack of knowledge that the judicial system faces about technical and scientific issues (Agarwal VK 2005), most significant cases experience significant delays. *Bloomberg Businessweek* estimates that there were over 31 million cases open from the Supreme Court to the lower courts, and a ratio of 15.5 judges for every one million people (Lasseter 2015). There are several avenues outside the legal system that could be made available to lawyers fighting cases to protect protection for the environment, specifically, increasing the availability of technical experts and scientific evidence to 'prove' harm. At the moment, the "polluter pays" principle is the main avenue for enforcement. We see our efforts as the former, rather than the latter.

There are a litany of environmental legal cases that offer precedents for rulings in cases. Through the High Courts (HC), matters that fall under the State list and through the Supreme Court (on matters falling under the Union list), are ruled upon. Municipalities have been directed by HCs to remove garbage within a period of 6 months *(LK Koolwal v. State of Rajasthan*[1]); courts have expanded the definition of the Constitutional right to life and personal liberty (Article 21) to also include environmental protection in the form of a 'decent', 'healthy' and 'pollution free' environment (*Chameli Singh v. State of UP*[2], *Rural Litigation and Entitlement Kendra*, *Dehradun* v. *State of UP*[3], *MC Mehta v. Union of India*[4], *Charanlal Sahu V. Union of India*[5], *FK Hussain v. Union of India*[6]); petitioner *societies* have been granted the same rights as individuals, to move courts to prevent ecological degradation and restore ecological balance (*Goa Foundation v. State of Goa*[7]). An interpretation of Article 47 resulted in the Madhya Pradesh HC mandates separate and covered sewage lines and public washrooms to uphold public health as a primary duty of the Government (KC Malhotra v. State[8]). 'Right to livelihood' was granted to pavement dwellers who were A) being evicted without

[1] AIR 1988 Raj 2
[2] AIR 1996 1051
[3] AIR 1985 SC 652 (Popularly known as the Doon Valley case)
[4] AIR 1987 SC 1086 (Popularly known as the Oleum Gas Leakage case)
[5] (1990) 1 SCC 613
[6] AIR 1990 Ker 321 at 323
[7] AIR 2001 Bom 318 at 319
[8] AIR 1994 MP 48

adhering to procedure established by law (*Sodan Singh v. NDMC*[9], *Ramesh Chander* v. *Imtiaz Khan*[10], *Ahmedabad Municipal Corporation* v. *Nawab Khan Gulab Khan*[11], *Olga Tellis* v. *Bombay Municipal Corporation*[12]) and B) displaced by governmental plans without proper. Environmental Impact Assessments (EIA) (*K. Chandru v. State of TN*[13]) (Manoharan S 1969. Most recently on March 17, the rights of the holy Ganga and Yamuna rivers were elevated to human rights (*Salim* v. *State of Uttarakhand*).

The judiciary is a catalyst in speeding environmental conflict resolution, while at the same time navigating the fine balance between environmental protection and economic development. The lack of uniform interpretations and a unique judiciary body for environmental issues, as well as the hierarchy and division of subjects within the legislative framework can often lose out on the side of the environment due to sheer work load on the Courts and a lack of scientific appreciation of the significance of these issues. This gap in the legislative system has made it possible for projects such as the VRDP to start clearing sites for construction and dislocate slum dwellers, alongside constructing hazardous housing structures right on the unstable banks of the Vishwamitri (such as under the guise of "river-view apartments") without the mandated Environmental Clearances.



The above schematic diagram is a representation of the judicial hierarchy in India. (Source: http://scholarship.law.cornell.edu/cgi/viewcontent.cgi?article=1144&context=ijli)

[9] (1989) 4 SCC 155
[10] (1998)4 SCC 760
[11] (1997) 11 SCC 121
[12] AIR 1986 SC 180
[13] AIR 1986 SC 204

Indian Constitution, Legislative Powers, and the Environment

The first draft of the Indian Constitution did not contain any specific provisions for the environment (Agrawal VK 2005). Then, the Stockholm Declaration of 1972 saw the first female Prime Minister, Smt. Indira Gandhi, voice her concerns about environmental pollution brought about by the "prosperity of man" (L.,1972). This propelled the 42nd Amendment to the Constitution into existence and incorporated two specific articles that tasks both the State and the Citizens with the protection and improvement of the environment. The preamble of the Constitution can further be interpreted to include 'environmental justice', and the 'right of citizens to know', 'access' and 'participate' in Governmental decisions to aid in the success of environmental policies (PS Jaswal and Nishtha Jaswal, 2009).

Legislative powers in India are shared between the 'Union' and 'State' governments, giving ample provisions to make and modify laws at two levels. The Constitution further divides the subject areas of legislation, giving parliament exclusive rights over inter-state rivers (one of the subjects in the Union list) while the state legislatures have powers over subjects such as public health, agriculture, irrigation, water supplies, and fisheries (State List). Certain subjects such as the protection of wildlife and forests have shared jurisdiction under both the State and the Union (Concurrent list) (Manoharan S 1969). The Supreme Court has the highest authority in case of conflict on a concurrent list. However, a State Law passed after a Central Law can prevail if it receives presidential assent. Local bodies such as the District Courts, the Panchayats, and the National Green Tribunal serve as additional governing bodies for environmental disputes.

Indian Supreme Court (Source: Indian Supreme Court, http://supremecourtofindia.nic.in/)

Legislative Framework in India

The legislative framework consists of multiple laws and acts that were enacted under the Constitution for safeguarding the environment. **Agencies such as the Ministry of Environment and Forest (MoEF), the Central pollution Control Board (CPCB), the State Pollution Control Board (SPCB), National River Conservation Authority** act as the administrative and enforcing bodies. A summary table is provided below[14]:

The constitution of India provides a two- fold provision for the protection of the environment: where the State and the Citizen are tasked with the protection of the environment (Article 48A 51A(g)), and the right to a healthy environment as a right to life (Article 21).	Constitutional Provisions
The Indian Penal Code (IPC) and the Citizen Rights Protection Council (CrPC) deal with various offences and their penalties. For eg., polluting any public water reservoir is	General Laws

[14] adapted from the guide on Environmental Jurisprudence by Puskar on Green Clean guide. See http://greencleanguide.com/environmental-jurisprudence-in-india-part-1/ for more details.

punishable under IPC Section 277. Section 133 CrPC provides for speedy and summary remedy in case of urgency where damages to public health or interest is concerned.	
These are legislations in addition to Constitutional mandates specifically designed for the protection of the environment. These include the Air Act, Water (Prevention and Control of Pollution) Act, the National Environmental Tribunal Act, National Green Tribunal.	Special Acts
In addition, policies have been formulated in response to Constitutional Provisions, and include the National Environmental Policy 2006, National Agriculture Policy, National Forest policy etc. They lay out principles, guidelines and standards which are useful in the protection of the environment.	Policies

State of Gujarat Legal System Summary

Gujarat's judicial hierarchy consists of the Gujarat State High Court (HC) at the top (and only subordinate in certain matters to the Supreme Court) followed by the District Courts and the Village courts called "Lok Adalats." These Courts function independent of the executive and judiciary branches of the Government, as specified in the Constitution. In addition, **the Gujarat Pollution Control Board (GPCB)** acts as the enforcing body to regulate pollutants and prevent the pollution of the environment. This working definition of the judicial system and enforcing agency in Gujarat can be expanded to understand their relevance to our study site: the Vishwamitri River Watershed. As the entire watershed of is within Gujarat's state boundaries, all legal disputes over the river fall under the purview of the HC (entry 17 of the state list under Schedule 7 of the Indian Constitution) and with the National Green Tribunal (NGT; under the National Environment Tribunal Act). The guidelines set forward by the GPCB and the CPCB serve to protect the water quality and the overall quality of Vishwamitri.

The legislative framework and the judicial system may be jointly comprehensive and sufficient to address the issues relating to environmental quality management and

enforcement. However, our study of the river and our design process revealed gaps in the legal system which need to be addressed to bring our vision to fruition. We present our understanding of these gaps in a legal analysis that reflects our design vision at three scales.

Summary of Upper Watershed

The upper watershed region for the river Vishwamitri stretches from the Pavagadh hills (its origin) to the very start of the city at National Highway 8, and comprises of land uses including agriculture (supported by the local villages established in pockets spread throughout this region) and commercial (arising from the spread of the city towards the origin of the river). The Pavagadh hills with their dry deciduous forests are home to a variety of forests. The main branch of the Vishwamitri flows down from these hills to the Ajwa Lake, a manmade reservoir that also serves as the main freshwater supply to the City of Vadodara.

The City of Vadodara experiences frequent flooding, and while this can be attributed to urban development within the city (which encroaches upon and adds grey, impervious infrastructure to existing natural floodplains), it can also be understood by rapidly shifting landuse dynamics in the upper watershed region. Shifting agriculture practices along with reducing forest cover add to increased sediment inflow into the Ajwa reservoir and finally into the downstream flow of the river. The problem is further compounded by increased urbanization which reduces detention and infiltration of monsoon rains. This, combined with reducing holding capacity of the Ajwa reservoir, contribute to increased flood flows of the Vishwamitri in the monsoon.

We address these issues through our design goals that aim at reducing sediment and flood flows into the river by GI measures. These techniques aim at **increasing the forest cover** by using native species (in and around Pavagadh, and along field margins), using **temporary rainwater harvest systems** (such as Khet Talavadis in addition to the ongoing Sardar patel Jal Sanchayan Yojana, which uses check dams and percolation ponds), adding **canopied riparian buffers**, **preserving ox-bow lakes** and using mined landscapes as **runoff reservoirs**. In addition, we suggest the implementation of rip-rap and additional off channel storage downstream of the Ajwa Lake to reduce its load during the monsoon.

Summary of City Scale

Within the city scale (which reaches from beyond the boundaries of the river defined by the VRDP to the city's boundary limits), engineered drainage systems and

impervious surfaces act as the foundational fabric on which the entire city has been designed. This prevents groundwater recharge, thereby compounding flooding issues within the city. Indirect effects also include reduced water quality and human-wildlife conflicts. We employed the concepts within Kristina Hill's hydrologic function typologies (Hill 2009) to prioritize urban sewer sheds for the implementation of green infrastructure. This is aimed to increase multifunctionality within a single landscape by targeting improved water quality and ecosystem services, shared community spaces and increased flood flow detention areas.

The sprawl of green infrastructure and resulting impervious surfaces necessitate adequate data collection on sewer sheds and stormwater sheds. With changing landscapes, they need frequent updates to ensure proper installation and maintenance of GI. Thus, we require enforcing agencies to expand their monitoring and evaluation procedures to reduce data gaps and maintain performance records in peak monsoon flows. In addition, the Water Act also needs revision to define stormwater and sewer sheds, standards and directive principles for their maintenance, as well as penalties for non- compliance. We also suggest that this function fall under the purview of the Watershed Council to prevent conflicts arising out of discrepancies in the State and Union legislative terminologies.

Summary of Influence Zone

This zone was defined by the VRDP as an average width of 500m or up to a major road along the river's course- representing about 7% of the city's spatial extent. After addressing the upper watershed and the city to allow for increased water retention, we further increase the flood plain's capacity to handle peak water flows through the river channel. We utilize the dynamic, meandering flow of the river through the city to extend its floodplains where possible and allow for off channel storage along with afforested riparian buffers which serve as biodiversity hotspots for native flora and fauna. Our Influence Zone design displays further about how these landscapes can serve as shared community spaces with opportunities for interactions with the riparian ecosystem (similar to the existing Sayaji park at the heart of the city), while providing for improved ecosystem services.

The main rationale behind our suggestions for the influence zone was to shift the notion of a river from a channel for disposal of waste to a thriving ecosystem full of opportunities for the mutually beneficial integration of man and wildlife. This requires legislature to reflect this ideology (as mentioned in the above section on upper watershed dynamics). We thus need to include morphological restructuring of rivers

(such as channelization and concretization practices) as 'man-made alterations to rivers' within the IWRD Act. Boundaries of rivers need expansion to the floodplain river (within the influence zone) and monitoring strategies need to evaluate quality of riparian edges and wetlands. Urban development needs to be reviewed for compliance with prescribed impervious/ pervious surface ratio standards in addition to other Environmental Impact Assessment clearance requirements.

Watershed Policy

Our need to address the wider watershed scale arises from the lack of adequately defined linguistics in the legislature surrounding water bodies and their quality. The Water (Pollution and Prevention) Act for example only specifies standards for industrial effluents disposed into surface water bodies[15]. The Interstate River Water Disputes Act (IRWD Act), enacted under Article 262 of the Constitution, only defines directives for inter-state river water conflicts that arise from the actions of one state affecting another state(s). Activities such as damming (downstream) and obstructing average river flows and quality (either through constructing water reservoirs or through consumptive uses upstream) are considered as potential conflicts. It also defines excessive silting/ turbidity as a "man-made water quality alteration" arising from deforestation and mining activities, and using water from other river basins (Agrawal 2005).

Recommendations

Our field visits and analysis show a contrasting picture which highlighted the gaps in the legislative framework:

1. The Water Act, while assuring water quality (on paper) through the CPCB and the GPCB, does not specify directives for non- point pollution sources.
2. The absence of adequate forest cover, which naturally catches sediment and prevents erosion is unaddressed in the IRWD Act While the IRWD Act suggests this to be a result of man-made activities such as deforestation and mining, the Act limits this definition to inter-state river, and not watersheds (although this is

[15] CPCB's environmental standards for effluents only refers to point sources of pollution, and surface water quality is purely determined on the basis of designated best use (see critique section on water quality assessment for more info). Also refer CPCB website (under environmental standards for more details).

a widely observed phenomenon with seasonal rivers experiencing changing land-uses).

3. We also observed that the reduced capacity of the Ajwa reservoir results in increased flood flows during the monsoon. While the constructing of water detention structure has been recognized as a potential conflict, the IWRD Act once again limits this to inter-state rivers, and in certain cases, only to upstream or downstream section of rivers.

We thus have the following policy suggestion and recommendations for the Indian legal system, if enforcement of environmental laws is a *priority*:

1. The Water Act could be revised to add additional standards for monitoring pollution levels arising from non-point sources. We also suggest expanding the current Bureau of Indian Standards (BIS) to reflect point and non-point non-industrial effluent pollution loads.
2. The scope of the language and directives of the IWRD Act needs expanding to include all rivers. We also suggest changing the definition of "altered flows of rivers" to include excessive flooding because of anthropogenic activity, in addition to the obstruction of normal river flow and water quality.
3. While GPCB may serve as the enforcing authority for maintaining the overall quality of Vishwamitri, its definition does not ensure adequate monitoring or protection of the entire stretch of the river and its basin. Therefore, we suggest the establishment of a Watershed Council which defines a river's boundaries based on its natural flow and hydrology, and not through limiting terminology that favor beneficiary use for humans. In addition, the Council will work alongside the government, in a somewhat autonomous capacity, in an effort to reduce conflicts arising out of differences in the State and Union legislature. In particular, the Council will **use scientific critique to address concerns of water quality and management at the watershed level.**

Conclusion

The Gujarat Ecology Commission, in its report on environmental Strategies for Gujarat recognizes the need for policy action in addressing water conservation issues, but does this to address the bigger question of water scarcity (GEC report, 2014- 2019). This is a prime example of environmental legislature in India, which seemingly provides localized solutions to problems, often by ignoring the bigger picture. This is also seen in the case of the IWRD Act, where legal terminology (that are often linked with the "Urban Stream Syndrome") is used to resolve inter-state disputes over rivers, while failing to recognize the more global phenomenon of rivers being impaired by anthropogenic activity- interstate or otherwise. In a similar narrative, the Biodiversity Act limits its definition to the 'unequitable use of resources and knowledge'. Broader concerns for the loss of invaluable riparian ecosystems in a river-fed India is acceptable in the name of 'urban development', as is restricting water quality standards to industrial effluents. Conflicts between land and development, although seemingly prevented by mandating Environmental Clearances, can often be ignored by developers (as seen in the case of VRDP). We thus observe that the lack of adequately defined and revised linguistics in Environmental Laws and Acts are causes for unsatisfactory enforcement.

While there have been precedents of the judicial acting in favor of the environment, such as right to livelihood, right to clean environment and right to equality under interpretations of the 42nd Amendment of the Constitution, these actions have been possible by the undying (and often threatened) environmental activists. **The ASP Foundation in Gujarat, in particular, has had success in staying the VRDP on the grounds of negligence in getting environmental clearance, illegal construction and clearance activities along the Vishwamitri.**

The two-fold provision for the protection of the environment (under the 42nd amendment of the Constitution) and the extremely comprehensive legislative and judicial framework are laudable in their motive and in their innovative interpretations of the law to provide for environmental protection[16]. Nevertheless, the varying degrees of success and the process of challenging the faulty agencies can be streamlined by revising the existing legal framework to have a unifying authority. In our case, that of the Vishwamitri River, a Watershed Council can plug the aforementioned gaps, and bring our vision of the Vishwamitri to fruition with the lead of local citizens.

[16] This is seen in the judgement rulings of the Indian Courts (see section on enforcement mechanisms on environmental law) where rights and duties under the Constitution have been interpreted to be more inclusive and accountable.

Summary Table of Environmental Acts

Description:	Act and Year Passed:
This provides for the prevention and control of water pollution by preventing discharge of industrial pollutants beyond a certain standard. It also lays down penalties for non-compliance with its standards. In addition, it set up the enforcing bodies - CPCB and SPCB - and its functions at the national and state levels. respectively.	Water (Prevention and control of Pollution) Act (1974)
This implements the decisions taken in the Stockholm conference to ensure the control and abatement of air pollution by establishing standards. Under this Act, every industrial operator is required to have a permit from the State Board.	Air (Prevention and Control of Pollution) Act (1981)
This was enacted to protect and improve the environment and prevent, control and abate its pollution. It lays standards for environmental quality maintenance and monitoring in addition to defining penalties for non-compliance.	Environment (Protection) Act (1986)
This was enacted for ensuring strict liability for damages arising out of environmental accidents and hazards. Also led to the establishment of the National Green Tribunals.	National Environment Tribunal Act (1995)
This was enacted to protect wild animals, birds and plants by preventing hunting and other damage to flora and fauna. It also established a State Wildlife Advisory Board to advise the State Government in policy decisions, and in designating protected areas.	Wildlife (Protection) Act (1972)
This was enacted to check deforestation of forests by mandating previous approval from the Central Government prior to the destruction/use of forest land for non-forest purposes, along with afforestation.	Forest (Conservation) Act (1986)
This accounts for the preservation of biodiversity in India and provides for equitable share of benefits from the use of traditional biological resources and knowledge.	Biological Diversity Act (2002)

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A River and its Reign

APPENDIX 4
FULL COMMUNITY SURVEY

નીચે આપેલા પ્રશ્નો એક શૈક્ષણકિ સંશોધન માટે છે. આ સંશોધનનો ઉદ્દેશ્ય વડોદરા ના વાસયિો નો અભપ્રિાય સમજવું છે. તમારા જવાબો અનામી રેહશે.

○ હું ઉપર લખેલા વાક્યઓ થી સેહમત છું.

1. આ શહેર માં તમારી મનપસંદ જગ્યા જ્યાં તમને સમય પસાર કરવો ખૂબ ગમે છે એનું નામ લખો?

_____

2. શું તમેં બરોડા શહેર ની અજુ બાજુ કોઈ જગ્યાઓમા રજાઓ પસાર કરવા જાઓ છો? અગર હા તો ક્યાં અને કેમ?

_____

3. તમે કેટલી વાર કોઈ બાગ માં જાઓ છો ?

- ☐ દરરોજ
- ☐ મહનિા માં 2 -3 વખત
- ☐ વશિષ પર્વની વખત
- ☐ અઠવાડયિામાં કોક વાર
- ☐ મહનિા માં એક વાર
- ☐ ક્યારેય નહ

4. તમને બાગ માં કેટલી વાર જવું ગમશે

- ☐ દરરોજ
- ☐ મહનિા માં 2 -3 વખત
- ☐ વશિષ પર્વની વખત
- ☐ અઠવાડયિામાં કોક વાર
- ☐ મહનિા માં એક વાર
- ☐ ક્યારેય નહ

5. તમારે બાગ માં જવા માટે કેટલું દૂર જવું પડે છે ?

- ☐ 15 મનિટિ ચાલવા કરતાં ઓછુ
- ☐ 15-30 મનિટિ વાહન પર
- ☐ 15-30 મનિટિ ચાલવા જેટલું
- ☐ ૩૦ મનિટિ થી વધારે વાહન પર

6. તમે બાગ માં જવા માટે ૫-૧૦ રૂપયિા જાળવણી માટે આપવા રાજી થશો ?

- ☐ હા
- ☐ ના

7. એક શબ્દ માં વશિ્વામત્રિી નું વર્ણન કરો:

_____

8. આ નદી માં શું સારું છે ?

- ☐ વન્યજીવન અને છોડ અવલોકન કરવાની તક
- ☐ હવા અને ઠંડક ના કારણે આરામ કરવાની જગ્યા
- ☐ મનોરંજન
- ☐ કુદરતી પર્યાવરણ ની ઝલક માટેનું સ્થળ
- ☐ બીજું કોઈ કારણ_____

9. આ નદી માં શું સારું નથી ?

- ☐ પ્રદુષણ
- ☐ દુર્ગંધ
- ☐ ઓછી મનોરંજનની તકો
- ☐ ઈમારતોના કારણે કુદરતી દૃશ્યો નો અવરોધ
- ☐ બીજું કોઈ કારણ_____

10. તમે શું કારણે નદીએ જાઓ છો અને કેટલી વાર? (લાગુ પડતું બધું પસંદ કરો)

	દરરોજ	અઠવાડયિા માં કોક વાર	મહનિા માં 2 -3 વખત	મહનિા માં એક વાર	વશિષ પર્વની વખત	ક્યારેય નહ	પ્રસાર કરેલો સમય
ઘરેલું કામ, જેવું કે કપડા ધોવા, વાસણ ઘસવા, વગેરે							
નદી ને જોવા							

કુદરતી અને વન્યજીવન જોવા

નદી પાર કરવા

જૂહાડે જવા

અન્ય કારણો સ્પષ્ટ કરો

_____

11. શું તમે નદી ની નજીકમાં એક નિવાસી છો? અગર હા, તો પછી તમે નદીની કેટલી નજીક રહો છો?

- ☐ 5 મિનિટ ચાલવા કરતાં ઓછુ
- ☐ 5-15 મિનિટ ચાલવા જેટલું
- ☐ 15-30 મિનિટ ચાલવા જેટલું
- ☐ 30 મિનિટ થી વધારે

12. વશિષ્ઠમિત્રી નદીમાં શું સૌથી વધારે મહત્વનું છે ? (લાગુ પડતા બધા પસંદ કરો)

- ☐ મનોરંજન માટે સ્થળો
- ☐ મગર ને એમના કુદરતી વસવાટ માં જોવાની મજા
- ☐ પૂર અંગે વ્યવસ્થા
- ☐ પાણી ની ગુણવત્તા
- ☐ પાણી, લાકડા વગેરે ની ઉપલબ્ધી
- ☐ તહેવારો અને ઋતુઓ સાથે સંકળાયેલ સાંસ્કૃતિક કાર્યક્રમ

13. નીચે આપેલા કયા કારણો થી બરોડાની અનેક જગ્યાઓ માં પાણી ભરાઈ છે જેના લીધે વિવિધ વિસ્તારોમાં પુરની સમસ્યા છે?

- ☐ બાંધકામ ના કારણે નદીની અજુ બાજુ ના નીચલા વિસ્તારો નું ભરાણ
- ☐ કાંસ નું ભરાણ
- ☐ નબળી ડ્રેનેજ વ્યવસ્થા
- ☐ નદીમાં ડેમનું પાણી છોડવા ના કારણે

14. તમારી દૃષ્ટીએ માનવીય પ્રવૃત્તિ ના કારણે વનસ્પતિ અને પ્રાણીશુષ્ટિ માં થયલું નુકશાન કેટલું ગંભીર છે?

- ☐ થોડું ગંભીર
- ☐ ખૂબ જ ગંભીર
- ☐ ગંભીર સમસ્યા નથી
- ☐ મને ખબર નથી

15. શું તમે જાણો છો કે ભારત માં આવતી નદિયોં માં વશિષ્ઠમિત્રી એક આધી વશિષ નદી છે જેમાં તંદુરસ્ત મગરોની વસ્તી શહેરી ઈલાકા માં વસે છે?

- ☐ હા
- ☐ ના

16. શું તમે જાણો છો કે કાયદા પ્રમાણે મગર એ પ્રજાતિ છે જેનું અસ્તિત્વ જોખમમાં છે?

- ☐ હા
- ☐ ના

17. તમે ક્યારેય વડોદરામાં મગરનો સામનો કર્યો છે?

- ☐ ક્યારેય નહિ
- ☐ પેપર, રેડિયો અને ટીવી દ્વારા સાંભળ્યું છે
- ☐ મેં નથી કર્યો પણ મારી ઓરખાણ ઓળખાણ માં કોઈ એ કર્યો છે
- ☐ હા, જોવા માં આવ્યો છે
- ☐ હા, શારીરિક સામનો કર્યો છે

18. વશિષ્ઠમિત્રી મગરો વશિ નીચેની કયા નિવેદનો સાથે તમે સમ્મત છો ?

- ☐ વશિષ્ઠમિત્રી ના કુદરતી વસવાટ માં રેહતા મગર વડોદરા ને વશિષ બનાવે છે. શહેરે તેમની રક્ષા કરવી જોઈએ અને તે દ્વારા પ્રવાસન આવક આકર્ષિત કરાઈ.
- ☐ મગર એક અસુરક્ષિત જીવ છે. કોઈપણ માનવીય પ્રવૃત્તિ નદી પાસે એમના કુદરતી વસવાટોમાં ના હોવી જોઈએ.
- ☐ બધા મગરોને એમના કુદરતી વસવાટમાં રાખવા જોઈએ અને નદી ના અમુક ભાગ માનવીય ઉપયોગ માટે રાખવા જોઈએ.

- [ ] બધા મગરોને ને એક અલગ પાર્ક માં રાખવા જોઈએ
- [ ] મગર જોખમી છે. શહેર મગર મુક્ત હોવું જોઈએ.

19. શું તમને લાગે છે મગર ની આબાદ વસ્તીને લીધે વશિ્વામત્રિી નદી ગીર રાષ્ટ્રીય ઉદ્યાન ની જેમ એક પ્રવાસન આકર્ષણ બની શકે છે?

- [ ] હા
- [ ] ના

20. નીચે આપેલા ક્ષેત્રો માં અગર સરકાર બદલાવ લાવા ઈચ્છતી હોય , તો તમારા હસિાબે ક્યા <u>તરણ</u> ક્ષેત્રો માં સરકારે કામ પ્રથમ કરવું જોઈએ?

- [ ] વ્યાપારી પ્રવૃત્તા
- [ ] ઉદ્યાન અને મેદાનો
- [ ] કુદરતી પર્યાવરણ / નેચરલ હેરટિજ
- [ ] સાંસ્કૃતકિ વારસો
- [ ] લોકો ની સુરક્ષા
- [ ] ઝૂંપડપટ્ટી માં સુધારણ
- [ ] ઘર વ્યવસ્થા
- [ ] સફાઈ અને પ્રદુષણ મુક્ત

21. શહેરમાં ઘણા મોલ્સ અને એપાર્ટમેન્ટ ખાલી છે, શું તમને લાગે છે વધારે ની જરૂરયિાત છે?

- [ ] હા, ઘણી જરૂર છે
- [ ] હા, થોડી જરૂર છે
- [ ] ખબર નહ
- [ ] બલિકુલ જરૂર નથી

22. સામાન્ય રીતે તમને લાગે છે કુદરતી પર્યાવરણ ને જાળવવું શહેરી વકિાસ માટે અગત્યનું છે?

- [ ] પુરી રીતે સહમત
- [ ] હું સહમત છુ
- [ ] મને ખબર નથી
- [ ] હું સહમત નથી
- [ ] પુરી રીતે અસહમત
- [ ]

23. જો સરકાર શહેર ના અન્ય ભાગ માં તમને રહેવાની વ્યવસ્થા આપે તો તમે તમારી વર્તમાન વસાહત છોડીને જવા તૈયાર છો?

- [ ] હા
- [ ] ના

24. શક્ષિણ

- [ ] પ્રાથમકિ શાળા
- [ ] મધ્યમકિ શાળા
- [ ] ઉચ્ચતર માધ્યમકિ શાળા
- [ ] ગ્રજુએટ
- [ ] પોસ્ટ-ગ્રજુએટ
- [ ] પી .એચ. ડી

A River and its Reign

APPENDIX 5
TEAM PROFILES

TEAM PROFILES

SNRE Research/Design Team Profiles

Dhara Mittal (resident of Vadodara, sourced this project)
Dhara Mittal is a current Master of Landscape Architecture student. She has an undergraduate degree in Architecture and is passionate about river systems. Her interests lie in systems conscientious design and community engagement in design decision making. She has worked actively for the river systems of Vadodara city and has successfully formulated her vision for one of the creeks in the city into an Architectural Design thesis that has been awarded at the State and Regional levels.She is adept at design skills and softwares and aims to synthesize her learnings from the diverse courses at SNRE with these to create designs that are meaningful, holistic and engaging. Her interest in the Vishwamitri and engagement and work with the stakeholder group VRAT led her to pursue this topic as a Master's project at SNRE.

Interests: Urban wilds, interrelationships between natural and cultural systems, vernacular designs, community engagement in designs, ecological design, conflict resolution through design and the evolution of man- nature interaction over the years
Skillsets: AUTOCAD, ArcGIS, Adobe Photoshop, Adobe Illustrator, Google Sketchup, MS Office, Plant identification.

Alex Kinzer
Alex is a current Master of Landscape Architecture (MLA) student, also pursuing a dual-degree in Conservation Ecology. She earned a Bachelor of Science in Environmental Studies from Wheaton College (IL), which laid a solid foundation for her work in coastal forest conservation in East Africa before coming to SNRE. Her main interests are the incorporation of ecological principles into land-use decisions and design, especially in areas of human-wildlife conflict or conflict over natural resource use. She hopes to use her ecological understanding and design skills to create spaces for the mutual thriving of communities and their environment.

Interests: habitat restoration, stormwater management/water quality, community-based design, conservation of forests, wetlands, and rivers, conflict resolution through design
Skillsets: site engineering, AutoCAD, Adobe products, GIS/ArcMap, plant identification, insect identification, big-picture thinking and getting lost in the details

Xinming Liu
Xinming is a current Master of Landscape Architecture (MLA) student in first year. She earned a Bachelor of Landscape Architecture (BLA) from Beijing Forestry University. Five years of design experience gives her proficient skills in design and planning. Her major interest is combining ecological design with urban planning principles to make cities a better place to live, not only for human, but also for all kinds of living things. Also, she is good at humanized design and spatial building.

Interests: urban design, urban ecology, planning
Skillsets: AutoCAD, Adobe products, 3D modeling, spatial data analysis

Rubin Sagar
Rubin is a first year Master's student specializing in Conservation Ecology. Before joining SNRE, he was in VIT University an engineering college in Vellore, India. Having done mechanical engineering for his undergraduate degree, Rubin has made a drastic career change, due to his passion for the environment and has a strong desire to utilize skills and knowledge gained in SNRE to solve environmental issues, especially in developing countries. He is a part of this project because the major concerns which the project focuses on are what Rubin would like to dedicate his career to - ecological restoration, wildlife conservation and management and human-wildlife conflicts.

Interests: ecological restoration, human-wildlife conflict, conservation and management
Skills: Identification of flora and fauna, ecological restoration modelling, GIS, data sampling and data analysis, using design software (AutoCAD, SolidWorks), Microsoft Office and ArcGIS.

Krithika Sampath
Krithika is a current first year Masters student at SNRE, specializing in Conservation Ecology. Having pursued Environmental engineering in her undergraduate, she aims at combining her knowledge and skills in both fields to work on large scale restoration projects in diverse ethnic communities.
Interests: Conservation Biology, Restoration Ecology, Water Engineering, Management
Skills: ArcGIS, ERDAS IMAGINE, Identification of flora, Soil analysis, Microsoft Office

Chase Stone
Chase Stone is a Master of Science-candidate (2017) at the University of Michigan focusing on environmental policy and microeconomics at the School of Natural Resources and Environment. Prior to Michigan, Chase completed his Master of Arts degree from the California Institute of the Arts "Aesthetics and Politics" program in Critical Studies and Bachelor of Arts degree from Oberlin College. In 2015, Chase aided nature conservation efforts with the European Union "Partnership for Peace" in Jerusalem and will be working with the Department of Interior – Office of Policy Analysis in Washington D.C. in 2016.
Interests: ecosystem-based adaptation, microeconomics, environmental justice, stakeholder analysis
Skills: policy, stakeholder analysis, microeconomic modeling, interviews, photography, Microsoft Suite, Adobe Suite, R Studio, LaTex

Yundi Yang
Yundi is a second-year master's student pursuing a dual degree in Conservation Ecology and Environmental Health Sciences. She did her undergraduate study in Environmental Engineering at Tongji University in Shanghai, China. Yundi is interested in applying theories and techniques of restoration ecology and environmental engineering to this real world design project and developing an alternative framework for river interventions. Besides her knowledge in environmental

contamination and restoration, Yundi also has skills in environmental sampling, statistical and spatial data analysis.

SNRE Advisor Profiles

Professor Allen Burton, PhD
Professor, School of Natural Resources and Environment
Director, Cooperative Institute for Limnology and Ecosystems Research
(bio below from http://www.snre.umich.edu/research/faculty/allen_burton)

Dr. Burton has an Honorary Doctorate from the University of Roskilde (Denmark), is a Concurrent Professor at Nanjing University and an Honorary Professor at the State Key Laboratory of Environmental Criteria and Risk Assessment in Beijing China. His research on ecological risk assessment, sediment quality criteria, and aquatic ecosystem stressors has taken him to all seven continents with Visiting Scientist positions in Denmark, New Zealand, Italy and Portugal. His research has focused on sediment and stormwater contaminants and understanding bioavailability processes, effects and ecological risk at multiple trophic levels, and ranking stressor importance in human dominated watersheds. He is Editor-in-Chief of the international journal, Environmental Toxicology & Chemistry, past president of the Society of Environmental Toxicology & Chemistry, and has served on numerous national and international panels with over 160 peer-reviewed publications.

Professor Johannes Foufopoulos, PhD
Associate Professor, School of Natural Resources and Environment
(bio below from https://lsa.umich.edu/pite/people/teaching-faculty/jfoufop.html)
Johannes Foufopoulos is a faculty member in the School of Natural Resources and Environment. His research centers broadly on two areas: (i.) the science behind the conservation of wildlife populations and natural ecosystems and (ii.) the ecology of infectious wildlife diseases.
More specifically, he studies how habitat fragmentation, global climate change and emerging pathogens impact global biodiversity and ecosystem function. The research group also investigates the ecology of parasitism and disease in vertebrates by studying the ecological, physiological and evolutionary aspects of host-parasite interactions. To do so, lab members use an integrative approach with methodologies borrowed from field ecology, comparative physiology, ecological immunology, evolutionary biology and population genetics.
Teaching Interests: Conservation biology, disease ecology
Research Interests: Conservation biology of terrestrial vertebrates, ecology and evolution of parasitic organisms and the impact they have on their hosts.

Professor Joan Nassauer, FASLA
Professor, School of Natural Resources and Environment
Co-Editor-in-Chief, Landscape and Urban Planning
(bio from www.joan-nassauer.com and the SNRE website)

Joan Iverson Nassauer works in the field of ecological design. She develops design proposals to improve ecosystem services, and uses social science methods to learn how human experience affects and is affected by landscapes. A Fellow of the American Society of Landscape Architects (1992) and a Fellow of the Council of Educators in Landscape Architecture (2007), she was named Distinguished Scholar by the International Association of Landscape Ecology (IALE) (2007) and Distinguished Practitioner of Landscape Ecology (1998) by US - IALE. The strategies she has developed for basing ecological design on strong science and interdisciplinary collaboration have been applied internationally. An early discovery and continuing theme of her research is that evidence of human care in the landscape has a powerful normative effect on human perceptions and behavior to change landscapes. Her research has influenced green infrastructure design, ecological restoration, urban and rural watershed management, transportation planning, and the development of metropolitan neighborhoods and brownfields.

Teaching Interests: Teaching focuses on landscape ecology and landscape perception, with applications in design and planning of agricultural and metropolitan watersheds.

Research Interests: Human preferences and behavior in relation alternative landscape patterns and management.regimes and associated ecosystem services; Design techniques for contributing to transdisciplinary research and policy development.

Client Profiles

Amrut Sitaram Pradhan (ASP) Foundation

ASP Foundation is registered charitable trust under the Bombay Public Trusts Act, 1950 bearing Registration No. E.6389 – Vadodara dated 3-Oct-03 & PAN No.AAFTA1207Q of the Income Tax Department of Government of India.

The ASP Foundation is a Non Governmental Organization whose mission is "Education Development and Clean Environment for All".

To fulfill its mission statement, the Foundation is initiating various activities and projects focusing on Sustainable Development.One of the Foundation's focus areas is ENVIRONMENT, with an object to carry out all types of activities relating to improvement and maintenance of healthy environment and ecology both in Urban & Rural areas and to carry out activities for waste and desert land development.

Under the campaign "Conserving water bodies and their surroundings", the Trust has initiated following programmes/studies:

Observed the issues related to the Gotri Talav and have jointly conducted awareness, cleaning and conservation programmes with the local residents, other concerned citizens and the VMC. (2004-till date)

A status paper was presented by Smita Pradhan, Managing Trustee ASP Foundation, as a National Resource Person the fifth international workshop on "Ecotourism and Biodiversity : Shrinking Wetlands" organized by the Indo American Environmental Leadership Program (IAELP) of United States Educational Foundation in India (USEFI) (2005).

Since 2012 till date it has been actively involved in creating awareness on the status of the River VIshwamitri especially man animal (crocodiles) conflict and as a part of this campaign its volunteers were invited by the Forest Department to undertake a census on number of crocodiles in the River Vishwamitri (2014-2015).

Smita Pradhan
Member – Wildlife Advisory Board – Gujarat State
Trustee – ASP Foundation
Past: Director - Gujarat State Office - World Wide Fund for Nature - India (WWF India)

Proven long term experience in conceptualizing, organizing & executing environment related projects in rural and urban sectors, environmental planning, education & training programs, for rural management and community development, environment pollution management, water and wastewater recycle & reuse, environmental assessments, wildlife and forestry issues and social forestry. Is especially geared towards Project Planning, Appraisal, and Administration of Participatory Management Programs related to Sustainable Development with over 10 years experience in working at senior level in international NGO (WWF- India), environmental consulting, training and organising workshops at the National level for State, National and International agencies(viz. WWF- India,UNIDO, UNITAR,GTZ)

• Consultancy services in the in the field of environmental planning and management covering Environmental Impact Assessment (EIA), formulation of Environmental Management Action Plans (EMP) & CRZ Clearance of various port related projects; viz:

• Has worked extensively in the industrial, municipal and development sector on promoting Environmental Programmes especially those related to International Conventions and Issues such as Climate Change, Renewable Energy and Toxics.

• Involved as a team member in inventory and report preparation (including Impacts) of selected Chemical Sectors at the National level on National Chemical Management Profile, a project awarded by CPCB and supported by UNITAR.

• Responsible for preliminary assessment to identify the requirements for developing a National Implementation Plan in India as a first step to implement the Stockholm Convention on Persistent organic Pollutants (POPs). The project was sponsored by UNIDO and has been undertaken through MOEF-ITRC.

URBAN DEVELOPMENT -
• A United State Trade Development Agency (USTDA) project to carry out a "Feasibility Study for the Gujarat Industrial Development Corporation (GIDC) Wastewater Recycling Project" for reuse of treated effluent generated from industrial estate of Ankleshwar, Jhagadia and Panoli. Government Project

• A United State Trade Development Agency (USTDA) project to carry out a "Feasibility Study for the Gujarat Industrial Development Corporation (GIDC) and Ahmedabad Municipal Corporation Wastewater Recycling Project" for reuse of treated effluent generated from industrial estate of Naroda, Vatva, Odhav and the STP's in Ahmedabad.

• As team leader worked in a United State Trade Development Agency (USTDA) project to come out with feasibility for reuse of treated sewerage generated from Hyderabad City and ten Municipality adjoining Hyderabad. The feasibility to reuse 592 MLD treated sewage has been suggested. EIA for the proposed reuse option including its route of transport has been carried out. Government Project

• Conceptualized solid waste management project for Kapadwanj taluka of Kheda district, made presentation, prepared a techno-commercial offer, got the job awarded and successfully completed the project on solid waste management for the town as per the regulation of NRCD/ NLCP guidelines.

• DPR's for Solid Waste Management for city of Bidar, Raichur, Bijapur, Bellary, & Gangavati of Karnataka state.

• .In 1993 conducted a status survey of ground water contamination for the Ankleshwar Industrial Area in Gujarat - this is Asia's largest chemical industrial area. The report was submitted to the MOEF and CPCB.

Professor Shishir Raval, PhD
Director of Vadodara Regenerative Action Team (VRAT)
Professor of Architecture, Maharaja Sayajirao University
SNRE Alumnus

Dr. Raval is an SNRE alumnus and currently a Professor of Architecture at the Maharaja Sayajirao University in Vadodara, Gujarat, India. His research and teaching interests are focused on integrating ecological sciences, people's perceptions and participation, and ethics in defining and addressing critical and neglected built environment issues and opportunities. Having educational

and professional background in architecture, landscape architecture, and natural resources management, Dr. Raval has been involved with projects in various settings (from wilderness and protected areas to rural and urban core) and of various sizes (from square meters to square kilometers) both as knowledge as well as design consultant. In addition to teaching courses such as 'Climatology', 'Landscape Design', '<Research><Architecture><Practice>', 'Ecology and Environment', 'Architectural Design Studio', 'Regional Planning Studio', and guiding final year thesis projects both in the B. Arch. and MURP programs on related subjects, Dr. Raval has been active, along with his cohorts, in his city and neighborhood for raising important ecological planning and design issues and offering alternatives for the same. He is a restless soul in search of saner development and design alternatives (professionally and in personal life) while practising patience,nurturing passion, and testing knowledge and biases. Gratefully, serendipity and equanimity often become good companions on his many planned and unplanned sojourns as well as journeys.