FLUCTUATING CURRENTS

Balancing urban growth and restoring native riverine synergies in Mumbai - the case of Dahisar River

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Ajay Nayak

Educated Environments, Mumbai <edencolab@gmail.com>

Kimaya Keluskar

KRVIA/Educated Environments, Mumbai <kimayak.eden@gmail.com>

Vikram Pawar

Urban Conservation KRVIA/SAHEC <vikrum.pawar@gmail.com>

ABSTRACT: In 1690 CE, a transformation was initiated by the British East India Company on the seven islands along India's western coast. These islands, once primarily Portuguese territories featuring indigenous communities deeply intertwined with rich ecological and cultural histories spanning millennia, underwent a gradual metamorphosis into the major metropolis known as 'Bombay,' a trajectory that persists today in its rebranded identity as 'Mumbai.' This article delves into how the commonly accepted imaginations of urban utopia progressively turned away from the perceived stagnant waters of rivers and estuaries that, in reality, served as vital coastal ecological buffers. The expansion of Mumbai city propelled its citizens, particularly marginalised low-income groups and traditional settlement inhabitants, towards the outskirts where vestiges of natural ecosystems endure. This shift granted them rudimentary necessities such as water and outdoor spaces, including prospects for agriculture. The convergence of socially vulnerable communities with ecologically delicate zones frequently led to heightened intricacies and debilitation, placing immense stress on both the city's ecological and social resources. This article centres on the examination of urban rivers, using the Dahisar River, a representative seasonal watercourse in Mumbai, as a focal point. Through this exploration, it seeks to scrutinise the multifaceted networks intertwined with Mumbai's river systems, emphasising the urgency of recalibrating perceptions of rivers in Indian urban landscapes. The study also reflects upon the tumultuous socio-political dynamics of the city, involving governing bodies, indigenous stewards, urban residents, and industries. Amid the array of potential solutions, technical and ecological facets often take a backseat to the socio-political determination required to adopt a more ecologically conscious stance. Nonetheless, optimism persists, as climate change mitigation and urban well-being emerge as entrepreneurial prospects for the nation's economic hub. The national leadership aims to position itself as a catalyst for change, aligning with global ecological narratives on the political stage.

KEYWORDS: urban rivers, Dahisar river, natural ecosystems, eco-buffers, water ecologies, climate change, estuarine waters, coastal cities

Introduction:

Up until approximately 210 years ago, the islands that would later become recognised as Mumbai constituted a landscape dominated by a central cluster of hills, encompassed by tidal flats. Adjacent to these, smaller islands lay on the western side, traversable during low tide, with one known as Dharavi accessible solely by boat. The tallest elevation within this arrangement was the conical peak of Kanheri, soaring at 467 metres in the northern expanse of the island. Presently, this locale houses the Sanjay Gandhi National Park, one of the world's largest parks situated within city boundaries. The five primary riverine systems the Mithi, Poisar, Oshiwara, Dahisar and Chenna originate from this park's grounds.

Over the subsequent 150 years, the islands underwent not only the bridging of gaps but also reclamation, driven by pressures to find more land for a growing population. The pressures of industrialisation and urban expansion imposed a significant toll on the delicate natural ecosystems within the city's confines. Mumbai, India's financial hub, magnetised countless aspirants who flocked to the city daily, contributing to its burgeoning population. The land reclamation efforts not only made all seven islands accessible but also merged the newly formed landmass with the mainland, giving rise to the Mumbai Metropolitan Region (MMR), encompassing 9 municipal corporations and 20 smaller municipal councils.

As the Mumbai landmass evolved, the river ecology underwent a series of transformations, disrupting other water ecosystems such as lakes, wells, creeks and wetlands. The onset of the industrial era replaced rivers as direct freshwater sources with piped water supply systems and tap connections, except for indigenous populations who maintained their reliance on these natural sources. This disconnect escalated over time, raising concerns about water security. As urban densities increased, land was increasingly absorbed for development, leaving minimal open spaces and channels for stormwater percolation, especially during the monsoon season. To mitigate flooding, natural channels like rivers, streams, and tributaries were transformed into drainage pathways for urban runoff, and for informal settlements, formal housing lacking drainage infrastructure, small-scale industries, and retail establishments along riverbanks. A staggering 40,000 million litres of sewage are generated daily by Indian cities, with a mere 20% undergoing treatment. The 2011 survey by the Central Pollution Control Board revealed that only 2% of towns possessed both sewage systems and treatment plants (Shah, 2015). 2700 million litres per day (MLD) sewage is being generated in Mumbai. Available sewage treatment capacity is 1998 MLD, where 1700 MLD sewage is collected for treatment. Out of 62 sewerage treatment plants (STPs), 4 have treatment capacity of more than 200 MLD and 48 STPs have a treatment capacity less than 1 MLD (Bawa, Nimkar, Khale *et al.,* 2014).

The Ramboll Foundation's 2015 report on the Mumbai case study indicated that over 50% of the city's Blue and Green Infrastructure (BGI*) had been compromised to accommodate expanding development. This BGI encompasses features such as hillocks, vegetated islets, water bodies, beaches, lakes, inter-tidal zones, and mangroves. The advancing high tide line encroaching upon inter-tidal zones led to the shallowing and narrowing of creeks and channels, disrupting drainage patterns. The proliferation of impermeable surfaces due to concretisation and vegetation loss, coupled with heightened surface runoff, resulted in the inefficacy of natural drainage systems. Consequently, the once-buffering rivers were encroached upon by development or informal settlements, culminating in heightened pressure on natural ecologies to maintain their functionality within the urban fabric.

This historical review traces the evolution of Mumbai's geography from estuarine ecologies to riverine watersheds and the rise of industries that shaped the island city into a connected megalopolis leading to an increasing disconnect between water ecologies. This narrative underscores the city's priorities, which propelled the transformation of deprived ecologies and contributed to the global crisis of climate change. As imbalances in stakeholder relationships and the detachment of economies and ecologies became more evident, natural resources and traditional livelihoods took a backseat (Dossal, 2010). Discussion of this progression culminates in a dialogue centred on the escalating indicators of these imbalances and disconnections.

I. The historical evolution of Mumbai's changing geographies: The progression of environmental disconnections

Mumbai's history spans over 300 years of reclamation efforts, reflecting a relentless struggle against the sea to accommodate its growing population. Emerging from a cluster of fishing villages inhabited by the Koli community[1] across seven islands, Mumbai's trajectory saw it pass through various rulers' hands, with constant interactions with the sea. Under the dominion of the Gujarat Sultanate, Mumbai was ceded to the Portuguese in the 16th century. In 1535, the area comprised an estuarine archipelago, with significant hilly islands to the north and lower-lying islands to the south. Over time, these islands coalesced into a single landmass through infill and reclamation, with its appellation shifting from the Marathi term *Mumba devi* to the old Portuguese phrase *bom baim*, (meaning 'good bay'). As the British East India Company acquired control of the area, the southern islands formed the nucleus of the sprawling urban conglomerate known today as Mumbai (Figure 1). The delineation between land and sea was further defined through survey techniques.

The first major reclamation project, the Mahim-Sion Causeway, was realised in 1708, connecting two islands. This endeavour was followed by subsequent projects such as the Hornby Vellard[2] - a causeway constructed over the shallows between Parel, Worli, Bombay, Mahim, and Mazagaon islands in 1782-84, which was one of the first major engineering projects aimed at transforming the original seven islands of Bombay into a single island with a deep natural harbour, setting the stage for further development. A more comprehensive reclamation plan was drawn up in 1843. The 18th century witnessed the emergence of causeways, bridges, embankments, and reclamation projects connecting the southern Bombay islands. The pace of reshaping the estuarine landscape was so rapid that by the 1860s, it was difficult to conceive Mumbai as based on an archipelago. Further land reclamation projects in the mid-19th century were supported by both local and imperial incentives.

In 1784, under Governor William Hornby's guidance, the Great Breach between Dongri, Malabar Hill, and Worli was sealed, resulting in the creation of Kamathipura. The connection between islands gained momentum, evidenced by projects like Bellasis Road and the construction of the Byculla Railway station. Hornby's major schemes in 1817 led to the reclamation of sea portions between islands, ultimately connecting five islands. By connecting all seven southern islands, Old Bombay emerged, encompassing 435 sq km. Subsequent expansion and consolidation efforts shaped the modern city of Mumbai. From

[1] See Hegde (2015) for discussion of the community.

[2] *Vellard* is a local modification of the Portuguese term *vallado*, meaning fence or embankment.

1870 to 1970, rapid industrial and commercial development necessitated further reclamation, leading to the creation of the Back Bay reclamation land.

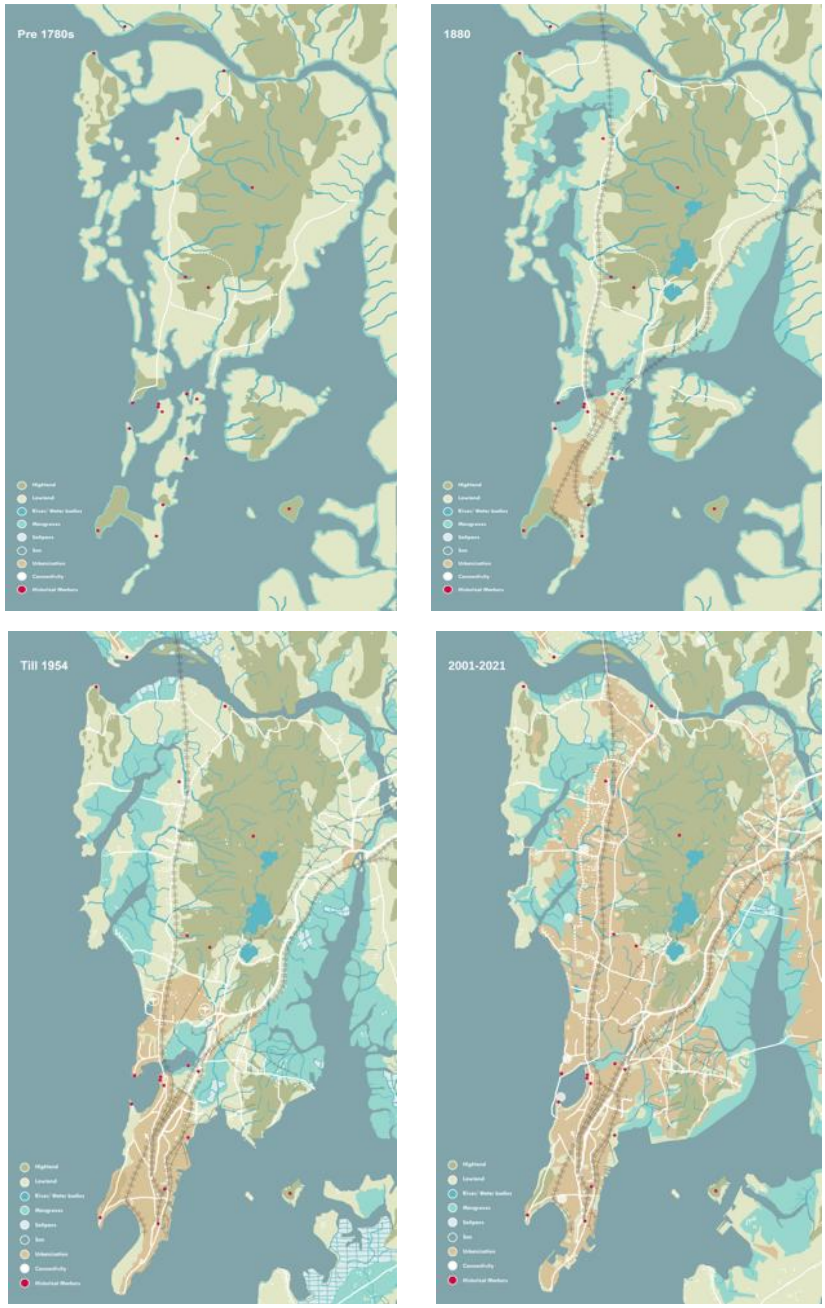

Figure 1 - Mumbai's spatial timeline (pre-1700, 1880, 1964 and 2000-2001) showing disappearing ecologies.

The Suez Canal's opening in 1869 reduced travel times between India, Europe and the east coast of the USA and allowed for increased export of Indian cotton and ushered in prosperity, fostering migration and infrastructure demand. Railway viaducts and road bridges connected Bombay to Sashti (Salsette island) and, in turn, Sashti to the mainland. Mumbai's expansion, driven by migration and industrialisation, placed immense pressure on once-functional natural ecosystems. Unplanned reclamation measures deteriorated the city's ecology, underscoring the altered geographies.

I.a. *Water dependencies and the imperative for native riverine ecological conservation and management*

The relationship between water sources and the people of Mumbai is intricate and spans a diverse array of elements, including rivers, streams, tanks, wells, reservoirs, and modern piped water connections. This narrative unfolds with a focus on optimisation, self-sufficiency, sustainability and the gradual disconnection that transpired in the 'post piped water' era. In a historical context, the island city of Mumbai historically is considered to be located on the seven islands to south. Salcette also known as Shashti (meaning sixty six and referring to 66 villages present there) is the larger island to the north forming part of greater Mumbai and Sopara (present day Vasai-Virar, with Nala Sopar as one of its railway stations), which was a port town in ancient India and is to the north of Salcette. With an average annual rainfall of around 2500mm, the islands of Bombay and Salcette were bestowed with abundant water resources, effectively harnessed by tanks and wells to fulfill not only drinking needs but also to support food production.

The development of knowledge systems related to water harvesting is revealed through remnants of ancient man-made dams and sophisticated rainwater harvesting systems at sites like Kanheri. The presence of tanks such as Banganga, along with other surviving reservoirs in the Salcette and Sopara regions, attests to this ingenuity. Even during colonial times, designating a significant portion of the city as catchment areas for reservoirs and subsequently supplying water through pipelines was made possible by the region's generous rainfall and the indigenous understanding of percolation potential and the preservation of freshwater within coastal and marine environments.

The Western Ghats (an area of uplands),[3] constituting 6% of India's land cover and inhabited by 8% of its 1.428 billion population, play a critical role in providing water resources for the southern region of the country. With an average annual rainfall of 250cm spanning 0.2 million sq km, nearly half of the 500 billion metric cubic metres of rainwater that falls on the Western Ghats is estimated to flow towards the western coast, nurturing rich biodiversity and supporting traditional livelihoods along the coastal stretch. However, the fragility of the Western Ghats and its vulnerability to human-induced activities are well-established, with recent catastrophic events directly attributed to insensitive infrastructure development, natural resource exploitation, and unchecked urban expansion (Gadgil *et al*., 2011). Despite their pivotal role, rivers along the west coast south of the Tapi River often assume the status of mere monsoon drains.

As Mumbai grapples with these complex dynamics, its historical relationship with water showcases indigenous water management practices that predate modern infrastructure. These practices were not only essential for water preservation but also formed the

[3] *Ghat* is a term used in the subcontinent to refer to a range of stepped hills.

backbone of support for local communities (Desai, 2013). However, rapid urbanisation and population growth have cast a shadow on Mumbai's water sources and infrastructure, giving rise to water scarcity and pollution (Figure 2). Amid the challenges of urbanisation and the looming spectre of human-induced climate change, the importance of resilient water management strategies becomes evident. Changing rainfall patterns and rising sea levels add urgency to the quest for effective solutions (Mishra et.al 2020). Furthermore, the preservation of riverine ecosystems emerges as a crucial aspect of conserving Mumbai's biodiversity. These ecosystems serve as havens for native species and provide essential habitats (Chavan & Pande, 2015).

The preservation of Mumbai's water resources requires more than infrastructure; it requires community participation. Engaging communities in riverine ecology conservation stands as a cornerstone of sustainable water resource management (Saberwal & Rangarajan, 2003). While governmental policies and regulations play a role in shaping water management practices, their effectiveness remains under scrutiny (Government of Maharashtra, 2018). Through the interplay of historical legacies, contemporary urban dynamics, climate resilience, biodiversity conservation, community engagement, and governance, the intricate tapestry of water dependencies in Mumbai comes to light. Preserving native riverine ecology becomes an imperative that bridges tradition and modernity, local stewardship and global concerns. This holistic approach holds the key to addressing Mumbai's evolving water challenges while ensuring a sustainable and thriving future.

Figure 2 - Multiple assaults on the Dahisar river bed: 1. Deep foundations of urban transit systems 2. The direct outfall from the public toilets of informal settlements. 3. High retaining walls offer complete visual disconnect (photo: Ajay Nayak, 2023).

I.b. *A missing narrative in a larger national dialogue on rivers*

The rivers within the Mumbai Metropolitan Region (MMR) have little prominence within the national discourse on significant rivers due to their reduced scale and the extensive pollution that has negated any recognition of them as a water source. The rivers in MMR – which include Vaitarna, Tansa, Ulhas, along with tributaries like Varan, Kamvadi, Kumbhari, Bhatsa, Kalu, Murbadi, Barvi, Poshir, Shillar, Peb; Amba, Bhogeshwar, Balganga, Patalganga, Kalundre, Navde, Taloja, Chenna, Dahisar, Poisar, Oshiwara, Mithi, and Mahur – have been found to have 'bad to very bad' water quality at most locations, barring just two spots during the pre-monsoon period (Environment Status Report of Mumbai Metropolitan Region [MMR], n.d.). The pollution renders these rivers unsuitable for activities such as drinking, bathing or fishing, further exacerbated by debris and waste accumulation that aggravate their contamination.

In April 2022 the Government of India designated 13 major rivers as 'National Rivers' due to their significance in water supply, irrigation, and transportation (Ministry of Jal Shakti, 2022). However, Mumbai's rivers fell short of meeting the criteria for such classification due to their perceived lack of importance for these essential functions. Although attempts to restore Mumbai's rivers have been initiated, the effectiveness of these efforts remains limited. The severity of pollution in Mumbai's rivers necessitates substantial investments of time and resources to induce meaningful change. Several reasons underpin the omission of Mumbai's rivers from the list of significant national rivers:

1. Reduced Scale: Mumbai's rivers are comparatively shorter and narrower compared to the major rivers in India.
2. Urbanisation Impact: urban expansion has encroached upon the riverbanks, leading to diminished river widths.
3. Infrastructure Consequences: urban development, marked by the construction of roads, bridges, and buildings along riverbanks, has constricted rivers like Dahisar, Mithi, Oshiwara, and Poisar. This constriction reduces their capacity to accommodate monsoon rainfall and heightens the risk of flooding.
4. Limited Water Supply: Mumbai's rivers provide insufficient water volumes for irrigation or drinking purposes.

Furthermore, construction activities have disrupted the rivers' natural flows, resulting in sediment accumulation and debris build-up. This complex interplay not only diminishes the rivers' width but also alters their flow dynamics, making navigation during monsoons more perilous.

The rapid urbanisation of Mumbai has far-reaching consequences not only for the city's physical landscape but also for its delicate riverine ecosystems (Figure 3). Urban expansion encroaches upon once-natural riparian zones, contributing to habitat degradation and riverine environment erosion. This urbanisation-linked pollution, coupled with the proliferation of impermeable surfaces and unchecked waste disposal, exacerbates the deterioration of Mumbai's rivers (Patankar & Sharma, 2019). The degradation of Mumbai's rivers reverberates across socio-economic strata, disproportionately affecting marginalised communities. Water source contamination disrupts clean water accessibility, disproportionately impacting vulnerable populations reliant on tainted water sources. Additionally, declining water quality and aquatic ecosystems have direct ramifications for traditional livelihoods like fishing, reliant on robust riverine ecosystems (Uttara et.al, 2012).

Pollution in Mumbai's rivers carries direct implications for public health, fostering waterborne diseases and health complications among residents (Kakde *et al.,* 2014). Moreover, the visual degradation and noxious odours of polluted rivers cast an unfavourable light on public perception and urban living quality, subsequently influencing tourism and local economies (Mishra *et.al.,* 2020). Despite formidable challenges, endeavours aiming to restore and conserve Mumbai's rivers have surfaced. Notably, initiatives like the Mithi River Development and Protection Authority have diligently worked to enhance the condition of the Mithi River. These initiatives encompass a spectrum of actions, from riverbed cleansing and desilting to controlling encroachments and fostering environmental awareness within local communities (Schmutz *et. al.*, 2018). These initiatives underscore the pivotal role of collaborative efforts involving governmental bodies, local residents, and environmental organisations. The revival of Mumbai's rivers hinges upon comprehensive urban planning approaches. Incorporating river management strategies within urban planning frameworks safeguards natural riparian belts, mitigates pollution, and bolsters flood resilience (Chavan & Pande, 2015). Such integrated approaches harmonise urban growth with ecological conservation, culminating in a more sustainable urban milieu.

Figure 3 - Metro line and vehicular bridge across the Dahisar River before it connects to the mangroves and the creek (photo: Vikram Pawar, 2023).

When juxtaposed with other river-based cities across the subcontinent, where sources are distant and disconnected from cities that both draw water and dump waste into them without consideration of downstream impacts, Mumbai's unique context provides an

opportunity for in-depth study. Additionally, Mumbai's affiliation with the Western Ghats, a UNESCO World Heritage Site, underscores the significance of its riverine ecosystems, fostering potential for further exploration and conservation initiatives. Amid the prospect of intensifying urbanisation and the growing frequency of climate change-related events, Mumbai's urban-river relationship offers valuable insights for shaping more sustainable urban futures.

I.c. *Diversity density and demand: Unveiling the* nullah *in native ecologies and riverine ecosystems*

The term *nullah* originates from the Indian hinterlands, denoting a watercourse that flows through steep valleys, often providing drinking water for local communities (Kelkar & Kumthekar, 2019). In Maharashtra, it represents more of a run-off than a sewage channel. However, within urban contexts, it transforms into a polluted water channel meandering behind houses, laden with city waste. This dual identity is historically significant. Between 1870 and 1890, Mumbai initiated significant centralised water infrastructure development to meet industrial demands. Nonetheless, the city was struck by its first major flood in 1985, disrupting rail and road traffic and causing substantial financial losses. Urbanisation, compromised natural drainage systems and land reclamation and altered topography, exacerbating stormwater discharge issues.

In the 1970s, many industries left Mumbai, and the city transitioned to a service-oriented economy. This led to an increase in the population, which put a strain on the city's stormwater disposal system. In 1993, the Brihanmumbai Stormwater Disposal System (BRIMSTOWAD) project involved extensive studies on drainage and sewer management by Watson Hawksley International Pvt Ltd and Messrs A.I.C. The project did not account for unchecked waste disposal and encroachment on riverbeds. The city's stormwater and sewer drainage system is over 100 years old and spans 480 km. It includes underground and roadside drains and major nullahs. The system is designed to handle a rain intensity of up to 25mm per hour at low tide. However, the system is often overwhelmed by heavy rains, leading to flooding and waterlogging. The collapse of the stormwater and sewer drainage system has given nullahs a negative connotation. Nullahs are natural waterways that are used to drain rainwater. However, they have become polluted due to unchecked waste disposal.

Mumbai features 107 major outfalls, with some directly draining into the Arabian Sea, Mahim Creek, Mahul Creek, or Mithi River. The significance of rivers in stormwater discharge is evident through these statistics, suggesting the potential for restoration to provide biodiversity hotspots and 'sponges'[4] for excess stormwater. The drainage challenge in Mumbai goes beyond traditional infrastructure, emphasising the importance of natural drainage. However, the slum rehabilitation scheme (SRS) has led to encroachments on natural drainage sites, exacerbating the *nullah*-blockage problem. Moreover, reclamation projects contribute to poor landward drainage, as evidenced in Bandra and Malad.

Obstructions within drains and their deteriorating conditions contribute to runoff stagnation. The slow process of desilting water drains due to blockages from other services, such as water and sewage pipes, exacerbates the issue. The outdated stormwater drainage system, designed for a maximum of 25 mm of rain per hour during high tide, combined

[4] A term used in urban planning to refer to areas in which water can drain – rather than simply move across impermeable grey infrastructures.

with inadequate structural conditions, amplifies the problem. The unplanned development further complicates drainage, divided into seven sewer zones, each posing unique sewage collection, treatment, and disposal challenges.

The ramifications of degraded rivers extend beyond ecology, significantly impacting marginalised communities and public health. Contaminated water sources expose vulnerable populations to waterborne diseases, exacerbating health disparities. Additionally, the decline in water quality disrupts traditional livelihoods such as fishing, undermining socio-economic stability (Uttara *et.al*, 2012). The degradation of Mumbai's rivers triggers concerns beyond health and livelihoods. Polluted and unsightly rivers diminish the public perception of the city's liveability and aesthetic appeal. This degradation could negatively influence tourism and local economies (Mishra *et.al*, 2020).

Despite the challenges, efforts to restore Mumbai's rivers are underway. Initiatives like the Mithi River Development and Protection Authority underscore the importance of community involvement and environmental awareness campaigns (Schmutz *et.al*, 2018). Collaborative efforts between governmental bodies, local communities, and environmental organisations are crucial for effective river restoration. In light of the urgency of addressing the declining state of Mumbai's rivers, integrated urban planning is imperative. Coherent policies that prioritise ecological restoration alongside urban development can pave the way for resilient, sustainable, and inclusive cities (Ande, 2015). By embracing a nature-based approach to urban planning, Mumbai can reclaim its rivers, foster biodiversity, enhance the quality of life, and mitigate urban vulnerabilities.

Mumbai's rivers embody historical, ecological and cultural narratives, encapsulating the multifaceted relationship between urbanisation and natural ecosystems. The term *nullah*, with its duality of meaning, mirrors the complexity of this relationship. The journey from *nullah* to a thriving river necessitates a paradigm shift in urban planning and environmental consciousness. Through collaborative efforts, ecological restoration, and policy innovation, Mumbai can re-establish its rivers as vibrant symbols of sustainable urban living.

II. The case of the Dahisar River

II.a. *The profile of the Dahisar River*

Dahisar River, originating in Tulsi Lake within Sanjay Gandhi National Park (SGNP) at the northern boundary of Mumbai, flows through diverse landscapes (Figures 4 & 5), encompassing both the protected areas of the park and the urban suburbs. Spanning 12 km, the river's catchment area covers 3488 hectares, experiencing an annual rainfall of 1685mm. It consists of 20 sub-catchments, each contributing to its flow. Dahisar River's trajectory leads it from the Sanjay Gandhi National Park through areas such as Sri Krishna Nagar, Daulat Nagar, Leprosy Colony, Kandar Pada, Sanjaynagar, and Dahisar Gaothan (an indigenous settlement), ultimately emptying into the Arabian Sea via Manori Creek. The river's basin encompasses 34.88 km^2, with varying ground elevations ranging from 0.35 to 490.35 m above mean sea level (MSL). The upstream region exhibits higher ground elevation, while the downstream area displays a gentler gradient. Noteworthy *nallah*s (streams) linked with the river within its catchment include Rawal Pada Nallah, Chandawarkar Lane Nallah, Ghartan Pada Nallah, and Bhayander-Mira Nallah. The river's

course is marked by distinct segments, each characterised by similar land uses and challenges, mirroring the rapid urbanisation trends of the region.

Figure 4 – The Dahisar River within the SGNP boundary (photo by Kimaya Keluskar, 2022).

Figure 5 – The Dahisar River exiting the SGNP (photo by Kimaya Keluskar, 2022).

The Dahisar River, amidst the urban landscape of Mumbai, harbours a surprising diversity of flora and fauna that contribute to its ecological significance. The river's riparian zones and surrounding habitats provide a haven for various species, showcasing the intricate web of life within this urban ecosystem. Meiofauna frequents the riverbanks, with sightings of kingfishers, herons, and egrets showcasing the importance of the river as a feeding and breeding ground for these birds. These avian species not only bring vibrancy to the area but also play a role in controlling insect populations (Kavita Salian *et.al.*, 2022). Apart from birds, the river sustains a range of aquatic life, including various fish species. Fish diversity is crucial not only for the river's ecosystem health but also for the livelihoods of local communities that rely on fishing. The presence of fish species indicates the overall water quality and ecosystem balance, making their conservation a priority (Kavita Salian et.al, 2022). Additionally, the vegetation along the riverbanks and adjoining areas contribute significantly to biodiversity. Various plant species, both native and exotic, thrive in these habitats, supporting insect populations, providing shelter to small mammals, and enhancing the overall ecological resilience of the region. Insects, often overlooked but integral to any ecosystem, also find their home along the Dahisar River. The interplay between insects and the vegetation they feed on creates a dynamic ecosystem that forms the base of the food chain. Insect diversity is crucial for maintaining ecosystem health and for providing food to higher trophic levels such as birds and small mammals (D'Cruz, 2019).

The Dahisar River's biodiversity underscores the importance of efforts to conserve and restore it. The presence of diverse species indicates the potential for ecological recovery and revitalisation. By safeguarding this biodiversity, Mumbai can not only enhance its urban ecology but also create spaces for residents to reconnect with nature and experience the richness of urban biodiversity.

II.b. *The impact of the 2005 deluge and Chitale Commission report recommendations*

On 26th July 2005 a major rainfall event that recorded 944 millimetres in a single day inflicted economic and social devastation upon the region. During this deluge, approximately 10,000 residences and businesses in Rawal Pada, Ghartan Pada, and Sri Krishna Nagar bore the brunt, with submersion leading to substantial losses. Water levels surged to around 2.5 metres in these areas, exacerbated by the influence of high tides that raised water levels even further to about 3 metres in locations like Daulat Nagar, Leprosy Colony, Mhatre Wadi, and Kandar Pada. This calamity underscored the critical need for a comprehensive investigation into the viability of tide regulatory gates at the river's mouth. The impact of the deluge left thousands of poverty-stricken families bereft of shelter overnight, stripping them of their entire livelihoods.

Dahisar (Figure 6) is one of rivers that flooded during 2005 deluge and Chitale Commission report recommendations were made for the Dahisar river as well along with Mithi, Poisar and Oshiwara. Among the distinctive attributes of the Dahisar River catchment (Figure 7), the presence of both dense and sparse vegetation emerges as noteworthy. These features ought to be harnessed to fulfil their intended roles in shaping the environmental behaviour of the basin. In particular, implementing ponding facilities within the Category 4 area could enhance the basin's long-term sustainability and contribute to the quality of life in the vicinity of these ponds. Comprehensive studies in this context are indispensable to guide effective implementation.

Figure 6 – The Dahisar River water level during the monsoon season (photo: Vikram Pawar, 2019).

Sr. No.	Class	Area in Ha	% of Total Area
1	Slum (Dense Built-up Land)	376	9
2	Built-up (Spare)	650	15
3	Dense Vegetation/Forest Cover	842	20
4	Spare Vegetation	1344	32
5	Barren Land	208	5
6	Land with Grass/Rough Pasture	309	7
7	Mangrove Forest	294	7
8	Marshy Vegetation	9	0
9	Exposed Rock	157	4
10	Water Body	37	1
	Total	**4226**	**100**

Figure 7 – Distinctive features of the Dahisar River catchment

Tragically, the riverbed and banks of the Dahisar River have fallen victim to encroachments that have constricted and compromised the watercourse, magnifying the hazards of

flooding. Alarming field observations reveal that the river contends not only with debris from construction and industrial activities but also with municipal solid waste dumping into its waters. The situation is further exacerbated by inadequate annual desilting efforts. Bank encroachments by buildings, industries and slums, along with alterations to the river's course and local stream diversions, have compounded the flood risk. A non-exhaustive list of glaring encroachments includes bridges spanning the Dahisar River between the Western Express Highway and S. V. Road, a marble shop adjacent to the Western Express Highway, encroachments within the Leprosy Colony, slum pockets stretching between Bhagwati Hospital and Rustamji Park, and Ranchhoddas Marg. Addressing the issue of flow obstructions and encroachments requires swift action to mitigate their impacts.

The aftermath of the 2005 Deluge prompted the Maharashtra government to commission a fact-finding report on the floods from a committee headed by former chairman of the Central Water Commission, Madhav Chitale (often referred to as the Chitale Report) that was completed in 2006 and offered recommendations to rectify the situation. The BMC (Brihanmumbai Municipal Corporation) took cues from the commission and proposed a series of measures. These included the removal and relocation of unauthorised structures along the riverbanks, the construction of retaining walls, the establishment of sewage treatment plants with capacities of 0.5 MLD, 1 MLD, and 5 MLD at specific locations, the widening of the river at certain points through the removal of unauthorised settlements, and the enhancement of drainage capacities through new sewer construction and nullah widening. Although these engineering solutions were implemented, they largely disregarded the integral ecological and environmental aspects of the river and its basin. Consequently, a comprehensive approach that encompasses a variety of factors is pivotal to effectively addressing the complex issue of urban flooding. Furthermore, the presence of Sanjay Gandhi National Park (SGNP) in proximity to the Dahisar River underscores the urgency for ecological restoration and rejuvenation. The incorporation of nature-based solutions and a robust e-governance model not only aids flood mitigation but also yields additional environmental benefits. E-governance is important for monitoring activities for various kinds of projects proposed by the government with respect to urban rivers. The data is available to all to access and understand the impact of the project on social, economic as well as environmental aspects of the city and its blue infrastructure. The model needs to be created and practiced to achieve efficiency and innovation in the field of water resilience in urban environments especially coastal cities where vulnerability index is high with respect to climate change and sea level rise. This approach can facilitate excess water discharge during monsoons while enhancing the city's overall surface drainage system.

The case of the Dahisar River epitomises the fate of many urban rivers that gradually succumb to the repercussions of inadequate planning and execution by administrative bodies, exacerbated by the mounting pressures of urbanisation. However, the adjacency of Sanjay Gandhi National Park elevates the Dahisar River's significance, rendering it a component of a broader biodiversity hotspot when compared to neighbouring rivers like Poinsar and Oshiwara. The presence of the national park at the river's mouth, along with the *gaothan* (traditional village) at its end, injects optimism for the potential of ecological restoration and conservation efforts. This article probes into the challenges and stigmas that plague urban rivers through the example of the Dahisar River, which navigates through forest boundaries and compromised urban neighbourhoods in the suburbs.

The proliferation of concrete walls along the banks of the Dahisar River has had significant implications on urban flooding within the region. These rigid structures, initially intended to channel and contain the river's flow, have inadvertently exacerbated the problem by impeding natural water absorption and increasing runoff during heavy rainfall events. The concrete walls restrict the river's ability to naturally expand its course, trapping water within its confined channel and preventing excess water from being absorbed by the surrounding soil. This situation becomes particularly critical during intense downpours and cloudbursts, where the rapid inflow of rainwater overwhelms the capacity of the river and its constricted banks. This phenomenon leads to water overflow, inundation of adjacent areas, and a heightened risk of flooding. Research has indicated that the alteration of natural river morphology through concrete structures disrupts the delicate balance between flow capacity and flood resilience. The resulting reduced permeability and increased velocity of water contribute to the amplified vulnerability of urban areas to flooding events (Rafiq *et al*., 2016). The prevalence of concrete walls along the Dahisar River underscores the need for a reimagined approach to urban river management that prioritises ecological considerations and supports sustainable flood mitigation strategies (Figure 8).

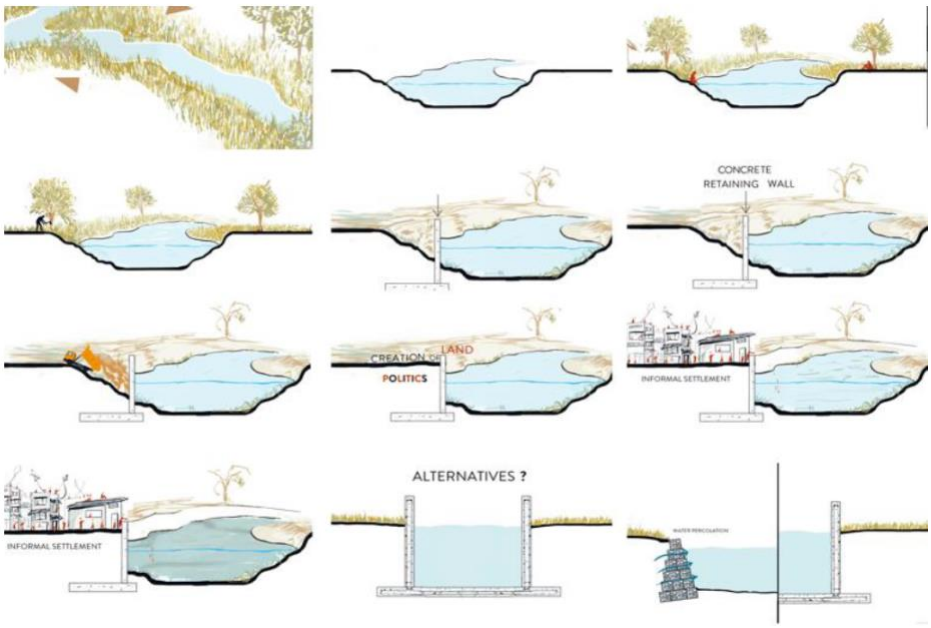

Figure 8 – Process of concretisation of river edges in Mumbai and proposed alternative for river training work.

II.c. *Shifting the paradigm: Towards a holistic approach for urban rivers*

The rivers of Mumbai bear witness to a historical connection that extends beyond mere ecology. They hold cultural significance, particularly in the context of *gaothans*, which persist to this day as vibrant communities with fishing as their primary livelihood. These communities share an intrinsic bond with Mumbai's rivers, rooted in the network of wells that once lined the riverbanks, supplying water to the *gaothans*. However, over time, the

network of wells has declined, falling victim to urban development, and many have been dismantled. Some remnants of these wells still exist along the Dahisar River, though they are either abandoned or contaminated, rendering them ineffective as water sources for the community. Moreover, the advent of piped water systems in households has gradually severed the age-old dependency on these natural resources. Meanwhile, informal settlements have encroached upon the riverbeds, further complicating the situation.

The intricate interplay of amenities and livelihoods along the riverbanks draws various authorities into the equation. Given the monumental scale of the challenge, a systematic approach is imperative, necessitating the engagement of all stakeholders. The project's vast scope demands the convergence of ecology and technology, forging a robust methodology. The historical trajectory of natural resources within the city, coupled with significant events like the recurrent floods that have afflicted Mumbai, highlights the insensitivity exhibited by administrative bodies and authorities towards these vital resources. Mumbai's Land Use Development Plan Map #2034 (2018) is a testament to this shift, acknowledging the existence of rivers only after persistent objections raised by individuals, committees, and advocacy groups who have consistently pressured authorities through protests and activations. This underscores the dire need for a reformative approach within government bodies entrusted with the management of natural resources.

The lack of empathy towards natural systems underscores the urgency for knowledge enhancement within various organisations and departments. Capacity building is pivotal to nurturing the expertise required to undertake such an intricate, large-scale project. Recognising that rivers are dynamic, interconnected entities, the proposed solution demands a holistic approach that encompasses the entire watershed, from the upstream to the downstream where the river meets the sea. This approach can draw inspiration from the concept of ecosystem services, utilising it as a catalyst to generate innovative governance tools and advocacy strategies. In doing so, stakeholders, aquatic life, and terrestrial ecosystems can collaboratively shape the restoration journey.

Central to this endeavour is the creation of a comprehensive water discourse, meticulously designed with a robust framework. This discourse can serve as a common platform for all stakeholders, enabling them to define their roles and responsibilities across the entire restoration timeline. As the city transitions from being an island to a resilient urban hub, the integration of blue and green infrastructure is pivotal. By restoring and enhancing these vital components, Mumbai can attempt to ensure a harmonious coexistence of ecological, societal, and economic interests, redefining its relationship with its rivers and securing a sustainable future for generations to come.

III. Rivers as Climate Risk Mitigation Measures

III.a. *Socio-cultural tools for engagement*

Along the rivers of Mumbai, a network of wells once symbolised traditional knowledge systems that provided potable water to the *gaothans*, sustaining their daily needs. However, due to the aforementioned well contamination along the Dahisar river, these wells were abandoned or repurposed solely for activities like clothes washing and rickshaw cleaning. The advent of piped water systems in households further reduced the community's dependency on these natural resources. The amenities and livelihoods along

the river edges connect diverse authorities and socio-economic categories, forming a complex network (Shah *et al.*, 2020).

Many indigenous cultures worldwide revere rivers as sacred, a phenomenon observed in Africa, South America, Oceania, and Asia (Chattaraj, 2022). In India, numerous rivers are personified as goddesses or mothers, reflecting their cultural significance (Gupta, 2017). Notably, New Zealand and Bangladesh granted rivers living entity status in 2017 (Gupta, 2017). While the High Court of Uttarakhand granted Ganga and Yamuna similar status, legal challenges arose, questioning the practicality of implementing rights and duties for rivers (Hansche, 2021). This perspective, however, often applies to perennial rivers, leaving seasonal rivers like Dahisar (with intermittent dry periods) overlooked, despite their vital ecosystems (Shah *et al.*, 2020).

The scale of river conservation requires systematic engagement with stakeholders to integrate ecology and technology, considering historical resource evolution, urbanisation pressures, and development plans. The development plan for 2034 acknowledged rivers after sustained advocacy efforts. However, a lack of empathy towards natural systems in urban planning necessitates reform within government bodies. Capacity-building is crucial across organisations and departments for a project of such magnitude (Shah *et al*., 2020).

Global frameworks like Integrated Water Resources Management (IWRM) promote sustainable and coordinated development and management of water resources, ensuring social, economic, and environmental sustainability (UNESCO, 2021). In alignment with global efforts, the Sustainable Development Goals (SDGs) recognise the importance of water-related challenges, particularly Goal 6, which aims to ensure the availability and sustainable management of water and sanitation for all (United Nations, 2021). Integrating these frameworks can provide a comprehensive approach to river restoration and conservation, transcending local boundaries and perspectives.

A watershed-based approach at the watershed level from upstream to downstream could utilise ecosystem services as tools for governance and advocacy. Incorporating ecosystem services can help establish a common platform for stakeholders, aiding the transformation of the island city into a resilient hub by restoring blue and green infrastructure. The restoration of rivers, whether through cultural, ecological, or technological means, is a global concern (Shah *et al.,* 2020). Moreover, the impact of river restoration extends beyond ecological benefits to economic gains. Healthy river ecosystems contribute to local economies through services like water supply, fisheries, and tourism. Active community involvement and interdisciplinary collaboration are essential to successful river restoration projects (Tallis *et al.,* 2008). Additionally, river restoration contributes to biodiversity conservation by creating habitats for various species (Naiman *et al.,* 1993). However, the challenges of informal growth in ecologically sensitive areas and the need for a well-defined policy framework should not be underestimated. Successful river management also requires acknowledging rivers' roles in urban planning and integrating terrain information into development plans (Hawken *et al*., 2021).

In the context of the Dahisar River restoration, the integration of nature-based solutions (NbS) with socio-cultural tools presents a dynamic approach to address urban river management challenges while harnessing the benefits of both ecological and human systems. Socio-cultural tools, encompassing traditional knowledge, community engagement, and cultural values, offer a profound understanding of the river's significance to local communities. The historical network of wells along the Dahisar River exemplifies

the intrinsic connection between human societies and the river ecosystem. Moreover, indigenous cultures globally have revered rivers as sacred entities, illustrating their deep spiritual and cultural importance (Chattaraj, 2022). By recognising and building upon these socio-cultural aspects, the restoration project can foster community involvement, promote awareness, and instil a sense of stewardship among residents.

Nature-based solutions complement socio-cultural tools by aligning with the natural processes of the river ecosystem. Strategies such as wetland restoration, reforestation of riparian zones, and green infrastructure development can synergise with the existing socio-cultural fabric. The revitalisation of traditional wells and their incorporation into wetland restoration efforts not only brings back historical water sources but also enhances flood resilience by creating water-absorbing landscapes (Naidoo *et al.,* 2008). These solutions capitalise on the river's historical importance while addressing contemporary challenges.

The benefits of such an integration of nature-based solutions and sociocultural tools amplifies the project's effectiveness in the following regards:

1. Community Empowerment. Engagement with local communities through their socio-cultural ties to the river fosters a sense of ownership and commitment to its restoration.
2. Ecosystem Resilience. Nature-based solutions rooted in ecological principles strengthen the river's ability to absorb excess water, minimising flooding and erosion risks.
3. Cultural Revival. The revival of traditional wells and promotion of cultural practices reconnect communities with their heritage, enhancing cultural resilience.
4. Education and Awareness. Socio-cultural tools provide platforms to educate communities about the ecological importance of the river and the role of nature-based solutions.
5. Sustainable Livelihoods. Incorporating eco-tourism, traditional fishing practices, and other sustainable activities can generate livelihoods linked to the river's restoration.

By intertwining socio-cultural tools and nature-based solutions, the Dahisar River restoration project can create a holistic framework that nurtures the river's ecological health while respecting its cultural significance. This approach not only leverages traditional wisdom but also harnesses the regenerative power of natural processes for a more resilient and sustainable urban environment.

III.b: *Harnessing transformative change: A holistic approach for urban rivers*

The process of restoring and transforming urban rivers in coastal Indian cities requires a multifaceted approach that blends socio-cultural tools with nature-based solutions. By recognising rivers as potent tools for holistic urban development, a comprehensive strategy emerges that amalgamates diverse concepts and strategies.

i) Watersheds and ownership: A geo-hydrological paradigm

Watershed development provides a foundational framework for comprehensive urban river management. It entails conserving, regenerating, and balancing the use of natural resources within a geographical unit. Watersheds, rooted in physical and societal

interactions, offer an ideal canvas for inclusive and sustainable urban planning. Going beyond conventional land-based ownership to acknowledge rivers' fluid nature becomes imperative. Collaborative platforms, uniting stakeholders around a shared vision, facilitate coordinated participatory planning and implementation.

ii) Integration of socio-cultural tools: Cultural relevance and engagement

The fusion of socio-cultural tools with restoration efforts yields a transformative alliance. This alliance acknowledges the emotional and moral connection communities have with their rivers. Rejuvenating traditional practices such as fishing and engaging with indigenous narratives rekindles rivers' cultural significance. By mobilising citizens and fostering collective consciousness, this approach catalyses the safeguarding of these vital water bodies.

iii) Nature-based solutions: Merging heritage with ecology

Nature-based solutions can harmoniously blend with socio-cultural tools, grounding restoration in ecological principles. Strategies like wetland restoration, riparian zone revival and green infrastructure can align with rivers' historical essence while addressing contemporary challenges. The incorporation of traditional wells within wetland restoration not only revives historical water sources but also bolsters flood resilience (Naidoo *et al.,* 2008). This amalgamation of cultural heritage and ecological wisdom nurtures a balanced urban ecosystem.

The integration of socio-cultural tools and nature-based solutions produces a range of benefits:

1. Community Empowerment. Communities connected through cultural heritage become empowered stewards, actively participating in river restoration and conservation.
2. Ecological Vigour. Nature-based strategies enhance rivers' capacity to absorb water, reducing the impact of floods and erosion.
3. Cultural Renaissance. By resurrecting traditional practices, communities regain their cultural identity and values.
4. Educational Platforms. Cultural events, guided tours, and educational programs raise awareness about rivers' ecological and cultural significance.
5. Sustainable Livelihoods. The reintegration of cultural practices, such as fishing, can foster sustainable livelihoods linked to the river.

iv) The narrative of transformation: Fostering collective change

Through alignment with the transformative change-making process, a compelling narrative emerges. This narrative envisions rivers not merely as ecological assets but also as economic drivers, enriching urban life. Workshops and community engagements facilitate dialogues, enabling diverse stakeholders to converge on a common vision.

v) Reimagining urban Infrastructure: Balancing form and function

Revamping urban infrastructure involves transitioning from concrete-bound channels to eco-sensitive buffer zones. Eco-friendly embankment slopes, restoration of riverbed porosity, and innovative reinforcement techniques counter soil erosion while preserving ecological integrity (Figure 9).

Figure 9 - Widening the existing bridge and increase in the elevated level of the bridge as a measure of flood mitigation strategy by the governing authorities (photo: Vikram Pawar, 2023).

vi) Inclusive Governance: Facilitating Collaborative Management

River cell units hosted by municipalities can promote comprehensive river governance by uniting experts, communities, and governance bodies. These units can drive collaborative watershed development, transcending administrative barriers.

vii) Driving holistic transformation: A path forward

The integration of sociocultural tools, nature-based solutions, and transformative narratives yields a dynamic approach to urban river rejuvenation. It revitalises the bond between people and rivers, redefines urban development, and positions urban rivers as agents of equitable, sustainable, and resilient cities.

III.c. *Aligning with sustainable development goals and economic models for Indian urban river restoration*

Indian urban river restoration efforts can find strong alignment with the United Nations' SDGs, presenting a strategic framework that integrates environmental rehabilitation, socio-economic well-being, and holistic urban development. Additionally, integrating an economic model further strengthens the case for reviving urban rivers, emphasising their role as crucial assets for sustainable growth in Indian cities. The SDGs can serve as a comprehensive roadmap for fostering sustainable development across diverse dimensions on several counts:

1. Clean water and sanitation (SDG 6). Revitalising urban rivers enhances water quality, ensuring access to clean and safe water for local communities.

2. Life on land and life below water (SDGs 14 and 15). Indian urban river rejuvenation supports terrestrial and aquatic ecosystems, promoting biodiversity and contributing to the conservation of land and water habitats.
3. Sustainable cities and communities (SDG 11). Urban river revival enhances the urban environment's aesthetics, quality of life, and resilience against disasters, fostering sustainable urbanisation.
4. Partnerships for the goals (SDG 17). Collaborative river management mobilises governments, local communities, NGOs, and businesses, fostering collective efforts to restore urban rivers and achieve sustainable development.

Economic models can be used to quantify the benefits of river revival, making a stronger case for investing in these initiatives. The benefits of river revival can be difficult to quantify, but economic models can help to estimate the value of these benefits. This can make a stronger case for investing in river revival, which can have a positive impact on the environment and the economy. For example, a study by the World Bank found that the economic benefits of river revival in India could be as high as $100 billion per year (Brisco & Mailik, 2006). This includes benefits such as improved water quality, reduced flood damage, and increased tourism. By quantifying the tangible benefits of river revival, economic models can help to elevate the argument for Indian urban river revival. This can make it more likely that governments and investors will support these initiatives.

1. Ecosystem services. Assigning economic value to the ecosystem services provided by restored urban rivers, such as flood control, water purification, and recreational opportunities, offers a measurable indication of their contribution to India's economy.
2. Tourism and recreation. Revived urban rivers attract tourism and recreation, generating revenue streams, job opportunities, and economic growth, while also invigorating local businesses.
3. Property values. The proximity of properties to rehabilitated urban rivers positively influences property values, resulting in indirect economic gains for local communities and municipal bodies.
4. Job creation. River restoration projects create employment opportunities across various sectors, from construction and landscaping to eco-tourism and education, contributing to local economic development.
5. Cost-benefit analysis. Economic models guide resource allocation by providing a structured framework for assessing the long-term advantages of restoration against initial investments.

The integration of SDGs and economic models facilitates a collaborative framework that reinforces the rationale for restoring Indian urban rivers. This approach underscores the significance of breaking down silos and encouraging comprehensive participation, enabling stakeholders to communicate effectively, make well-informed decisions, and drive transformative change. The alignment of SDGs with economic models represents a powerful strategy that leverages the inherent synergies between ecological restoration and economic growth in the context of Indian urban river revival. This integrated approach serves as a catalyst for unlocking broad-based support and active participation from various stakeholders, including government bodies, private sector entities, civil societies, and local communities, enabling them to pursue:

1. A holistic vision that envisions urban river restoration not merely as an ecological endeavour but also as a comprehensive strategy that addresses multiple

dimensions of sustainable development. By considering both the environmental and economic aspects, the restoration efforts take on a holistic character that resonates with a broader audience.

2. A common agenda that bridges the interests of diverse stakeholders that aligns the goals of environmental protection and economic well-being, forging a common ground where various entities with distinct priorities find overlapping objectives.
3. Investment Attraction via economic models that offer quantifiable data on the potential benefits arising from urban river restoration. This data includes economic gains from increased tourism, enhanced property values, job creation, and improved ecosystem services. As a result, the economic rationale behind restoration becomes evident, attracting investments from both the public and private sectors.
4. Informed decision-making. The combination of SDGs and economic models empowers decision-makers with comprehensive information that enables them to weigh the ecological, social, and economic implications of restoration projects, facilitating more informed and balanced choices that align with sustainable development objectives.
5. Collaborative partnerships among stakeholders. Government entities can collaborate with private sector players to fund and implement restoration projects that yield economic benefits while achieving environmental goals. Civil societies and local communities can actively participate by contributing their insights, resources, and efforts towards shared objectives.
6. Local Ownership. Restoration projects that demonstrate economic viability hold greater appeal for local communities. As these communities perceive tangible benefits, their ownership and engagement in the projects increase. This local ownership further ensures the long-term success and sustainability of restoration initiatives.
7. Public Awareness. The integration of SDGs and economic models generates compelling narratives that can resonate with the public. This can highlight the positive impact of river restoration on quality of life, economic prospects and environmental well-being. This awareness mobilises public support, creating a demand for restoration actions.
8. Policy advocacy. The integrated approach provides evidence-based arguments that can drive policy changes and regulatory support for urban river restoration. Data-backed economic models bolster policy advocacy efforts by showcasing the socio-economic advantages of restoration, making a stronger case for government interventions.

In essence, the alignment of SDGs with economic models creates a dynamic synergy that not only amplifies the restoration efforts' impact but also garners support from a diverse array of stakeholders. This integrated approach transforms urban river restoration from a niche environmental concern to a shared mission that advances the socio-economic prosperity of Indian cities while safeguarding their ecological health.

Conclusion

The transformation towards creating healthy cities through the restoration and preservation of urban rivers necessitates a comprehensive and multi-faceted approach. This initiative involves engaging a diverse range of stakeholders through experiential tools

and conscious communication strategies. By taking children and adults to natural heritage areas, creating educational immersions to assess riverine health parameters, and leveraging the presence of the Sanjay Gandhi National Park, the narrative of healthy cities can be driven with a blend of awareness about impending threats and the promise of positive change. Furthermore, integrating SDGs into the restoration efforts amplifies the impact and relevance of this initiative. The SDGs provide a strategic framework that aligns with ecological rehabilitation, socio-economic well-being, and holistic urban development. The restoration of Indian urban rivers directly corresponds to several SDGs, including clean water and sanitation, life on land and life below water, sustainable cities and communities, and partnerships for the goals. By adopting the SDGs as guiding principles, urban river restoration gains a broader significance that resonates with international agendas for sustainable development.

In addition to the integration of the SDGs and economic models, the implementation of a strong governance and advocacy model further enhances the potential for successful urban river restoration. Effective governance is a cornerstone of any transformative change, ensuring that policies are enacted, resources are allocated, and stakeholders are engaged in a coordinated manner. A robust governance framework should involve government bodies, (NGOs, local communities, and private sector entities (Borrini-Feyerabend *et al*., 2013). This collaborative approach allows for diverse perspectives and expertise to be integrated, leading to well-informed decision-making.

The advocacy component complements governance by helping mobilise public support, fostering awareness, and pushing for policy changes that align with the goals of urban river restoration. Advocacy campaigns can leverage the economic models mentioned earlier to convey tangible benefits to stakeholders, demonstrating how restoration efforts can yield both environmental and economic returns. Engaging media, organising public events, and utilising social media platforms are avenues to effectively communicate the urgency and potential of river restoration to a broader audience.

By integrating this strong governance and advocacy model with the economic approach, urban river restoration gains a comprehensive framework that addresses the complexities of policy making, implementation, and public buy-in. This multi-pronged strategy not only streamlines the decision-making process but can also build a network of support that sustains the restoration efforts over the long term (Heinmiller *et al*., 2023). As a result, the transformation of urban rivers from neglected spaces to vibrant ecosystems can become a shared vision that encompasses the interests of various stakeholders, assisting a healthier and more prosperous future for cities and their inhabitants. The roadmap for this transformation embraces both top-down and bottom-up approaches, acknowledging the complexity of the issue. Government involvement, media releases, and discussions with political and government bodies address the top-down aspect, while community workshops, youth networks, academic programs, and engagement with specialised stakeholders form the bottom-up foundation. This comprehensive approach aims to bridge the gap between ecological concerns and urban development, which often clash due to unchecked urbanisation.

The challenges posed by urbanisation, including flooding, pollution, and deteriorating air quality, can find solutions in the potential of green and blue infrastructure along dynamic river edges. To tackle these issues, it is crucial to approach river restoration with a holistic perspective that encompasses social, technical, and environmental considerations. The Transformative Change Making method (TCM) (Saxer, 2017) may be worth considering in

this regard, as it could provide a lens to navigate through these complexities and challenges, enabling planners, architects, and city authorities to overcome hurdles and re-envision urban rivers as collective resources.

This article underscores the intricate web of social, technical, and environmental factors that define urban rivers, particularly in the context of Mumbai. It advocates for a paradigm shift from existing approaches to urban river management, urging a people-led responsive development model that prioritises ecology and biodiversity. By doing so, it aims to create healthier, more liveable cities for all, even within the spatial constraints of a city like Mumbai. Ultimately, this approach resonates with the vision of sustainable and resilient ecosystems that can shape the cities of the future, emphasising the interconnectedness of natural resources and urban development. Through these concerted efforts, the transformation of urban rivers from neglected entities to vibrant catalysts for holistic urban growth becomes not only possible but also imperative for the well-being of present and future generations.

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