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Article

Reviewing Historic Urban Water Transitions to Advance Water-Sensitive Urban Design for Bhuj, India

Geert J. M. van der Meulen [1,*], Gargi Mishra [2], Machiel J. van Dorst [1], Mona Iyer [2] and Taneha Kuzniecow Bacchin [1]

[1] Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, 2628 BL Delft, The Netherlands
[2] Faculty of Planning, CEPT University, Ahmedabad 380009, India
* Correspondence: g.j.m.vandermeulen@tudelft.nl

Abstract: In rapidly growing urban contexts, water plays a pivotal role in the transitions the urban environment goes through to sustain the quality of life of its population. Spatial planning and design are essential for the facilitation and manifestation of such transitions. Focusing on Bhuj, a rapidly growing Indian city in a hot arid desert climate, its crucial yet changing sensitivity to urban water flows over time is assessed. The concept of water sensitivity is coined as a goal to pursue by the Water-Sensitive Urban Design approach. In India, however, much of the urban design and development processes are of an unplanned and informal nature, seemingly inhibiting the water sensitivity of urban transitions. Reviewing spatial planning paradigms and their manifestation in space in Bhuj over time, however, brings to light a pre-existing water sensitivity. Yet it also shows a shift from the supply security-oriented ingenious watershed expansion to catastrophe-steered and urban expansion-driven water system negligence. Review and discussion of past and present urban water transitions and management points out drivers, barriers, and their interrelationships, to enable and advance water-sensitive urban development tied to local history, traditional knowledge, and context specificities.

Keywords: historic urban development; secondary cities; spatial planning; urban design; urban water transitions framework; water sensitivity

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1. Introduction

Urbanization, alongside the climate crisis and accompanying shifting societal values, drastically pushes for transitions in urban environments. Contrary to prevalent perception, absolute growth of urban populations and intensity of socio-economic changes is highest in smaller and less-studied secondary cities. Especially in India, where population growth contributes most to the urban increment, with its level of urbanization doubled and its population tripled since 1950 and the increase ongoing [1]. Commonly characterized by a lack of infrastructure, service provision, and planning [2–5], secondary cities undergoing sustainable transitions would have substantial collective environmental impact.

To secure the sustainability of transitions, water demands a central role. Of all urban water cycles, hydrological and natural processes (e.g., stormwater drainage, groundwater recharge) are the foundational ones facilitating others (e.g., supply, sewerage, navigation). Water-Sensitive Urban Design (WSUD) is a concept and intention that calls for joint management of all such urban water cycles and the built environment while protecting and conserving aquatic environments in urban areas by operationalizing the collaborative and multidisciplinary nature of urban design and spatial planning [6]. Accompanying WSUD, the Urban Water Transitions Framework (UWTF) [7] assists in the evaluation of the progress of urban transitions toward "water sensitivity" as an ultimate goal for cities to pursue. The framework presents theoretical cumulative stages of transitions to water sensitivity, each

underpinned with hydro-social contracts consisting of intrinsic expectations and values of society on how water is managed.

Conceptualized in Australian academia and applied in the country's primary city context, WSUD faces knowledge gaps regarding its applicability in urban contexts in countries like India [8] and concerns regarding its transferability have been raised [9]. Furthermore, for secondary cities, a knowledge gap can be perceived in the form of the availability of data, with WSUD being data-intensive [10] and secondary cities portrayed as data-lacking. Necessary formal data sets can be unavailable, outdated, inaccurately scaled, or uncoordinatedly stored while resources to produce data consistently fail to keep pace with high secondary city dynamics [11], whereas emphasis on and recognition of context specificity of water sensitivity is required [9,12].

It is this call for context specificity and the knowledge gaps between the secondary city context and the WSUD concept that define the specific direction of the theoretical framework of this study. Beyond the limitations a secondary city context poses to WSUD, as scoped above [8–11], the article addresses possible pitfalls of WSUD. Being an act of design [13], the suitability of universal water sensitivity as a guiding concept, the frame of references, and other aspects considered or presupposed in design processes can be questioned when addressing secondary cities. Urban environments do not transition homogeneously, instead, they know coexisting conditions and states of development within administrative boundaries, such as built-up and greenfield or formal and informal areas [14]. With the primary idiom of urbanization being informal, WSUD approaches in contexts like India should adjust to local spatial planning and urban design discourses [15] and move beyond its techno-centered nature to acknowledge the role and value of cultural and historical connections between people and hydrological processes or urban water cycles [16]. Valuable achievements in WSUD approaches in other contexts continue to call for more research on design guidance of WSUD implementation considering local conditions, such as Indian secondary city dynamics [17]. However, by deploying WSUD based on accustomed design principles from a specific context, in a contrasting one, the global uptake of WSUD also appertains to the greater project of "decolonizing design" [18], calling for unlearning and context specificity in all design approaches.

Motivated to inquire into design mechanisms for a WSUD approach better capable of facilitating sustainable secondary city transitions, this article visits Bhuj, India. Located in a hot arid desert climate, water bodies and streams commonly run dry, which, together with limited data or documentation about them, contributes to a certain invisibility of crucial urban systems. Confronting the theoretical UWTF and its hydro-social contracts with Bhuj's remarkable urban water transitions contributes to closing the perceivable data gap with a chronicle of the city's water-linked urban development. The inquiry looks for promising combinations of WSUD and water sensitivity in Bhuj's particular context. Rather than constructing missing data sets, the historical account is used as a necessary design action and method of reading space to develop an understanding of urban water management processes beneficial to water-sensitive urban development. Rather than positioning water sensitivity merely as a goal that may remain unachievable in certain contexts, water sensitivity is, in this historical account, recognized as a variable of context [9] and distilled as such from each period discussed. This approach and understanding of water sensitivity seeks answers to the questions: what aspects have enabled and halted water sensitivity in Bhuj's past urban water transitions? And what is the relevance of those aspects to ongoing and future transitions in Bhuj? To do so, this article reviews past and ongoing transitions and underlying local practices, communities, infrastructures, knowledge, and their urban footprint and influence on hydrological processes, as drivers and barriers of water sensitivity. Knowing the transitions through which Bhuj reached its current state, planning for future transitions can be informed [19]. This study aims to contribute to promoting context-specific water sensitivity and urban design methods for urban transitions to advance the sustainability of its outcome with insights of value to local spatial planning practice.

2. Methods

As a secondary city, much knowledge of Bhuj exists in stories passed on within communities and families, whereas formal documentation or data sets are lacking. To construct the city's historical narrative, answering the necessity of describing and writing down its development over time, the research elaborated a review of the existing literature with additional qualitative methods. Field visits were carried out in June–July 2022, February 2023, and July 2023 to conduct workshops, interviews, and fieldwork. In addition, field visits were also carried out in January–March 2018 for preliminary research work and documentation of participatory water management practices. Three formal workshops, within the framework of Water4Change (i.e., a collaborative research program between India and the Netherlands) and with up to twenty attendees, addressed urban water challenges, water-sensitive visions, and barriers in Bhuj. In the workshops, representation of civil society was higher compared with public agencies, which inclined focus group discussions to demand management, participation, and traditional knowledge. The inquiry therefore followed with multiple semi-structured interviews, with fourteen different participants, equally concentrated on developments of urban water challenges and their management. Thus, while focus group discussions through workshops brought together diverse viewpoints of actors, interviews provided in-depth narratives around Bhuj's urban water transition.

Participants of the workshops and interviews included five members from public agencies, six from NGOs (one interviewee was both active in public service and an NGO), one from academia, and one from design and planning practice, yet each simultaneously represented local communities and residents of Bhuj. Narratives of workshop participants and interviewees were triangulated to derive "meaning out of analysis" [20]. The process of triangulation is essential to identify convergence and divergence of various viewpoints and ensures and provides validation and stronger substantiation of viewpoints, constructs, and arguments [21,22] by improving confidence in collected qualitative data or narratives of people while minimizing biases. As such, these insights contributed significantly to constructing the synopsis of Bhuj's urban development.

With a double perspective of spatial planning and urban design, emphasis was placed on dissecting planning paradigms and the spatial manifestation or performance of such plans. Spatial manifestation can contrast with plans in a context in which development recurrently takes place in a partially unplanned, informal, or organic manner [15]. To provide a spatial planning perspective at Bhuj, a two-step approach and a related set of methods were applied. At first, all three Development Plans (DPs) (e.g., 1976, 2011, and 2025) for Bhuj were chronologically reviewed to reflect on changing land use patterns and processes. Subsequently, interviews with experts and practitioners from government and non-government sectors were conducted alongside secondary research of media articles and reports, among others, to identify drivers behind changing land use over the past five decades (since the formation of the first DP). Further, direct and indirect observations were made through field visits to map the current status of water bodies and surrounding settlements. This also supported the urban design perspective which deployed immersive designerly fieldwork methods, such as walking, drawing, photography, mapping, and interviews, focusing on physical components and documenting small-scale observations in space with the aim of advancing the understanding of landscape- and urban-scale processes of interest and associating social and cultural dimensions of such processes [23].

Insights collected from workshops, interviews, and fieldwork are the basis of both context description and discussion in this article. An elaborate description of the context and review of its history was, instead of being part of the introduction, a fundamental part of the research's methodology of unfolding Bhuj urban water systems by compiling information collected on-site and through a literature review. In fact, a review of historical context is one of the key domains of the situatedness of urban design processes [13], yet is not formalized in WSUD, despite its call to operationalize urban design approaches. Processing the description as data in the discussion provides for a dialogue on drivers

and barriers of water sensitivity in past urban water transitions and the relevance of those insights for potential water-sensitive urban development in Bhuj.

3. Urban Development and Water Transitions of Bhuj

Reviewing Bhuj's urban transitions in hindsight directs focus to pivotal paradigms in between them. Paradigms are, in their turn, demarcated by the city's key disruptive events. Firstly, the city's foundation in 1510 and the developments that followed until the 19th century. Secondly, the arrival of the British in 1819 and developments in the colonial period under British rule until 1947. Thirdly, the departure of the British and consecutive Indian Independence in 1947 and developments in the post-colonial period until the end of the 20th century. Fourthly, the Bhuj earthquake in 2001 and the emergency-steered reconstructions and developments that followed. At last, the article discusses the present situation and offers a look ahead. Each paradigm reviews the spatial planning of the time and how such plans manifested in space to construe the periodic urban development logic. At the end of this chapter, Table 1 provides a summary of spatial planning and its spatial manifestation per period. Figures 1 and 2 provide fieldwork mappings as an overview of the mentioned locations.

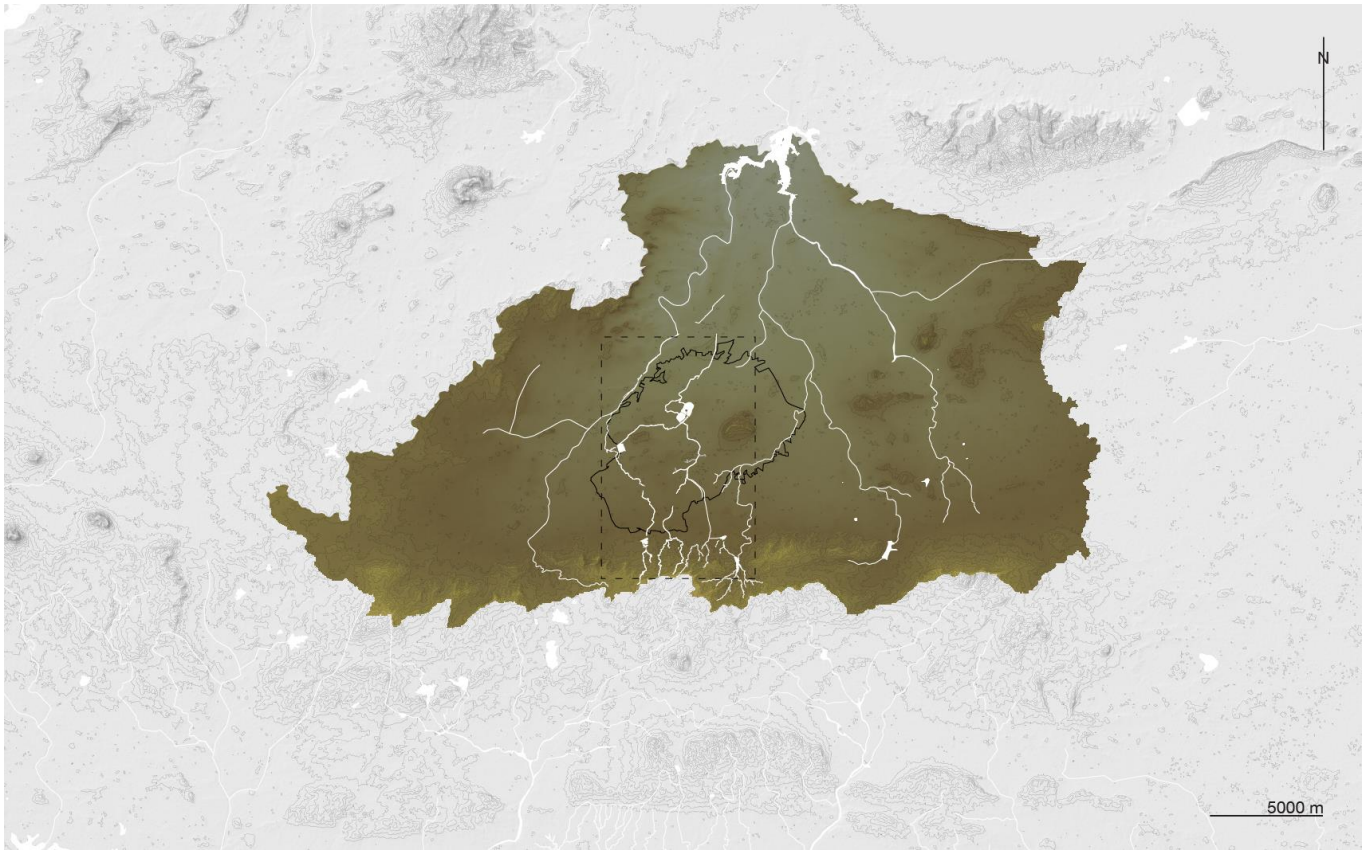


Figure 1. Bhuj's location in the watershed (authors 2023).

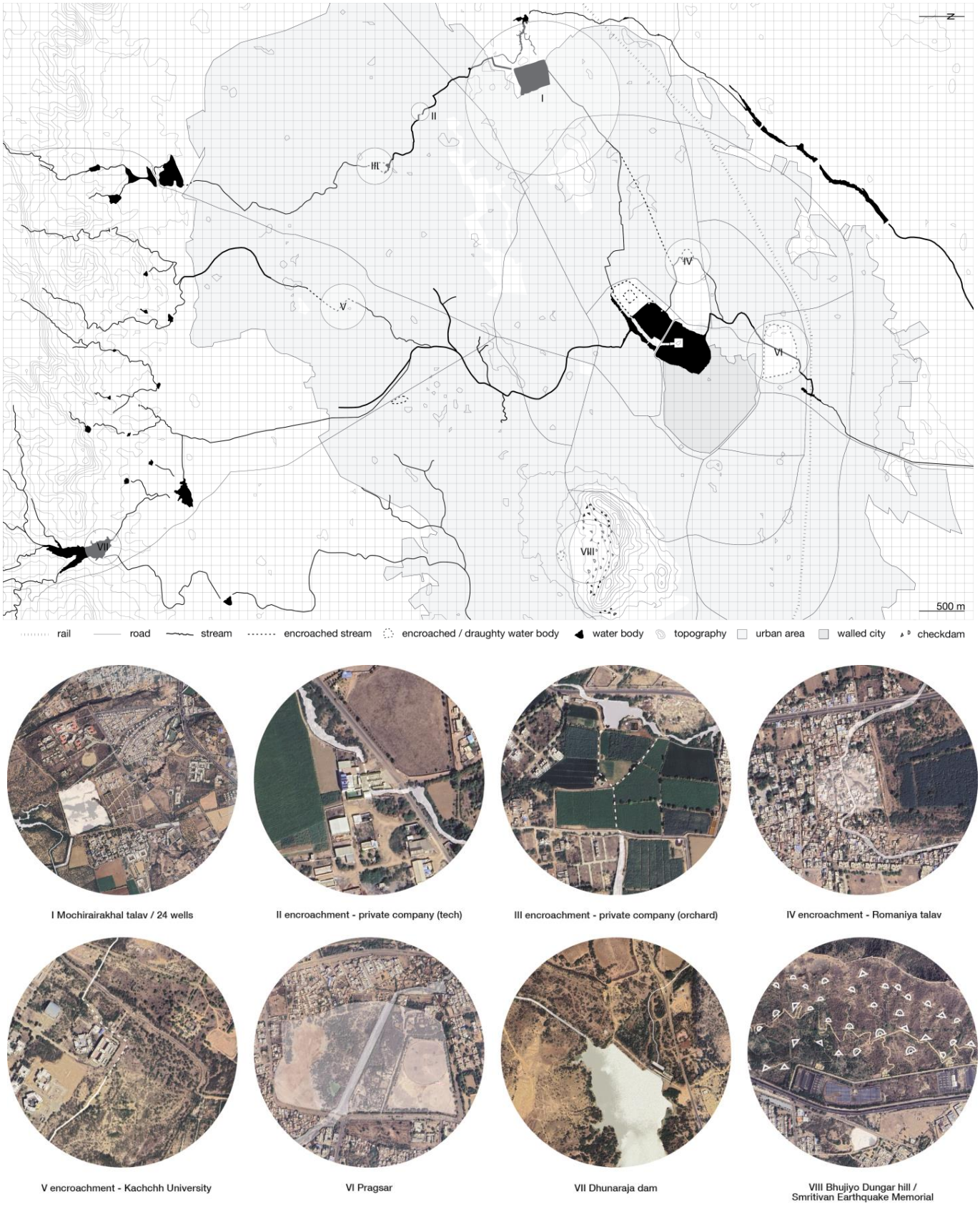


Figure 2. Fieldwork mapping (authors 2023).

3.1. Foundation of Bhuj, 1510–19th Century

Founded by King Maharao Hamir in 1510, the city of Bhuj was positioned on a plain amidst modest hills. One of which—Bhujiyo Dungar hill, home to Bhujang the great serpent according to mythology—provided an efficiently defensible location for a fort adjacent to the walled city and gave the city its name [24]. King Hamir's son and successor, Khengarji I, made Bhuj the capital of the state of Kutch in 1549, followed by an increasing population [25]. Kutch means "intermittently changing from dry to wet", referring to the condition of its seasonal salt marsh (i.e., Rann of Kutch). Furthermore, the state has no perennial rivers, low rainfall, high evaporation rates, few surface water resources, no recharge potential from neighboring areas, and salinization due to its adjacency to the sea.

To sustain a growing city in this circumstance and the hot arid desert climate and fulfill the needs of its inhabitants, local hydrogeological comprehension was imperative. The establishment of a water system to efficiently capture the little rain the area receives and recharge the landmark human-made Hamirsar Lake adjacent to the city at the beginning of the 16th century highlights the traditional mastery of hydrology. Consisting of separate areas for people, animals, and washing, Hamirsar provided water to all. Despite the city's ruling being passed on over time, a series of complementary ingenious interventions in the following three centuries continued to connect neighboring watersheds and deviate water flows toward the central lake, enhancing water provision to the city [26]. By digging the Haripar canal and constructing the Dhunaraja dam, water from the Hamidrai, Dhunaraja, Lakki, and Tapka catchments was redirected to Hamirsar Lake instead of flowing around Bhuj on its east side (Figure 2, VII). A qanat system of 24 wells connected to an underground canal funneled water from a reservoir, named both Umasar Lake and Mochirairakhal talav, through a hill separating the Mirzapar catchment from Hamirsar Lake instead of water flowing around Bhuj on its west side [27] (Figure 2, I and Figure 3). Such water works, deepening of water bodies, and maintenance of the system were carried out collectively by employing the local population, who were paid in cash or in kind [26].

(**a**) (**b**)

Figure 3. (**a**) A 500 m long drain discharges water from Umasar Lake toward the qanat system of 24 wells, of which two are depicted in image (**b**), to transport the water underneath a hill toward Hamirsar (authors 2022).

The interventions upscaled the catchment which discharges to Hamirsar from 7 to 35 km^2. At the time, the lake was three times the size of the walled city, securing water supply and preventing droughts and famines which did strike surrounding villages in

the region [26,27]. At disintegrated locations, the unique system remains in place and contributes to the establishment of an urban water culture in the water-scarce region. The rare occasion when the water level of Hamirsar reaches the feet of two wall sculptures of decorated elephants on each side of an "aaro"—an accessway on the lake's east side—is celebrated with a holiday, rituals, and community dinners to this day [28] (Figure 4).

(**a**) (**b**)

Figure 4. Hamirsar Lake access with elephant sculpture marking the celebrated water level of the lake: (**a**) low water levels in early July 2022 (authors 2022); (**b**) the water catchment almost filled in late July 2023 (authors 2023).

3.2. British Rule, 1819–1947

Located on fault lines, the Kutch area and Bhuj have a history of earthquake disasters. 1819, the year in which British armed forces attacked Bhuj and took over the Kutch government, was additionally marked by the 1819 Rann of Kutch earthquake which caused significant loss of life and building damage. The shocks altered the routes of water flow, cutting off some of Bhuj's important water supply sources. Nevertheless, Bhuj's population rapidly continued growing as a British military post [25] (Figure 5). The colonial rule introduced the position of a District Collector responsible for land revenue collection and partition of land holdings. Like in many colonial cities in India, the British imported and imposed their spatial planning, water management, and other infrastructural approaches [19]. Managed by engineers unaware of traditional water knowledge, new infrastructure, such as dug wells, seaports, public transport, and air services [28], addressed the short-term needs of elite minorities [29], especially following the 1844 earthquake which triggered novel British technology-laden reconstructions. Perception of water provision and practices of water collection shifting away from Hamirsar set off the neglect of the unique local water

system, affecting vulnerable hydrological processes in the scarce region and resulting in recurring water shortages [27].

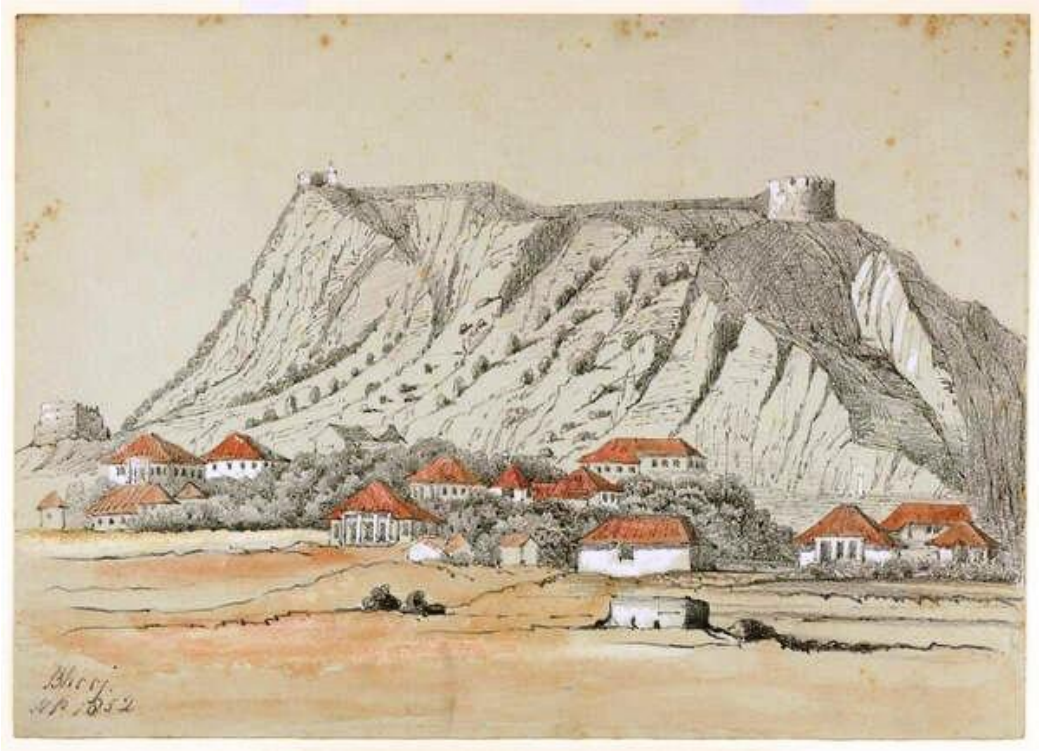


Figure 5. British army camp bungalows and Bhujiyo Dungar hill. Pencil and watercolor by Harriet Parr (partner of a British army official), 1851 [30].

The 1947 Indian Independence Act brought the rule of the British Crown to an end and the princely State of Kutch merged into the Union of India. Under the rulers of the latter, throughout colonial occupation and the imposition of alternative systems, traditional water system knowledge was passed on to successive generations. This bequest of knowledge continued until the ruler's entitlements were abolished in 1971. Half a century later, there is a struggle to sustain the bequest of water system knowledge, which results in neglect. Post-colonial India today still knows "internal colonization" [31] in which colonial legacies of hierarchy and extraction and its associated knowledge and value systems continue to prevail, overruling its indigenous equivalents and building up ecological degradations, yet admired and pursued as modernity [12,32,33].

3.3. Post-Colonial Period, 20th Century

Post-independence, Bhuj had a palimpsest-like landscape of imposed water systems which would fall under the responsibility of Bhuj Nagar Palika (BNP) (or Bhuj Municipality), an elected urban local body, and Kutch district and Gujarat state-level authorities. Builders of modern India focused on modernization and centralization, further concealing traditional knowledge and systems [19,26] while shifting to real-estate-demand-driven urban development. Like many Indian cities, Bhuj experienced historical financial neglect due to the colonial period and lacked inclusive or suitable investments [15], drawing up the adaptation urgencies in post-colonial Bhuj.

Although it is located in the area comprising 15% of Kutch known as the "tubewell zone" and on a sponge-like cretaceous sandstone [24], the city's traditional hybrid natural-artificial water system failed to provide water security due to impacts of imposed foreign infrastructure. Supply failures and public health concerns surrounding waterborne diseases pressured the introduction of piped water provision in 1968, which would increase domestic water usage and demand. Bhuj now became dependent on sources up to 11 km outside of

the traditionally connected water catchments while groundwater tables dropped due to rising water extraction with developing technologies [26,27,34].

National land surveys under ongoing government centralization in the 1970s, which visited the arid region in a time of drought, failed to recognize temporarily dry or ephemeral water bodies and assigned the status of "wasteland" to many of them. However, stemming from the colonial project, "wasteland" was at the time, in fact, a modern concept to characterize indigenous land use as inefficient in the spatial logic of modernity [32]. On that account, surveyors drew boundaries and edges ambiguously in the context of "fluid" systems, yet also where they are unnecessary constituents of cultural imagination [35]. Traditional knowledge of the water system and bodies, concurrently, continued to fade through redistribution of management and maintenance responsibilities and a general lack of documentation. After subsequent years of drought, dry grounds of water bodies would unwittingly be encroached. With new and more formal legal status documentation rescinding previous documents, water bodies were lost on paper and, instead, development on them would now become permitted and facilitated. Bhuj's first DP in 1976 (Figure 11a), following the state's first urban development act of the same year, on the other hand, failed to regulate urban growth altogether [36]. Devoid of details, the 1976 DP incorporated the bare minimum aspects of land use planning, only including zoning principles to roughly color code parts of town into residential, commercial, agricultural, and institutional uses, among others.

Equally lacking physiographic and hydrological details on aspects like topography, drainage, and the aquifer, engagement of the DP in urban water system management or planning was limited to marking main city-level water bodies and surrounding land uses. Despite many of the city's water bodies rarely conveying or retaining water, the negligence new developments and encroachments would have of their collective contribution to water drainage and groundwater recharge would drastically alter Bhuj's hydrology. Due to such changes, in 1959 the city suffered a severe flood after heavy rainfall. To facilitate stormwater drainage and mitigate future flood events, Hamirsar was equipped with an additional channel from the qanat wells and an overflow going around the Sharad Baug royal palace grounds to a depression and impermanent water body, called Romaniya talav. Both interventions were dug to connect to the west side of the lake but would soon be encroached upon after a few years without heavy rainfall or flood events and remain inhabited to this date (Figure 2, IV and Figure 6). The current inhabitants of Romaniya talav encroachment interviewed are not aware of the water body in which they reside, exemplifying the general perception of the droughty water system.

(**a**) (**b**)

Figure 6. Encroachment of Romaniya talav: (**a**) the drainage stream can be recognized flowing through the neighborhood's main road (authors 2023); (**b**) the stream is used to dump waste (authors 2023).

3.4. Post-Bhuj Earthquake, 2001

On the morning of 26 January 2001 an earthquake hit Kutch with its epicenter only 60 km east of Bhuj. Despite locally enforced seismic building codes in place, their lack of enforcement had resulted in weak building constructions, in some cases with rooftop water tanks, around narrow streets in the dense and organically evolved walled city. This combination would lead to grave destruction of buildings and supply systems and severe loss of life in the city, followed by limited reachability for emergency workers.

With national and international humanitarian and financial aid for large-scale redevelopment works in the months after, the Gujarat state government established frameworks for reconstruction and mitigation. Instead of relocating Bhuj to a non-earthquake-prone area, the city was "built back better" on its original grounds around Hamirsar. Spatial planning was key in reconstruction processes, under pressure by trade-offs between time required, quality of work, and level of public participation [37]. The Bhuj Area Development Authority (BHADA) was established to supervise the set-up of a revised second statutory DP (Figure 11b). BHADA is chaired by the District Collector whose role continues to exist to organize and collect land revenues. The DP had a timeline until 2011 and was assembled within 11 months after the earthquake in an attempted comprehensive and participatory manner [36]. Besides the rehabilitation of affected communities, the DP aimed to focus on trade, commerce, and tourism. Prioritizing the preservation of culture, identity, and economy, the DP directed that focus to rapid reconstruction of the walled city through limited application of micro-level Town Planning Schemes (TPSs).

TPSs deploy a model of land pooling, readjustment, and reconstitution. By appropriating private land for public purposes and utilizing space formed by collapsed structures, streets were widened, new ones were created, and cul-de-sacs and bottlenecks, which caused much harm during the earthquake, were removed (Figure 7). By doing so, the DP identified growth areas and locations for infrastructure [38]. With 12,000 land plots, 24,000 properties, and 30,000 ownership claims within the 1 km^2 walled city, the execution of TPS was highly complex [37,39]. At the time, it was assumed that micro-level plans would only provide structural building design inputs. Outside of the walled city, no part of town, to date, has been planned at this micro-scale. With a new road network, land use zoning, and allocation of relocation areas, the DP further utilized macro-level planning, again limited to zoning. In terms of infrastructure development, the DP only highlighted the need to have centralized water supply, drainage, and sewerage networks with efficient treatment to improve the quality and quantity of water.

Figure 7. Town Planning Scheme (TPS) with road network adjustments by land pooling for the walled city of Bhuj: (**a**) the road network of the walled city before the TPS; (**b**) the new road network with higher road density and reduced block sizes after the TPS [39].

To promptly respond to the disruption of water supply from remote sources, Bhuj tapped into the more remote Narmada canal supply [27] (Figure 8b). Transporting water from the Sardar Sarovar Dam in the Narmada River via hundreds of kilometers of its main canal and Kutch branch, the Narmada canal connection controversially increased the distance between Bhuj and its water source seventy-fold, from 11 km to over 700 km, amplifying the unwieldiness of 77% of the city's dependency. A total of 23% of the city's water remains locally sourced from sumps and borewells [24,34]. For water provision, the state nowadays enforces BNP to focus exclusively on the development of the Narmada supply, most of which is destined for industries it aims to attract, increasing dependency.

As a planning approach reactive to catastrophe, developed under the pressure of the emergency situation, the DP focused on built development. With micro-level focus limited to the walled city and macro-level planning indifferent of catchment-level issues, the DP's recommendations failed to discuss ecological disruptions caused by the earthquake. Hydrological features of the urban landscape were insufficiently taken into consideration or ignored and short- and long-term consequences of the rapid developments, particularly on the catchment and natural drainage system, were disregarded. With the catastrophe striking in a dry period, water bodies standing dry were obvious locations for the disposal of rubble from earthquake destruction. In particular, Pragsar, a dried-out depression north of Hamirsar was nearest to the debris from the walled city [19]. The rubble was eventually flattened by bulldozers, reducing the depth of the water body (Figure 2, VI). The

locations of relocation sites were assigned regardless of the subtle watersheds in the plain and disturbed natural drainage patterns and traditional water system infrastructure. The westernmost Rawalvadi relocation site (Figure 8a) was constructed on top of the droughty stream constructed after the 1959 flood as an extension to the city's ingenious ephemeral water system. Instead of connecting to Hamirsar, the historic system is now obstructed and provides water to a private commercial orchard encroaching on the connection and benefitting from the water supply (Figure 2, III). Encroachment on Bhuj's temporary water streams from orchards to secure their water supplies is occurring more frequently.

(**a**) (**b**)

Figure 8. (**a**) Rawalvadi relocation site [40]. (**b**) The location where Narmada water reaches Bhuj and is stored (authors 2023).

Advocating systemic preservation of the built environment while paying little to no attention to identifying and addressing ecological and water-sensitive issues is concerning for an arid city like Bhuj in which susceptibility to earthquakes is joined by an ongoing vulnerability to water scarcity. With changes in global precipitation patterns and encroachment on drainage systems, the city faced major waterlogging and flooding in 2006. Both in response to the 2001 earthquake and the 2006 floods, from within the community, numerous NGOs and other civil society organizations were established to collectively complement and inform reconstructions and developments. Efforts included sensitizing and capacitating people to promote traditional earthquake-resistant construction techniques, traditional management of waste and livestock, decentralization of governance and water management, and revival of water bodies, among others.

3.5. Present Bhuj

With Kutch becoming the most invested-in district of India, its capital attracts industries and faces urban growth, with its population doubling to approximately 200,000 in the last 20 years [41], calling for necessary developments. Hesitant to live in multilevel buildings due to earthquake risks, urban sprawl spreads following the major national and state highways connecting Bhuj, rapidly expanding the city's footprint in the plain. Counting 1 km^2 in surface area in 1950, the city nowadays covers 48.6 km^2 [24]. Both planned and informal settlements on vacant plots inside this footprint continue to encroach on dry water bodies and streams [19] and contribute to increasing the invisibility of the system, which, in turn, expedites further encroachment (Figure 2, II). Invisibility, furthermore, contributes to a general indifference and loss of water system knowledge.

Krantiguru Shyamji Krishna Verma Kachchh University was constructed in the droughty wetland of the Tapka catchment in 2007 (Figure 2, V). Disregarding the recommendation of a 7 m wide drain to compensate for the campus' encroachment by only installing a 0.45 m wide drain resulted in flooding of the campus in the following years, after which the drain

was widened to a meager 2 m (Figure 9a). While other floods on campus may have been prevented, floods downstream in Bhuj's center intensified [19,24] (Figure 9b). In 2022, the drain was blocked by a newly constructed fence but re-opened after public opposition. An opposite example is Pragsar, which was controversially sold by BNP in 1979 [19,24], yet designated as public and police cricket grounds. As a frequented public space it may be considered to fend off encroachment and flooding and secure stable space for future water retention (Figure 2, VI). Local water scarcity is attributed to the failure of rains, whereas, in fact, this emanates from traditional systems being replaced by unregulated drainage and groundwater exploitation beyond rechargeable limits [26].

(**a**) (**b**)

Figure 9. (**a**) The new 2 m drain to compensate for constructing the university campus in a droughty wetland (authors 2022). (**b**) Urban flooding after heavy rain in July 2022 (authors 2023).

The only ongoing effort to revive the ancient water system lies with NGOs, such as Arid Communities and Technologies (ACT). Since 2006, ACT has initiated awareness generation projects around the traditional system, such as hosting educational tours and cleaning activities, disseminating informative posters and newspaper articles, and carrying out revival works [27] (Figure 10a). The value of their efforts to map the system is frequently underestimated and disregarded in BHADA's spatial planning and BNP's drainage and supply maintenance. The lacking formality of the documentation and availability of staff might be a justification. BHADA and BNP currently have limited capacity to (train to) use GIS applications, as BHADA's spatial planning responsibilities are conducted by only one planner, and BNP's numerous drainage and supply maintenance tasks are performed by only one engineer, working around the clock. Nevertheless, the value of maintaining accurate maps is recognized [37] and the present BHADA planner is invested in formalizing existing maps and using them in their current development control regulations [42], such

as permitting development only at 9 m distance from the edge of streams and water bodies which appear in government documents.

(**a**) (**b**)

Figure 10. (**a**) Hydrological models at ACT to increase awareness (authors 2023). (**b**) A neglected decentralized wastewater treatment plant project from 2006 (authors 2023).

Bhuj's history in communal water system mastery can, conceivably, be recognized in the relatively high level of active participation in water governance, however sporadic and inconsistent at times [12]. National and state-level actors provide for funding, monitoring, and evaluation of projects and frameworks. Local-level stakeholders aim attention at the preparation and implementation of urban water management. The well-networked group of local NGOs and citizen groups ensures water remains a priority in urban development and initiates rainwater harvesting, groundwater recharge, wastewater reuse, waterbody cleaning, and educational projects [12,24,43]. The citizen group Jalstrot Sneh Sanvardhan Samiti (JSSS) succeeded in discontinuing a BNP beautification project of Hamirsar that endangered the lake's bed and biodiversity [44]. Continuity of other such efforts or interventions, however, is lost the moment maintenance responsibilities and costs are passed on to alternative local communities or authorities (Figure 10b). Furthermore, the network suffers from a lack of funds, and consultation and collaboration between NGOs and local authorities is limited [12].

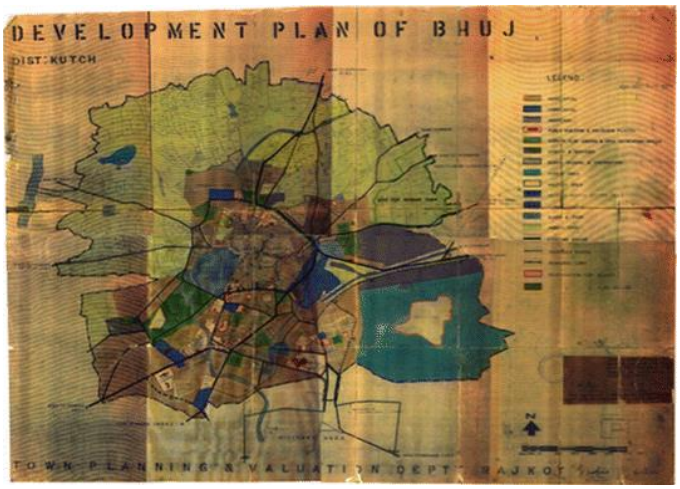
Most urban water redevelopment projects in town focus on the revitalization of water bodies, yet deliver only beautification, deteriorating the water system [24]. Epitomizing the loss of traditional or general water system knowledge is perhaps the Smritivan Earthquake Memorial Museum and park, completed in 2022. However deserving the commemoration of the more than 13,000 victims of the 2001 Bhuj earthquake, the location, configuration, and materialization of the pilgrimage heavily affect local water flows. Located on 470 acres

of the Bhujiyo Dungar hillslopes, fifty half-round or triangular stepwell-shaped check dams and a network of broad walkways to connect them serve as a memorial park, yet obstruct the drainage of the hill and recharge of the downhill Shrijinagar Lake (Figure 2, VIII). In fact, in the context of arid Bhuj and the moderate, yet landmark, Bhujiyo Dungar hill, the dimensions and quantity of the check dams and the choice of the stepwell-shaped check-dam typology are profoundly out of place and the project could be considered as an example of populist architecture [45]. Moreover, tickets to enter the museum are too costly for many of Bhuj's inhabitants.

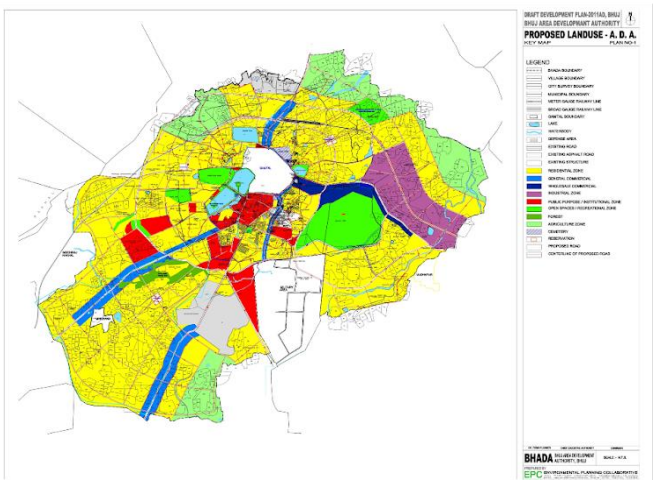
3.6. Future Bhuj

As emphasized in previous periods, the DP is the most important legal spatial planning tool to guide future development and provides a look ahead for Bhuj. Again, with a delay in preparation and a large gap of 18 years after the sanction of the previous DP, the 2025 DP (Figure 11c) was sanctioned in 2019 to be prepared by BHADA and its appointed external consultant, Nascent Technologies. A DP generally consists of three parts: a report with existing situation analysis and recommendations, a land use or zoning map, and development control regulations consisting of building bylaws. In Bhuj, however, DPs are repeatedly sanctioned by the state without report, which implies that future development of Bhuj will be solely based on a land use map and the state's development control regulations [42] to guide land uses. A DP report is crucial for providing information on longer-term projections and gaps in existing infrastructure, especially considering soaring global climate change impacts, such as longer periods of drought and intensified precipitation events frequently flooding the city's center, a population projected to cross 450,000 by 2050 [34], and urban sprawl expected to expand the city's current footprint of 48.6 km^2 to 75.6 km^2 by 2035 [24]. The lack of capacities within BHADA and the private consultant was reported to be the primary reason for the absence of this DP report. Consequently, failure in the identification of future projects in a statutory DP provides room for ad hoc or needs-based development in Bhuj, often driven by political needs until the sanction of the next DP. Outcomes of this gap in envisioning the long-term needs of the city include the ambitious and costly 24 × 7 Narmada water supply, which is driven by the state's development agenda for the district, however, it is unmentioned in the DP.

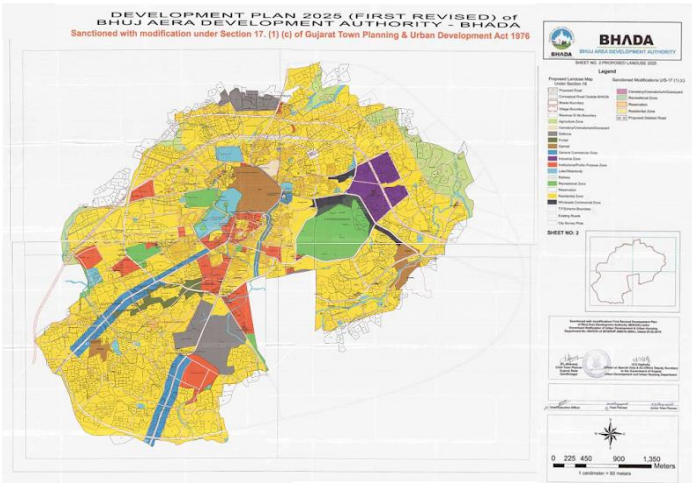
Progress, however, is seen in the growing influence and effect of local citizen groups on enhanced water sensitivity of spatial planning agendas. After their successful efforts to discontinue a municipal beautification project, the JSSS members continue to push for the identification and demarcation of lost water bodies and their inclusion in revenue records and DP 2025. For example, Umasar Lake, part of the traditional water system, is among five newly recognized water bodies in the latest DP. Despite the acknowledgment of such inputs, collaboration between BHADA and citizen groups or NGOs remains non-formalized. Pressure is then, for example, exerted through a public interest petition filed at Gujarat High Court by JSSS, successfully resulting in a High Court order to the District Collector and municipality to include all 25 currently unregistered lakes in prompt restoration efforts [46].



(**a**)



(**b**)



(**c**)

Figure 11. (**a**) Bhuj Development Plan (DP) 1976 [37]; (**b**) DP 2011 [47]; and (**c**) DP 2025 [48].

Table 1. Spatial planning and its spatial manifestation per period.

Period	Spatial Planning	Spatial Manifestation
Foundation of the city, 1510–19th century	- Foundation of the city - Construction of a defensible walled city - Designation as capital - Provision of water security in water scarce region	- Water infrastructure (i.e., canals, dams, qanat system) to supply to Hamirsar Lake - Population growth - Urban water culture (i.e., water security celebration)
British rule, 1819–1947	- Designation as a military post - Provision of water security after first water shortages - Housing growing population - Reconstruction with novel British technologies after the 1844 earthquake	- Altered water flows after the 1819 earthquake partially cutting off the water supply - Oscillating population (20,000 in 1818; 30,000 in 1837; 24,000 in 1872 [25]; 26,000 in 1901; 19,000 in 1921; and 26,000 in 1951 [49]) - Exogenous water infrastructure (i.e., dug wells) imposition on traditional water infrastructure - Bequest of water system knowledge via the royal family and local communities

Table 1. *Cont.*

Period	Spatial Planning	Spatial Manifestation
Post-colonial period, 20th century	- Modernization of urban life - Centralization of urban water services - Provision of water security after ongoing water shortage - Provision of water supply infrastructure after perceived health concerns - Execution of national surveys - First Development Plan, 1976 - Real-estate demand-driven development following nationwide liberalization	- Concealment of traditional water infrastructure, systems, and knowledge - False recognition of (droughty) water bodies as wasteland - Encroachment of the water system, mostly due to new market-centric urban development - Urban flooding due to reduced drainage - Expansion of the traditional water infrastructure system - Dropping groundwater tables with the advancement of extraction technologies - Water supply dependency from remote sources (11 km away) - Population growth (136,000 in 2001 [49])
Post-Bhuj earthquake, 2001	- Reconstruction and relocation after the 2001 Bhuj earthquake - Second Development Plan, 2001–2011 - Town Planning Schemes for land pooling and road widening in the walled city - Provision of urban water infrastructure due to infrastructural deficits - NGOs and citizen groups capacitating people and promoting local means for reconstruction and decentralization	- Rubble riddance in a dry water body - Reconstruction of the destroyed walled city - Relocation sites encroaching on the natural and traditional water systems - Water supply dependency (77%) from Narmada canal (700 km away) - Urban flooding due to reduced drainage
Present Bhuj	- Investments in Kutch district - NGOs and citizen groups capacitating people and securing priority of water in urban development - Lacking documentation, staff, and expertise to conduct advanced spatial planning - Earthquake memorial - Housing growing population	- Population growth (188,000 in 2011 [49]; approximately 200,000 in 2020 [41]) - Urban sprawl (avoiding earthquake-sensitive high-rises) - Invisible (droughty) water system - Encroachment on the water system - Urban flooding due to reduced drainage and precipitation intensified by climate change
Future Bhuj	- Third Development Plan, 2025 (lacking report) - Housing growing population (450,000 projected for 2051 [34]) - Increased identification of water bodies	

4. Discussion of Drivers and Barriers to Water Sensitivity

This historical account provides insight into the urban development of Bhuj in relation to hydrological processes and urban water cycles. Historic events determine shifting hydro-social contracts, urban water management regimes, and urban transitions. Spatial elements and cultural aspects of previous urban water arrangements, however, do not disappear when the urban environment has transitioned. Remaining as artifacts, ongoing development settles on them. Ongoing developments are rooted in, or originating and evolving from, these artifacts as a previous establishment. In this discussion, these lost and remaining spatial elements and cultural aspects of urban water transitions are reviewed as fragments with the potential to understand or capacitate local water sensitivity and seek promising combinations with WSUD. Highlighting the contextual specificity of water sensitivity, this discussion is organized around two evident barriers due to Bhuj's arid and earthquake-prone surroundings.

4.1. Arid Bhuj

A constant objective—from the establishment of the walled city, during the period as a British military post, to modern times—is to provide the city in an arid region with water security. Tangible artifacts in space, once controlling flow directions and capturing water of the natural drainage system, underline how water security has been fundamental to securing and expanding the local power systems and its accompanying urban settlement. Provision and perception of water security, however, can be achieved using methods that may differ per ruling authority. Intangible urban water culture underlines how water security is still perceived as a cornerstone of arid urban life. Development of the urban environment, however, no longer sets conditions for how water security is achieved, while relative and absolute demand grows.

The transition from water-centric to land-centric development is attributed to the adoption of new water management technologies [24]. Additionally, the introduction of different technology interlinks with shifting hydro-social contracts as novel technology alters hydro-social contracts while upcoming hydro-social contracts also call for modern technology. Both are the case in Bhuj, where exogenous British water infrastructure and water service expectations imposed new value systems and reshaped local views regarding how water should be managed and provided. In later periods, modernizing perceptions of water health and assumptions of water availability in the arid region challenged local resource dependency and appealed to infrastructure to deliver solutions. While demanding ongoing modernization, Bhuj's urban population increases, adding to the water demand. Securing the image of modernity by reproducing exogenous water resource management routines may, however, carry coloniality forward [12]. Interlinkage of technology and hydro-social contract particularly becomes a threat the moment the deployed technology or prevalent contract disregards or affects local hydrological processes while the tech-contract relation and dependency strengthen. Besides decreasing awareness of hydrological processes and the traditional water network, this threat is invigorated by the invisibility of these flows due to the aridness.

Besides being a barrier, the arid context does provide drivers for water sensitivity by challenging urban development and urban water management. One of the key principles for practice underpinning WSUD in fact calls to use cities as water supply catchments with a diversity of infrastructures [50]. Unlike the formation of most cities—in which water was initially imported into town to exploit and be disposed of out of town when polluted—Bhuj's foundational layout and infrastructure had already been conceived to maximize efficient capture and use of water. However, suffering from encroachment and reduced visibility and performance of the traditional water system interventions, many elements of the system remain in place as a network, still recognizable in the city's urban form, waiting to be re-operationalized [51] in line with the city's persisting urban water culture.

Another key principle for WSUD practice calls upon the city's communities and institutional capacity for water-sensitive decision making and behavior [50]. The citizens' care for Hamirsar and other water bodies (e.g., by JSSS and ACT) alludes to a potential upscaling toward the historic water system. A barrier to overcome is the lack of collaboration between local planning and development authorities and NGOs and citizen groups. The increased identification of water bodies can then be advanced to active protection and conservation and include consideration of water bodies as an interconnected system to the same degree as traditional watershed management succeeded to do in previous centuries.

4.2. Earthquake-Prone Bhuj

Detrimental features of Bhuj's urban development history and logic are its earthquake susceptibility, recurring earthquake events (i.e., 1819, 1844, 1956, and 2001), and reconstructions in response. Earthquake-pressured decision making for urban redevelopment commonly fails to use the opportunity to avert vulnerabilities, yet it entails the establishment of additional or alternative ones [37]. Many of Bhuj's interventions or developments insensitive to water should today be seen in light of its post-2001 Bhuj earthquake

emergency context in which priority to water (sensitivity) was considered unaffordable. Nevertheless, as a piece of history unfortunately repeating itself, the earthquakes, interventions, and their effects in Bhuj make up the current and future agenda of urban water management challenges.

At the same time, earthquake incidents and their repercussions have given rise to awareness of the inhabitants of the region regarding water and heritage. By uniting in NGOs and citizen groups, inhabitants put their awareness into practice to compliment, encourage, or critique government initiatives and further its dissemination [24]. Efforts have been directed at participatory urban water management and the traditional water system (e.g., by ACT), as well as traditional earthquake-prone construction practices and use of local construction materials (e.g., by the Hunnarshala Foundation) and halting encroachments (e.g., by JSSS). It suggests citizen-instigated care for heritage and tradition for which the 2001 earthquake can be considered a turning point, following an era of insensitivity and abuse of the traditional system by development authorities [24]. Local authorities, however, continue to lack independence from district or state-level authorities to join the approach of comprehensive heritage conservation. Despite earthquake risk calling for decentralizing urban water infrastructure—in fact, re-operationalizing the city's traditional system [51]—authorities at multiple levels continue to opt for a centralized focus on Narmada and miss opportunities for drainage and recharge.

Weak governance of water service provision and spatial planning in countries like India recurrently challenges water-sensitive urban development as responsible authorities operate in silos (i.e., scalar and disciplinary) and obstruct integration and collaborative policy establishment [15]. Planning in Bhuj inclines to address short-term targets motivated by urgencies ordered by its earthquake history. The city's spatial planning is, furthermore, limited to macro-level zoning efforts, whereas alternative or additional micro-level and catchment-level focus on water bodies and hydrological processes would enable water sensitivity.

Water-sensitive intentions do exist among Bhuj's local officials, resulting in improved documentation of the water system, an increased number of water bodies featured in DPs, and their inclusion in development permits. Yet the prevalence of short-term strategies and the lack of capacities in terms of finance, skill sets, staff, and knowledge impede formalization, upscaling, and enforcement of this intention and obstruct it from becoming an integral enabler of water sensitivity. The city's network of NGOs and citizen groups face similar limitations. Its emergence, however, highlights the major potential to leverage local values toward water sensitivity [12].

5. Conclusions

WSUD succeeds in tapping into past urban water transitions of the world's primary city contexts and guiding their future transitions sustainably toward water sensitivity as a goal. The city of Bhuj, however, exemplifies a secondary city with a remarkably rich water history defining its urban development and different urban conditions coexisting within the city, notably differentiating it from cities in which WSUD has been conceptualized. Water sensitivity can, in Bhuj, instead be recognized in past and present practices and infrastructures, yet it is at times challenged by current transitions rather than improved. Rapid urbanization, short-term spatial planning, aridity, and perceived data deficiency are among the context specificities raising concerns regarding the suitability and transferability of the WSUD approach to the alternative urban conditions.

To go deeper into design mechanisms behind WSUD and context-specific opportunities and obstacles for water sensitivity—highlighting promising combinations of established WSUD and local water sensitivity—this article deploys a set of qualitative methods. Through a literature review, interviews, workshops, and fieldwork, a historical narrative of Bhuj's urban development and water transitions was constructed, chronologically arranged in six periods from its foundation to its future, focusing on spatial planning and its spatial manifestation. The historical account of Bhuj's context serves as an analysis to cast light on its effects on hydrological processes and urban water cycles as drivers and barriers

of water sensitivity. As such, the article deploys a design act of reading and describing space and reviewing historical context, common to situated urban design processes [13], yet unaccounted for in WSUD. Two prominent context specificities organize the discussion that follows: the city's aridness and earthquake risk. The inventory around these context specificities provides answers to the research question on both enablers and disablers of water sensitivity in past urban water transitions. Despite the fact that these context specificities generally encumber water-sensitive urban development, ingredients for water sensitivity seem to gravitate around them.

Triggered by earthquake vulnerability, they include a general citizen awareness for and cultural and historical connection to geophysical systems, care for heritage, well-networked NGOs and participatory citizen groups engaged in local water resource conservation, and a strong argument for decentralization of water systems. The arid context, additionally, provides a pursuit for water security to be a part of the city's urban water culture and is represented in remaining artifacts. Furthermore, the city and district are subject to large investments. Yet at the same time, barriers to the operationalization of these potentialities remain and require to be overtaken. Despite the natural argument for decentralization, local authorities opt for centralization fitting their short time frames, immediate needs, and availability of funds. These often align with the central government's urban development agenda. Investments fail to reach or engage urban local bodies, NGOs, and other citizen groups. Without additional resources, local authorities and citizen groups lack collaboration and the development of skills to succeed in operating in a transdisciplinary manner. Various capacities for water sensitivity may be present, yet remain sporadic, inconsistent, and selective [12]. Manifesting in response to catastrophic events, an ad hoc approach can be recognized in contemporary spatial planning in Bhuj. Short-term targets dictated by an emergency state hinder envisioning long-term goals and accounting for ecology and hydrological systems.

The descriptive narration of a context and its history has provided insight into barriers and drivers of water sensitivity. That description and review as a design act, however, contribute to redefining notions of relevance to WSUD and the role of spatial planning and urban design. Context specificities, like aridity and earthquake risk, seemingly inhibit sustainable urban water transitions in Bhuj as proposed by WSUD theory. The city's infrastructural deficits may imply a long way to go for Bhuj to develop into the ideal water-sensitive city [51]. Yet by using insights acquired through design action, into history, context specificities, traditional knowledge, and the state of infrastructure and framing and reviewing them as an existing water sensitivity in place, sustainable urban transitions can potentially be unlocked. As such, this approach responds to the question of the relevance of the gained insights for ongoing and future urban transitions in Bhuj. This article does not intend to offer a framework or principles for locating drivers and barriers or unlocking sustainable transitions, nor does it intend to answer the formulated research questions exhaustively or once and for all. Instead, it showcases how furthering the intention to operationalize urban design and spatial planning processes to fuller extents and more consciously (e.g., by review of historic development) can improve the capacity of WSUD to understand ongoing urban transitions and facilitate sustainability of future ones. Collaboration between urban design and spatial planning fields provides a double perspective on real development means, motivation, and logic of an urban environment in which entry points for WSUD and sustainable transitions reside. Furthermore, by focusing on urban design mechanisms, WSUD can embrace the complex reality of urban environments rooted in multilayered past developments and the open-endedness and uncertainty that apply to planning transitions for such contexts. It is in this manner that questions inquiring into barriers and drivers of water sensitivity and their relevance to ongoing and future transitions are addressed.

Centering drivers and barriers of context-specific water sensitivity through emphasized urban design approaches allows us to challenge current efforts of modernization and urban development and its roots in colonial values. By acknowledging stronger ties to local

history, traditional knowledge, and the influence of context specificities in ongoing urban processes, this study is part of a greater project of "decolonizing (urban and water infrastructure) design" [18]. As an imperative to which all acts of design should be oriented [52], decolonizing design entails an enhanced focus on the context to be addressed by design acts and unlearning and reconsidering the roots of accustomed design approaches. By considering water sensitivity as present throughout the histories of cities like Bhuj and as a variable that can be strengthened, WSUD can facilitate context specificity and improve the sustainability of future urban transitions. Toward furthering the decolonization of design, future research should be directed at making alternative readings of urban environments, such as historical accounts, and at making those readings systemic, acknowledged, and engaged in by local spatial planning, water management, urban design, and urban development practices, each represented by their complete fields of stakeholders, especially concerning contexts where such practices are influenced by informality.

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