Addressing Climate Change Through Water Landscapes In India

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The escalating problems of water scarcity and urban flash floods are only expected to get worse under the joint pressures of urban development and climate change. In an effort to better understand these challenges in the South Asian context, this paper surveys four simple water management landscapes currently used in India: the pond or *talaab* system, stepped river-fronts or the *ghat* system, artificial glaciers and snow barrier bands. Talaab are man-made ponds that capture and store monsoonal water for use later in the year; ghat are stepped edges of rivers which prevent riverine flooding; artificial glaciers store glacial meltwater as ice for use in spring; and snow barrier bands divert snow into high mountain watersheds so that the meltwater will become usable during the warmer months of the year. This research is based on both direct field studies and archival document studies, conducted during the course of the past three years. In considering these four disparate approaches to water management, one can better understand the wide variety of design decisions, implications for climate-adaptive planning, and opportunities for more widespread use that these examples offer.

INTRODUCTION

Water has always played an important role in dictating human settlement patterns. This is particularly visible on the Indian sub-continent, where one of the most ancient urban human civilizations flourished along the banks of the Indus River. The weather patterns of this region, which include long dry periods as well as intense rainfall, has necessitated a close relationship between water management and human settlement. In India, many sophisticated and elegant water harvesting techniques have been developed and perfected through the centuries because rainfall is seasonally limited and thus, water storage is essential. Because water management has been refined over centuries in this part of the world, Indian case studies offer a useful and time-tested precedent for future, climate-adaptive design of water landscapes.

Water is a contested resource in India. Indian agriculture relies heavily on inconsistent monsoons and snowfall, which in recent years have been further decoupled from the agricultural seasons by the effects of climate change[11 21]. According to Baier, India provides a timely opportunity to "understand the applicability of urban growth theories in non-western contexts, and for developing methods to examine the patterns and processes that impact water conditions in human-dominated landscapes"[3]. The country's current intense urbanization, coupled with dwindling or mismanaged resources, has resulted in its acute water management challenges. While rapid urbanization can be found all over the world, the most explosive growth has been recorded in South Asia, where there was a five-fold increase in urban population in the last fifty years[23]. Several authors in recent years have also pointed to the increase in flood and water scarcity events in Indian cities and their connection to urbanization[13 2]. In the Indian subcontinent, the imminent exhaustion of groundwater is a threat to agriculture and human survival itself, as are the rapidly receding glaciers in the North[9 15]. This water scarcity suggests a demand for greater reliance on surface water supply systems[4] and landscapes that could support water husbandry.

In recent years, climate change has complicated the pressing urban water management issues in India[12]. Climate change is projected to cause an increase in extreme climate events[25], as well as endemic drought, flooding, and resource conflict[8 14]. It may also encourage an even greater rural to urban migration, further exacerbating urban water pressures and affecting the lives of millions of people. In this context, research on the relation between the monsoonal problems of flooding, the erosion of glacial mass, water scarcity and existing water landscape systems becomes doubly important, as these systems could have the potential to provide sustainable low-cost solutions to regional hydro-climatic threat management. In the face of the severe water shortages and increasing flooding incidents facing Indian cities and towns, existing flexible water systems could help to re-direct settlement planning to help mitigate these issues in India.

WATER MANAGEMENT LANDSCAPES IN INDIA

This paper charts four unique and flexible climate-adaptive water management strategies currently in use in India: the talaab system in Raipur, the ghat system in Varanasi, snow barrier bands in the Himalayas and artificial glaciers in Ladakh. First and foremost, these disparate examples

Figure 1: Map of India showing the location of field-studies.

serve as a means of managing, regulating, and conserving water under the twin pressures of climate change and resource scarcity. However, they are also examples of social and cultural spaces with deeply intertwined ecosystem services. These multifunctional landscapes offer insight into the many climate-adaptive strategies currently in place, and as such provide important design lessons. In India, as in many other countries, water has long been considered a part of the commons. It is understood to be both a shared resource and a basic human right: critical for the subsistence agricultural practices that support much of the population. Beyond this functional role, water infrastructure and landscapes hold extraordinary social, cultural and religious meaning for many Indians. Without the effective management of water resources in the coming years, there will be many social, economic, and environmental repercussions.

Only 15% of homes in slums in India have water, sanitation and electricity in their homes, while 63% of the more affluent households have these amenities[7]. For example, slums in Raipur, in central India have about 22,777 dwelling units with a population of 1,59,120 lacking basic facilities of water, sanitation and electricity[9]. The people living in slums depend on monsoonal water stored in the talaab for fulfilling most of their domestic requirements. Further, in this part of the country, the majority of the area under agriculture is irrigated through monsoonal rainfall. Many Indian farms are completely dependent on the monsoons for fulfilling their water requirements. Likewise, in the tiny high-Himalayan villages of Ladakh, the meltwater from glaciers and snowfields has always been treated as a form of the commons. Here, subsistence agriculture villages must actively collaborate to manage limited meltwater: directing, stockpiling, and equitably dividing it over the course of a year. As such, surface water management—the collection, retention, and dispersion of flowing meltwater from glaciers and snowfields above—has become a central planning concern of the Ladakhi village. Ladakhi villages have adopted several relatively new innovations, typically in the form of a design intervention that bolsters the functioning of extant water infrastructure.

METHODOLOGY

Original data derived from field studies is the basis for all information presented in this paper unless otherwise cited. Data from field studies was collected through direct observation and documented via field notes, sketches, mapping and photographs. Visual observations at each of these water systems were supplemented with studies of archival reports, existing literature and information gleaned through informal interviews of people using the water systems or living in adjoining neighborhoods.

Studies of 103 talaab was conducted during years 2011 - 2012 in rural and urban Raipur, the capital city of the state of Chhattisgarh in central India. Raipur receives an average of 1,462 mm annual monsoonal rainfall in three to four months, which is collected in the paddy fields directly for irrigation and in the numerous talaab for use after the monsoon season. Chhattisgarh state has over 48,000 talaab in use for irrigation, of which 36,000 are in Raipur district. In the Bastar district, talaab provide water for 60% of the net irrigated area (Tiwari & Jain, 1989). Thus, Chhattisgarh is still largely dependent on the talaab for irrigation and has an area of 105,000 hectares under talaab irrigation. The talaab in Raipur are being used by thousands of people on a daily basis.

Field studies of 84 ghat were conducted in 2015 on the banks of river Ganga in Varanasi, India. A ghat is the Hindi word for a series of cascading steps and intermittent platforms constructed on the natural levees of a river which provides physical access to the river water for bathing and other purposes, even when the water level changes significantly between the summer and late monsoon period. Almost all cities with a river flowing through or adjacent to it have a ghat system. Sometimes cities developed around the ghat because of the ghats' sacrality. The ghat system in Varanasi is particularly spectacular because the ghat form a continuous linear edge to the river. The four-mile long crescent-shaped Ganga riverfront of Varanasi is reconstructed into a series of continuous steps and platforms, coupled with a magnificent building skyline. This waterfront is also one of the holiest in India and attracts a large number of pilgrims and tourists from within India and abroad.

Field studies of snow barrier bands and artificial glaciers were conducted during two consecutive summers, in 2014 and 2015. In all, seven artificial glaciers and many dozens of snow barrier band walls were mapped, measured and diagrammed. While these ice formations are in the process of melting during the summer months, the infrastructure, engineering and landscape components of these designs can be better understood, while visible, in the warm season. Both designs help to direct and stockpile glacial meltwater in the form of ice or snow over the course of the calendar year. In the far northern Indian Himalaya, these design interventions are used by farmers to better cope with fluctuating water conditions over the course of the year.

Figure 2: Shitla Talaab in Amlidih, Raipur, Chhattisgarh, India.

THE TALAAB SYSTEM

The pond or talaab in Hindi is a layered ancient water management system through which rainwater is stored in man-made depressions on the land during the monsoon season and used throughout the year for various purposes. According to one estimate, there have been 1.3 million of these human-made lakes and ponds in India[22]. Over centuries, these natural low points of the landscape have been translated over the parameters of culture to become key centers of adjacent neighborhoods, through richly-layered utilitarian, ecological, social and religious performance, in addition to the primary function of storing water[16]. Of these, three functions make the study and conservation of the talaab system important, in relation to climate change: first, the use of talaab water to satisfy non-potable domestic water requirements; second, its potential for being reused as a source of irrigation water; and finally, its role as a decentralized urban flood management system. Talaab are an intrinsic part of urban as well as rural settlements. In this part of the country, all settlements, whether small or large, were accompanied by the construction of big and small talaab. As the settlements grew to become large cities, so did the talaab in number, and often a single city would have more than a hundred water bodies distributed throughout the city. These numerous water bodies would collect the monsoonal runoff for later use, thus preventing downstream riverine flooding.

Once a robust system, the talaab system has deteriorated due to many reasons in contemporary India. Even in its deteriorated state, the talaab system still acts as the main source of water for fulfilling most of the non-potable water requirements for the country's urban and rural poor. In India, only 15% of homes in slums have water, sanitation and electricity in their homes, while 63% of the more affluent households have these amenities[7]. Talaab in Raipur are used by a large number of people from the economically weakest sections of society on a daily basis. Further, beginning in 1960, groundwater irrigation has developed at an explosive rate in India while talaab or tank irrigation has almost disappeared. Currently, 50% of the irrigation water in India is sourced from the ground (Swain 2004) and this era of unchecked groundwater utilization has led to the massive depletion of groundwater levels. Chigurupati has documented, in Hyderabad, the connection between the loss of talaab and increasing waterlogging in the city during the monsoons, coupled with evidence on increasing water shortages in the city during summers since the mid-1980s when residents began to receive piped municipal water[5]. Such incidents of flooding are increasingly being reported in many parts of the country (ibid). These trends suggest that the irreversible loss of

Figure 3: Assi Ghat in Varanasi, Uttar Pradesh, India.

the talaab system will have problematic consequences for urban flood management in Indian cities.

THE GHAT SYSTEM

Similar to the talaab, ghat are an integral part of the lives of people in India. According to Samant, ghat are manifestations of the spiritual importance accorded to rivers in India[20]. These popular public spaces adjoining rivers in India are used for many activities: people bathe at the ghat, wash clothes, perform various religious rites, children play on the ghat, and young and old gather to socialize. Much like the talaab, the microclimate at the ghat is cooler than the temperature in the city because of the adjoining water body, and the shaded areas provide a welcome relief from the heat.

Ghat act as retaining structures, stabilizing the river banks and channeling water safely away, thereby protecting the adjoining settlement from changes in the river's course. Most importantly, they allow people to access the water commons throughout the year, while simultaneously preventing the adjoining city from being flooded when the river's water level increases during the monsoonal rainfall. The design of the ghat with steps and intermediate platforms creates a functional space irrespective of the water level.

It is precisely this design flexibility, particularly with respect to its role in preventing urban flooding that could provide value with respect to some of the challenges predicted under climate change. An increased number and intensity of storm events can cause unexpected increases in riverine water levels. The massive built form of the ghat, combined with a solid architectural building edge ensures that increased water levels and violent post-storm flows do not pose a threat to adjoining settlements. India is experiencing unprecedented urbanization. It is estimated that from years 2006–2030, India will add 270.8 million to its urban population[19]. This rapid poorly-planned urbanization cases a hardening of the earth's surface upstream and increases riverine water flow during peak monsoon season. Thus, these stepped embankments need to be built up higher to protect adjoining settlements and address the increasing high-water levels of rivers.

ARTIFICIAL GLACIERS

Artificial glaciers are massive ice dams, built into the land high above villages in the Indian Himalaya. They work by capturing meltwater from even higher glaciers in the fall, where it is stored over winter as ice, for irrigation use in the spring. These enormous landscape infrastructure interventions effectively manipulate annual freeze-thaw cycles to stockpile water above agricultural sites[1]. Artificial glaciers are composed of a series of linked harvesting pools connecting high-altitude natural glaciers

Figure 4: An artificial glacier above the village of Nang, in Ladakh, India

with agricultural holdings below, and diversion gates that enable farmers to control the flow of water coursing through this system.

As such, these design interventions can be considered extremely low-tech, affordable site-specific works that rely on gravity, local knowledge and solar aspect[11 17]. Nine different systems have been deployed in both Ladakh and Zanskar, with interventions that stretch over a mile in length. In this region, the glacial pools are built using village labor, site-sourced stone and ancient masonry wall construction techniques[6]. By collecting water that naturally courses through the watershed during late fall and holding it for use in spring, these glaciers make efficient use of an otherwise untapped resource[24]. In the context of climate change and resource scarcity, this additional water cache acts as a safety net for subsistence agricultural communities.

As parent glaciers diminish in size due to climate change, and release less water, irrigation water supplies are becoming increasingly scarce. Once self-sufficient subsistence agricultural communities in this Himalayan mountain range have recently encountered multi-year drought conditions and are witnessing the persistent loss of glacial mass[10 15]. In contrast to the ghat, talaab, and snow barrier bands, artificial glaciers are a relatively new water management strategy in India and can be considered a regionally-specific climate-adaptive design.

SNOW BARRIER BANDS

Snow barrier bands also capture Himalayan water, in the form of snow, for agricultural use. They can be formed by linking a series of low masonry walls across the upper portion of a high-mountain watershed. While these stone walls may only stand four or five feet tall, they can extend hundreds of feet in length. Working together to funnel snow into an agricultural drainage, these design interventions stockpile snow over the winter for its use as meltwater in the following spring.

Because many high Himalayan villages have chosen to orient to the sun, they often locate themselves in south-facing drainages. A single mountain range may have many more south-facing villages than north-facing villages. In these cases, the snow barrier bands located at the top of high mountain passes will direct wind-blown snow into the southern drainage, rather than allowing the snow to crest the pass and enter the north facing drainage. In so doing, the snow barrier bands increase the amount of meltwater made available to southern-oriented villages without causing downstream losses that might impact other villages in the region.

While snow barrier bands have a long history of use in the far northern mountain regions of India, they have recently become more widespread, as water resources in the area have dwindled. Warmer seasons, combined with shifting weather patterns that reduce annual snowfall, have created drought conditions in the area. Although high-altitude, arid

Figure 5: Behind the yaks, a snow barrier band at Warila Pass, 17,500' in Ladakh, India.

Ladakhi landscapes have historically lacked irrigation reserves, climate change has exacerbated these environmental conditions[10 18]. Today, village communities that are almost entirely reliant upon the meltwater from snowfields work together to maintain, extend, and resurrect ancient snow barrier bands.

CONCLUSION

The design interventions outlined in this paper highlight just four of the different water harvesting and management solutions currently in use in India. India is an enormous country, with a wide range of lifestyles, cultural needs, water uses, topographical conditions and climatic regions. However, in each of these water management systems, a series of common qualities can be discerned. For instance, these forms of water husbandry are responsive to the local climate and social context, providing both culturally appropriate and site-specific interventions. The solutions feature low implementation costs, low-tech construction and relative flexibility over time. In all cases, the water management strategies simply improve existing harvesting systems, so they represent a relatively low-risk response to climate-change adaptation.

There is an urgent need to study the systems of water management such as the talaab, ghat, artificial glaciers and snow barrier bands in the context of India to ensure that developmental funding is being channeled into sustainable and resilient long-term solutions. Moreover, these water management strategies may also provide design guidance for regions beyond India. Each system suggests the benefits of dispersed small-scale solutions. Unlike many of the top-down, state-supported infrastructural projects underway in India and abroad, these four designs are affordable, scalable and accessible even to rural populations. These design interventions can be deployed in an extant natural watershed and in so doing, improve the efficiency, safety and legibility of that system, without diminishing or displacing other uses.

Water has become an invisible part of the commons in many parts of the world. In many of these places water may be harvested, diverted, pumped, and sanitized in highly engineered, "off-limits" pipes, channels, and physical facilities. This loss of legibility, and the concomitant loss of contextually-responsive design thinking, suggests a missed opportunity for resilient planning under climate change. If such sites instead brought water management to the surface, both physically and philosophically, and invited legibility and interaction among stakeholders, one could imagine better assessment, engagement, and design outcomes.

As water scarcity becomes increasingly pronounced across the globe, water management solutions will need to shift to support the resilience characteristics of flexibility, scalability, layering and adaptability. These Indian cases suggest that in order to be effective, climate-adaptive design solutions must work incrementally within a specific context. Indeed, these water management practices highlight the necessity of integrating water environments with social, environmental, religious and cultural contexts; elevating water management to a valued and visible place, physically, in the commons.

ENDNOTES

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