Down To The Last Drop: Rainwater Harvesting In India

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ABSTRACT
Only recently has rainwater harvesting begun to gain momentum as a viable, sustainable practice within the United States. However, in India, where economic resources are limited and where the health and survival of the population ultimately depend on rainwater from seasonal monsoons, citizens have been harvesting rain since antiquity. Harvesting is now prevalent at all scales, from rural villages to urban households; citizens use a multitude of techniques to capture and store rainwater and recharge groundwater.

Rainwater-harvesting systems are extremely effective environmentally, though to remain socially and culturally sustainable, they must foster opportunities for environmental education, social engagement, and cultural pride too. Thus, the design of contemporary rainwater-harvesting systems worldwide can use examples in India that transcend mere infrastructure to engage the community. This paper synthesizes first hand field research, personal interviews, detailed diagrams, and photographs of various examples across India to show how these systems can infuse amenity within infrastructure, blending art with science to ensure rainwater-harvesting practices remain successful, resilient, and continually adaptable to ecological needs and human desires.

1 INTRODUCTION
As a necessary means for survival, rainwater harvesting in India has been practiced for centuries. Attuned to local climatic conditions and functional needs, citizens have developed many regionally specific ways to capture and store rainwater, and recharge groundwater, especially in rural areas. However, partly because of rapid urbanization and the widespread reliance on groundwater from bore-wells, many traditional rainwater-harvesting systems are no longer used and have fallen into disrepair. Yet in Tamil Nadu, the first Indian state to mandate universal rainwater harvesting, citizens have not only begun to revive lost traditions but have developed many contemporary strategies to better suit present day urban society. Though incredibly effective environmentally, contemporary urban practices, however, have yet to fully resonate socially or culturally within modern Indian society. In rural areas, however, rainwater-harvesting systems have transcended mere infrastructure to encompass social and cultural benefits as well.

2 BACKGROUND
Like many cities throughout India, Chennai, faces particularly difficult climatic conditions: flooding during monsoon season and drought during the summer months. Located along the Bay of Bengal in Tamil Nadu, nearly 60% of Chennai's 1300 mm of annual rainfall is lost as it flows into storm drains and sewers, running to the sea (Raghavan, 2008). The city, however, is not rain starved; that is, it receives enough annual rainfall to supply its metropolitan needs. At times, it can become water starved, meaning it does not have enough accessible supply to fulfill basic needs. Home to upwards of 7 million people, the city has often faced severe water shortages, especially in years of drought, given the population's increasing demands and the ever-diminishing freshwater supply.

Many citizens of Chennai rely on local open-wells, or deeply dug bore-wells, for their personal water supply; that is, they directly tap groundwater resources.[1] Before the mid 1990s, the groundwater in Chennai was high quality and seemingly plentiful, thus leading farmers, citizens, and industries to extract too much. By 2000, groundwater was being extracted faster than it could be recharged naturally. In many areas, the water table dropped to levels below the reach of wells, and because Chennai is a coastal city, saltwater intrusion caused much well water to become saline and largely unsuitable for household use. Ultimately, the over pumping, coupled with years of extreme drought and the destruction of most natural water bodies, left Chennai paralyzed by dramatic water shortages. Open-wells ran dry, groundwater water quality was poor, and the municipal supply was at an all-time low. These events served as a catalyst for India's first statewide rainwater harvesting law.

In 2002, the Tamil Nadu government enacted a rainwater harvesting law, requiring rainwater harvesting systems for all existing and proposed structures across the entire state. While architects, plumbers, and engineers were at the forefront of designing and implementing micro-scale urban systems, engineers, academics, and various private donors collaborated on the design, funding, and implementation of larger, macro-scale systems in rural areas. Mandatory retrofitting ended just short of a year after the law was enacted, but all new construction must still, by law, incorporate rainwater harvesting.

1 An open-well refers to an excavated chamber, dug deep enough into the ground that it reaches the water table. If the soil is clayey or sandy, the sides of the chamber are reinforced with bricks, masonry, or pre-cast concrete rings to keep the well from collapsing. The chamber is generally circular with a diameter of 1-4m in urban areas and is rarely deeper than 15m (Ragade 2005).
A bore-well is a small-diameter hole, 100-250mm. Drilled generally much deeper into the soil than the open-well, it can tap multiple layers of underground water. The holes are often lined with PVC pipe to prevent collapse (Ragade 2005).

Figure 1: Contemporary oorani in Tamil Nadu

Figure 2: Traditional ery in Tamil Nadu

3 METHODS
To examine the severity of water shortages and how rainwater-harvesting systems are designed and implemented across Tamil Nadu, field study was essential. Most of the research for this paper came from a synthesis of direct observations, personal interviews, and data collected from documented case studies. For two weeks, the author was in India meeting with local rainwater harvesting experts, citizens, scholars, scientists, and government officials, asking about local challenges and benefits of rainwater harvesting, as well as examining social and cultural associations with the practice. Working alongside Dr. Sekhar Raghavan, the director of Chennai's Akash Ganga Rain Centre, the author saw many examples of rural and urban systems, documenting in conceptual diagrams, measured drawings, and photographs.

4 FINDINGS
This field study strongly confirmed the overall importance and pervasiveness of rainwater harvesting in India. To understand how these practices might begin to influence other cases, it is important to illuminate the simplicity of the rainwater harvesting process, the social and cultural influences on the process, as well as the need to increase awareness of water scarcity and environmental stewardship.

4.1 Process of Rainwater Harvesting
Regardless of size and form, all rainwater-harvesting systems function to capture, convey, and store collected rainwater. Catchment occurs where rainfall lands, whether onto impervious surfaces such as rooftops or pervious surfaces such as agricultural fields. The process of conveyance involves directing the catchment, typically through pipes or channels, into storage structures. Water for immediate use is stored in either constructed or natural structures like tanks, open wells, reservoirs, lakes, or lagoons. Water for later use is recharged into the soil, in essence, stored in aquifers. Although the process of rainwater harvesting may seem complex, according to Dr. Sekhar Raghavan, "It is a simple solution to a complicated problem" (Raghavan, 2008).

Whether water is stored or recharged largely depends on rainfall patterns, soil composition, physical space constraints, land uses, and user needs. In rural areas, villagers most commonly capture and store rainwater in large surface tanks, keeping it readily available for irrigation, livestock, and household needs. In urban areas where space is extremely limited, surface storage is not practical, so rainwater is predominantly recharged to replenish wells. That is, surface runoff is collected in trench drains or percolation pits and directed into the soil through deeply drilled recharge shafts. Effectively simulating natural percolation, recharge not only allows aquifers to be replenished but helps mitigate urban flooding during the monsoon season as well.

Traditionally, villagers used two main types of open-air storage basins: the ery, an earthen basin, for livestock and irrigation supply, and the oorani, a masonry basin, used for drinking supply and household needs (see Figures 1, 2).[2] Urban residents depended primarily on masonry tanks known as temple tanks for their water supply (see Figure 3).[3] The gradual decline of these traditional systems are, in part, due to haphazard urbanization, a lack of appropriated funding, and the widespread use of the bore-well, which shifted reliance to groundwater instead of surface water. Though most of these traditional systems stand as mere relics within contemporary India, considerable effort focuses on reviving these lost traditions, tailoring them to be more suitable for present day culture.

2 The ery system, which dates back to the second century AD, is a network of water bodies, also referred to as a 'chain of tanks.' Capitalizing on topographic low points, farmers added earthen berms around the perimeter of catchment fields. Channels were then dug to connect multiple erys into an overall system which was then fed either by local rivers or by monsoon rains.
The oorani is a rain-fed surface tank. Traditionally, each village commonly had three ponds: one for washing, one for cattle, and one for drinking (the oorani). For centuries ooranis were crucial to the survival of villagers. Contemporary ooranis are square or rectangular masonry basins, typically 4 to 6m deep, with sloped sides and a perimeter wall around the top to keep livestock out.
3 The temple tank, a traditional urban rainwater harvesting structure, it was designed to capture and store rainwater for recharge. Dating back centuries, these in ground, open-air, rectangular basins can range from .2 to 3 hectares in surface area, 3-6m deep. Throughout Chennai, every city neighborhood and village had at least one, and in fact, many had several (Dr. Raghavan 2008).

Figure 3: Traditional Temple Tank in Tamil Nadu.

4.2 Social and Cultural Influences on Rainwater Harvesting

One of the most significant distinctions between rural and urban rainwater harvesting are the social and cultural underpinnings of the practice. In rural areas, rainwater harvesting is implicitly a communal act. Structures are understood to be community infrastructure and the capture, storage, and transport of rainwater is a social act. In villages with a central water source, residents congregate, waiting for their turn to draw water into their household buckets. A task predominately undertaken daily by village women and children, this act of water gathering fosters community interaction (see Figures 4,5). For many villagers, their livelihood necessarily depends on harvested rains, and thus they have a vested interest in the functionality of these structures. This direct connection helps encourage greater care for and awareness of water quality and water conservation, because residents can visually and physically connect with their water supply.

In contrast, the practice of rainwater harvesting in urban areas is taken for granted. For urban residents, unlike for villagers, rainwater harvesting is a learned practice, not an ingrained means of survival. Because rainwater in urban areas is usually used to recharge aquifers, not stored, captured rains flow efficiently into trenches, percolation pits, and wells without human intervention, out of sight and out of mind, leaving few opportunities for social engagement and cultural pride (see Figures 6,7). This physical and visual disconnect has left many urban residents unaware of the processes and benefits of rainwater harvesting. Residents are, thus, not engaged with the source of their water supply.

This lack of social and cultural connection to rainwater harvesting in urban areas has not always been the case, however. Temple tanks, once highly revered open-air water basins, provided urban residents amenity and recharged the groundwater. Typically located near the main entrance of a temple, the temple tank, when full, was a peaceful, pleasing body of water. Stone steps lined the basin's inner perimeter, cascading down to water level, providing a place for citizens to gather and be cooled by surface breezes. Here one could come to socialize, to relax, or even watch a local performance or festival. However, subjected to informal urban development and illegal dumping, most of these once celebrated cultural features have fallen into great disrepair, no longer a focus of community pride.

Figure 4: Village Well in Tamil Nadu

Figure 5: Village Pump in Tamil Nadu
Image by Suzanne Ernst

Figure 6: Urban Rainwater Tanks.

Figure 7: Urban Percolation Pit
Image by Suzanne Ernst

4.3 Awareness of Rainwater Harvesting

According to Dr. Raghavan, in urban areas "The real importance of rainwater harvesting has not been fully realized by the general public. Though they are aware of what rainwater harvesting is all about, there is no sense of pride in them" (Raghavan 2008). More understanding and knowledge about the water supply is crucial in building environmental awareness and fostering concern about rainwater harvesting.

The biggest obstacles for rainwater harvesting in urban areas are apathy and social stigma. Urban residents often believe, incorrectly, that rainwater harvesting is a practice only for the less fortunate. Santha Sheela Nair, the Secretary of New Delhi's Department of Drinking Water Supply, strongly believes rainwater harvesting must be a collaborative community practice: "it should not be seen as something only poor people need to do," but instead, as something everyone does (Nair, 2008). Dr. Raghavan explains the issue in more detail: the "educated urban elite always look for complex solutions even for simple problems. Rainwater harvesting, being a simple solution for a complex problem, does not seem to be attractive for them" (Raghavan, 2008). Given this situation, education and awareness about rainwater harvesting will be crucial to maintaining an understanding of the necessity and value of rainwater harvesting, especially in urban areas.

In 2002, Chennai opened the privately funded Akash Ganga Trust Rain Centre. This resource and demonstration center was the first in the country. Inaugurated by then Chief Minister of Tamil Nadu and headed by Dr. Sekhar Raghavan, the center's mission is to provide citizens with information and assistance in harvesting rainwater. Through display panels, working models, videos, and a library full of implementation handouts, the center seeks to make everyone aware of rainwater harvesting-from school children, to college students, architects, engineers, plumbers, city officials, and anyone else interested in learning. Seeing the success of Chennai's rain center, several other have opened across India, but as Dr. Raghavan states, "rain centers are only one solution."

Another avenue for fostering cultural awareness about rainwater harvesting is environmental education, which is now appearing in primary school curricula across the country. Children are becoming acutely aware of the environmental problems facing India. The Shri Ram primary school, for example, begins its environmental education program for children at age four. The headmaster, Mrs. Madhu Bhatnagar, believes that "You can't just say change, you have to show how to change." Therefore, she has incorporated environmental stewardship into the curriculum. "Enlightening the students about the living world around them is just the first step," she states. "Showing them how environmental stewardship is implemented is invaluable" (Bhatnagar 2008).

Gradually, cultural ignorance and social misconceptions about rainwater harvesting are changing. In part because of Tamil Nadu's rainwater harvesting law, awareness campaigns, such as

that provided by the Rain Centre, and environmental education, such as that provided by the Shri Ram school, residents are more willingly taking part in rainwater harvesting.

Now, as rainwater harvesting systems become more widespread throughout the United States, Chennai's successes and struggles can serve as precedent. Though it is important to have contextually based systems, functionality alone is not enough to sustain the practice. To promote a greater awareness and care for water conservation, systems should be designed to resonate socially and culturally, providing physical structures that can support amenity and recreation as well.

5 CONCLUSION

Undoubtedly we need rainwater-harvesting systems for their ecological value: to mitigate hazards of flooding or drought, to regulate climate conditions and water supply, to filter pollutants, and to cleanse the water. However, we also need rainwater-harvesting systems for their human value: to meet aesthetic needs, affording visually stimulating and engaging spaces; to fulfill social needs, providing areas to gather or retreat; and to expand cultural perceptions, creating significant or meaningful experiences that foster a better understanding of and care for the environment. Thus, for the practice of rainwater harvesting to become a resilient, widely accepted sustainable practice, it must become culturally relevant.

The technology of rainwater harvesting is not new, nor does it need to be reinvented. However, culture and society should be acknowledged as we re-design rainwater harvesting systems to make them more appealing, giving users a greater sense of pride and encouraging their use. In rural areas, community participation is essential to the success of rainwater harvesting systems. Increasing public participation and bringing community members together could allow rainwater harvesting in urban areas to simultaneously serve as a celebrated practice as well as an amenity for families, households, or entire neighborhoods - one in which they become involved with their water supply and effectively come to appreciate and care for their environment as a whole, eventually changing the paradigm, so that citizens understand that rainwater harvesting is important.

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7 REFERENCES

Bhatnagar, Madhu, interview by Jessica Canfield. Head Master Shri Ram School. August 2008.

Che, David. Water resource management key to Chennai's future. July 18, 2007. http://chennai.metblogs.com/2007/07/18/water-resource-management-key-to-chennais-future. March 2009.

Conservation of Ecological Heritage and Sacred Sites of India. Sacred Tanks of India. http://www.ecoheritage.cpreec.org. March 2009.

Hill, Margarita M. "Teaching with Culture in Mind: Cross-Cultural Learning in Landscape Architecture Education." Landscape Journal, 2005: 117-124.

Integrated Rainwater Harvesting . Project Overview. http://oorani.tn.nic.in/projectoverview.php. March 2009.

Meyer, Elizabeth K. "Sustaining Beauty - The Performance of Appearance." Journal of Landscape Architecture, Spring 2008: 6-23.

Mozingo, Louise A. "The Aesthetics of Ecological Design: Seeing Science as Culture." Landscape Journal, Spring 1997: 46-59.

Nair, Santha Sheela, interview by Jessica Canfield. Secretary of the Department of Drinking Water Supply - New Delhi. August 2008.

Nassauer, Joan. "Messy Ecosystems, Orderly Frames." Landscape Journal 14(2), 1995: 161-170.

Ragade, Indukanth S. Self Reliance in Water. Ms. Jayanti Ragade: Chennai. 2005.

Raghavan, Dr. Sekhar, interview by Jessica Canfield. Akash Ganga Rain Centre. September 2008.

Raghavan, Dr. Sekhar. Rainwater Harvesting. Power Point, Akash Ganga Rain Centre, 2007.

Spirn, Anne Whinston. "The Poetics of City and Nature: Towards a New Aesthetic for Urban Design." LandscapeJournal, Fall 1988: 108-126.

Walther, Dirk, interview by Jessica Canfield. Centre for Environmental Studies Anna University, India. September 2008.

Professor Canfield is bringing her research into the classroom this semester as a co-instructor of Planting Design with Professor Lee Skabelund. As part of the Manhattan Mennonite Congregation site design and planting plan, students were challenged to creatively address issues of stormwater runoff, in essence creative applications of rainwater harvesting practices. Many chose to propose rain-gardens and/or vegetated swales as a means of providing ecologically and aesthetically beneficial design solutions.

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Mauricio Rocha-Iturbide with Professor and Architecture Department Head Dr. Peter Magyar