STEERING WATER THROUGH ENVIRONMENTAL BEHAVIOR:
Urban Water Management Decision-making in Mumbai's Strained Ecosystem of the Mithi River

by

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ABSTRACT

Building on the fundamental proposition that community stewardship is integral to the success of any urban design and engineering intervention, in this dissertation, I investigate *how people-centric approaches can help decision-makers in urban water management better intervene in strained ecosystems*. The study deep dives into the case of the polluted Mithi River in Mumbai, which gained traction only after the devastating deluge of 2005, laying bare the gravity of pollution and urban flooding. These issues will further exacerbate climate change's impact on the coastal city of Mumbai. This empirical research engages a representative subset of decision-making community members (n=30) to rethink their urban water management practices from an environmental behavior framework, probing mechanisms beyond the conventional large-scale designs, and hard-engineering solutions. For instance — incentivizing positive behavior of communities, businesses, and entities, establishing a social support network to reinforce pro-environmental behavior, and recruiting change agents or role models within the communities.

In this study, the decision-making community is the primary data point or unit of analysis, and the polluted urban river postulated as a consequence of anthropogenic factors is the broader unit of analysis. The study draws on a mixed methods research design of semi-structured interviews, assessment surveys, field observations, and secondary data. An essential part of this research is defining the decision-making community, guided by frames of equity, representation, and agency while acknowledging that people close to the urban problems are often closest to the solutions. Furthermore, in exploring behavior change as a tool in steering urban water management, the research builds upon the Pro-environmental Behavior (PEB) as a methodological framework to engage decision-makers, analyze current practices, and identify opportunities. Driving on the primary research question of how the decision makers are thinking about behavior change in light of their current practices and experiences of the Mithi river since the deluge, I attempt to (1) construct the problem through the perspective of the decision-making community and their relationship with the river, in conjunction with the spatial dimension through an overview of the environmental history of the urban river, (2) gauge the potential to influence environmental behavior at the individual, collective and policy levels, and (3) assess the effectiveness of river restoration through a behavior change framework. Findings show that the decision-making community identifies "Fractured governance" as the highest responsible factor contributing to river pollution, followed by "Domestic level discharge of untreated sewage", and lacking "Solid waste disposal services." The governing landscape of the river's 17.84 km (11 mi) stretch is highly complex, often favoring a pro-development outlook and viewing the river body as something that needs to be fixed or treated. When the governing agencies that are the most critical change agents in the river's future are also a crucial part of the problem, there emerges a need for a fundamental shift in the perception driving their interventions and presenting a vital opportunity.

Further, the decision-making community identified "Service delivery" and "Shaping Knowledge and Training" as the most effective Behavior Change Techniques for river restoration, making a case for a systems-level approach to infrastructure projects through service provisioning rather than surgical interventions like the retaining walls, by creating collective awareness through ownership of this urban resource. The analysis revealed themes of *Systems Approach*, *Governance*, and *Narrative Shift* in understanding the gap between the vision and the outcome of the Mithi River. It is important to consider these findings within the bounds of the participant group which is one of the many ways to assemble a representative and equitable decision-making community.

The Mithi River is an urgent issue confronting Mumbai city and its climate future. Several research participants are currently at the forefront of driving solutions. For them, this research attempts to make a viable case for shifting their perspectives and prioritizing interventions to target collective behavior at multiple levels of society — like business associations, small-scale industry groups, through CSRs, the residents, including informal settlements, indigenous tribes — that inhabit the river basin rather than solely focusing on the river body, and potentially severing it from the city. Moreover, the research methodology situates various response strategies through a behavioral framework. This framework can be effective in the case of Mumbai, and similar Global South contexts, fostering consensus-making among working groups representing wide-ranging interests by foregrounding behavior change in urban water management.

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LIST OF ABBREVIATIONS

AIILSG: All India Institute for Local Self Governance

BCT: Behavior Change Technique (BCT)

BKC: Bandra Kurla Commercial Complex

BMC: Brihanmumbai Municipal Corporation

CCC: Concerned Citizens Commission

COM-B: Capability Opportunity Motivation - Behavior

CRZ: Coastal Regulatory Zone

CSR: Corporate Social Responsibility

ESG: Environment, Social, and Governance

IIT-B: Indian Institute for Technology, Mumbai

KRVIA-ES: Kamala Raheja Vidyanidhi Institute for Architecture and Environmental Studies

MCGM: Municipal Corporation of Greater Mumbai, also used interchangeably as BMC

MIAL: Mumbai International Airport Ltd.

MMRDA: Mumbai Metropolitan Regional Development Authority

MPCB: Maharashtra Pollution Control Board

MRDPA: Mithi River Development and Planning Authority

NBS: Nature-Based Solutions

NEERI: National Environmental Engineering Research Institute

NGO: Non-governmental Organization

NGT: National Green Tribunal

PEB: Pro-Environmental Behavior

RWA: Resident Welfare Association

SES: Socio – Ecological Systems/ Socio – Environmental Systems

SGNP: Sanjay Gandhi National Park

SPA: Special Planning Agency

SRA: Slum Rehabilitation Scheme

STP: Sewage Treatment Plant

SWMD: Storm Water Management Department

WRI: World Resources Institute

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INTRODUCTION

1.1 Framing the Study

Research Purpose and Approach

The objective of my dissertation is to explore the ways in which the decision-making process for urban water management can be enhanced by placing a higher emphasis on people-centered methods to address ecosystem concerns. Instead of primarily concentrating on infrastructure-focused solutions for polluted urban rivers, I propose a decision-making practice that considers all existing and emergent interventions from an environmental behavior perspective. In challenging the current status quo of practice, I probe mechanisms beyond conventional large-scale designs and hard-engineering solutions through this study. These mechanisms include incentivizing positive behavior among communities, businesses, entities, and institutions; enhancing education and capacity building; establishing social support networks to reinforce pro-environmental behavior and collective resource ownership; and engaging change agents or role models within communities. Based on the proposition that the success of design and engineering solutions hinges on community stewardship, I put forth the hypothesis that behavioral methodologies could play a critical role in bridging the substantial implementation gap. When applied and scaled suitably for infrastructure projects, these methodologies can steer environmental policies and programs in the desired direction.

My academic curiosity was initially sparked by the condition of the deteriorated urban rivers in developing metropolises, particularly the Yamuna River in New Delhi, the urban rivers in Chennai that culminate into the Indian Ocean, and Mumbai's rivers that merge with the Arabian Sea, within the context of India. These cities' distinctive coastal and riverine environments shape their unique urban water challenges, such as severe pollution, flooding, and water scarcity, which are further intensified by climatic extremes. This dissertation conducts an in-depth analysis of the polluted Mithi River in Mumbai, a case that garnered significant attention only after the catastrophic flood in 2005. This event underscored the severity of pollution and urban flooding, which are anticipated to amplify the effects of climate change on Mumbai's coastal areas. Particularly in resource-challenged developing regions like India, behavioral interventions can

effectively mobilize the community (including residential, industrial, private, and institutional sectors) to take greater ownership and management of their water resources. This involves recognizing how their daily actions can positively influence and contribute to river restoration and equip them better to demand accountability from responsible agencies and organizations.

The primary unit of study is the decision-making community associated with the polluted Mithi River, while the broader unit of analysis is the river context itself (Fig. 1). The core research methodology is based on involving a segment of this decision-making community in a Pro-environmental Behavior (PEB) framework. This framework aspires to encourage environmentally responsible behavior by focusing on attitudes, social influences, and environmental contexts (Steg & Vlek, 2009). Participants from the decision-making community, all deeply engaged with the situation and future of the Mithi River in various capacities — affected residents, businesses, key staff from public agencies, experts, academics, and activists — were encouraged to reevaluate and scrutinize the state of urban water management practices

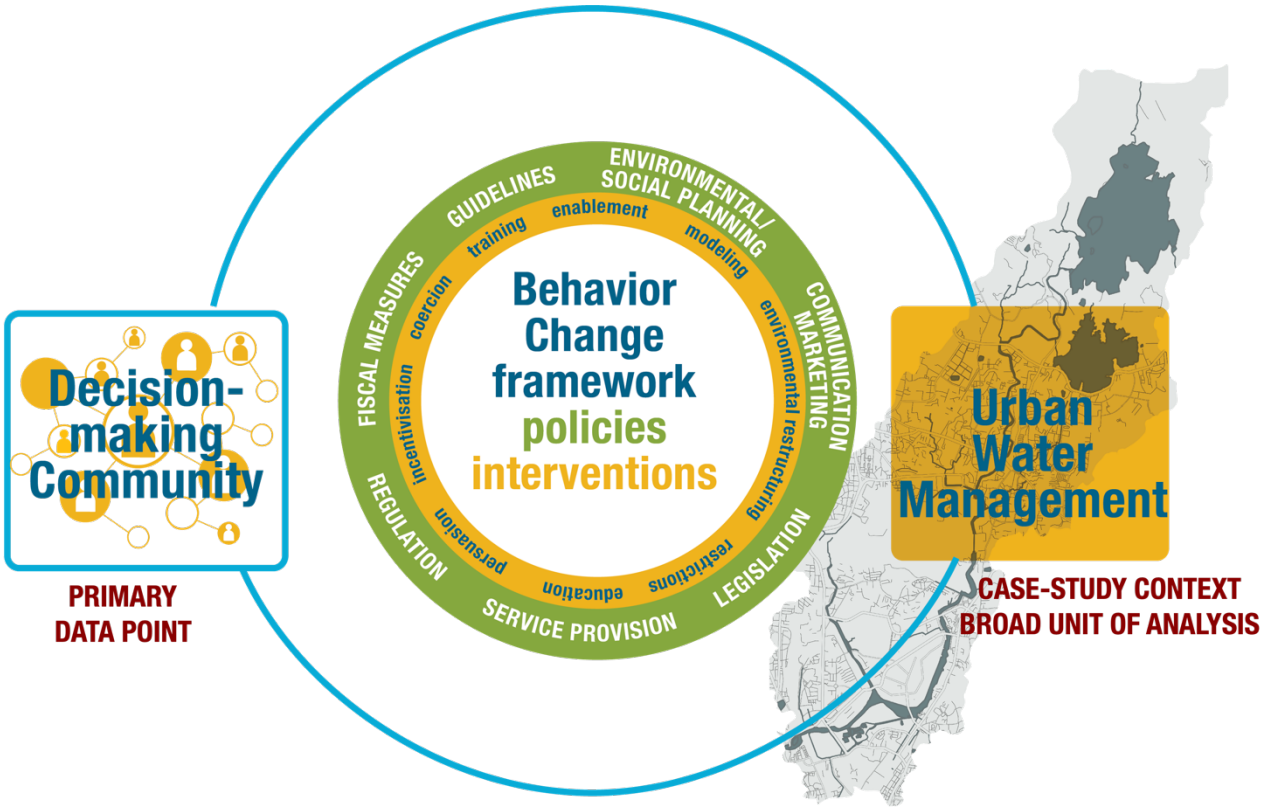

Figure 1 Conceptual Model for Pro-Environment Behavior (PEB) (adapted from Michie et. al, COM-B system, 2011)

through this pro-environmental behavior framework. The mixed-methods research design for the case study of Mumbai's Mithi River incorporates semi-structured interviews, assessment surveys, field observations, comprehensive archival research, and mapping analysis.

Approaching cities as dynamic urban ecosystems, the theoretical framework was inspired by *Socio-Ecological System (SES)* thinking, which allows for a holistic understanding of urban rivers as human-dominated resources. This framework acknowledges the significant influence of human activities on urban rivers, leading to visible and systemic impacts on both ecological systems and human communities. The concept revolves around viewing an urban river like the Mithi in Mumbai as a deeply complex socio-ecological system, where sociocultural and economic factors shape human decisions, subsequently impacting the built environment and urban ecology. The Mithi River serves as a relevant case study to illustrate these dynamics. In exploring the role of behavior change in steering urban water management, this research builds on the *Pro-environmental Behavior (PEB)* framework (Michie et al., 2011) as a methodological approach. This framework enables engagement with decision-makers, analysis of current practices, and identification of opportunities for sustainable water management.

A crucial aspect of this research involved defining the decision-making community guided by principles of equity, representation, and agency. Recognizing that those closest to urban problems are often closest to the solutions, the research emphasizes the importance of including and empowering individuals who possess shared or co-produced knowledge to identify and sustain interventions (Mehta, 2014). By examining what this shared knowledge entails, the study aims to shed light on how such decision-making can address persistent challenges in urban water management for the Mithi River.

Research Questions

Based on this framing, the following research questions guide the case study of the Mithi River in Mumbai, providing insights into the broader challenges and practices of urban water management in rapidly developing cities of the global south.

Analytical

(1) How does the decision-making community in urban water management practices in Mumbai's Mithi River perceive and understand their interventions within the context of a pro-environmental behavioral framework?

   a. Where do they see the **potential to influence environmental behavior** contributing to urban water degradation at the individual/ household, group, and policy levels?
   b. What **opportunities** exist for applying the behavioral framework in urban water management, and how do these opportunities compare to current efforts aimed at restoring the Mithi River?
   c. Based on the opportunities identified by decision-makers, what **specific strategies and interventions** can be proposed for addressing the case of Mithi River?

Reflective

(2) What is the potential for human actions to serve as a regulatory feedback mechanism in the urban environment? What is the role of urban planners in facilitating this process and acting as intermediaries between knowledge and action?

By addressing these research questions, my dissertation aims to uncover insights into the perspectives of decision-makers regarding pro-environmental behavior in urban water management, identify areas for potential interventions, and reflect on the decision-making process that bridges knowledge and action.

Outcome: Shifting Approaches

One of the key insights from this study is the universal recognition that the problems facing Mumbai's Mithi River fundamentally necessitate a shift in environmental behavior. An analysis of participant responses and a review of various expert committee reports, and restoration plans from the past and future reveal that there are currently very limited and fragmented strategies to effectively implement and realize a behavior change-driven approach. These are insignificant when compared to large-scale gray engineering solutions.

Despite 18 years of targeted and disparate interventions at restoring the Mithi River, the effects on both the river's ecosystem on the river's and the community's relationship with the river

remain inconsequential. The research findings call for a fundamental shift in the narrative and approach that must be rooted in and driven by governing ecosystem, their agencies have spearheaded the implementation of a multitude of projects and initiatives, and continue to be the target of public ire, dissatisfaction, and accountability. However, the governing agencies also emerge as the foremost critical change agent in the river's future. This study expands on the idea of change agents, including communities and entities situated within Mithi's watershed. The research underscores that the task of restoring the river and the city's urban ecology is a shared responsibility. It promotes the idea of change agents driving the watershed towards collective ownership of this natural resource, creating avenues for distributed accountability.

The case study of the Mithi River gives rise to three significant themes. These themes subsequently inform the key takeaways, underscoring the need for a shift in approaches:

1. Systems Approach: By recognizing the interconnectedness of various factors such as urbanization, pollution, and climate change, decision-makers can develop comprehensive and sustainable strategies that target the root causes of issues.
2. Governance: It highlights the need for strong institutional frameworks, effective policies, and coordinated efforts among relevant authorities and stakeholders.
3. Narrative Shift: It emphasizes the importance of reframing the resource narrative of an urban river in the public realm. While also reframing the discourse from a reactive and crisis-based perspective to a proactive and holistic one.

By adopting a systematic methodology based on Michie et al.'s (2011) Behavior Change framework, the decision-making community has the potential to move beyond entrenched working and thinking patterns. This framework can guide them in pinpointing potential interventions at the policy, community, and individual levels to address specific river pollution contributors. Seen through the lens of behavioral change, the decision-making community can set a precedent for fairly assessing a wide range of strategies and interventions, which could include design, engineering, nature-based, planning, and community solutions.

Several success stories and smaller-scale interventions emerged from the context during fieldwork, indicating opportunities for scaling up and collaborating with people, groups, and departments that haven't traditionally worked together. These could complement or possibly

realign the structural interventions that have so far dominated the scene. In a sense, the behavior and involvement of people are the missing pieces in this puzzle. Ultimately, this research attempts a methodological behavioral approach that caters to varied interests of within a representative decision-making community, identifying solutions to address diverse aspects of Mumbai's Mithi River problem. This approach shifts focus from the waterbody alone, fostering a more comprehensive understanding of the issue.

1.2 Dissertation Organization

The dissertation is structured around two empirical research papers. The first one focuses on constructing the problem of the Mithi River in Mumbai (Chapter 2), while the second offers a framework for the river's transformation (Chapter 3).

Chapter 1: Contextualizing the Research and Methodology

This chapter lays the foundation for the overall dissertation study, providing a background, a literature review, and a research design. The background situates the river within the rapidly expanding, densely populated metropolis of Mumbai. The literature review tackles methods of understanding this Urban Condition, including the theoretical frames for the study. The Research Design maps out the method, scope, tools, and data for the dissertation.

Chapter 2: Mithi River as an Exemplar of a Strained Urban Ecosystem: Problems and Prospects

The primary focus of this empirical study is to unravel the "problem" of the Mithi River, exploring different perspectives and understanding the decision-making community's perception of behavior change and the factors contributing to river pollution. This study addresses Analytical Research Question 1.a. Its goal is to offer a comprehensive understanding of the pressing urban water management issue of the Mithi River. Accomplishing this involves examining the problem through two lenses: spatial insights and environmental history informed by archival research and field observations, and the perspective of the decision-making community as assessed through interviews and survey evaluations of polluting factors.

Chapter 3: Enhancing Decision-Making through a Behavioral Framework: Transforming the Mithi River

This chapter study presents a behavioral approach to address the identified issues of the river and proposes opportunities for interventions and policies. It responds to Analytical Research Questions 1.b and 1.c. This empirical research introduces the behavioral framework as a comprehensive strategic decision-making exercise aiming to facilitate change or vision for the restoration of the Mithi River. Utilizing a behavior change framework to develop strategies and interventions, the paper delves deeper into understanding the current state of ongoing initiatives related to the river. It also assesses opportunities arising from this evaluation, as reported by the study participants. Although each of these decision-makers is a change agent in their own right, this paper further explores the role of critical change agents from the community, public agencies, and other entities in driving these interventions. These change agents lay the groundwork for community stewardship of interventions.

Conclusion: Steering Practice Steering Water

I conclude this dissertation by discussing the implications of the findings and reflections for the case of the Mithi River and the practice perspective. My intention is to inform and enhance current practices related to the river. This section of the dissertation addresses Reflective Research Question 2. I also suggest a program for future research, spotlighting several potential areas for further investigation. The overarching aim is to expand the existing discourse and guide future efforts toward improving the Mithi River's condition.

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1 Contextualizing the Research and Methodology

1.1 Background

In addressing strained urban ecosystems, the dissertation examines the multifaceted issue of urban water management in rapidly developing cities of the South. A case study of Mumbai's polluted Mithi River, and associated water practices is the focus of analysis by proposing mechanisms to integrate a behavioral framework with urban environmental planning and engineering practice. The study focuses on decision-making as a collective consensus-making endeavor while analyzing policy, organizational, and individual implications towards river restoration.

In developing regions, extensive infrastructure and engineering projects take much longer to build, and even after completion, there remain impediments to project operation and maintenance. Many plans, and investments to restore the Mithi River have either failed or resulted in unintended externalities, with most efforts directed towards increasing the carrying capacity of the river primarily in response to safety. However, there is an evident implementation gap in the infrastructure vision and outcomes. The initial phase of this research focused on comprehending the various sources of pollution that contribute to the degradation of the river. Additionally, it seeks to assess the outcomes and repercussions of the river restoration efforts, while exploring the potential to influence behavioral changes that can contribute to its revitalization. I propose that in addition to the large-scale engineering solutions, there is great potential to integrate incremental people-centric as well as decentralized physical infrastructure approaches. There is a lack of initiatives that leverage social capital, create incentives, reward positive outcomes, and empower communities and stakeholders. With this perspective in mind, I hypothesize

Figure 2 Location of Mumbai, India

that there is an imbalanced emphasis on restructuring the physical environment through centralized capital-intensive engineering solutions.

The state of rivers in Indian cities reflects an urban crisis and the pressing urgency in the face of looming climate change. During extreme climate events, nature becomes visible when infrastructure fails. This is especially notable in Mumbai, one of the most densely populated cities in the world, where people and their development practices came into perspective to gain a deeper understanding of the intricate socio-ecological system at play. The Mithi River in Mumbai exemplifies such a strained urban ecosystem. In the context of this dissertation, exploratory research focused on studying the distressed section of the Yamuna River in New Delhi, India. The Yamuna River serves as another prominent example of an urban ecosystem constantly facing adverse impacts from the city, further emphasizing the challenges faced by these urban river systems.

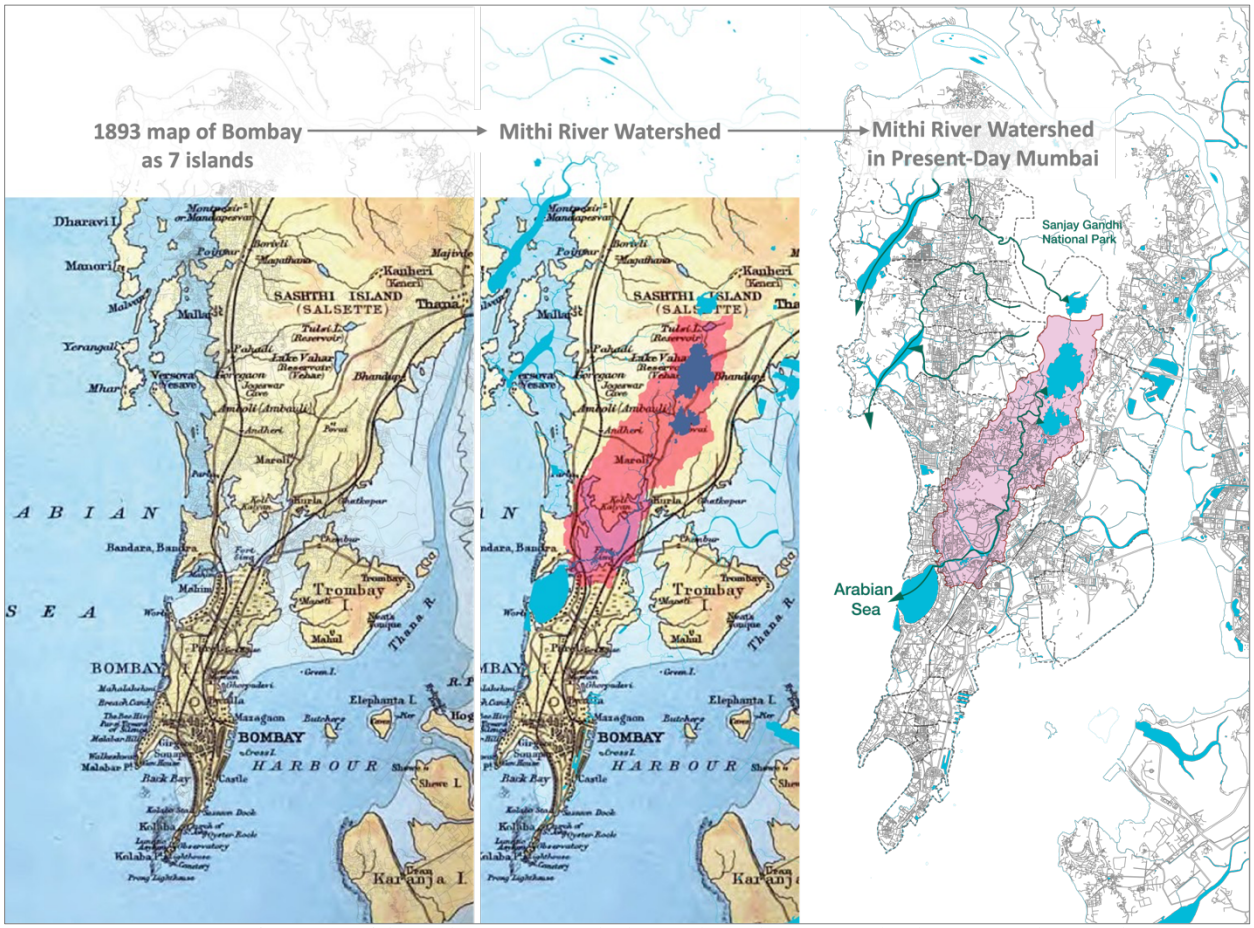

Figure 3 Transformation of the Mithi River Watershed to Reclaimed Low-Lying land in present-day Mumbai (adapted from Constable's Hand Atlas of India, 1893 edition)

Mumbai, being an island city situated in an estuary, underwent land reclamation approximately 150 years ago, resulting in the formation of the present-day city landmass from the original seven islands (Fig.3). Consequently, a significant portion of the city's development took place on low-lying lands, making it susceptible to inundation and flooding. When considering the current reality of climate change, Mumbai, as a coastal city, faces the challenges of rising sea levels and an increased frequency of extreme rainfall events. In addition to these climate-related issues, anthropogenic factors such as pollution and inadequate infrastructure have severely compromised the natural and functional integrity of the Mithi River and its floodplain.

In the case of cities in India, local governance systems are responsible for infrastructure delivery, yet the political processes for creating such infrastructure are often unidirectional, emanating from the central or state government. Decentralized efforts to mediate the urban-planning process and cultivate collective agency thus often fizzle. In this conundrum, the role of an urban planner is contested – a decision broker, an intermediary between knowledge and action. It becomes crucial to reestablish the people's dimension in this endeavor by redefining governance through a decision-making community that authentically represents the diverse range of decision-makers emerging from the local context. This decision-making community should encompass a wide array of stakeholders, including citizens, practitioners from various agencies, professionals, activists, representatives from public and private sectors, non-profit organizations, Residential Welfare Associations (RWAs)[1], and groups with specific interests or providing expert services. This dissertation attempts to present one sample version of Mithi's decision-making community.

1.1.1 The Mithi River – July 2005 Mumbai deluge and Birthday of the Mithi River

Every *Mumbaikar* [2] that witnessed the catastrophic 30 hours starting the late morning of July 26 (26/7) in 2005, can claim to have experienced the "once in hundred years" flood scenario – the worst-case scenario that every disaster management and municipal agency must account for in their plans and programs. While it was the lethal concoction of unprecedented rainfall of 994 mm

[1] Resident Welfare Association (RWA) are formed of community volunteers to represent the residents and their interest from a community complex, locality or neighborhood.
[2] *Mumbaikar* is a local term used for a resident or inhabitant of the city, I would even use it as a term for someone who feels a sense of belonging with the city.

(37.2 inches) in 24 hrs, timing of high tide of up to 4.48 m and gusty winds hitting the coastal city of Mumbai all at once resulting in unprecedented damage, this event also exposed the pollution and gross mismanagement of the city's critical natural resources like the Mithi river that aggravated the impact of the rainfall. Mithi which is significant managing urban drainage of suburban Mumbai, was identified as the main trigger causing flooding in over 60% of the city (Chitale, 2006), with an inundation of up to 10-15 ft. The city that never sleeps came to an absolute halt on this catastrophic day, its administrative agencies and citizens caught totally unawares, with 410[3] confirmed deaths, leaving a population of 150,000 stranded (MCGM, 2017). Crippling lives, business, infrastructure breakdown of telecommunications, electricity, roads, railways, and complete shutdown of the international airport. As the city embarked on the long road to recovery, the Mithi River and its immediate surrounds in the floodplain became the focal point of all deliberations, actions, and interventions.

This event marked a significant turning point, bringing the presence of the Mithi River to the forefront of people's minds and highlighting its crucial role in Mumbai's physical and social landscape. This realization led to the recognition of the Mithi River's significance by public agencies, with one official dubbing it the "Birthday of the Mithi" in July 2005 (MMRDA-15). One of the key reporting of the fact-finding committee was that the river had been reduced to an open drain due to encroachment and industrial effluent discharge, with over 54% of the original river lost to development (Chitale, 2006). People discovered that a natural river system originates within the city's own natural park, it flows through their immediate surroundings, traversing through the dense urban fabric, and eventually meets the sea through the mangroves, which Mumbaikars zipped daily during commutes via highways and local trains.

Living in Mumbai, I remember my daily train commutes across Mahim Bay, about 20 plus years ago. Overlooking the bustling cityscape, I was welcomed by a unique breeze, the sight of mangroves and large water pipelines. The stinging scent of sewage and chemicals would hit me, marking a transition from the island city to the suburbs. It never occurred to me that I'd be crossing a river. Initially repugnant, this aroma gradually became part of my routine journey,

[3] This is the official number reported by MCGM, other sources have reported up to 1000 plus deaths.

signaling that I had crossed Mahim and Bandra was next. It was an extraordinary sensory experience interwoven into my everyday life.

1.1.2 Mithi River in Mumbai's Climate Urgency

The Mithi River holds a crucial role in shaping the future of Mumbai, especially in light of climate change and the projected rise in sea levels that will significantly impact the city. Mumbai, being situated on reclaimed lands with a significant portion of its shoreline below the mean sea level, is expected to face severe consequences according to predictions made by climate scientists. The catastrophic flood event of 2005, initially considered a once-in-a-century occurrence, now serves as a stark reminder of increasingly dire and unprecedented future scenarios. As a result, it becomes imperative for Mumbai to take proactive measures and actively work towards developing a climate-resilient urban landscape (Tiwari, 2019a, 2019b). Issues such as high tides, extreme and continuous rainfall, and urban flooding have seen a drastic increase in frequency due to climate change. These problems are further aggravated by two primary factors. Firstly, the extreme pollution of the river hampers its ability to perform its natural function of urban flood management. Secondly, the appropriation of the floodplain by both formal and informal developments exacerbates the impact of flooding on the city. Regardless of the nature of development, the consequences remain the same.

1.1.3 Mumbaikars

Mumbai, one of the most populous cities of 20 million and growing, pulsates through its 6.5 million inhabitants residing in informal settlements, forming the city's backbone. The L-ward of Kurla, near the Mithi River, hosts 84% of Mumbai's slum dwellers (See Appendix J for population density map) (Kirtane, 2011; Revi, 2005). The city's resilience is exemplified by its citizens' actions when anthropogenic disasters strike. As civic services faltered during the 2005 floods, Mumbaikars united to aid those stranded, tirelessly working overnight in dangerous conditions. This adversity most acutely struck the urban poor, living in vulnerable, low-lying settlements, which suffered extensive damage and disease outbreaks (Concerned Citizens Commission CCC, 2006). Mumbai's informal settlements support the city's economy and population in a symbiotic relationship. Under the Slum Rehabilitation Authority (SRA) scheme, most squatter settlements along the Mithi River were eligible for rehabilitation. However,

rehabilitation has been slow, marred by a lack of public involvement and claims of privatization being exploited by builders (MMRDA, 2013; NHSS, 2012; Swami, 2001).

Although Mumbai bustles relentlessly, the city's crisis response unveiled a reservoir of social capital. The memory of the 2005 deluge remains vivid, and the prospect of leveraging this social capital to manage the Mithi River is promising. The river's floodplain is home to communities sharing common experiences and potential motivations to restore the river. Slum dwellers' pivotal role in the aftermath of the 2005 floods exemplifies Mumbai's "true spirit" (Anjaria, 2006). In light of Mumbai's Mithi River and its people, this interdisciplinary dissertation seeks to scrutinize urban conditions through an environmental psychology framework, concentrating on decision-making and participation in urban planning practice. Fieldwork and methodology involve the decision-making community, identifying interventions rooted in their experience with the urban river (drain), its sub-watershed, community, neighborhood, representative organizations, and responsible entities.

1.2 Literature Review

1.2.1 Urban Condition

Water is one of the most critical physical and social urban infrastructures. Growing urbanization pressure on this natural resource has led to intense pollution and scarcity of water resources in rapidly developing cities. The primary function of urban rivers like the Mithi that run through the cities is to balance the impact of run-off and discharge from development on its receiving natural river system that receives through a network of drains in Mumbai city. However, today in several rapidly growing cities, urban rivers exist as spines of deteriorating urban systems, revealing governance failures, inadequate infrastructure, mismanagement, and compromised human habitation. One way in which urban planning characterizes strained urban conditions are "wicked" problems where there is no definitive solution; therefore, the rational approach that inherently deals with "tamed" problems is bound to fail in these contexts (Rittel & Webber, 1973). On the other hand, ecologists have acknowledged that no ecosystem is independent of human influence (McDonnell & Pickett, 1993).

Urban environmental issues are fundamentally rooted in social issues. Urban rivers and drains are integrators of human activities, not just providing critical ecosystem services and maintaining ecological habitat but also creating opportunities for "positive feedback" for urban revitalization and fostering community cohesion (Groffman et al., 2003). Sharan's (2016) description of the Yamuna River in New Delhi, is a vivid reality that echoes the Mithi River's floodplain, wherein "the rivers, the slum dwellers, the urban elite and the public authorities all covet the same parcels of land on either bank, as a floodplain, as a fragile system for informal housing, as spaces for the construction of monumental buildings, high-end residential, as well as public infrastructure." There exists an extreme "developmentalist camp" that argues for the river as subordinate to the city, available for 'public purpose' as much a 'private profit' (Sharan, 2016). While the exclusively environmentalist camp may not always acknowledge the fact that there are existing life and settlement along the floodplain that is integral to its condition, the approach of the developmentalist camp is detrimental, also evident through various ways in which the Mithi River's floodplain continues to be appropriated, even in its most recent state of urgency.

From the planning theory perspective, cities of the developing region, mainly the Global South share striking similarities of resource constraint, governance, socio-cultural heterogeneity, and informality within which one can start to construct the specific conditions of "urban strain." Over the past decades, there has been an increased focus on South Asian cities within the broader discourse of the Global South (Bhan, 2019; Watson, 2009). While we attempt to define complex urban problems of developing cities, analysis, and solutions that are rooted in context, there is also a realization that this nature of research has to be driven by non-western ethical and value frameworks. It is pertinent to reflect on the work of planners, urbanists, and anthropologists working in India, and broadly within the Global South like Ananya Roy (2009a, 2009b, 2016), Abdou Maliq Simone (2004, 2014), Asher Ghertner (2013, 2015), Gautam Bhan (2012, 2019; 2016) and James Holston (2015, 1991,1998). While constructing the unique identity of cities of the south through their work, they concurrently address the decentralized models of planning that arise from "within" the place as opposed to planning "of" the context on examining practice and models of engagement in such complex urban environments. It is the "dynamic relational aspects" of practice (professional), daily life as well as visions that create urban conditions. Along with the seminal proposition of Certeau's (1984) practiced everyday life and Lefebvre's

(1991) urban theory of ‘space’. Lefebvre makes a case for understanding the “knowledge of space” by considering the social, historical, and political constructs, through the well-referenced spatial triad of ‘spatial practice – perceived space’ of the daily life and urban reality; ‘representations of space–conceived space’ wherein practitioners like scientists, planners, technocrats dominate and shape spaces through the disposition of their powers of representation; and the ‘spaces of representations – lived space’ through the imaginations and representations of its inhabitants (Lefebvre, 1991). This theory while intending to construct a holistic meaning of urban spaces, it also establishes in a way the “dominance” of the practitioner’s control of the ‘spatial’ through their professional dispositions as the conceived space. At the same time, behavior as a relational as well as a mental construct is also inherent in this theory of space, through the perceived (actual behavior) and lived (imaginations and ideals).

Cities are dynamic ecosystems constantly shaped by human decisions. I position my research through this proposition that Research within a city cannot happen in isolation; it has to integrate the knowledge and actions that operate within an urban ecosystem. In fields of environmental science, the notion of urban ecology of cities is rooted in Socio-Environmental Systems (SES) approach, it attempts to bridge practice and knowledge production in order to generate action-knowledge (Groffman et al., 2003; S. T. A. Pickett et al., 2001, 2008). Elinor Ostrom’s collective action, co-production framework alludes to institution building by involving actors and their actions (Ostrom, 1990, 1996, 2000, 2009a). Since this dissertation research is fundamentally empirical, it is helpful to establish my positioning on the modes of knowledge production, they ought to be shared rather than rational or discrete in order to gain traction or incite action. With the purpose to produce “action knowledge” and “practice knowledge” Bent Flyvberg (Flyvbjerg, 2004), Argyris (Argyris, 1996), Bruno Latour (Argyris, 1996; Flyvbjerg, 2004; Latour, 2004) help position this approach. Cities are dynamic ecosystems constantly shaped by human decisions. I position my research through this proposition that Research within a city cannot happen in isolation; it has to integrate the knowledge and actions that operate within an urban ecosystem.

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On Informality. Mumbai is home to Dharavi –one of Asia's largest informal settlements, sitting on the Mithi River, exemplifies this challenge of the 21st century. Predominantly occupied by marginalized migrant communities, numerous informal settlements[4] stand on environmentally precarious sites, susceptible to landslides or alongside rivers. Such situations, characterized as "bourgeois environmentalism," underline how urban informality impacts water management in developing cities, with development ideologies often leading to displacements under the pretext of environmental improvement (Baviskar, 2011).

In the global South, contested riverscapes like the Mithi River are vital resources. Within these contexts, narratives of environmental management and displacement are intertwined. Urban floodplains managed by overextended local authorities emerge as the most vulnerable areas.

[4] Urban informal settlements also called squatter settlements, slums, shanties are essentially housing for the urban poor or migrant population, built by the residents themselves or with the help of their immediate community, usually unsupported by local municipal infrastructure. Inhabitants either own or rent, they have no security or tenure for the areas they inhabit (UN-Habitat, 2015). Dwellings are incrementally built over time, do not conform to prescribed form or morphology, initially built by using temporary construction materials and sometimes evolve into upgrading to masonry or other permanent material over time. Some other characteristics are high density, inadequate water, sanitation, and waste amenities.

Informal settlements proliferate in these ignored spaces, where the urban poor are drawn to job opportunities and water availability. These vulnerable communities become the most visible targets for development authorities, often resulting in eviction and displacement to the city's fringes. However, eviction is always contentious and rarely a sustainable solution. It leads to densely populated resettlement buildings, often furthering developers' interests (Anand & Rademacher, 2013; Doshi, 2013). In the Mithi River's context, the blame for sewage and waste blockages causing floods is often placed on these slum dwellers, overlooking the detrimental effects of formal developments on the river's ecology. The narrative seeks to pacify middle-class frustrations, viewing slum dwellers as polluting encroachers lacking civic responsibility (Doshi, 2019). Nevertheless, these communities are essential for survival in the labor-dependent informal economy of these regions (A. Ghertner, 2013, 2015). Studies on urban informality and displacement expose the reproduction of inequality and discuss the "aesthetics" role through norms and perceptions (Bhan et al., 2016; Ghertner, 2015; 2008). These studies map issues of urban informality, illegality, and displacement of urban poor, emphasizing the right to the city (Bhan, 2009; Menon-Sen & Bhan, 2008). They suggest these evictions represent a "misrecognition" of the poor, contributing to the increasing "aestheticization" of poverty and city space, which influences how the poor are represented within the city (Bhan, 2009).

Due to the pervasive infrastructural deficit in cities of the global South, the urban poor inhabit local waterways to meet their water and sanitation needs, exposing them to hazards like flooding and constant eviction threats (Vollmer & Grêt-Regamey, 2013). Urban regimes often tolerate these settlements until system breakdowns put their existence at risk, creating layers of governance that threaten their survival. Existing in a gray area between legality and illegality, urban regimes often tolerate informal settlements but fail to integrate them into practice (Roy & AlSayyad, 2004). Research from Delhi, Kolkata, and Jakarta reveals the intrinsic informality of state practices, where the tolerability of these settlements rests on the public authorities' discretion (Roy, 2009c; A. Simone, 2014). In cities ike Mumbai, the state tends to favor property-owning citizens while marginalizing the propertyless residents of informal settlements on sensitive floodplain sites without tenure (Baviskar, 2018; Doshi, 2013; Roy, 2016). Evictions often occur not solely for environmental protection but paradoxically for large-scale developments and landfill activities sanctioned by the state, further intensifying urban

informality (Roy, 2009a). Informality is not merely a physical trait of Indian cities but an integral part of planning and governance practices marked by deregulation, ambiguity, and exception, creating hurdles for governance, justice, and development (Roy, 2009a).

1.2.2 Methodological Approach – Environmental Behavior

This dissertation seeks to explore the crucial role of behavior change as a tool for guiding urban water management practices, specifically within the ecosystem of Mumbai's Mithi River. Rather than relying exclusively on engineered solutions, it delves into alternative approaches by scrutinizing a variety of strategies through a behavioral framework. This framework allows for the integration of both individual and collective actions, engaging stakeholders beyond standard public agencies. Behavior has traditionally been studied within domains like psychology, sciences, and social sciences, where it is treated as a dependent variable, influenced by an array of physical and metaphysical factors. However, a recent paradigm shift views behavior as an independent variable that can impact the environment. This shift posits that the "application of behavior analysis can effectively mitigate environmentally destructive behaviors while promoting those that protect the environment (Cairns et al., 1994; Cone & Hayes, 1984; Dwyer et al., 1993; Geller, 1992, 2002)."

Pro-Environmental Behavior (PEB) theory, rooted in environmental psychology, aids in environmental sustainability by minimizing harm and promoting positive benefits for the environment (Michie et al., 2011; Steg & Vlek, 2009). Interventions targeting PEBs aim to enhance environmental quality and sustainability (Abrahamse, 2016). PEB, originating from the relational Social Cognitive Theory (SCT), is significant for directing systemic actions in complex urban environmental conditions (Bandura, 1977). Through this theory, three types of agencies—direct, proxy, and collective—can be understood (Bandura, 1977, 2001), providing insight into decision-making processes and behavioral shifts connected with Mithi River's urban visions.

Behavior Change Techniques (BCTs) can address different scales, including macro (e.g., political), meso (psychological influences and norms), and personal (Gifford & Nilsson, 2014).

Gifford & Nilsson (2014) delineate 18 personal and social factors influencing pro-environmental behavior, offering a transferable framework to synthesize the contributing factors (See right-side Fig 4). In the Mithi River context, these constructs can guide behavioral policies and interventions. Along similar lines, Understanding the interplay between capability, opportunity, and motivation is crucial for comprehending behavior, and vice versa, and are essentially driven by Physical, Social, and Psychological factors; encapsulated in the 'COM-B model' or 'behavior system' framework proposed by Michie et al. (2011). In this research, the COM-B model emerged as a valuable tool for characterizing interventions and sources of behavior, further expanded through the Behavior Change Wheel (BCW) (See Fig. 4 left-side portion) directing intervention and policies (Michie et al., 2011).

This study underscores the significance of influencing behavioral approaches and interventions as a catalyst for change. However, it acknowledges critiques surrounding the lack of field implementation and robust feedback mechanisms for environmental protection issues (Geller, 2002; Michie et al., 2013). A potential reason for this could be the limited dissemination of applied behavioral methodology outside of the field of psychology. However, many public, and private organizations, and government bodies over recent years have established behavioral insights teams or "nudge units" to enhance policies and programs. Yet, their field implementation in terms of environmental impact, particularly on complex urban environments like Mumbai's Mithi River, remains to be seen.

1.2.3 Conceptual Approach – Socio-Environmental Systems (SES)

The Socio-Environmental Systems approach (SES)[5] acknowledges that human decisions and influences are structurally intertwined within urban and natural ecosystems, underscoring the

[5] The Socio-Environmental Systems (SES) approach, is similar in concept and used interchangeably with terms like Socio-Environmental-Systems or SES, Socio-Ecological Systems or SES, Actor-oriented framework, Human-Ecosystem Model, Urban Ecological Systems (Flynn & Davidson, 2016; Grove & Burch, 1997; McDonnell & Pickett, 1993; Ostrom, 2009; Mooney, 2016; S. T. A. Pickett et al., 1997, 2001, 2011, 2017; Turner II et al., 2016). SES also builds on the idea that community engagement is critical in bringing science to people through a two-way process breaking away from the perception of science as distant. Enhancing environmental justice and equity is also a critical component of the approach, by requiring that all communities, ethnic, and income groups are included in decision-making based on social dialog. (Pickett et al., 1997). Analogous to the "urban ecosystems" model, SES goes further in emphasizing Ostrom's theory of collective action and self-organization of entities and sub-entities in managing their natural resources (Ostrom, 1990, 2009a).

necessity of considering these elements in environmental management. This perspective is particularly relevant to ecosystems predominantly shaped by human activity. The SES approach, also known as the Socio-Ecological Systems approach, builds upon Ostrom's influential work "Governing the Commons," which emphasizes self-governance, institution building, organization, and community decision-making (Ostrom, 1990, 2000, 2009a, 2011). This framework embodies the conviction that environmental issues are embedded within social dilemmas, necessitating that research within cities incorporate local knowledge. This conviction incites a shift from producing standalone, rational knowledge to generating shared or common understanding. Such knowledge is co-produced “with” people who have a critical understanding of their human living conditions.

In the complexity of urban environments, individuals form the social infrastructure. As such, interventions can empower these individuals to become stewards of their resources (McDonnell & Pickett, 1993; S. et al Pickett, n.d.; S. T. A. Pickett et al., 2017b). Modeled after Ostrom’s approach to governing commons, SES posits human agency as central, at both individual and collective levels. It promotes action-oriented science through the co-production of knowledge, integrating inputs from individuals outside of formal organizational structures, like citizen participation, in the provision of public goods and services (McLeroy et al., 1988; Ostrom, 1990, 1996, 2009a).

This research employs SES approach in conceptualizing urban rivers, known as "nallahs" or drains in India, as shared resources. This involves understanding spatial contexts and institutional dynamics to pinpoint decision-making entities, management regimes, and reevaluate relationships among organizations, communities, and individuals (Ostrom, 1990, 2009a; S. T. A. Pickett, Burch, Dalton, & Foresman, 1997)[6]. It should be noted that the application of Ostrom's SES approach in urban contexts has been somewhat restricted, largely due to challenges in monitoring, a crucial component for the successful governance of common urban resources. An

[6] Note that this research does not apply Ostrom’s analytical frame of SES for the river entity since operationally the Pro- Environmental Behavioral (PEB) Framework is central to the study to identify entities and interventions. For reference, Ostrom’s framework categories the Interactions (I) and outcomes (O) of actions informed from the Resource (RS) and Governance Systems (GS) defined by Resource Units (RU) and Actors (A) (Ostrom, 2009a)

additional application of this approach is the Socio-Ecological Model (SEM), widely utilized in public health research. The SEM aids in understanding and designing interventions across multiple layers of influence and their interactions, which impact human behavior in society (CDC, 2015; McLeroy et al., 1988). These layers align well with Michie's COM-B model for understanding Pro-environmental Behavior and the personal and social factors outlined in Gifford & Nilsson's review (2014).

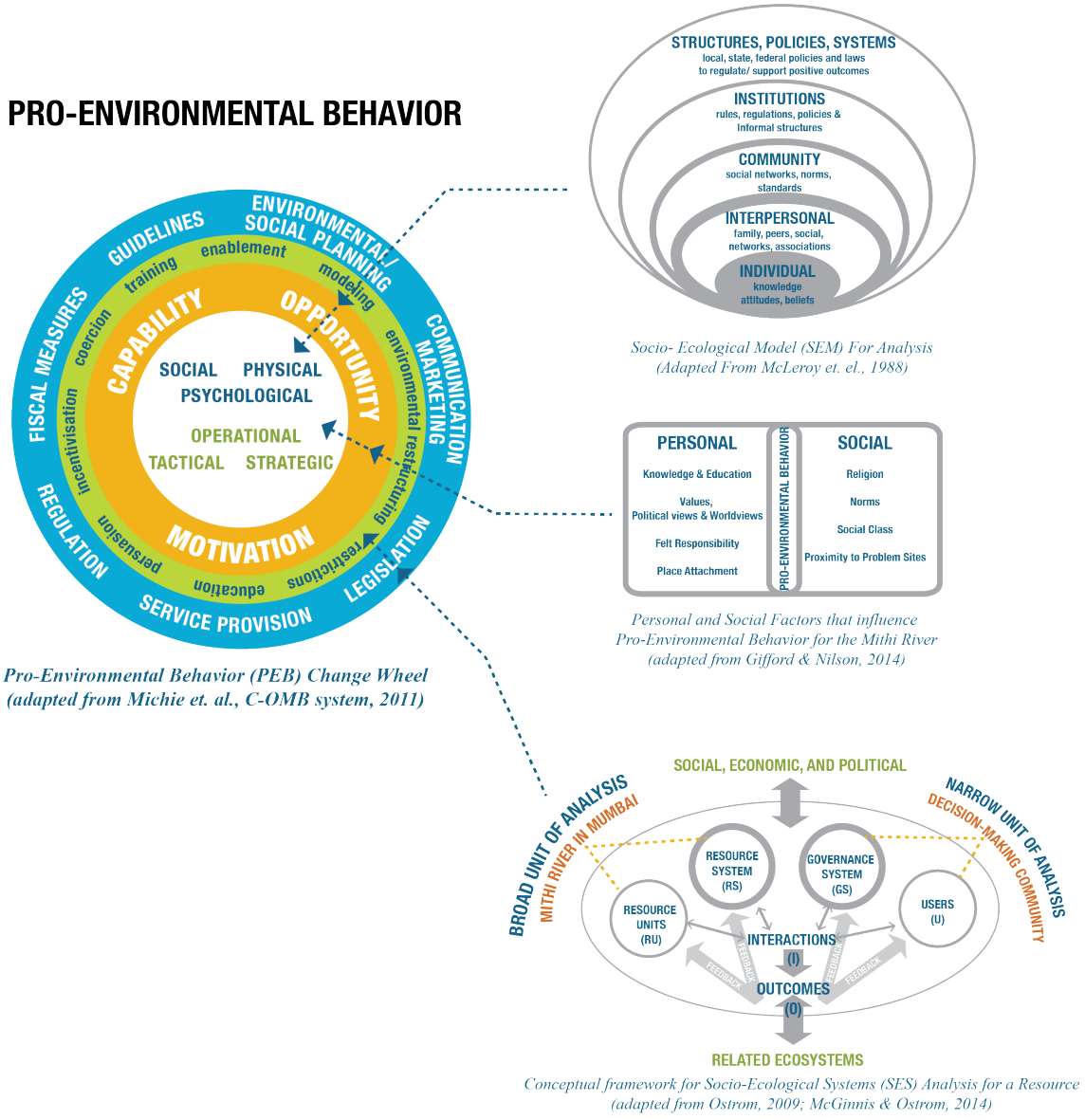

Figure 4 Pro-Environmental Behavior and Intersecting Theoretical Frameworks

The Socio-Ecological Systems (SES) and Pro-Environmental Behavior (PEB) frameworks collectively offer a comprehensive approach for understanding behavioral change and implementing river restoration initiatives. PEB, rooted in the COM-B system (Capability, Opportunity, Motivation-Behavior), dissects the process of behavior change, considering personal and societal factors impacting behavior across varying societal strata. This approach facilitates the identification of factors requiring modification to encourage pro-environmental behaviors. Concurrently, the SES framework provides an exhaustive understanding of the relations between diverse actors and entities involved in resource management and utilization, considering the interconnectedness and interactions between social, economic, and ecological dimensions. The amalgamation of these frameworks guides future research in exploring implementation mechanisms for river restoration. By defining target behaviors, identifying effective behavior change techniques from the PEB framework, and understanding the broader system through the SES lens, researchers can gain a holistic perspective of behavior change dynamics and devise effective river restoration strategies considering individual factors and the overarching socio-ecological context.

1.3 Research Design

1.3.1 Levels of Inquiry and Units of Analysis

In this dissertation, I address multiple levels of inquiry, extending from the macro scale of stressed urban ecosystems within rapidly expanding global south cities to the specific case of Mumbai's Mithi River, which I use as the broad unit of analysis. Further, I focus on the decision-

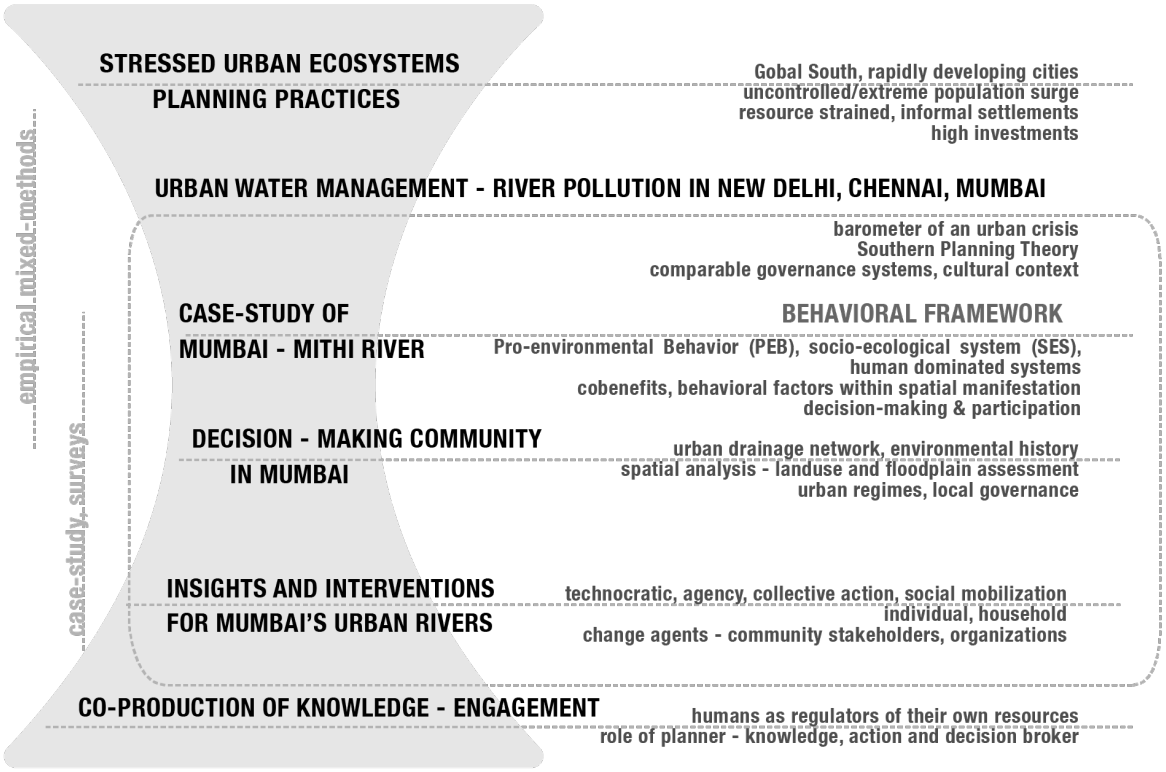

Figure 5 Levels of Inquiry through a Research Hourglass

making community as the narrow unit of analysis, examining their water management practices through a behavioral framework. My aim was to engage a representative decision-making community and study their water management practices through a behavioral framework, identifying avenues for improvement. By focusing on the decision-making community, I seek to delve into their perspectives, experiences, and decision-making processes related to urban water management. Finally, I reflect on the research methodology I used in the study and scrutinize the role of urban planners and humans within their environments. This introspection adds a reflective layer to my research, analyzing how the research process itself and the involvement of urban planners influence the study outcomes and the broader understanding of urban water management issues.

1.3.2 Research Paradigms and relevant concepts

In my research on Mumbai's Mithi river, I utilized a mixed-methods design, incorporating both qualitative and quantitative elements. My focus primarily leaned towards qualitative research, but I infused quantitative components through survey assessments to enrich the data, provide an engaging structure for participant responses, and foster participant engagement. This combination proved to be particularly valuable given the highly intricate socio-ecological nature of the issue I was investigating.

I integrated quantitative analysis and data representation alongside qualitative findings in my research, aiming to enhance the accessibility and comprehensibility of the case study for the target audience, which consisted of the decision-making community. By presenting both qualitative and quantitative insights, I strived to provide a well-rounded perspective that was relevant and useful to those making decisions regarding the Mithi river. I conceptualized the research design as a suggestive methodology to facilitate a broader consensus-making exercise beyond the study scope. [7]

I used the case-study approach to investigate characteristic contexts, understand governance structures, and analyze context-specific challenges and mitigation approaches. I adopted Flyvberg's case study approach of context-generated practical knowledge or "phronesis", and its synthesis with informational material (Flyvbjerg, 2004, 2011; Flyvbjerg & Sampson, 2001). As a native of the region, I had direct experience and understanding of the urban water challenges in Mumbai (emic perspective). However, the opportunity to engage diverse decision-making entities allowed me to reconstruct the subject matter through a new qualified lens. The reconstruction was informed by interaction and analysis from various stakeholders, guided by the Interpretivism/ Constructivism paradigm for phase two. Within this framework, theoretical formulations about the issues were derived from an inductive/retroductive approach, aiding in a deeper understanding of the existing urban systems, hegemonic planning practices, and socio-cultural context of this urban issue (Alford, 1998; Glesne, 2016). Through this framework,

[7] For example, in a real-world scenario, this could be part of a Policy-Delphi method; which is a decision-making communication/ consensus tool implemented amongst a selected group of expert participants through successive surveys (minimum two).

knowledge accumulation takes place through individual and informed reconstructions by the participant's (actor's) point of view through an iterative approach (Erickson, 1985; Guba & Lincoln, 1994).

Flyvberg argues for moving away from a form of knowledge that is devoid of context to a knowledge/action theory of planning within the communicative paradigm, thereby introducing the concept of "Phronesis" as context-generated knowledge in planning practices (Flyvbjerg, 1998; Flyvbjerg & Sampson, 2001). I adopted the concept of "Phronesis," as Flyvbjerg proposed, and scrutinized the case-study method, considering it a form of context-dependent knowledge. Referencing Aristotle, Flyvberg (2004) (2006) offers the following proposition which inspired my approach:

> *Phronesis concerns values, and goes beyond analytical, scientific knowledge (episteme) and technical knowledge or know-how (techne). It involves judgements and decisions made in the manner of a virtuoso social actor. I will argue that phronesis is commonly involved in practices of society, and therefore that any attempts to reduce social research to episteme or techne, or to comprehend them in those terms, are misguided.*

In my research, the survey tools primarily followed a deductive paradigm structured around the Pro-Environmental Behavioral Framework (PEB), based on the COM Behavior Change Model. This model further expands to an application framework of Policies and Interventions towards a target behavior change, which in this case is broadly built on the resource of the Mithi River and its restoration objective, proposing a model of eight broad Behavior Change Techniques (BTCs) based on the context, and feasibility of communicating these to the participant Decision-Making community for this research (see Survey Assessment 2 in Appendix C). This framework facilitated knowledge accumulation by encouraging participants to provide individual and informed reconstructions based on their own perspectives. The iterative approach I adopted in this study, drawing on principles from Erickson (1985) and Guba & Lincoln (1994) allowed for the refinement and evolution of the survey tools beyond the scope of this project. The overarching goal was to collectively analyze the participants' responses and utilize the findings to contribute constructively towards the development of strategies and interventions rooted in impacted environmental behavior.

The interpretive paradigm was essential for this study as it aimed to understand how different decision-makers and the general population engaged with and responded to specific urban water issues related to the Mithi River, aligning with the second research question. Grounded in constructivist theory, this study recognizes humans as active agents rather than passive recipients of social forces. It emphasizes the role of language and communication in shaping emergent actions (Glaser & Strauss, 1967; in Charmaz, 2014). For analyzing participant data and field observations, I also employed Kathy Charmaz's Constructivist Grounded Theory approach, which acknowledges the subjectivity of human experiences and the researcher's involvement in constructing and interpreting data (Charmaz, 2014).

I incorporated two assessment surveys alongside semi-structured interviews as primary research instruments, ensuring that a diverse group of decision-makers opinions were considered when estimating the impact, consequences, and acceptability of evaluation options. The intention was to prioritize group opinion over individual views and eliminate power dynamics and bias that may arise from relying solely on select experts (Turoff, 2002). Furthermore, the data collected from participant interactions was used inductively to refine the understanding of the decision-making entities, as well as the proposed menu of polluting factors and behavior change strategies and interventions for the survey assessments. In real-life scenarios, this could also contribute to an iterative process of collective decision-making.

1.3.3 Sampling Strategy

Data collection for this mixed-methods research was chiefly steered by purposeful, or judgment, sampling. This was primarily because the goal was to encompass diverse types of data and, crucially, a broad assortment of primary participants. Participants, as well as specific sites for field observations, were carefully selected in line with these criteria, ensuring representation, variability, and triangulation of data sources. The following table delineates the guiding intent behind the various strategies employed in purposeful snowball sampling across different phases of research. (Creswell & Poth, 2017; Miles & Huberman, 1994).

The sampling units for this research encompass individuals, groups such as organizations and communities, locations, and events. In light of the post-pandemic timing of the fieldwork, the scope and duration of fieldwork had to be significantly curtailed. Consequently, data saturation through interviews cannot be claimed as the basis for defining final concepts; instead, the focus shifted to emergent themes as presented in the discussions for each of the following chapters and the overall study conclusion. Nevertheless, as I anticipated purposeful sampling from field observations and from a diverse pool of decision-makers provided a comprehensive spectrum of perspectives for analyzing the outcomes. For triangulation and data validation, content from

Type of Sampling	Intent
Critical case	Guiding the choice of exploratory case-studies (New Delhi, Chennai, Mumbai) based on specific characteristic of their urban water challenges, and identifying Mumbai for detail study. Helpful in logical generalization and application of information for other cases.
Maximum variation	Intentionally selecting diverse range of individuals and entities that would qualify as decision-makers. Useful for generating wide range of responses (Guest et al., 2013).
Stratified purposeful	For field interviews and policy-delphi survey respondents, I want to ensure I cover different groups of participants like general residents, local business owners, advocates, professionals, etc.
Inductive/Theory based	An incremental and iterative sampling approach to where participants are progressively selected to examine emerging concepts and theories from interview data being gradually analyzed throughout the course of data collection (Charmaz, 2014; Glaser & Strauss, 1967; Seamon & Gill, 2016)
Convenience	People or institutions that are most willing and easy to contact, in most cases through existing network (at initial stages)
Snowball or chain	Using referrals, and social networks of participants that could provide specific information

Table 1 Sampling Strategy for the Study

phase one, comprising secondary sources was used, supplemented by cross-reviewing responses from other interviews on comparable subjects.

1.3.4 Overview of Data Collection

My empirical case study followed a mixed-methods research design over three distinct phases. I collected a variety of information to provide a comprehensive understanding of the subject matter, which included archival material, media reporting, documents & reports, interviews, surveys, direct observations, and participant observations.

Phase One: Preliminary/ Secondary data collection and analysis – Qualitative

In phase one, I primarily analyzed secondary data related to the case study of Mumbai's Mithi River. I framed this study on Mumbai around my exploratory case study of the Yamuna River transect in New Delhi, which I conducted earlier in my research[8]. The first phase of the Mithi River case study followed a similar research path to that of New Delhi. I dove deep into understanding Mumbai's environmental history through mapping analysis, identifying potential sites for field observations, carrying out archival research, drafting a preliminary outline of decision-making bodies, and tailoring the study protocols from the initial exploratory case study to suit the Mithi River context. I also prepared for fieldwork in Mumbai, identifying key collaborators and participants and submitting Institutional Review Board (IRB) approvals.

Before fieldwork in India commenced on Jan 2023, I delved into secondary data sources to begin creating a comprehensive document on Mumbai and its urban water condition. The main subcomponents of this phase included: spatial mapping, material review, understanding local decision-making regimes, initiating remote contacts, finalizing interview protocols, and securing approvals from the Institutional Review Board (IRB).

- *Spatial Analysis* involved preparing base maps, acquiring accessible GIS data, conducting basic spatial analysis, identifying key drains of urban rivers and their sub-watersheds, and creating analytical maps for field engagement.
- *Material Review* encompassed a wide array of secondary literature, documents from organizations, public records, research papers, court rulings, memos, and so on. It also included diverse media such as news reports, analyses, blogs, websites, photographs, videos, audio recordings, documents, and oral history records.

[8] As a doctoral fellow at UVA's Yamuna River Project, I conducted a case study on the polluted urban rivers of New Delhi in 2018 and 2019. Additionally, I participated in a brief 10-day field visit accompanying the advanced studio field trip to India in 2018. In addition, several coursework papers were built around New Delhi's Yamuna River, all of which ultimately shaped this dissertation research on Mumbai. The findings of my previous research were presented at the ACSP conference in 2019, where I presented a paper and a supplementary poster for spatial analysis using GIS. See Appendix J for list of conference papers. These presentations provided valuable insights into the challenges and potential solutions for managing water resources in urban environments, particularly focusing on the Yamuna River in New Delhi and the socio-behavioral aspects of ecologically strained urban ecosystems in both New Delhi and Mumbai, India.

- Insights into the *Decision-making regimes* from secondary sources and remote research that I could build upon during fieldwork fieldwork. Furthermore, I explored network mapping and power-dynamics to understand the impacts of the various decision-making entities. With the intent that these could be validated and expanded upon during the fieldwork.
- *Other preparatory measures* for fieldwork data collection included initiating remote contacts, finalizing interview protocols, and working on obtaining Institutional Review Board (IRB) approvals (UVA IRB-SBS #5214).

Phase Two –Fieldwork/ Data Collection – Qualitative

I considered this the most critical and decisive phase of data collection. The success of this phase would define the scope of my research and analysis. It depended heavily on successfully accessing and recruiting participants from Mumbai. The primary data collection involved field observations, interviews, and the recruitment and interviewing of local decision-makers who would respond to a three-part interview and survey assessment. I conducted a 7-month fieldwork exercise in Mumbai, from December 2021 to July 2022. This allowed for an in-depth investigation of the Mithi river's condition through qualitative interpretive methods. During this phase, I made field observations and river walks across the city, providing a comprehensive understanding of the river, its surrounding context, the local populace, the drainage network, and sub-watershed. I maintained a fieldwork memo journaling my experiences and analytical thoughts throughout the process.

I recruited thirty participants from the decision-making community through purposeful snowball sampling for a three-part interview, which included a semi-structured interview and two assessment surveys tied to the research question.

- *Field observations* covered the physical setting, participants, activities, and interactions along the river sections in diverse urban environments.
- *Field interviews and informal conversations* were conducted both on and off-site with locals, collaborators, and agency officials.
- *Host institution and advisor:* I was fortunate to gain access to my undergraduate school, Kamla Raheja Vidyanidhi Institute for Architecture and Environmental Studies (KRVIA-

ES) in Mumbai, which served as my host institution for the final three months of my fieldwork. This proved to be a critical step in snowball sampling for my data collection.

- *Identifying the decision-making community and recruiting study participants:* Understanding the landscape of influence and decision-making for the Mithi river was a constant priority. I made several iterations of the Decision-making mapping diagram and received valuable feedback and suggestions. I reached out to various entities to understand the network of influence – municipal and public agencies, institutions, religious institutions, businesses, consulting design engineering agencies, and other organizations, RWAs from select communities.

A personal note on field experience. During this time, I hiked up almost all sections of the Mithi river, many sites were difficult to access due to either being walled-off, dense settlements, or the locals mainly in the informal settlements feeling sort of threatened by my presence. Nevertheless, it was a very enriching experience, many locals especially women were curious and welcoming, sharing their stories and guiding me to portions from where I could see and photograph the Mithi. I also found local buddies or young kids who were excited to walk me around their neighborhood for brief stretches of time or hand me over to someone they thought was senior or more knowledgeable in the surroundings. I was most excited to connect with a group called *Hallu Hallu*[9] wherein mostly locals or visitors interested in deeper cultural and historic understanding of the city got together for walking tours. I joined the group for two river walks, in February 2022 in the Kurla area and the Mithi river stretch, and in May 2022 the Dahisar River inside the national park precinct and the local settlements of the *Warli* tribe. Dahisar River is a comparable context to the Mithi River in Mumbai, which originates in the National Park. Very soon I began to feel reasonably acquainted and established connections with some local gatekeepers to support me during this exercise. Some of the elements I recorded during field observations were daily activities along the rivers, infrastructure especially sanitation and waste along the river, typology of housing, condition of the river along with specific uses like residential, industrial, airport land, and new commercial complex of the BKC.

[9] *Hallu Hallu*, is a colloquial Marathi expression, translating to slowing down, the idea being that in a fast-paced city of Mumbai the group focused on slow exploration of local non-touristy parts of the city, understand its local history through the lens of locals and tribes and the spaces they inhabit in the city

Also, the state of the river in wet and dry seasons. Mapped Infrastructure components like water, wastewater facilities, wetlands, green infrastructure, and public amenities. In many places the retaining wall, newly constructed access roads along the river in some sections, remnants of river widening, and clearance of informal settlements were visible, the yellow backhoes and machinery for dredging were a common site in the upper and middle reaches.

Phase Three –Fieldwork/ Data collection – Qualitative + Quantitative

The 30 primary participant interviews and surveys were primarily conducted in person, with virtual follow-ups, when necessary, to ensure data collection completion by November 2022. The combined use of qualitative and quantitative approaches allowed for a more nuanced analysis and laid the groundwork for research and relationships beyond this dissertation project.

Interviews of the primary participants, and study implementation:

- The final data collection exercise involved interviewing the decision-making community and implementing the 3-part study. Participants responded through varied mediums, mainly individual interviews[10], focus groups[11], and completing the surveys independently over paper or email. Participants interviewed during their personal time, such as private consultants or resident representatives, were offered an honorarium of 1500 INR, disclosed at the start of interviews during the consent process[12]. Out of the total of 30 participants, 11 received an honorarium.
- Interviews were conducted mostly in person, some of them through zoom or phone follow-ups, while some were presented with the option to complete the surveys on their own and turn them in (See Fig. 3 in Chapter 2). Some experts even argue that participants

[10] With two exceptions wherein I allowed a few peers to join while the focus still remained on the primary participant, and in one instance 3 participants representing different entities participated in the interviews and survey together focus groups.
[11] Focus group is essentially a small, selected group of participants, agreed to discuss a topic of common interest, convened, and facilitated by the researcher who acts as the moderator. The moderator needs to hold an objective position during the session to balance power and acknowledgment of all perspectives put forward.
[12] The honorarium was never discussed during the initial engagement or recruitment. Some declined it, while others appreciated this acknowledgment of their time contribution. Three participants in a group interview each received a 1000 INR honorarium and snack meal. I, as the Principal Investigator decided on when to offer the honorarium, based on appropriateness and fairness to the best of my judgment. To avoid possible offense or expectations, the honorarium was not always offered to participants, especially for representatives from institutions or officials from public agencies and institutions, per approved IRB protocol for this study. This flexible approach to honorariums could be seen as a limitation, suggesting that a more systematic method could be beneficial in future research.

must have options for completing the assessment surveys in format of their choosing and convenience, importance of "asynchronicity" (Manley, 2013). This intention aligned well with my approach of presenting the survey through multiple media – electronically and printed version. The survey assessment were presented to them as a tool (Turoff, 2002): To present the best possible **information** ensuring all options are up for consideration; To estimate the **impact** and consequences of any particular option; To examine and **estimate the acceptability** of any particular option. This offered participants flexibility and aligned with my intention of using the survey assessments as an effective policy and decision-making tool. It presents a range of factors, with no specific correct answers, but a wide variety of potential solutions.

1.3.5 Research Instrument

The primary research instrument utilized to engage study participants was a three-part tool comprising a semi-structured interview and two survey assessments (See Appendix A, B & C). The first survey aimed to understand the contributing factors to river pollution, and the second evaluated behavior change techniques and interventions. These surveys, or evaluation questionnaires (conceived as menu of options), were shaped by initial expert feedback during early stages of phase two. The behavioral framework from the exploratory case study and phase one of the study provided a preliminary draft, which was eventually fine-tuned to finalize the list of evaluation items for the survey. The final assessment surveys were translated into Hindi and Marathi to accommodate the diverse range of participants, many of whom were local residents.

Keeping in mind the cultural context of India, I found in-person interviews most effective, as they also allowed for a guided conversation. The surveys, integrated as part of the interview, offered respondents a space to share their preferred behavior change techniques. They could consider the subject holistically and feel validated as their responses were recorded through scoring or the Likert scale, with ample opportunity for open comments that were recorded and analyzed along with the interviews.

The analysis of this primary data is built upon two incremental stages.

1. **Synthesis of Contributing Factors** for the urban condition (Survey Assessment 1)

2. **Assessment of interventions and policies** in context by applying the Behavior Change Techniques at individual/ household and stakeholder level. (Survey Assessment 2)

The semi-structured interview and the first survey were mainly designed to answer the first analytical research question: identifying the polluting factors and understanding the **potential to influence environmental behavior** contributing to urban water pollution at individual, group, and policy levels. The second survey connected to the other two subsections to identify the range of **opportunities and specific strategies and interventions** for river restoration through a behavioral framework. To answer the second reflective research question, the interview responses and qualitative content were analyzed. Together, I believe the interviews and surveys provided a balanced perspective on technical (what is possible) and policy (who could, would, or should do what) issues.

I approached interviews and research dialogues for my study as performances and sites for exploration, emergent understandings, and validation of experiences. They provided an opportunity to integrate knowledge based on the reality of human experiences, situations, and meanings, with the analytical understanding of the Mithi river case study. The semi-structured protocol with open-ended questions established the direction of questioning, with some questions allowing for free-range responses (Seamon & Gill, 2016) (see appendix exhibit A). Depending on the participant's level of knowledge and involvement in the issue, some interviews evolved into a discussion format. Supplementary research from phase one helped validate, triangulate, and fill in much information. After each interview, I wrote brief memos to summarize the content and any implicit observations or notes or ideas on developing theories that could be tested with subsequent interviews using the established instruments.

1.3.6 Validity and Effectiveness

As this research employs multiple methods to investigate a specific urban issue, it may be beneficial to discuss thoughts on validity and effectiveness.

- *Validity:* The survey assessments in the specific form a critical quasi-experimental portion of the research. The underlying assumption that the selected study respondents will

represent a wide range of decision-makers could be argued as a difficult goal to achieve within the bounds of a dissertation. However, this will hold true in any real-life scenario or practice. Therefore, for internal validity, it is critical to see the results of this research within who comprised of the decision-making community, including which entity levels they were categorized as within this research since this is a complex web and many entities could be placed in different levels (See Fig. 6 in the following chapter). I also acknowledge the fact that assembling different stakeholders might yield different results. However, I also use various other qualitative methods of analysis that all ultimately focus on one subject matter of the Mithi River case study, hopefully in a rich triangulated inquiry (Creswell & Poth, 2017; Marshall & Rossman, 2016). And I hope that at the broader level, this will contribute to the project's external validity and generalizability through the triangulation of data-gathering methods.

- *Participation fatigue and attrition:* The respondents were expected to engage multiple times, a minimum of two, while also reflecting on comprehensive content relating to environmental behavior techniques. As anticipated, some respondents displayed participation fatigue, while others showed extended interest. Some respondents completed the interviews and the surveys in a single 45–50-minute session, while others required 2-3 sessions totaling up to 2-3 hours.

1.3.7 Positionality

Reflecting on my role as the primary research instrument, I am acutely aware that I have been personally invested in urban water management issues, particularly within the context of India, and globally, through most of my academic and professional career. I was stranded for two days during the severe Mumbai floods of June 2005, an experience that inspired me to focus my undergraduate thesis on the Mithi river through a design project. I acknowledge that I approach this issue with a degree of frustration and a perspective rooted in failed urban interventions and governance systems. Despite this, I maintain an open-minded attitude toward discovering new perspectives informed by the experiences of others, not just my own. Incorporating a behavioral approach in my research has allowed me to explore new ways of perceiving, learning, and analyzing topics such as social capital, collective action, decision-making, and human resilience. A crucial aspect of my research involved assembling one version of this representative decision-

making community of over thirty participants for the survey. This offers an opportunity to test and reflect on concepts of equity, access, and agency, and consider how I leverage my position within this community to recruit participants. During my fieldwork, I attempted to regularly document my observations in field notes and engage in weekly self-reflection (Marshall & Rossman, 2016). As an interdisciplinary research practitioner, I find it helpful to remind myself that, as an urban planner, my aim in utilizing new tools of social inquiry is to improve the built environment by testing different approaches, not to claim expertise in an entirely new subject matter.

Lastly, it's crucial to frame my experiences and various aspects of the study through the lens of the COVID-19 pandemic, which has had a profound impact on my dissertation research and the study context. The pandemic significantly influenced the feasibility of completing my fieldwork in India, leading me to choose Mumbai's Mithi river as a case study due to my direct association and familiarity with the city. Consequently, I deferred the investigation of the Yamuna River in New Delhi to exploratory research. In retrospect, the pandemic compelled me to narrow down my scope, reinforcing the advice consistently provided by my advisor and committee.

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2 Mithi River as an Exemplar of a Strained Urban Ecosystem: Problems and Prospects

2.1 Introduction

> *The concept of a river is lost on the population of Mumbai at least the majority of the population doesn't even know that Mumbai has four rivers now. All these rivers incidentally are called as 'nallahs13' in the records! it's still called nallahs by the corporations14. Now when they call it a 'nallah' you [are] basically looking at like a stormwater or a sewage disposal. So, people don't see what is the river and they don't have the sense of ownership. It is like, as the government has made a drainage channel. [And] we have to get rid of the sewage from our house, where does it go? It has gone to the river and where else? That's the problematic perception of how it has been portrayed within our development plans.* (Dayanand, S.-28, 2022)

This statement encapsulates the technical as well as the institutional narrative surrounding the Mithi River in Mumbai. In the context of rapidly developing cities in India, such as Mumbai, the Mithi River represents a contested state, it is a symptom of several interconnected urban factors. To comprehend the challenges it faces, it becomes crucial to adopt a Socio-Ecological Systems (SES) approach, which allows us to identify the various contributing factors at play. These factors include land use patterns, infrastructure planning and provision, informal settlements, as well as existing socio-cultural systems and practices. Together, they constitute an urban ecosystem of the Mithi River comprising biophysical, built, and social systems (Nagendra & Ostrom, 2014; S. T. A. Pickett, Burch, Dalton, Foresman, et al., 1997).

Building on the background section from Chapter 1 of this dissertation, this paper will attempt to construct the problem of the Mithi River from the perspective of the primary participants in this research, which is the representative decision-making community, and through a spatial lens. Driving on the primary research question of how the decision makers are thinking about behavior change in light of their current practices and experiences of the Mithi river since the 2005 deluge; the paper attempts to (1) understand the problem through the perspective of the decision-making community, their own relationship with the river, while also understanding the spatial

[13] "nallah" in Hindi, is a term used in India to describe a drainage channel carrying sewage or stormwater runoff in urban areas.
[14] Implied local governing agency, specifically the Municipal Corporation of Greater Mumbai (MCGM)

dimension through an environmental history of the urban river, (2) gauge the potential to influence environmental behavior at the individual, collective and policy levels.

In pursuit of these objectives, this portion of study will chart out the decision-making community for the Mithi River, providing a snapshot of the participating respondents (n=30). Recognizing that individuals closely connected to urban problems often hold valuable insights into potential solutions (Mehta, 2014). These individuals, who constitute the primary data point of analysis, are also representative of this community. The case of the Mithi River remains the broad unit of analysis throughout the study. Adopting an urban systems approach, and centering the perspective of the decision-making community, this study aims to understand the complicated dynamics encircling the Mithi River. Subsequently, the paper will present a concise environmental history of the river, adding a spatial dimension to its complexity. It will also underscore why governing this seemingly manageable 17.84-kilometer stretch has evolved into a remarkably complex and unsustainable endeavor. Lastly, the crux of this study will present findings from interviews and survey assessments that grasp the multitude of factors contributing to the pollution of the Mithi River. These insights, derived from the decision-making community's responses, will also in a way help construct the issue of the Mithi River through their perspective.

2.2 Method

The central methodology expands on the case study approach through a mixed-methods research design, examining the Mithi River case using diverse data sources such as interviews, field observations, documents, archival research, and media (See Chapter 1, Research Design). The data sources for this study were Spatial, Qualitative Interviews, and Quantitative surveys.

The initial task of mapping the decision-making community was beneficial in identifying the varied entities I came across during the research and as a medium of engagement on the field for field stakeholders to ascertain their place in this network and offer their valuable input. The participants were selected via purposeful sampling, with the snowball method playing a significant role. The decision-making community map (Fig. 6) served as a reflective tool for identifying the participants recruited for the study.

2.2.1 Data Collection

Participants (n=30) engaged in a brief semi-structured interview (see Appendix A), sharing their perception of the river, their thoughts on major polluting factors, and their vision for the river's future. They were then presented with a survey assessment featuring an initial exhaustive list of 18 pollution factors identified from secondary research, and classified into five subgroups: Domestic Life, Infrastructure, Urban Uses, Industrial, and Governance. Despite the interrelated nature of these factors, listing them in this manner facilitated a comprehensible way for participants to express their concerns and rank them by influence on pollution. They were also asked to identify the potential to influence “human behavior" for Mithi’s environmental issue at various levels: Individual/Household, Groups/Community/Organizational, and Policy (see Appendix B).

As an urban planner and designer, I have been trained to use spatial analysis as a key tool for understanding issues. This research involves providing a brief overview of the environmental history, which adds an important spatial dimension to the analysis and provides another perspective for interpreting the complex governing system of the river. For spatial analysis, various maps were constructed using base GIS data from the Municipal Corporation of Greater Mumbai (MCGM). Research conducted by the Indian Institute of Technology - Bombay (IIT-B) and National Environmental Engineering Research Institute (NEERI) for the Mumbai Metropolitan Region Development Authority (MMRDA) provided reliable mapping elements, such as the Mithi River watershed boundary, topography, and flooding hotspot analysis. This mapping also served as a basis for field excursions and observations. Selected photos from field walks were compiled into a photo essay to offer an on-the-ground perspective to the spatial analysis.

2.2.2 Data Operations

The interviews and survey responses were mostly recorded in audio or Zoom videos. Two interviews were submitted in text format by filling in the responses, and two interviews were in the form of personal notes because the participants did not agree to recording their responses. English interviews were transcribed with Otter.ai software, while those in Hindi were translated.

The text data was then coded using Dedoose software for qualitative analysis. Initially, the data was open coded using deductive coding (etic) based on the formulated concepts around which the interviews and survey assessment were structured. Dedoose was primarily used as a data bucketing tool. Through this process there were also several emergent themes identified, resulting in broad categories for thematic analysis (Appendix G). Following this, the next stage was axial coding wherein three main guiding overarching themes emerged, each with their sub-themes from initial codes. The survey responses for the quantitative data section were primarily recorded on paper, verified by relistening, and transcribing the recordings, and open-ended comments were coded in Dedoose. All survey responses were logged in Excel where cleaning and some transformations took place. All statistical analysis was conducted using SPSS software.

2.2.3 Analytical Approach

The analytical approach for data analysis is more comprehensible when broken down into the following steps, which structure the subsequent findings section:

1. The findings begin by **establishing the decision-making community** for the Mithi river, its entities and situates the research participants within this identified network.
2. In order to decipher the problem of Mumbai's Mithi river, the next step in the data analysis for this paper involves **understanding the relationship between the decision-making community and the river,** through their interview responses, which is important to reinforce, are mainly personal opinions. I aim to examine their sense of connection to the river as they describe it through its physical attributes, sensory impressions, and associations. The guiding hypothesis is that these outcomes mirror the overall sentiment of the Mithi's community.
3. Following this, the analysis delves into a **brief summary of the river's spatial environmental** context, identifying its key physical attributes to enhance our understanding of the river's issues specifically in conjunction with the participant perspectives.
4. The next stage of the analysis involves an examination of the survey results **primarily focusing on evaluating the factors contributing to river pollution**.
5. After establishing the problem of the Mithi river through this multifaceted process, the second part of the survey analysis aims to **identify the potential for integrating**

Environmental Behavior at various levels of influence. This will also consider the proposed ideological approach to people-centric behavioral solutions versus engineering-oriented interventions of the decision-making community.

2.3 Findings and Analysis

2.3.1 Decision-making community for the Mithi River

Mapping the Decision-Making Network

The decision-makers form the primary data point for this research. The following diagram below aims to map out the various decision-making entities and their interconnections that influence the Mithi River in Mumbai (See Figure 6). These entities are categorized through broad organizational levels: international, national, state, city, neighborhood, private institutional, and non-governmental organizations (NGOs). These levels aid in identifying the decision-making entities pertinent to this study, which is centered on the pollution of urban rivers in Mumbai, particularly the Mithi River and similar urban waterways like Dahisar.

Throughout the research and expert consultations, numerous entities were identified and situated within these broad organizational levels. The international and national entities as crucial in shaping extensive policy decisions, judiciary affairs, and in providing aid, while state and local entities are primarily involved in regional project implementation and subsequent operation and maintenance of infrastructure interventions. Neighborhood-level organizations, private institutions, and NGOs embody the local communities directly affected by river pollution. These bodies include ward-level municipal agencies, professional and research services, and community watchdogs. Notably, this diagram assisted in pinpointing the primary participant respondents for the study, ensuring a comprehensive representation.

This diagram, having undergone multiple iterations over five months of primary data collection, has been updated based on feedback from interviewees and consulted professionals. The diagram demonstrates that most entities are interconnected, sometimes nested, which complicates the clear categorization of interviewees. For instance, a part-time academic might also function as a professional consultant in varying capacities. In such cases, the participant was classified as a

professional consultant based on their relevant engagement to the study. Likewise, participants might have help roles in different organizational levels, leading to categorization under the most pertinent decision-making level of the study's context. Senior water experts and private consultants that have worked for multilateral bodies like the World Bank, or the Asian Development Bank were classified as international-level decision-makers due to their role in shaping international loans and programs related to urban water infrastructure. Furthermore, institutions range from academic institutions like IIT Mumbai to public institutions like the National Environmental and Engineering Research Institution (NEERI) or non-profit think tanks like the World Resources Institute (WRI). NEERI, being a governmental entity, was placed under the national level, while others like IIT Mumbai and All India Institute of Local Self Government (AIILSG) were categorized under the institutional organizational level. While one could suggest alternate organizational levels or argue for different entity placements, entities were placed under categories where their engagement or services most clearly aligned with the impact outcomes for the purpose of this research. The diagram's current version sets the foundation for continuous feedback and engagement and is open to new interpretations and revisions. The decision-making community map serves as both a constraint and a chance for further research. It's crucial to note that the study's outcomes are limited to this particular group of participants, which can be assembled in various ways. The primary participants recruited for this research are identified in the bottom row of the diagram (Fig 6), along with their entity classification and overall composition also listed below in Table 2.

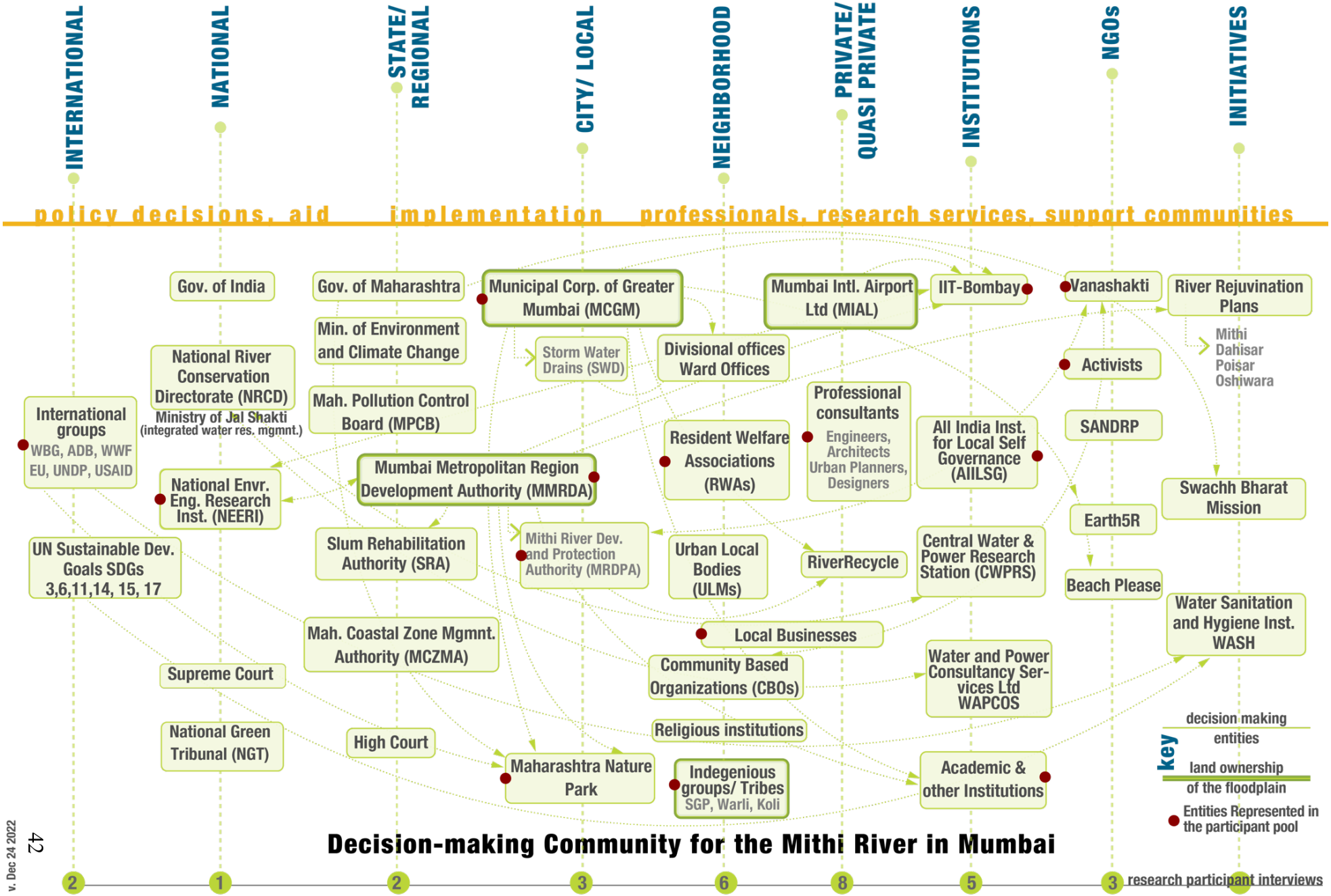

Figure 6 Mapping of the Mithi River Decision-making Community

Decision-Making Entity	Participants (n)
International	2
National	1
State or Regional	2
City or Local	3
Neighborhood	6
Private	8
Institutions	5
NGOs	3
Total	**30**

Table 2 Participants classified under Decision-Making Entities

Overview of the participant data

The study's participants represented a diverse group of decision-making entities. These included state and local governing agencies, experts from academia, urban designers, environmental planners, architects, engineers, activists, and residents from local communities. Among them is a member of the *Warli*[15] tribe. He asserts that his ancestors have lived there for generations, and he currently resides there with his family and extended family. Of the total 30 participants, 28 were locals of the Mumbai metropolitan area. Many of them were professionally involved with the Mithi River, while others were residents or business owners situated directly along its banks, one of them worked at the Mahim Nature Park nestled along the Mahim Bay area by the river and the Dharavi settlements. A few respondents also brought up the comparable Dahisar river context. Additionally, one participant, a Senior water infrastructure expert in India for a multilateral organization, provided a critical broader perspective on urban rivers and water infrastructure practice and its challenges in the Indian context with secondary knowledge of the Mithi. The interviews were conducted from June 2022 to November 2022, primarily in-person, though

[15] Dinesh Barap, one of the study participants, is a third generation of his Warli tribe residing in the national park area of Mumbai. His community has been relocated within the park precinct, and they now hold specific rights to live inside the protected area. Dinesh learned the traditional Warli art form from his grandmother, using natural paints and conveying stories passed down through generations. He showed us several houses in his village where he was commissioned to embellish the walls with warli artwork to make the special wedding occasions. The Warlis are an indigenous tribe primarily residing in the mountainous and coastal areas of Maharashtra state. They are renowned for their distinctive style of painting, which vividly reflects both human communities and the natural habitats they live in. As residents of forest lands, the Warlis have a long-standing connection with the forest, which deeply influences their art and stems from their belief system. I also want to point out that the Koli tribe deeply associated with the fishing community of the region inhabits the mouth of the Mithi river along the Mahim Bay.

alternative formats were also used. The following diagram provides an overview of most of the respondents. Out of all participants, four responses were confidential. The gender distribution consisted of 9 females and 21 males.

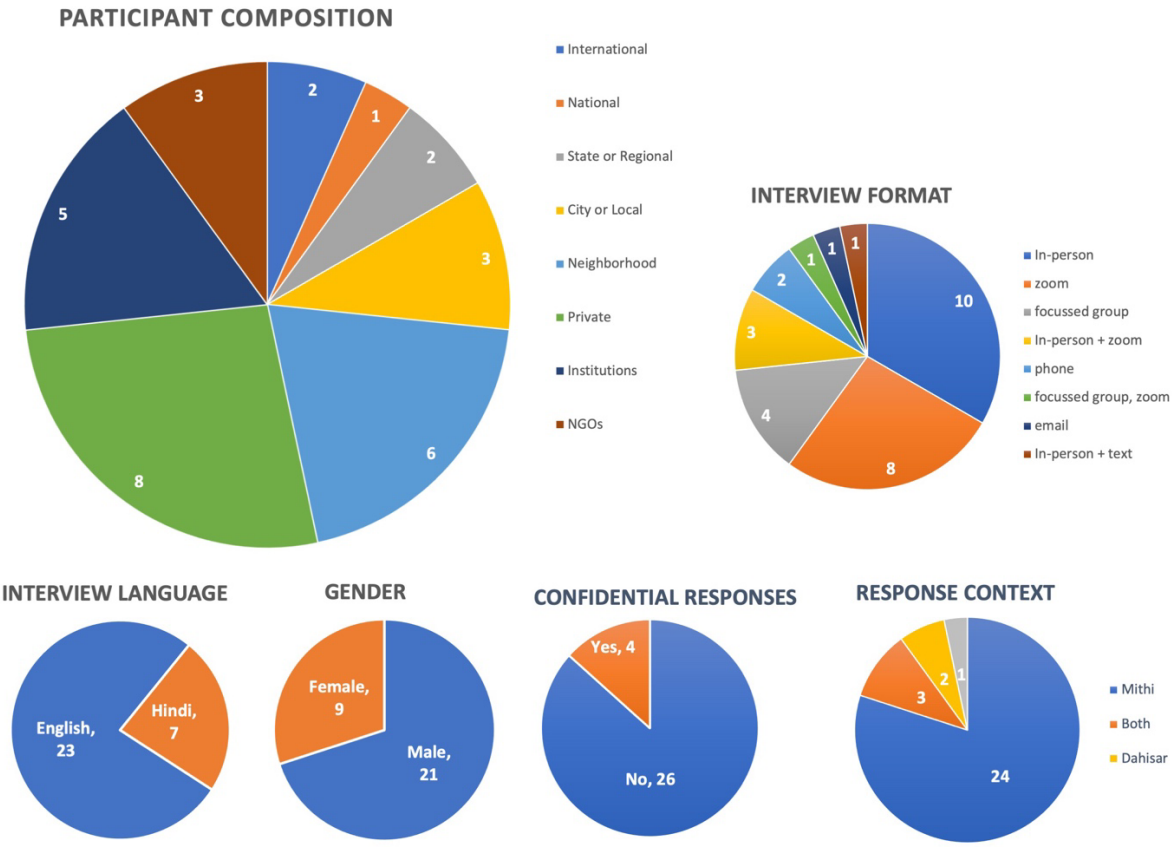

Figure 7 Profile of Study Participants and their Engagement

The following table lists down all the respondents and their association.

No	Name/ In-text citation	Decision-Making Entity	Designation & Association
1	Sonawane, R.-1	State	Secretary, Maharashtra Water Resource Regulatory Authority; ex- Officer on Special Duty in 2006 MRDPA
2	Devanand-2	Neighborhood	Resident, Treasurer RWA at Satyajivan Society, Kurla area
3	Wankhede, A-3	State	Director of Land Acquisition MCGM; ex- Jt. commissioner 2006-2011 MMRDA
4	Ekbote, A.-4	Private	GIS expert consultant, Urban Designer and Academic
5	Dikshit, AK.-5	Institutions	Professor, Centre for Environmental Science and Engineering, Indian Institute of Technology, Mumbai IIT-B
6	Serrao, A.-6	Neighborhood	Resident, Committee Member RWA at MIRA CHS, Marol area
7	Patil, Y.-7	City	Asst. Program Manager for Educational Programs, Maharashtra Nature Park
8	Mandke, P.-8	Private	Social Engagement Expert
9	Jonnalagadda, M.-9	International	International Development Consultant in Water Sector
10	Gomare, M.-10	NGO	Project Lead and Natural Organic Farmer, Art of Living River Rejuvenation Project
11	Ashraf-11	Neighborhood	Second generation Scrap Business Owner
12	Kanekar, S.-12	Institutions	Senior Program Associate, World Resources Institute (WRI India)
13	Keluskar, K.-13**	Private	Senior Sustainability Expert, Educated Environments; Assistant Prof. KRVIA
14	Bhandari, P-14	Private	Environmental Architect, Alchemy (Consulting), & Academic
15	MMRDA-15	City	*(Confidential),* Mithi River Development and Protection Authority, MMRDA
16	Das, S-16	Private	Lead Architect, Urban Designer, PK Das & Associates
17	Saiyad, A-17*	Private	Photographer, Mumbai Rivers Project, cofounder of *Hallu Hallu* – a walking project
18	Barap, D.-18*	Neighborhood	Resident, National Park (SGNP) & Warli Artist
19	Mohan, D.-19*	Neighborhood	Resident, Goregaon area
20	Marathe S.-20	Institutions	Advisor, All India Institute for Local Self Government (AIILSG), ex- Chief Deputy Engineer MCGM
21	Parthasarthy, S.-21	Institutions	Professor, Department of Humanities and Social Sciences, Indian Institute of Technology, Mumbai IIT-B
22	MCGM-22	City	*(Confidential),* Municipal Corporation of Greater Mumbai (MCGM)
23	Vaidya, N.-23	NGO	Environmental Activist, Communications and Media professional
24	Deval, Y.-24	Private	Area Director, RiverRecycle
25	Sadananda, G.-25	Neighborhood	Resident, Kalina area
26	Tiwari, A.-26	Private	Urban Planner and Research Associate, Integrated Design
27	WBG-27	International	*(Confidential),* World Bank, India
28	Dayanand, S.-28	NGO	Environmentalist and Director, Vanashakti
29	Jothiprakash, V-29	Institutions	Professor, Water Resources Engineering, Indian Institute of Technology, Mumbai IIT-B
30	NEERI-30	National	*(Confidential)*, CSIR – National Environmental Engineering Research Institute (NEERI)

Table 3 Participant List.
Notes Saiyad, Barap, Mohan participated in the study as a group, with recorded individual responses;*
*** Pawar, V., Nayak, A. participated in the semi-structured interview portion with Keluskar, K. as the primary participant.*

2.3.2 Community's Contentious Relationship with the River

The relationship between the participants representing the decision-making community and the Mithi River manifests in various forms – in their descriptions of the river's current state, shared memories, perceptions, or of belonging. They also discuss the ways the river has shaped their lives and how they have, in turn, impacted the river. For research of this nature, it's crucial to highlight the positionality of this decision-making community before delving deeper into the issue-specific aspects of the Mithi River. Given that these decision-makers are actively engaged with the river in their daily lives or professional capacities, the river's future is, to a large extent, a reflection of their relationships with it and their feelings of belonging and connectedness.

Self and the River

Sense of Belonging

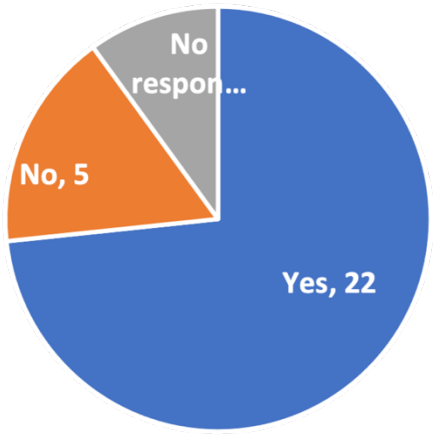

Figure 8 Participant Responses on Sense of Belonging and Identity with the Mithi River

In terms of feeling a sense of belonging to the river, the majority of respondents strongly agreed. Out of the 30 respondents, 22 expressed a deep connection and personal ownership towards the river. Dinesh Barap, a resident of the National Park precinct and a member of the Warli tribe, shared his strong personal and community's sense of belonging, stating, "from my childhood to now, I have observed that there is a deep connection and relation of the tribal people with the river—going to the river, fishing, crabs, and water for drinking. We had no taps, so the drinking water was also secured from the river, we would make small wells for drinking water." Ms. Marathe, a retired engineer at the municipal agency, also shared her emotional attachment, saying, "it's my river, I've been seeing it from my childhood." While some respondents did not express immediate personal connection, many quickly shifted the focus to the broader public or the community as a whole, highlighting a sense of collective belonging rather than individual attachment. Responses like, "[It belongs to] Everyone. It's not for one person… It doesn't mean, I should not think, that you will maintain, and I will use it, or you should not think that he's using let him maintain. So, it is collective" (Jothiprakash, V-29), indicating shared ownership and collective responsibility towards the river.

All the respondents emphasized the importance of maintaining and preserving the river for the benefit of the community. As Mandke, one of the respondents, stated, "It is collective. I respect that it's an asset…I'm a user of this asset. I don't own it. I think I get benefited, or I would call myself a beneficiary of the asset." These responses reflect a deep understanding that the Mithi River is a public asset that holds significance for all residents of Mumbai, one of the respondents claiming, “It is one of the heritage waterbodies in Mumbai…” (NEERI-30). The sense of belonging extends beyond personal level, with a strong emphasis on communal responsibility and the recognition of the river's value as a shared resource.

> *Yes, especially because, you know, it's right in front of us [IIT-B campus]…and also because we've been working on and studying in Bombay. There are parts where, you know, people feel that it's the neglect that has led to flooding, and especially around Mahim Bay. [But], if you look at it from, because we do a lot of work in the fishing communities here - the Kolis. For them, they don't look at the river as a source of flooding. Because it's a source of fish. It's a source of biodiversity, its part of the coastal wetland system. And, it's part of the* estuary. *So in that sense, I think depends on who you ask. I would definitely say yes. (*Parthasarthy, S.-21)

> *Very much, very much. Because the water body, even though we administratively, say that some government body has to maintain it [or whatever], but it belongs to each and every citizen, there is a sense of belonging to the citizen who is residing there itself but it is for everyone.* (Wankhede, A-3)

> *“Of course, it belongs to the people of the city and the people of this country…See, the government is the custodian it's not the owner. And, whatever you do to a river, now the courts have also said that the river is a living entity, living entity. So, you cannot take the right of a river away to exist and sustain life within it. What is the life that you see in the Mithi river? there's nothing.”*
> (Dayanand, S.-28)

Contrarily, a few decision-makers disavowed sense of personal connection with the Mithi River when asked if they felt a sense of belonging. Their responses made it evident that this sentiment was rooted in the river's polluted condition, its status as a seemingly failed project, and its unsightly appearance, which induced feelings of despair. One respondent expressed, "I would want it to belong to me, I don't think it does" (Das, S-16), while another stated, "Not that river!" (Dikshit, AK.-5). Some more responses along these lines,

> *No. It doesn't, in the sense, I would like to do something about it, as an environmental professional but in terms of does it belong to me? No, because and not even after exploring it. I don't see, I mean, I have explored the entire length of it, there is an apathy, apathy even amongst the people who are living right at [the river]. So that apathy is very*

> *deep, and that needs to be uprooted, if that gets uprooted and one can, you know own. It needs to be citizens beyond those who live in the proximity.* (Bhandari, P-14)

> *No, sorry, in its current state, No… [However] Stepping back and looking at its impact, I need the infrastructure…And that's why I'm responsible for the river in whatever condition it is. So, I think from that perspective [yes].* (Nayak A, with Keluskar, K.-13)

These sentiments mirror not only the feelings of the participants but also of the wider populace affected by the river and those residing in the city. Even amid these personal sentiments, it is significant to highlight the strong commitment and dynamic participation displayed by these decision-makers in the river restoration initiatives. Many offered expert services on a pro-bono basis or for reduced compensation. Although they might not harbor a personal connection to the river in its current state, they acknowledge its importance and are actively engaged in enhancing its condition. This demonstrates a sense of responsibility and devotion to positively impacting the river's future, regardless of their personal attachment or lack thereof.

Influence of the River

The participants reflected on the personal impact of the Mithi River on themselves and vice versa, at three distinct levels: self or personal, daily lives, and beyond (See Table 4). At a personal level, there was a deep sense of negative impact, ranging from sensory experiences like unpleasant smells and sights to emotional effects such as pain and loss of well-being. Many participants naturally identified with how their daily lives were impacted by the river. One participant reinforced the idea that being located in the center of the city, the Mithi River has the potential to bring all aspects of daily life to a standstill (Bhandari, P-14). For a city that never stops, the impact of the river is most acutely felt when commuting becomes impossible. A handful of participants also shared perspectives on the river's influence beyond themselves and their daily lives, discussing climate change impacts, habitat loss, and contamination.

Quotes such as "It disheartens me, it saddens me, and it certainly impacts my life" (Das, S-16) and "seeing the plight of the river really pains me greatly" (Vaidya, N.-23) capture the emotional strain felt by individual decision-makers, which is likely echoed by the wider community. Mr. Patil, who heads the Education Program at Maharashtra Nature Park, shared his experience of the unpleasant odor permeating the nature trail near the Mithi River. He indicated that this negatively

SELF	DAILY LIVES	BEYOND
smell, stink	pollution	climate change
unpleasant sight	damage/ loss of property	habitat- loss of mangroves
sanitation, public health issue	displacement	habitat- impact on migratory birds
disgust, dirty	impact on businesses	loss of water habitat, fishes
Sad, pain	Flooding - city comes to a standstill	contamination of coastal ecology
disheartening	can't commute - roads get affected, railway lines shut down	contamination of ground water
loss of well-being	impact on *Warli* and *Koli* fishing community	Negative image for the city and local area

Table 4 Perception and Influence of the River

affects not only their personal experiences but also the educational and leisure experiences offered to park visitors. However, Patil also highlighted a glimmer of hope, noting that they recently spotted a few flamingoes. The numbers may be fewer than in the past, but he suggested that this slight resurgence could potentially be attributed to recent dredging and desilting activities.

> *Basically, rivers are as important as the veins in our body, those rivers could be anywhere. If any one of our veins gets blocked, we feel a lot of pain and suffering. Similarly, this situation of the rivers is impacting climate change, its not just mithi but all the polluted rivers in some way or the other affect climate change and in turn mankind. Whatever chemicals are going into the river, it is percolating into the ground somewhere or the other and polluting a water source, and we use these water sources leading to causes of several diseases like cancer.* (Gomare, M.-10)

While some participants shared reflective realizations about their indirect impact on the state of the river, many discussions focused on individual behavior and the need for citizens to take responsibility. Some participants recognized their contribution to pollution and expressed a desire for individuals to actively take part in preventing pollution "by doing their part as citizens" and not solely rely on the government (Vaidya, N.-23). One participant shared their realization, saying, "I also use the same products. And this is where it ends up at the end of the day. So yeah, I am an equal contributor as anybody else who's staying in this city" (Tiwari, A-26). Another participant emphasized the shared responsibility of individuals who choose to build in flood-prone areas, emphasizing that everyone is accountable for their actions (Ekbote, A-4). This recognition of individual responsibility signifies a shift towards a more proactive and empowered approach to environmental stewardship. Many participants acknowledged that their

choices and actions, such as proper waste management, reducing plastic consumption, and supporting sustainable development practices, can contribute to the overall health of the river.

Physical Attributes of the River

Memories and Perception

Many participants shared their negative perceptions of the Mithi River, revealing that they were oblivious to its existence until the devastating floods of July 2005. Now, they're profoundly aware of the physical challenges and associated issues linked with the river. Numerous participants voiced strong objections regarding the use of the term "nallah" to characterize the river, asserting that it diminishes their recollections of the river and influences how it's handled by authoritative entities. Das, an urban designer, noted that people frequently reduce the Mithi River to being a gutter or drain, rather than recognizing it as a river, a sentiment shared by other participants like Dayanand, Keluskar, and Tiwari, among others. He opined that this dismissive view is prevalent in Indian urban cities where other water bodies are similarly disregarded, leading people to treat the river as a garbage dump, while overlooking its real potential. In the same vein, Parthasarthy, a professor at IIT-B who has worked extensively on the Mithi River and other urban and coastal water issues in the city, conveyed that many people were ignorant of the river's existence in their surroundings prior to 2005. The prevalent perception among residents is that it's merely a "nallah" or drain. They hold the belief that a river should possess a certain level of flow, a trait that the Mithi River lacks due to sewage dumping, solid waste disposal, and encroachments. This stark contrast between its official designation as a river and its actual treatment by both the government and communities contributes to a sense of disillusionment (Parthasarthy, S-21).

For many participants, their awareness of the river came as a revelation. They reflected on their experiences as urban citizens crossing numerous nullahs (drains) without understanding the true nature of these water bodies. Realizing that the Mithi River is a natural river and not man-made was a significant lesson for them. Their accounts reveal a prevailing perception of the Mithi River as a neglected and polluted water body, often referred to as a drain or nallah. This perception highlights the urgent need for efforts to not just restore the river but more also redefine its status as a vital natural resource in the city.

> *As an urban citizen, we used to cross a lot of nullahs. See we are not, in school, we are not taught about the environment. There is no definition of nallah, and there is no definition of the river [local/ urban river]. Suddenly we figure that this is a nallah and nallah is also an organic [entity], which is also the definition of a river, so suddenly I discovered this is a river and this river is not manmade this is natural. So that was a very important lesson for me. When I became a photographer, everything changed for me. So if this is a river, why have we polluted it so much, and why do we have no culture to conserve it, we keep calling it nallah we are degrading it. So that was very shocking for me.* (Saiyad, A-17)

> *I have mainly only heard its mention, like you are doing research about it or in the news, I don't know anything about it. Behind my shop all I know is that there is a nallah, that is what I know of, I didn't know it's a river.* (Ashraf -11)

> *As a Bombay citizen being born and brought up over here, I haven't seen a single River in my life, until I joined the Aarey movement, and I came to know that there are, four rivers! Ohh we have four rivers from really, we never knew that there is something called as rivers [in this city]. And when you see the rivers over here, they are more like sewage, they are nallahs, you don't see any river... they don't even look polluted, they look dark, like sewage. So, I don't see a river around me, unfortunately...* (Vaidya, N-23)

In contrast, Anita Serrao, a member of the housing society Resident Welfare Association (RWA) located in the middle-upper reaches of the Mithi River in the Marol area, holds a rather positive perception of the river. From the vantage point of the seventh floor of her building, she finds the river beautiful and scenic, appreciating the surrounding greenery. However, she acknowledged the unfortunate behavior of people who indiscriminately dispose of waste, including animal carcasses, into the river. To prevent further pollution and maintain the river's aesthetic appeal, she advocates for the installation of a retaining wall that separates human activity from the river's body. The various memories and perceptions shared by participants highlight the need for comprehensive efforts to reshape the narrative surrounding the Mithi River.

2.3.3 Spatial Insights: An Aggressive Development-Focused Environmental History

Adding a spatial dimension to the decision-making community's perspective of the Mithi river is crucial for understanding its urban ecosystem construct as a socio-ecological system – demonstrating how this singular river system mirrors the tension from its natural, development-related, and institutional demands within Mumbai. This establishes an imperative narrative of Mithi's socio-ecological system, and a narrative of the technical and the institutional story.

> *"When we came here in '87 there was no BKC, there was nothing at all, none of that [pointing across the river]. Actually, when I came here in '87 there was no Mithi, nothing visual like a river. It was just like a nallah [water stream] and ahead there were all mangroves, the entire BKC area was mangroves. There used to be a lot of rainfall, even now it rains the same amount and intensity, [but back then] how much ever it rained it never was a trouble for us. When it rained the water would be completely absorbed by the mangroves and the rains never really affected us. How much ever it poured the mangroves would take it all in, we never had any troubles. But as the BKC reclamation, construction began, along with it the water started to divert in this [our locality] area. The government to keep up with their [development] policies, reclaimed and made BKC to a higher elevation and pushed us into the gutters. They constructed a high land, it is not even all their fault, because they were planning for development in the future, accordingly, they had to build [reclaim] BKC to a higher level. They maintained their higher ground, and as a result, we ended up in a low-lying area"* (Devanand-2).

Mithi Embodies the Diversity of Landuses and Landforms in Mumbai's Urbanscape

As we delve into understanding the spatial context of the Mithi River in Mumbai, it is essential to briefly explore the river's environmental history of in context of land reclamation in the city. The maps in Chapter 1, Fig 2 highlight the Mithi River watershed, we can observe how the city has transformed from its original state as a collection of seven islands (as depicted in the 1893 map) to its present-day form. Over the past 150 years, the Mithi River watershed has undergone significant and aggressive land reclamation, making it the most dynamic inland landscape in Mumbai. Oral histories shared by some of the participants add further valuable insights into the evolution of the river and its surroundings. For instance, Sonawane mentions that the BKC area, which originally had holding ponds along the river, has now been completely reclaimed. Additionally, Sadananda, shares oral histories that highlight the river's historical use for fishing and navigation. Marathe S. further shared her knowledge that the Marol area was one of the oldest settlements along the upper reaches of the river. Immigrants to the city chose to settle between the national park and Filterpada area, as these environmentally sensitive sites were relatively secluded from authorities and challenging to access for eviction. While proximity to suburban Mumbai provided employment opportunities. Considering this historical context, it is unsurprising that the Mithi River, along with its urbanized watershed, is situated in a low-lying area highly susceptible to flooding from both inland sources and coastal surges during high tides.

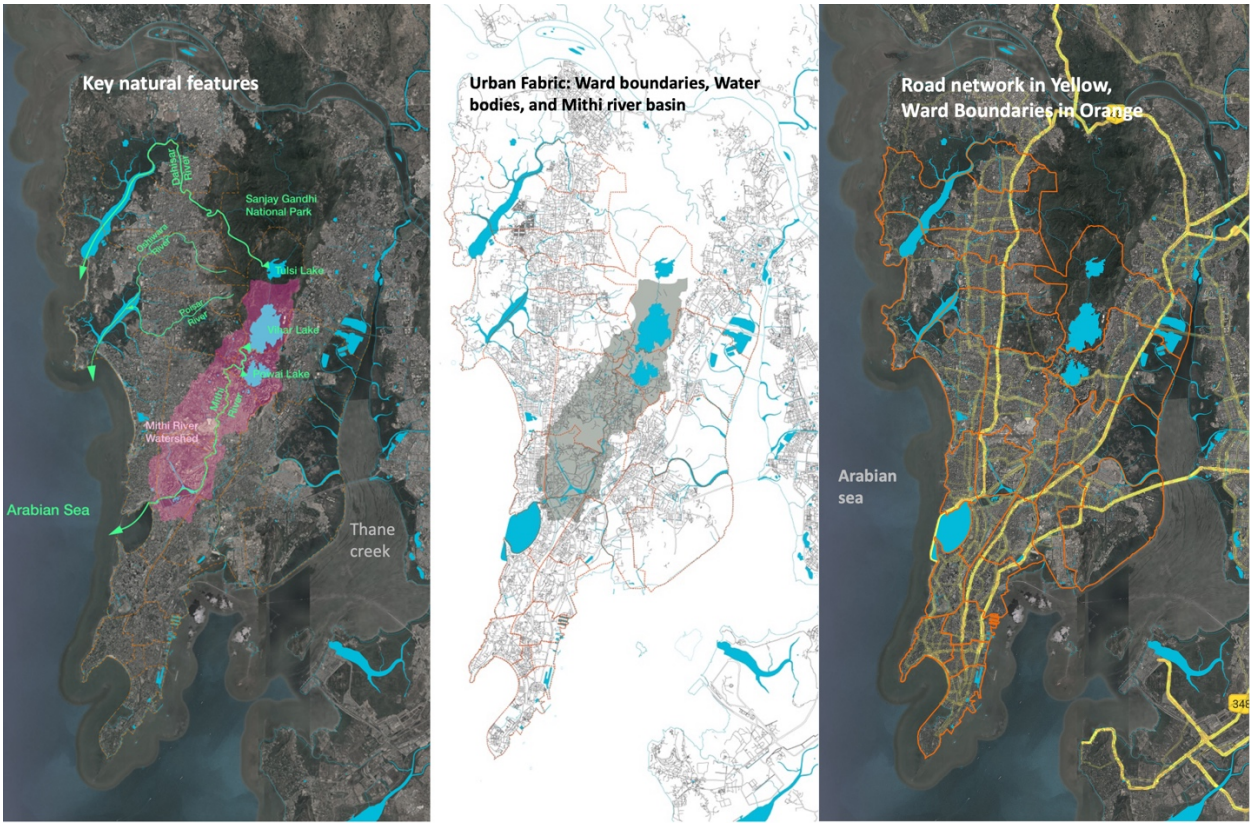

Figure 9 Maps of Greater Mumbai, locating the Mithi River within its shaded watershed.

This vulnerability to flooding underscores the challenges associated with managing this dynamic and ever-changing landscape.

Present day Mumbai is an island city, one of the densest populations and in the world of approximately 29,666/ sq km[16] the city is also characterized by several key natural features – its very own protected forest called the Sanjay Gandhi National Park (SGNP) 87 sq km/ 20% in greater Mumbai region, it encompasses 3 artificial lakes that were the original source of fresh water supply to the city, with elevations ranging from 30-400 plus meters[17] above the mean sea level. This is also where 4 urban rivers originate from the reservoir overflow traversing through the city and finally culminating into the Arabian ocean through the Mahim, Malad and Gorai creek on the western waterfront. The city has 160 plus kms of waterfront promenades and

[16] Calculated from reported total Mid-Year Estimated Population (M.Y.E.P) of 2020 from MCGM
[17] World Atlas website

beaches (PKDA, 2012) along with expansive marshes and creek both towards the western and eastern waterfront [18]. The 4 natural rivers of the city – the Mithi (17.84kms/ 11mi), Dahisar (12 km/ 7.5 mi), Poisar (11.5kms/7mi), and Oshiwara (7 km/ 4.3 mi) originate and culminate within the city characterizing them as urban rivers (See Fig. 10) (MCGM, n.d.; *MMRDA - Mithi River Development and Protection Authority*, 2013). These urban rivers play an extremely vital rule in urban water management of the city – regulating the surface drainage, storm water and other discharge within their basins. The Mithi river originates in the highlands of the National Park from the overflow of the Vihar and Powai Lake within a pristine area traversing through dense development while intersecting with all major urban infrastructure of rails, roads, and airport ultimately emptying into the Arabian Sea. It runs 17.84 kms/ 11mi long serving a catchment area of 72.95 sq km, which is approximately 17% of the total city area of 434 sq kms[19]. The river passes through mainly the L and K/East wards (see Appendix J for population density map of Mumbai with ward boundaries), with population density ranging from 70,000 – 150,000 per sq mi. Of Mumbai's approximate 12.8 million population, approximately 6.5 million live in some form of informal settlements, the L-ward of Kurla in the

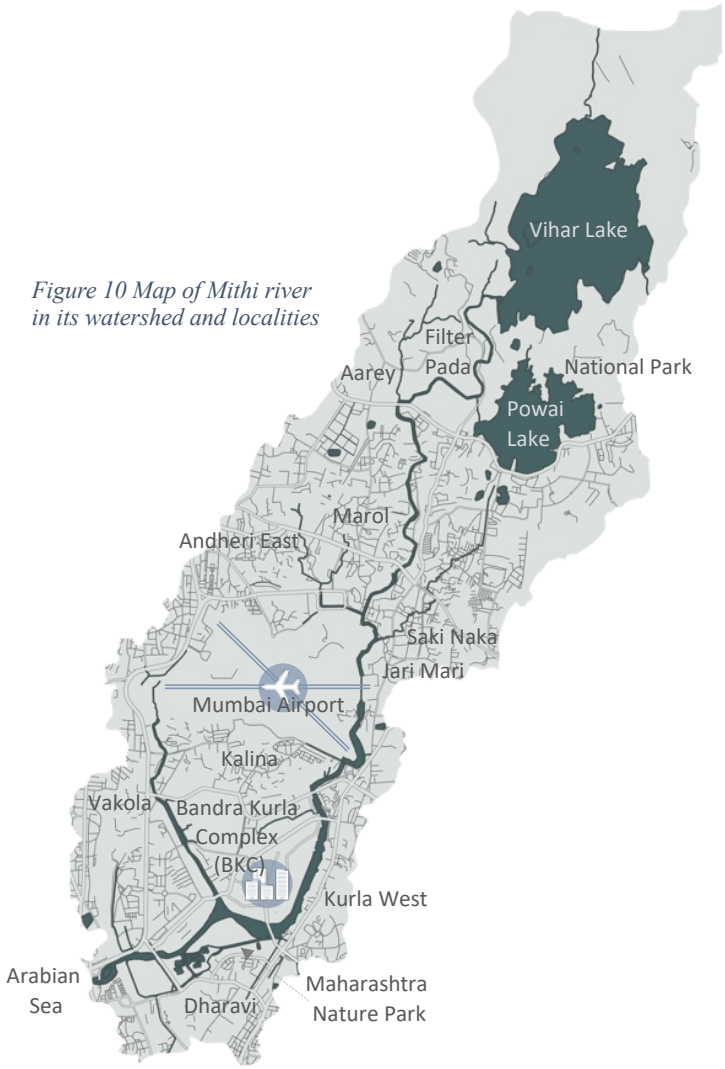

Figure 10 Map of Mithi river in its watershed and localities

[18] See Open Plan project for detail natural and water feature typologies from PK Das & Associates Mumbai Waterfronts Center, 2012
[19] (MCGM, n.d.)

vicinity of the Mithi river houses 84% of the total city's slum population (Kirtane, 2011; Revi, 2005).

At its origin there are pockets of indigenous *Warli* tribe settlements, then entering the urbanized area in upper reaches characterized by the informal settlements and low-income settlements along the *Aarey* colony and *Filterpada*, followed by middle income housing and industrial complexes in Marol and Sakinana area, informal settlements and scrap industries of *Jhari Mari*, *Bail-bazar, Kranti Nagar, Kurla*, passing through the Mumbai runways, Airport Authority of India (MIAL) owned land operated privately, followed by old residential area of *Kalina*, informal settlements of Kurla east into the recently developed Business and Commercial District of Bandra Kurla Complex (BKC). The *Vakola nullah* meets the Mithi River, again passing through dense industrial and residential area, carrying heavily polluted discharges. The lower most reaches of the river also passes along Dharavi in Mahim area, one of the largest informal ecosystem of settlement in Asia, abutted by the mangroves and marshes where the Maharashtra nature park sits on a land that was once a garbage dumping ground, eventually reclaimed and developed to a nature park and educational center in the mid 90s. Shrinking mangroves line the final river stretch, intersected by the western railway line and a highway along the Mahim creek with last remnants of *Kolis*[20] fishing community along the coast where the river meets the Arabian sea (Shukla, 2007). It is critical to note that of the approximate 18kms stretch, almost 6 kms towards the lower reaches is subject to tidal action from the sea, this adds another layer of complexity to the river management and dynamics.

On the ground, this seasonal river manifests itself in many different ways (see adjoining Fig 11 photo walk along the river from fieldwork conducted in Feb 2022- June 2022). The river's width ranges from 5m in the upper reaches to 25 m in the middle to 70 m in the lower reaches – it has been focus of many interventions like widening, training, resettlement etc. Today as one walks along the river, most many parts of the river course is lined by a retaining wall, ensuring that one cannot see of feel the presence of the river in many sections. This retaining wall is one of the major interventions in the recent years towards river restoration.

[20] *Kolis* are known as the original inhabitants of Mumbai.

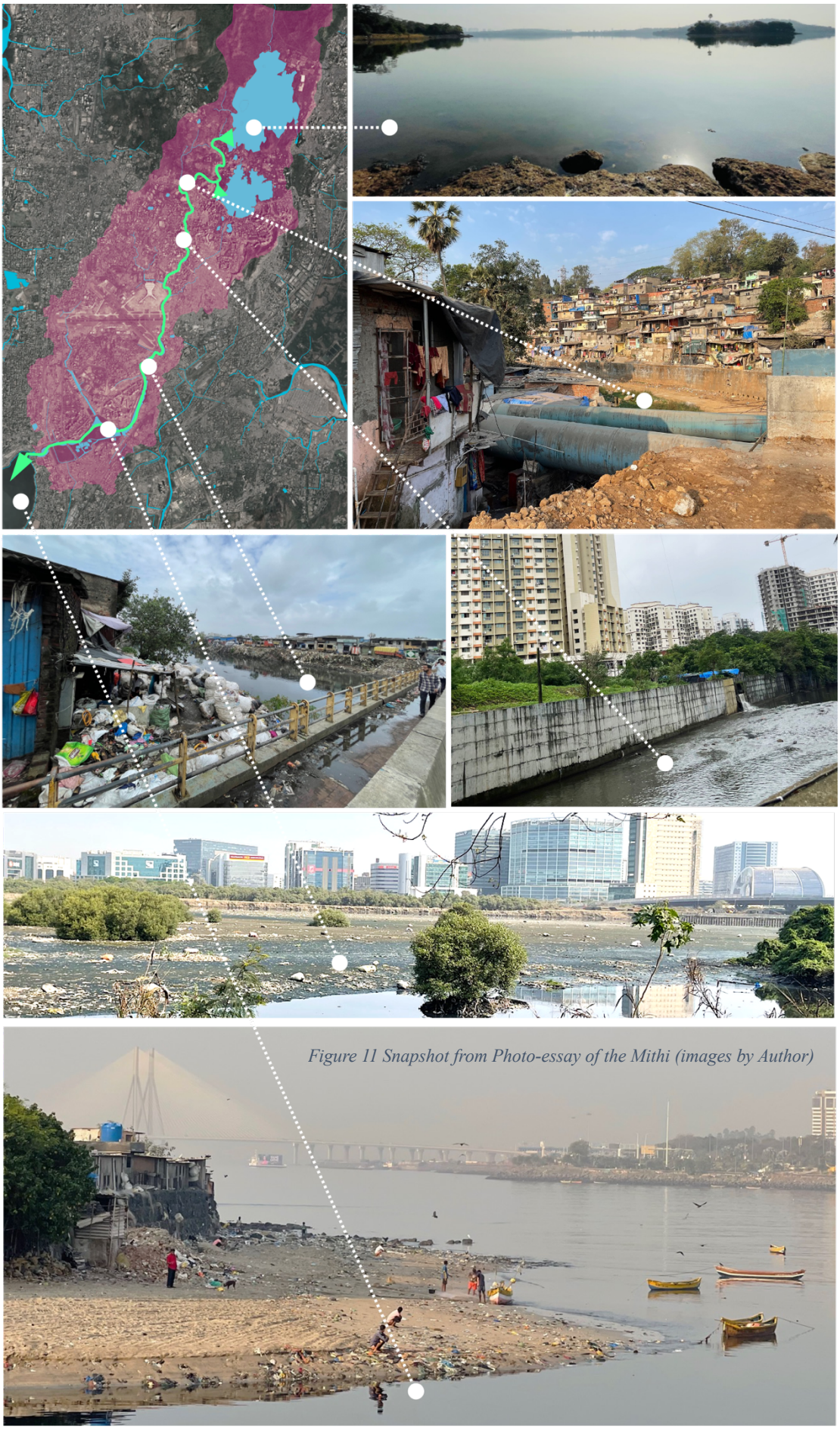

Figure 11 Snapshot from Photo-essay of the Mithi (images by Author)

Seasonal and Topographic Variations

The dynamic nature of the Mithi River showcases the resilience and adaptability of this waterway. The Mithi river is quite dynamic, the stark contrast between the dry periods and the monsoon season paints a vivid picture of the Mithi River's ever-changing character. Unlike our perception of rivers in general, the Mithi is not a perennial river, majority of respondents were aware and emphasized this key aspect of the Mithi River. It is a seasonal river that runs dry for most of the year, except during the monsoon months of June to October[21]. During this time, the river experiences a significant surge in water volume, transforming into a powerful force of nature. It swells, overflowing from the lakes in the highlands and experiencing tidal action in one-third of its lower reaches.

> *Anybody who, who dismisses the river, and these water bodies as drains of sewage channel should see its fury during the rains…I would say the resilience of it, whatever you do to it, it just stays. It may morph itself from being a gutter to another to a seasonal drain. But it's it's persistence to just be, whether the highlands have made it into a slim snake somewhere or it grows (swells up) during a monsoon it just engulfs the whole city.*
> (Keluskar, K. with her colleagues Pawar, V. and Nayak, A.)

The seasonal variations of the Mithi River have significant implications for its management and the challenges it presents. During dry months, the exposed riverbed reveals the impacts of pollution, sedimentation (including sludge from informal settlements), and degradation. In the lower reaches, daily tidal action introduces coastal pollutants. Conversely, the monsoon season poses challenges in managing excessive water flow and mitigating flood risks, particularly during high tide in the lower reaches. Understanding and acknowledging the seasonal nature of the Mithi River is essential in developing effective strategies for its conservation and management. It calls for a holistic systemic approach that considers both the dry and monsoon periods.

In addition to the seasonal variations, the Mithi River displays notable topographic variability, it goes through a high gradient change, majority of the developed area is low lying, with one third of its lower course subject to inland tidal action. Kanekar, S. who leads the work on urban

[21] Also important to note that these rivers are overflows of artificially constructed lakes with dams in the highlands of the national park, built in 1860s and late 1800s for water supply for the city during the British rule.

flooding in the city at the WRI, highlighted that the river's topography, cross-section, and the vulnerability of surrounding settlements are in a constant state of flux. This dynamic nature presents challenges for river management and underscores the necessity for contextually responsive strategies that can effectively address the evolving conditions of the river.

Mithi river's complex landscape of governance and land management

The Mithi River, threading its way through the metropolis of Mumbai, navigates not just the city's physical contours but also an intricate tapestry of land usage, ownership, and governance. This diverse landscape of jurisdiction is dictated by a myriad of governing agencies, making urban impact management a complex task. The local Mumbai municipal corporation (MCGM) manages the 11kms of the river up until the airport, whereas the lower stretch spanning 6-7 kilometers is overseen by the state agency MMRDA. Several other departments, such as the Forest Department, Environment Department, Mangrove Cell, and Coastal Regulated Zones (CRZ), also share responsibilities for different facets of the river's management (Ghosh et al., 2020; Kamath & Tiwari, 2022; Tiwari, 2019a). Meanwhile, the Maharashtra Pollution Control Board (MPCB) is responsible for regulating the river's water quality.

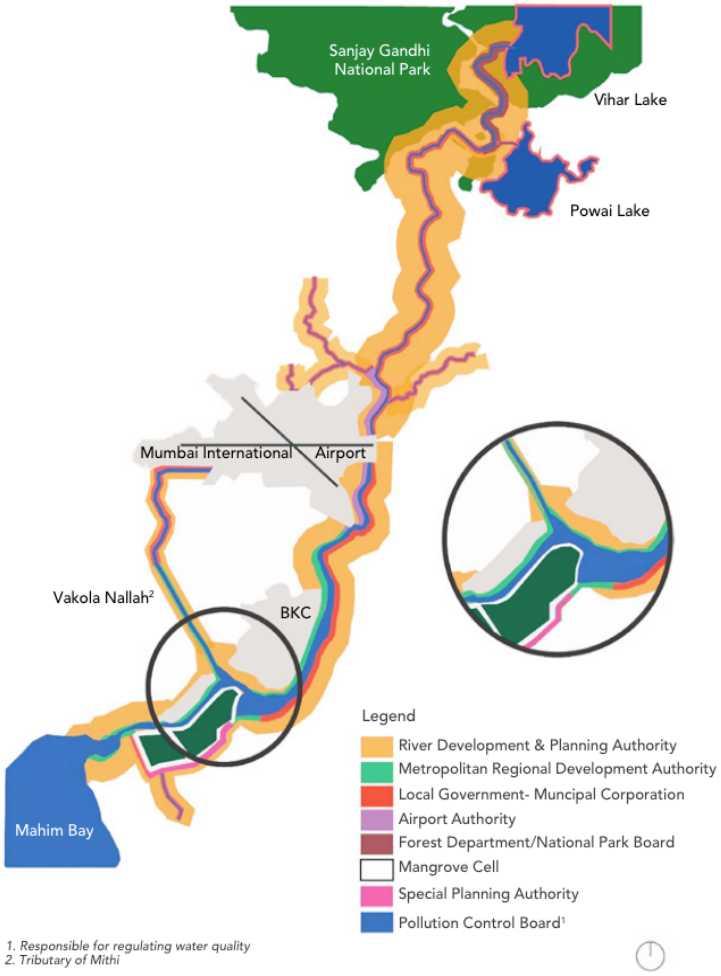

Figure 12 Map of Mithi River's web of Governance (Kamath, Tiwari, 2022, Reproduced with Permission)

Dayanand, an environmental activist, shared an eloquent analogy of Mithi's Governance:

> *River is divided between MCGM and MMRDA. Both have their own jurisdictions, and they try not to trespass into each other's area, which makes the river really like the child of a divorced parents where, you know, either one, the child doesn't get the complete attention, but the father and mother are taking their own route to please the child.*

Prof. Parthasarathy, the Principal Investigator for the Socio-Economic Assessment of the 2005 Floods commissioned by MMRDA (IIT-B, 2014), further investigates this issue in his 2016 research article (Parthasarathy, 2016). He critiques the prevailing governance landscape, characterizing it as the "Balkanization of the Mithi," primarily through the city's spatial, sectoral, and disaster management practices. One of the participants shared how nobody takes ownership of the problem. One participant echoed these sentiments, lamenting the lack of accountability," if you talk to, River Authority, they say cleaning river is not our mandate, if you talk to the Municipal Corporation, they will say that everything [waste] is coming from upstream. So, nobody takes the responsibility." Similarly, participant and urban scholar Tiwari (2022; 2019) reproached what she defines as "Ambivalent Governance" concerning the "Forgotten" Mithi River. Her discussion centers on the disjointed practices of environmental preservation, which appear to prioritize economic growth and property development over ecological integrity. She underscores the imbalances generated by state policies and actions regarding informal settlements. Her findings suggest that policies tend to privilege the vested interests of a select few over addressing the grievances of the majority.

The Chitale committee in 2006 identified discordance among agencies managing the river and suggested the establishment of the Mithi River Planning and Development Authority (MRDPA) for improved coordination. However, nestled within the Mumbai Metropolitan Region Development Authority (MMRDA), with overlapping responsibilities and shared leadership, MRDPA's impact is difficult to gauge amidst MMRDA's wider goals and competing priorities. Public agencies frequently outsource a wide range of services, from expert consultation and research to outreach and routine engineering tasks. However, due to various constraints, these agencies might not always be actively engaged or possess the capacity to effectively implement the recommendations. As a result, it's not rare for expert suggestions and reports to be shelved, sometimes for decades. This trend has led to a growing sentiment of underappreciation among

contributors who yearn to see measurable impacts from their efforts. An MRDPA participant underscored the absence of an overarching vision and expressed the need for strategic goals that would enhance coordination within the myriad of public agency entities. A participant from MRDPA highlighted the lack of a unifying vision and stressed the need for strategic goals that would bolster coordination among the many public agency entities involved. One participant envisaged integrating the city's brand with the Mithi River, expressing the sentiment, "Mithi is the Living Room of Mumbai". Yet, without support from top-level decision-makers, the work persists in a reactive "firefighting" mode rather than systemic proactive planning and action.

Tracing the Genesis of the Mithi River's Crisis

> *In the months of July-August, our ground floor residents, they live like on border[22] they will face the bullet at any time [due to the flooding impact]. They are always in full tension, you see this man standing here [another resident walks in and has joined the conversation] his house is on the ground floor, he's under tension 24 hours of the day, so many times it has happened that they go to sleep and wake up to water racing into their houses. Where do they go with all their belongings? 2005 there was sooo much water, up until here [pointing to a line marking on the walls close to the ceiling].* (Devanand -2)

A resident of Kurla West, Devanand talks of the recurrent flood impact and the ordeal of its residents. The 2005 Mumbai flood exposed the city's antiquated drainage system, originating from the colonial era (Gupta, 2007). The BRIMSTOWAD report

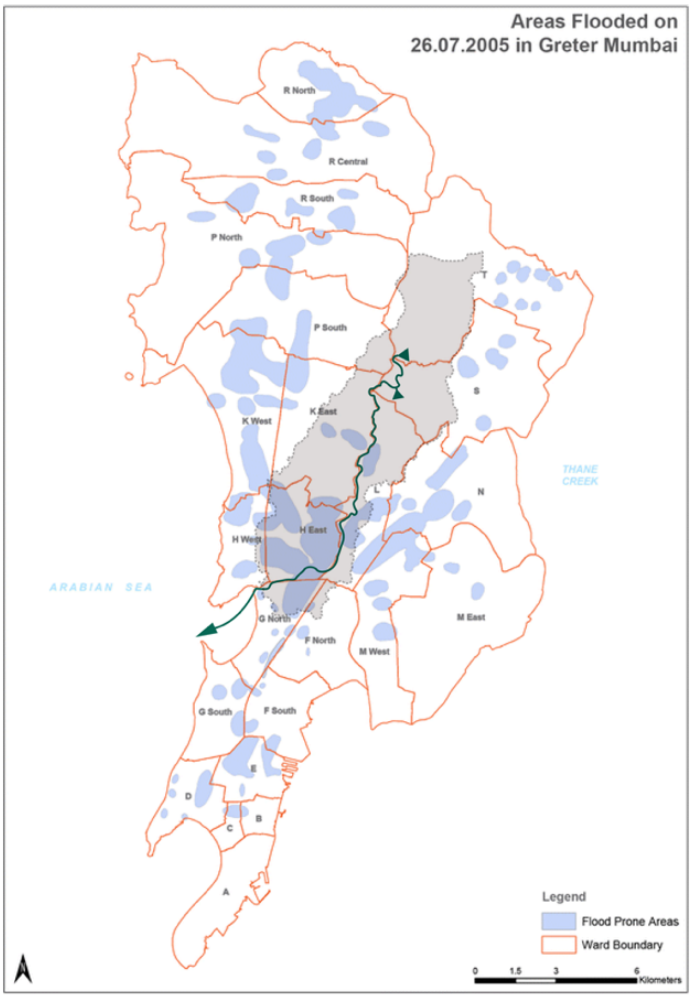

Figure 13 Mithi River Watershed Overlaid on MCGM's 2005 Flooding Map: Highlighting Areas of High Urban Flooding Susceptibility in the Middle Lower Watershed

[22] Implying the contentious India-Pakistan border.

(1993), the city's last major drainage study, advised improving drainage capacity within catchment regions. After the 2005 flood, this urban flood resilience plan became a focal point. However, it required revisions to accommodate a rainfall intensity of 100mm/h (Gupta, 2007). Beyond its vulnerability to natural urban flooding and tidal actions, the Mithi River's natural flow has been hindered by both formal and informal urban development activities.

1. Informal settlements interspersed along the river course: Following the 2005 deluge, the Mithi River Chitale Fact Finding Committee (FFC) recommended widening the river, establishing buffer zones, and clearing slums (Chitale, 2006)These interventions ignored the intricacies of the heavily urbanized floodplain.
2. Mumbai's International Airport: The Mumbai International Airport, a Special Planning Agency (SPA), has significantly affected the Mithi River's ecosystem. The extension of the secondary runway in the mid-90s caused the river to negotiate four sharp right angles over a short distance, exacerbating the 26/7 floods (CCC, 2006).
3. New Commercial and Business District – BKC: The Bandra Kurla Complex (BKC)[23], constructed over a wetland along the river, violated Coastal Regulation Zone (CRZ) norms and exacerbated flooding (CCC, 2006; *MMRDA*, 2013; Vijay et al., 2005). Despite warnings from NEERI in 1996, environmental clearance for BKC was granted by CWPRS, a government entity (Kelkar, 2006)[24].

Amidst this, aspirations for redevelopment[25] in Kurla West, across the upscale BKC area, located on the Mithi River's eastern banks, have risen. Residents of this low-lying region bear the brunt of urban water management issues, especially during extreme weather events. They face hurdles due to Coastal Regulation Zone (CRZ) guidelines while witnessing the transformation of nearby marshes and mangroves into commercial and residential developments. This underlines the disparity between BKC and neighboring middle-income communities affected by the river. The existing housing redevelopment aspirations often take a backseat due to CRZ restrictions, while

[23] In response to the city's growing need for space, a long-term reclamation process was initiated by MMRDA in late1970s along the Vakola, Bandra East and Mahim Bay area abutting the Mithi River.
[24] Also identified in the 1990 environmental report by National Environmental Engineering Research Institute (NEERI)
[25] Redevelopment of housing societies in Mumbai involves the process of demolishing old buildings and constructing new ones to accommodate modern amenities and improve living conditions for residents. It typically entails the participation of developers, housing societies, and government authorities to ensure compliance with regulations and to address the housing needs of the city's growing population.

pro-development forces prioritize new development areas, which seem to bypass strict regulations.

2.3.4 Assessment of Factors Contributing to River Pollution

Survey Results

This section of the study aimed to delve into the problems impacting the Mithi River, by using a structured methodology to evaluate all possible contributing factors. This approach enabled a holistic understanding of each factor in relation to others, specifically from the standpoint of the decision-making community. When solicited individually in an open-discussion format, the majority of responses pointed towards solid waste management, industrial activities, and informal settlements along the river as the primary sources of pollution. However, when introduced to a more encompassing framework through a survey (See Appendix B) presenting all polluting factors (Table 5, they were also grouped for easier understanding) participants were able to examine a broader spectrum of issues. Moreover, throughout this process, participants reflected on the potential to influence environmental behaviors and identified effective intervention levels. These ranged from individual or household units, to group, community, or organizational levels, and the policy-making level.

Grouped Factors	Contributing Factor for River Pollution
Domestic Life (DL)	DL1 Domestic Life- Discharge of Untreated Sewage
	DL2 Domestic Life- Open Defecation
	DL3 Domestic Life- Religious Practices (offerings, idol immersions)
Infrastructure (INF)	INF1 Infrastructure- Sewage and Sanitation Amenities
	INF2 Infrastructure- Solid Waste Disposal services
	INF3 Infrastructure- Disposal of Chemical, Biomedical waste, and Debris
	INF4 Infrastructure- Under-Capacitated Sewage and Treatment facilities
	INF5 Infrastructure- Untreated Runoff
	INF6 Infrastructure- Inadequate Dredging and De-silting of drains
Urban Uses (UU)	UU2 Urban Uses- Informal Development
	UU3 Urban Uses- Formal Development
Industrial (IND)	IND1 Industrial- Effluent from Industries: chemicals, paper, sugar, leather, distillery, pharmaceuticals, power
	IND2 Industrial- Small scale Businesses discharging unregulated waste (e.g. scrap industries, dairy farms)
Governance (GOV)	GOV1 Governance- Fractured Governance
	GOV2 Governance- Inadequate Coordination in Municipal Agencies
	GOV3 Governance- Lacking Community Involvement

Table 5 List of polluting factors for Survey Assessment 1

The accompanying chart (in Fig 9) presents an evaluation of pollution-contributing factors. Participants were asked to score each factor on a scale from 1 to 3, where 1 represented a low contributing factor and 3 indicated a high contributing factor [26]. Upon individual assessment of a total of 16 factors[27], "Fractured Governance" was identified as the highest contributing factor with a mean value of 2.79 (*SD*=0.49). It was followed by two domestic-level factors, "Untreated Sewage Discharge" and "Solid Waste Disposal Services," each with a value of 2.73 (SD=0.52 and SD=0.69 respectively). The fourth-highest contributing factor was "Governance-related Inadequate Coordination in Municipal Agencies" with a value of 2.67 (*SD*=0.55), and the fifth highest was "Urban Development related to Informal Settlements" with a value of 2.66 (*SD*=0.61).

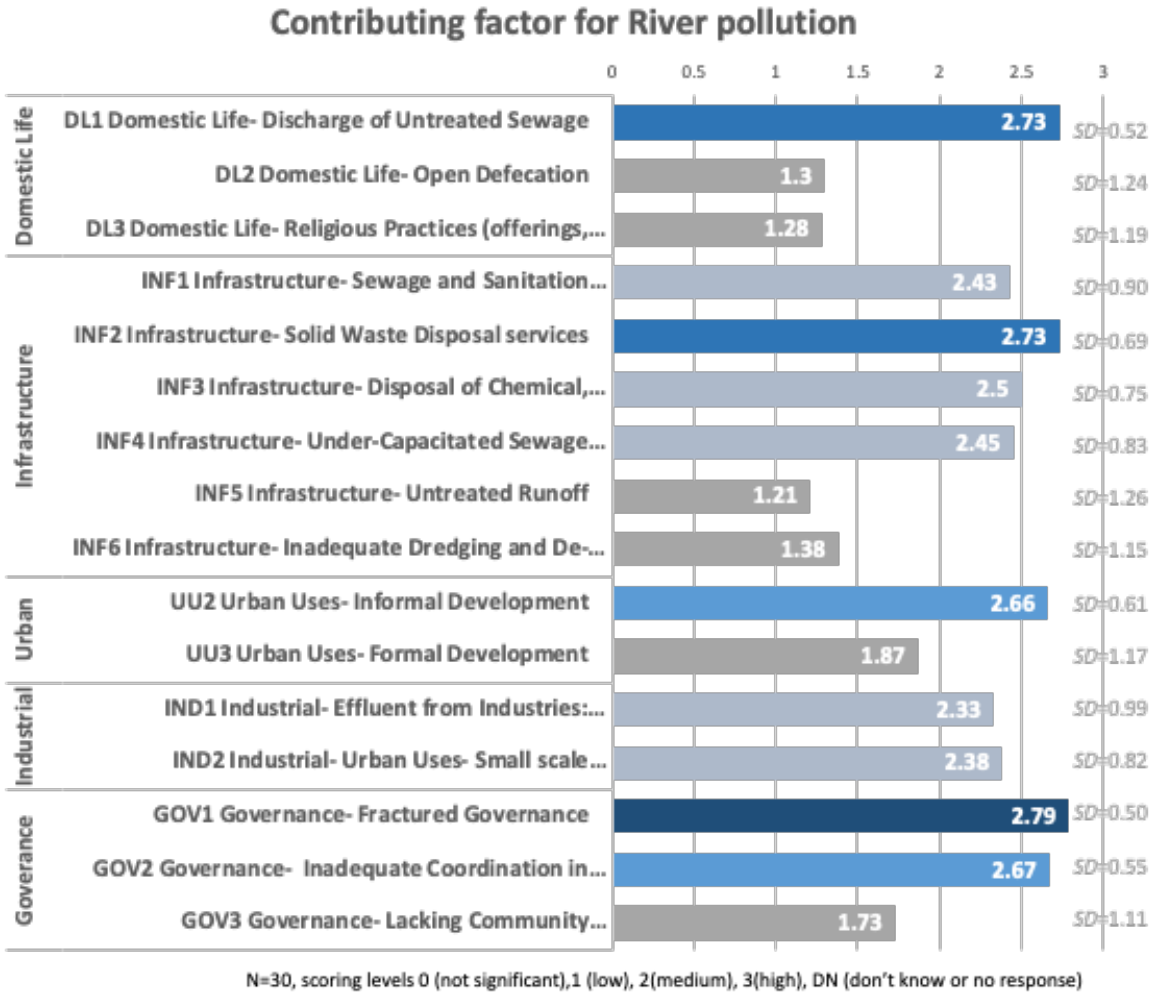

Figure 14 Survey Results for Assessment of Contributing Factors for River Pollution

[26] scoring scale of – 0 (not significant),1 (low), 2(medium), 3(high), DN (don't know or no response)
[27] Out of the initial 18 factors, (see Appendix B) two were eliminated as part of the analysis, due to their irrelevance for Mithi's context. As a result, a total of 16 factors are presented in findings of the results.

This analysis shows the entire participant group (n=30) viewed Governance as the leading contributor to river pollution, followed by factors related to Industrial, Urban, Infrastructure, and Domestic sectors. Analyzing data through this method starts to dismantle both the technical and institutional narratives, emphasizing that river restoration is not just a technical endeavor. Institutional dynamics, primarily at the governance level, are equally critical. While this aspect is generally acknowledged, it often doesn't receive equivalent deliberation (leading to interventions) compared to technical engineering and urban development factors during restoration effort discussions.

Insights from the Aggregation of Decision-Making Entities

The following section presents these findings from another construct, by forming super-groups of different decision-making entities (See Fig. 10). For this, the data has been aggregated into four super-groups of entities – Agencies (State + City), Local (Neighborhood + NGOs), Institutions (International + National + Institutions), & Private, some interesting variations in responses emerge. While these variances aren't significantly large, they provide valuable insights for a more fine-grained analysis that can inform specific strategies and interventions. This perspective underscores the importance of having a diverse representation of stakeholders in this community.

For instance, in the case of Formal Development (UU3), while the Agencies perceive it as a very low contributing factor towards river pollution (mean score=0.8), the Locals consider it a fairly significant contributing factor (mean score=2.56). Conversely, Agencies assessed Small Scale Businesses like scrap industries and other informal industries (IND2) as a very high contributing factor (mean=2.8), while Locals deemed it to be a much lower factor (mean=2.11).

Interestingly, the Governance factors were scored high across all groups, which includes the Agencies themselves (mean score=2.75). This key finding indicates that the governing agencies, who are the most critical change agents for the river's future, also contribute significantly to the problem. This finding calls for a fundamental shift in the perceptions that drive their interventions, thereby presenting an opportunity for change - potentially a behavioral change not only at the organizational and policy levels, but also among individuals who occupy positions of power and leadership.

		Super Groups of Decision-Making Entities				
Grouped Factors	Contributing Factor for River Pollution	Agencies (State+City) n=5	Local (Neighborhood+NGOs) n=9	Institutions (International +National+Institutions) n=8	Private n=8	mean score
Domestic Life	DL1 Domestic Life- Discharge of Untreated Sewage	3	2.78	2.75	2.5	2.73
	DL2 Domestic Life- Open Defecation	2.4	0.89	1.25	1.13	1.3
	DL3 Domestic Life- Religious Practices (offerings, idol in	0.6	2.11	0.57	1.38	1.28
Infrastructure	INF1 Infrastructure- Sewage and Sanitation Amenities	2.6	2.33	2.38	2.5	2.43
	INF2 Infrastructure- Solid Waste Disposal services	3	3	2.75	2.25	2.73
	INF3 Infrastructure- Disposal of Chemical, Biomedical w	2.6	2.33	2.5	2.63	2.5
	INF4 Infrastructure- Under-Capacitated Sewage and Tre	2.2	2.33	2.57	2.63	2.45
	INF5 Infrastructure- Untreated Runoff	0.8	0.78	1.14	2	1.21
	INF6 Infrastructure- Inadequate Dreding and De-silting	1.6	1.67	1.29	1	1.38
Urban Uses	UU2 Urban Uses- Informal Development	2.6	2.78	2.86	2.38	2.66
	UU3 Urban Uses- Formal Development	0.8	2.56	1.62	2	1.87
Industrial	IND1 Industrial- Effluent from Industries: chemicals, pap	2.6	2.56	1.88	2.38	2.33
	IND2 Industrial- Small scale Businesses discharging unr	2.8	2.11	2.43	2.38	2.38
Goverance	GOV1 Governance- Fractured Governance	2.75	2.78	2.63	3	2.79
	GOV2 Governance- Inadequate Coordination in Munic	2.8	2.78	2.5	2.63	2.67
	GOV3 Governance- Lacking Community Involvement	1.6	2	1.38	1.88	1.73

Figure 15 Assessing the River Polluting Factors through Lens of Aggregate Decision-Making Entities

Examining the data from this lens not only reinstates the value of assembling a representative decision-making community but also highlights the varied stances and points of convergence on different issues. This approach unifies all perspectives, providing a shared foundation to shape the river's future.

2.3.5 Potential to Influence Environmental Behavior

Survey Results

The second portion of this assessment survey prompted participants to reflect on where the greatest potential lies in influencing "human behavior" to address Mithi's urban river pollution issue. As they considered each polluting factor, they were given cues at three levels, as indicated in the accompanying chart (Blue-Individual/HH, Orange- Group, Grey-Policy).The responses were evaluated as dichotomized outcomes for the three multiple-choice, with the aim to identify the greatest potential to influence behavior in tackling the identified polluting factors at three specific levels: individual entities and households, community, groups or organizational levels, and policy levels.

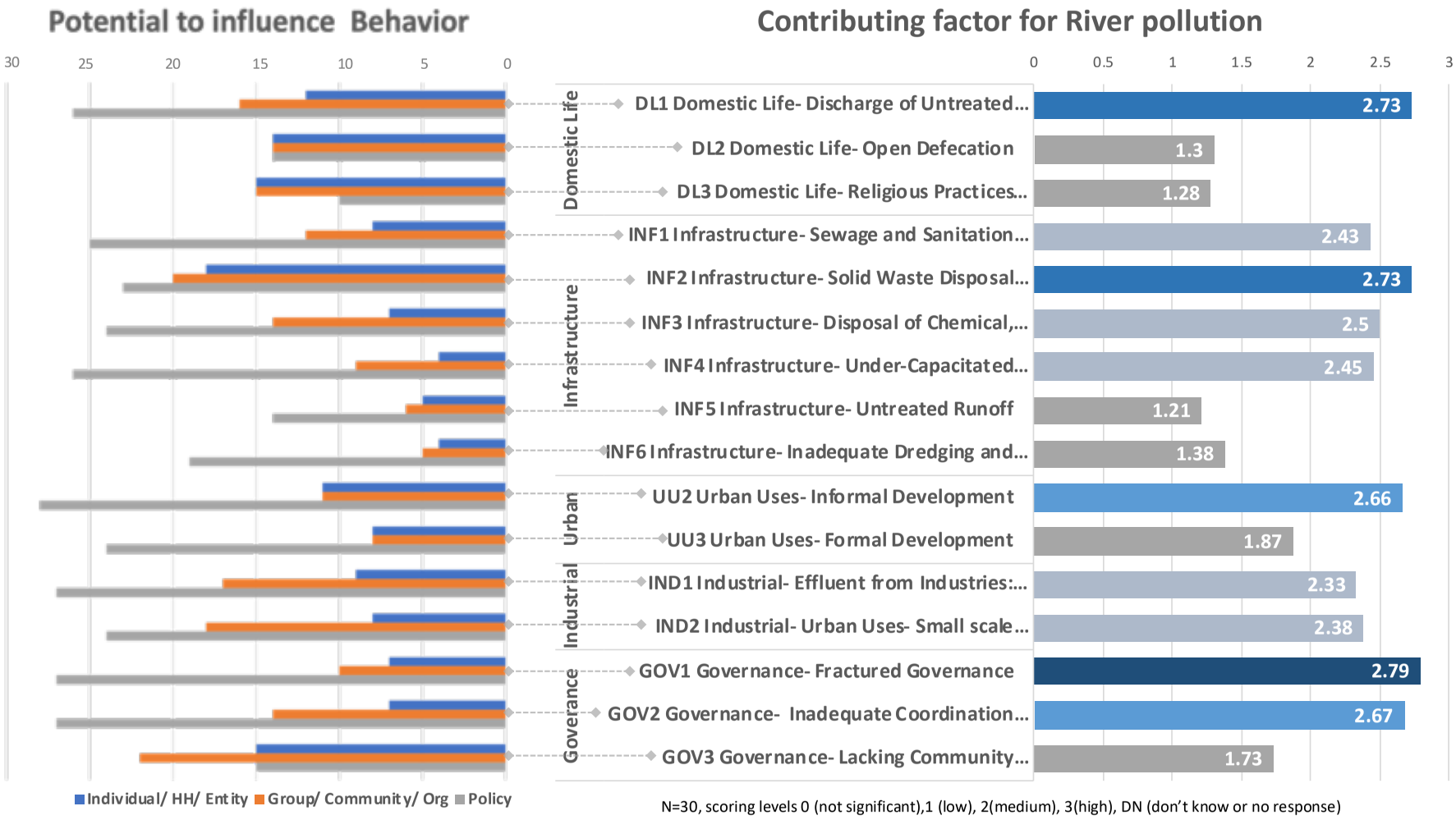

Figure 16 Identifying Behavior Influence Potential in Relation to Factors Contributing to River Pollution

The survey results (Fig 16, left-side) begin to answer the first part of the analytical research question, aiming to gauge how this community perceives behavior change in the context of Mithi's problem. Assessing these factors in terms of the potential to influence behavior at an individual, group or Policy level, all respondents recognized the domain of Policy as the highest potential to influence behavior. Their idea of policy was also primarily related to governance issues or governance-related infrastructure provisioning. However, for factors associated with Domestic Life such as Open Defecation (DL2) or Religious Practices (DL3), and Community Participation under governance, respondents identified individuals and groups as having the highest potential to influence environmental behavior. During personal discussions, participants exhibited significant potential to impact behavior at an individual level. However, through this assessment exercise that encourages structured and comprehensive reflection, it became clear that policy holds greater potential to influence environmental behavior toward river restoration.

Brief Overview of Pollution Factors and Potential for Behavior through Broad Grouping

After categorizing the polluting factors into five categories (see Fig. 12) - Domestic Life, Infrastructure, Urban Uses, Industrial, and Governance[28]; Governance emerged as the primary contributor with a mean score of 2.40. This was followed by Industrial factors with a mean score of 2.36, Urban Uses with a mean of 2.27, Infrastructure with a mean of 2.12, and Domestic Life, which held the lowest cumulative mean of 1.77 among the five categories. This result corroborates the finding that the entire participant group (n=30) viewed Governance as the leading contributor to river pollution. In terms of the potential to influence behavior, similar categorization of the polluting factors led to the same conclusion - the Policy level holds the most significant potential to influence behavior, particularly regarding Domestic level issues. This finding strengthens the frequent assertions made by participants that a significant gap in domestic-level service delivery, such as sanitation and solid waste collection, substantially contributes to river pollution. It underscores the argument that these issues need to be tackled primarily at the policy level.

[28] A limitation to be noted in grouping the data in broad categories, it assumes that each factor as an equal variable to average their mean results.

2.3.6 Most Prominent Interventions for the Miti River

Based on interviews, reports, and archival research, prominent interventions for Mithi River restoration post-2005 floods included increasing the river's width and depth, resettling informal settlements, constructing retaining walls, dredging and desilting, beautification projects, proposing new Sewage Treatment Plants (STPs), and local interest groups organizing intermittent river cleanings.

A closer examination indicates that the majority of these interventions are centered on addressing the physical aspects of the river itself, akin to treating a symptom. A significant number of participants expressed intense opposition and concern towards the "retaining walls". Many participants argued that justifications related to increased carrying capacity and residents' safety were unfounded and implied that they represent misplaced priorities. These participants highlighted the detrimental impact of disconnecting the river from the people, both ecologically, spatially, and visually, through the construction of these walls. The use of concrete (as opposed to the more adaptable gabion wall proposed in 1993 BRIMSTOWAD report) in these structures

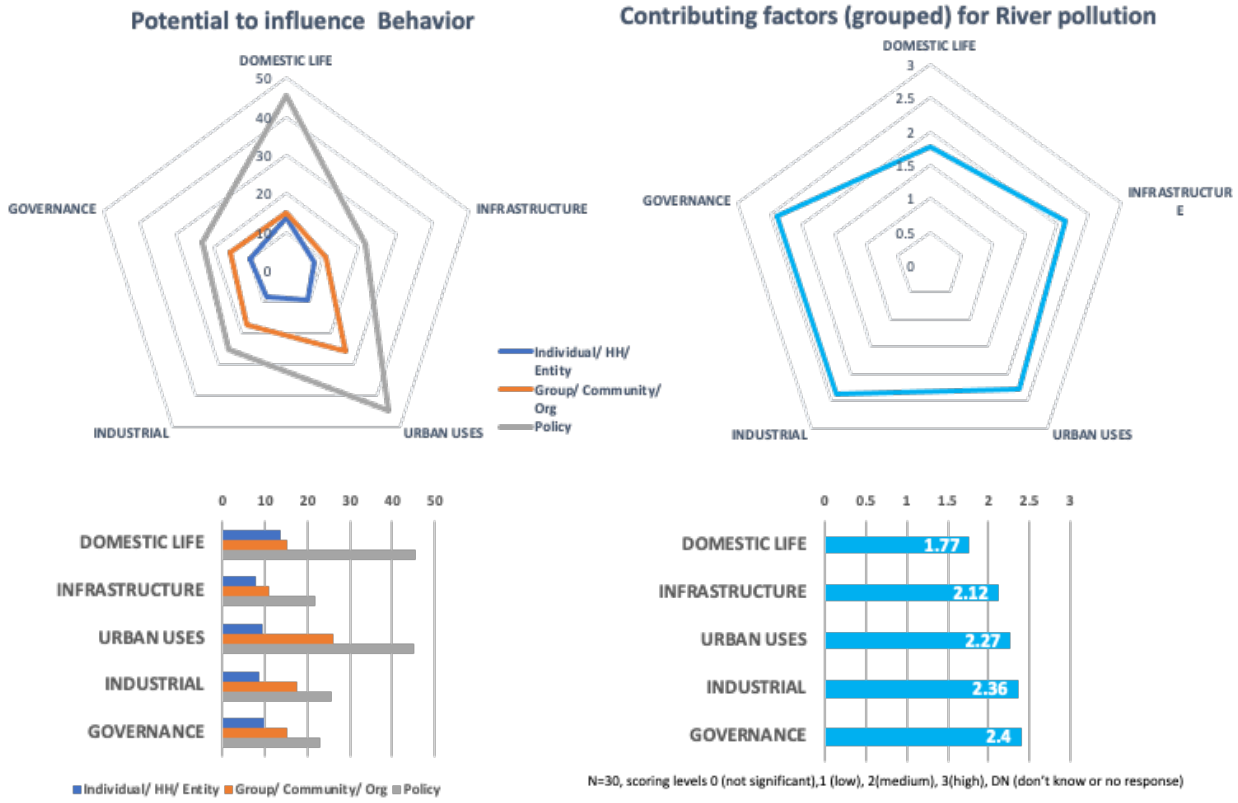

Figure 17 Evaluating Survey Results through Grouping of Polluting Factors

further exacerbated the problem of managing surge in water volumes. In addition, many participants outrightly dismissed the continual dredging and desilting work. They deemed it a profiteering opportunity for agencies that doesn't yield tangible benefits for the river, thereby questioning the need for year-round dredging and desilting. According to one water engineering expert participant, cleaning by dredging and desilting should ideally be a one-time activity, subsequently followed by responsible river management. These sentiments align with a critical perspective that deems the metrics of carrying capacity, dredged volumes that drive such interventions as a "slippery calculus of capacity" (Chitra, 2022).

However, efforts to widen the river, conduct blasting, and construct retaining walls, despite being underway, continue to spur serious disputes due to various environmental concerns. These include potential loss of habitat and the inverse effect of increased flooding and tidal action. For more details, refer to the 2016 National Green Tribunal (NGT) ruling on a stay order filed by NGOs Jalbaridari and Vanashakti (Press Trust of India (PTI), 2016). In the media, there are continuous references to substantial public funds allocated for the Mithi River restoration, with assertions that most of the work remains unfinished and has yielded no visible results. Calls for an audit of expenditures have been frequent, with the most recent from Galgali A., an activist who demanded an audit of a total of 1,150 crore INR (approximately 140 million USD). This sum is only a part of the funds, with thrice as much still allocated in the budget for future works (Kasale, 2023).

On the subject of this expenditure, Gomare, a study participant known for successfully implementing river rejuvenation projects in the state's rural areas, was invited by Mumbai's local municipal agency. He implied that a disproportionately large amount of money has already been spent on this river, yielding no results, which alluded that something fundamental is missing in the efforts so far.

> *"As you know, the government has already spent 1,500 crores on this river. If this money was invested elsewhere for a river of 16 km length, we might have had an entirely new river! What did we spend 1,500 crores on for a stretch of 16 km, there's nothing to show for it? That's why the solution does not lie in engineering; it lies within our mindset. Since this is a manmade issue, we*

ourselves have to find the solution, and it lies within us. The most crucial factors are 'mansikta' and 'ichashakti' (mindset and willpower)" (Gomare, M.-10)

Another participant highlighted the inherent issue of the affinity to large engineering works, stating that such projects lead to contracts, “everyone wants contracts because this is how the money moves up and down” (WBG -27). In a way, this challenge explains how behavioral focused interventions don’t fall under this traditional mode implementation contracting practices, calling for a radical system shift in how we approach environmental solutions.

2.3.7 Decision-Makers' Reflections Integrating Behavioral Approach with Engineering

When exploring behavioral approaches in river management, decision-makers universally emphasized the critical role of community. Participants endorsed people-centric interventions that encourage pro-environmental behavior but offered a variety of perspectives on how to balance these with engineering strategies, suggesting proportions ranging from 70-30, 50-50, to 0-100. Despite differing perspectives, all seemed to agree that managing a river effectively requires more than the hard-infrastructure solutions.

Inherent

Decision-makers agreed on the inherent value of behavioral interventions. “Infrastructure projects won't succeed without it. Micro-successes exist, but scaling is needed,” shared a participant (WBG – 27). Das argued that engineering should operate subtly in the background, serving larger goals like integrating river spaces into the public realm, fostering vigilance, ensuring accountability, and facilitating long-term maintenance. Vaidya suggested that behavioral changes, being cost-effective and more likely to withstand bureaucratic obstacles, should precede structural changes. Both Gomare and Mandke implied that the success of engineering solutions depended on social or community leadership, necessitating structured mechanisms beyond standard education, awareness, and project update meetings.

Subordinate but Significant

Most of the participants from governing agencies acknowledged the need for 'public sensitization' but considered it subordinate to larger technological interventions like slum clearance, river training, dredging, and desilting, and river widening. One official pointed out

that these complex engineering solutions are beyond the general public's scope since it requires a lot of synchronizing deep expertise. Also, in this discussion, many respondents made a case for decentralized and nature-based engineering solutions which are expected to be more functionally responsive and successful in the context of cities like Mumbai.

Caution

Tiwari, another participant, is against 'hardwiring' the river, focusing instead on raising civic awareness, especially about waste management. She shared that walls built to prevent waste disposal into the river did not entirely solve the waste problem as trash continued to pollute the river as she has witnessed people “flipping” things into the river, damaging its natural ecology. She added, that if people living right along the river are lacking civic awareness, we have to question the value in pursuing even more sustainable technological solutions like blue-green infrastructure and nature-based solutions. However, Bhandari was explicit in her warning that behavioral interventions also cannot be all of it, in the context of the Mithi river, the “treatment” solution [of the damaged water as well as the components like waste entering the river] will be needed, calling for ways of a deeper and wider involvement of citizens, from creating direct local employment to involving community beyond Mithi to support through funding mechanisms like CSRs.

The Tough Reality of Mumbai

Participants expressed concern about the demanding and resource-strapped life in Mumbai, especially for the middle- and lower-income populations in Mithi’s Watershed. The long commutes, high costs, and fast-paced life create obstacles to civic participation. The fatigue and subsequent disengagement, particularly when their efforts do not align with the governing agencies, add to the prevalent pessimism. For the transient migrant population in informal settlements, their sense of belonging to the river differs from that of permanent residents and businesses. Despite this, they could potentially be mobilized by initiatives that directly benefit them, such as job opportunities, services, and amenities, demonstrating that even in challenging circumstances, community-centric approaches remain central to successful river management.

2.4 Discussion

In the analysis and exploration of the Mithi River's issues, three essential themes emerge – Systems Approach, Governance, and Narrative Shift. These themes present a comprehensive framework to comprehend the complex problems of the Mumbai' Mithi river as well as a strategic blueprint for envisioning change. They provide a perspective that accommodates both the institutional and technical narratives. These themes also serve as valuable reflection points on the primary research questions raised in this paper, specifically examining the Mithi's problems through both institutional and technological lenses, while simultaneously considering potential interventions for behavior change.

At the heart of the institutional narrative lies the governance framework, which requires extending our perspective beyond traditional agencies within the Mithi rivers complex and unique Socio-Ecological System. Issues on Governance needs to be approached, reassessed, and restructured with an expertise and rigor as the technical or infrastructural aspects. Moreover, the implementation of an environmental behavior framework could significantly assist in tackling challenges at both institutional and technical levels, offering a holistic strategy to navigate the intricacies of the Mithi river's problems.

2.4.1 Systems Approach

Survey respondents identified the discharge of untreated sewage and solid waste as major contributors to river pollution. However, these issues stem from larger systemic failures in service delivery within the Mithi river watershed, and policies concerning the settlements and development along the river. Singular interventions like river widening or constructing retaining walls often overlook systemic challenges at both institutional and infrastructural levels, while not truly address the root causes of river degradation.

A watershed-level approach, looking at river pollution holistically and addressing root causes rather than treating the river body as a separate entity, is another critical systems strategy. Several participants rallied for decentralized and environmental strategies such as nature-based solutions

(NBS) and the incorporation of green-blue infrastructure. These solutions are not only cost-effective and low maintenance but also hold potential for local community engagement and employment. The national campaign for Clean India led to the construction of public toilet blocks along the river. However, a singular focus on eradicating open defecation clearly missed the opportunity to provision sewage and septage management infrastructure for these blocks along with the river system. As a result, these facilities discharge untreated septage directly into the Mithi river, exacerbating the pollution. Technological interventions, like RiverRecycle, a CSR initiative, employs locals for waste management, can be designed to integrate the local community.

Furthermore, environmental management interventions often disproportionately impact vulnerable areas, such as informal settlements. The urban poor, who suffer the most during floods, must be integral to future risk management strategies. A holistic consideration of Mithi river's management and protected buffer zones ought to have accountability mechanisms for all stakeholders including entities like the BKC and MIAL.

2.4.2 Governance

While survey results highlight fractured governance and lack of coordination among governing agencies as significant contributors to river pollution, the participants also acknowledged that the agencies alone cannot be blamed. There emerged a strong sense collective responsibility to address the issue, suggesting an opportunity to redefine the governance narrative for the Mithi river by promoting shared responsibility and fostering integration among diverse entities. Mumbai, like most Indian cities is often grappling with resource scarcity and overextended infrastructure systems, would greatly benefit from such an approach.

Governance level approach of controlling, taming the river, and treating the river body as a nallah or a sewage channel is evidently negatively impacting the perception of the river, this is where the governing agencies could also play a key role in shifting the narrative and therefore the fundamental perception of the river as a resource versus the strictly utilitarian value leading to neglect.

Moving away from simply blaming the government to establishing mechanisms of shared accountability can lead to alternative governing approaches and policies. A recurring idea within the decision-making community suggests the establishment of an independent body or group, such as a "working group" or "urban water association," or even more specific ones like “CSR for Mithi” or “Crowdfunding for the Mithi." However, the critical roles of governing agencies like the local MCGM and state-level MMRDA must not be overlooked, especially to initiative and reinforce such initiatives. Many community-led and non-profit groups already existing in Mumbai, possessing substantial social capital, often go unnoticed in broad river restoration plans. Including these groups in planning and decision-making processes could be instrumental for Mithi's future.

2.4.3 Narrative Shift

Apart from issues of governance and systemic shortcomings, participant interviews, archival research, media, and reports all underscore the urgent need for a narrative shift around the Mithi River. The current perception of disgust and apathy towards the river body informed from participant experiences echoes a distrust and hopelessness towards governing agencies needs to be challenged. The 2005 shakeup serves not only as a reminder of the river's issues but also as evidence of its importance to Mumbai's landscape and people. A renewed narrative can help reestablish the value of the river within the city's consciousness.

Future research can address the following:

1. The methodology of identifying the decision-making community could potentially inform the development of a "working group" or "urban water association" for the Mithi River. However, this concept requires extensive research, particularly considering the existing governance landscape consisting of Special Planning Agencies, Urban Local Bodies, and people-oriented NGOs, Community-Based Organizations, and Self-Help Groups.
2. There is room for further exploration of potential behavioral interventions at the policy level. Participant responses suggest that these interventions could significantly contribute to the river's restoration. This research could provide valuable insights into how to leverage public opinion and behaviors for environmental conservation and restoration.

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3 Enhancing Decision-Making through a Behavioral Framework: Transforming Mithi River

3.1 Introduction

Each decision-maker brings a unique perspective to the transformation of the Mithi River. However, the ultimate goal remains consistent - the only way to clean the river and prevent flooding is by restoring its sustainable ecological function. Integrating the river into Mumbai's culture is integral to achieving this goal. This research study encapsulates that there's no one solution to achieve this goal, but a range of solutions should be considered. Even if big solutions emerge, their success depends on people-centric factors of community stewardship and ownership of the resource. The dissatisfactory outcome of the past 18 years of restoration efforts and investments in the Mithi River is stark evidence for this proposition.

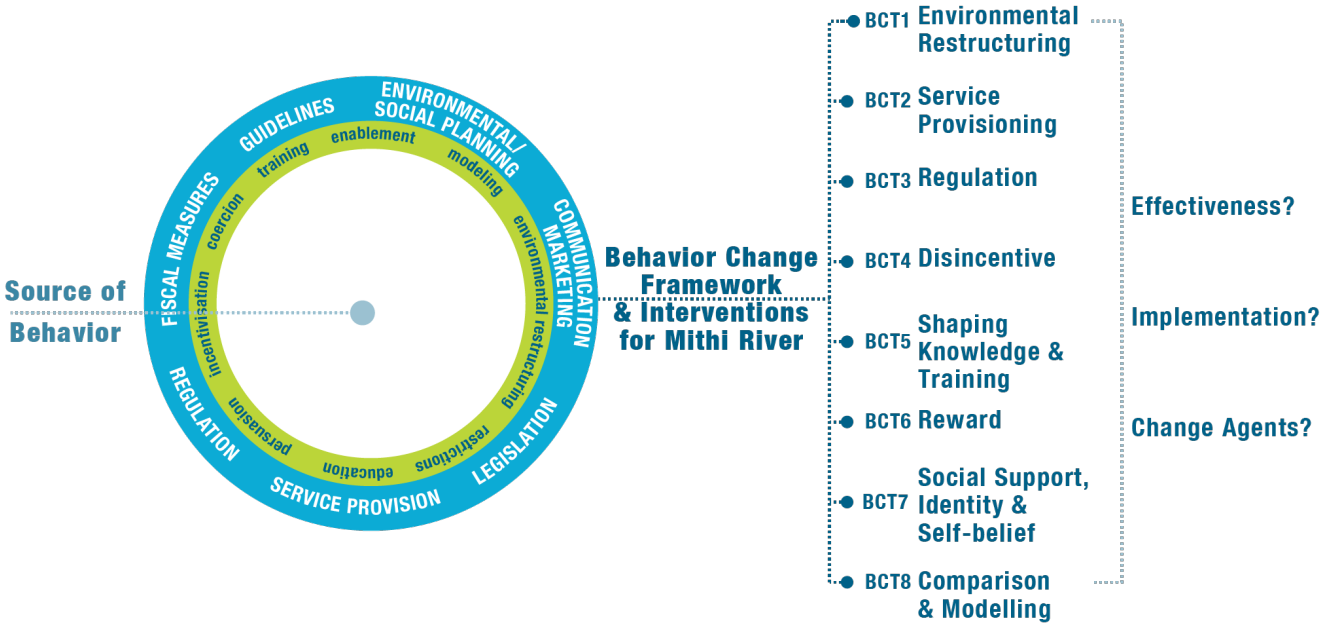

Figure 18 Behavior Change Framework for the Mithi River (Based on Michie, et al., 2011)

This dissertation calls for an environmental behavior approach for transformative change for the river. This paper presents a version of what this change would look like when based on a behavioral approach building on the Pro-Environment Behavior (PEB) Framework, modeled off

Michie et al. (2011) (Refer to ch1 Literature review for the PEB conceptual model). Based on this framework, I identified eight broad Behavior Change Techniques (BCT) proposed for this study to capture all possible engineering and social strategies in building a behavior change framework for the Mithi River (Fig 1). These eight categories are Environmental Restructuring, Service Provision, Regulation, Disincentive, Shaping Knowledge & Training, Reward, Social Support Identity & Self-belief, Comparison & Modelling. Driving on the primary research question of how the decision makers are thinking about behavior change in light of their current practices and experiences of the Mithi river since the 2005 deluge, the study attempts to (1) assess the effectiveness of the proposed Behavior Change Techniques (BCTs) (2) understanding these in context of the current efforts in abating the water pollution and flooding impacts for Mumbai's Mithi (3) identify specific opportunities and specific strategies for addressing the river's transformation problem. The findings close with the proposition of Change Agents, which each participant broadly reflected on as part of this BCT assessment exercise. Future research or decision-making for designing target interventions could build on this study's findings and develop further by understanding the source of behavior in the Mithi River context.

3.2 Method

The central methodology for this study continues to build on the case-study approach for the Mithi River through a mixed-methods research design (See Ch1 Research Design section) using qualitative and quantitative data sources. The polluted Mithi River is the broad unit of analysis, and the participants (n=30) from the Decision-making community are the primary unit of analysis. This study's findings are structured around data gathered from the assessment survey, with supporting data from the participant interviews. The participants comprising the decision-making community were selected via purposeful sampling, with the snowball method playing a significant role.

3.2.1 Data Collection

In the survey titled "Behavior Change Techniques (BCTs) & Evaluation of Interventions," several techniques are proposed for restoring the Mithi River. These include Environmental Restructuring, Service Provision, Regulation, Disincentive, Shaping Knowledge & Training, Reward, Social Support, Identity & Self-belief, Comparison & Modelling (Fig 1 & Appendix C

for the survey instrument). The BCTs are widely categorized under the proposed behavior change framework so that the diverse and representative decision-making community could relate with and deeply engage in this research. It is essential to recognize that these techniques are not mutually exclusive, and some are closely related, but for this study, the participants consider each of these independently. To gather data, I interviewed 30 participant members of the decision-making community and recorded their responses. During the interview, I explained each of these BCTs through possible Interventions and Policies for the context of the study. Participants were asked to rate the effectiveness of each technique on a Likert scale and assess their implementation status in the Mithi River context using Yes, No, or Partially.

Furthermore, as per their knowledge, the participants assessed the "implementation status" of these techniques in the context of the Mithi river, recording responses as -- Yes, No, and Partially. The main findings and analysis build on the results of this survey, along with qualitative data from the semi-structured interviews conducted before the survey (Appendix A). These interviews allowed participants to share their vision for change for the river and their thoughts on how long it would take to achieve that change.

3.2.2 Data Operations

As part of the survey, participants were interviewed and provided with a survey copy to aid their responses. I documented their answers on paper and audio for open comments. Later on, the survey responses were entered into Excel for cleaning and data conversion and then utilized for SPSS statistical analysis. The semi-structured interviews were recorded, transcribed, translated when needed, and categorized using Dedoose software. For more on data operations, please refer to Section 2.2 in Chapter 2.

3.3 Findings and Analysis

3.3.1 Decision-making Community for the Mithi River

As part of the dissertation, a critical exercise was identifying and mapping the Mithi River's decision-making community. This community was divided into eight Decision-Making Entities: international, national, state, city, neighborhood, private, institutions, and non-governmental organizations (NGOs) (See table 2 in Ch. 2). A total of 30 participants were recruited from

different entities within this community. Chapter 2, section 3.1, explains the community mapping and provides an overview of the participant data. Additionally, a detailed list of participants and their associations is also included in Chapter 2. Adjoining Table 1 shows how the participants are classified within their respective entities (also in Appendix D).

3.3.2 Community's Vision for Change

> *"Problem is [that] we are first thinking about the solution, we are not thinking about "the" problem."*

Ms. Marathe, a former municipal chief engineer, passionately remarks, reflecting on the current state of the Mithi River. While Chapter 2 delves deeper into the complexities of the strained Mithi River, her statement succinctly captures the essence - a paradigm shift is necessary in how we approach river issues. She fondly recalls working alongside Madhavrao Chitale Sir on the Fact-Finding Committee report (Chitale, 2006) following the 2005 deluge, sharing how he was a role model who was open to understanding all facets of the issue, and he greatly influenced her work as an engineer in the municipal agency. Now, Ms. Marathe is an advisor at the All-India Institute of Local Self-Governance (AIILSG), working on developing a professional program focused on water sustainability.

In their interviews, participants shared diverse perspectives on change, ranging from structural and policy-related changes to larger concepts regarding the collective public will. Emotion often colored their vision of change, which included a broad spectrum of approaches. Some participants focused on citizen-oriented strategies like sustainable waste management and technical solutions based on physical infrastructure, landscape designs, and information technology. Others leaned towards regulatory measures concerning monitoring, development regulations for informal settlements and industries, indigenous community rights, punitive actions, and ideas on alternative governance and accountability through CSRs. There were also strategic approaches mentioned, such as outreach campaigns utilizing social media, recruiting Bollywood stars, citizen science, and redevelopment incentives for existing housing stocks along the river. Many emphasized the need for increased river monitoring and public vigilance against littering in the river.

A consistent call for behavioral change resonated among participants, with numerous ideas on landscape and recreation to "connect the people to the river." This desire for connection implied a collective action and ownership. Many feared that current interventions of the retaining wall were obstructing this vision: "First thing you need to do is connect people to the river, that connection has to be made then it would have more value, people would start to bond with the river. And then, when the river changes its color, then people raise their voices" (Dayanand, S-28). The idea of creating public spaces and empowering people to care for them was also shared by Ekbote. Saiyad highlighted the need for primary-level education to foster a generational shift in attitudes towards the river.

“All the people living in the river’s radius must believe that we cannot throw a single plastic bottle or trash into the river; after this, there are always infrastructure solutions [to go along] expressed Mr. Gomare, who spearheads river restoration in rural areas through the spiritual Art of Living Foundation. Another participant from a public agency emphasized that what mattered most was that the “river should look clean.” Jonnalagadda, emphasized the need for more citizen voice, “the way politics and governance works is – whatever is more voiced is more is heard, and sort of more [ends up] put on the agenda.”

In summary, the shared visions for the Mithi River point to the behavior of individuals and entities as the key driver for change. The Pro-Environmental Behavior (PEB) framework, with the proposed Behavior Change Techniques (BTCs) discussed through the survey, provide a structure for understanding these behaviors within broader strategies and repositioning these propositions through a people-centric lens.

Timeline Projections

During the study, participants were asked to provide an estimated timeline for how long it would take to realize their proposals for the Mithi River change. The majority answered with an average response of just over five years (See Fig 19). The lowest timeframe was less than two years

considering the urgency of the matter; one official put forth a two-part time frame of "6 months for branding" and "2 years for pollution control." However, a few participants found this question rather difficult to answer and did not feel comfortable providing a timeframe. Some expressed hopelessness, saying, "Maybe not in my lifetime!" some alluded to a "generation," while others cited scientific evidence, such as the 12-year hydrological cycle[29] of a river. Many mentioned the 5-year government tenure in the local political cycle or the as a good measure of change. Understanding these diverse responses is crucial to comprehend this decision-making community's sentiment and how optimism or pessimism can impact decision-making scenarios. The participants constantly cited "political will" and "public will" as critical determinants of change; few mentioned "good intent" and "sincerity."

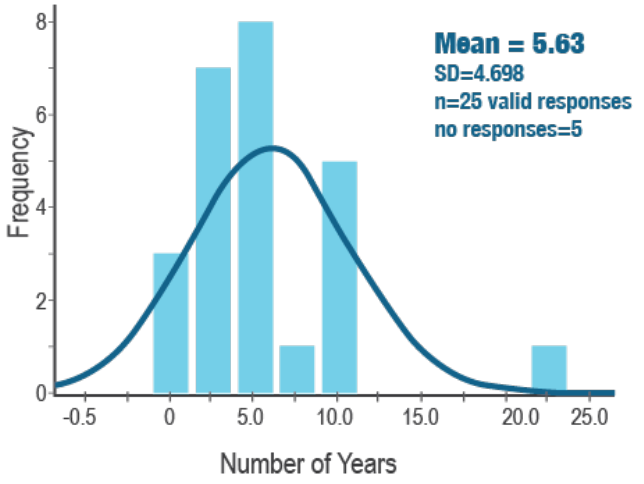

Figure 19 Participant Response on how many years to bring about the change?

3.3.3 Assessment of Strategies and Interventions Through a Behavioral Framework

Effectiveness of Behavior Change Techniques (BCTs)

The primary aim of this survey was to establish a comprehensive behavioral framework assessing various interventions, including community-proposed strategies. Many participants' visions for change already incorporated key facets of behavioral influence conducive to effecting significant change in the Mithi River. The framework guided participants in critically analyzing and understanding these interventions on a deeper level.

Participants evaluated the effectiveness of each technique using a Likert scale of 1-5, where 1 denotes the lowest and 5 as the highest effectiveness. They were encouraged to view these

[29] In India, the *Kumbh Mela* is organized every 12-year following a cosmic hydrological cycle, based on that it was proposed the river will be self-cleaned. But this assumes that there will never be any human interference in the resource, which contradicts the socio-ecological system of the Mithi river in Mumbai.

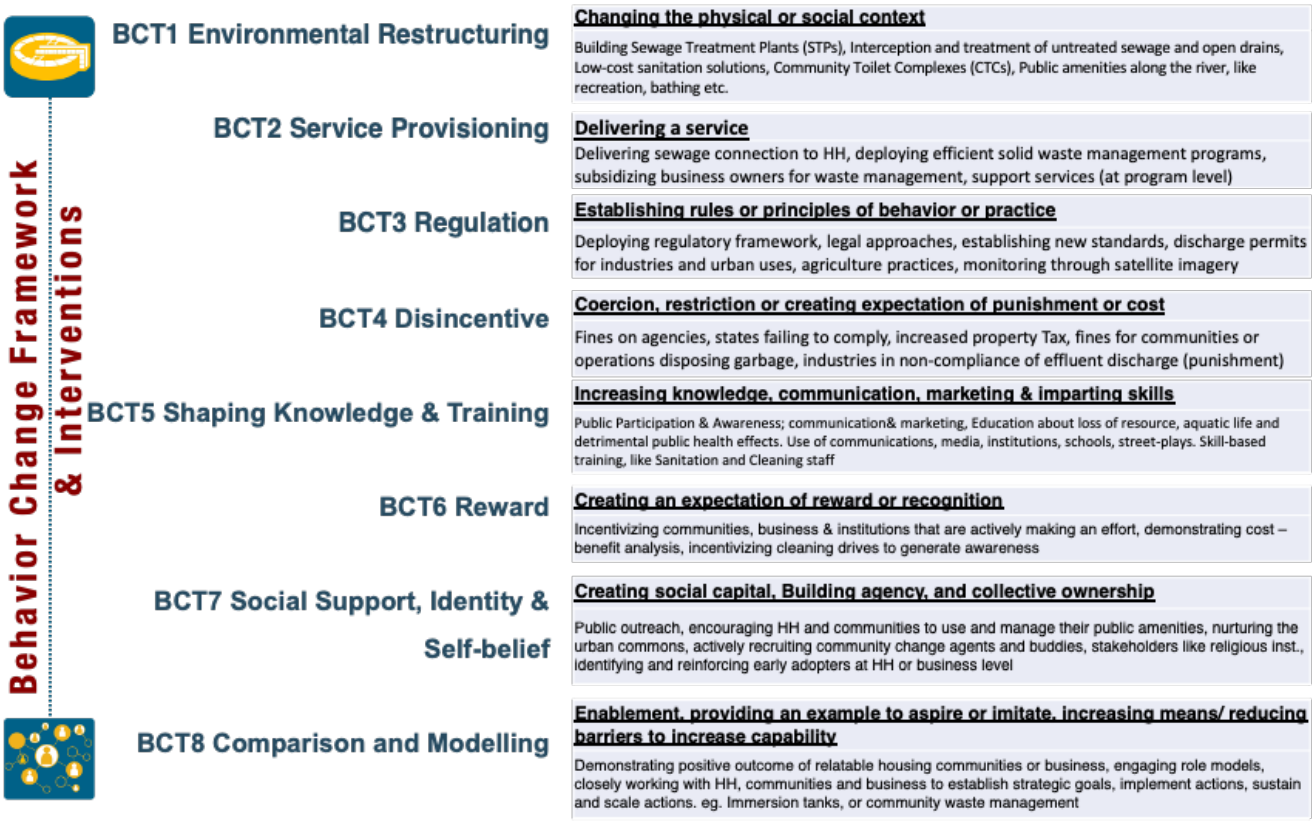

Figure 20 Proposed Behavior Change Framework for Decision-Making in Mumbai's Mithi River

interventions individually and within the broader context of all interventions through the suggested BCT categorization. Moreover, they were prompted to consider the implementation status of each intervention based on their understanding and identify the key change agents for each intervention. The survey also encouraged open comments and thoughts, fostering an engaging yet organized reflection. The survey incorporated the following eight Behavior Change Techniques, based on Michie et al.'s PEB model (2011): Environmental Restructuring, Service Provision, Regulation, Disincentive, Shaping Knowledge & Training, Reward, Social Support, Identity & Self-Belief, and Comparisons & Modelling (Fig 20).

Of the eight strategies in the Behavioral framework evaluated by 30 participants, BCT2 "Service Provisioning" received the highest rating, with a mean score of 4.42 on a Likert scale of 1 to 5 (see values in Fig 21), followed by BCT5 "Shaping Knowledge and Training" with a mean score of 4.27. These two techniques were identified as highly effective in restoring the river.

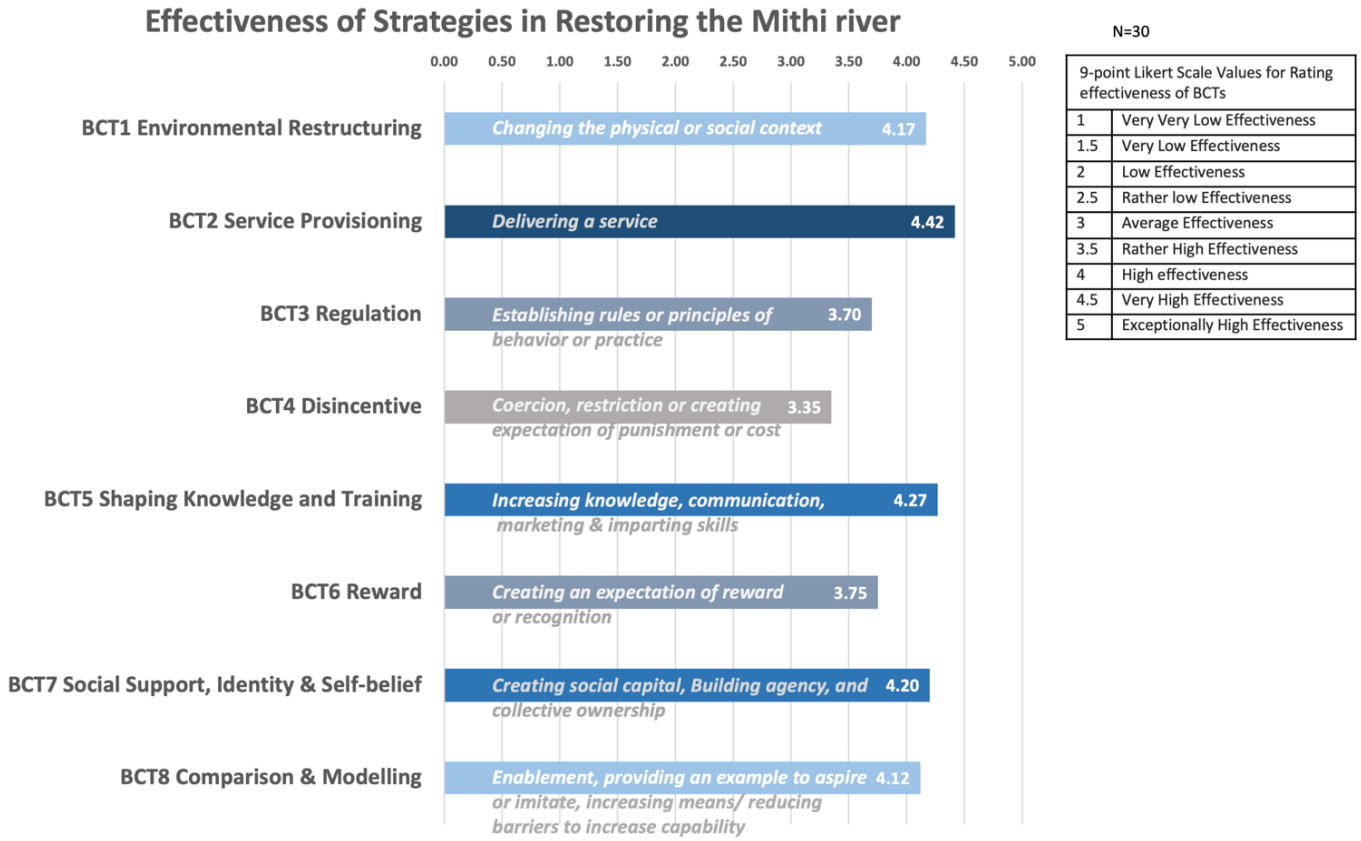

Figure 21 Survey Results on Effectiveness of Behavior Change Techniques in Restoring the Mithi River, in mean values.

Subsequently, BCT7 "Social Support, Identity, and Self-Belief" was ranked third with a mean score of 4.20, and BCT1 "Environmental Restructuring" ranked fourth with a mean score of 4.17. Strategies under these categories were rated as "Highly Effective". The ranking is as follows:

rank	Strategies	Mean (*SD*)
1st	BCT2 Service Provisioning	4.42 (*SD*=0.74)
2nd	BCT5 Shaping Knowledge and Training	4.27(*SD*=0.94)
3rd	BCT7 Social Support, Identity and Self - belief	4.20 (*SD*=1.06)
4th	BCT1 Environmental Restructuring	4.17 (*SD*=1.18)
5th	BCT8 Comparison and Modelling	4.12 (SD=1.18)
6th	BCT6 Reward	3.75 (*SD*=1.29)
7th	BCT3 Regulation	3.70 (*SD*=1.34)
8th	BCT4 Disincentive	3.35 (*SD*=1.42)

Table 6 Rank order of Survey Results on Effectiveness of Behavior Change Techniques (BCTs)

It is essential to mention that participants were asked to rate the effectiveness of already established techniques for this context. All eight techniques were rated above average in terms of effectiveness. Nevertheless, participant feedback suggested that BCT4 "Disincentives" was viewed as the least effective strategy.

Unexplored Opportunities – Implementation Status of Behavior Change Techniques

The survey delved deeper into the efficacy of strategies by probing participants about the current implementation of these strategies for the Mithi River. Participants were asked to respond with either - Yes, No, or Partially. The results, presented as percentages, are outlined on the right side of Figure 5. The focus was on whether these strategies were being considered or employed in current practices to their personal knowledge (See Fig 22).

The survey revealed that the least implemented technique was BCT6 "Reward", with 76.7% of respondents indicating it was not used, despite its high effectiveness (mean score of 3.75). BCT8 "Comparison and Modelling" also emerged as underused with 60% of participants confirming it was not being employed, despite a high effectiveness score (mean score 4.12). BCT7 "Social Support, Identity & Self-belief" and BCT5 "Shaping Knowledge & Training" were also underutilized, with 50% of respondents indicating these were not pursued in restoring Mithi River. The most effective strategy, BCT2 "Service Provisioning," was perceived to be implemented by only 10% of the respondents, with 56.7% indicating partial implementation and 26.7% denying its implementation.

The results present intriguing insights, revealing a gap in exploring the high-rated BCTs 5, 6, 7 & 8. Most respondents indicated that these strategies were not pursued for Mithi River, with a meager 23.3% affirming the use of BCT5, and none validating the use of BCT8. A mere 6.7% believed that BCT7 strategies were implemented for Mithi River.

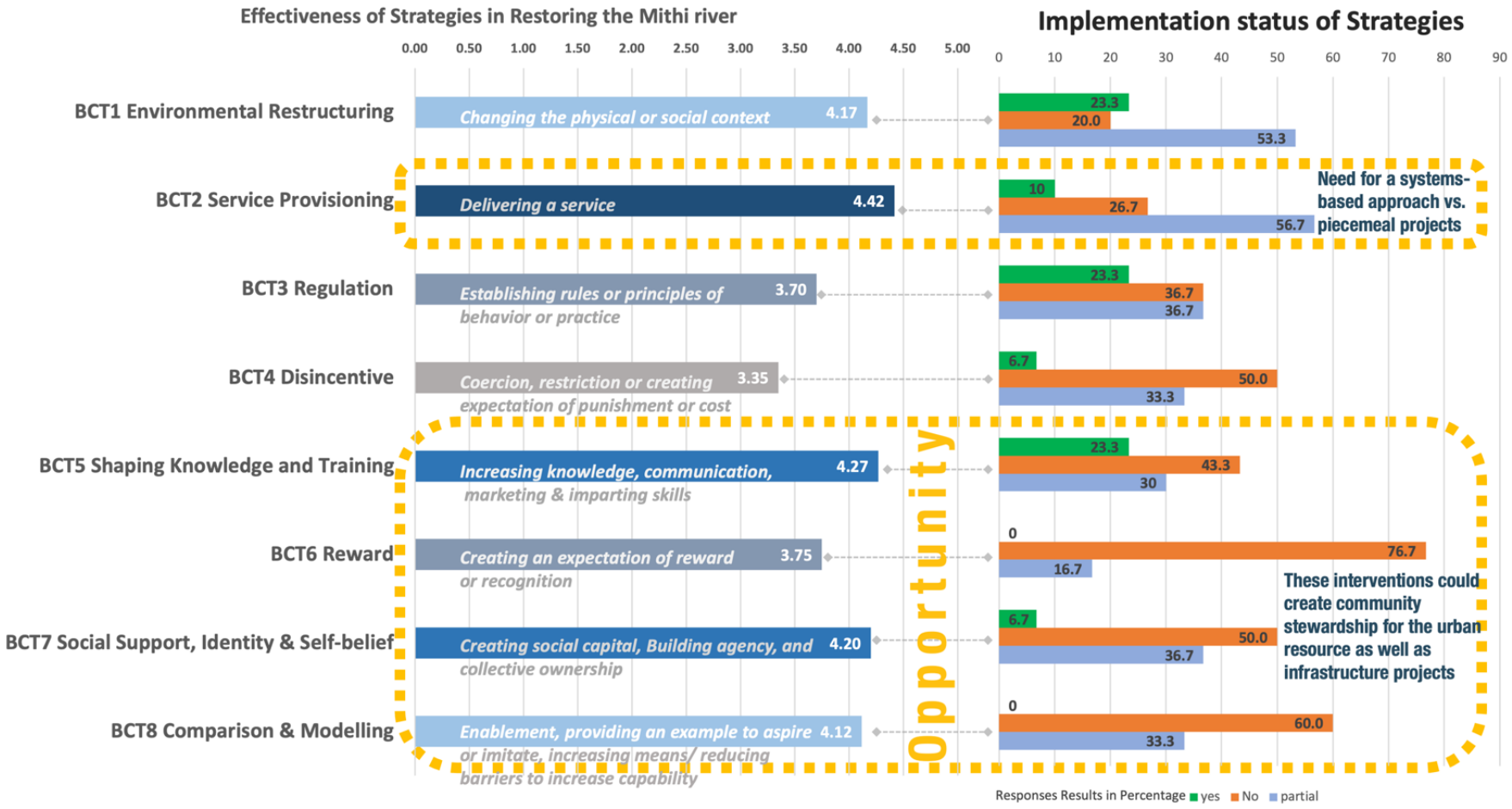

Figure 22 Implementation Status of Strategies for the Mithi River

The findings suggest a current focus on engineering and regulatory measures, yet they also reveal a preference for broader, people-centric strategies. It is clear that there is a significant opportunity for the Mithi river to tap into these underutilized techniques. As anticipated, BCT1, BCT2, and BCT3, mainly involving engineering and regulatory measures, remain the most prevalent interventions for these environmental challenges. In sum, the survey points to many unexplored opportunities for people-centric behavioral approaches in addressing environmental issues relating to the Mithi river. As such, there's considerable potential for a reevaluation and expansion of the strategies currently being pursued in decision-making for the Mithi river.

Findings through Decision-Making Supergroup Aggregate

Another insightful construct to look at these findings on assessment of behavioral strategies came from the perspective of Decision-Making entities. For the purpose of analysis, the eight entities were consolidated into four supergroups. As illustrated in Figure 6, out of the total 30 participants, the Agencies supergroup was composed of State and City entities (n=5), the Local supergroup consisted of Neighborhood and NGO entities (n=9), Institutions included International, National, and Local institutions (n=8), while the Private entities remained unchanged (n=8).

	Super Groups of Decision-Making Entities				
Effectiveness of BCTs	**Agencies** (State+City) n=5	**Local** (Neighborhood+NGOs) n=9	**Institutions** (International +National+Institutions) n=8	**Private** n=8	mean score on Likert Scale (1-5) low to high
BCT1 Environmental Restructurin	4.40	4.11	4.50	3.75	4.17
BCT2 Service Provision	4.60	4.56	4.63	3.94	4.42
BCT3 Regulation	4.20	3.56	3.38	3.88	3.70
BCT4 Disincentive	4.00	3.50	2.88	3.25	3.35
BCT5 Shaping knowledge & Trair	4.10	4.28	4.25	4.38	4.27
BCT6 Reward	3.80	3.56	3.81	3.88	3.75
BCT7 Social support, Identity and	4.40	4.72	3.56	4.13	4.20
BCT8 Comparisons/ Modelling	3.90	4.78	3.88	3.75	4.12

Figure 23 Assessment of Behavior Change Techniques (BCTs) through Aggregate of Decision-making Entities

The results revealed a noteworthy trend of diverging and converging focuses, for instance among the Agencies and Local supergroups. Agencies tended to prioritize BCT1 Environmental Restructuring (mean score 4.40), BCT2 Service Provisions (mean score 4.60), mainly concentrating on infrastructure engineering and BCT3 Regulations. Interestingly, the Agencies

supergroup also rated BCT7 Social Support, Identity & Self Belief near the high effectiveness range with a mean score of 4.40. This ranking aligned closely with the Local supergroup's assessment of BCT7, which they rated as exceptionally effective with a mean score of 4.72. Local entities, consisting of residents, tribes, and NGOs, gave very high ratings to people-focused interventions of BCT8 Comparison Modelling and BCT7 Social, Support Identity & Self Belief (with average scores of 4.78 and 4.72, respectively). BCT2 Service Provisioning, while overall scored as the most effective, wasn't rated as highly by the Private entities. This group, composed of a mixed array of local experts, many of whom have worked on the Mithi River restoration to some professional capacity, saw Service Provisioning not as the most effective. This divergence invites further exploration into their unique perspective. Interestingly, all entity groups consistently favored the strategy of "Shaping Knowledge & Training". These findings suggest that "Shaping Knowledge & Training" holds significant relevance across all decision-making entities, suggesting it could be a unifying force for effective interventions.

This evaluation accentuates the diversity of perspectives within the decision-making community and underlines the necessity of equitable representation in decision-making processes, as well as mechanisms for achieving consensus through this research method approach. This approach respects the priorities of various stakeholders. This principle may further be extended to the operations and maintenance of interventions aimed at the restoration of the Mithi River.

3.3.4 Analysis of Proposed Strategies Through a Behavioral Framework

Environmental Restructuring (BCT1)

Environmental restructuring involves modifying the physical or social context, typically through design and engineering interventions. Examples include constructing sewage treatment plants, developing interceptor drains for sewage treatment, providing sanitation solutions, and building community toilet blocks. Environmental restructuring could also involve landscape and design interventions such as parks, blue-green infrastructure, or public amenities for recreation along the river. Participants ranked these strategies as 4th in terms of their effectiveness through a behavioral framework (mean score 4.17). Around 23.5% of participants confirmed that these

measures were being implemented for the river, 53.3% stated that they were partially implemented, and 20% reported these strategies were not yet put into practice.

In the context of the Mithi River, several interventions related to environmental restructuring have been proposed, with some parts partially implemented (MPCB, 2019). These primarily focus on altering the river course and body to increase carrying capacity. Implemented measures include river widening and deepening, the construction of retaining walls along the river course, and dredging and desilting. Smaller "beautification" projects, particularly around the Bandra Kurla Complex (BKC), have also been undertaken, often on sites involving the removal of informal settlements[30]. Reports indicate plans for ongoing projects such as new sewage treatment plants, sewer lines and effluent treatment. Notably, in 2016, a competition was held to solicit proposals for redesigning the Maharashtra Nature Park along the Mithi River's Mahim Bay, after declaring a winning team in 2017, its present status remains unclear[31].

Participant Thoughts on Environmental Restructuring

Participants largely concurred that these environmental restructuring measures were crucial for the river restoration, offering the most visible and widely debated interventions. Many suggested the integration of parks and adaptable landscape designs that blend the water's edge, along with trails and tracks for community access, as critical methods to foster a connection between people and the river. The process of "cleaning up" the river primarily involved dredging. However, this remained a contentious endeavor, as participants questioned the tendering and contracting process, which was based on the volume of dredged material and did not account for how the material was managed post-dredging. One participant recounted witnessing dredged material left on the banks, only to be washed back into the water body during rains. This, in turn, necessitates re-dredging the same material. Another expert participant expressed that river cleaning and desilting should ideally be a one-time activity, with the expectation that future control measures will prevent pollutants from entering the river. Some exemplar technological interventions and

[30] Also referred as "slum encroachments"

[31] Winners Revealed in Competition to Redesign Mumbai's Maharashtra Nature Park. (2017, January 24). *ArchDaily*. https://www.archdaily.com/804057/winners-revealed-in-competition-to-redesign-mumbais-maharashtra-nature-park

filter technologies are being tested, for example the RiverRecyle's[32] waste recovery unit. This technology collects floatable wastes along the lower reaches of the river, recycles the material, and also aims to create additional direct benefits by employing locals to operate the system.

While the Mithi River remains under considerable strain, a majority of participants expressed trepidation regarding the "retaining wall," one of the most noticeable interventions in the river since the 2005 deluge. This intervention was implemented with the calculus enhancing the river's carrying capacity, improving flood safety, and preventing pollution by restricting access to the river body, thereby curbing waste disposal. However, concerns were raised about the potential of this "wall" to further isolate the river from the city's urban landscape and citizens' collective consciousness, at a time when it is more critical than ever to foster a connection between people and the river. The choice of material for the wall, specifically the use of concrete as opposed to a more permeable option like a gabion wall, was another point of contention. This decision raised ecological concerns, as drastically altering the river cross-section could increase water flow with the sole purpose of driving it out of the city and into the sea. Such changes could have significant impact on river habitats and potentially heighten flood risks for nearby communities during periods of high-water swell. Some participants even suggested that any effective change would first require deconstructing the existing retaining wall.

Service Provision (BCT2)

Service Provision involves delivering a service as part of an infrastructure management system conceptualized at the programmatic level. This category closely relates to Environmental Restructuring, as many of its components can be either technological or social elements. Examples include delivering sewage connections to households, integrating unserviced areas of informal settlements with alternate or decentralized solutions, implementing solid waste management programs, and subsidizing business owners for waste management and related support services. These strategies were ranked highest by the participants in terms of effectiveness when viewed through a behavioral framework (with a mean score of 4.42). Around 10% of participants confirmed that these measures were being implemented for the river, 56.7%

[32] Part of CSR initiative of Huhtamaki, a Finnish packaging company. See more https://www.riverrecycle.com/huhtamaki-india-tackles-floating-waste-in-mithi-river/

stated that they were partially implemented, and 26.7% reported that these strategies were not yet in place.

Participants most naturally associated these strategies with influencing environmental behavior, particularly through solid waste management and decentralized sanitation solutions. As outlined in Chapter 2, both domestic and industrial solid waste were major contributors to river pollution, with visible pollutants floating on the river surface. However, many participants identified a clear issue: inadequate waste management services that failed to reach several areas along the river course, particularly informal settlements, and informal industries. Observations during fieldwork corroborated this, with waste collection sites along the river frequently overflowing, posing significant public health hazards.

Participant Thoughts on Service Provision

One participant, a scrap business owner in the Kurla area, explained how the lack of services many times led businesses in their industry to dispose off waste in domestic waste collection sites under the cover of night. Despite being aware of the municipal e-waste collection program, he had difficulty taking full advantage of it, suspecting that most of his counterparts in the area were either unaware or struggled to utilize the municipal e-waste services. Similarly, sanitation services were significant as domestic sewage discharge was a highly rated pollution contributor. The most conspicuous infrastructure along the river's course were community toilet blocks, many installed as part of the 2015 Clean India Campaign aimed at eradicating open defecation. Many of these sites along the river are state-owned, expediting the toilet block construction process. However, these facilities often lacked the connection to the sewage infrastructure, and most lacked an effective septage or sludge management infrastructure, leading to direct sewage discharge into the river. These shortcomings intensified pollution while ostensibly providing sanitation services (Biswas et al., 2020; Motohashi, 2022). The overall consensus indicated that isolated interventions are ineffective and must be conceived as part of a system, primarily concerning infrastructure services and provisioning. While this category closely aligns with Environmental Restructuring, the preference for Service Provisioning underscores the need for a systems-level approach. Most interventions could be driven by policy-level decisions for new or

alternative service provisions, using decentralized, low-cost solutions combined with large-scale infrastructure elements.

Regulations (BCT3)

Regulations in this context refer to the establishment of rules, principles of behavior or practice through a regulatory framework. This includes legal approaches, setting new standards, granting discharge permits for industries or urban uses, and incorporating monitoring mechanisms at various scales, from testing effluents to satellite imagery. When viewed through a behavioral framework, participants ranked these strategies as relatively the least effective, 7th in order of efficacy, with a mean score of 3.70. Approximately 23.3% of participants confirmed that these measures were being implemented for the river, 36.7% reported that they were partially implemented, and 36.7% stated that these strategies had not yet been put into practice. Interestingly, these regulations seemed to be the most pursued and deployed strategies in the context of the river. However, a significant theme echoed in the responses was the issue of implementation. Most participants expressed that while there are abundant regulations in place to address these issues, the biggest challenge lies in their enforcement. There was a widespread sense of frustration regarding this matter, indicating that issues related to governance require further understanding.

Participant Thoughts on Regulations

Participants shared a consensus on the weakness of the existing regulatory framework for the Mithi River. The lack of political support, corruption, and long timelines for legal action, despite the NGT, meant to expedite cases concerning the environment, were noted as significant issues. Participants expressed the view that while numerous standards and regulations exist, the main problem lies in their implementation and monitoring. Competing priorities of various governing bodies, limited resources, and a lack of accountability and consequences for flouting regulations were seen as hindrances. The need for improved monitoring methods, such as CCTV cameras, satellite monitoring, and river sensors was emphasized. Participants also pointed to the lack of relatable impact indicators and the complex, intermingled governing layers as implementation challenges. The importance of public awareness alongside regulations, the need for independent regulatory bodies, and citizen involvement were stressed. Concerns were raised about large

stakeholders with special powers violating regulations, suggesting the need for proportional accountability. The call for differential penalties for wealthy and vulnerable polluters underscores the need for a nuanced approach to regulation.

Disincentive (BCT4)

Disincentives in this context refer to coercion, restriction, or creating expectations of punishment or cost. Like fines on agencies or authorities failing to comply, increased property taxes, fines at level of communities or operations disposing garbage, industries in non-compliance of effluent discharge etc. The Participants ranked Disincentive strategies as the least effective of all the proposed interventions through a behavioral framework with a mean score of 3.35 at average level. Since they were least rated it was not very useful to investigate their implementation status in context of Mithi, however a substantial 33.3% of the participants responded that they were partially implemented with 6.7% were more affirmative that they were being implemented and about 50% said that they were not being implemented.

The responses to this strategy for Disincentives were very wide-ranging, with also the realization that this could also be closely related to regulations however it would be the outcome of non-compliance as such, so it made sense to treat this as a separate strategy, and at more granular level of individuals, communities, or groups it would manifest differently from regulations. Some responded that punishment is necessary to change polluting behavior, these were many participants from agencies, and big institutions calling for punitive measures at large, whereas most other participants responded that they would never work, especially when compared to the other strategies and in the cultural context of India – everyone tries to flout the rules, or cited the widespread culture of ethics, corruption or bribing to get by and not change behavior.

Participant Thoughts on Disincentive

Responses to the strategy of Disincentives (BCT4) in the Mithi River context varied. While some viewed disincentives as a necessary part of a carrot-and-stick approach to regulating behavior, others expressed reservations about their effectiveness. The importance of providing alternatives and only penalizing willful polluters was stressed. Some argued that while disincentives could hold agencies, private entities, and individuals accountable, they could also lead to bribery and

corruption. For these participants, larger fines and stricter monitoring appeared necessary to deter violations. Others underscored the need for moral responsibility over punitive measures. Disincentives were seen as effective in deterring industrial pollution, but many believed people find ways to avoid penalties or simply accept fines. The temporary effect of disincentives and their lack of true behavior change was a shared concern. Participants suggested that disincentives should be applied at all levels, including government officials, and that blanket disincentives were ineffective. The potential of penalization to unfairly impact smaller industries was raised, with a call to hold large industries accountable. Overall, there was a preference for positive reinforcement strategies, like rewards and recognitions, over punitive measures.

Shaping Knowledge & Training (BCT5)

Shaping Knowledge and Training Techniques aim to enhance public awareness, knowledge, and skills at all entity levels. This may involve communication, marketing, and skill imparting means. In the context of environmental issues like that of the Mithi River, education about resource loss, aquatic life, and public health impacts are crucial. Interventions primarily cover communication modes, media campaigns, performances, and the vital roles of institutions and schools. Another component of this approach is skill-based training and capacity building for officials and staff directly involved in aspects related to urban infrastructure management, including sanitation and cleaning staff training.

Participants rated Shaping Knowlede & Training (BCT5) as a highly effective strategy towards river restoration within a behavioral framework, with an average score of 4.27. Most participants found these strategies relatable and perceived them as a means to express how various community and people-focused behavioral approaches could be beneficial for both the present and future, potentially leading to systemic change. Around 23.3% of participants confirmed that these measures were being implemented for the river, 43.3% stated that they were partially implemented, and 30% reported that these strategies were not yet in place. Many participants themselves were directly or indirectly engaged in these interventions aligned with knowledge & training for the Mithi river.

Participant thoughts on Shaping Knowledge & Training

Participants' responses to the Shaping Knowledge and Training (BCT5) strategy in the context of the Mithi River were diverse. Some stressed the need for improved training and communication, with a warning about the dangers of misinformation. Certain interventions were highlighted as examples of effective community education and resources. However, some questioned the sufficiency of knowledge alone, suggesting that without practical alternatives, individuals might fall back on damaging behaviors. Some participants viewed this strategy as a long-term intervention linked to capacity building. The need for context-specific training for government professionals was underscored, as well as training for staff directly involved in river and sanitation work. However, concerns were expressed about the gap between knowledge and action, and the risk of knowledge saturation leading to apathy and pessimism. Participants emphasized the importance of open access to data for informed decision-making and pointed to the reactive nature of knowledge interventions, often occurring only in response to crisis events. The necessity of capacity building within meteorological departments and disaster communication was highlighted. Overall, participants saw the need for shaping knowledge and training at both societal and governing agency levels.

Reward (BCT6)

Rewards create an expectation of recognition, either through direct or indirect mechanisms. They can apply to communities, businesses, institutions, and individuals that exhibit a proactive positive effort. Rewards can also be demonstrated through cost-benefit analysis of actions. Other mechanisms include incentivizing efforts such as cleaning drives or awareness campaigns. Participants, when viewing through a behavioral framework, ranked this technique as average, placing it 5th with a mean score of 3.75. While many participants saw these as promising motivators, none believed that these interventions were actively pursued in the context of the Mithi River. A total of 16.7% responded that these were partially pursued, while a significant 76.6% of participants felt that these interventions were not being pursued for the river at all.

Although the concept of rewards was easily relatable, many respondents believed that in the context of India, direct monetary benefits did not significantly influence behavior. This sentiment

suggests that a more in-depth study is needed for future research. However, the idea of being recognized for efforts and creating a positive impact was broadly supported.

Participant Thoughts on Rewards

Participants' responses to the Reward strategy in the context of the Mithi River were varied. The need to incentivize performance, particularly in areas like sewer management, was highlighted by some, advocating for rewarding pollution-preventing industries. However, others raised concerns about cultural fit and effectiveness of reward systems, favoring strict regulations. Several participants suggested the consideration of rewards only as a last resort or for maintenance efforts. Yet, the power of incentives, especially monetary, in motivating eco-friendly behavior was recognized by many. The idea of indirect rewards, such as tax discounts or enhanced public services, was also proposed. The effectiveness of rewards, particularly among disadvantaged communities, was underscored with successful examples from other Indian regions. Participants urged for consistent, performance-based rewards. They also emphasized the need for direct recognition of individual contributions. However, concerns were raised about the temporary nature of rewards and their potential to fade over time. Despite these concerns and skepticism due to trust issues with local agencies, the consensus leaned towards a carefully implemented, sustained reward system.

Social Support, Identity and Self-belief (BCT7)

This approach is intended to create social capital, foster agency, and establish collective ownership of resources, such as the Mithi River. This approach has interconnections with BCT5 Shaping Knowledge and BCT6 Reward. However, the methods for achieving these outcomes might be more nuanced or distinctive, characterized by a sense of identity or ownership associated with a resource, which may not necessarily be the goal of BCT5 and BCT6.

In the context of the Mithi River, specific interventions could include public outreach programs, encouraging households and communities to use and manage their public spaces, promoting the concept of nurturing communal resources, actively recruiting community change agents and partners, involving stakeholders such as religious institutions and other public organizations, and proactively identifying and bolstering early adopters. Such interventions aim to encourage

community stewardship and work towards the preservation of environmental resources from this perspective.

Many participants found this concept more intrinsically relatable and shared numerous anecdotal examples of how these approaches have worked within the cultural context of India and in communities with pre-established social capital. This capital could potentially be reoriented towards improved management of resources. Viewed through a behavioral framework, participants ranked this technique relatively high, placing it in 3rd position with a mean score of 4.20. Only about 6.7% responded that these strategies were being pursued, while 36.7% said they were partially pursued, and approximately 50% of participants felt that these interventions were not being pursued at all for the river.

Participant Thoughts on Social Support, Identity and Self-belief

Participant responses to the strategy of Social Support, Identity, and Self-Belief (BCT7) in the context of the Mithi River varied. Some participants saw this strategy as instrumental in fostering a connection between people and the river, potentially leading to greater environmental consciousness and pressure on the government to address pollution. However, concerns were raised about the sustainability of efforts like endless beach cleanups, suggesting the need to address pollution at its source. The codependency with the river was highlighted by some participants, emphasizing the unavoidable nature of this relationship. This strategy was viewed optimistically by others, who believed in the inherent goodness of people and their desire for a better living environment, albeit acknowledging that change might come gradually or in spurts. Some suggested this strategy could demand accountability from the state but pointed out the need for official recognition and support of collective efforts to build social capital. Despite their enthusiasm for grassroots work, some participants expressed frustration about the disproportionate time and effort required to achieve outcomes, especially if higher authorities were not in alignment. The role of community watchdogs was stressed by some, while others suggested leveraging spiritual beliefs and religious institutions to foster collective ownership. The importance of relatable, measurable metrics for effective communication and education institutions in building community resilience was highlighted. Despite the perceived idealism in these approaches, the effectiveness of community ownership was widely acknowledged.

Comparison and Modelling (BCT8)

Comparison and modelling are essentially means of facilitation. By presenting a relatable example to aspire to or emulate, the strategy can potentially aid in diminishing perceived obstacles, thereby enhancing capability. Participants found this concept easiest to relate to when framed in terms of benchmarking or aspiring to perform on par with another individual, community, entity, or even river restoration projects. This approach can be achieved by showcasing the positive outcomes of a relatable entity, such as housing communities or businesses, involving role models, working closely with entities to establish strategic goals, implementing actions, and devising mechanisms to sustain and scale those actions.

In the context of Mumbai, almost all participants could relate to sustainable waste management initiatives implemented in many residential communities, especially over the past 5. They could see demonstrable positive outcomes, which provided them with a model to emulate by essentially establishing the groundwork.

Participants rated this as a highly effective strategy for river restoration within a behavioral framework, with a mean score of 4.12. Most participants found these strategies relatable and saw them as a way to demonstrate how various community and people-focused behavioral approaches could be beneficial for both the present and the future, potentially leading to systemic change. While many participants viewed these as promising, none believed that these interventions were actively being pursued in the context of the Mithi River. Around 33.2% responded that these strategies were partially pursued, while a significant 60% of participants felt that these interventions were not being pursued for the river at all.

Many related to model of the immersion tanks for the Ganesh festival in Mumbai as a success story. Traditionally, people immersed idols in freshwater bodies and the sea, but today they have fully embraced sustainable immersion methods such as local tanks and have also switched to using sustainable idol material instead of Plaster of Paris (POP) with toxic paints. When the idea of immersion tanks was first introduced in 2006, it was highly opposed and even offended several communities. However, over a decade later, this practice has become the norm. This is an example of aligning religious sentiment with community sustainability. While benchmarking is

quite often used in engineering and design planning practices, expanding this approach to pro-environmental behavior as a whole was quite positively received.

Participant Thoughts on Comparison and Modelling

Participant responses on the strategy of comparison and modelling in the context of the Mithi River varied but were generally positive. One participant underscored the power of tangible success in persuading communities to embrace sustainable practices. Others stressed the need for contextually appropriate models and cautioned against blindly adopting practices labeled as "best practices". One individual cautioned against replicating strategies without considering cultural nuances. Concerns were raised about the feasibility of advanced engineering solutions in localized settings. For some participants, comparison and modelling serve as informative tools for agencies, fostering a beneficial feedback cycle. It was tied to motivation, with successful models suggested as a way to fuel change momentum. Effective models were considered as persuasive tools for making bolder design decisions. Some identified comparison and modelling as essential tool for influencing people and scaling up interventions. There was also advocacy for an updated scientific approach, emphasizing the need to inform design decisions with current data instead of outdated models. On the other hand, comparison and modelling were seen as a way to critique and learn from failed strategies.

3.3.5 Change Agents

The notion of change agents is integral to environmental behavior strategies in river restoration, as interventions are fundamentally people-centric. People's behavior is the ultimate target, and the "who" involved in implementing these strategies becomes equally, if not more, important as the "how", which refers to the strategies themselves. The "who" component of the proposed behavioral framework is embodied in the concept of Change Agents. This exploratory proposition of change agents, as suggested by the decision-making community, presents a significant opportunity for addressing the issue of Governance in the case of the Mithi river, irrespective of whether they operate in a subordinate, independent, or integrated manner within the existing governing system.

Participants envisioned change agents from various perspectives, frequently as they voiced wide-ranging visions for river change in terms of responsibility and care, as well as in connection to specific behavior change strategies through this survey study (See Fig 24). This section offers a synopsis of these findings. Nevertheless, further research is required for a more comprehensive exploration of this dataset from the decision-making community's perspective and will serve as a vital next step towards behavior-focused interventions.

In the context of the Mithi river, participant decision-makers were all asked to identify the Change Agents, primarily concerning their visions for change, and particularly for each of the Behavior Change Strategies (BCTs) they contemplated during the survey study. A surprising insight emerged from analyzing their responses: the "Governing Agency"33 was identified as the primary contributor to river pollution, and it was also recognized as the most prominent change agent when evaluating responses for strategies. Chapter 2 attempts to establish the complexity of the governance for the Mithi river. However, the key takeaway from the participant responses is that the while they believe governing agencies are the biggest “polluting factor” they also identified governing agencies as the most critical change agent for transforming the Mithi. Expressions like “Buck has to stop at the governing agencies,” “It has to come from the top.”

Simultaneously, no participant claimed that the responsibility lay solely with the governing agencies. Phrases such as "We all have a responsibility" emphasized the value of collective governance management and ownership of the river. However, there was a shared belief that any collaborations would fail without the support or initiation from governing bodies, highlighting the need for new groups to maintain independence. Yet, a shared belief emerged that none of these efforts or collaborations would work if not supported or initiated by the governing bodies; they also highlighted the value of new groups maintaining their independence. This dichotomy of the governing agencies being both the critical change agents for the river's future and a key part of the problem underscores the need for a fundamental shift in the perception driving their interventions, indicating the need for a people-centric approach.

[33] In the context of the Mithi river, the term "governing agency" is broad but primarily refers to the local municipal governing body, the MCGM, and the state governing body for the metropolitan region, the MMRDA, along with numerous departments and entities under each covering services, environment, and urban development.

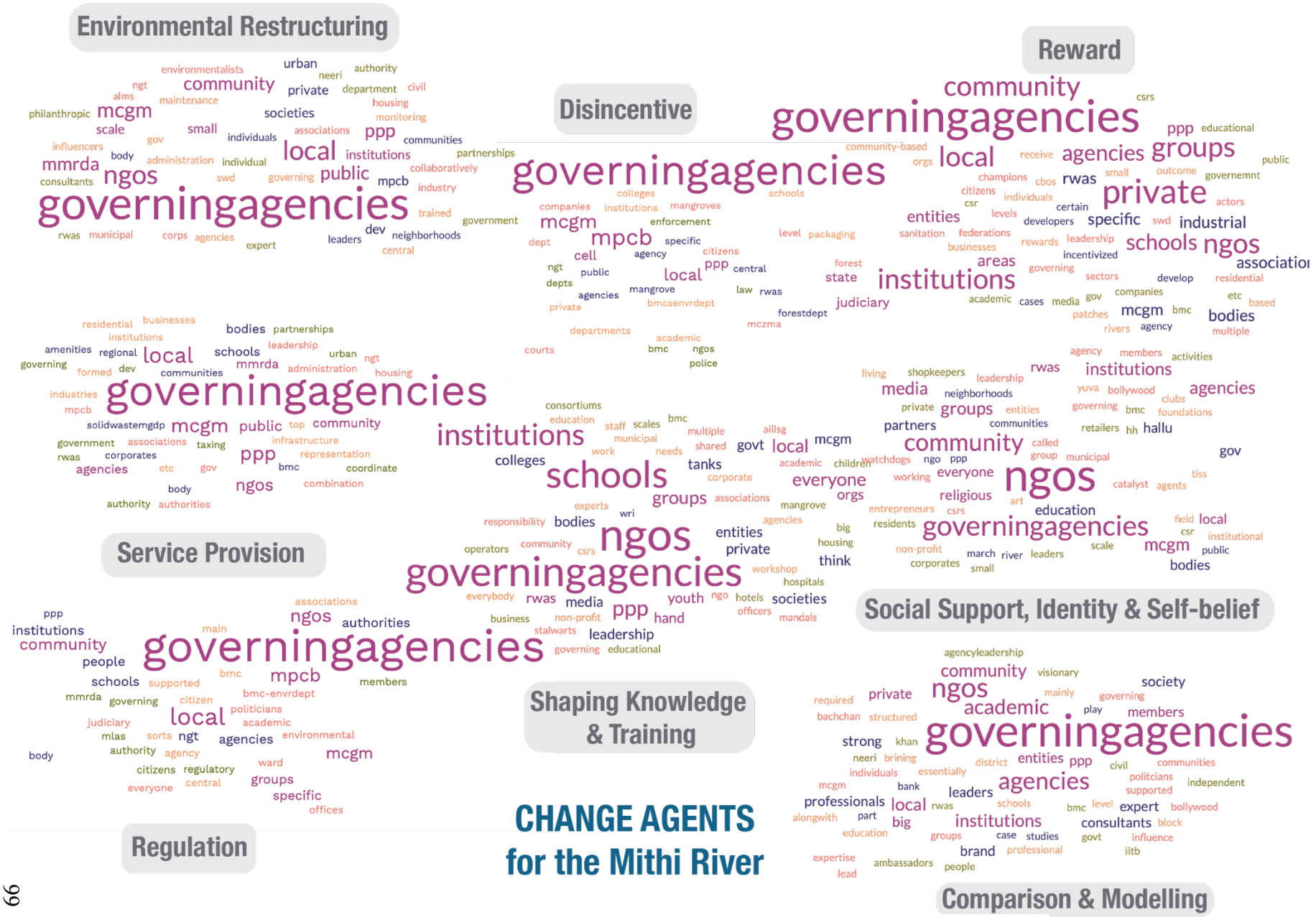

Figure 24 Participant Responses on Change Agents for Propose Behavior Change Techniques (BCTs) for the Mithi

When discussing specific interventions from BCT1 to BCT 8, governing agencies were identified as key change agents. However, for techniques like BCT 5 Shaping Knowledge, BCT7 Social Support & Identity, and BCT8 Comparison & Modeling, the focus shifted more towards the community, public and other institutions, NGOs, schools, and Resident Welfare Associations (RWAs) (See adjoining Fig 24 word cloud of responses). Several strategic suggestions came up, such as creating a Working Group for the Mithi, a Water User Association for the Mithi, Mithi CSRs, and involving Bollywood. These present opportunities for new collaborations to strengthen the governance system, like Public-Private Partnerships (PPP), Philanthropic collaborations, and Environmental Social and Corporate Governance (ESG) and Corporate Social Responsibility (CSR) Initiatives. In addition, it is crucial to involve other significant landowners in Mithi's floodplain, such as the MIAL, the National Park, and the indigenous tribes, while also finding representative mechanisms for the vulnerable informal settlements. Post-deluge, numerous city NGOs, including the Concerned Citizens (Concerned Citizens Commission CCC, 2006), mobilized to aid affected communities. Sustaining such efforts as a single entity over an extended period is challenging. A working group could provide these organizations a platform for representation and coordinated efforts, potentially transforming them into true change agents. Given the diversity of land uses across the course of the Mithi river, similar to interventions, the working group or change agents model will need to be contextually representative and adaptive.

3.3.6 Fostering Consensus in Decision-Making

A compelling methodology emerges when river restoration approaches—ranging from traditional engineering-based to the lesser- explored people-centric—are examined through the lens of the pro-environment behavior (PEB) framework. In my fieldwork, it became evident that respondents were more acquainted or strongly related to interventions like BCT1 Environmental Restructuring, BCT2 Service Provisioning, & BCT3 Regulations. However, strategies that leaned heavily on social capital while loosely aware appeared less familiar or relatable to the participants when thinking about bigger and scaled impacts. During survey assessment 2 (Appendix C), many participants experienced revelations about the efficacy of community-focused strategies. The structured effectiveness scale and the clear response options presented in survey assessment 2 proved pivotal in these moments of clarity. Intriguingly, even participants

from public agencies, typically at the helm of decision-making, seemed to have similar epiphanies. Post-survey, a number of them confessed a predominant focus on engineering solutions, having not given equivalent attention to BCTs 5, 6, and 7 in their professional pursuits. However, this exercise attempted to present a comprehensive model for all strategies and interventions through an environmental, behavioral framework, facilitating a consensus-building process within the decision-making sphere. It allowed decision-makers and stakeholders to broaden their perspectives, acknowledging the potential of interventions rooted in social capital and community involvement. Through this exercise, decision-makers appeared to broaden their perspectives and account for diverse strategies and perspectives, fostering a more inclusive approach to addressing the challenges of restoring the Mithi River.

3.4 Discussion

The findings and analysis of this study aim to encapsulate the collective perspective of the decision-making community on the Mithi River. This is achieved by applying the behavioral framework to a comprehensive unit of analysis and identifying opportunities and specific strategies to facilitate the river's transformation, in response to the primary research questions raised in this paper. This section offers a reflection on the findings for the Mithi river, drawing on the emergent themes of a Systems Approach, Governance, and Narrative Shift. To further build upon this study and advance the "behavioral strategies" and "change agents" identified herein, this section also proposes a direction for analyzing behavioral drivers and establishing target behavior. Proposed for future research, this can be done using the Capability Opportunity and Motivation Model to Influence Behavior (COM-B Model, see Table 7), which is based on the Pro-Environmental Behavior (PEB) methodology used in this dissertation research (Michie et al., 2011). In conclusion, the research methodology employed in this paper for consensus-making regarding the Mithi River has the potential to further extend its application beyond, serves as another tool for guiding future practice and research.

3.4.1 Emergent Themes

Systems Approach, Governance, and Narrative Shift, themes established from the previous paper attempts to construct the problem of the Mithi River, are also pertinent in this study and become

the basis for understanding and redirecting interventions for the Mithi River through a behavioral perspective (Figure 25).

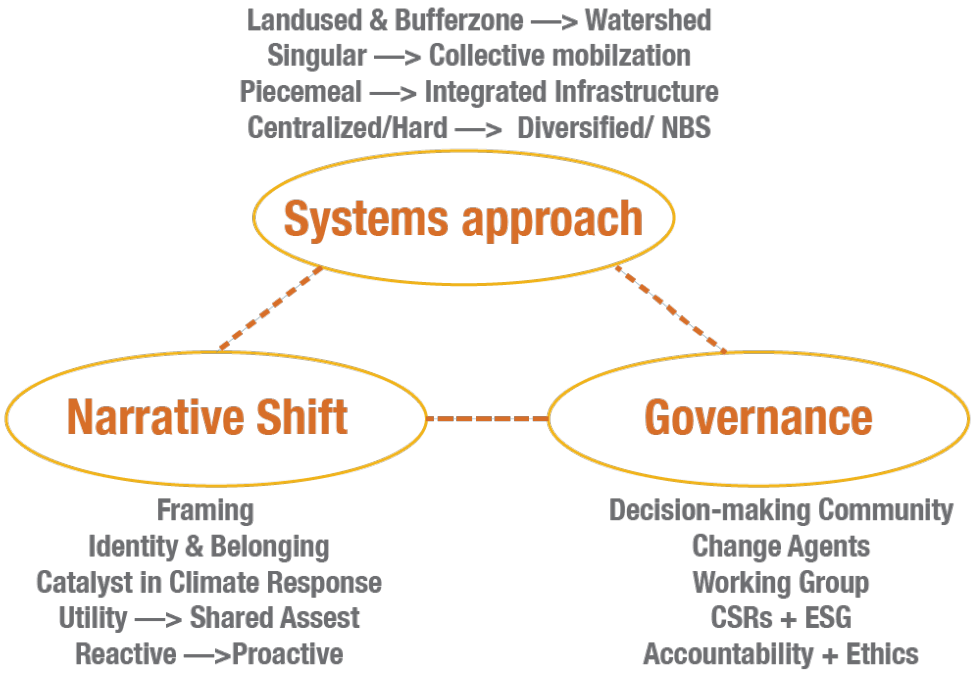

Figure 25 Emergent Themes for the Mithi River

Systems Approach

Current interventions for the Mithi river appear reactive, fragmented, and symptomatic of a firefighting approach. The most visible efforts since 2005 have not effectively improved the river's condition, signaling the necessity for a more systemic approach. This study underscores a compelling need for systems-level strategies that address environmental behaviors (root-causes) as opposed to the current unsuccessful piecemeal approaches that merely focus on symptoms. The participant responses call for a comprehensive spectrum of infrastructure interventions, which should range from hard, blue, to nature-based solutions, and from centralized to decentralized systems.

The theme of a systems approach could be manifested through watershed or floodplain-based interventions, providing an alternative to narrowly focused water cleaning efforts and land-use specific interventions. Participants voiced the idea of provision of outdoor recreation paired with the concept of functional landscapes offers considerable potential for design level interventions

informed by a socio-ecological systems approach. Interventions like these hold the potential to activate the riverscape while also improving neighborhood satisfaction relating to both actual and perceived environmental improvements (Hager et al., 2013). By viewing the Mithi River within a broader ecological, social, and regulatory context, stakeholders can better comprehend the complex dynamics at play. This in turn allows for the development of comprehensive strategies that address root causes of the issues rather than merely tackling surface symptoms. Such a systemic approach also promotes collaboration and synergy among various stakeholders, facilitating collective action towards the shared goal of river restoration and beyond as an integral part of Mumbai's urban ecosystem.

Governance

A unique paradox emerges from this study regarding the theme of 'Governance.' While it is identified as a contributor to river pollution, it also simultaneously surfaces as a crucial change agent. The proposition of mobilizing a Decision-making Community and Change Agents, which are Governance-Led and driven by context-specific Stakeholders, provides a robust framework for enhancing the governance model for the Mithi River. In the immediate term, the existing governance ought to reevaluate the narrative underpinning their practices for the Mithi. While it continues to address systemic corruption and ethical disparities that persistently taint the perception of local governance in Mumbai. Thus, this theme of governance, as depicted in the study, calls for a delicate balance between authoritative regulation and collective, community-driven efforts toward Mithi's transformation.

Narrative Shift

A key theme that emerged from the study is the potential power of a Narrative Shift. There was broad agreement among participants on the need to utilize knowledge and training to reshape the narrative surrounding the Mithi River and to foster a sense of collective ownership. Strategies for achieving this include finding ways to draw people to the river and fostering a sense of belonging and attachment to the place. This shift in narrative is also crucial for governing agencies. It serves as an impetus for engagement and upholding the responsibilities the public has bestowed upon them for the upkeep of this urban asset.

Analysis of participant responses regarding the implementation status of proposed strategies revealed a disproportionate focus on engineering and regulatory approaches. Yet, there is a significant preference, or perhaps belief, in the effectiveness of strategies that build on social capital and engage the community, highlighting a clear opportunity gap. To enact strategies under this behavioral technique, the narrative shift serves as the foundation upon which technological and social interventions can be implemented and sustained. It suggests that water quality might potentially benefit from social engagement. By involving the community in planning, implementation, and maintenance stages, the long-term effectiveness of best practices could be improved. This can result in behavior changes that positively impact the quality of neighborhoods, thereby underscoring the profound potential of a narrative shift.

3.4.2 Future Research

Analyzing Behavioral Drivers and Establishing Target Behavior using the COM-B Model

As this study concludes, it's important to revisit the concept of the "source of behavior" within the behavior change wheel that shaped our methodology study (Fig 26, Also see Fig 4. Introduction section). Given the now-established understanding of the Mithi river's situation, the evaluation of strategies and interventions through a behavioral lens, and the identification of potential change agents, future research could expand on analysis of target behavior for specific interventions and policies.

Figure 26 Source of Behavior (Adapted from, Michie et. al, 2011)

The Capability, Opportunity, and Motivation (Michie et al., 2011) COM-B model34 provides a framework to guide behavior modification. These components are instrumental in intervention design under Behavior Change Techniques (BCTs), where a specific intervention might alter one or more components of the behavior system. This study comprehensively covered the BCTs in context of the Mithi river. The previous paper presents a synthesis of factors contributing to the

[34] The model places Motivation, defined as "habitual processes, emotional responses, and analytical decision-making," at its center, while Opportunity is largely dictated by the context, whether social or physical.

Mithi River's urban condition, the findings can guide the identification of opportunities to influence individuals, groups, and inform policies. With this insight, we can start defining target behavior as a part of intervention design and strategy. The following model (Table 7) suggests a way to deconstruct behavior in the context of this study, its application will need careful refining when designing detailed interventions and identifying factors that can be targeted through interventions for different societal entities.

COM Model for Behavior Change ** (Michie et al., 2011, Roe, 2018)		**APPLICATION**	
		INDIVIDUAL / HOUSEHOLD	GROUPS/ STAKEHOLDERS
Capability	The *psychological* and *physical* capacity to engage in the behaviour. Also described as *ability* in other behavior models	• Personal ***agency*** • Shift in ***perception*** • ***Cognitive*** functions • ***Safety*** of health and environment	• ***Agency*** • ***Collaboration*** & ***influence*** • ***Regulation***
Opportunity	Everything that makes a behavior possible or prompts it, *social* or *physical.* Most contextual	• ***Provision*** of essential infrastructure • Household ***practices*** • Social ***norms*** & ***Power relations***	• Infrastructure ***service delivery*** to areas • Social ***norms*** • Bureaucratic *norms/* ***status quo*** • Distribution of ***power***
Motivation	Motivation includes both unconscious habits and conscious thoughts and goals. *Intrinsic* vs *extrinsic* motivation.	• ***Aspirations*** to change practices • ***Intention*** to transform detrimental practices • ***awareness*** and ***empathy*** towards deteriorating resources	• ***Decision-making*** • Demand for ***transparency*** • Group level ***intention*** or ***commitment*** • Realization of ***responsibility*** Internal ***accountability***

Table 7 Framework for altering target behavior (or influencing concern) in restoring polluted urban rivers.
*Note: ** Capability, Opportunity and Motivation interact to generate Behavior which in turn influences these factors.*

The urgency of the Mithi river issue is integral to Mumbai's climate future. With several research participants currently engaged or in a position to influence solutions, this research aims to pivot their perspectives. It argues for a shift towards interventions targeting collective and environmental behavior across various societal strata — residents, informal settlements, indigenous tribes, small-scale industry groups, and business associations extending the local governance model through several proposed ideas through the concept of change agents— all within the river basin. This approach emphasizes an integrated perspective, one that sees the city and the river as cohesive unit rather than isolated entities. Recommendations for immediate and long-term interventions for the Mithi River include a two-tiered approach. In the immediate term, consider a form of working group, expand CSR and ESG initiatives, invest in training and

monitoring, implement nature-based solutions, and develop decentralized infrastructure solutions. These solutions, being adaptive and feedback-responsive, are both low-maintenance and low-cost, making them manageable by trained community members. For longer-term sustainability, the focus should be on continued efforts in knowledge dissemination, education, capacity building and training. The creation of employment within the communities is crucial, as is the exploration and testing of shared governance models, ensuring an integrative approach to managing and preserving the Mithi River.

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4 CONCLUSION: Steering Practice Steering Water

As an Urban Planner and Designer, I focused my research on the issue of polluted urban rivers, specifically the Mithi River in Mumbai, a river under significant strain. My investigation primarily stemmed from the glaring "implementation gap" in the following areas:

1. The **gap between the vision and the reality of restoring the Mithi River** resource and enhancing urban environments in overburdened, rapidly developing cities, such as Mumbai.
2. Soon, this gap also shed light on **the disconnect between knowledge and practice** and, in turn, action. This disconnect extends to the interpretations and applications of knowledge in the Global South while inherently positioned in the privileged Global North (Bhan et al., 2018; Roy, 2009b; Watson, 2009).

Another related gap that my doctoral studies experience attempted to navigate was in the domain of interdisciplinary studies. In my case, it was bridging the gap between the fields of engineering, urban planning & design, and psychology. This exploration led me to the field of Environmental Psychology, which sparked with my research interests and in large part was the foundation for my dissertation. However, I maintained a critical awareness of its basis in the Western research tenets of the Global North.

As doctoral researchers, we typically begin by identifying and defining the knowledge gap to ground our research premise. In my case, two significant knowledge gaps formed the bedrock of my study. These gaps became starkly apparent and often deepened into substantial crevices when I engaged with complex environments such as the Yamuna and Mithi rivers in cities like New Delhi and Mumbai. These gaps, deeply intertwined, set the context within which I present the conclusion of my dissertation, entitled “Steering Practice [for] Steering Water”.

Climate urgency is a palpable issue in our era of extreme and transformative change, it becomes crucial to place this dissertation within this paradigm. We are already experiencing the profound impacts of climate change in various facets of our daily lives, underscoring the need to identify and operationalize these gaps I identify as opportunities. Bearing these motivations in mind, this

conclusion probes the implications of my research on these " gaps" or "opportunities" through (1) the case of the Mithi River and (2) knowledge and practice (3) note on limitations & generalizability. The dissertation concludes with reflections on potential opportunities for (4) future research both within this specific project and in the broader context of climate change.

4.1 The Mithi River – Between Vision and Outcome

The polluted urban Mithi River, currently under significant strain, provided an invaluable case study for examining all facets of practice and discourse. As it risks further detachment from the city's urban landscape and the inhabitants' collective memory, the results of this empirical research, aimed at influencing urban water management decisions for the Mithi River through an environmental behavior approach, fall under the following emergent themes as elaborated in Chapters 2 & 3.

4.1.1 Systems Approach

The notion of the Mithi River floodplain or the river as an integral part of its watershed basin is conspicuously absent from restoration plans, although it features in maps in research reports. The watershed has surfaced as the backbone of not just its physical system but also its socio-cultural system, with the river's state reflecting the land use and environmental behavior of its sub-systemic components. Fragmented interventions such as community toilet blocks lacking proper sewage infrastructure or inadequate waste service provision to informal settlements and businesses, only exacerbate the river's pollution, demonstrating a lack of systems-level approach. At the same time, this study introduces robust initial approaches like viewing infrastructure as part of a service provisioning system, assessing the feasibility of decentralized services, and considering soft infrastructure systems. These insights create a significant opportunity to shape the river's future interventions and strategies through a Socio-Ecological System approach, potentially guiding governance and policy issues and initiating a shift in the Mithi narrative.

4.1.2 Governance

On the governance front, the urgency to implement reactive, piecemeal projects becomes notably evident under intense scrutiny from political entities and concerned citizens responding to calls

to action. Yet, before reaching a point of no return, it becomes critical to reassess whether such hard infrastructure interventions might harm the Mithi River's ecological and cultural integrity. The governing agencies appear to juggle various competing priorities. However, there's a recurring call for a government-initiated but independent “working group” or “water user association” dedicated solely to the Mithi River, possessing real decision-making authority. Backed strongly by Corporate Social Responsibility (CSR) initiatives and other funding mechanisms, and closely integrated into the Environmental, Social, and Corporate Governance (ESG) missions of several key stakeholders and businesses within the Mithi River’s floodplain, this body would operate along the lines of governing agencies. Such a proposal warrants deeper study and consideration as a potential short-term measure. Existing local governance divisions, like city wards, could share responsibilities. These wards, being the closest to the issues at hand and directly involved in city governance, could reinterpret their roles within a broader systems-level approach.

4.1.3 Narrative Shift

I believe this dissertation initiates a path towards actionable strategies and policies aimed at transforming the negative narrative surrounding the river. The Capability, Opportunity, Motivation for Behavior (COM-B) model (See Fig 26, Table 7 in Ch. 3) provides a focused approach to target different segments of society, directly driving the Narrative Shift. Strategies that foster awareness and agency, such as Shaping Knowledge & Training, Recognition, Social Support, and Modelling, have been identified by the decision-making community as highly promising but have largely remained unexplored. These strategies align with the perspectives of the decision-making community and hold the potential to position Mumbai's Mithi River as a catalyst for transformative change.

4.2 Limitations and Generalizability

Limitations

It's vital to recognize that the primary data for this research is sourced from a specific participant group representing the decision-making community, following a purposeful snowball sampling approach. Engaging a different group might have resulted in distinct quantitative and qualitative insights, though I am confident this study adequately highlights the relevant issues. I elaborated

on the constraints of the participant group early in Chapter 2, emphasizing that multiple permutations of these 30 participants could have been possible. In terms of gaps in entity representation, while NGOs addressed the concerns of informal settlements, there was a lack of direct representation from this vital stakeholder group of informal settlements, even if their issues were inherent in participant feedback. Future studies could actively engage with participants from the Dharavi or other settlements along the Mithi floodplain to fill this gap, especially those who've secured housing rights and in-situ settlements might feel more confident in participating in this decision-making process. Additionally, there's an opportunity for future research to bring in participants from other pivotal public agencies, such as the Maharashtra Pollution Control Board (MPCB) which oversees pollution regulation and monitoring. Despite several efforts, I couldn't foster a relationship or onboard participants from the MPCB. Similarly, other essential regulatory bodies focusing on the environment and Coastal Regulatory Zoning play a crucial role in decision-making. It's worth noting, however, that these organizations eventually coordinate with the MMRDA and the MCGM (refer to Fig 6). Initially, my research proposal recommended another round of participant interaction to present the average survey outcomes, allowing them to reflect upon or modify their responses based on aggregated results. Such a feedback mechanism could have further authenticated the findings and their application in real-world scenarios, but it wasn't feasible within the scope of this dissertation.

Generalizability Considerations

The decision to focus on the Mithi River through purposeful critical-case sampling stemmed from the distinctive urban water challenges Mumbai faces. Although this in-depth case study is primarily designed for logical generalization within Mumbai's unique context, it shares parallels with other developing cities in the Global South. These parallels can be observed in aspects like developmental patterns, resource limitations, socio-cultural diversity, and governance landscapes. From the Matanza-Riachuelo in Latin America's Argentina to the Buriganga in South Asia's Bangladesh, cities confront challenges reminiscent of Mumbai. The behavioral framework and methodology presented in this case study, with the spatial-cultural contextualization, can be applied to other cities in developing nations. Nevertheless, the insights derived from this case study, while echoing broader global circumstances, are intrinsically Mumbai-centric. It's imperative to interpret them within the specific scope of the 30 participants involved in this

study. Numerous cases similar to the Mithi River exist in India and other developing regions, but it's crucial to contextualize these results within factors specific to Mumbai's context, similar to the first section in Chapter 2, which sets up the research by constructing the urban water management problem from various perspectives.

4.3 Knowledge and Practice

During my fieldwork on the urgent environmental issue of the Mithi River, I encountered a range of emotions from participants - from intense passion and practical considerations to feelings of underappreciation, saturation, and despair. As such, the participants, who embodied the decision-making community, became the focal point of my research. The focus continually shifted between the environmental context and the participants' perceptions, underscoring that any solutions for the Mithi River must be people-centric, reflecting the collective decision-making of these individuals. This recognition brought to light the daunting challenge faced by practitioners providing professional services in such contexts. It made me introspect on my role as a professional planner, the broader realm of interdisciplinary studies, and strategic approaches for disseminating this research.

4.3.1 Reflections on the Practitioner

Reflecting on my role as an urban planner, my conviction solidified that engaged practice is vital to make a significant impact. This involves using "co-produced knowledge" from the community and putting "people as infrastructure" at the forefront of all interventions to influence behavior and actions. Recent studies by Simone in developing regions of Africa, Indonesia, and India also emphasize the importance of this approach when dealing with the complexities of mega-cities in the Global South (A. Simone, 2004, 2004, 2014; A. Simone & Pieterse, 2017)." This body of literature highlights the potential for building social capital and community through engagement in practice, which can be considered scientific and relevant (Putnam et al., 1994) and valuable in the context of Mumbai.

4.3.2 Interdisciplinary Studies

As I near the end of my academic journey at UVA, the disciplinary boundaries of my research remain elusive. My work is rooted in Environmental Engineering, Urban Planning, Environmental Sciences, Social Psychology, Public Policy, Leadership, Political Science, or Architecture? This ambiguity, while seemingly counterintuitive, perfectly embodies the nature of the "interdisciplinary space." Despite the practical challenges inherent in interdisciplinary studies, we stand on the brink of generating truly multidisciplinary knowledge. I am grateful for the opportunity to traverse this cross-disciplinary path through my research on Mumbai's Mithi River. The interdisciplinary endeavor initially appeared daunting, but I found reassurance in leveraging my strengths as an urban planning and design professional. This provided a solid foundation for my interdisciplinary explorations and knowledge acquisition, allowing me to carve new paths and contribute meaningful insights that resonate across various fields.

4.3.3 Dissemination

The findings of this study, essential for developing cities across multiple disciplines, warrant dissemination to both academic and professional communities. Since 2019, I've workshopped this research at conferences including the American Collegiate Schools of Planning (ACSP) and the Environmental Design Research Association (EDRA). These platforms have enabled me to refine ideas and connect with individuals and communities in fields such as International Development, Urban and Environmental Management, and Behavioral Sciences.

In the future, my commitment is to consistently contribute to conferences and contribute to peer-reviewed journals, with the aspiration to serve both practitioners and academics, especially within Mumbai and the expansive Global South. To facilitate this aim, this dissertation has been crafted around two empirical research papers. A comprehensive list of associated conference papers and posters can be found in Appendix K.

I had the privilege of sharing insights from this study most recently at the June 2023 EDRA conference, with the theme "Environmental Behavior in Reclaiming Polluted Urban Rivers: Rousing Mumbai's Mithi", held in Mexico City. I also plan to present at the upcoming ACSP conference in October 2023 ACSP, presenting "Prolonged Water Woes of Mumbai's Mithi Urban

River: What Are Decision-Makers Missing?". My presentation at the EDRA conference struck a chord with several attendees, especially those from Mexico City and other Latin American locales such as Lima in Peru. They resonated deeply with the study, identifying the absence of behaviorally-driven interventions in their regions and contributing insightful perspectives from their respective cities. I plan to continue identifying opportunities to disseminate this research to audiences engaged in climate change research and practice.

4.4 Future Research

The findings presented in this dissertation represent merely a snapshot of the research I began as part of my Ph.D., opening up several avenues for valuable future research. I feel confident about moving this research forward in various impactful ways and propose a program for future research that extends this topic and, more importantly, will be helpful in shaping near-term policies and decision–making processes for the case of Mumbai's Mithi:

4.4.1 Policy window

In Chapter 2, I conducted a survey to understand the pollution problem in Mithi. The results revealed that the decision-making community rated “fractured governance” as the highest contributing factor, followed by Domestic level infrastructure. However, they also felt that the communities along Mithi were behaving rationally within the bounds of lacking infrastructure services they received. After analyzing the polluting factors, the decision-making community agreed that policy had the most potential to influence environmental behavior, while groups and individuals also had significant influence. This has led to an exciting future research agenda in which I plan to explore the policy levers towards managing urban ecosystem resources.

4.4.2 Testing theories of common pool resources in the context of Mumbai’s Mithi River

This research focuses on the management of Mumbai's Mithi River using Behavior Change Techniques based on ideas of collective ownership and the Urban Commons. The approach is based on the Socio-Ecological Systems (SES) concept, drawing from Ostrom's work on collective ownership and self-governance of the common pool resources (Ostrom, 1990). While Ostrom's model holds significant merit, its implementation in urban settings remains limited (Nagendra & Ostrom, 2014). This is primarily due to the absence of robust monitoring systems

(McGinnis & Ostrom, 2014; Ostrom, 2009b). Additionally, the prerequisite of a shared pool resource that all stakeholders are equally committed to safeguarding poses challenges in intricate urban landscapes such as Mumbai. Recent urban scholars propose the idea of “co-cities,” which suggest that common resources can be managed collaboratively without privatization or public authority monopoly. Instead, a mix of "public and private instrumentalities" is used (Foster, 2017; Foster & Iaione, 2022). Future research on the case of Mithi River can explore these avenues of managing common pool resources in complex urban environments using the empirical research findings from this study. The institutional elements identified through this research can also be applied to Ostrom's SES framework or co-cities, many institutional elements that have already been identified through the decision-making community mapping presented in this dissertation through Chapter 2.

4.4.3 Research on Implementation of Behavioral Techniques and Opportunities

This dissertation research has identified strategies and interventions through Behavior Change Techniques (BCTs framework in Chapter 2). To apply the behavioral framework, further research is needed to develop the identified opportunities. Future research could cover this domain, by beginning to identify target behavior through the Capability, Opportunity, Motivation-Behavior (COM-B) model. Additionally, research mechanisms should be considered to assess the effectiveness of behavioral interventions (Abrahamse, 2016; Michie et al., 2011, 2013).
Some key research questions that need to be explored are:

- How can public education integrate environmental justice, displacement, and public health issues?
- What are the Systems based infrastructure imaginaries for the Mithi River’s floodplain to explore the possibility of an Integrative “Human Riparian Ecosystem”? Wherein riparian areas or buffer zones along the deteriorating urban streams like the Mithi not only improve ecological functions but also become the mechanism for improving quality of life, socio-economic factors like equity, recreation, and education (Hager et al., 2013; S. T. A. Pickett et al., 2001, 2020).
- What are the ways to utilize institutions like the All India Institute for Local Self Governance (AIILSG) in India to improve skill-based training and capacity of government employees but also include training on ethics and address corruption

problems in development practices in Mumbai? Ethics in the face of climate change matters now more than ever.

4.4.4 Urban Informality

The interplay between environmental behavior and the informal settlements along the Mithi River has ignited a deep personal research interest. Recent scholarship and body of literature in Indian cities have delved into this topic, drawing on ideas of preferential environmentalism, which often subjects the most vulnerable city dwellers in informal settlements to unfair treatment (Baviskar, 2011; Bhan, 2012; A. Ghertner, 2015; Mitlin & Patel, 2014; Syal, 2019). While my dissertation has explored this subject as part of broader analyses, urban formality in the context of Mumbai's Mithi warrants a more targeted research agenda in the future. The participants in this study shared unique perspectives on the informal settlements in the context of the Mithi River, presenting a good starting data-set for future analysis. The narratives touched upon the challenges of the vulnerable immigrant population, "floodplain encroachment." rehabilitation, resettlement, and in-situ development carried out by the Slum Rehabilitation Authority (SRA) in Mumbai. There is also recent scholarship that focuses on the subject of informal settlements in Mumbai, their interplay with water infrastructure, and critiques on how these issues have not been adequately addressed in Mumbai's recent Climate Action Plan (Anand, 2017; Anand & Kamath, 2021; Doshi, 2013). This growing body of knowledge calls attention to the need for a more inclusive and comprehensive approach to environmental planning and policymaking in Mumbai that I would be keen to contribute through my research.

4.4.5 Research in Action

The following are potential avenues for future engagement in research-informed action:

Recognizing the Urgency of the Mithi River Issue

Considering the urgent situation surrounding the Mithi River in Mumbai, it becomes essential to share the findings of this study with the decision-making entities, opening up discussions about potential applications of this research. The goal of this study is to shift their perspectives towards prioritizing systemic interventions and actively incorporating measures to influence narrative change. These strategies include addressing the collective behavior of communities residing in

the river basin, thus moving away from an exclusive focus on the river itself towards a shared ownership.

Leveraging Research Methodology for Consensus Building

The methodology employed in this study places a spectrum of responses within a shared pro-environmental behavioral framework. This could prove instrumental in fostering consensus among working groups that represent a range of interests, underlining the need for behavior change in urban water management.

Aligning with Local Initiatives

It is critical to closely align the work of the Mithi river with existing local initiatives. The Mumbai Climate Action Plan (MCAP) in conjunction with C40 cities released in 20222, was led by the Municipal Agency MCGM. It is a potential example of a cross-sectoral comprehensive plan that attempts to situate the city within the climate change urgency, by analyzing various infrastructural and socio-economic factors. It strongly promotes nature-based solutions and calls for a redirection through a people-centric approach (BMC, 2022). The Mithi River project can be a catalyst within this plan, in synergies with the subsequent Vision 2030 by city's solid waste management division's (SWMD) which identified behavioral transformation as an underlying objective (SWMD, BMC, 2022). Similarly, the MCAP's proposal for a restructured governing body aligns with this study's suggestion for a Mithi Working Group or a Water User Association. The findings of this dissertation can potentially align with and contribute to the MCAP, helping streamline the city's approach towards a socio-ecologically balanced climate future. Moreover, the MCAP's proposed restructuring of the environment governing body to deploy its plan aligns with this study's recommendation for a Mithi Working Group or an Urban Water Association. The insights derived from this study could potentially dovetail with and augment the MCAP, aiding in streamlining the city's progression towards a balanced socio-ecological climate future.

This study aimed to shed light on the complex challenges urban ecosystems grapple within growing cities. By doing so, it underscored the necessity of confronting these concerns by prioritizing interventions centered on the needs of the local population and incorporating their knowledge. By merging the Socio-ecological perspective into a Pro-environmental Behavioral

Framework for urban infrastructure planning, the research identified environmental issues as intertwined with social problems. This recognition leads to more efficient management of urban ecosystems. Although engineering solutions play a critical role, the Pro-environmental Behavior framework offers a unique insight that transcends the conventional structural methodologies. The study successfully shared people experiences and perspectives that can shape environmental outcomes by proposing a way to bring in behavioral approach into community decision-making processes, thereby bridging the disconnect between the envisioned goals and actual outcomes for the Mithi River in Mumbai.

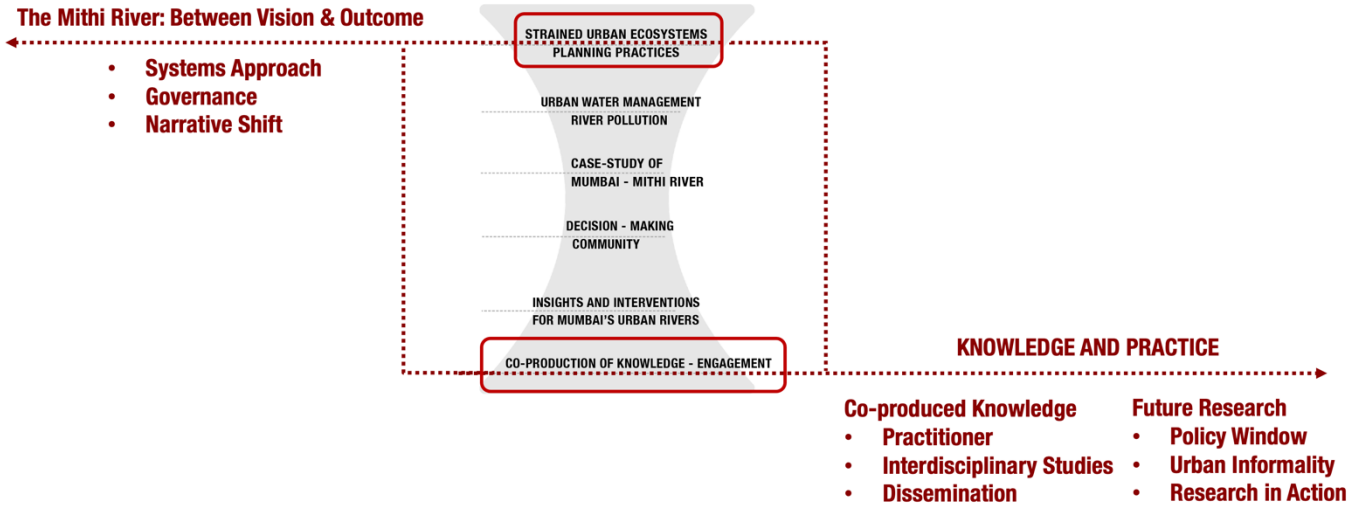

Figure 27 Research Implications

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APPENDIX

A. SEMI-STRUCTURED INTERVIEW PROTOCOL

B. SURVEY ASSESSMENT 1

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APPENDIX A: SEMI-STRUCTURED INTERVIEW PROTOCOL

UVA IRB-SBS #5214

1. Semi-structured Interview guide

No	Question	Purpose Question
	Consent Record DATE: TIME: LOCATION:	
	Initial questions	
1	Where do you live around this area, how long have you lived around here, how far is it? (mainly for respondents on the field) Identity marker	Location
2	How many members in your household?	demographics
3	What kind of housing do you live in, rental or owned?	
4	Employment information.	
5	How would you describe this river?	basic perception of the river
6	Have you noticed any changes in the river, either daily, monthly or seasonally? If so, what changes?	
7	Are there specific times when the river is more polluted than the other?	
8	Condition of the river during any extreme events like rains, floods?	
	Intermediate questions	
9	Who is responsible for the upkeep of the river? (Probe: rank if more than one)	influence
10	Do you feel like this river belongs to you?	attachment/relationship
11	Does the condition of this river impact you or your life around here in any way?	relationship with the river
12	Do you feel like your actions are directly or indirectly responsible for the state of the river? If yes, then how?	
13	Are there some people that care more about the river than others? If so, who do you think they are?	
14	How has this river been useful to you, positive and negative aspects? Role in daily life.	deeper understanding of the river
15	What are the 2 or 3 most important factors contributing to the pollution of the river?	
16	What are the 2 or 3 most important factors that could restore the condition of the river?	
	Ending Questions	
17	How do you wish for the river and its vicinity to change?	desire, responsibility
18	How long would it take to bring in that change?	
19	Who all could contribute to bring about that change?	
20	Is there something else you would like to add? (Probe - Because of our conversation, did something new occur to you that you hadn't thought of before)	
21	Is there anything you would like to ask me?	reciprocate
	Addnl. Intermediate questions [DECISION-MAKING ENTITY/ Experts]	
22	Please describe the working of your organization, how big, funding and basic functions wrt the river	
23	What is the most critical impact of your organization for the river?	
24	Who is responsible for the river? What does the network look like?	
25	Describe some of the most important activities or initiatives undertaken by you or your organization?	
26	Would you like to share any critical aspects of the river? (Unique, technical or scientific)	
27	Are these approaches based on engineering infrastructure, policy, other?	
28	What is the potential to integrate human-behavioral aspects (individual, group, organizations) into these approaches?	
29	Which of these are techniques could be most impactful, do you have thoughts on more specific strategies or interventions? (or skip is participating in the next level of survey)	
	Participation in the interview surveys	
30	Would you be willing to participate in an evaluation survey-based exercise with your decision-making counterparts? (Explain how the survey is an extension of the feedback exercise, and format of the survey)	
31	If Yes, check for availability and preference for an in-person, individual workshop or digital?	

APPENDIX B: SURVEY ASSESSMENT 1

UVA IRB-SBS #5214

2. Survey - Synthesis of contributing factors for pollution of Mumbai's urban rivers

Prompt1 – As a "- - - " you are a critical stakeholder in this community, and your actions and decisions influence the state of this urban river. From your experience:

1. *What are the 3 or 5 main factors contributing to the river pollution?*
2. *Are they included in this draft list? If not, add and categorize them*

Prompt 2 – Where is the biggest potential to influence "human behavior" in tackling the issue of urban river pollution? It should be targeted at the level of - individual/ HH, community/ group, or policy?

	CONTRIBUTING FACTORS FOR MUMBAI'S URBAN RIVER POLLUTION (Including its Watershed)	RANK/ IDENTIFY	POTENTIAL TO INFLUENCE BEHAVIOR *+ positive potential (if not leave blank)*		
			INDIVIDUAL/ HOUSEHOLD	GROUP/ COMMUNITY/ ORGS*	POLICY
DOMESTIC LIFE	Discharge of untreated sewage (from public toilets along the rivers, or private services collecting septage from unsewered areas)				
	Open defecation (related to lacking sanitary services)				
	Religious practices (offerings, idol immersion from individuals and public places)				
	Bathing, Washing laundry				
INFRA-STRUCTURE	Sewage and Sanitation amenities				
	Solid Waste Disposal services				
	Disposal of Chemical, Biomedical waste, or debris				
	Under capacitated sewage treatment facilities				
	Untreated runoff				
	Inadequate dredging and de-silting of drains				
URBAN USES	Civic amenities like Crematorium (immersion of ashes, bodies)				
	Unregulated informal developments				
	Regulated formal development				
INDUSTRIAL	Effluent from industries: chemicals, paper, sugar, leather, distillery, pharmaceuticals, power.				
	Small scale businesses discharging unregulated waste (eg. scrap industries, dairy farms)				
GOVER-NANCE	Fractured governance				
	Inadequate coordination in municipal agencies				
	Lacking community involvement				
	Sample response	✓ / 1,2,3	+ +	+	+ + +

Notes:
Denote the level of positive potential as + small, + + medium & + + + high
* Groups can be singular or multiple operate at local community level, municipal, state or national level business, organization, private and public agencies, civic spaces.

3. Assessment Survey Interview – ***Behavior Change Techniques & Evaluation of Interventions***

Prompt – As a "- - - " you are (or were) a critical decision-maker, your daily or professional actions and decisions directly influence the state of Mithi river.
Could you kindly review the following survey, and assess every technique informed by your experience or expertise? Furthermore, for each intervention, kindly identify the target level, propose change agents, respond whether these interventions have been implemented to your knowledge, and finally, their effectiveness in comparison to the other and open comments as desirable.

No	Behavior Change Techniques BCT	Interventions & Policies for Regeneration of the Mumbai's urban river Definitions and Sample descriptions	TARGET LEVEL		Change agent (who is enacting) Eg. Public, private, PPPs, governing bodies, local institutions, RWAs, NGOs, schools etc. others	Implemented (Y/N/ Partial)	Effectiveness LIKERT SCALE (1 – 5) least (1) to most (5) effective	Comments Open ended
			Individual/ Household (Y/-)	Group (Y/-)				
1	Environmental Restructuring	**Changing the physical or social context** *Building Sewage Treatment Plants (STPs), Interception and treatment of untreated sewage and open drains, Low-cost sanitation solutions, Community Toilet Complexes (CTCs), Public amenities along the river, like recreation, bathing etc.*						
2	Service Provision	**Delivering a service** *Delivering sewage connection to HH, deploying efficient solid waste management programs, subsidizing business owners for waste management, support services (at program level)*						
3	Regulation	**Establishing rules or principles of behavior or practice** *Deploying regulatory framework, legal approaches, establishing new standards, discharge permits for industries and urban uses, agriculture practices, monitoring through satellite imagery*						
4	Disincentive	**Coercion, restriction or creating expectation of punishment or cost** *Fines on agencies, states failing to comply, increased property Tax, fines for communities or operations disposing garbage, industries in non-compliance of effluent discharge (punishment)*						
5	Shaping knowledge & Training	**Increasing knowledge, communication, marketing & imparting skills** *Public Participation & Awareness; communication& marketing, Education about loss of resource, aquatic life and detrimental public health effects. Use of communications, media, institutions, schools, street-plays. Skill-based training, like Sanitation and Cleaning staff*						
6	Reward	**Creating an expectation of reward or recognition** *Incentivizing communities, business & institutions that are actively making an effort, demonstrating cost – benefit analysis, incentivizing cleaning drives to generate awareness*						
7	Social support, Identity and self-belief	**Creating social capital, Building agency and, collective ownership** *Public outreach, encouraging HH and communities to use and manage their public amenities, nurturing the urban commons, actively recruiting community change agents and buddies, stakeholders like religious inst., identifying and reinforcing early adopters at HH or business level*						
8	Comparisons/ Modelling	**Enablement, providing an example to aspire or imitate, increasing means/ reducing barriers to increase capability** *Demonstrating positive outcome of relatable housing communities or business, engaging role models, closely working with HH, communities and business to establish strategic goals, implement actions, sustain and scale actions. eg. Immersion tanks, or passionate waste management*						

(Adapted from Michie, van Stralen, & West, 2011)

APPENDIX C: SURVEY ASSESSMENT 2

APPENDIX D: STUDY PARTICIPANT LIST

The following table lists all the respondents and their associations.

No	Name/ In-text citation	Decision-Making Entity	Designation & Association
1	Sonawane, R.-1	State	Secretary, Maharashtra Water Resource Regulatory Authority; ex- Officer on Special Duty in 2006 MRDPA
2	Devanand-2	Neighborhood	Resident, Treasurer RWA at Satyajivan Society, Kurla area
3	Wankhede, A-3	State	Director of Land Acquisition MCGM; ex- Jt. commissioner 2006-2011 MMRDA
4	Ekbote, A.-4	Private	GIS expert consultant, Urban Designer, and Academic
5	Dikshit, AK.-5	Institutions	Professor, Centre for Environmental Science and Engineering, Indian Institute of Technology, Mumbai IIT-B
6	Serrao, A.-6	Neighborhood	Resident, Committee Member RWA at MIRA CHS, Marol area
7	Patil, Y.-7	City	Asst. Program Manager for Educational Programs, Maharashtra Nature Park
8	Mandke, P.-8	Private	Social Engagement Expert
9	Jonnalagadda, M.-9	International	International Development Consultant in Water Sector
10	Gomare, M.-10	NGO	Project Lead and Natural Organic Farmer, Art of Living River Rejuvenation Project
11	Ashraf-11	Neighborhood	Second generation Scrap Business Owner
12	Kanekar, S.-12	Institutions	Senior Program Associate, World Resources Institute (WRI India)
13	Keluskar, K.-13**	Private	Senior Sustainability Expert, Educated Environments; Assistant Prof. KRVIA
14	Bhandari, P-14	Private	Environmental Architect, Alchemy (Consulting), & Academic
15	MMRDA-15	City	*(Confidential),* Mithi River Development and Protection Authority, MMRDA
16	Das, S-16	Private	Lead Architect, Urban Designer, PK Das & Associates
17	Saiyad, A-17*	Private	Photographer, Mumbai Rivers Project, cofounder of *Hallu Hallu* – a walking project
18	Barap, D.-18*	Neighborhood	Resident, National Park (SGNP) & Warli Artist
19	Mohan, D.-19*	Neighborhood	Resident, Goregaon area
20	Marathe S.-20	Institutions	Advisor, All India Institute for Local Self Government (AIILSG), ex- Chief Deputy Engineer MCGM
21	Parthasarthy, S.-21	Institutions	Professor, Department of Humanities and Social Sciences, Indian Institute of Technology, Mumbai IIT-B
22	MCGM-22	City	*(Confidential),* Municipal Corporation of Greater Mumbai (MCGM)
23	Vaidya, N.-23	NGO	Environmental Activist, Communications and Media professional
24	Deval, Y.-24	Private	Area Director, RiverRecycle
25	Sadananda, G.-25	Neighborhood	Resident, Kalina area
26	Tiwari, A.-26	Private	Urban Planner and Research Associate, Integrated Design
27	WBG-27	International	*(Confidential),* World Bank, India
28	Dayanand, S.-28	NGO	Environmentalist and Director, Vanashakti
29	Jothiprakash, V-29	Institutions	Professor, Water Resources Engineering, Indian Institute of Technology, Mumbai IIT-B
30	NEERI-30	National	*(Confidential)*, CSIR – National Environmental Engineering Research Institute (NEERI)

Study Participant list.

*Notes * Saiyad, Barap, Mohan participated in the study as a group, with recorded individual responses; ** Pawar, V., Nayak, A. participated in the semi-structured interview portion with Keluskar, K.*

APPENDIX E: IRB PROTOCOL APPROVAL

Vice President for Research

Human Research Protection Program
Institutional Review Board for Social & Behavioral Sciences
iProtocol

Current User: **Vuppuluri, Richa (rsv8ab)**

Protocol Number: 5214

IRB of Record: UVA

Title: Steering Water through Environmental Behavior: Decision-making for Urban Water Management in Mumbai's Strained Ecosystem

Descriptive Title: This research investigates how decision-makers in water management can better intervene in strained urban ecosystems like Mumbai, through human-centric behavioral approaches. The primary data point of the study is the decision-making community.

Previous IRB-SBS Protocol Number:

Date Approved: **2022-07-06**

This protocol record was electronically approved on 2022-07-06

This protocol record is currently Approved.

Personnel (UVA Only)

Principal Investigator: Vuppuluri, Richa (rsv8ab) - Status: Graduate Student
Department: U1:Architecture Graduate
Title: No Data in UVa LDAP
CITI Training:
2022-02-08 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS
2018-09-19 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS

Faculty Sponsor: klotz, leidy (lk6me)
Department: E0:EN-Center for Transportation Studies
Title: E0:Associate Professor

CITI Training:
2021-08-10 - Conflicts of Interest - Stage 1
2017-05-12 - Conflicts of Interest - Stage 1
2020-12-11 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS
2017-11-08 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS
2008-08-18 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS
2020-12-11 - IRB-SBS RESEARCHER REFRESHER COURSE
2017-11-08 - IRB-SBS RESEARCHER REFRESHER COURSE
2014-10-09 - IRB-SBS RESEARCHER REFRESHER COURSE
2021-11-09 - Undue Foreign Influence: Risks and Mitigations

Contact Person: Vuppuluri, Richa (rsv8ab)

Research Team (Sub-Investigators):

Department Chair: Moomaw, Suzanne (swm2x)

non-UVA Research Team (Sub-Investigators)

non-UVA Sub-Investigator: Singh, Binti
Institution: Kamla Raheja Vidyanidhi Institute for Architecture and Environmental Studies (KRVIA-EH)

APPENDIX F: ORAL CONSENT

UVA IRB-SBS #5214

Oral Consent Text

As you know, I am a Ph.D. student studying urban and environmental planning at the University of Virginia in the United States. I am conducting a study on integrating environmental behavior in decision-making for urban water management in Mumbai's polluted urban rivers, like the Mithi. I would like to ask you some questions about that and possibly even request you to participate in a two-part structured survey interview. To participate, you must be 18 years or older. It could take a total of approximately 3 hours over two meetings. I would like to audio record our conversation and keep a paper copy of the survey, or video record if you are engaging in this study virtually so that I can get your words accurately. If you feel uncomfortable answering a question at any time during this process, please let me know, and you don't have to answer it. Or, if you want to answer a question but do not want it recorded, please let me know, and I will turn off the device. If at any time you wish to withdraw from this study, please tell me, and I will erase the recording of our conversation.

Since I will be collecting your personal identifying information, I will respect your wishes to have your identity acknowledged if you feel comfortable doing so. Or keep it confidential as you respond to the interviews and the surveys. Please let me know your preference. If you decide to keep your information confidential, I will either use a generic descriptive identifier without a name or a pseudonym, with your consent for my research purpose. Furthermore, I will not reveal the content of our conversation beyond myself and the people helping me whom I trust to maintain your confidentiality. I will do everything I can to protect your privacy if you choose to remain anonymous, but there is always a slight chance that someone could find out about our conversation. As such, I do not see any risk in you participating in my research, mainly since your responses to the survey-based interviews will be analyzed in aggregate form along with other respondents, and the interview responses will be your personal opinion. Once the active research phase is completed, the data will be maintained in a secured HDD storage for future access for research purposes. There are no direct benefits to you for participating in this research study. The study may help us understand how we can use behavioral interventions in managing polluted rivers, along with the myriad of other structural interventions underway over the past several years. Your participation in the study is entirely voluntary.

(This section is only for a subset participant group)
An honorarium of 1500 INR will be given for your response to the structured assessment surveys. Form of payment for the honorarium – cash, cheque, digital payment UPI mode like google pay. This is for your valuable time sharing your experiences and expertise.

Now I would like to ask you if you agree to participate in this study and talk to me about your knowledge, experiences, and opinion regarding the Mithi river and its restoration. Do you agree to participate and allow me to record our conversation and your survey responses?

If you have questions about the study, I will share the following contacts with you:

Richa S. Vuppuluri
University of Virginia, Charlottesville, VA 22903
KRVIA Mumbai, Vidyanidhi Marg, Gulmohar Road, J.V.P.D. Scheme, Mumbai, Maharashtra 400049
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+91 6303671672/ dean.research@krvia.ac.in

To obtain more information about the study, ask questions about the research procedures, express concerns about your participation, or report illness, injury or other problems, please contact:
Tonya R. Moon, Ph.D.
Chair, Institutional Review Board for the Social and Behavioral Sciences
One Morton Dr Suite 500
University of Virginia, P.O. Box 800392
Charlottesville, VA 22908-0392
Telephone: (434) 924-5999
Email: irbsbshelp@virginia.edu
Website: www.virginia.edu/vpr/irb/sbs

APPENDIX G: CODEBOOK DRAFT

P-CODE no	CODE (parent)	Sub-Codes (Depth 1)	Description
1	**2005**		The deluge, what happened since, reference to this year in the context of Mithi
	1	**deluge impact and experiences**	
	1	**initiatives or efforts since**	
		retaining wall	mentions of the wall, different perspectives
2	**TIME**		how long and related comments
3	**BALANCING APPROACHES**		responses specific to balancing Engineering design interventions vs people-centric/ behavioral
4	**BEHAVIOR**		specific thoughts on behavior
5	**CHALLENGES OR PROBLEMS**		different from identifying direct polluting factors, but more expanding on it highlighting institutional or other issues
	1	**politics**	political cycle
6	**CHANGE**		Vision for change, factors that could restore the river condition, desire, aspirations, goals, expectations
	1	**Physical**	Design Tech Infrastructure Hard interventions
	1	**policy related**	regulations
	1	**vision**	broader vision (check if this is needed as a separate code)
		human'-'centric	behavioral, social, non physical
7	**CLIMATE CHANGE**		issues of high tide, extreme incessant rains, urban flooding (their frequency has increased many folds due to climate change).
8	**COLLECTIVE**		mention of collective impact, group, together, citizen groups, industrial groups, businesses groups
9	**DESC**		How participants describe the river, their perception, changes, memory, Negative and positive emotions
	1	**Feelings_negative**	
	1	**Feelings_Positive**	
	1	**Memory**	anything regarding the rivers past, or oral histories
	1	**Physical characteristics**	
10	**INFORMAL SETTLEMENTS**		mentions of slums, encroachments, migrant population rehabilitation, SRA, displacement
11	**Participant info**		about the participant, their work and association
12	**POLLU**		Polluting factors, problems, issues and challenges (q.15 on interview and open comments from survey 1)
13	**REFLECTIVE**		role of the practitioner urban planner
14	**RESP**		Influence, who is responsible, some people care more, change agencies, who could contribute, individuals/ entity, public/ groups, CSRs. Corporates
	1	**community_general public**	
	1	**governing bodies**	
	1	**Institutions**	
	1	**NGOs**	
15	**RIVERBED, FLOODPLAIN, WATERSHED**		mentions of river not as a singular entity but subset of a larger system explain the buffer zone in context of the floodplain, CRZ
	1	**buffer zone**	
16	**SELF**		Relationship to the river, Sense of belonging, impact of the condition of river, direct or indirect impact of your actions on the river
	1	**how your Actions impact the river**	Direct or Indirect impact of your action responsible for the state of the river
	1	**I didnt know about Mithi, until...**	
	1	**Impact of the river on you or you**	How does the condition of the river impact you (direct or indirect)
	1	**Sense of belonging**	Do you feel like the river belongs to you
17	**Survey1_PollutingFactors**		Open comments. In the assessment Participants rank the contributing factors on 1,2,3 (1 being the highest) and identify the potential to influence behavior at the Individual, collective or policy level wrt specific polluting factors
18	1	**DOMESTIC LIFE**	
		DL1 Discharge of untreated sewage	
		DL2 Open defecation	
		DL3 Religious Practices	

		DL4 Bathing washing laundry	this was deleted for analysis based on n/a participant responses
19	1	**GOVERNANCE**	
		GOV1 Fractured Governance	
		GOV2 Inadequate coordination in municipal agencies	
		GOV3 Lacking Community Involvement	
20	1	**INDUSTRIAL**	
		IND1 Effluent from Industries	Chemicals paper sugar leather distillery pharmaceuticals power
		IND2 Small Scale businesses discharging unregulated waste	like scrap industries and dairy farms
21	1	**INFRASTRUCTURE**	
		INF 6 Inadequate dredging and de'-'silting	
		INF1 Sewage and Sanitation amenities	
		INF2 Solid Waste Disposal services	
		INF3 Disposal of Chemical Biomedical and Const Debris	
		INF4 Under Capacitated Sewage treatment facilities	
		INF5 Untreated Runoff	
22	1	**URBAN USES**	
		UU1 Civic Amenities	this was deleted for analysis based on n/a participant responses
		UU2 Unregulated informal development	
		UU3 Regulated Formal Development	
23	**Survey1 _All BEH**		from survey 1 open comments, potential to influence behavior at the Individual, group or policy levels
24	**Survey2_BCTs Strategies and Interventions**		Participants responses and open comments to 8 BCT strategies and interventions. In the assessment participants rate effectiveness of strategies, talk about state implementation and thoughts on change agents
	1	**BCT1 Envr Restr**	
	1	**BCT2 Service Prov**	
	1	**BCT3 Regulations**	
	1	**BCT4 Disincentive**	
	1	**BCT5 Shaping Knowledge & Training**	
	1	**BCT6 Reward**	
	1	**BCT7 Social Support Identity Self Belief**	
	1	**BCT8 Comparison Modelling**	
24	**WHO can contribute towards the CHANGE**		from interview and survey responses, change agents
26	**CARE**		These people care more about the river than others

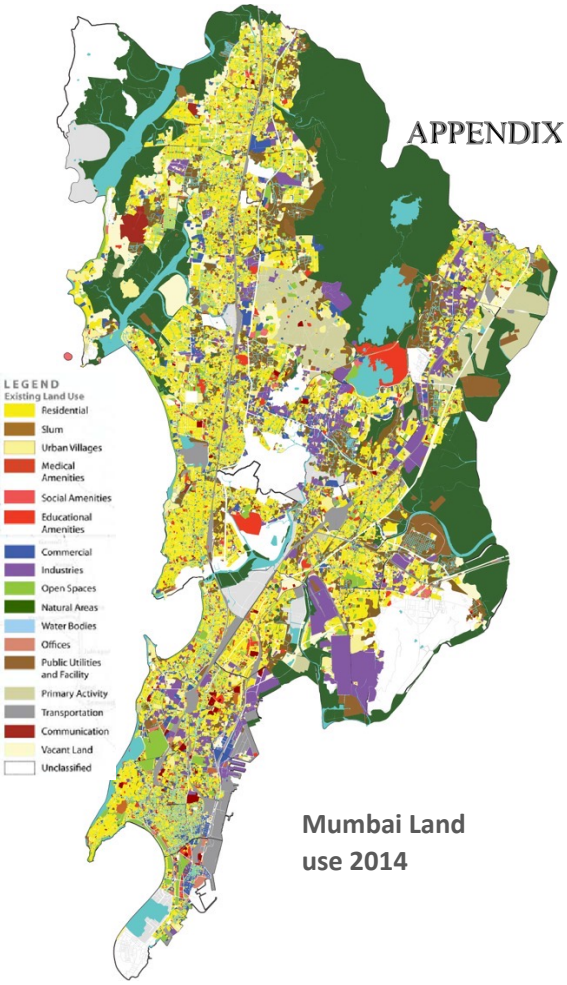
APPENDIX H: DATA COLLECTION PHASES (PROPOSED)

	Phases for Research and Data Collection	2022											
		Jan 22	Feb 22	Mar 22	Apr 22	May 22	June 22	Jul 22	Aug 22	Sep 22	Oct 22	Nov 22	Dec 22
1	**PHASE 1 - SECONDARY DATA COLLECTION**												
1.1	Base maps (GIS) + Spatial analysis												
1.2	Urban/ Environmental history of the rivers in 2-3 cities of India												
1.3	Secondary literature + Material study: Reports, records, documents, media, court rulings												
1.4	Identify decision-making community - agencies, local, regional, state, national levels, Institutions, NGOs, interested groups, residential and biz.												
1.5	Draft scoping analysis for Envir. Behavioral framework for restoring Mithi River IRB approvals for Interview protocols + surveys												
1.6	Identify collaborators (academic institutions, grads, orgs) + funding support												
2	**PHASE 2 - FIELDWORK - DATA COLLECTION - MUMBAI**	Jan 22	Feb 22	Mar 22	Apr 22	May 22	June 22	Jul 22	Aug 22	Sep 22	Oct 22	Nov 22	Dec 22
2.2	Field Observations - People, Places, Activities												
	walk sections of the river, photo documentation, field mapping												
	daily activities, festivals, document wet/ dry season												
	specific uses - residential, industrial, other uses												
	identify main infrastructure - water, wastewater, overfalls, wetlands, etc.												
	identify specific sites of failure												
2.3	Field interviews: 1-1 unstructured, semi-structured												
2.4	Entity/ Stakeholder Mapping												
2.5	Identify/ select participants for the survey interview												
3	**PHASE 3 - FIELDWORK - IMPLEMENTATION SURVEY STUDY - MUMBAI**	Jan 22	Feb 22	Mar 22	Apr 22	May 22	June 22	Jul 22	Aug 22	Sep 22	Oct 22	Nov 22	Dec 22
3.1	Structured Survey Interviews (in 2 parts)												
3.2	Share outcomes with intereted stakeholders + followup closing discussions												
3.3	Preliminary Synthesis												
3.4	Interim report-in with PhD Committee												
	Data analysis & Dissertation writing 7 months (target defense Apr 2023)												

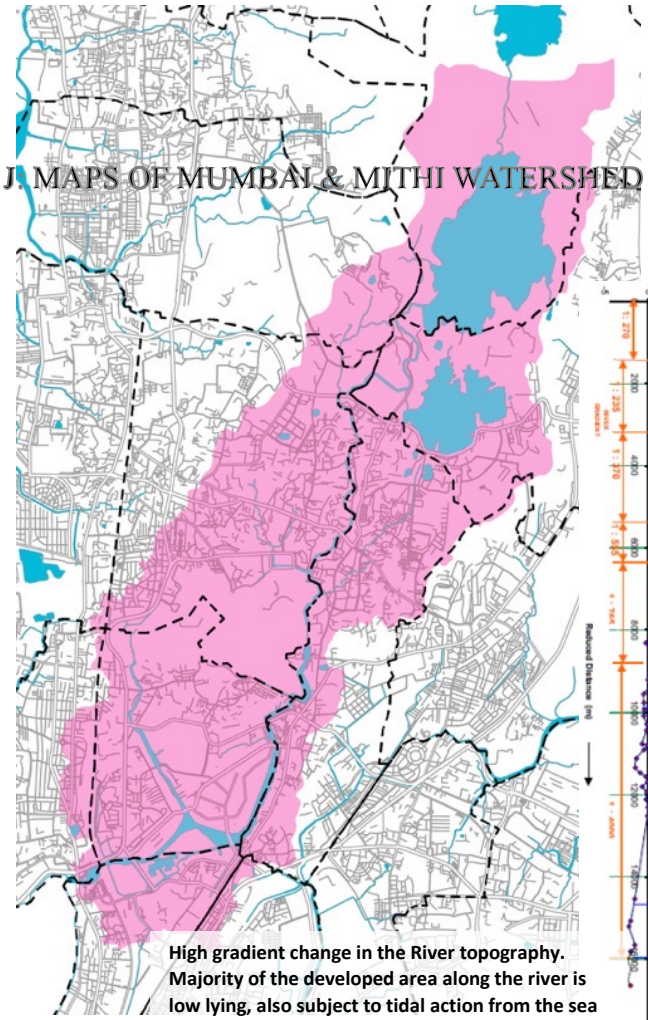
APPENDIX I: MITHI RIVER TIMELINE AND REPORTS (NOTES)

YEAR	EVENTS, REPORTS, ACTIONS OUTCOMES
1975	The Natu Committee Report
1978	CWPRS -- BKC report
1984 or 85	Major floods - that lead to the BRIMSTOWAD
Late 1980s	Airport runway extension over mithi
1988	Shah Technical Consultantsreport - Dharavi Stormwater Drainage System Report
1993	BRIMSTOWAD report
1980s-1990	BKC land reclamation
1994	Mah Nature park opens along the estuary, previous used to be a dumpling ground. It was eventually reclaimed and convernted into a park. today it's a nature education park
1996	NEERI report to study the Impact of the removal of mangroves at BKC due to reclamation work. The report concluded that mangrove removal at BKC is the main cause of flooding in the Mithi River and recommended that an environmental assessment of the area needs to be carried out to assess ecological impact.
2004	MPCB Report on "Pollution Study of the Mithi River Basin," Klean Environmental Consultants report (July 2004)
	NEERI report assessing flood prone areas along the Mithi river
2005	**DELUGE**
2006	MPCB, "Report on Mithi river Water Pollution and Recommendations for its Control" by Klean Environmental Consultants Pvt. Ltd (March 2006)
2006	CWPRS, "1-D Mathematical Model and Desk Studies for Mitigating Floods of Mithi River in Mumbai
2006	CHITALE COMMITTEE FFC REPORT
2006	Concerned Citizens Commission report
2006	CESE IIT-B, Development of Action Plan for Environmental Improvement of Mithi River and Along its Banks (June, 2006)
2008	Center for Environmental Engineering and Engineering (CESE) IIT-B, Baseline Socio-Economic Survey for the Mithi River and Vakola Nallah: Final Report,
2006-2011?	Relocation and resettlement of 5000 (?) informal settlements, relocation of indistries
2011	NEERI Report, 2011: Current Status of Mithi River and Possible Solutions
2014	MPCB Comrpehensive Mithi River Profiling study 2014
2014	IIT-B report submitted to MMRDA "Integrated Impact Assessment of Mithi River: Remote Sensing, GIS and Socio-Economic Studies of Mithi Catchment (June 2014)
2015	NEERI report for MRDPA (May, 2015) Integrated Impact Assesment Study for the Mithi River
2017	MNP redesign call for competition
2017	2017 Mumbai Flood (highest rainfall 468 mm in 12 hours since 1997)
2017	NEERI report
2015 - 2020	Construction of the retaining walls
2019	NGO Vanashakti's appeal against MMRDA blasting before the NGT goes before the SC. In 2017 SC directed the state environment secretary for expert report analysis of the Mithi to be conducted by NEERI + IIT-B (TOI)
2020	MRDPA supported RiverRecycle waste recovery unit installed
2022	Floodrisk in Mumbai -- Consltative Stakeholder Workshop by WRI
2022	Mumbai Climate Action Plan
Refences:	MMRDA office, Mumbai
	MMRDA report by IIT-B on Baseline Socio-Economic Survey, 2008
	MIT BGI Wescoat report, 206
	NEERI 2015 report - Integrated Impact Assessment Study for Mithi River (prepared for MMRDA)

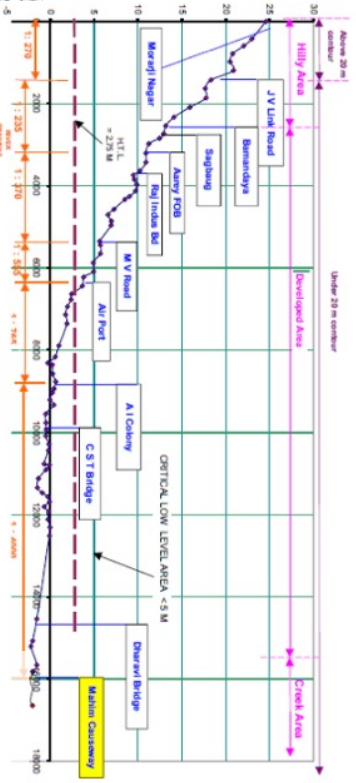
APPENDIX J. MAPS OF MUMBAI & MITHI WATERSHED

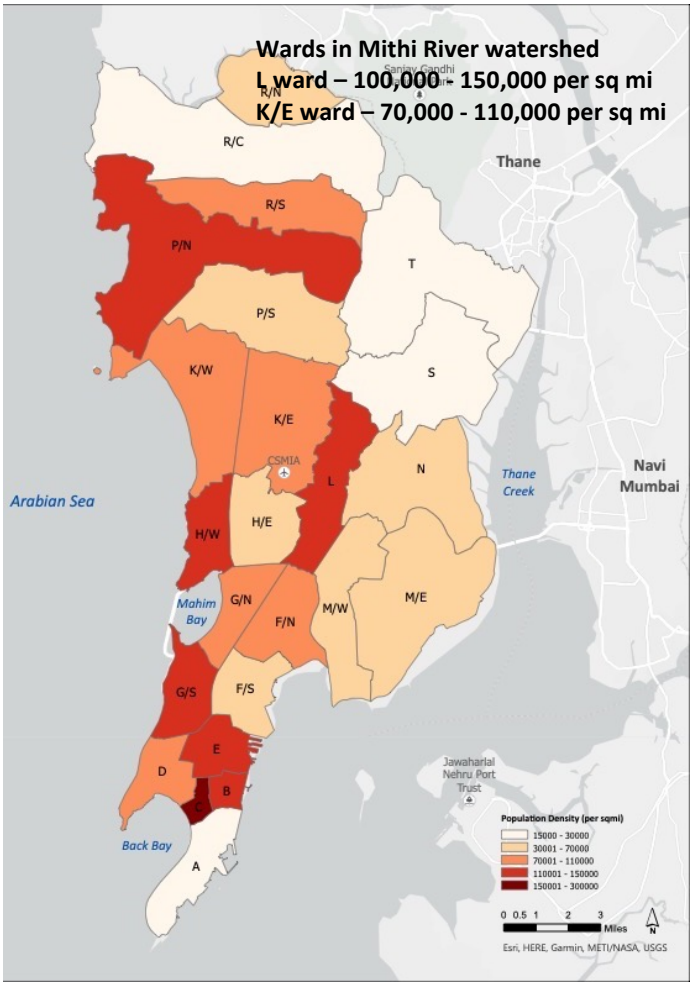


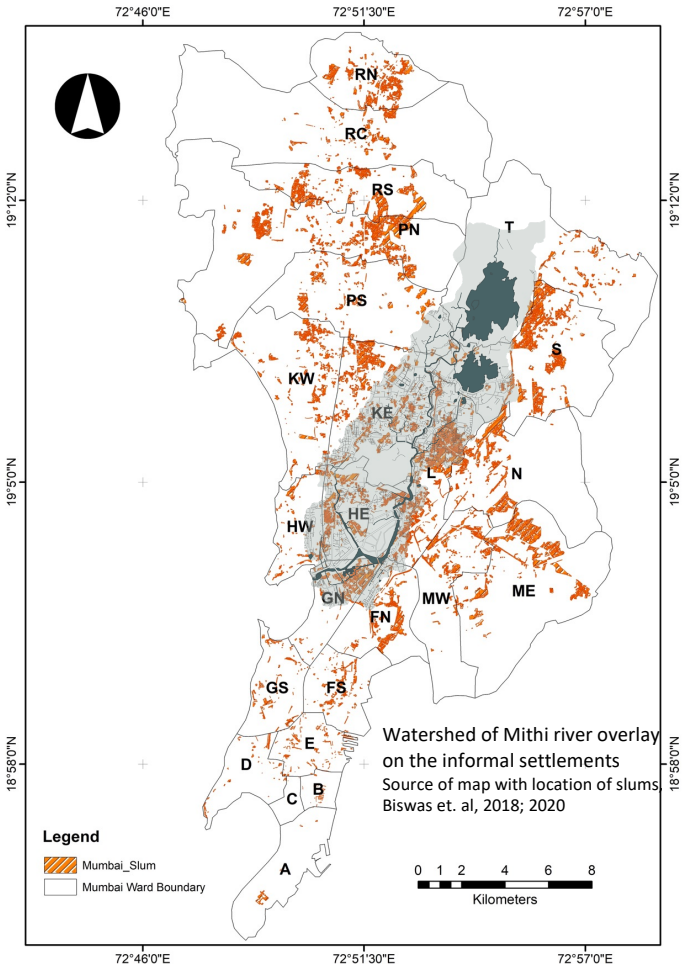
Mumbai Land use 2014



High gradient change in the River topography. Majority of the developed area along the river is low lying, also subject to tidal action from the sea (gradient section source, Chitale FFC 2006)







Watershed of Mithi river overlay on the informal settlements
Source of map with location of slums Biswas et. al, 2018; 2020

APPENDIX K: LIST OF CONFERENCE PAPERS

List of academic presentations and conferences:

Association of Collegiate Schools of Planning - ACSP 2019 (paper) – *Steering Urban Water Management in Strained Environments: Case of the Yamuna River in New Delhi, India*

ACSP 2019, Greenville, SC (poster) – *Spatial Evaluation of Urban Triggers for The Yamuna River Pollution in New Delhi, India*

Tulane School of Architecture, Spring 2019, (invited speaker and panelist) – *River and Coastal Urbanism Dialogues*

ACSP 2020, virtual (paper) –*Socio-behavioral Framework for Ecologically Strained Urban Ecosystems: Exploratory Insights from New Delhi and Mumbai, India*

Environmental Design Research Association EDRA54 2023, Mexico City, June 2023 (paper) *Environmental Behavior in Reclaiming Polluted Urban Rivers: Rousing Mumbai's Mithi*.

ACSP 2023, Chicago, Oct 2023 (upcoming, paper, co-author Bassett, E.) –*Prolonged water woes of Mumbai's urban drains: What are decision-makers missing?*