Churning the water after the wave: water components of housing reconstruction in post-tsunami south India

Luke Robert Juran
University of Iowa

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CHURNING THE WATER AFTER THE WAVE: WATER COMPONENTS OF HOUSING RECONSTRUCTION IN POST-TSUNAMI SOUTH INDIA

by

Luke Robert Juran

An Abstract

Of a thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Geography in the Graduate College of The University of Iowa

December 2012

Thesis Supervisor: Professor Rangaswamy Rajagopal
ABSTRACT

This dissertation provides an authoritative account of reconstruction in the water sector after the 2004 Indian Ocean tsunami in coastal, deltaic South India. In particular, this study examines 14 newly constructed housing settlements in the adjacent study areas of Nagapattinam District, Tamil Nadu, and Karaikal District, Puducherry. There is currently a paucity of literature dedicated to water components of reconstruction. Thus, this study expands the discourse and posits water elements of post-disaster processes as unique and therefore deserving of increased scholarly attention. The study is informed by a multi-methods approach and a geographical perspective. The methodologies include, inter alia, qualitative and quantitative survey instruments; key informant interviews; focus group discussions; the employment of primary documents; and environmental analyses through bacteriological and chemical water quality testing. Geographically, data, information, and actions are perceived as the coalescence of localized socio-cultural, politico-economic, and environmental fabrics. This approach to viewing circumstances is imperative for dissecting the outcomes of reconstruction processes in a specific context, and consequently for understanding problems, identifying solutions, and gauging the appropriateness of particular configurations in place-based systems.

This dissertation critiques the models utilized for reconstruction in the two study areas. The scales of inquiry are demographically and geo-physically similar, yet differ in political organization. It is argued that Nagapattinam executed a model of reconstruction founded on collaborative governance, while Karaikal exercised a single agency approach. Thus, various governmental agencies were responsible for specific reconstruction activities in Nagapattinam, whereas a single agency was responsible for all activities in Karaikal. In general, the latter approach, which was less layered, produced comparatively better outcomes. Moreover, both jurisdictions implemented ‘hard’ paths for water management and operationalized panoptic and revenue-based methods of
reconstruction, albeit inefficiently. Numerous shortcomings in reconstruction outcomes were uncovered (e.g., water quality, quantity, and pressure), as were an array of organic coping mechanisms established by affectees in order to surmount such inadequacies. To that end, it is contended that: the coping mechanisms fail to remedy the condition; much of the waterscape is beyond the control of the subjects; and the governments are ultimately deficient in responding to the needs of their citizens. The post-tsunami waterscapes are also analyzed quantitatively through the development of a contextualized, multi-scalar Water Poverty Index (WPI). The WPI is deployed with three distinct weighing schemes and reveals that, on the whole, the sites situated in Karaikal generally perform better than those in Nagapattinam. Interestingly enough, the sites located in rural Nagapattinam outperform their urban counterparts. This case—primarily a product of different water treatment processes—challenges conventional rural-urban dichotomies. Given the occurrence of poor water quality, an investigation of boiling as a method of household water treatment (HWT) surfaces several barriers to and caveats of its adoption. Data indicate that boiling is less effective than could be; thus, it is argued that boiling may not be the optimal strategy for HWT. Lastly, advised by the corpus of data, this dissertation presents a novel framework for managing water components of post-disaster reconstruction. The framework identifies common project failures, can be harnessed independently or alongside existing instruments, and possesses diagnostic, management, and evaluative potential.
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Thesis Supervisor: Professor Rangaswamy Rajagopal
CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

Luke Robert Juran

has been approved by the Examining Committee for the thesis requirement for the Doctor of Philosophy degree in Geography at the December 2012 graduation.

Thesis Committee:

Rangaswamy Rajagopal, Thesis Supervisor

George Malanson

Paul Greenough

Nandita Basu

Jerry Anthony
To Dalia, the beautiful flower that has blossomed in my life, and to our little one on the way;

To my parents, who wielded support from the outset to the summit of this winding journey;

To Sangeeta, whose smile beams across the seas and into my heart;

And to the people of Nagapattinam and Karaikal, without whom none of this would be possible.
For the world’s good your homes are sacrificed;
Your ruined palaces shall others build.

-Voltaire, Poem on the Lisbon disaster;
or an examination of the axiom, ‘all is well’
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<td>D.5</td>
<td>Saveriyarkovil – bacteriological presence-absence at water access points</td>
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<td>D.6</td>
<td>Theti – bacteriological presence-absence at water access points</td>
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<td>Uzhuvar Nagar – bacteriological presence-absence at water access points</td>
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<th>Full Form</th>
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<tr>
<td>(A)BDO</td>
<td>(Additional) Block Development Officer</td>
</tr>
<tr>
<td>ALRI</td>
<td>Acute Lower Respiratory Infection</td>
</tr>
<tr>
<td>ARC</td>
<td>American Red Cross</td>
</tr>
<tr>
<td>BEDROC</td>
<td>Building and Enabling the Disaster Resilience of Coastal Communities</td>
</tr>
<tr>
<td>BBB</td>
<td>Build Back Better</td>
</tr>
<tr>
<td>BIS</td>
<td>Bureau of Indian Standards</td>
</tr>
<tr>
<td>BSC</td>
<td>Balanced Scorecard Model</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
</tr>
<tr>
<td>CPHEEO</td>
<td>Central Public Health and Environmental Engineering Organisation</td>
</tr>
<tr>
<td>CRZ/CMZ</td>
<td>Coastal Regulation Zone / Coastal Management Zone</td>
</tr>
<tr>
<td>DDMA</td>
<td>District Disaster Management Authority</td>
</tr>
<tr>
<td>DJIA</td>
<td>Dow Jones Industrial Average</td>
</tr>
<tr>
<td>DMA</td>
<td>Disaster Management Act of 2005</td>
</tr>
<tr>
<td>DRDA</td>
<td>District Rural Development Agency</td>
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<tr>
<td>DRI</td>
<td>Disaster Risk Index</td>
</tr>
<tr>
<td>ECR</td>
<td>East Coast Road</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FGDs</td>
<td>Focus Group Discussions</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GDI</td>
<td>Gender Development Index</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning Systems</td>
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<tr>
<td>HDI</td>
<td>Human Development Index</td>
</tr>
<tr>
<td>HUDCO</td>
<td>Housing and Urban Development Corporation</td>
</tr>
<tr>
<td>HWT</td>
<td>Household Water Treatment</td>
</tr>
<tr>
<td>HWTS</td>
<td>Household Water Treatment and Safe Storage</td>
</tr>
<tr>
<td>IIT-M</td>
<td>Indian Institute of Technology-Madras</td>
</tr>
<tr>
<td>IRAM</td>
<td>Infrastructure Risk Analysis Model</td>
</tr>
<tr>
<td>IRR</td>
<td>Impoverishment Risks and Reconstruction Model</td>
</tr>
<tr>
<td>IWR(L)M</td>
<td>Integrated Water Resources (and Land-Use) Management</td>
</tr>
<tr>
<td>LFM</td>
<td>Logic Framework Method</td>
</tr>
<tr>
<td>LPCPD</td>
<td>Liters Per Capita Per Day</td>
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<tr>
<td>MDGs</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>MOU</td>
<td>Memorandum of Understanding</td>
</tr>
<tr>
<td>NABARD</td>
<td>National Bank for Agriculture and Rural Development</td>
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<tr>
<td>NDMA</td>
<td>National Disaster Management Authority</td>
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<tr>
<td>NEC</td>
<td>National Executive Committee</td>
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<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
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<tr>
<td>NIDM</td>
<td>National Institute of Disaster Management</td>
</tr>
<tr>
<td>NIUA</td>
<td>National Institute of Urban Affairs</td>
</tr>
<tr>
<td>NMC</td>
<td>Neighborhood Management Council</td>
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<tr>
<td>OADU</td>
<td>Open Air Defecation and Urination</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>OHT</td>
<td>Overhead Tank</td>
</tr>
<tr>
<td>PIA</td>
<td>Project Implementation Agency</td>
</tr>
<tr>
<td>PTSD</td>
<td>Post-Traumatic Stress Disorder</td>
</tr>
<tr>
<td>PWDP</td>
<td>Public Works Department of Puducherry</td>
</tr>
<tr>
<td>SAC</td>
<td>Shelter Advisory Committee</td>
</tr>
<tr>
<td>SC</td>
<td>Scheduled Caste</td>
</tr>
<tr>
<td>SDMA</td>
<td>State Disaster Management Authority</td>
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<tr>
<td>SODIS</td>
<td>Solar Disinfection</td>
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<tr>
<td>SoVI</td>
<td>Social Vulnerability Index</td>
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<tr>
<td>ST</td>
<td>Scheduled Tribe</td>
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<tr>
<td>SusTLE</td>
<td>Sustainable Total Living Environment Model</td>
</tr>
<tr>
<td>TDIU</td>
<td>Tsunami District Implementation Unit</td>
</tr>
<tr>
<td>TDS</td>
<td>Total Dissolved Solids</td>
</tr>
<tr>
<td>TNEB</td>
<td>Tamil Nadu Electricity Board</td>
</tr>
<tr>
<td>TNPWD</td>
<td>Tamil Nadu Public Works Department</td>
</tr>
<tr>
<td>TPIU</td>
<td>Tsunami Project Implementation Unit</td>
</tr>
<tr>
<td>TRC</td>
<td>Total Residual Chlorine</td>
</tr>
<tr>
<td>TWAD</td>
<td>Tamil Nadu Water Supply and Drainage Board</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
</tr>
<tr>
<td>UFW</td>
<td>Unaccounted for Water</td>
</tr>
<tr>
<td>VAT</td>
<td>Value Added Tax</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WPI</td>
<td>Water Poverty Index</td>
</tr>
<tr>
<td>WWF</td>
<td>World Wildlife Fund</td>
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</table>
CHAPTER I: INTRODUCTION

1.1 Setting the stage

The day—prominently etched in millions of people’s memories—was December 26, 2004. Greater than 1,500 miles from India, the earth violently trembled deep below the seemingly serene, blue water. It was a Sunday; it was Boxing Day. Fishermen fished, women swept their homes, and sleepy-eyed children awoke with plans of enjoying one last carefree day before trudging back to school the following morning. But school would be canceled on Monday. Unbeknownst to the coastal inhabitants of Tamil Nadu and Puducherry, their lives would indelibly change on that particular day, and perhaps even more so in the years to follow.

1.2 The hazard’s impact

The life-altering event was a massive tsunami originating from a 9.3 M\text{w} underwater earthquake that struck near the coast of the Indonesian island of Sumatra.\textsuperscript{1} Radiating from the epicenter (3.29°N, 95.98°E\textsuperscript{2} at an estimated focal depth of 6.2 miles\textsuperscript{3}), towering waves reaching several building stories in height traveled hundreds of miles per hour for several thousand miles.\textsuperscript{4} Inundation in proximal locations penetrated well over one mile,\textsuperscript{5} scoring beaches,


Stein and Okal, 2006: p. 25

uprooting trees, and fashioning a veritable *tabula rasa* in the process. While the kinetic properties of the geo-physical event are truly awe-inspiring, its social corollaries shall remain the focus of this study.

By the time the waves subsided, the tsunami had affected fourteen countries. In terms of human loss, a staggering 225,000 to upwards of 300,000 estimated deaths resulted from the 2004 Indian Ocean tsunami, with Indonesia, Sri Lanka, India, and Thailand most impacted in this regard, respectively. In mainland India, the political units of Nagapattinam District (in the state of Tamil Nadu) and adjacent Karaikal District (an enclave of the union territory of Puducherry)—both located near the southeastern tip of the country—were acutely affected. Research studies and tsunami models have posited that the region’s heightened devastation resulted from a combination of several factors: distance from the epicenter; wave impact angle and shape of the coastline; bathymetry, stratigraphy, and geomorphology (i.e., shallow coastal waters compounded by a narrow continental shelf and the presence of significant underwater features, such as the offshore Cauvery and Krishna River basins); a deltaic coastal topography engendering low mainland elevation and channels for waves to inundate; and a refraction of waves off Northeast Sri Lanka. Due to these factors, Chadha *et al.* (2005) argue that the Nagapattinam-Karaikal area bore both the greatest wave amplitude (17 feet) and lateral inundation (close to ½ mile) compared to the rest of mainland India.

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5 Murthy *et al*., 2006: p. 1535.


Murthy *et al*., 2006.


Raval, 2005.

The human toll in India is estimated at 10,749, with 5,640 listed as ‘missing.’ Furthermore, approximately 377,512 persons were displaced into transitional shelters and 646,820 individuals were temporarily relocated to safer places. Based on official government statistics, Nagapattinam and Karaikal, the focus of this study, were the most devastated de jure territories of mainland India, with 6,065 confirmed deaths in Nagapattinam and 492 confirmed deaths in Karaikal (note that Cuddalore District, Tamil Nadu, experienced more deaths than Karaikal, but Karaikal’s death rate exceeds that of Cuddalore when area, coastline, and population are considered). In the aftermath, communities were shaken and issues surrounding stalled public utilities (in particular, water and electricity), damage to housing stock, shocks to livelihood (namely fishing, agriculture, livestock, and microbusinesses), disrupted kinship networks, and gender came to the foreground.

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8 IFRC (2005), “South Asia earthquake and tsunami: affected population” (ReliefWeb Map Centre).


N. Nirupama (2008), “Socio-economic implications based on interviews with fishermen following the Indian Ocean tsunami,” Natural Hazards 48(1).


Following a prolonged period of immediate response, the governments of Nagapattinam and Karaikal planned the construction of nearly 20,000 and 7,500 new houses, respectively. A ‘vision’ for reconstruction (codified in government orders through the medium of Memoranda of Understanding, or MOUs) soon surfaced declaring modern, Western-style pakka houses at free of cost to all affectees who would forsake their damaged dwellings near the shoreline for a ‘safer’ settlement at a minimum distance of 500 meters (1,640 feet) from the mean high tide line (a controversial stipulation of the newly introduced Coastal Regulation/Management Zone, or CRZ/CMZ).

Affected communities—established by pre-tsunami village settlement patterns based on religion, caste, class, and occupation—would be whisked away en masse to ‘middle-class’, disaster resistant housing colonies constructed through the joint effort of government entities and disaster relief organizations. According to the MOUs, accompanying individual houses would be electricity, access to treated government water, and a latrine with a proper septic tank, leach pit, or sewerage connection. Accompanying the settlement, inter alia, would be hard surface

12 Government of Nagapattinam, no date, accessed 6 April 2012.

Government of Karaikal, no date, accessed 6 April 2012.

13 Pakka is a word from the Hindi language that translates as ripe, permanent, or lasting, while kaccha translates as unripe or immature. In colloquial vernacular, pakka is used to denote high quality items and concrete houses, while kaccha is used to denote low quality items and thatch huts.

14 This paper will refer to individuals affected by disasters as ‘affectees.’ The term affectees acknowledges avenues of capacity, resiliency, and agency that exist among disaster-affected populations, whereas the oft used term ‘victims’ indicates a lack of such coping mechanisms.

15 J. Radhakrishnan (2012a), former District Collector of Nagapattinam, personal interview.


internal roads, community halls (also for use as marriage halls and cyclone shelters), workspaces (e.g., for mending fishing nets), parks for children, and anganwadis. Some settlements even came equipped with non-governmental organization-provided (NGO) water treatment centers, grey and stormwater drainage systems, full-fledged schools, livelihood training facilities, ration shops,17 medical centers at which health professionals could visit in order to see patients and dispense pharmaceuticals, and generic buildings that inhabitants could be rent to operate a tea stall, tailoring unit, barber shop, petty shop, and other micro-businesses. While ostensibly benevolent, (one cannot help but think that) a venture entailing such a volume of occidental concepts and governmental and physical restructuring resembles a strategic, development-based social experiment of introducing visible peri-urban organs onto the landscape. Interestingly enough, in tandem with the new settlements came government registration, house taxes, and water and electricity fees—perhaps akin to statecrafting and the politically motivated Scottian concept of ‘seeing like a state.’

Given the scope of reconstruction in Nagapattinam and Karaikal, coupled with the sheer magnitude of the disaster, crystallizing all or even a few components of the reconstruction process writ large would prove too colossal a task (and possibly be unproductive). Thus, this study will investigate one crucial, yet understudied, element: the provision of water infrastructure in permanent, newly constructed post-tsunami housing settlements. This dissertation employs a multi-disciplinary methodology and original qualitative and quantitative data to generate an evidence-based analysis of the intersection of water and disaster-based reconstruction. In particular, this study will critique the framework developed to manage

16 Anganwadis are village healthcare centers aimed at improving levels of child and maternal health. At the study sites, anganwadis provide meals to children and new and expectant mothers, and they also focus impart education. The services are free and are overseen by the government.

17 Ration shops are government outlets that provide free or subsidized commodities such as rice, flour, sugar, and kerosene to ration card holders.

18 J. C. Scott (1998), Seeing like a state: how certain schemes to improve the human condition have failed (New Haven: Yale University Press).
reconstruction projects (specifically their water components), survey project outcomes borne from the framework (through the lens of water), and, most importantly, describe the water scenario in the post-tsunami settlements and how inhabitants cope with any shortcomings. The study will culminate with the development of a novel, informed framework for incorporating water infrastructure into the post-disaster reconstruction process.

1.3 Motivation for research and review of water-disaster interface

The motivation for research is the need for increased understanding of the complex, transformative process of disaster reconstruction, as well as the resettlement of affectees in new housing—which is as much a social process as it is physical and technical. Resettlement often means involuntary exclusion from a previous settlement, and it can be considered a ‘social disaster’ when resultant cascades of social issues overshadow those of the antecedent environmental disaster. In particular, this research will focus on the provision of water infrastructure in newly constructed housing settlements after the tsunami in the coastal district of Nagapattinam, Tamil Nadu, and the adjacent district of Karaikal, Puducherry.20


20 The topic was chosen after visiting post-tsunami housing settlements in South India and Sri Lanka, holding focus group discussions (FGDs) with inhabitants, and observing stark issues related to water access, quantity, and quality. This will be expounded upon in the methodology section.
comprises several distinct components (e.g., housing, transportation, employment, sanitation, and water), yet scholars have paid little attention to the water component. The role of water in reconstruction is significant because safe water is not only essential for promoting public health, but is also critical for reducing the impacts of future disasters (e.g., preventing waterborne illnesses), building capacity and resiliency, and addressing a wide range of socioeconomic inequities. Thus, conducting this research will not only expand the scope of reconstruction literature, but it will also speak to issues of public health and development broadly defined.

A review of the literature on water elements of disaster reconstruction illustrates marked gaps. Thus, there is an urgent need for more informed scholarly research on: the provision, operation, and maintenance of newly introduced water infrastructure after disasters; site choice for such infrastructure; the potential legacy of long-term impacts initiated by post-disaster water projects (both social and physical); and coping mechanisms developed by affectees who are subjected to the infrastructure. As will become apparent, the literature has not sufficiently


HIC-HLRN and PDHRE (2005), International human rights standards on post-disaster resettlement and reconstruction (Giza: Habitat International Coalition, Housing and Land Rights Network).


addressed these pressing issues, and water has yet to be established as a vital element of reconstruction.

Beginning the literature review, Clasen et al. (2006), McCluskey (2001), and Hederra (1987) examine water supply services and household water treatment (HWT) during and immediately after disasters (i.e., purely at the stage of initial response), but neglect to situate water as a component of reconstruction or mention latent issues that typically arise in the years to follow. Similarly, a substantial collection of practical publications by NGOs and government bodies exists. While informative, this suite of publications does not embody independent academic research, nor does it address the introduction of new infrastructure. Rather, it focuses primarily on immediate response, service restoration, and establishing minimum standards in temporary relief camps and transitional settlements. In an attempt to bridge the myopic


PAHO, 2002.


treatment of the water-disaster nexus, Randall *et al.* (2007) provide a discussion of the World Wildlife Fund’s (WWF) programs for water service and management implemented after the tsunami in Indonesia, Maldives, and Sri Lanka. The programs do consider spatial, long-term implications (i.e., watershed management), but they merely constitute organizational changes in WWF operations with partner organizations. Thus, reconstruction and its consequences fail to enter the picture, and it is not a research publication, but simply an NGO communicating its post-tsunami programs.25

More germane to this study, Moll *et al.* (2007) published at the interface of water and disaster reconstruction. The American Red Cross (ARC) and the Centers for Disease Control and Prevention (CDC) executed a three-year field study to assess the joint impacts of water-based reconstruction and knowledge dissemination on public health after Hurricane Mitch (1998) in Honduras, Nicaragua, El Salvador, and Guatemala. However, the focus of the study was not on infrastructure provision and did not critique the reconstruction process per se. Rather, the crux of the study was to gauge the efficacy of a post-disaster intervention (information dissemination) on the adoption of hygienic behaviors (hand washing and toilet use), which was measured via the rate of diarrheal prevalence in children and water quality testing both before and after the intervention.26 Thus, the study does not investigate the water scenario and associated coping mechanisms that surfaced following distinct reconstruction processes, but instead focuses on altering the post-disaster settlement context through sensitization campaigns aimed at changing behaviors.27

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27 This dissertation will also examine the adoption of hygienic practices (e.g., the effects of storage on water quality, and methods of HWT and their efficacy and appropriateness), but it will analyze
The most pertinent literature is a project proposal by Valsangiacomo (2007) and a baseline survey undertaken by Swiss Solidarity, the Swiss Red Cross, and Development Alternatives (2007). Interestingly enough, Valsangiacomo proposed to probe water and sanitation issues in post-tsunami settlements in Tamil Nadu. The study set out to describe the water and sanitation conditions, issues of water quality, and hygienic practices, and subsequently to convey the findings in relation to the United Nations Millennium Development Goals (MDGs). Unfortunately, the project was denied funding.

A publication funded by Swiss Solidarity, the Swiss Red Cross, and Development Alternatives investigated water and sanitation issues in three post-tsunami housing settlements they collectively constructed in Karaikal: Kottucherrymedu, Karaikalmedu, and Kilinjilmedu—a site included in this study. The objective of the study was to document issues surrounding water, defecation, solid and liquid waste disposal, and disease; a secondary objective was to contrast the severity of issues between men and women. The survey sampled 19 men and 19 women in each settlement for a total of 114 respondents. In terms of water, major findings demonstrated that women were more cognizant of and affected by water woes, while, on the whole, men remained indifferent to water issues. Women cited the irregularity of water supply, conflicts over water, the household management of water, and quality as their primary concerns. Furthermore, access to other sources of water—beyond the irregular availability of government-provided water—was of vital importance. This dissertation study will further document the issues presented in the NGO publication, although with more data, a more detailed narrative, summative such responses as grassroots coping mechanisms developed to ameliorate the outcomes of reconstruction projects, and the behaviors have not been ‘planted.’


recommendations, and a culminating framework. While the study by Swiss Solidarity, the Swiss Red Cross, and Development Alternatives is a rare gem of a publication in terms of its parallels with this dissertation, it lacks depth in methodology and rigor in analysis of data, which is often characteristic of an NGO publication.

Ezell, Farr, and Wiese (2000) developed a model for evaluating the vulnerability of water supply systems. The authors present the Infrastructure Risk Analysis Model (IRAM) for municipal water distribution systems as an instrument for identifying risks to potential hazards and detecting possible methods for mitigation. However, preparedness is the focus (reconstruction is not explicitly addressed), and the intended audience is civil engineers possessing a strong grasp of computer programming and statistics (event modeling, hierarchical holographic modeling, and partitioned multi-objective risk method), which may be out of the intellectual and financial reach of ‘hands-on’ NGOs and local governments engaged in reconstruction activities.30 Likewise, Grigg (2003) offers suggestions for anticipating threats to water systems, pinpointing vulnerabilities, and determining corrective measures for risk reduction, while Chang, Svelka, and Shinozuka (2002) simulate the disruption of water services from earthquakes in Memphis and provide guidelines for action.31 Both publications address structural and non-structural mitigation in the pre-disaster phase, but they fail to consider the sphere of reconstruction.32

Having surveyed the intersection of water and disaster, it is useful to draw attention to a modest number of publications on post-tsunami housing reconstruction in Tamil Nadu that is


32 It is worth mentioning that Chang, Svelka, and Shinozuka’s simulation is also likely inaccessible for the majority of NGOs and local governments engaged in reconstruction.
relevant both geographically and content-wise to this study. First off, Menon, Karuppiah, and Stephen (2008) focused on the 500 meter CRZ/CMZ that was introduced after the tsunami in both Nagapattinam and Karaikal Districts. The publication focuses on the concerns of the affected populations, namely longer distances to the shore for fishing, loss of ancestral lands, and fears that the land would later be developed for secondary and tertiary economic purposes. The publication essentially sums up its narrative with the question of relocation “for whose development?”

In the same journal issue, Vembulu, Kumar, and Sathyamala (2008) document issues that arose in post-tsunami transitional housing in Tamil Nadu (namely immediate relief, security, privacy, and disease), and move on to briefly outline issues in permanent housing reconstruction (in particular, the release of pattas, or house ownership certificates, to tsunami housing residents). Besides matters emanating from dislocation and contractor-driven reconstruction, the authors pinpoint issues related to drainage and sewerage, notably the lack of adequate, functioning infrastructure and how such infrastructure would be maintained and sustained once contractors pull out. Furthermore, Barenstein (2008) and Barenstein and Pittet (2007) focus on the contractor-driven housing reconstruction model in Tamil Nadu and how its modular, output-oriented approach lacked cultural input, the use of local materials (e.g., thatch), and ignored traditional layouts. Thus, the two publications question the long-term sustainability of such houses in terms of everyday usage, cultural appropriateness, and resident satisfaction.

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34 *Pattas* not only provide residents with property security, but also serve as a form of asset.


Last and most pertinent, a recent publication by Arlikatti and Andrew (2012) examines the housing stock in Tamil Nadu before and after the tsunami. Chief among the findings are that affected populations are structurally better off in the post-tsunami sphere as a result of a “stricter adherence to building standards and materials.” Arlikatti and Andrew, in their survey of 558 households in Nagapattinam District, found that the quality of flooring, roofing, and walls improved, whilst the average size of homes decreased. Turning to water—which is not the authors’ focus, data suggests that, compared to the pre-tsunami situation, there was a 13.6% increase in households that have access to piped water. While there was a 23.1% decrease in households that have access to piped water in their home, the average distance households must walk to access water (i.e., to public taps) decreased, as did the reliance on untreated handpump-sourced water. The authors also documented an increase in sewerage and drainage infrastructure. While the publication hones in on housing, the limited data and two paragraphs dedicated to water inform this dissertation study.

Next, several noteworthy frameworks have been developed for managing reconstruction projects. With promises of streamlining the process, the objective of the frameworks is to (attempt to) avert common ‘failures’ that have proven salient across space. This is accomplished by bringing consistent issues to the foreground, establishing key determinants for success, and standardizing the process vis-à-vis goals and benchmarks. The frameworks typically commence with resettlement (a frequent element of post-disaster processes) after a hazard event, move on to reconstruction, and often culminate with a feedback loop (theoretically ensuring enhanced processes in the future based on the complementarity of lessons learned from previous projects),

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38 Ibid.: p. 38.


thereby rendering them cyclical. While the existing frameworks prove pragmatic and meritorious, they neglect to explicitly delineate—let alone adequately address—water as a component of reconstruction, and they fail to include water as a significant determinant of project ‘success.’

Coburn, Leslie, and Tabban (1984), in their longitudinal study on post-earthquake resettlement and reconstruction in Turkey, argue that three main factors are crucial for determining the success or failure of resettlement and reconstruction projects: the physical environment of the new site (climatic exposure and suitability of the land to cultural practices); the new site’s relationship with the original site (distance from original site and proportion of affectees who relocate); and the capability of the community to (re)develop itself.41 As for evaluating resettlement and reconstruction success, Coburn, Leslie, and Tabban contend that there are six indicators: the occupancy rate of the settlement; extent of modification of the internal layout of houses; additions to and investments in the houses; the construction of private buildings; the degree of maintenance and state of (dis)repair; and the introduction (by households) of gardens, trees, and other aesthetic endeavors.42 While agreeing with Coburn, Leslie, and Tabban’s six indicators for assessing success, Oliver-Smith (1991 and 1992) went on to modify their three determinants of successful post-disaster resettlement and reconstruction. Oliver-Smith subsumes Coburn, Leslie, and Tabban’s determinants of success into four categories: quality of new site (both in terms of physical geography and relation to the original site); settlement layout (whether it facilitates household privacy and sufficient space for cultural activities); quality of housing (no inferior or culturally unacceptable materials, insulation from heat/cold, and whether houses are modifiable or able to be added onto); and popular input

(consultation with resettlers informs the three aforementioned determinants and also instills a sense of ownership).43

Cernea (2007, 2006, 2000, 1998, and 1997) has gone on to develop the Impoverishment Risks and Reconstruction model (IRR) for resettlement and reconstruction, which is the product of dozens of observations of World Bank projects across more than two decades.44 Cernea argues that resettlement is the “physical exclusion from a geographic territory,” and that it carries intrinsic risks—the greatest being the production of an intractable spiral of increased poverty and vulnerability.45 Thus, resettlement and reconstruction have the proclivity to exacerbate impoverishment and vulnerability, and this should be mitigated through preventive measures. The model postulates that the risk for “decapitalization and pauperization”46 can be deconstructed into eight identifiable risk components: landlessness, joblessness, homelessness, marginalization, food insecurity, increased morbidity, loss of access to common property and resources, and community disarticulation.47 At this point, the model preempts each risk with

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46 M. Cernea, 2007: p. 36.

eight correlative methods of reconstruction. Reconstruction must counter each risk by moving from: landlessness to land-based resettlement; joblessness to reemployment; homelessness to adequate housing; marginalization to social inclusion; increased morbidity to improved health; food insecurity to adequate nutrition; loss of access to restoration of community assets and public services; social disarticulation to rebuilding networks and community.48

Johnson, Lizarralde, and Davidson (2004) and Lizarralde (2002) adapted the Logic Framework Method (LFM) for monitoring reconstruction projects and to learn from their outcomes for future benefit.49 The authors demonstrate the model for post-earthquake housing projects in Colombia, and claim that it has also been used by the United Nations, World Bank, Canadian International Development Agency, and the Organization for Economic Cooperation and Development. It is postulated that the LFM is a holistic evaluation tool that bridges two gaps: evaluation of the system vs. evaluation of results, and evaluation through qualitative methods vs. evaluation through quantitative methods.50 To confront the gaps, 10 questions—each with agreed upon objectives—linked to five distinct aspects of a reconstruction project (inputs, outputs, results, impacts, and external factors) must be satisfied. Short of narrating the 10 questions, suffice it to say that the authors assert the LFM fosters a synergistic project life-cycle that ultimately procures augmented results.

Mukherjee (2005 and 2003) developed the Sustainable Total Living Environment model (SusTLE) for disaster-based reconstruction. The objective of SusTLE is to “break the cycle between damage, reconstruction and other losses from hazards” by bringing “a sustainable


impact into the settlement through disaster mitigation.”

Mukherjee notes that current reconstruction practices serve to heighten vulnerability, which entrenches communities in cycles of disaster: a disaster strikes, inadequate reconstruction escalates community vulnerability, and then the next disaster strikes and affects the community even more acutely as a result of prior reconstruction failures. Therefore, Mukherjee argues for the SusTLE model, which entails four stages: the creation of a Neighborhood Management Council (NMC), the decision making stage, the proposal appraisal stage, and the resource allocation and implementation stage. However, Mukherjee fails to fully explain the tasks conducted at each stage, leaving the reader to question how effective the model is in reality. Moreover, there is an arrogant proclamation that the model is universally applicable, and genuine limitations of the model are not presented.

The Balanced Scorecard Model (BSC), a business management tool conceived by Kaplan and Norton (1992), has been recast by Moe et al. (2007) to apply to disaster reconstruction. By deploying the BSC model, Moe et al. (2007) claim that reconstruction actors are able to implement more successful projects (i.e., enhanced results) and gain a better understanding of the efficacy of mitigation measures taken. The BSC was adapted to evaluate five stages of disasters: preparedness, warning, relief, rehabilitation, and reconstruction. Each stage is evaluated against benchmarks set from four perspectives: donor, target beneficiaries, internal (NGO, government, or executing organization), and innovation and learning. Each benchmark is

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55 Moe et al., 2007: p. 792.
measured by assigning a green (2 pts., met requirements), yellow (1 pt., requires monitoring and minor corrections), or red light (0 pts., requires immediate correction). Subsequently, each stage is assigned a minimum compliance score and projects cannot progress to the next stage until the compliance score is achieved. Interestingly enough, the BSC has only been utilized for the first two stages of the disaster cycle (preparedness and warning for flooding in Thailand), and thus the bulk of the model has yet to be demonstrated—the reconstruction stage included. Despite warranted uncertainties, Moe et al. declare the BSC an efficacious tool for reconstruction.

Lastly, before summing up the literature on water components of reconstruction, the nature of two germane concepts, namely ‘build back better’ (BBB) and popular input, must be highlighted in relation to reconstruction. It would not be uncharacteristic to claim that most publications on reconstruction, after first accounting for the pitiable situation, proceed by touting the developmental opportunities that have simultaneously been ushered in by the disaster. While this notion can imply a pejorative connotation, there exists value in that reconstruction does offer methods to improve housing and water infrastructure, reduce vulnerability, implement more sustainable land-use planning, decrease disparities, encourage economic integration, and that, in the end, affectees can be left ‘better off’. However, a recent discourse has emerged that dissect the agenda of benevolent reconstruction actors to ‘better’ society by comparing the theoretical seizing of opportunities to its outcomes in practice. Gunewardena and Schuller (2008) and Klein (2007) struck out at the incongruency of politics and neoliberalism with the idea of post-disaster ‘opportunities,’ and others claim that BBB fails to secure positive results.

56 Cuny (1983) claims that disasters and development are overlapping domains, and that there was even a “conceptual failure by aid organizations to link disasters to development.” [F. Cuny (1983), Disasters and development (New York: Oxford University Press): p. 11.]

57 See former U.S. President Clinton (2006), who drafted 10 propositions for BBB after the 2004 Indian Ocean tsunami. The publication is now a prototype for actors engaged in reconstruction. [W. J. Clinton (2006), Lessons learned from tsunami recovery: key propositions for building back better (New York: United Nations, Office of the UN Secretary-General’s Special Envoy for Tsunami Recovery).]

because the diverse stakeholders (e.g., affectees, governments, NGOs, and donors) have conflicting, and possibly mutually exclusive, interpretations of what ‘better’ means—not to mention issues of power relations.\textsuperscript{59} For example, does ‘better’ mean bigger, more Western, enhanced aesthetics, or a portrayal of affluence? Ultimately, scholars have argued that the notion of BBB, which is premised on opportunism, is subjective and should be reframed. To that end, it has been suggested that ‘build back safer’ may serve to produce more channeled outcomes because ‘safer’ is less interpretable and aligns with reducing vulnerability to future disasters and system shocks.\textsuperscript{60}

Popular input is recognized as a significant, yet underutilized, component of pre- and post-disaster processes. Participatory approaches to development first surfaced in the non-disaster realm, and were subsequently applied to disaster reconstruction.\textsuperscript{61} It is argued that garnering input from affected populations, in the forms of local geographical knowledge, cultural

\begin{itemize}
\item M. Lyons (2009), “Building back better: the large-scale impact of small-scale approaches to reconstruction,” \textit{World Development} 37(2).
\item Kennedy \textit{et al.,} 2009.
\item Kennedy \textit{et al.,} 2008.
\item It is also argued that ‘build back better’ in theory morphs into ‘build back faster’ in the field. A ‘numbers game’ ensues in which rapid output is rewarded, often at the cost of infrastructure quality and mitigation in the built environment.
\end{itemize}
practices, and labor, leads to houses that are not only physically habitable, but socially habitable as well. Popular input can restore confidence to affected populations, instill empowerment, facilitate ownership of project outcomes, build capacity, bequeath skills and employment, and preserve cultural and architectural heritage.\(^\text{62}\) Genuine popular representation entails more than information gathering and information dissemination, it transcends such token efforts by allowing for affectee decision-making and control over the process. The result, it is contended, is that affectees are not only more informed, but are able to exert influence over their (uncertain) future and generate final products (water infrastructure included) that are more culturally acceptable and better maintained over time.\(^\text{63}\) Thus, participatory approaches to disaster reconstruction foster the social sustainability of projects and a sense of *communitas* among the affected community.

Having furnished a review at the interface of water and disaster (as well as outlining frameworks for reconstruction), it shall remain evident that the literature does not grant water the attention it demands. Rather, the preponderance of publications exhibit marked gaps because they:


S. Barakat (2003), *Housing reconstruction after conflict and disaster* (London: Overseas Development Institute).

\(^\text{63}\) It must be mentioned that Bruns (2003) has developed a ladder for citizen participation in water projects, which is relevant to this study. [B. Bruns (2003), “Water tenure reform: developing an extended ladder of participation,” paper presented at *Politics of the Commons: Articulating Development and Strengthening Local Practices* (Chiang Mai: Regional Center for Social Science and Sustainable Development, Chiang Mai University).]
• focus on the urgency of meeting water needs during and in the immediate aftermath of disasters, but fail to consider permanent post-disaster water infrastructure and its implications in the long-run;
• have been published by governments and NGOs, thus demonstrating a paucity of independent scholarly work;\textsuperscript{64}
• model for vulnerability reduction of water distribution systems in the pre-disaster phase, thereby discounting reconstruction and the impacts of introducing new infrastructure to disaster-affected populations;
• confront water components of reconstruction superficially by assuming that they have already been included with housing, ultimately leaving water elided in frameworks for reconstruction (i.e., water is neither a constituent of frameworks nor listed as a determinant or indicator of project ‘success’).

\textit{Ergo}, on the whole, the literature concentrates primarily on water as it relates to immediate response, glossing over water components of reconstruction. To compound matters, due to gaps in the reconstruction literature, actors are forced to consult literature outside of the disaster arena when implementing water projects. In turn, this practice reinforces the tendency for newly introduced water infrastructure to be conceived \textit{sans} a disaster lens (i.e., executed as a ‘normal’ water project). Thus, there is a propensity to return to the pre-disaster status quo—a reification of the disaster cycle by disregarding vulnerability reduction of the community and their systems—and a failure to anticipate the cascade of long-term effects caused by the introduction of new infrastructure to unique, affected populations.

Despite what the literature articulates, observations from the field indicate that water projects triggered by reconstruction processes not only depart from immediate response, but they also vary from ‘normal’ water projects in several discernible ways. First, the subjects (or

\textsuperscript{64} It is also worth noting that such parties rarely critique their projects and often opt to laud themselves for a ‘job well done’—both actions being counterproductive.
beneficiaries) have been affected, if not traumatized, by a hazard event, rendering the subjects different from ‘normal’ beneficiaries in both their nature and needs.

Second, post-disaster water projects differ in that they have recovery and rehabilitation components, are part of a larger disaster mitigation and reconstruction plan (i.e., scale), and likely have different funding and organizational structures (a progeny of scale and the introduction of external actors).

Furthermore, resettlement is more often invoked, which necessarily induces land-use change, hydrological perturbations, and the uprooting of people, consequently disturbing physical and social systems. Lastly, the milieu of a post-disaster political atmosphere, with NGOs being held accountable by donors for ‘outputs,’ short-term socio-political rewards for speedy reconstruction, pressure exerted from the media, and conspicuous affectees wallowing in transitional shelters, exudes a temporal dimension that engenders post-disaster water projects exceedingly more urgent when juxtaposed with ‘normal’ projects. Thus, due to time constraints, a (stated or unstated) ‘rhetoric of returns’ often takes root in which the quality of infrastructure loses superiority to rapid, measurable ‘progress.’

Each of these variances entails a range of socio-physical corollaries that collectively distinguish post-disaster water projects from ‘normal’ ones. ‘Normal’ projects are generally modest and specific; for example, connecting a community to a water supply, increasing accessibility, or improving existing water quality. However, post-disaster water projects are generally more capital-intensive, larger in scale, and possess a combination of the


Scudder and Colson, 1982.


66 Water constitutes merely one of the many components of each individual project, and individual projects themselves are nested within the city or region’s greater vision for reconstruction. This is imperative, because decisions and actions related to one aspect of reconstruction may degrade or interfere with the provision of water, and vice versa. A recognition of these direct and indirect effects is vital in the post-disaster sphere.
aforementioned variables layered on top, rendering them much more complicated than their normal-time counterparts. Given the dissimilarities between post-disaster water projects and ‘normal’ water projects, there is both theoretical and practical value in analyzing and implementing such projects differently, which is woefully lacking in the present.

1.4 Geography in water-disaster research

This study operates under the premise that geography and its sub-disciplines embody the appropriate platform for research on and contributions to water and disaster. First off, exposure to hazards is inherently geographic, and geographers have generated significant research on various aspects of disasters.67 Secondly, geography possesses several applicable tools for disaster planning, risk and vulnerability mapping, and infrastructure development, such as Global Positioning Systems (GPS), Geographic Information Systems (GIS), geo-informatics, and remote sensing.68 Furthermore, geographers maintain a keen interest in human-environment interaction and societal adaptation to the built environment.69 Geographers also operate with a careful


68 P. A. Longley et al. (2010), Geographic information systems & science, third edition (Hoboken: Wiley).


consideration of space, scale, and time, which are essential for comparative and contextualized research, and they are prominently involved in water resources management. Lastly, geographers are especially interested in the role of culture and the appropriateness of particular approaches and technologies in distinct socio-physical contexts. Thus, understanding problems, identifying solutions, and analyzing the outcomes of project interventions are filtered through unique spatial, political, historical, economic, sociocultural, and environmental contexts that interact with each other (i.e., place-based, systems-based, and ecosystem approaches that consider cumulative effects). This approach is imperative when studying water and disasters.

1.5 Research questions and expectation of findings

After visiting 35 post-tsunami housing settlements in Tamil Nadu and Puducherry from 2008-2012, it became apparent that issues encompassing water were seriously impacting the

70 S. Perveen and L. A. James (2012), “Changes in correlation coefficients with spatial scale and implications for water resources and vulnerability data,” The Professional Geographer 64(3).


G. F. White (1945), Human adjustment to floods (Chicago: The University of Chicago, Department of Geography Research Paper No. 29).

lives of inhabitants. Thus, I formulated three comprehensive research questions founded on personal observations and discussions with individuals subjected to poor, inconsistent water provision:

- **Research question 1**: Considering 14 newly constructed post-tsunami settlements in Nagapattinam and Karaikal as a microcosm, how do responsibilities for the water sector shift between the government and NGOs in the spheres of reconstruction and recovery:
  a. In terms of water reconstruction, what were/are the responsibilities of the Government of Nagapattinam, Government of Karaikal, NGOs, and affectees, and what process/framework determined that?
  b. What reconstruction outcomes (for water) did the process/framework generate, what variability exists, and how did such discrepancies come to surface?

- **Research question 2**: What are typical features of the post-disaster waterscape and how have affectees acculturated:
  a. How does the built environment for water problematize daily life?
  b. How do sewerage and drainage infrastructure compound the water situation?
  c. How have households and individuals coped, adapted, modified, subverted, and resisted the water scenario?

- **Research question 3**: Given the outcomes in Nagapattinam and Karaikal, do the short-term goals of immediate water sector recovery and the long-term goals of sustainable water development dovetail or conflict? In other words, through the lens of water, is it flawed to exploit reconstruction as a means for accelerated development—a practice commonly referred to as BBB?

In response to the research questions, a corresponding expectation of findings was composed:

- **In response to question 1**: It is assumed that the unexpectedness of the tsunami, scale of magnitude, and preexisting level of preparedness and planning fashioned an arena of immediacy in which post-disaster reconstruction roles, responsibilities, standards, and a
holistic vision could be characterized as fluid, *ad hoc*, inconsistent, and sometimes nonexistent. Given this canvas, I expect the outcomes of water reconstruction to vary across space, with incongruities present both within and between Nagapattinam and Karaikal.

- **In response to question 2:** Having visited the study sites before conducting formal dissertation fieldwork, I observed shortcomings and difficulties in the provision, usage, and operation and maintenance of water infrastructure. Furthermore, I documented the mal-effects of sewerage and drainage on water services. Thus, I expect formal research to reveal significant water woes that have propagated alterations in daily life and domestic cycles. I also expect to uncover a wide array of homegrown methods for coping with such water-based problems—whether they comprise adaptation, modification, subversion, or resistance.

- **In response to question 3:** The tsunami damaged or destroyed thousands of coastal homes in the territories of Nagapattinam and Karaikal. Consequently, affectees were residing in damaged homes, or were displaced to transitional shelters or relatives’ homes for a lengthy duration. One year after the tsunami, not a single house had been constructed and affectees still resided in temporary dwellings. In this light, affectees, the media, activists, and the funders of NGOs (not to mention local elections held in the meantime) exerted significant pressure on the reconstruction process. Given this scenario, the reconstruction process (water included) was ultimately executed with both a stated and unstated goal of speed. Thus, I anticipate that short-term choices trumped long-term visions in the implementation of water elements of reconstruction projects. For example, securing access to piped water, but not considering issues of supply and social hydrology; inferior site choice or not opting for site infill for the sake of rapid development; and deciding that drainage infrastructure is optional without contemplating the monsoon climate, frequency of cyclones, topography of sites, and often clayey soil composition.
While non-exhaustive, this coupled set of research questions and expectation of findings will provide a foundation for understanding and analyzing the physical introduction of water-based infrastructure after the tsunami, and for scrutinizing the social ramifications of such ventures.

1.6 Procession of chapters

This dissertation proceeds with Chapter 2, which commences by profiling Nagapattinam and Karaikal Districts in geographic, cultural, and political and economic terms. Next, the criticality of water and disasters in the study region is communicated. A recent cyclone that affected the region and its impacts on the water sector are described, thereby buttressing the need for a scholarly examination of the water-disaster interface. Water in the study region is also demonstrated as a scarce, contested, and multi-dimensional resource. The chapter continues by highlighting general attributes of the 14 study sites, and goes on to introduce each study site with a short narrative and GIS map for representative purposes.

Chapter 3 details processes of data collection and the study’s methodology. After first recounting pre-dissertation fieldwork and site selection, qualitative methods—namely household, governmental, and key informant interviews, as well as focus group discussions (FGDs), primary document acquisition, and photography—are detailed. Thereafter, quantitative household surveys and their randomized stratified sampling are explained, as are methods for technological (i.e., GIS and GPS) and laboratory-based (i.e., water quality testing) procedures. In this chapter, data are not presented and analyses are not performed. Rather, data and analyses are provided as relevant topics arise in the ensuing content chapters.

Chapter 4 narrates the reconstruction process and its outcomes in Nagapattinam and Karaikal Districts. The chapter begins by scrutinizing the recent passing of the Disaster Management Act (DMA) of 2005 by the Central Government. Following is a critique of reconstruction processes for water in each district, which serves to identify the origins of often lackluster outcomes. The frameworks operationalized in each district exhibit similarities, but patent differences also exist and will be made apparent. The chapter ends with practical and
theoretical criticisms of phenomena that have cropped up as a result of tsunami reconstruction. In particular, the condition and capacity of the water sectors and ‘hard’/supply-side approaches of the governments are touched upon. Next is a complementary discussion on the instrumentalization of revenue- and ‘sight’-based (i.e., panoptic) methods of reconstruction.

Chapter 4—which tends toward the historiographical—prefaces a similar examination in Chapter 5 of the actual outcomes of water-based reconstruction in the 14 study sites. First, the status of water quality, pressure, and quantity are detailed. Accompanying each theater of inquiry are accounts of organically derived coping mechanisms developed in order to circumvent shortcomings. Photographs are employed in order to provide evidence of the outcomes and to bring coping mechanisms, which are often difficult to explain in words alone, to life. Next, conflicts over water resources and the ‘colonization of water’—both pervasive products of reconstruction processes—are described. The chapter concludes by demonstrating discrepancies between the waterscapes in Nagapattinam and Karaikal Districts in the arenas of quality, pressure, quantity, and conflict.

Chapter 6 supplements the previous chapter’s narrative account of the status of water infrastructure. After first conceptualizing the idea of ‘water poverty,’ the WPI is introduced and critiqued as a tool for assessing the extent of water poverty at multiple scales. Next, the classic WPI is modified to fit the Indian and post-tsunami contexts, which involves the introduction and elimination of indicators. The modified WPI and its indicators are defended, thus allowing for the manipulation of original quantitative data to describe and compare contexts at the site, district, and rural-urban scales. Furthermore, three weighting schemes are employed: equal weight, one conforming to the degree of significance as reported in surveys, and expert weight. Multi-scalar analyses utilizing the parallel weighting schemes are undertaken, which segues into a discussion on the outputs of each scheme and their relative usefulness.

Chapter 7, which appears to be a digression, is an extension of the narrative in Chapter 5 on coping mechanisms harnessed by affectees in order to adapt to post-tsunami waterscapes. Thus, this chapter—informed by prior substantiations of poor water quality—harnesses
quantitative, qualitative, and observational data to produce an ethnographic understanding of the quality improving strategy of boiling water. First, the rate of boiling water (at the household scale) and its results in bacteriological terms will be posited. Next is an appraisal of the efficacy, barriers to, and caveats of boiling water at the study sites, which collectively inform a subsequent section on increasing its efficiency and surmounting barriers and caveats. Chapter 7 closes by offering practical recommendations for selecting, introducing, and scaling up HWT methods among target populations. A contextualized approach that can be sustained over the long-term is promoted, and prolonged exposure by the interveners coupled with early, meaningful participation of the target population is imperative.

This dissertation concludes with Chapter 8, which presents a novel framework for integrating water infrastructure into post-disaster reconstruction. The framework is informed by the corpus of data posited in the preceding chapters and is founded on the contention that water components of disaster reconstruction inherently differ from ‘normal’ water projects. It is argued that water elements of reconstruction are unique because they are profoundly influenced by six overarching factors: the nature and needs of the subjects; existence of recovery and rehabilitation components; scale; funding and organizational structure; resettlement; and temporal constraints. Thus, a framework incorporating these distinctions and noting their implications is developed in order to avert shortcomings that were documented throughout the dissertation study. It is argued that the first-of-its-kind framework has diagnostic, management, and evaluative potential, and that it can be harnessed independently or conjoined with existing frameworks for reconstruction. It is also contended that reconstruction processes occur within distinct socio-cultural, politico-economic, and environmental contexts. Thus, place-based, participatory approaches that consider cumulative effects in the local nature-society system should be utilized.
CHAPTER II: THE STUDY AREA

This chapter formally introduces the study area of Nagapattinam and Karaikal Districts. The study area is dominated by coastal and deltaic geographies and a monsoon climate. Furthermore, the region is threatened by numerous hazards (e.g., tsunamis, cyclones, and floods), and there is a history of issues surrounding water, including access, quality, and quantity. After narrating the geographies, hazard risk, and nature of water in the study area, this chapter concludes with profiles of the 14 post-tsunami housing settlements included in this study.

2.1 Geographies of the study area

Nagapattinam District,72 situated on the coast of the state of Tamil Nadu, lies between 10.10°N and 11.20°N latitude, and 79.15°E and 79.50°E longitude (see Fig. 2.1).73 The elongated district occupies 87 miles of coastline along the Coromandel Coast of the Bay of Bengal, extending to Palk Bay at its southernmost reach.74 Nagapattinam District is bisected into northern and southern sections, with Karaikal District nestled in the center, comprising a total area of 1,048 square miles.75

A monsoon climate and location in the Cauvery River delta dominate the geography of Nagapattinam District. The District and region are heavily dependent on precipitation from the drier southwest monsoon (July-September) and relatively wetter northeast monsoon (October-December). These climatic patterns not only dictate the fishing and agricultural seasons, but also the culture and daily life of the people. The main drivers of the monsoons are the decadal El Niño cycle and the Indian Ocean oscillation, which influences the Ocean’s surface temperature

72 A ‘district’ in India is a political equivalent of a ‘county’ in the United States.


74 Ibid.

75 Ibid.
Figure 2.1: Locator map of study area
Elongated Nagapattinam District (cream color) rests along the Bay of Bengal, with Karaikal District (white color) nestled in the center.


dynamics. Consequently, heavy rain events inducing flash flooding and waterlogging, as well as drought during the summer months and times of lean precipitation, are common. The Cauvery River basin opens to the Bay of Bengal in Nagapattinam and Karaikal Districts (giving rise to an erosional and depositional geomorphology), hence, the low lying topography, networks of canals, and presence of sand dunes. The soil types in the study region are primarily loamy clay and calcareous cracking clay. In addition to surface water from the Cauvery system,

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groundwater is plentiful via the Orathanadu Aquifer (beneath the Cauvery), shallow Pliocene and Quaternary aquifers, phreatic aquifers, and the high water table along the coast.\textsuperscript{78}

The economy of the study area is based primarily on fishing and fishing-related services (e.g., boat maintenance, equipment supply, and fish vending), port-related work, and daily wage labor comprising mainly of general construction work, seasonal agriculture, and work in locally-run businesses. Agricultural production is concentrated in rice, but cereals, millets, and pulses such as cholam, cumbu, ragi, and green and black gram are widely cultivated.\textsuperscript{79} Gingelly, bananas, coconuts, chili peppers, and cotton are also grown, but on a much smaller scale. In recent years, prawn and fish aquaculture has cropped up due to its profitability, easy access to saline water, and the degradation of land otherwise reserved for agriculture (which is suitable for aquaculture).

According to the most recent national census (2011), Nagapattinam District’s total population is 1,614,069,\textsuperscript{80} with 22.54\% residing in urban areas.\textsuperscript{81} Demographically, the literacy rate is 84.09\%,\textsuperscript{82} the religious breakdown is 89.2\% Hindu, 7.6\% Muslim, and 3.1\% Christian, and Scheduled Castes (SC) and Scheduled Tribes (ST) comprise 29.6\% and 0.23\% of the

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\textsuperscript{78} Ibid.
\textsuperscript{82} Ibid.: p. iv.
population, respectively. Linguistically, Tamil is the predominant language of Nagapattinam District, although English is spoken among some professionals and college and school students.

Turning to water and sanitation, the average number of households in Tamil Nadu consuming government-provided tap water as their main source is 79.8%, yet for Nagapattinam District the rate is only 64.7%. Similarly, the number of households consuming (untreated) groundwater as their primary source is 32.7% in Nagapattinam District, whilst the figure is just 12.8% for the state of Tamil Nadu as a whole. A rural-urban gap is apparent within Nagapattinam District, with 20.6% of rural households possessing access to water on their premises while 73% walk to water sources ‘near the premises;’ this contrasts with 42.6% and 52.4% in urban areas, respectively.


Note that data on religious, SC, and ST compositions come from the 2001 census. Such data from the 2011 census will not be made available until March 2013.

SCs comprise the lowest rung of the caste system (actually, they are external to and not technically part of the caste system). Being of the lowest caste, or varna, such populations have been historically disadvantaged (as attested to by data on income, literacy rates, life expectancy, etc.) and are granted reservations in order to combat their ‘backwardness’ (e.g., quotas in universities and government jobs and various subsidies). SCs are known as dalits, untouchables, or harijans (a name given by Gandhi meaning ‘child of god’). STs also considered ‘backward classes’ are granted similar reservations. [Y. Singh (1993), Social change in India: crisis and resilience (Delhi: Har-Anand Publications). F. R. Westie and M. L. Westie (1957), “The social-distance pyramid: relationships between caste and class,” American Journal of Sociology 63(2).]


A rural-urban bias exists in access to piped water. At the national scale, persons lacking access to piped water are seven times more likely to reside in rural areas. [World Bank (2011), Atlas of global development, third edition (Washington DC: Harper Collins): p. 109.]


It is important to note that ‘near the premises’ is defined differently for rural and urban households. The threshold is less than 100 meters in urban areas and less than 500 meters in rural areas. Thus, this difference in definition further skews the rural-urban divide.
The lack of sewerage infrastructure is also striking. A staggering 4.1% of households in Nagapattinam District are connected to a piped sewerage system, 30.3% have pour-flush latrines connected to a septic system, while the majority of households (57.8%) have no sewerage infrastructure whatsoever and practice open air defecation and urination (OADU). As with water, a rural-urban dimension in sewerage facilities exists within Nagapattinam District, with 1.3% of rural households connected to a piped sewerage system in rural areas compared to 14.5% in the urban setting, 24.8% possessing a septic tank in rural dwellings vis-à-vis 50% in the urban context, and 67% of households practicing OADU in rural Nagapattinam District juxtaposed with only 24.8% in urban demarcated sections of the District. Lastly, the provision of drainage infrastructure is disconcerting in Nagapattinam District. The majority of households (73.3%) have no drainage infrastructure to speak of, while 13.2% have open drainage canals or ditches, and 13.4% have closed, underground drainage.


Here it must be noted that the physical presence of sewerage infrastructure does not necessarily translate to the household actually using the coverage, or that the entire household population utilizes the infrastructure. For example, based on interviews in the study sites, the use of toilets provided in the post-tsunami settlements is infrequent, with many opting for OADU. The preponderance of individuals and households practicing OADU weighs significantly upon this study because it negatively impacts water quality—especially given the magnitude of households that rely on untreated groundwater as their main source of water for consumption. Recent data from three post-tsunami settlements in Karaikal District confirm these assertions, with only 11% of women and 4% of men using the provided toilet and sewerage infrastructure (women tend to relieve themselves in nearby shrubby areas, while men prefer the beach). [Sieler and Eppler, 2007: p. 30.]

87 Directorate of Census Operations, Tamil Nadu, 2012d.


Although some form of drainage exists for roughly a quarter of households, it is common for drainage to be plugged with solid waste, sludge, and silt. Furthermore, it is common for households to intentionally block drainage channels with sand or cement in order to stop their neighbors’ impure grey water from flowing near their house, or to mitigate the breeding of mosquitoes near their house. Thus, the physical existence of drainage infrastructure does not guarantee that it actually works and is being maintained.
water quality, lack of drainage compounds the water scenario. Sans adequate drainage, individuals must trudge through standing water to access water supply points, and stagnant water percolates through the vadose zone to the water table (possibly with remnants of solid waste and human and animal excreta), where it is in turn harnessed by wells and handpumps for consumption.

As mentioned previously, Nagapattinam District is a sub-territory of the state of Tamil Nadu (this differs from the political organization of Karaikal District, which will be explained shortly). In India, the administrative system of states is modeled after that of the union of states (i.e., the Central Government). There is an elected head (Chief Minister), a state court (High Court), ministerial departments, locally elected representatives (Members of Legislative Assembly), a head of each district (District Collector), and elected heads of lower bodies such as municipalities (mayors or municipal commissioners) and panchayats.89

Transitioning to Karaikal District, it is tucked geographically between the northern and southern sections of bifurcated Nagapattinam District (depicted in Fig. 2.1 above), with 12 miles of coastline along the same Coromandel Coast. Karaikal District is an enclave district of Puducherry Union Territory; thus, it is situated roughly 70 miles south of Puducherry proper as the crow flies. In absolute terms, Karaikal District lies between 10.49°N and 11.01°N latitude, and 79.43°E and 79.52°E longitude, occupying an area of 62 square miles.90

For all practical purposes, the monsoon climate, deltaic physiography, alluvial geomorphology, soil types, and surface and groundwater resources of Karaikal District are

89 Panchayats are localized assemblies of self-governance in rural India. A three-tiered system exists in which district panchayats (district scale) oversee block/union panchayats (geographically delineated sub-district blocks known as tehsils or talukas), which in turn oversee a collection of lower order gram (village) panchayats within their territory. Gram panchayats are the lowest level of panchayats; in the study area, their leaders are often ‘agreed upon’ or self-appointed based on hierarchies of caste, age, lineage, and social and financial status. Indian law has established reservations for SCs, STs, and women (33% representation), but the law is not heeded. [S. S. Singh and S. Misra (1993), Legislative framework of panchayati raj in India (New Delhi: Intellectual Publishing House).]

identical to that of Nagapattinam District. Likewise, the economy of Karaikal District resembles that of Nagapattinam, with fishing and its ancillaries, port-related work, the agricultural production of like crops, and daily wage labor constituting the predominant livelihoods. Aquaculture is also present in Karaikal District, but on a smaller scale compared to Nagapattinam District.

Mining the 2011 census, the population of Karaikal District is 200,314, with 49% living in urban areas. In terms of demography, the literacy rate is 87.83%, the religious breakdown is 76.5% Hindu, 14.0% Muslim, and 9.5% Christian, and SCs and STs comprise 18.1% and 0% of the population, respectively. Linguistically, Tamil is the prevailing language, although English is spoken among professionals and college and school students. French is spoken among a small, elite group consisting mainly of government workers, professionals, and academicians.

As for access to water, 90.8% of households in Puducherry Union Territory primarily consume government-provided tap water, whereas the number stands at 82.5% for Karaikal District; the figures for households that rely on untreated groundwater are 4.4% for the Union Territory and 8.9% for the District. While there is a noticeable discrepancy, it is useful to

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92 Ibid.


94 Presence of the French language, albeit to a limited degree, is a historical artifact derived from Karaikal’s previous status as a French colony.


It must be stated that the mere existence of a tap in the household does not convert to the household accessing water from that point. Many household taps in the post-tsunami settlements in both
mention that in 2001 Karaikal District was one of “only 22 districts in the country [of India]” to have “households with tap as source of drinking water to total houses” above 80.01%.96 Just as was visible in the case of Nagapattinam District, there exist rural-urban binaries in water access in Karaikal District. Urban households in the District access water on their premises at a rate of 70.7% versus 50.2% in rural-defined areas, and 27.5% of urban households access water near their premises contrasted with 46.4% of rural households in Karaikal District.97 Turning to sewage, a scant 2.3% of households in Karaikal District are connected to a piped sewerage system, while 57% have pour-flush latrines connected to a septic tank and 36.2% have no sewerage infrastructure and therefore practice OADU.98 The rural-urban theme persists, with less than 1% of rural households connected to a piped sewerage system contrasted with 3.7% in the urban setting, 45.5% of rural households possess pour-flush latrines compared to 69.3% of their urban counterparts, and 50.9% of rural households practice OADU vis-à-vis 20.5% in urban sections of the District.99 Finally, while 12.5% and 37.7% of households in Karaikal District have closed and open drainage, respectively, virtually half (49.8%) of all households have no drainage infrastructure whatsoever.100

Owing to its status as a sub-unit of a union territory, the political organization of Karaikal District differs significantly from that of Nagapattinam District. Tamil Nadu joined the union of Indian states in 1947 after the partition of India by Great Britain, its former colonial power.

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97 Government of India, 2012d.


99 Ibid.

100 Government of India, 2012b.
However, Puducherry was under French colonial authority until it joined India as a union territory in 1963—several years after India’s independence. As a union territory, Puducherry is administered by the President of India and his/her cabinet, the Home Minister, and through a Lieutenant Governor appointed by the President. Thus, while Puducherry and its *de jure* territory of Karaikal District have their own elected government bodies (similar to that of districts and states), it retains direct links to the Central Government. According to Kumar (1991), this pattern of administration means that Karaikal District “enjoys more powers,” and that the Central Government is more intricately involved in financing the territory (e.g., water, roads, education) and looking after its general well-being.  

A prime example of Karaikal District’s status as a union territory is its comparatively lower tax rates, particularly for indirect and value added taxes (VAT). One need only witness the throngs of vehicles crossing the Nagapattinam District border into Karaikal District to avail cheaper petrol, durable goods, sundries, and alcohol.

A brief sketch of key attributes of Nagapattinam and Karaikal Districts has been presented. On the whole, it is evident that the two territories are virtually identical geographically and geologically, and sufficiently similar in social and economic respects (e.g., language, comparable literacy rates and religious composition, and analogous modes of livelihood).  

Furthermore, since the territories are adjacent and physiographically similar, one can assume that the magnitude of the tsunami’s force was roughly equal in both locales. Moreover, the larger frameworks for reconstruction utilized in the Districts were essentially mirror images. As a result of these parallels—many of which hinge upon spatial proximity—it is argued that analyzing reconstruction and recovery after the tsunami in Nagapattinam and


102 This practice is illegal for some goods.

103 Moreover, the study sites and inhabitants of the sites included in this study are even more homogenous than when speaking broadly of Nagapattinam and Karaikal Districts.
Karaikal Districts will not only benefit the understanding of disaster response writ large, but will also serve as a platform for comparative research. That is, while distinctions in political and financial capacity are palpable,\footnote{This helps to explain differences in water, sewerage, and drainage coverage between the two jurisdictions.} Nagapattinam and Karaikal Districts are congruent in many regards. Thus, the case delivers an ‘apples to apples’ social experiment à la Mill’s ‘method of agreement’ in his seminal \textit{A system of logic} (originally published in 1843).\footnote{J. S. Mill (2002), \textit{A system of logic, ratiocinative and inductive} (Honolulu: University Press of the Pacific).}  

\section*{2.2 Hazard risk in the study area}

Hazard risk and the manifestation of disasters—occurring when a hazard event impacts an anthropic system—are all too real facets of everyday life in India. In fact, extensive historical data upholds that India is one of the most disaster-prone countries in the world. According to Dworkin’s (1974) study on natural disasters from 1947-1973, globally, India ranked second in number of disasters with 58.\footnote{J. Dworkin (1974), \textit{Global trends in natural disasters 1947-1973} (Boulder: Natural Hazards Center, Working Paper #26): p. 16.} Carrying the research forward, Guha-Sapir, Hargitt, and Hoyois (2004) ranked India third in number of natural disasters from 1974-2003 with 303 (the United States of America and China ranked first and second, respectively).\footnote{D. Guha-Sapir, D. Hargitt, and P. Hoyois (2004), \textit{Thirty years of natural disasters 1974-2003: the numbers} (Belgium: Centre for Research on the Epidemiology of Disasters, University Press of the Catholic University of Louvain): p. 76.} During that 30-year time frame, India ranked second only to the USA. It is likely that, in addition to America’s undeniable disaster vulnerability, the combination of large concentrations of costly infrastructure, freedom of press (i.e., greater rate of reporting), and the study having been conducted in America (i.e., first-hand access to information on disasters affecting the country) led to America topping the list.

In the study, a hazard event must meet at least one of the following requirements to qualify as a disaster: at least 100 injured, at least 100 deaths, at least USD $1 million in damages.

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In the study, a hazard event must meet at least one of the following criteria to qualify as a disaster: at least 100 injured, at least 10 deaths, a state declaration of emergency, or a state call for international assistance.
period, it is calculated that more than 1.8 billion persons were either killed or affected by natural disasters in India (allowing for repeat affectees), and the economic damage totaled USD $43,378 million (2003 base year). Furthermore, the two largest disasters (in terms of number of affected) both occurred in India: droughts in 1987 and 2002 that each affected 300 million persons. What is perhaps even more striking is that India ranks number one from 1992-2003 in the amount of humanitarian funds received for alleviating the impacts of natural disasters, followed by the neighboring country of Bangladesh. Thus, the two historical studies establish and ratchet up the relevancy of disaster studies in India.

Much has been postulated as to why India is affected by disasters at such an amplified rate. First off, India is home to expansive concentrations of people, many of whom suffer from poverty and occupy vulnerable areas (e.g., flood plains, coastlines, sites near large industries, and slums themselves as loci vulnerable to a range of natural and manmade hazards). Secondly, India is characterized by rapid, haphazard development that frequently lacks safety standards and can generally be branded as low-quality. Next, India exhibits a reliance on technocratic approaches to mitigation, in effect contesting nature and engaging in risk transference, running

108 Ibid.: p. 82.
110 Ibid.: p. 29.

Four of the top 10 disasters in this category occurred in India.
111 Ibid.: p. 51.


contrary to the McHargian prescription to ‘design with nature.’

Further compounding India’s disaster canvas is inadequate preparedness, warning, and evacuation processes (India tends to be more reactive, as opposed to proactive), and a vicious disaster cycle magnified by poor resettlement and reconstruction practices.

For example, Nagapattinam District’s response to the tsunami was an ad hoc rendition of its preparedness plan for floods and drought, and the operationalization of their District Contingency Plan proved ineffectual because it had been drafted simply to comply with statutory requirements. Furthermore, as evidenced by Prater et al. (2006), “Nagapattinam had no predisaster recovery plan in place, and the disaster response plan was not closely tied to the district’s needs or administrative realities.”

Lastly, lack of insurance, a common thread across Asia, and the political and financial capacity of governments to meaningfully address disasters in both the pre and post phases (i.e., a cohesive and functional plan for disaster management) positions India at a disadvantage relative to more wealthy and politically capable countries.

The sum, or at least a combination, of these disadvantages are


115 Guha-Sapir et al., 2006.


Winchester, 2000.

Echoing the reactive nature of India, Bhardwaj (2008) notes that “India is relatively good at putting out fires, but not so good at preventing fires. India is prone to disasters and will encounter them from time to time. This must be addressed.” [J. R. Bhardwaj (2008), “Emerging social science perspectives in disaster management,” paper presented at International Conference on Re-Examining Disaster, Recovery and Reconstruction: Social Science Perspectives on the Tsunami (New Delhi: Centre of Social Medicine & Community Health, Jawaharlal Nehru University).]


117 A. Mulvany (2011a), Flood of memories: narratives of flood and loss in Tamil South India (Ph.D. Dissertation, Department of South Asia Regional Studies, University of Pennsylvania).

Prater et al., 2006.
rampant throughout the massive country of India, Nagapattinam and Karaikal bearing no exception.

According to Mosse (2003), Nagapattinam and Karaikal Districts are characterized by “uncertainty and risk” to a spectrum of hazards, with the “twin spectres of drought and floods being only the most visible manifestations of a pervasive social and ecological condition.”

Thus, hydro-meteorological hazards, namely cyclones, storm surges, torrential monsoon rains inducing flash and sustained flooding, and periodic droughts encompass ‘ordinary’ phenomena that are to be expected in the region. Furthermore, risk to geophysical hazards, such as tsunamis and earthquakes, as well as windstorms, epidemiological hazards, and manmade hazards of technological and industrial origin, is ever present. For example, in terms of cyclones, the most frequent large-scale hazards that impact the region, Nagapattinam and Karaikal Districts fall into the highest risk category of the Saffir-Simpson scale of tropical storm intensity. Parsing a multitude of literature, government documents, and news articles, an incomplete but notable list of disasters that have affected the region includes: the 1721 Madras Cyclone, a drought in 1928, a storm surge in 1952 that infiltrated up to five miles inland, the 1964 Dhanushkodi Cyclone, a drought in 1966, four high intensity cyclones between 1967-1979, four droughts between 1980-1989, a flood in 1991 and cyclones in all three years between 1991-1993, a flood in 2004 followed by the Indian Ocean tsunami, and Cyclones Fanoos (2005), Nisha (2008), Jal (2010), and Thane (2011) in recent years. Given the region’s vulnerability,


119 Flood frequency, intensity, and duration are escalated as a result of the flat coastal topography, the region lying on the receiving end of the voluminous Cauvery basin, and a lack of drainage.


121 Recall that this represents only a partial list, with numerous disasters omitted from the list for the sake of brevity. Furthermore, several localized flooding and windstorm events have likely gone
citizens of Karaikal District were warned that it must “be recollected that the U.T. of Puducherry had experienced by heavy flood/cyclone [sic.] in many occasions in the past including the Tsunami tragedy on 26th December 2004,” and therefore citizens should be prepared to activate a set of precautions when hazards strike in the future.122

In order to buttress the relevance of this dissertation research, Cyclone Thane—the most recent disaster to impact the region—shall be recounted, specifically in terms of its consequences on water infrastructure (i.e., the water-disaster intersection continues to surface).123 Thane made landfall on December 30, 2011 in Cuddalore District and Puducherry Union Territory proper, less than 50 miles north of the post-tsunami settlements selected for this study. While the study sites escaped the direct brunt of the Cyclone, they were exposed to whole gale-force winds that interrupted electrical supplies and fell scores of trees, and to more than three days of heavy rains that deluged water access points, septic tanks and leach pits, internal roads, and even the inside of houses. Headlines from local newspapers, many comparing the event to and even elevating it above the 2004 tsunami, crystallize the disaster cogently: Officials brace up as cyclone threat looms over Nagapattinam; Cyclone Thane batters Nagapattinam coast; TN, Pondy pulverized; Thane worse than 2004 tsunami; Cyclone was a small tsunami: fisherfolk; Cuddalore sees tsunami II; and TN was not prepared for cyclone: PIL.

unreported, while there is also the prospect of undocumented, ‘invisible’ disasters that were never recorded by the hands of history.


123 The post-disaster water-disaster interface is nothing new. In fact, Lester (1900), in his firsthand account of the great Galveston hurricane, noted that “Water supply is limited. Very scarce now,” “At present the crying need of Galveston is water,” and “What the city needs most, in my estimation, is pure water.” Furthermore, the continued supply of safe water during a recent 500-year flood in Cedar Rapids, Iowa was of chief concern, although the issue, for the most part, was averted. [D. Elgin (2009), Public Works Director of Cedar Rapids, personal interview. P. Lester (1900), The great Galveston disaster: containing a full and thrilling account of the most appalling calamity of modern times (Chicago: Providence Publishing Co.).: pp. 188, 204, and 208, respectively.]
Cyclone Thane claimed at least 46 deaths, some attributed to pre-disaster water infrastructure mitigation and post-disaster water response. Although higher level officials called for local governments to chlorinate, and even over-chlorinate, water supplies, quality was nevertheless breached, and electrical outages and damage to water pipes and sewerage infrastructure complicated the quantity and quality scenarios. In Puducherry proper, over 600 people visited hospitals with complaints of diarrhea, vomiting, and nausea, prompting the Department of Health to host camps to screen for water-borne illnesses; a female octogenarian died of gastroenteritis and a pregnant woman suffered a miscarriage reportedly due to dehydration.\footnote{“Gastroenteritis cases see a spike in Pondy after cyclone” (2012) \textit{(Times of India}, 10 January): p. 2.} In addition to compromised water pipes tainted with floodwater and sullage from damaged sewerage infrastructure, electrical outages meant that no water could be pumped from underground sumps to water towers, where gravity subsequently conveys the water to taps. Thus, hundreds of diesel powered generators and tanker lorries brimming with water were deployed from nearby cities to assist with the relief effort. However, water remained steadfastly scarce, attested to by the pathos-invoking newspaper photo of a young girl standing with a stainless steel \textit{kodam}\footnote{\textit{Kodam} is the Tamil term for a vessel commonly used for retrieving and storing water.} having waited for water for three days.\footnote{“Cuddalore sees tsunami II” (2012) \textit{(Deccan Chronicle}, 4 January): p. 2.}

Anger and desperation ensued: 68 protesters demanding water and electricity were arrested for blocking the Puducherry-Villupuram national highway, while others were dispersed forcefully by police \textit{lathi} charges.\footnote{S. Prasad (2012), “Thane-hit take to roads, caned” \textit{(Deccan Chronicle}, 3 January): p. 4.} The situation degraded as affectees implored for assistance:

\textit{Lathi} translates as ‘stick’ from Hindi. It is a long wooden cane used in law enforcement and for crowd control in South Asia (the equivalent of a policeman’s ‘night stick’ in America).
In Cuddalore, thirsting residents of numerous coastal hamlets and suburban areas intercepted tankers bringing water from neighbouring districts. Despite tall claims by the administration that over 80 tankers had been pressed into service to supply drinking water, there was no supply to households in Cuddalore municipality. “How can a family of four live without water for more than three days? The authorities have not made any alternative arrangements,” asks Ms. J. Usha, a resident of Cuddalore old town. “There is no power for the last four days to store water in tanks. We have run out of water and generator suppliers charge rupees 500 per hour to pump water into tanks,” adds another resident T. Neelavannan.128

Other media described affectees “living in most hostile conditions with precious litter water to quench their thirst,” individuals making a “beeline for rivers or the spillway point to wash their clothes” and bathe,129 and “residents scampering for water all over the district because they could not get protected water supply from municipal taps and private tanker supply”—even bottled water was unavailable.130

After much lamenting by affectees and a bulwark of ill-attention by the media, the governments began to admonish their mitigation and response efforts. In an article entitled Relief work lethargic: Minister, Puducherry Union Minister of State V. Narayanasamy proclaimed that the Rangaswamy-led government in Puducherry “let down the people,” noting that earmarked funds set aside from the Central Government after the tsunami should have been used by Puducherry to mitigate and respond to Cyclone Thane and other disasters; thus, “it would not be proper for the territorial government to blame the Centre for lack of funds.”131

After having “wondered where the Puducherry government’s money had gone”:

The minister said that he had already informed Prime Minister Manmohan Singh and Union home minister P. Chidambaram about the situation in Puducherry and the Prime Minister assured him that there would not be a

128 Ibid.: p. 4.

In this study, rupees (₹), the currency of India, are converted as ₹50 = USD $1.


funds crunch and that the Centre would allocate money as liberally as possible. . . . Narayanasamy also felt that the ruling AINRC government was politicising the relief work.132

Meanwhile, the Government of Tamil Nadu attempted to stave off harsh, well-deserved criticisms of the post-Thane water scenario. Headlines such as State prioritises water supply sprang up as J. Jayalalitha, the Chief Minister of Tamil Nadu, surveyed the destruction, personally distributed relief items, and pledged that “the government machinery” would alleviate post-cyclone water woes “on a war-footing.”133 Furthermore, Jayalalitha, in a quote that reeks of BBB and can be construed as an affront to families still enduring the pangs of post-tsunami reconstruction, assured afffectees: “Do not worry. The government is ready to extend all necessary assistance . . . This government is elected by you. It is people’s government. . . . Be confident that a bright future is awaiting you.”134

The recounting of Cyclone Thane solidifies water components of reconstruction as deserving of study. Not only was the study area impacted by the tsunami, but post-tsunami reconstruction of water infrastructure—particularly in terms of mitigation for impending disasters—appears to have been insufficient, not to mention to the paltry level of preparedness and response. However, not only are disaster-related water problems repeating in the same region, but such problems are transpiring on top of an already pitiable water situation.

2.3 Water in the study area

Nagapattinam and Karaikal Districts are subject to water issues of virtually every variety. First off, as portrayed earlier with census data on access to and supply of water, not all households in the study region have achieved the golden standard of piped, government-treated water—let alone accessing that water on their premises. Rather, universally supplied piped


water is more of a ‘pipe dream:’ due to a minimal and sometimes nonexistent supply, a significant number of households are forced to rely on consuming untreated groundwater from manual, electric, or diesel-powered pumps, while others resort to washing clothes and bathing in heavily polluted bodies of surface water. The Governments of Tamil Nadu and Puducherry are in a state of self-paralysis, because they refuse to proactively raise the price of water in order to circumvent the political costs of meaningful reform. The result is that cost-recovery is abysmal and thus there is a shortage of funds for treatment, repairing broken pipes, extending services to slums, and reducing unaccounted for water (UFW) that leaks from damaged pipes.135 Even the Ministry of Urban Development of the Government of India lambastes local administrative units for not securing an inflow of funds for propagating adequate water services:

The high levels of commercial and physical losses in the distribution network are compounded by the unwillingness of local/state governments to levy adequate user charges. Water utilities in India are typically able to recover only 30-35 per cent of the operations and maintenance (O&M) cost. In the Philippines and Cambodia, most water utilities recover the full O&M cost. Even in Bangladesh, water utilities recover about 64 per cent of their O&M cost.136

Interestingly enough, while the price of government-supplied water has remained marginal in an attempt to assist the poor,137 it is the poor that end up spending more money on water (e.g.,

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U. P. Raghupathi (2005), Status of water supply, sanitation and solid waste management in urban areas (New Delhi: NIUA, Government of India).


137 In the study region, piped, government-supplied water is free at community taps, and, speaking broadly, costs a flat ₹50 per quarter for an individual household connection.
private vendors, pre-packaged water, tanker lorries, and constructing wells to tap groundwater reserves) because the supply fails to reach them or fails to do so sufficiently. Adding insult to injury, not only are such sources more expensive, they are also unregulated and (customarily) untreated, so there is a flagrant absence of quality control.

The opening line of Baviskar’s (2008) *Contested grounds* aptly proclaims: “We live in a world where conflicts over natural resources are writ large upon the landscape.” Nowhere is this quote more fitting than for the study region. The Cauvery River basin possesses a history rife with conflict, prompting Shiva (2002), after discussing conflicts spurring “bloodshed,” to distinguish it as India’s “most contentious river,” while Pearce (2004) remarks on “deaths during riots . . . over the waters of the Cauvery.” Conflicts primarily relate to equitable access to surface water for irrigation, disputes between the head- and tailenders of canals, the construction of dams and diversions, and excessive well drilling that depletes groundwater resources. Contestations are a product of the alarming extent of scarcity/shortage and stress:

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defined mathematically, the Cauvery basin exhibits both a ‘severe water shortage’ with close to
2,000 persons per million meters cubed of water per year,¹⁴³ and a stress level of ‘over-
appropriated’ with a greater than 0.8 usage to availability ratio (see Fig. 2.2).¹⁴⁴ Furthermore, in
a recent interview, Karupppiah, a researcher at the Government of India’s Institute for Water
Studies in Chennai, claims that surface water in the region is 100% exploited and groundwater is
85% exploited.¹⁴⁵ No matter the optics, an examination of the data indicates that the region is
teetering on ‘physical water scarcity,’ meaning that it lacks adequate blue water resources for
self-sufficiency. To that end, Karupppiah places the blame squarely on the government:

The government puts forth no action. They are too short-sighted and they
don’t want to fix the problem because they would have raise prices or tell
the truth about the horrible situation, and that would hurt their votes. An
example of inaction is that the Government of Tamil Nadu passed a law in
2003 called the Tamil Nadu State Groundwater Development and
Monitoring Act of 2003. The law was passed, but it was never
implemented and put into action because it might be politically hurtful.¹⁴⁶

¹⁴³ M. Falkenmark (2009), “Water and the next generation – towards a more consistent
approach,” in Water management in 2020 and beyond, (eds.) A. K. Biswas, C. Tortajada, and R.
Izquierdo (Heidelberg: Springer): p. 73.

¹⁴⁴ Falkenmark, 2009: p. 73.

¹⁴⁵ M. Karupppiah (2011), Deputy Director of Photo Geology at Institute for Water Studies,
personal interview.

¹⁴⁶ Ibid.
Figure 2.2: Water scarcity and stress in the Cauvery
With scarcity/shortage on the x axis and stress/usage to availability ratio on the y axis, the Cauvery basin is one of the most exploited and crowded bodies of surface water in the world. Other surface waters in India are also experiencing scarcity and stress, such as the Indian-Coast Drain, Krishna, Ganges, and Narmada.


While governments in the study area avoid the slowly unfolding, intractable issue, some are acknowledging the groundwater extraction problem and feel powerless in its grips. According to Murugan, Junior Engineer of Water Supply and Maintenance in Kottucherry Commune Panchayat in Karaikal District:
We [the panchayat] can’t supply enough water. People here need water, so they must install handpumps or borewells. We know it’s unsustainable, but it’s their only option for meeting water needs.\footnote{V. Murugan (2011), Junior Engineer of Water Supply and Maintenance in Kottucherry Commune Panchayat, personal interview.}

Issues of quantity engendering water crowding, over-extraction, and the appropriation of water to the point of environmental flows is only a portion of the problem. The profound, fundamental issue is the distributional flow, or ‘social hydrology,’ of scarce water resources. Swyngedouw (2009 and 2006) has written on the theoretical underpinnings of inequitable water distribution, owing to power dynamics, capitalism, politics, city structure, and infrastructural shortcomings.\footnote{E. Swyngedouw (2009), “The political economy and political ecology of the hydro-social cycle,” \textit{Journal of Contemporary Water Research and Education} 142.} For example, in the study region, ownership of land (and thus access to surface water and space for constructing wells), caste hierarchies, rural-urban supply discrepancies, distance from the supply node, and being on the tail-end of a supply pipe are all factors that shape the social hydrology. Similar cases surrounding water allocation have been documented by Mehta (2008) in Kutch, Gujarat, Meinzen-Dick and Mendoza (1996) in several parts of India including Tamil Nadu, and both textually and pictorially by Larmer (2010) in Delhi as part of a special issue on water by \textit{National Geographic}.\footnote{L. Mehta (2008), “Constructs and constructions of scarcity,” in \textit{Contested grounds: essays on nature, culture, and power}, (ed.) A. Baviskar (New Delhi: Oxford University Press).} In fact, the National Institute of Urban Affairs (NIUA) of the Government of India has ordered that “problems of intra-city distribution should be taken up immediately by the local authorities,”\footnote{R. Meinzen-Dick and M. Mendoza (1996), “Alternative water allocation mechanisms: Indian and international experiences,” \textit{Economic & Political Weekly} 31(13).} while the
Ministry of Urban Development asserts that “allocation” with a “focus on people and equity” is imperative.\textsuperscript{151}

Water quality is yet another realm of concern. Without attempting to be overly dramatic, the quality of water in the study area can be labeled as abominable. While water deep below the surface (1,000 feet) is generally safe, surface water, shallow groundwater tapped by households, and even government-provided tap water should not be considered potable by any credible water quality expert. Common constituents naturally present in the study region include iron, dissolved solids (e.g., sodium, magnesium, and calcium), and fluoride, known to cause skeletal and dental fluorosis.\textsuperscript{152} Common constituents of anthropogenic origin include, but are not limited to, nitrates (e.g., raw sewage carrying fecal coliform and other microbial \textit{flora}),

\begin{itemize}
\item \textsuperscript{151} Ministry of Urban Development, 2011: p. 60.
\item \textsuperscript{152} Karuppiah, 2011.
\end{itemize}


Sivashanmuganathan, 2010.


The report by Balachandran, Dhayamalar, and Ravichandran (2010) maintains four monitoring points in the study area for consistent sampling. Monitoring points are located in Nagapattinam Municipality, Velankanni (located three miles south of the southernmost study site), Nagore (located in between the study sites in Nagapattinam and Karaikal Districts), and Tharangambadi (located 2.5 miles north of the northernmost study site). Thus, their findings on the most common natural and anthropogenic contaminants are extremely relevant. [Balachandran, Dhayamalar, and Ravichandran, 2010.]

It has also been posited that the tsunami increased the level of nitrates, phosphates, silicates, and turbidity along the southeast coast of India. [H. Chandrasekharan \textit{et al.} (2008), “Variability of soil-water quality due to tsunami-2004 in the coastal belt of Nagapattinam District, Tamilnadu,” \textit{Journal of Environmental Management} 89(1). K. Satpathy \textit{et al.} (2008), “Post-tsunami changes in water quality of Kalpakkam coastal waters, east coast of India with special reference to nutrients,” \textit{Asian Journal of Water, Environment and Pollution} 5(4).]
agricultural and industrial chemicals, detergents, and dissolved solids and salts introduced by human activities (e.g., saline intrusion as a result of over-extraction).153

Naturally and geologically present parameters aside, the low level of water quality chiefly derives from the influx of upstream contaminants combined with point-source pollution. The main culprits comprise: raw sewage emanating from population centers (e.g., seepage from septic tanks, leach pits, and underground sewer lines into the groundwater, direct inflows from municipal sewer lines into surface waters,154 and OADU; see Fig. 2.3); solid waste that finds its way to surface water and/or becomes part of the groundwater as it decomposes (see Fig. 2.4); agricultural runoff (e.g., fertilizers and pesticides); and industrial effluents (e.g., from tannery, textile, and dyeing units) from upstream cities such as Erode and Tiruchirappalli. Furthermore, the accelerated extraction of groundwater and the upshot of aquaculture represent catalysts for saline intrusion and an increase in the brackishness of freshwater sources (see Fig. 2.5).155 It is

Karuppiah, 2011.
Sivashanmugunathan, 2010.


Chidambaram, a resident of Velankanni (Nagapattinam District), three miles south of most southern study site, owns and operates 20 acres of prawn farms. Chidambaram’s prawn, which are
worth stating that water supply and management officials in the study area downgrade issues of groundwater salinity, claiming that “This is not so much of a problem because saltwater intrusion won’t happen if everybody only takes a little water from shallow levels.” However, this is not the standard practiced by farmers and households.

Figure 2.3: Seepage from septic tanks
Low quality and damaged sewerage infrastructure complicate the already poor water quality situation, as seen with this septic tank in Chennai, Tamil Nadu.

exported primarily to Japan and the United States, require saline water to survive. He pumps saltwater into the ponds (more than one mile inland) at concentrations of roughly 40 parts per thousand (ppt) in the dry season, and 10 ppt during the rainy season. It is no doubt that the concentrations of salt affect the groundwater and arability of nearby agricultural land. [R. Chidambaram (2009), prawn aquaculture farmer in Nagapattinam District, personal interview.]

156 T. Ragunath (2011), Executive Engineer of Maintenance Division of Water Supply at TWAD, personal interview.
Figure 2.4: *Pollution deteriorates water quality*
Solid waste peppers the banks of the Cauvery River as it flows through the study area.

Figure 2.5: *Prawn aquaculture*
A prawn aquaculture operation north of Velankanni near the study sites in Nagapattinam District.
Even treated, piped water fails to arrive safely to taps in Nagapattinam and Karaikal Districts. To begin with, water is often under- or over-chlorinated—the former unsuccessful in eliminating microorganisms and ensuring residual treatment capacities, and the latter producing harmful disinfection byproducts (e.g., chloramines). Post-treatment, a non-continuous water supply (i.e., dry distribution pipes for a majority of the day), serial and branched distribution networks, and compromised pipes collectively yield low in-pipe water pressure and permit groundwater, floodwater, and sewage to penetrate distribution lines. Furthermore, piped water is often further tainted once it arrives to local water towers—which are infrequently cleaned by local authorities and thus habitually contain sediments and microbial growth. Thereafter, water is stored by households for a duration close to 24 hours (when the next water supply window arrives), in which there are numerous chances for post-point contamination.

Ultimately, the indisputable fact is that the quality of water is rapidly deteriorating to the chagrin of the masses (who possess little redress), and that government supply and distribution patterns fail to alleviate the situation. Water is habitually turbid and odorous, cases of diarrhea persist, dysentery, cholera, typhoid, amoebiasis, and gastroenteritis abound, and some families are forced to traverse long distances to fetch relatively safe water. In fact, a recent field study by the United Nations Children’s Fund (UNICEF) in conjunction with the Tamil Nadu Water Supply and Drainage Board (TWAD) uncovered high levels of fluoride and calculated that 82% of water access points tested positive for bacteriological contamination in rural Tamil Nadu, which UNICEF claimed “is largely attributed to poor operation and maintenance.” The UNICEF-TWAD study echoes water quality tests conducted throughout South India by Philip, a professor of environmental and water resources engineering, MacDonald and Ali, Ph.D. students


engaged in water quality research in Chennai, and in the study area by Kottucherry Commune Panchayat and the author.

A survey of water issues in Nagapattinam and Karaikal Districts, as well as in India more broadly, would not be complete without the consideration of gender and ageism. It is women, as well as children (especially young girls), who shoulder both the obligations and inconveniences of retrieving water. Therefore, Sultana (2011), arguing from a feminist political ecology perspective, contends that the waterscapes in countries such as India typify geographies in which women suffer both for water, and from water.159 Addressing water in India, Bapat and Agarwal (2003) capture Sultana’s contentions vividly:

A disproportionate share of the labour and burden of ill-health related to inadequacies in provision of water and sanitation in the household and neighbourhood falls on women. It is typically women who collect water from public standpipes, often queuing for long periods in the process and having to get up very early or go late at night to get the water. It is typically women who have to carry heavy water containers over long distances and on slippery slopes. It is typically women who have to make do with the often inadequate water supplies to clean the home, prepare the food, wash the utensils, do the laundry and bathe the children. It is also women who have to scrounge, buy or beg for water, particularly when their usual sources run dry. It is important not to underestimate this side of the water burden.160

The situation narrated above is all too common in the post-tsunami study sites, where women and children trudge to public taps, wait in lengthy queues, return home hauling heavy vessels of water two at a time, and then repeat the course until the tap runs dry (the process is often interrupted by heated arguments over access and quantity, and by veritable scrambles for water).

In fact, a recent study in three post-tsunami settlements in Karaikal District found that women collect 96.49% of the water, with the remainder toted by young girls.161 While the water burden


confronted by women impinges opportunities in education and employment—thereby reinforcing deep-seated inequities—fortunately, the significance of women’s knowledge of water resources is finally being recognized through participatory management, access, and distribution programs throughout India and in the study area (e.g., *pani panchayats*).  

Lastly, the multi-dimensionality of water in the context of India and the study region must be addressed, specifically water as a social good. Water and the hydrologic cycle are vital to nearly all aspects of human life, and they steadily maintain the earth’s vast, diverse environmental systems. Water is not only required to hydrate our bodies, but is also necessary for bathing and cleaning, to prepare food and run industries, various forms of recreation and ecosystem services, and it provides sustenance to *flora* and *fauna*. Thus, while water possesses physical and biological dimensions, its pluralistic nature in South India as a “matrix of culture” and a medium “through which a variety of social relations have been structured” shall remain the focus.  

First off, all of the predominant religions in the study area—and religions in general according to Eliade (1958)—maintain sacred tangencies with water. Muslims use water to perform ablutions (*wudu*) before prayers, and water from Makkah, known as *zam zam*, is exceptionally sacred. Christians recognize holy water, the cleansing ritual of baptism, and Jesus’

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miracle of turning water into wine as religious symbolisms. Furthermore, Hinduism, the most prevalent religion in the study area, retains numerous intersections with water. According to Rajagopalan, a professor of sociology familiar with the study sites, “most Hindu rituals involve water,” and water itself is seen as an antiseptic, singlehandedly turning “pollution into purity.”

Thus, women cleanse the entryways and front doorsteps of their post-tsunami houses with water every morning and evening because they do not want an impure barrier to impede gods—who may beget wealth, luck, health, and general prosperity—from entering the home. To entice the gods further, a *kollam* (an aesthetic design traditionally made with ground rice flour) is sketched in front of the house, which can only be placed upon a surface purified by water. Many households wash their kitchen floor with water every day because the kitchen is considered a sacred space; many individuals wash their feet with water before entering the home (to avoid tracking impurities into the home); and post-tsunami settlement inhabitants bathe, or at least wash their face, before delighting in their morning tea or breakfast (to accept the bounty in a cleansed state). Furthermore, myriad rivers are named after Hindu goddesses (e.g., the Cauvery, Saraswati, Ganga, and Yamuna Rivers), and fishermen in the study area worship the goddess Kanniamman, who guards the boundary between the hazardous seashore and the village. Kanniamman not only protects the village from crashing waves of water, but she also looks after the safety of fishermen whose livelihood revolves around the dangerous medium of water.

In addition to its religious and ritualistic pluralities, water can assume a conduit for knowledge, identity, and social transactions. Water access points can be considered social settings or hubs in which information is disseminated, bonds of solidarity are sewn, village identities are molded, and cultural ethics and norms are generated and put into practice. In the post-tsunami settlements, public taps morph into legal spheres in which procedures dictating

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For example, Hindus should bathe before going to a temple (especially if they consumed meat that day) in order to enter the home of the gods in a state of purity, and corpses are ritually washed with water before cremation.
access and quantity are negotiated, and they represent centralized locations for spreading gossip, inquiring about community members’ health, and announcing marriages and other familial functions. Thus, it has been rightly noted that local conceptualizations of water are “the result of millennia of human development,” and that altering deeply embedded societal water traditions “could have significant social impact.”

Ergo, pressures upon and culturally insensitive configurations affecting access and equity, quantity and quality (e.g., from reconstruction), have the potential to deteriorate social structures.

2.4 Profile of the study sites

A total of 14 newly constructed post-tsunami settlements, seven each in Nagapattinam and Karaikal District, were selected for this study (see Fig. 2.6 and Table 2.1). The distance from the southernmost site in Nagapattinam District to the northernmost site in Karaikal District is 17 miles; the closest distance between sites in the two territories is nine miles. In terms of political organization, in Nagapattinam District, three sites are administered by Nagapattinam Municipality, and four sites are in areas defined as rural and are therefore administered by panchayats and the District. In Karaikal District, five sites are administered by Karaikal Municipality, and two sites by panchayats and the District as they are rurally delineated. All of the residents’ original villages were located near the Bay of Bengal at the time of the tsunami; now, measured from site-centroids calculated in a GIS, the closest site is 418 meters (roughly ¼ mile) from the sea, while the furthest site is almost 2.7 miles from the shore (see Table 2.2). Distance from the sea is crucial because most sites relied on fishing prior to the tsunami, and

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168 Table 2.1 is a preface to Tables 2.2-2.6 because it provides a snapshot of the study sites’ size and spatial characteristics. The six tables are referred to throughout this section; thus, they are positioned in between this general description of the 14 sites in toto, and a short description of each site that follows.

169 Location in a municipality or panchayat is significant because it determines the water provider, whether houses retrieve water from individual or community taps, and has bearings on water quality.
many continue to engage in fishing today. On the average, study sites in Karaikal District were reconstructed closer to the sea compared to their counterparts in Nagapattinam District. Two of the study sites—one in each district—were rebuilt in situ, while the majority (12) were erected ex nihilo (see Table 2.2). In situ reconstruction after the tsunami was rare and should thus be considered an anomaly.

![Map of study sites](image)

**Figure 2.6: Study sites**
Map depicting seven study sites each in Nagapattinam and Karaikal Districts.

Demographically, the 14 study sites accurately represent, or at least do not misrepresent, the religious composition of the *de jure* territories. Of the 14 sites, 11 are Hindu, two are
Christian, and one is a Muslim community. Additionally, there are two SC communities—one in each district—both being Hindu (see Table 2.3). Seven of the sites identify themselves as fisher communities exclusively, three sites are best characterized as a coexistence of fisherfolk and laborers, and four sites are almost wholly engaged in labor (see Table 2.3). All of the sites are employed virtually exclusively in either fishing or labor were so engaged prior to the tsunami. However, the three mixed labor sites were fisher communities before the tsunami, but have experienced shifts in livelihood as a consequence of resettlement (i.e., longer distance to the sea). Lastly, when the term ‘labor’ is used, it is intended to be denotatively generic and all-encompassing. Site residents engaged in labor do so in permanent, temporary, seasonal, and daily capacities. Just like its temporal dimension, the work performed is equally diverse: bricklayers, mixing and carrying mortar and cement, general construction, rickshaw-wallahs and chaiwallahs, deliverers and transporters, agricultural labor, loading and unloading cargo at the harbor, restaurant cooks, petty shop employees and owners, clothing launderers and pressers, cremation and burial workers, solid waste collectors, hotel staff, mechanics, maids, vegetable and fruit vendors, and everything else that allows the region to function economically, socially, and culturally.

The physical attributes and internal layouts of the 14 study sites can be generally envisaged as flat, low altitude, bare swathes of land with gentle undulations. In the pre-construction phase, the sites were leveled with excavators, and the flat, vegetation scarce environment prevails to this day—although some residents have planted trees and kitchen gardens and some shrubs have sprung up. In general, the completion of site construction and

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170 It is worth noting that residents of the two Christian sites practice Christianity, attend church and identify themselves as Christians. However, there is visible syncretism in which Hindu customs, for example, spreading cow dung in front of or near the house for purposes of hygiene and household prosperity, are followed.

171 Wallah is a suffix in Hindi that qualifies the preceding word as a task that one habitually performs or engages in for a living. Thus, a rickshaw-wallah is a rickshaw driver and a chaiwallah is a chai/tea maker.
population of the sites occurred in 2007, give or take a year (see Table 2.2). However, some sites were still only partially complete and therefore partially populated up until 2009, primarily owing to lack of public services, namely water and electricity. Six of the sites were designed and constructed by foreign NGOs, which is defined here as an NGO existing outside the borders of India or an international NGO with offices and operations in several countries (e.g., Rotary International, Care International, and Salvation Army). Domestic NGOs constructed four of the sites, while the remaining four sites were conceived through the joint-effort of both foreign and domestic NGOs (see Table 2.2). Some site inhabitants are under the impression that foreign NGOs constructed culturally insensitive housing while domestic NGOs erected superior settlements. However, based on my exposure and research, simply put, there is no credence in the quality of settlements as a function of the NGO’s foreign or domestic status.

In area, the study sites range from 1.4 to 44.72 acres; half of the sites (7) range between 10-19 acres (see Table 2.1). Sites in Nagapattinam District are generally larger than those in Karaikal District, and there is much variation within the districts: the largest site acreage is greater than 20-fold and 15-fold the smallest site acreage in Nagapattinam and Karaikal Districts, respectively. Area was calculated in a GIS by drawing boundaries around the greatest functional perimeter of the sites. Therefore, frontage roads, resident-trodden dirt paths on the periphery, empty plots of adjacent land that have been put to use, bodies of surface water used by residents, and other unofficial extents were included as they comprise the sites’ footprint of social, economic, and cultural space. Within this metes and bounds demarcated space, the prototypical post-tsunami houses are concentrated in extremely dense, gridded layouts. The lattice structure postures houses, each one identical to the next, roughly 3-6 feet apart (see Fig. 2.7). Thus, when housing density is figured using the ‘official’ site area (developed area less the empty and adjacent, yet functional, spaces), it ranges from 17.32 to 36.92 houses per acre—a concentrated built-environment indeed (see Table 2.1).

The total number of houses per site is as low as 22 and runs as high as 892, but most sites (10) contain between 100-350 houses (see Table 2.1). The number of houses in each settlement
Figure 2.7: Housing density
A photo depicting both a typical house in the study sites and the extreme density of housing (distance between houses is three feet). This photo was taken in Vettakaramedu.

is generally larger in Nagapattinam District, which helps to explain its larger acreages. However, at the intra-district scale there is much variation: the smallest settlement comprises more than 20 times fewer houses than the largest settlement in Nagapattinam District, and the smallest settlement in Karaikal District contains nearly 15 times fewer houses than the largest settlement. Occupancy rates, an established indicator of reconstruction success, also vary (see Table 2.1). Site occupancy rates are an astonishing 59.09% at the lowest and 83.75% at the next lowest, with the remaining 12 sites exhibiting rates above 90%—nine positioned between 96-100% occupied. In terms of population, the weighted mean household size of sites in Nagapattinam and Karaikal District is 4.74 and 4.21, respectively, and the total estimated population of sites in Nagapattinam District is 2.9 times greater than Karaikal District (see Table 2.4). Household size and site population are relevant because they will be tied to liters per capita per day (LPCPD) of water later in this study.
All of the study sites, with the exception of two, are composed of individual houses. Although the governments encouraged NGOs to build twin-houses, units comprising four houses, and still larger blocks of housing (in an effort to make efficient use of scarce space and capital), such structures are not common. That being said, one site in Karaikal District consists of 100 twin-houses, and one site in Nagapattinam District that was built through the collective effort of three NGOs contains a combination of individual houses, twin houses, and units of four connected dwellings (each NGO erected different layouts). In general, all of the post-tsunami houses in the study sites and more broadly across the region are similar in exterior and internal layout. They are all one floor with a square footage of about 325 (minimum size dictated in both districts), supposedly designed for a nuclear family of 4-5 members—which does not mesh with cultural habitation practices of having joint families and elderly parents living with their children, not to mention the existence of relatively larger families among the poor.

Existing in the limited square footage are one bedroom, a small living room, a kitchen, and a bathroom (the latrine and washroom are sometimes one room, and sometimes two separate rooms). The use of kitchens varies, depending on whether the family can afford natural gas for cooking; otherwise, local shrubs, vegetation, and sticks are used as cooking fuel and thus cooking takes place outside near the front or back of the house. The utilization of latrines is minimal (this will be discussed in Chapter 5). Households often bathe in the washroom or the room that doubles as a toilet and washroom, but they overwhelmingly prefer not to use the toilet for multiple reasons: the family did not have a toilet before the tsunami, they have always practiced OADU, and they have yet to begin using a toilet even though they now possess one; they enjoy relieving themselves outside in the fresh air; and they perceive a room with a toilet as a filthy, impure space that defiles the house and therefore deters the entry of gods into the home. Spatio-cultural beliefs surrounding the impure connotation of toilets has led many

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172 This phenomenon may be characterized as a form of ‘theo-spatial’ semiotics—with the latrine and its contiguous space constituting a negative symbol—or as an adapted form of Eco’s (1976) ‘topo-sensitivity’ in a religious sense. [U. Eco (1976), A theory of semiotics (Bloomington: Indiana University Press.)]
households to permanently block toilets by filling them with cement, while others have converted the space into *puja* rooms (a Hindu prayer room), storage rooms for water and foodstuffs, and even pens for goats (see Fig. 2.8). Additional rationale for not using the latrines is that space is at a premium and thus should be put toward other beneficial uses (i.e., the family can easily relieve themselves outside and use the space for more valuable ventures), and that pumping the septic tank once or twice a year has been deemed too costly.

![Bathroom converted to puja room](image)

*Figure 2.8: Bathroom converted to puja room*
This household in Vettakaramedu turned their bathroom into a *puja* room. The reason for the conversion is that “The toilet and leach pit are too close to the house, which is not a good symbol of our house. It’s a bad symbol, it’s a bad thing.” Such beliefs are predicated on *vastu shastra*, a traditional Hindu system of geographical (compass rose and relatively defined) housing design. *Vastu shastra* calls for a puja room to be constructed on the east wall of homes.

In terms of water supply, the study sites in Nagapattinam Municipality receive water from two government entities (see Table 2.5). TWAD conveys water from the Kollidam branch of the Cauvery River to the city—a distance of 56 miles—where it is treated using a silver
ionization process. Subsequently, the Municipality distributes the water and maintains the water towers and distribution pipes. As for sites in rural Nagapattinam, TWAD treats the same Kollidam water with the same ionization process and in turn supplies it to proximally located water towers in panchayat areas. It is then the respective panchayat’s responsibility to distribute the water and maintain the infrastructure. It is worth noting that many panchayats secondarily treat the TWAD-provided water with chlorine.

In Karaikal Municipality, the Public Works Department of Puducherry (PWDP) executes all supply, treatment, and operation and maintenance processes (see Table 2.5). PWDP-provided water arrives to all study sites in the Municipality from a collection of five deep tube borewells (1,000 feet in depth) located five miles to the west-northwest in Nedangadu. The water undergoes chlorination at its source, and is treated a second time with sodium hypochlorite (i.e., shock chlorination) when it reaches sumps near central Karaikal Municipality; from there it is supplied to the study sites as well as other Municipal areas. Lastly, sites in rural Karaikal District are supplied water that has been extracted from infiltration wells, treated (with chlorine), and distributed by their respective Commune Panchayat (Karaikal is comprised of the Municipality and five Commune Panchayats, which are rural governments that administer their geographically defined areas with collections of village panchayats beneath). Commune Panchayats are responsible for the operation and maintenance of all infrastructure.

As for access to water, all seven sites in Nagapattinam District (both rurally defined and those in the Municipality) must walk to public taps to access water. Conversely, while the two

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173 TWAD also supplies a limited amount of water to study sites in western rural Nagapattinam via a collection of three borewells (950 feet in depth) in Kilvelur, located roughly 11 miles west of the supply sites. This water is treated by TWAD with chlorine, not silver ionization.

174 Ragunath, 2011.

175 Murugan, 2011.

A. Murugesan (2011), Assistant Engineer of Water Supply Sub-Division of PWDP and IPH, personal interview.
sites in rural Karaikal District retrieve water from public taps, all sites in the Municipality (5) were provided individual house connections (see Table 2.5). Interestingly enough, water pressure is exceptionally low at many households with individual connections (flow is divided among many taps rather than a lesser amount of community taps). This phenomenon is so acute in Kizhakasakudimedu (Karaikal Municipality) that close to half of the individual taps fail to dispense even a single drop of water.

Turning to sanitation, houses at seven of the sites have leach pits, whereas six sites have septic tanks and one site is connected to an on-site World Bank-funded underground sewerage system complete with a treatment plant (see Table 2.5). Generally speaking, the septic tanks are of low quality and therefore flood during rainy times and seep directly to the vadose zone and shallow groundwater table in normal times. This is a public health hazard because many households rely on consuming shallow groundwater in the absence of sufficient quantities of government-provided piped water. On the other hand, the leach pits are designed to allow their contents to leach into the soil and groundwater. This process is benign when it happens slowly and ‘naturally’; however, high coastal water tables and waterlogging produced by monsoon rains accelerate this process thereby espousing a health hazard.\(^{176}\) As for the sole sewerage system, while all intentions are laudable, the system broke down soon after it commenced operation, causing households to revert to OADU; it remains defunct to this day. Drainage is another area of concern because its existence or nonexistence attenuates or exacerbates waterlogging and topographical contours that induce flooding, which in turn complicates water access and quality (see Tables 2.5 and 2.6). The study sites in Karaikal District exhibit much greater drainage coverage compared to their counterparts in Nagapattinam District. Six sites in Karaikal District have full drainage coverage and one site is partially, but mostly, covered. On the other hand, in Nagapattinam District, two of the study sites are partially covered and the five remaining sites have no drainage provision whatsoever (see Fig. 2.9).

Figure 2.9: Nonexistent drainage
A lack of drainage in Andana Pettai means that precipitation and grey water must forge their own path, aided by guidance from households, in order to drain from the site.

Following are the six tables (Tables 2.1-2.6) referenced in the preceding paragraphs. The tables present much of the data that was discussed, as well as additional parameters. Data are at the site scale and are informed by original fieldwork including: GIS and GPS, 300 surveys and 74 interviews at the household scale, interviews with government officials, primary documents, and multiple site visits across more than three years. As stated in an earlier footnote, the tables have been placed here since they are referred to in both the general study site descriptions above and the individual site descriptions to be presented next. Succeeding Tables 2.1-2.6 is a short description of all 14 study sites along with GIS maps for representative purposes. First, the
seven sites in Nagapattinam District (see Fig. 2.10 for site identification) are discussed alphabetically, followed by the seven sites in Karaikal District (represented and referred to later in Fig. 2.22). The tables are referenced in the site descriptions.

Table 2.1: Study Sites – Housing and Density Profile

<table>
<thead>
<tr>
<th></th>
<th>No. of houses</th>
<th>No. of occupied houses</th>
<th>Occupancy rate</th>
<th>Total acres</th>
<th>Housing density (houses/acre)*</th>
<th>Occupied housing density (occ. houses/acre)*</th>
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<tbody>
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<td></td>
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<td></td>
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<tr>
<td>Akkaraipettai</td>
<td>186</td>
<td>186</td>
<td>100%</td>
<td>15.85</td>
<td>17.32</td>
<td>17.32</td>
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<tr>
<td>Andana Pettai</td>
<td>222</td>
<td>203</td>
<td>91.44%</td>
<td>23.71</td>
<td>20.69</td>
<td>18.92</td>
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<tr>
<td>New Nambiyar Nagar</td>
<td>892</td>
<td>859</td>
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<td>44.72</td>
<td>36.92</td>
<td>35.55</td>
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<td>340</td>
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<td>14.99</td>
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<td>Saveriyarkovil</td>
<td>350</td>
<td>346</td>
<td>98.86%</td>
<td>18.84</td>
<td>32.14</td>
<td>31.77</td>
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<tr>
<td>Theti</td>
<td>269</td>
<td>250</td>
<td>92.94%</td>
<td>14.11</td>
<td>24.06</td>
<td>22.36</td>
</tr>
<tr>
<td>Uzhuvur Nagar</td>
<td>44</td>
<td>26</td>
<td>59.09%</td>
<td>1.92</td>
<td>25.88</td>
<td>15.29</td>
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<td><strong>Karaikal</strong></td>
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<td></td>
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<tr>
<td>Akkam Pettai</td>
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<td>96%</td>
<td>10.22</td>
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<td>Amman Kovil Pathu</td>
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<td>7.78</td>
<td>25.41</td>
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<td>Kilinjilmedu</td>
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<td>100%</td>
<td>7.11</td>
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<tr>
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<td>100%</td>
<td>1.40</td>
<td>21.36</td>
<td>21.36</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>65</td>
<td>64</td>
<td>98.46%</td>
<td>2.52</td>
<td>30.95</td>
<td>30.48</td>
</tr>
</tbody>
</table>

* Density expressed as number of houses per developed acre (i.e., less empty spaces and hinterlands)
Table 2.2: Study Sites – Situational Geography

<table>
<thead>
<tr>
<th>In situ or ex nihilo</th>
<th>Distance from original site (meters)</th>
<th>Distance from sea (meters) *</th>
<th>Year site occupied</th>
<th>Municipality or panchayat</th>
<th>Foreign, domestic, or mixed relief agency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>in situ</td>
<td>---</td>
<td>418</td>
<td>2006</td>
<td>panchayat</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>ex nihilo</td>
<td>4,196</td>
<td>2,829</td>
<td>2007-08</td>
<td>panchayat</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>ex nihilo</td>
<td>2,322</td>
<td>1,769</td>
<td>2008</td>
<td>municipality</td>
</tr>
<tr>
<td>Samanthanpettai</td>
<td>ex nihilo</td>
<td>626</td>
<td>641</td>
<td>2007</td>
<td>municipality</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>ex nihilo</td>
<td>4,113</td>
<td>1,866</td>
<td>2008</td>
<td>municipality</td>
</tr>
<tr>
<td>Theti</td>
<td>ex nihilo</td>
<td>4,208</td>
<td>2,226</td>
<td>2007</td>
<td>panchayat</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>ex nihilo</td>
<td>874</td>
<td>1,519</td>
<td>2006-07</td>
<td>panchayat</td>
</tr>
<tr>
<td><strong>Karaikal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>ex nihilo</td>
<td>600</td>
<td>620</td>
<td>2007</td>
<td>panchayat</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>ex nihilo</td>
<td>1,088</td>
<td>1,080</td>
<td>2007</td>
<td>municipality</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>ex nihilo</td>
<td>603</td>
<td>644</td>
<td>2009</td>
<td>municipality</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>ex nihilo</td>
<td>705</td>
<td>732</td>
<td>2008</td>
<td>municipality</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>ex nihilo</td>
<td>508</td>
<td>535</td>
<td>2007</td>
<td>panchayat</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>in situ</td>
<td>---</td>
<td>706</td>
<td>2007</td>
<td>municipality</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>ex nihilo</td>
<td>4,244</td>
<td>4,297</td>
<td>2007</td>
<td>municipality</td>
</tr>
</tbody>
</table>

* Distance to the sea is relevant, because the original sites were near the sea before the tsunami, and many households rely on fishing. Furthermore, residents retain identity with the original sites, with many frequently visiting, cleaning and maintaining, using, and even partially occupying their original homes.
Table 2.3: Study Sites – Socio-Cultural Geography

<table>
<thead>
<tr>
<th></th>
<th>Predominant religion</th>
<th>Scheduled caste</th>
<th>Predominant livelihood</th>
<th>Mean income (₹/mo) *</th>
<th>Mean educational attainment ^</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>Hindu</td>
<td>no</td>
<td>fishing</td>
<td>7,690</td>
<td>10.67</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>Christian</td>
<td>no</td>
<td>mixed</td>
<td>3,833</td>
<td>9.14</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>Hindu</td>
<td>no</td>
<td>fishing</td>
<td>5,189</td>
<td>9.62</td>
</tr>
<tr>
<td>Samanthanpettai</td>
<td>Hindu</td>
<td>no</td>
<td>fishing</td>
<td>4,885</td>
<td>9.69</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>Christian</td>
<td>no</td>
<td>mixed</td>
<td>5,337</td>
<td>9.62</td>
</tr>
<tr>
<td>Theti</td>
<td>Muslim</td>
<td>no</td>
<td>labor</td>
<td>5,652</td>
<td>8.78</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>Hindu</td>
<td>yes</td>
<td>Labor</td>
<td>4,667</td>
<td>9.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mean = 5,322</td>
<td>mean = 9.56</td>
</tr>
<tr>
<td><strong>Karaikal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>Hindu</td>
<td>no</td>
<td>fishing</td>
<td>3,410</td>
<td>9.11</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>Hindu</td>
<td>no</td>
<td>mixed</td>
<td>6,539</td>
<td>8.58</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>Hindu</td>
<td>no</td>
<td>fishing</td>
<td>4,427</td>
<td>10.71</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>Hindu</td>
<td>no</td>
<td>fishing</td>
<td>3,919</td>
<td>7.76</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>Hindu</td>
<td>no</td>
<td>fishing</td>
<td>5,521</td>
<td>7.78</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>Hindu</td>
<td>yes</td>
<td>labor</td>
<td>6,000</td>
<td>11.20</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>Hindu</td>
<td>no</td>
<td>labor</td>
<td>3,922</td>
<td>5.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mean = 4,820</td>
<td>mean = 8.71</td>
</tr>
</tbody>
</table>

* Total household income

^ Highest grade level completed by an individual permanently residing in the household

Note: Rupees (₹) are the currency of India and are converted in this study as ₹50 = USD $1
Table 2.4: Study Sites – Population Geography

<table>
<thead>
<tr>
<th>Study Sites</th>
<th>No. of occupied houses</th>
<th>Mean household size</th>
<th>Estimated population (site size) *</th>
<th>Estimated population (district size) ^</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>186</td>
<td>5.00</td>
<td>930</td>
<td>882</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>203</td>
<td>4.43</td>
<td>899</td>
<td>962</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>859</td>
<td>4.70</td>
<td>4,037</td>
<td>4,072</td>
</tr>
<tr>
<td>Samanthanpettai</td>
<td>340</td>
<td>5.08</td>
<td>1,727</td>
<td>1,612</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>346</td>
<td>4.73</td>
<td>1,637</td>
<td>1,640</td>
</tr>
<tr>
<td>Theti</td>
<td>250</td>
<td>4.52</td>
<td>1,130</td>
<td>1,185</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>26</td>
<td>4.67</td>
<td>121</td>
<td>123</td>
</tr>
<tr>
<td><strong>Karaikal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>96</td>
<td>4.39</td>
<td>421</td>
<td>404</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>122</td>
<td>4.47</td>
<td>545</td>
<td>514</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>268</td>
<td>4.13</td>
<td>1,107</td>
<td>1,128</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>186</td>
<td>4.29</td>
<td>798</td>
<td>783</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>100</td>
<td>3.78</td>
<td>378</td>
<td>421</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>22</td>
<td>5.07</td>
<td>112</td>
<td>93</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>64</td>
<td>3.88</td>
<td>248</td>
<td>269</td>
</tr>
</tbody>
</table>

* Pop. = mean household size of site x no. of occupied houses

^ Pop. = weighted mean household size of district x no. of occupied houses  [Nagapattinam = 4.74; Karaikal = 4.21]
Table 2.5: Study Sites – Water and Sanitation Profile

<table>
<thead>
<tr>
<th>Water supplier</th>
<th>Individual or public tap</th>
<th>Sewerage type</th>
<th>Drainage coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>TWAD-panchayat</td>
<td>public</td>
<td>septic tank</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>TWAD-panchayat</td>
<td>public</td>
<td>septic tank</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>TWAD-municipality</td>
<td>public</td>
<td>septic tank</td>
</tr>
<tr>
<td>Samanthanpettai</td>
<td>TWAD-municipality</td>
<td>public</td>
<td>sewerage system</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>TWAD-municipality</td>
<td>public</td>
<td>septic tank</td>
</tr>
<tr>
<td>Theti</td>
<td>TWAD-panchayat</td>
<td>public</td>
<td>septic tank *</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>TWAD-panchayat</td>
<td>public</td>
<td>leach pit</td>
</tr>
</tbody>
</table>

**Karaikal**

<table>
<thead>
<tr>
<th>Water supplier</th>
<th>Individual or public tap</th>
<th>Sewerage type</th>
<th>Drainage coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akkam Pettai</td>
<td><strong>panchayat</strong></td>
<td>public</td>
<td>leach pit ^</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>PWDP</td>
<td>individual</td>
<td>leach pit</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>PWDP</td>
<td>individual</td>
<td>leach pit</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>PWDP</td>
<td>individual</td>
<td>septic tank</td>
</tr>
<tr>
<td>Mandapathur</td>
<td><strong>panchayat</strong></td>
<td>public</td>
<td>leach pit</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>PWDP</td>
<td>individual</td>
<td>leach pit</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>PWDP</td>
<td>individual</td>
<td>leach pit</td>
</tr>
</tbody>
</table>

* 100 houses have individual septic tanks, 100 are connected to a community holding tank, 40 share septic tanks among 4-6 houses, and 19 have no sewerage infrastructure

^ Leach pits shared among 4 houses

TWAD = Tamil Nadu Water Supply and Drainage Board

PWDP = Public Works Department of Puducherry
Table 2.6: Study Sites – Topography

<table>
<thead>
<tr>
<th>Study Sites</th>
<th>Elevation at center (feet) *</th>
<th>Elevation at corners/edges (feet) *</th>
<th>Range in elevation (feet)</th>
<th>Lowest elevation (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Nagapattinam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>15</td>
<td>16, 10, 10, 11, 18, 19</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>a: 11</td>
<td>a: 22, 16, 15, 17, 15</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>b: 14</td>
<td>b: 17, 13, 15, 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>a: 19</td>
<td>a: 21, 14, 32, 5, 19, 23, 20, 14</td>
<td>36</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td>b: 17</td>
<td>b: 18, 16, 14, 17, 10, 3, -2, 15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c: 19</td>
<td>c: 19, 12, 21, 22, 22</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>d: 21</td>
<td>d: 22, 14, 19, 19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samanthaipettai</td>
<td>18</td>
<td>14, 19, 23, 22, 18, 11, 18, 16</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>13</td>
<td>14, 16, 15, 19, 19</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Theti</td>
<td>18</td>
<td>19, 11, 15, 15, 20, 17, 16, 20</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>13</td>
<td>13, 14, 10, 16, 9, 12</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>* Karaikal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>10</td>
<td>3, 6, 11, 3, 7, 10</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>6</td>
<td>12, 14, 14, 11, 11, 8</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>17</td>
<td>13, 19, 20, 19, 18, 16</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>16</td>
<td>15, 16, 23, 15, 16, 17</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>10</td>
<td>-1, 9, 7, 7, 7, 14</td>
<td>17</td>
<td>-1</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>25</td>
<td>18, 15, 24, 13, 14, 14</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>13</td>
<td>9, 11, 10, 13, 11, 16</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

* Some sites are comprised of more than one large plot of land; hence, some sites exhibit more than one set of center and corner/edge elevations (expressed as a, b, c, d)

^ Corner/edge elevations reported in clockwise fashion beginning at northwest corner
1. **Akkaraipettai (see Fig. 2.11):** This settlement is administered by a *panchayat* in rurally defined Nagapattinam District. Residents claim they comprise 100% fisherfolk. Akkaraipettai is sandwiched between the Kaduvai River on the west, and Sethu Street on the east. To the east of Sethu Street lies the sea, to which it runs parallel. Prior to 1977, most residents occupied the shoreline on the east side of Sethu Street. However, in 1977 a cyclone impacted the area prompting the government to relocate most (but not all) of the residents on the west side of Sethu Street. As a result, the effects of the 2004 tsunami were greatly reduced from what could have been. One of the Akkaraipettai’s most unique characteristics is that it was built *in situ*, an anomaly being that most affected villages were resettled outside of the 500 meter CRZ/CMZ (see Table 2.2). While households located on the east side of Sethu Road (i.e., those who did not relocate after
the 1977 cyclone) were relocated to Tata Nagar and Salt Road in Nagapattinam Municipality, residents of Akkaraipettai on the west edge of Sethu Road were allowed to reside on site for a number of reasons. First, the site could not be shifted further from the sea (westward) due to the Kaduvai River obstruction. Second, there was a scarcity of land for resettlement in Nagapattinam District. Third, the residents resisted resettlement since they rely on fishing and are attached to the land (i.e., sense of place and topophilia). And finally, the panchayat, known as influential in the area, flexed its political strength. Thus, the site centroid lies 418 meters from the mean high tide line, while residents adjacent to Sethu Street are less than 350 meters from the sea (see Table 2.2). Another uniqueness of Akkaraipettai is that, because not all houses were damaged, NGO-constructed houses exist side-by-side with original pre-tsunami houses. Also, since only some of the houses were demolished and reconstructed, the land was not completely bulldozed for site preparation and thus the presence of trees and vegetation is astonishing compared to other sites. The relative abundance of vegetation and number of additions and modifications to NGO-provided houses is also likely a function of Akkaraipettai being the first finished and longest occupied of all settlements included in this study (see Table 2.2). The site is 100% occupied and, in terms of mean educational attainment and total household income, Akkaraipettai is the most educated site in Nagapattinam District and the most affluent site in toto (see Table 2.3). Water supplied by TWAD and the panchayat arrives once per day, just as it does to all sites in Nagapattinam District (see Table 2.5). However, water supply is highly irregular—often failing to arrive for several days at a time—leading households to intermittently rely on handpumps provided by the

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177 A. George (2012), Founder and Chief Executive Officer at BEDROC, personal interview.

Sankar (2011), President of panchayat at Akkaraipettai, Kechankuppam, and Kallar, Nagapattinam District, personal interview.

178 Income and education are elements of capacity, which is included in analyses in Chapter 6.
panchayat. Lastly, residents do not have pattas, but they do possess house insurance (provided by the NGO) for fire, floods, tsunamis, and other disasters or ‘acts of God.’

Figure 2.11: Akkaraipettai

2. **Andana Pettai (see Fig. 2.12):** This settlement is administered by a panchayat in rurally defined Nagapattinam District. Prior to the tsunami, residents were fisherfolk and lived near the beach on Ariyanathu Street, which is 2.5 miles from the current site. Not only are residents far from their original site, but they are located nearly two miles from the sea—a phenomenon that has forced some households to seek work as masons, carpenters, at a local sawmill, or as general laborers (see Tables 2.2 and 2.3). Andana Pettai exhibits the lowest mean total household income of all sites in Nagapattinam District and the

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179 All post-tsunami houses were to be insured by constructing NGOs for a period of no less than 10 years. However, not all NGOs satisfied this government-dictated requirement. Furthermore, all households were to be given joint pattas (when applicable) in the name of the male and female heads of household; however, that has also been left unrealized. Generally speaking, households in Nagapattinam District are more likely to possess pattas compared to those in Karaikal District, while many households in both districts were either not provided insurance or were not made aware of coverage.
second lowest overall (see Table 2.3). Owing to scarcity of land, the pre-tsunami village was divided into three post-tsunami housing colonies, the other two being Saveriyarkovil and Mahalakshmi Nagar (both in Nagapattinam Municipality). Andana Pettai is one of two Christian sites included in this study (the other being Saveriyarkovil), and is one of four sites with a small on-site water treatment center. The treatment center was built with a combination of NGO and panchayat funds. Interestingly enough, it does not supplement water supplied by TWAD and the panchayat, but simply runs a portion of government-provided water through a filter at a centrally located point and charges residents for each vessel they procure (2 per vessel, with each vessel 10-15 liters in volume). Serial monsoon flooding and waterlogging after periods of heavy rain are extremely common. In addition to no drainage provision, much of the flooding is a product the Andana Pettai being boxed in by a relatively high paved frontage road on the east and southeast, railroad tracks on the north, a national highway running through the center that essentially bisects the settlement, and a small pond on the west (which some households use for bathing and laundry). Most residents occupied the site in 2007, but not all houses were filled (see Table 2.1). The District Government was searching for beneficiaries to fill the empty houses when, after heavy rains and winds in June 2008, 39 affected families living near a bridge on Thonithurai Road—who were awaiting post-tsunami housing allocation—agreed to be relocated to Andana Pettai. The new arrivals feel discriminated against as they are perceived as ‘outsiders,’ citing the fact that all other residents possess pattas, while they have been denied pattas despite their legal, government-brokered occupation of the houses for more than four years. Lastly, it must be noted that Andana Pettai—along with Saveriyarkovil, which will be discussed shortly.

180 The national highway is East Coast Road (ECR), which runs parallel to a significant portion of the east coast of India. The highway runs arcs through the heart of the settlement and at a bending elevation of 20-40 feet with no curbs or gutters, causing precipitation to be conveyed into the settlement with little chance of it being drained thereafter.
hereafter—represent the two most dilapidated sites in the study. The houses appear to have been built decades ago, yet are only five years old, and the settlement truly resembles a blighted landscape. Residents are extremely dissatisfied with the quality of housing and infrastructure (see Fig. 2.13).

Figure 2.12: Andana Pettai

3. **New Nambiyar Nagar (see Fig. 2.14):** This is the largest (in terms of acreage, number of houses, and population) and most dense of all 14 sample sites (see Tables 2.1 and 2.4). New Nambiyar Nagar is located within the boundaries of Nagapattinam Municipality. Prior to the tsunami, residents resided on the coast in Nambiyar Nagar, which lies 1.4 miles from the current settlement of New Nambiyar Nagar (see Table 2.2). Residents continue to engage in fishing despite living more than one mile from the sea. Water failing to arrive during pre-defined water availability windows is a commonality, with
taps sometimes dry for 5-7 consecutive days. The settlement is prone to flooding whenever the sky dispenses rain, wreaking havoc on water access (see Fig. 2.15), catalyzing the seepage of sewage, and making it difficult for children to attend school. New Nambiyar Nagar is bifurcated into east and west sections by permanent and ephemeral bodies of surface water. The east side is smaller areally and in number of houses, higher in elevation, experiences limited flooding, and is closer to the sea. On the other hand, the west side contains roughly 750 of the 892 houses, is lower in elevation, experiences persistent flooding, and residents must trudge longer to sustain their sea-based livelihoods. Between the east and west sections of New Nambiyar Nagar are bodies of water where some households bathe and wash laundry. There is also a dry, scrub-dotted plot of land between the two sides that is used for OADU—men use the north part and women and children use the south part. The northwest side of New Nambiyar Nagar is adjacent to and meshes almost seamlessly into the southeast side of Saveriyarkovil (a site to be discussed shortly), with streets lined with houses built by one
NGO and belonging to one settlement on one side of the street, and houses built by a different NGO and part of the other settlement on the opposite side. Houses in New Nambiyar Nagar have the same insurance as those in Akkaraipettai (same constructing NGO), and all houses have pattas. As this is being written, the construction of a sewage treatment plant by TWAD is underway. However, the sewerage system will only service about 400 of the 892 houses as a result of a municipal-panchayat boundary crossing through the site. Currently, the boundary does not affect water supply, but TWAD’s new sewage treatment (which will soon be turned over to the Municipality for operation and maintenance) will only be connected to houses positioned on the municipal side of the boundary.

Figure 2.14: New Nambiyar Nagar

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181 P. Gunaseelam (2012), Assistant Executive Engineer of Rural Water Supply and Tsunami Sewerage Projects at TWAD, personal interview.
In New Nambiyar Nagar, women endure the hardships of fetching water in times of flood, and are also subjected to associated issues of water quality.

4. **Samanthanpetta** (see Fig. 2.16): This fishing settlement is 100% occupied and is located within the boundaries of Nagapattinam Municipality. The new settlement is proximal distance from the original settlement: the entire village was shifted westward from the coast leaving the centroid of the current settlement a distance of 641 meters from the coast and 626 meters from the original site (see Table 2.2). Thus, not only do residents continue to engage in fishing, but many households maintain and partially occupy their original houses. In fact, Sneha, a local NGO, provided funds to families whose houses were partially or fully damaged by the tsunami to assist them in rebuilding *in situ*—this practice was executed against CRZ/CMZ orders and much to the chagrin of the District Collector. The result is that many families enjoy two houses: an original that was

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182 George, 2012.

Radhakrishnan, 2012a.

It is interesting to note that Radhakrishnan, District Collector of Nagapattinam District at the time of the tsunami, battled with Sneha over their funding of reconstruction within the CRZ/CMZ. However,
repaired by funds provided by an NGO with no repayment whatsoever, and a new house further inland provided by a different NGO that signed an MOU with the government. Many families initially lived in their original homes, but were eventually coerced into occupying the new homes when the government turned off the electricity and water at the original site and proclaimed that they would withhold *pattas* and distribute the unoccupied houses to other deserving beneficiaries. Compelled to occupy the new houses, the families relocated (*pattas* were distributed to all site residents). However, the original houses are still maintained and partially occupied: fishermen store supplies in the houses, use them to lay down for a rest after a hard day of fishing, carouse while imbibing rum and *arrack* (locally made alcohol), and the houses are cleaned and decorated on festivals and days honoring ancestors. A state-of-the-art on-site water treatment center was constructed on the behalf of two NGOs who were allotted funds from UNICEF—one NGO was familiar with the region, while the other NGO specialized in building water treatment centers (see Fig. 2.17). However, in the face of water quality and quantity hardships, the trademarked ‘Dr. Water’ treatment plant was completed but never connected to a stream of water. Thus, despite more than USD $100,000 in funds, a year of construction, and a fully completed plant, the objective of providing safe water was torpedoed by fissures among the two overseeing NGOs, lack of community ownership, confusion over how to charge for water, and bungling the connection of the plant to a municipal water stream (being that the groundwater exceeded the limit for total dissolved solids, or TDS). The fate of Dr. Water: it has been sitting unutilized for three years, valuable pipes and fittings have been stolen by households, it has morphed into a playground for the settlement’s children, and it has fallen so deep into disrepair that it would require considerable toil from outside water engineering experts in order to

several years after reconstruction played out, Radhakrishnan now supports Sneha’s efforts because the location is preferable to residents and the practice does not require the government to coax and force people from their ancestral lands and livelihoods. [Radhakrishnan, 2012a.]
resurrect the plant. Similarly, a USD $250,000 World Bank-funded on-site sewage treatment plant met its demise and languishes backed up and defunct. All 340 houses were connected via underground pipes to the treatment plant built by TWAD. However, after fluctuating several times between being broken down and in operation, TWAD fixed the plant once and for all and transferred ownership to the municipality. One month later, the plant broke down and has been sitting idle and incapacitated for 2.5 years. Meanwhile, families are forced to practice OADU whilst the municipality and TWAD argue over whose responsibility it is to repair the plant. The plight of Dr. Water and the sewage treatment plant have been well-documented by interviewing site residents and actors from the overseeing agencies across several years. A more thorough history of Dr. Water will be provided in Chapter 5 when it is of more relevance.

Figure 2.16: Samanthanpettai
Figure 2.17: Dr. Water

Dr. Water sits unutilized at Samanthanpettai, despite an ongoing need for improved water quality and quantity.

5. Saveriyarkovil (see Fig. 2.18): This settlement is located in Nagapattinam Municipality, and its southeast edge blends into the northwest edge of neighboring New Nambiyar Nagar. Before the tsunami, families resided near the shore adjacent to Ariyanathu Street, where they engaged in fishing. After the tsunami, the village was split into three independently located settlements: Saveriyarkovil, Andana Pettai (a study site discussed earlier), and Mahalakshmi Nagar (not included in this study). Houses at Saveriyarkovil are 2.5 miles from where the residents lived prior to the tsunami (see Table 2.2). A majority of inhabitants remain engaged in fishing, in spite of the greater than one mile distance to the sea, but there is a trend of individuals seeking employment as painters, electricians, general construction workers, and in hotels and at the port (see Table 2.3). In terms of religion, it should be noted that Saveriyarkovil is one of two Christian communities included in this study—the other being Andana Pettai (see Table 2.3). Heavy flooding and waterlogging are persistent threats in Saveriyarkovil, serving to complicate water access and quality (see Fig. 2.19), as well as mobility (for adult
employment and children to reach school). In fact, in four years of site occupancy, numerous households have needed to relocate to a nearby school up to five separate times for a duration of 7-10 days on each occasion as a consequence of flooding. Unsurprisingly, Saveriyarkovil—along with Andana Pettai—represent the two most dilapidated, depressing, and aged settlements included in the study. Lastly, residents of Saveriyarkovil have secured pattas.

Figure 2.18: Saveriyarkovil

6. Theti (see Fig. 2.20): Theti is the northernmost site in Nagapattinam District and falls under panchayat administration. Residents were relocated 2.5 miles south from a beach in Silladi Nagar, Nagore, a small town north of Nagapattinam Municipality (see Table 2.2). They are disgruntled over the distance from and connectivity to their original location, which makes it difficult to travel to work. Theti is the only Muslim site in the
Figure 2.19: Inundated tap
An inundated and algae-engulfed community tap rests inaccessible and unused in Saveriyarkovil.

Figure 2.20: Theti
study, and it also figures as the least educated (see Table 2.3). Residents are engaged in labor, with many employed as rickshaw-wallahs, cooks, chaiwallahs, and construction workers. The settlement was built by a combination of three NGOs with the following artifact a result of the joint venture: 100 twin-houses with individual septic tanks, 100 houses connected in groups of four connected to a community septic tank (that has filled and backed up twice), and 69 individual houses with individual septic tanks (however, 35 of the houses were not provided septic tanks and 19 houses were left unfinished and are unoccupied). The government has issued pattas to residents of occupied houses.

7. Uzhuvar Nagar (see Fig. 2.21): This site is the southernmost in both Nagapattinam District and of all the study sites; it is located in panchayat territory between Nagapattinam Municipality and Velankanni, a small town to the south. Residents originally occupied land nearer to the coast ½ mile away. Uzhuvar Nagar is the smallest site in acreage, number of houses, and population in Nagapattinam District, and the second smallest in all three categories overall (see Tables 2.1 and 2.4). Uzhuvar Nagar is comprised of dalits; it is the only SC community in Nagapattinam District and one of two in the study (see Table 2.3). Many residents work as daily wage construction laborers or as cremators at a nearby cremation ground. The cremation ground is located just south of the site and is separated from the site by a tall concrete wall. Uzhuvar Nagar has the lowest occupancy rate of all sites by far (see Table 2.1), the result of a court case over house quality brought by some members of the community against the constructing NGO. The plaintiffs succeeded in a case that went to the Madras High Court (highest court in the state), forcing the NGO to retrofit the houses by making the walls stronger.\textsuperscript{183} Pattas have been withheld from the beneficiaries until retrofitting has been

\textsuperscript{183} C. Dhurairaj (2011), head of post-tsunami reconstruction for Salvation Army in Nagapattinam and Karaikal Districts, personal interview.

The court case and a boycott of the upcoming election are even outlined in a local daily. A portion of the residents of Uzhuvar Nagar refused to vote in elections in protest of the quality of housing
completed and the occupancy rate increases. Several households consume untreated groundwater from two handpumps that were provided by the panchayat because it is easier to retrieve water from the handpumps, there is uninterrupted supply (no water availability windows), and the water ‘tastes better.’

![Figure 2.21: Uzhuvar Nagar](image)

Having outlined the seven study sites in Nagapattinam District, the seven sites in Karaikal District will now be highlighted alphabetically (see Fig. 2.22).

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1. **Akkam Pettai (see Fig. 2.23):** This site is one of two in Karaikal District that fall under *panchayat* administration. Residents of Akkam Pettai were originally located 600 meters eastward on the beach; after the tsunami the site was shifted westward to the opposite side of a road that shadows the coast (see Table 2.2). The residents are wholly engaged in fishing and are still able to store boats and other equipment at the original site. In many respects, Akkam Pettai is a unique site: it is one of only two sites in Karaikal District with community water taps (the other being Mandapathur, which is also under *panchayat* administration); it is the only site in Karaikal District with twin-houses; it is the only site in Karaikal District with shared sewerage facilities (leach pits are shared by two sets of twin-houses); and it is the poorest of all 14 sites (see Tables 2.3 and 2.5).
Many families in Akkam Pettai prefer to consume untreated groundwater because they feel that it tastes better, is more ‘natural’ and contains ‘no chemicals’, and is more aesthetically pleasing. Residents do not have *pattas*, but they do possess calamity insurance for their houses.

![Figure 2.23: Akkam Pettai](image)

2. **Amman Kovil Pathu (see Fig. 2.24):** This site is situated in Karaikal Municipality, and residents were relocated ¾ miles from their original location that is now referred to as Old Amman Kovil Pathu (see Table 2.2). Prior to the tsunami, residents were fully engaged in fishing, but the newly imposed 2/3 mile distance from the sea has caused many residents to alter their employment. Thus, many who previously fished now earn income by working at petty shops, small-scale tailoring units, and as rickshaw-wallahs and daily wage laborers. Overall, Amman Kovil Pathu is the second wealthiest of all 14 study sites (see Table 2.3). The constructing NGOs equipped the settlement with
numerous amenities: an on-site reverse osmosis water treatment center, library, medical shop, *anganwadi*, community hall (also for use as a marriage hall and cyclone shelter), children’s park, and four shops which residents can rent to operate micro-businesses.\textsuperscript{184} While the *anganwadi* is bustling with activity and three of the four shops are occupied with small business units, a preponderance of the facilities remain unused: the library houses zero books and has never been used, the medical shop and community hall remain empty and locked, and the children’s park has yet to entice any children. Furthermore, the water treatment center has failed to treat a single drop of water in its nearly five years of existence (see Fig. 2.25). It sits with locked doors as the Municipality refuses to connect it to a water supply because “it was not properly handed over to PWDP by the NGO,” and “PWDP is only responsible for supplying water to the hamlet, which is being done, we are not responsible for maintaining other non-PWDP infrastructure.”\textsuperscript{185}

Amman Kovil Pathu is a quiet site, but undercurrents of tension are palatable among five Muslim families who are discriminated against by the Hindu majority (obliged to donate money to build a Hindu temple and forced to pay for their houses even though all tsunami houses—including the other 120 at the site—were to be provided free of cost), and among six local politicians affiliated with three opposing parties who bicker and are therefore unable to secure *pattas* for the residents. On the adjacent north side of the site is the post-tsunami settlement of MGR Nagar (also known as Sant Eknath Nagar), a collection of 120 houses built by the Government of Maharashtra.

\textsuperscript{184} The amenities provided by the constructing NGOs are listed as ‘accomplishments’ on the plaque that welcomes residents and visitors. The plaques, signs, gates, and monuments that greet affectees and visitors—conspicuously brandished with the NGOs’ names and insignias—are applications of ‘social auditing’ or ‘donor mapping.’

\textsuperscript{185} T. Chidambaranathan (2011), Junior Engineer of Water Supply Sub-Division of PWDP and IPH, personal interview.
Figure 2.24: Amman Kovil Pathu

Figure 2.25: On-site treatment plant
A reverse osmosis water treatment center sits locked and unused at Amman Kovil Pathu for nearly five years.
3. Kilinjilmedu (see Fig. 2.26): This site is positioned in Karaikal Municipality and lies roughly 600 meters west of the original seaside site, now referred to as Old Kilinjilmedu (see Table 2.2). Residents of the site still rely on fishing because the relatively longer post-tsunami distance is not too imposing and many families still partially or fully occupy their original houses. Just as in Samanthanpettai in Nagapattinam District, Sneha provided funds to families for repairing or rebuilding their pre-tsunami houses. Thus, some families primarily occupy their original houses, some primarily occupy their new houses yet maintain and partially occupy their original houses, while others use their original houses as storage and rest points to aid their fishing livelihood. Hence, it shall come as no surprise that Kilinjilmedu exhibits the second lowest occupancy rate of all 14 study sites (see Table 2.1). Residents of the settlement do not have pattas, but were granted insurance by the constructing NGO. Kilinjilmedu is sandwiched between two other post-tsunami settlements constructed by the same set of NGOs: Kottucherrymedu (159 houses) to the north, and Karaikalmedu (400 houses) to the south.

Figure 2.26: Kilinjilmedu
4. **Kizhakasakudimedu (see Fig. 2.27):** This site is under the administration of Karaikal Municipality and was shifted inland 705 meters from its original seaside location now known as Old Kizhakasakudimedu (see Table 2.2). Residents have persisted with their fishing livelihood despite the almost ½ mile buffer from the sea. Kizhakasakudimedu is the second least educated of all 14 sites (although third place Mandapathur, the next site to be discussed, is virtually tied for second), the second poorest of all 14 sites (although third place Vettakaramedu is essentially tied with Kizhakasakudimedu for second), and its water woes are among the worst of all the study sites (see Table 2.3). While individual water taps are provided for all post-tsunami houses in Karaikal Municipality, water pressure is so low in Kizhakasakudimedu that close to 40% of houses fail to receive any flow of PWDP-provided water. The dire situation has prompted one of the constructing NGOs to erect and manage—through an individual residing in a nearby household—a reverse osmosis treatment center (see Fig. 2.28). Although the treatment center is semi-centrally located, many households must walk more than 300 feet to the

![Figure 2.27: Kizhakasakudimedu](image-url)
facility, pay to fill the one or two vessels they brought (₹1 per vessel), and trudge home carrying the 30-60 pound brimming vessels. The on-site treatment center is a success story, but it is an artifact of the deplorable provision of water infrastructure in the reconstruction process. Households in Kizhakasakudimedu possess neither pattas nor house insurance.

Figure 2.28: Functioning on-site treatment plant
A reverse osmosis water treatment center is successfully maintained in Kizhakasakudimedu on the behalf of a site resident and one of the constructing NGOs.

5. **Mandapathur (see Fig. 2.29):** This site is one of two in Karaikal District that are administered by a panchayat. Like many post-tsunami settlements in Karaikal District, Mandapathur was shifted westward from the beach across a small road that runs parallel to the coast; the settlement is situated a little less than 1/3 miles from its original location
(see Table 2.2). This site is 100% occupied and continues to sustain its livelihood from fishing (see Tables 2.1 and 2.3). Mandapathur is the third least educated site overall, but is virtually tied for second (the three least educated sites in this study are all in Karaikal District) (see Table 2.3). A product of its location in panchayat territory is that households in Mandapathur must gather water from community taps, which differs from all sites positioned in the Municipality (see Table 2.5). As was the case in Akkam Pettai, some households prefer to consume untreated groundwater because the water is easier to retrieve and the taste is preferable. Drainage in Mandapathur is of chief concern—ditches are habitually clogged with solid domestic waste (see Fig. 2.30). Inhabitants of the site have not secured pattas, but they were provided with house insurance for disasters.

Figure 2.29: Mandapathur
6. Paravaipettai (see Fig. 2.31): This study site is located in Karaikal Municipality and was reconstructed *in situ*—the only study site in Karaikal District to be constructed in its original location, and one of two sites in this study to exhibit this anomaly (see Table 2.2). Paravaipettai is 100% occupied, the smallest site in the study, and also figures at the smallest population of all study sites (see Tables 2.1 and 2.4). Furthermore, Paravaipettai is the only SC community in Karaikal District and one of two in the study (see Table 2.3). That being said (and breaking with conventional stereotypes), Paravaipettai is the most educated of all 14 study sites, the wealthiest site in Karaikal District, and the second wealthiest site *in toto* (see Table 2.3). Residents are employed in general labor (primarily construction and street cleaners), with some working at a nearby landfill. Paravaipettai is relatively water rich, as it is one of two study sites that enjoys three water availability windows per day (Vettakaramedu—to be discussed next)—also benefits from three water
windows, while the other five sites in Karaikal District experience two windows and all seven sites in Nagapattinam District are sanctioned only one window per day). The eastern edge of the site is marked by an eight foot brick and mortar wall, which aided greatly in protecting the settlement from the brunt of the 2004 tsunami. A total of 24 houses comprise the site: 22 houses were demolished and rebuilt, while two survived the tsunami unscathed and were not rebuilt (these two houses are not included in the study). The 24 houses had pattas prior to the tsunami and were allowed to reside in situ (they still possess pattas today). However, another 23 families lived on or near the site as squatters, which prompted the government to relocate these families to MGR Nagar, which is roughly ¾ miles away. Residents of Paravaipettai do not have house insurance.

Figure 2.31: Paravaipettai
7. **Vettakaramedu (see Fig. 2.32):** This site lies within Karaikal Municipality and is positioned a little more than 2.5 miles from its pre-tsunami location (see Table 2.2). Vettakaramedu is the third smallest site overall in number of houses, acreage, and estimated population (see Tables 2.1 and 2.4). This site is the least educated by a significant margin, and ranks third overall (but is virtually tied for second) in total household income (see Table 2.3). Residents of Vettakaramedu are engaged in daily wage labor, primarily as masons, construction workers, and in agriculture. Vettakaramedu enjoys three water windows per day, a phenomenon shared by only one other site in this study. Unfortunately, leach pits are located under the front entryway of the houses, a factor that has led only one family in the entire site to use their latrine. The inconsiderate location of sewerage infrastructure surfaces issues of spatio-cultural purity.

*Figure 2.32: Vettakaramedu*
in which households refuse to use their latrines because the leach pit adulterates the front of their house, thereby tainting the portal that welcomes both guests and the gods. To bypass the issue, many households have converted their bathrooms into puja rooms, storage space, or have filled the latrine with cement and only use the room for bathing (see Fig. 2.33). In appearance, Vettakaramedu is the roughest and most unkempt site in Karaikal District. Residents of the site possess neither pattas nor house insurance.

Figure 2.33: Modified latrine
This latrine in Vettakaramedu has been filled with cement in order to prevent sewage from flowing into the leach pit, which is located in a culturally insensitive location. The household bathes in the bathroom, but opts for OADU to avoid socio-religious issues of spatial purity.
CHAPTER III: DATA COLLECTION AND METHODOLOGY

3.1 Qualitative methods

The methodology used to investigate water components of post-tsunami housing reconstruction in South India is predicated on regular field exposure over the course of several years. Informal pre-dissertation field visits began in 2008-09, when I was a doctoral student at the Indian Institute of Technology-Madras (IIT-M). Informal but increasingly more structured field visits continued through 2011, with 31 post-tsunami settlements visited in Tamil Nadu and Puducherry, India, and four settlements visited in southern Sri Lanka. The initial extended field visit combined with three trips to India and two trips to Sri Lanka over the course of three years enabled me to gain a greater understanding of local cultures, select a research topic, formulate research questions, design a research framework and methodology, and finalize the study sites.186

The string of pre-dissertation field visits provided me with the opportunity to observe and document salient issues in post-tsunami settlements across space and time, which was aided by the ability to hold dialogues and FGDs with dozens of settlement residents in which they pinpointed the issues that were most problematic—chief among them were water access, quantity, and quality. As a result, this dissertation does not hinge upon preconceived notions or hypothesis testing. Rather than constructing prognoses externally and subsequently proving or disproving their validity, the legacy of field visits fashioned a nuanced platform from which I could explore the deeper underpinnings of water-based issues, their extent and variation across space, and methods for coping with and modifying the post-tsunami waterscapes. Thus, fieldwork in the pre-dissertation phase proved formative by adding a longitudinal dimension, raising my level of cultural cognizance, and whittling possible research topics down to one that is significant both to the populations being studied and the literature.

186 Formal fieldwork then ensued from 2011-12.
It is important to note that this study operates under a set of ethics for disaster studies. Disaster-affected populations are often vulnerable, a cumulative product of human and property loss, possible post-traumatic stress disorder (PTSD), involuntary relocation, and changes in livelihood, quality of life, and health and nutrition. Furthermore, it is common for associated issues of communal and political fissures to crop up. Thus, as suggested by Kelman (2005) and Killian (1956), no research was conducted that could foreseeably enhance the vulnerability of affected populations, or exacerbate or create conflicts both within the study sites and between the study sites and their governments.\textsuperscript{187}

Similarly, this study is premised on a standpoint of human rights that includes housing and water as universal rights. In this study, Maslowian arguments for housing to sustain existential means and ends are vital. Furthermore, Turnerian perspectives of housing as a ‘verb’—thus, not a noun, object, or commodity—and housing as a ‘process,’ not a product, are key.\textsuperscript{188} Hence, houses are not merely assets or investments, but social structures that pass through evolutionary processes as families expand, incomes rise, and cultures express themselves upon the landscape. Houses are fundamental, transformative vehicles that afford physical protection from the elements, and affect mental health, privacy and security, dignity and identity, and social status. Furthermore, houses are linked to livelihood and can constitute work-bases.\textsuperscript{189}


\textsuperscript{189} P. Oliver (2006), \textit{Built to meet needs: cultural issues in vernacular architecture} (Italy: Elsevier Architectural Press).
Resonating with housing as a right and a social medium, water is also recognized as physically and culturally necessary for human populations. Put simply, water is not only the linchpin of human physical and biological existence, but it also mediates environmental health, sustains foodstuffs to support populations, fosters livelihood and economic and industrial growth, is a realm for recreation, and is a medium for practicing cultures and religions. Therefore, several scholars have called for the realization of sufficient quantities of water to be accepted as an inalienable human right.

Next, it is useful to comment on the geographic and temporal scales exercised in this study. Some interview and primary document data notwithstanding, this study utilizes multi-sited household data to portray each study site, which in turn cultivates the ability to compare sites between Nagapattinam and Karaikal Districts, the rural-urban level, as well as at the site and inter-site scales. Thus, in practice, several sites sharing the same ‘story’ or ‘biography’ (i.e., affected by the tsunami and now occupying newly constructed post-disaster housing) were brought under the same research framework in order to ‘map the terrain’ and then tease out

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Two recent articles in *The Hindu*, a leading newspaper in the study area, have also written on the significance of right to housing. [“Housing for the poor” (*The Hindu*, 20 April 2009). “Right to housing” (*The Hindu*, 21 March 2009).]

Much of this argument was already posited in Chapter 2 when commenting on the multi-dimensional nature of water in the study area.

Sultana and Loftus, 2012.


A recent article in The Hindu also calls for water as a human right. [“Water as a human right” (*The Hindu*, 23 March 2009).]
similarities and variances—in this case, in terms of water. This study also employs a longitudinal perspective. As evidenced by Barakat (2012), Dengler and Magoon (2005), Winchester (2000), Oliver-Smith (1986), Coburn, Leslie, and Tabban (1984), Germen (1978), and Mitchell (1976), a longitudinal perspective is imperative in post-disaster studies because it takes several years for short and long-term issues to surface, for communities to reestablish critical systems and take ownership of and invest in infrastructure provided, and to identify unexpected environmental outcomes. In the case of post-tsunami South India, the disaster occurred in late 2004, reconstruction commenced in late 2005, and most housing settlements were not completed and occupied until 2006-08. Thus, temporality is significant because studies

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Winchester, 2000.


For example, it was not until two years after site occupation that aesthetic and capital investment in the settlements became apparent: trees and gardens were planted, extra rooms were added to houses, fences were erected, houses were painted, and households began modifying community taps and installing wells and handpumps. Not only did it take time for families to take ownership of the settlements, but time also had to pass in order for houses to degrade, septic tanks and leach pits to overflow, drainage to clog, monsoon floods and dry seasons to come and go, and for families to adapt to and cope with the water situation.
conducted shortly after site occupation or over a short duration will likely fail to uncover issues that have arisen over time, as well as pinpoint their social, economic, political, and geographic underpinnings. Not only was this study conducted after the sites had been occupied for several years, but it is also primed by informal fieldwork from 2008-11 and formal data collection from 2011-12. Lastly, it must be mentioned that this study is the first-of-its-kind to focus on long-term issues associated with post-disaster water-based infrastructure.

This dissertation adopted the method of ‘thick description.’ In a Geertzian sense, this means shying away from ‘thin description’ (literal fragmentary observations), and striving for ‘thick description’ (interpreting the context of an interview in relation to society).194 Thus, observation and interpretation are wedded to arrive at the social and cultural undercarriage of a phenomenon. The thick descriptive method coincides with humanistic or hermeneutic geography, in which a “scenic understanding” is produced195 through the following process:

[A] set of personal or man-land relations abstracted by Verstehen. . . . become analytical constructs which the observer erects partly by taking the participants’ perceptions into account, but also by fitting together observations not available to the participants themselves.196

In order to achieve this goal of holistic interpretation in post-tsunami South India, it was important not to ‘go native,’ thereby identifying with the lived experiences of the participants and compromising my role as an objective observer and researcher. This was aided by adopting methods of ‘positionality and praxis,’ primarily informed by Chacko’s (2004) dissertation fieldwork in rural West Bengal, and partially informed by Pile (2010) and Sultana (2007).197


Chacko describes ‘positionality’ as recognizing the relative positions (e.g., race, class, and gender) of the researcher and interlocutor. The researcher must not misinterpret the interlocutor’s lived experiences through their own clouded or filtered perspectives. This can be complemented by ‘praxis’, which is practicing reflexivity to assess the researcher’s influence on the research findings. The researcher should be aware of their personal impressions on research findings, and should make the interlocutor and reader aware of the perspective from which the research is being conducted.

To sum up the previous paragraph with methodological pragmatics: (1) An attempt to move toward thick description was aided by interviewing—in addition to site subjects—central government, state/union territory, district, municipal, and panchayat officials, professors, researchers, NGOs, and self-proclaimed activists; by paying particular attention to government records, local newspaper articles, and the literature broadly defined; and by incorporating quantitative and more positivistic data. (2) Positionality and praxis (for removing biases and misinterpretations) were negotiated through site revisits, verification of statements by interlocutors (‘member checks’), including direct quotes from interlocutors (permitting the audience to see from where conclusions are drawn), and executing peer debriefings and audit trails.198 On this last point, I met frequently with Prema Rajagopalan, a professor of sociology

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at IIT-M, to discuss social, cultural, and religious issues confronted in the field, and to confirm the trustworthiness of data procured. Numerous meetings were held with Annie George, Chief Executive Officer at Building and Enabling the Disaster Resilience of Coastal Communities (BEDROC), to discuss the roles and responsibilities of interview subjects in the reconstruction process. Lastly, routinized meetings with Ligy Philip (a professor of water engineering at IIT-M) and Morgan MacDonald (a doctoral candidate conducting research on participatory water quality management in Chennai) were arranged to review water quality test results and discuss water geographies in India and their intersections with human settlements. Thus, genuine attempts were made to generate a thick, accurate, and triangulated description of the post-tsunami water situation in South India.

A total of 14 sites—seven in each district—were randomly chosen for this study. While 31 newly constructed post-tsunami settlements were visited in Tamil Nadu and Puducherry, four were eliminated from potential investigation on geographical grounds. An attempt was made to sample a (loosely) clustered set of sites in each district with the southernmost and northernmost site in Nagapattinam and Karaikal District, respectively, positioned at less than 20 miles apart (as mentioned earlier, that distance is 17 miles). Next, the 27 remaining sites were assigned to either Nagapattinam or Karaikal District, and two sets of seven sites were randomly chosen using a reputed random number generator’s ‘integer set generator’ tool. The 14 sample sites are of course unique in their own right, but are representative (or at least are not unrepresentative) of the region’s reconstruction process in terms of demographics, social parameters (e.g., livelihood, religion, and SCs), location (municipality or panchayat), and housing (e.g., number of houses, density, occupancy, quality of housing, constructing NGOs, and associated water-based issues). Thus, the 14 study sites promote no known biases, and every attempt was made to accurately portray the post-tsunami water situation.

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199 The random number generator is reputable (built and operated by Mads Haahr of the School of Computer Science and Statistics at Trinity College in Dublin, Ireland) and has been freely available on the World Wide Web since 1998. [Random.org (2012), “Random integer set generator,” available at: http://www.random.org/integer-sets/]
In depth, qualitative interviews were conducted with several households in each settlement through the method of purposive sampling, which aims to capture rich data and its variability in an efficient manner, the goal being to uncover breadth and reach data saturation.\textsuperscript{200} A purposeful sample was performed near the edge or corner of each site (where water issues are most variable—the highest or lowest water pressures, longest or shortest distances to fetch water, and most or least issues of flooding), and with other households that were expected to reveal both the successes and failures of water-based reconstruction. The naturalistic inquiries (see Appendix A) took place in the households; they consisted of 64 structured queries and lasted 1.5-2 hours each in duration.\textsuperscript{201} The interviews probed the following macro areas: site background, water issues, sewage and drainage issues, and a section garnering household perspectives on resettlement, participation in the reconstruction process, and temporal changes from the pre- and post-tsunami housing contexts.\textsuperscript{202} A minimum of five interviews were conducted at each sample site; six interviews were conducted at sites with more than 300 occupied houses (two sites), and seven interviews were conducted at the largest site of New Nambiyar Nagar. Thus, the number of qualitative interviews totaled 74.


\textsuperscript{201} The instrument in Appendix A was used at the majority (12) of sites. A similar version was implemented at the two \textit{in situ} sites in which the final set of questions on resettlement, participation in reconstruction, and pre and post changes was amended to reflect their \textit{in situ} statuses. The alterations constituted a rephrasing of only a few queries in which the heart of the questions did not change. Thus, only one version was appended.

\textsuperscript{202} While the interviews contained structured queries, they also exhibited an unstructured dimension as subjects frequently chose to digress on issues related to the pre-defined questions.
The interview dialogue was in Tamil. Therefore, interviews were conducted through carefully selected translators.\textsuperscript{203} The translator in Nagapattinam District is a resident of a post-tsunami housing settlement (not a settlement included in this study) who is not only familiar with the local use of language and the reconstruction process, but also the dynamics of localized politics, religions, livelihood, and cultures broadly defined. The translator in Karaikal District possesses a master’s degree in social work and carried out small projects in post-tsunami settlements during the course of graduate study. Analogous to the translator in Nagapattinam District, the translator in Karaikal District is fluent in the subtleties of place-based social and political phenomena. Lastly, the interviews were conducted during a time-window that may be described as a ‘temporal medium.’ In other words, the interviews took place in between the relatively dry and relatively wet seasons, with the goal of generating average, middle-ground, or replicable analyses. Thus, data portray the condition in post-tsunami settlements during the ‘normal time,’ which comprises a majority of a given calendar year.\textsuperscript{204} That being said, the interviews did probe seasonal extremes, and the succession of field visits (and thus observations) across 2008-12 occurred throughout all of the three generically defined seasons.

In addition to naturalistic inquiries at the household scale, one FGD was held at each study site with the assistance of a translator.\textsuperscript{205} Bosco and Herman (2010) conceptualize FGDs as dialogic activities during which:

\begin{itemize}
  \item The depth of the qualitative interviews required a reliance on translators. However, my (albeit limited) knowledge of Tamil allowed me to introduce and initiate the interviews, and to demonstrate comprehension of what the interlocutors were communicating. Thus, rapport between the researcher and researched was built throughout the interview process.
  \item The calendar year can be roughly categorized into 6-8 months of ‘normal time,’ 2-3 months of dry season, and 2-3 months of wet season.
\end{itemize}
Data are generated through a group discussion where social interaction is the norm, and such interaction in turn is moderated by a researcher who keeps the group ‘focused’ thorough a set of prepared questions and prompts. In this manner, groups of women and men, young and elderly were assembled to share their collective knowledge on the reconstruction process and its corollaries with the current water situation. The FGDs were instrumental in pinpointing areas of broad consensus and disagreement within each site, revealed the concerns of primacy at each site, and served as a means to verify data from household interviews and validate my external observations.

A battery of interviews with government officials and key informants contribute to this study. While most interviews were planned and detailed, a few were impromptu, and while most were personally executed in English, some were conducted in Tamil with the assistance of a translator (primarily interviews with panchayat officials). In Nagapattinam District, nine District officials, two Municipal officials, and seven panchayat officials were interviewed. Additionally, three officials were interviewed at the State (Tamil Nadu) level. In Karaikal District, seven District officials, two Municipal officials, and six panchayat officials were interviewed—an additional three interviews were conducted with State (Puducherry) officials. Furthermore, two Central Government officials engaged in water-related research in the southeast coastal region were interviewed. Supplementing the government interviews, 27 interviews were executed with key informants, ranging from NGOs that constructed the settlements to NGOs that built and/or operate on-site water treatment plants to NGOs carrying out humanitarian work. The key informant interviews also encompassed laborers employed in the building of post-tsunami houses, employees at anganwadis in the settlements, a local aquaculturalist, a journalist, and

FGDs were also utilized in the pre-research phase to assist with the choice of a study topic and to design methods of inquiry.

206 Bosco and Herman, 2010: p. 193.

FGDs were also used by Pincha (2008) in her examination of gender issues in post-tsunami Tamil Nadu. [C. Pincha (2008), Indian Ocean tsunami through the gender lens: insights from Tamil Nadu, India (Mumbai: Earthworm Books).]
professors. The government interviews assembled the ‘official’ biography of the reconstruction process and provided necessary data on which party was/is responsible for the provision, operation, and maintenance of post-tsunami infrastructure. The key informant interviews secured vital niche data at the interface of site residents and government officials that were crucial in triangulation. On the whole, the interviews probed water, specifically the roles and responsibilities, and shortcomings, successes, and limitations of water-based reconstruction after the tsunami.

Primary documents were acquired to authenticate this study. The most authoritative documents are MOUs between the Governments of Nagapattinam and Karaikal Districts and constructing NGOs that explicitly outline the responsibilities of the respective Government and relief organization. MOUs list whose responsibility it was to provide (or not provide) housing, water access points, sewerage, drainage, roads, electricity, community facilities, and so on and so forth. In addition to MOUs, Nagapattinam District held weekly Shelter Advisory Committee (SAC) meetings in which all concerned government and NGO officials met to detail their progress, update the reconstruction timeline, and assign specific reconstruction tasks to individuals and departments. The SAC meeting minutes were obtained in their entirety and were pored through in order to scrutinize the reconstruction process and identify the deemed responsibilities at each study site. Lastly, a collection of useful primary documents such as post-tsunami government orders, water quality reports, water fee schedules, house blueprints, site layouts, infrastructure ‘handover certificates,’ maps, and CRZ/CMZ regulations were acquired. Together, the documents refine the ‘official’ perspective of the Governments, and assist in shedding light on the current water situations at the sites.

Lastly, as an avid photographer, I took photos at each site and of pertinent water-based phenomena. Photographs were shot during fieldwork and subject interviews, and were correlatively cited in field notes and interview texts as reference or clarifying materials.207 This

method of data in conjunction with images augmented the dissertation writing process by enabling me to recollect idiosyncratic water and reconstruction situations, and by efficiently referring me to portrayals that were too complex to conceive in words alone. Furthermore, photographs surface throughout this study to allow the audience to bear witness to issues described and analyzed herewith. Through this presentational strategy, photographs are recognized as textual documents that capture records of cultural and physical landscapes. Moreover, these visual records of human-environment interaction enable the audience to literally see from where conclusions are drawn, thus serving a purpose analogous to that of including direct quotes from interlocutors.  

3.2 Technological, quantitative, and laboratory methods

This dissertation—à la Philip (1998) and Graham (1999)—employs multi-method research. That is, in addition to its interdisciplinary nature, this research employs several classifications of methodologies in order to present the water-disaster interface in a polyvocal manner. Thus, a set of technological, quantitative, and lab-based (water quality testing) methodologies complement the qualitative methodology detailed in the previous section.

Having already narrated the randomized choice of sites included in this study, which itself was based on a technology supported by algorithms, the next step was to examine the spatial attributes of the sites. This was done in a GIS using ArcGIS 10.0 software, and integrates


208 As a final qualitative method worthy of brief mentioning, newspaper articles from the region have been and will sometimes be included as references. The objective is to demonstrate broader societal interest in disaster and water-based issues, and to reaffirm the scenarios confronted by post-tsunami housing residents as very ‘real’ experiences.


data points and polygons logged in the field with a GPS. Road and satellite base maps from
Bing Maps and the GPS data (e.g., perimeters of sites, water access points, sampled households,
elevation, and points of interest) were used for representative purposes and to perform basic
analyses. These analyses include, but are not limited to: delineation of site boundaries (official
and functional), calculation of site centroids, measurement of distance from the post-tsunami
sites both to the original sites and to the sea, acreage, density/compactness, elevation and
gradient, as well as other data presented in Tables 2.1-2.6.210

Quantitative household surveys were implemented at all 14 study sites using random
sampling. Each survey encompassed 14 questions and lasted roughly 20 minutes in duration (see
Appendix B). The same random number generator and its ‘integer set generator’ tool was
utilized to choose a total of 300 houses: 169 in Nagapattinam District, and 131 in Karaikal
District (see Table 3.1).211 The only filter exercised in the sampling design was that each
selected house must gather water from a different tap (in order to avoid redundancy and capture
more data).212 Therefore, the method for sampling pragmatically categorized the sites into
subpopulations and can thus be denoted as a customized application of stratified sampling (see
Appendix C).213 The minimum number of household surveys conducted in each site was 15,

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210 While many of the analyses can be performed with tools existing within the GIS or externally
in Microsoft Excel, rationale from Longley et al. (2010) was used in the analyses and for usage of the
data product. [Longley et al., 2010]


212 This approach was relevant in Nagapattinam District and at two sites in Karaikal District,
where households retrieve water from public taps. However, sometimes the filter was infeasible as a
function of the number of taps present in the sites. For example, there are only four public taps in
Uzhuvar Nagar.

213 Longley et al., 2010.

Another household was randomly chosen if a selected house was unoccupied or if the household
was unwilling to partake in the survey.

P. J. Taylor (1977), Quantitative methods in geography: an introduction to spatial analysis
(Boston: Houghton Mifflin).
Table 3.1: Sampling – Household Surveys

<table>
<thead>
<tr>
<th>No. of occupied houses</th>
<th>No. of households sampled</th>
<th>Percent of households sampled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>186</td>
<td>21</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>203</td>
<td>21</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>859</td>
<td>37</td>
</tr>
<tr>
<td>Samanthanpettai</td>
<td>340</td>
<td>26</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>346</td>
<td>26</td>
</tr>
<tr>
<td>Theti</td>
<td>250</td>
<td>23</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>26</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total Nagapattinam</strong></td>
<td>2,210</td>
<td>n = 169</td>
</tr>
<tr>
<td><strong>Karaikal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>96</td>
<td>18</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>122</td>
<td>19</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>268</td>
<td>24</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>186</td>
<td>21</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>100</td>
<td>18</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>64</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total Karaikal</strong></td>
<td>858</td>
<td>n = 131</td>
</tr>
<tr>
<td><strong>Total all sites</strong></td>
<td>3,068</td>
<td>n = 300</td>
</tr>
</tbody>
</table>

with the majority of sites sampled at least 21 times. While some may question the number of surveys implemented at each site, several factors should assuage those concerns. First off, the sites are more homogenous than most sample sets. The post-tsunami settlements were moved en masse, each comprising a community with a similar religion, language, livelihood, and shared set of histories and lived experiences. Second, this study leans toward the descriptive and less
toward quantitative positivism. Third, penetrating the sites is difficult and onerous as a
‘Westerner’ or ‘outsider,’ especially when some inhabitants are distressed over their condition
and (rightly or wrongly) place blame upon Westerners broadly defined. Fourth, any perceived
thinness in survey samples should be attenuated by immersion in the field, a series of pre-
dissertation site visits across time, season, and space, and the result of having sampled 14 sites—
which is demanding in its own respect. Lastly, the audience should recognize this study as a
first-of-its-kind that could be used to inform a new field of inquiry within disaster studies.

Having studied Tamil for one year and traveled to the region several times, the surveys
were conducted personally, although assistance from a translator was attained when necessary.
The surveys provided much useful data, including, but not limited to: household size, estimated
site populations, total household income, highest level of educational attainment in the
household, and other data presented in Tables 2.3 and 2.4. Furthermore, the data allow for basic
analysis of distribution of phenomena through histograms. Moreover, survey data facilitate
scalar analyses, meaning that knowledge can be gained at the scales of site, inter-site, rural-
urban, and Nagapattinam-Karaikal District.

The household survey data will be manipulated to create a Water Poverty Index (WPI) in
Chapter 6. The WPI is a composite index conceived by Sullivan (2000 and expanded in 2001),
and it has since been adapted and critiqued. The original WPI comprises five supra-
parameters: resources, access, capacity, use, and environment. Through these parameters, a

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poverty alleviation,” *Water Policy* 5.

P. Lawrence, J. Meigh, and C. Sullivan (2002), *The water poverty index: an international
comparison* (Keele: Keele Economics Research Papers, Keele University).


International* 26(4).

Institute of Hydrology, CEH).
snapshot of the water scenario, or level of water poverty, is calculated at a pre-defined site-specific scale, which can then be exploited to: compare sites, quantify pre and post changes (i.e., assess project outcomes), measure a site’s water situation against agreed upon standards, and direct scarce resources to sites where water needs are the most urgent. While most WPIs have been calculated at the national scale, experts agree that smaller scales (e.g., the sites included in this study) represent the most appropriate scale because finer-scaled data is more precise and less likely to mask variability. Thus, the caveats of scale and coarseness of data are addressed in this study.

For the purpose of this study, I heavily modified Sullivan’s classic WPI in order to adapt to the Indian and post-tsunami settlement contexts. While the conceptual framework and the construction of sites’ ‘water poverty snapshots’ remain the same, several parameters have been introduced in an attempt to increase the scope and suitability of the WPI at the study sites. The inclusion of additional parameters is based upon much inquiry and deliberation. Ultimately, parameters were incorporated only when they satisfied all of the following conditionalities: (1) the parameter was spoken of by households, without prompting, as creating hardships or hazards in water provision and/or consumption; (2) the parameter was independently observed and thus validated as a hardship or hazard; and (3) the parameter is included in the academic literature as

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Based on a thorough review of the literature, the only WPIs calculated at a relatively small scale (village level) were in pilot studies in Sri Lanka, Tanzania, and South Africa, while a regional WPI was calculated in Benin. [CEH and UKDFID (no date), Using the water poverty index to monitor progress in the water sector (Wallingford: Institute of Hydrology, CEH). C. Heidecke (2006), “Development and evaluation of a regional water poverty index for Benin” (Washington DC: EPT Discussion Paper 145, Environment Production and Technology Division, International Food Policy Research Institute). Sullivan et al., 2003.]
a significant element of proper water provision broadly defined. Having fulfilled these provisos, the following list outlines the parameters included in this study’s modified composite WPI:

- **Distance to access point**: Distance traveled to water access points (e.g., community taps) is essential because it necessarily determines how long a trip to retrieve water will take, how far the heavy resource must be carried, and it embodies a crucial component of the burden imposed on those whose responsibility it is to gather water. Distance is even more critical in the Indian and post-tsunami housing contexts because water is only available in short windows of time. This renders short distances much more convenient, with shorter distances fostering the ability to make several trips and therefore to obtain greater quantities of water. Distance to water access point was measured in \( \frac{1}{2} \) meter increments from the household’s door to the distribution point. The measurement was logged ergonomically, meaning that linear distance to the access point ‘as the crow flies’ was forsaken for the natural route (‘as the human walks’—around obstacles, on foot-trodden paths, etc.) taken to gather water, which indicates the real distance traversed to obtain water.

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216 The bulleted list will briefly describe each parameter in terms of why it is significant and how it was measured. Literature affirming the parameters’ significance, analysis of the data, and explanations of analysis will not take place until Chapter 6, which is when the data will be fully presented and manipulated to create WPIs.

In addition to measuring the parameters, the survey culminated with households ranking the top three parameters in terms of significance for the household (i.e., which parameters are most problematic). This will inform weighting of the WPI parameters in Chapter 6. The classic WPI weights all parameters equally, whereas the modified WPI in this study will weight parameters differently based on their significance and level of difficulty for the sampled populations. Households were asked to articulate only the top three parameters because with such a large amount of parameters ranking appeared to become random after the first few were ranked. [L. Mayoux and R. Chambers (2005), “Reversing the paradigm: quantification, participatory methods and pro-poor impact assessment,” *Journal of International Development* 17(1). S. Abeyasekera (2001), *Analysis approaches in participatory work involving ranks or scores* (Reading: Statistical Services Centre and Natural Resources Institute, University of Reading). R. Dayal, C. van Wijk, and N. Mukherjee (2000), *Methodology for participatory assessments with communities, institutions and policy makers: linking sustainability with demand, gender and poverty* (Washington DC: Water and Sanitation Program, World Bank).
• **Hours of availability:** Total hours of water availability determine the maximum amount of time households can retrieve water from access points and is thus a determinant of quantity. Obviously, 24-hour supply is desirable and more hours of availability is preferable to fewer hours. Some sites are provided water for only one hour per day, while others enjoy water for 5 hours per day; furthermore, within the sites, some taps dispense water more often and for longer periods of time owing to pressure, proximity to the source node, and relative location along the underground pipe. Total hours of availability is measured in minutes (converted to hours), and the reported time is actually overstated (i.e., represented as better than reality). Availability is recorded as the total minutes water ‘normally’ comes and is supposed to come; however, it is common for water to arrive late, cease early, or not to arrive at all for one or several days.

• **Windows:** Water arrives to the study sites at set times each day (e.g., 6-8am or 5-6pm). However, some sites are only granted one water availability window per day, while others are sanctioned two or three. A greater number of windows propagates more opportunities for accessing water and less of a reliance on storage—which can erode quality and foster post-point contamination. Sites with one window must store and meticulously allocate water for close to 24 hours until the next window arrives. On the other hand, sites with more than one window are able to gather water more than once per day, thus limiting storage and not penalizing the household with no water if family members are unable to obtain water during one of the windows (e.g., left for work early or returned home late that day). Water availability windows are measured in discrete integers (i.e., 1, 2, and 3).

• **Density:** The number of households sharing each water access point is vital because it establishes how the scarce, dispensed resources must be apportioned. While most houses in Karaikal District have individual taps on their premises, houses in Nagapattinam District must walk to community taps shared by several households. High densities at such taps surface issues of queuing for water, power relations and ageism among water
gatherers, and conflicts and scrambles for water—all of which weigh upon quantity attained. In this study, density is calculated as the number of households sharing an access point.

- **LPCPD**: The quantity of water obtained per household and per individual is of vital significance. Lack of water not only impacts the health and hygiene of the corpus, but it also impinges on cultural and environmental health. LPCPD is highly variable both within and between the sites. LPCPD was measured by taking stock of all the water gathered by the household on the survey day. If water was not obtained that day, I returned the following day to sum the liters of water obtained that day (thus, the LPCPD parameter overestimates quantity and portrays each site as if water was obtained every day). Next, total liters was divided by household size to calculate LPCPD. Lastly, referring to the temporal nature of the parameter, LPCPD shall be considered an average, ‘middle ground’ of what is likely during the ‘normal season’ (the majority of the year that is not during the dry and wet seasons).

- **Flow rate**: This parameter is a surrogate for pressure, which is superlative because it necessarily affects water quantity—especially given scarce resources at queued-up community taps. Additionally, pressure also helps to preserve initial water quality: higher pressurized pipes are more capable of preventing out-of-pipe contaminants from tainting the water supply. This is particularly applicable at the study sites, where waterlogging and sewage regularly share space with pipes that are often in the vadose zone. Pressure at some sites is so low that, in order to entice flow, residents had to saw the in-pipe to the tap at a lower level, while others have intercepted the pipe 2-3 feet below the surface. Flow rate was recorded (with a stopwatch) in its raw form as the number of seconds taken to obtain 30 liters of water, which was also converted to liters per second (l/s). This volume is the amount taken to fill two 15-liter *kodams* (‘vessels’ in Tamil) or three 10-liter *kodams*, which are the two standard sizes of vessels used in
Furthermore, the flow rate fluctuates, so timing 2-3 vessels is more accurate a measure than timing only one vessel.

- **Conflicts**: Clashes over rights to, access to, and quantity of water are all too common at the study sites. Concomitant with distance, density, queuing, flow rate, and quantity, skirmishes over water affect site inhabitants both physically and mentally. Conflicts were defined as heated arguments or exchanges and ranged to physical outbursts—which primarily consist of throwing an individual’s *kodam* away from the community tap to denying access to rare cases of shoving and hair pulling. The parameter was computed as the number of conflicts over water in the last year experienced by the household.

- **Unimproved sources**: Unimproved sources are defined by the World Health Organization (WHO), United Nations (UN), and Palaniappan (2009) as untreated, non-piped sources of water, such as handpumps, open wells, shallow borewells, pre-packaged water, and water distributed by trucks (known as ‘tanker lorries’ in India). The classification of unimproved sources aids the United Nations’ (UN) monitoring of the MDG for increasing access to ‘improved’ sources of water. Thus, improved sources are typically defined as treated, piped water, although resources from protected wells and deep tubewells are also included. While governments administrating the study sites are expected to provide piped, potable water, residents are forced to supplement lean government flows with handpump, borewell, and surface waters. This substantiates access to unimproved sources as a coping mechanism. However, some individuals are unable to supplement low volumes of piped water with unimproved sources as a result of geographic (not located near surface water and/or the groundwater is saline) or economic

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217 This is also the amount of water that generally supports one trip back to the house, in hopes of returning for more water.

factors (cannot afford to install water improvements). In this study, the parameter of access to unimproved sources is classified in a graded scheme: is there access to an additional source of water (beyond government-provided tap water); is the source greater than 100 feet from sewerage infrastructure; and is the source treated (i.e., access to a supplemental improved source).219

- **Capacity:** The concept of capacity is multi-dimensional. In this study, capacity is understood as the ability of persons or systems (e.g., cities, regions, and economies) to modify their behavior in order to accommodate external stresses and short-term insufficiencies.220 Capacity is dependent upon coping mechanisms and adaptive strategies, such as household and political resources, flexibility in the acquisition and utilization of such resources, mitigation measures implemented in the pre-disaster period, livelihood options, social capital and support systems, and even prayer. Thus, higher

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219 While I agree with the official definition of unimproved and improved sources, I broke with the typology in this study. Pragmatically, I classified pre-packaged, bottled water (typically in 20-liter jugs in the study region) as improved water. The rationale is that I tested 16 pre-packaged jugs of water (one before commencing fieldwork, one along with each of the 14 sites, and one post-fieldwork) for biological and chemical parameters. The results were all negative for fecal coliform and revealed better levels of, *inter alia*, pH, nitrates, iron, and hardness when compared to government-provided tap water. Additionally, handpumps and borewells at the study sites are classified as unimproved sources because they are both unprotected and shallow. Furthermore, handpumps and borewells are compromised by the extent of waterlogging and solid waste on the ground surface, as well as a high concentration of shoddy sewerage infrastructure in the subsurface. A buffer of 100 feet should exist between groundwater sources and septic tanks or leach pits, and, when possible, the groundwater source should be placed uphill of sewerage infrastructure. The buffer is impossible to satisfy at the study sites as a result of high housing (and therefore sewerage) densities. Thus, the furthest handpump or borewell from sewerage infrastructure that I was able to measure was 30 feet. Also, while mild undulations are present, the sites are generally flat and rarely allow for the uphill placement of groundwater sources. [Philip, 2012. R. Woodson (2010), *A builder’s guide to wells and septic systems* (New York: McGraw Hill). T. D. Chinn (2009), “Water supply,” in *Environmental engineering: prevention and response to water-, food-, soil-, and airborne diseases and illnesses*, (eds.) N. Nemerow *et al.* (Hoboken: John Wiley & Sons).]


W. N. Adger *et al.* (2004), *New indicators of vulnerability and adaptive capacity* (Norwich: Tyndall Centre for Climate Change Research, University of East Anglia).

It has been postulated that capacity building should be part and parcel of the reconstruction process, with Coburn, Leslie, and Tabban (1984) denoting it as a determinant of successful reconstruction projects. [Coburn, Leslie, and Tabban, 1984.]
levels of capacity allow households in the study sites to absorb changes ushered in by resettlement and reconstruction, and to adapt to ongoing and unexpected problems, such as lack of water and flooding. In this study, capacity was gauged with five sub-categories: income, education, assets, social networks, and time living at the site.

- **Income** is significant because it provides funds to cope with, adapt to, and modify the water canvas. Income was measured in total ₹/month for the household, and includes regular remittances.

- **Education** is important because it is an indicator of general knowledge, which informs households on the germ theory, sanitation and hygiene, proper water handling techniques, HWT, and water quality. Furthermore, education can be harnessed to manage stresses upon and shocks to household systems. Educational attainment was measured as the highest grade level completed by an individual residing permanently in the household.

- **Assets** are a surrogate for wealth and represent capital that can be used to cope with stresses and water issues broadly defined; assets can also be converted to cash in times of need. In this study, assets include, *inter alia*, a vehicle, electrical connection, mobile phone or landline, owning an enterprise, owning work implements used for livelihood, and investments in water and the house (e.g., installing a handpump, borewell, or individual piped water connection, adding a room to the house, building a fence or shed, and planting trees or a garden).

- **Social networks** are a form of connectivity and social capital that can provide channels of assistance in times of emergency. Site inhabitants are better able to ameliorate water-based problems and cope with disasters when they can tap into funds and resources from self-help groups, neighbors, and kin. In this study, qualifying networks are membership in a civic, trade, religious, or cooperative organization (e.g., the South Indian Federation of Fishing Societies, microcredit
organizations, and the Lion’s Club), and the number of relatives (at the household scale) located within one kilometer (0.6 miles) of the surveyed household.221

- **Time living at the site** is crucial because it is a proxy for place-based knowledge on what to expect across time in the newly occupied space. For example, living at the site for several years bestows experience on the seasonal availability and variability of water, the frequency and magnitude of floods, the extent of government involvement at the site, and it also allots time to adapt to and modify the water situation writ large. In this study, time was measured as having lived at the site for: less than six months, 6-11.99 months, 12-17.99 months, 18-23.99 months, and 24 months or longer.

- **Household water quality**: Water quality is of primacy. Poor water quality not only transmits waterborne diseases that affect short-term health, but is also a factor in infant and child mortality and loss of productivity and human capital when diseases prevent individuals from working or attending school. The quality of water consumed at the study sites, and in India in general, is paltry. Water in the households has been transported (sometimes several hundred feet), stored (often for close to 24 hours or more), and is often handled in a manner that is unhygienic. For example, the storage vessel may be contaminated, and cups—along with the possibly contaminated hands grasping them—are generally dipped into the storage vessel to serve water. The bacteriological quality of water being consumed in each household on the day of the survey was tested with a sterilized H2S strip test that was incubated for 48 hours.222 The

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221 The distance of one kilometer was selected because the length can be traveled quickly on foot while carrying an armful of required items. Locations outside of a one kilometer radius become more difficult to access quickly, with children, and while toting necessary items.

222 Water quality experts and the WHO recognize the H2S strip test as a reliable means of testing the presence-absence of bacteriological contaminants in water. Furthermore, the method is commonly used in fieldwork, such as this study, when access to a laboratory is not possible. I was trained in using the H2S strip tests by Philip, a co-developer the testing kit, the manual that accompanies the kit, and the H2S media. The testing equipment and media were sterilized, stored, and incubated adhering to strict procedures laid out during training and in the manual. More information on the H2S strip test and its
test produces one of two results: positive or negative for hydrogen sulfide producing bacteria, which confirms the presence or absence of fecal coliform.

- **Water quality at access points**: Testing access points reveals the initial quality of water dispensed by the government, on-site treatment plants, and groundwater sources. The parameter can also be compared to the household water quality parameter to view the effects of storage and HWT. Access points were tested against nine standards as per the WHO, Environmental Protection Agency (EPA), and Bureau of Indian Standards’ (BIS) permissible and desirable limits. The following nine tests were performed:
  - **bacteria** (H₂S strip test incubated and reported as positive or negative);
  - **pH** (4-11 in increments of 0.25);
  - **hardness** (EDTA method as mg/l CaCO₃ measured in increments of 12.5);
  - **chlorides** (measured by titration of media as mg/l Cl⁻ in increments of 12.5);
  - **nitrates** (measured by titration of media and incubation as mg/l NO₃⁻ in increments of 0.25);
  - **fluoride** (measured by titration of media and incubation as mg/l F⁻ in increments of 0.25);
  - **alkalinity** (measured by titration of media as mg/l A₇ in increments of 12.5);
  - **iron** (measured by titration of media and incubation as mg/l Fe in increments of 0.5);
  - **total residual chlorine** (measured by titration of media and incubation as mg/l Cl₂ in increments of 0.1).

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224 For water quality, the BIS sets both ‘desirable’ (guidelines for what should be strived) and ‘permissible’ limits (less stringent standards that are supposedly enforceable).
The testing kit, developed by professors of water engineering at IIT-M, test for parameters suited to the study region, as imparted by Philip:

The nine parameters tested for are the major reported problems in Tamil Nadu and areas without heavy industry. Additionally, parameters such as pH, hardness, nitrates, alkalinity, and chlorides can be considered as surrogates or indicators for bacteria. This is because they either support or provide the climate for bacterial growth, or they represent dissolved solids that can shelter bacteria from treatment mechanisms [e.g., UV and chlorination] and harbor bacteria in their micro-pores and nano-fissures. 225

Adding to the appropriateness of the kit and its parameters, it shall be noted that the UN uses the same kit for water quality testing in South India, and governmental agencies in Tamil Nadu and Puducherry also test for the same parameters. Furthermore, the kit suits fieldwork when based too far from a laboratory. 226

Sampling methods for household surveys, which included bacteriological water quality tests, have already been described. Thus, the sampling methodology for testing the quality at government-provided taps, which was just outlined, must be clarified. A stratified method was adopted in which eligible taps constituted all the taps from where household samples obtained their water. 227 The taps were numbered and randomly chosen using the same random ‘integer set generator’ function. 228 A minimum of five taps were tested at each site, with six tested in sites containing over 300 occupied houses and nine tested in the largest site of New Nambiyar Nagar (see Appendix D). Uzhuvar Nagar is an exception to this rule because the site has only four taps in its entirety. In this case, all four access points and thus all panchayat-provided water sources were tested. A second caveat of the sampling method is that Akkaraipttai has three


226 All tests were conducted in a controlled setting following the procedures stipulated during training and in the manual.

227 Longley et al., 2010.


228 Random.org, 2012.
water towers that supply water to the site. Therefore, the five water quality tests in Akkaraipettai were randomized until taps from all three towers were represented. In addition to government-provided taps, other sources of drinking water that support the sites were tested. Thus, two functioning on-site water treatment centers were tested, as were one handpump and two borewells from which water is regularly consumed. In total, 75 government-provided taps and five other sources of water were tested (see Table 3.2).^{229} In terms of replicability, it must be imparted that all water quality data in this study shall be observed as a ‘middle ground’ snapshot. Because tests were executed in the seasonal ‘normal time,’ it should be expected that they represent the predominant water quality, and that parameter concentrations fall between those in the monsoon season (when contaminant load increases, but the volume of water supplied also increases and thereby serves to dilute their concentrations) and the dry season (when contaminant load is less, but concentrations increase as a result of a lower volume of water).^{230} For validity and confirmability, peer debriefing and audit trails were conducted with Philip and MacDonald—both agreed that the water quality test results not only appeared reliable, but also resembled their results from the region.^{231} Furthermore, test results parallel findings by Dohbal (2011) in Tamil Nadu, and seven tests performed in the last year by the Government of Puducherry in Kottucherry Commune Panchayat at two of the study sites.^{232}

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^{229} The number of taps tested was determined by a factor of feasibility. The chemical water quality tests take two hours to perform, thus rendering it infeasible to test all water taps used by the household survey sample set.

^{230} Falkenmark, 2009.

^{231} Morse et al., 2002.


Miles and Huberman, 1994.

Guba, 1981.

^{232} Dohbal, 2011;
Additionally, test accuracy was gauged by testing one jug of pre-packaged water before fieldwork commenced, one along with all of the 14 sites, and one after fieldwork ceased. The objective was to assess the constancy and thus trustworthiness of the testing equipment. Lastly, for comparative purposes, water quality tests were performed at three major government supply points that dispense water to a total of five sites—three in Nagapattinam District, and two in Karaikal District. The tests were carried out to check for inconsistencies and to observe how water quality changed during its path from the supply point, through underground pipes, up to water towers, and ultimately through underground pipes to the taps.

Lastly, although the main function of the household survey instrument was to generate a WPI, a question on HWT was also included. HWT, primarily boiling, is utilized by some households as a method to remedy the poor water quality scenario. HWT was measured in a bipartite manner: the household either consumes water directly from the tap or first treats the water by boiling, filtering, post-point chemical disinfection (e.g., chlorine tablets), or another method of HWT. The data will be examined in Chapter 7 along with data collected during qualitative interviews.

Table 3.2: Sampling – Water Access Points

<table>
<thead>
<tr>
<th></th>
<th>No. of govt. taps tested</th>
<th>Type of govt. tap</th>
<th>Other sources tested *</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipttai</td>
<td>5</td>
<td>public</td>
<td>---</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>5</td>
<td>public</td>
<td>1</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>9</td>
<td>public</td>
<td>---</td>
</tr>
<tr>
<td>Samanthanpettai</td>
<td>6</td>
<td>public</td>
<td>---</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>6</td>
<td>public</td>
<td>---</td>
</tr>
<tr>
<td>Theti</td>
<td>5</td>
<td>public</td>
<td>---</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>4</td>
<td>public</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Nagapattinam</strong></td>
<td><em>n = 40</em></td>
<td>---</td>
<td><em>n = 2</em></td>
</tr>
<tr>
<td><strong>Karaikal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>5</td>
<td>public</td>
<td>1</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>5</td>
<td>individual</td>
<td>---</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>5</td>
<td>individual</td>
<td>---</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>5</td>
<td>individual</td>
<td>1</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>5</td>
<td>public</td>
<td>1</td>
</tr>
<tr>
<td>Paravaippettai</td>
<td>5</td>
<td>individual</td>
<td>---</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>5</td>
<td>individual</td>
<td>---</td>
</tr>
<tr>
<td><strong>Total Karaikal</strong></td>
<td><em>n = 35</em></td>
<td>---</td>
<td><em>n = 3</em></td>
</tr>
<tr>
<td><strong>Total all sites</strong></td>
<td><em>n = 75</em></td>
<td>---</td>
<td><em>n = 5</em></td>
</tr>
</tbody>
</table>

* Sources of water consumed by the community that are not provided by the government (treatment centers in Andana Pettai and Kizhakasakudimedu, borewells in Akkam Pettai and Mandapathur, and a handpump in Uzhuvar Nagar)
CHAPTER IV: THE RECONSTRUCTION PROCESS FOR WATER

This chapter begins by outlining the recently passed DMA. Next, the reconstruction processes in Nagapattinam and Karaikal Districts are critiqued, which assists in identifying the origins of often poor outcomes. It is argued that Nagapattinam executed a model founded on collaborative governance, while Karaikal exercised a single agency approach. Thus, various government agencies were responsible for specific reconstruction activities in Nagapattinam, whereas a single agency was responsible for all activities in Karaikal. In general, the latter approach, which was less layered, produced relatively better outcomes. Both *de jure* territories implemented ‘hard’ paths for water management and operationalized panoptic and revenue-based methods of reconstruction, albeit inefficiently.

4.1 Introduction

Reconstruction after the 2004 tsunami in Nagapattinam and Karaikal Districts, and in India broadly, was not executed under the purview of pre-existing central, state/union territory, or district disaster management plans (not to mention the active five year plan). While new departments and authorities were established under statutes codified in various disaster management plans and within the bounds of local administrative powers, reconstruction commenced in what can best be described as a new model that was *ad hoc* in practice.

This liminal response, which was impromptu and informally planned, derived from the unexpected nature of the event compounded by its magnitude and geographic scope. State and local governments—thrust by citizen demand for political action, local elections in the interim, and ill-attention from the media— mollified the post-disaster situation with a multitude of fresh government orders, temporary measures (e.g., relief camps and transitional housing), and *ex gratia* funds.\(^{233}\) Furthermore, the Tsunami District Implementation Unit (TDIU) was created in

\(^{233}\) *Ex gratia* funds (sometimes referred to as ‘solatium’) are provided by government agencies to an individual, family, or relatives of an individual who was impacted or killed by a tragic event. After the tsunami, ₹200,000 per fatality was doled to affected families.
Nagapattinam District, the Project Implementation Agency (PIA) was established in Karaikal District, and several ‘special’ administrative heads were appointed to oversee relief and reconstruction activities in both locales.

As humanitarian need swelled, the Government of India sought financial assistance from external actors (i.e., primarily NGOs) in order to reconstruct thousands of damaged and destroyed homes, which was permitted under the Indian legal framework. External assistance was codified through prototypical MOUs—drafted by the State of Tamil Nadu and Union Territory of Puducherry—duly signed by respective District Collectors and NGOs promising to construct an agreed upon number of houses with stipulated amenities. The subsequent passing of the DMA in 2005 further permitted and explicitly encouraged the acquisition of funds from external agencies. Thus, the current post-tsunami settlement canvas writ large—study sites included—is a product of pre-tsunami disaster planning, the MOU model, and the DMA.

4.2 The Disaster Management Act of 2005

Besides establishing general practices and permitting the development of new administrative hierarchies, the quality of pre-existing disaster management plans and capacity of the administrative super-structure in the months following the tsunami can be considered shortsighted, hollow, and insignificant vis-à-vis the sheer scale of the disaster. Moreover, antecedent disaster plans focused on floods and cyclones, and were thus ill-prepared for managing the scope of reconstruction warranted after the tsunami. What ensued was the passing of the DMA. The DMA, 42 pages in entirety and a direct result of the tsunami, pursued a novel, much needed framework for disaster preparation and response for all levels of the Indian administrative hierarchy. Enacted by parliament on December 23, 2005 (just shy of a year after the 2004 tsunami), the enforceable legislation lays the groundwork for all disaster-related

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234 Mulvany, 2011a.

Prater et al., 2006.
activities from the date of enactment to the present day. Hence, the DMA was instrumental in shaping post-tsunami reconstruction processes—which were chiefly completed in 2008, but are ongoing in many respects today (e.g., newly created departments are still in operation, and the construction of amenities, such as septic tanks and sewerage connections, continues).

The DMA outlines the roles and responsibilities of the central, state/union territory, and district governments in relation to disaster preparedness, mitigation, response, and reconstruction. First off, the DMA conceived the National Disaster Management Authority (NDMA), which oversees all matters related to disasters in the country. Overseen by the NDMA are State Disaster Management Authorities (SDMAs) and District Disaster Management Authorities (DDMAs), as well as National, State, and District Disaster Mitigation Funds and National, State, and District Disaster Response Funds. Furthermore, the DMA established the National Institute of Disaster Management (NIDM), which exists alongside the NDMA and is responsible for data collection, research, training, and holding conferences. The NDMA, through its National Executive Committee (NEC), is accountable for approving a national plan for disasters, including: prevention and mitigation, minimum standards for relief (explicitly mentioning shelter, drinking water, and sanitation), ex gratia assistance, special provisions for widows and orphans, and the possibility loans to affectees (with repayment). Furthermore, and central to this dissertation, the DMA makes clear that NGOs are part and parcel of the

235 The DMA also states that the Government of India will support other countries in times of disaster.

236 The NIDM not only organizes a massive annual academic conference, but it is also partially responsible for including disaster management as core curriculum in schools adhering to the Central syllabus. [CBSE (2006), Together towards a safer India: a stride ahead – a textbook on disaster management for class X (New Delhi: Public Printing Service).]


It is important to note that actual standards or guidelines are never articulated to accompany the explicit proclamation of ‘minimum standards.’ Thus, no definition, numerical expression, or description of what constitutes a minimum standard (e.g., for drinking water) is ever penned.
disaster management process, citing in Section 24(j) that “states” must “ensure that non-governmental organisations carry out their activities in an equitable and non-discriminatory manner.”

The NDMA not only creates disaster-related policies that must be adhered to by all levels of the government, but it also lays down guidelines for SDMAs and DDMAs to draft idiosyncratic plans for managing disasters—DDMAs must submit their plans to the SDMAs, and SDMAs must submit their plans along with the plans of DDMAs to the NDMA. Thus, State Executive Committees (SECs), headed by their respective Chief Minister or Lieutenant Governor, must draft state plans, in accordance with standards set by the NDMA, as well as allocate funds for prevention, mitigation, relief, and capacity building. Moreover, as per Section 38(k), states must “provide rehabilitation and reconstruction assistance to the victims of any disaster.” Once SDMAs have approved a plan, it must be implemented, monitored, and evaluated, and the state must provide general education, awareness, and training to its citizens on disasters that commonly affect the region.

The DDMAs—headed by the District Collector, District Magistrate, or Deputy Commissioner—are to draft a district-level plan for disasters in a format similar that of its state/union territory. It should be noted that DDMAs must adhere to the same explicitly mentioned (albeit never defined) minimum standards, the same monitoring of policies, and the same disaster-based education of its citizenry. Here, it is crucial to cite the reiteration of

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239 Ibid.: pp. 9-10.
240 Ibid.: p. 23.
241 Ibid.: p. 11.
242 It is here that mandatory elements of education and capacity building in Nagapattinam District shall come under scrutiny. I was unpleasantly surprised to learn from Kamalanathan, head of the Disaster Risk Reduction Programme, that during “information and training sessions with people . . . We teach that they should expect disasters and we teach them how to cope,” which was further qualified with “For coping, the main thing is that they shouldn’t expect help from the government.” Kamalanathan continued by claiming that “the government cannot help each and every individual in each and every
NGOs as fundamental contributors to the post-disaster scenario. Having already denoted NGOs as part of the disaster management process, Section 30(xxvii) goes on to instruct DDMAs to “encourage the involvement of non-governmental organisations.”

Lastly, it is worth mentioning that the DMA proclaims itself an enforceable legislation. Strict punishments, including fines and up to two years of imprisonment, can be inflicted upon officials who obstruct the DMA process, misuse funds, or engage in dereliction of duty. However, Radhakrishnan, former District Collector of Nagapattinam and current Assistant Country Director and Head of the Disaster Management Unit for the United Nations Development Programme (UNDP) in New Delhi, argues that the DMA “has no teeth,” and that “no real penalties” exist for failing to abide by the DMA—all of this while India “claims it [DMA] as an advancement towards the Hyogo Framework and disaster risk reduction.”

4.3 The reconstruction process in Nagapattinam

Having set the stage for the administrative backdrop that oversaw a large portion of the post-tsunami reconstruction process, the models for reconstruction in Nagapattinam and Karaikal Districts, which were wedded with the DMA in SDMA and DDMA plans as time passed, will be recounted. After appointing an ‘Additional Collector,’ surveying damage, and scrambling for relief materials, the first reconstruction-based directive in Nagapattinam District was established...
on January 13, 2005. On this date, G.O.Ms.No.25, codified by the Government of Tamil Nadu, established the practice of MOUs as the official model for post-tsunami reconstruction across the state. Enacted by the state, the government order provided a universal model for districts to partner with NGOs and other relief organizations for constructing housing settlements for affectees. The MOU, penned at the state level, was District Collector-centric: District Collectors signed the MOUs along with NGOs, were in charge of overseeing the process, and were given discretion to slightly amend the MOUs so long as they fit within the MOU framework and satisfy ‘minimum standards’ set by the state.

G.O.Ms.No.25 first states the rationale for collaborating with NGOs and for deciding upon MOUs as the official model for reconstruction:

> Many non-Government organisations, voluntary agencies, corporate houses, charities, public and private sector enterprises etc have been in contact with the State Government to participate for the permanent relocation and rehabilitation of people affected by this calamity. The Government has considered these requests from such agencies and has decided to setout the framework for partnering with the State Government for permanent relocation and rehabilitation of the affected persons.\(^\text{246}\)

After providing the backdrop, the government order claims that the state “examined relevant criteria and the procedure to be followed for inviting such public-private partnership efforts on a large scale.”\(^\text{247}\) First, NGOs were invited to send proposals to District Collectors stating their interest in assisting in reconstruction while upholding “certain standards.”\(^\text{248}\) NGOs put forth in their proposals, according to their financial capacity, the number of houses they promised to construct (no less than 50), which must be accompanied by:


\(^{247}\) Ibid.: sec. 4.

\(^{248}\) Ibid.: sec. 4.

According to the MOU, proposals from NGOs must include, *inter alia*: background information (profile of NGO, bio-data of its trustees, and details on projects undertaken in the past three years); a certificate of registration as a trust, society, or non-profit organization; a sworn affidavit from the organization’s head; proof of funds; and tax documents from the previous three years. The MOU also states that priority should be given to NGOs that have already mobilized funds or are in the process of doing so. [Government of Tamil Nadu, 2005a.]
Good roads preferably cement roads with side drains with RWH [rainwater harvesting] facility, good water supply, sanitation, schools, noon meal centers, solid waste disposal facilities, street lights etc.249

Next, the District Collector accepted (or rejected) the proposal and forwarded it to the local government (municipality or panchayat) for secondary acceptance. The proposals were then converted into MOUs, which were duly signed by the respective District Collector and NGO(s).

Seven months later, G.O.Ms.No.119 developed the machinery for accepting and monitoring funds for NGO-assisted reconstruction. In the legislation, the Government of Tamil Nadu created the Tsunami Project Implementation Unit (TPIU) at the state level, and Tsunami District Implementation Units (TDIU) at the district levels, which were/are housed within the District Rural Development Agencies (DRDA).250 With funds allocated from TIPU, TDIU was to manage reconstruction projects, complete any mandatory work left unfinished by NGOs, and collaborate with other government departments responsible for infrastructure development. For example, TWAD was responsible for implementing water supply, the Tamil Nadu Public Works Department (TNPWD) was in charge of roads, and the Tamil Nadu Electricity Board (TNEB) was accountable for providing electrical connections. In this case, the framework for managing reconstruction in Nagapattinam District operated under the auspices of both a newly created standalone agency for dealing with a specific disaster (i.e., TDIU), and what Barakat (2012) refers to as ‘collaborative governance,’ in which separate agencies are accountable for different aspects of reconstruction (e.g., water, roads, and electricity).251

Before outlining the actual MOU exercised in Nagapattinam District, it is important to note that water infrastructure was recognized as a chief area of concern even before MOUs were

249 Government of Tamil Nadu, 2005b: annexure I.

Annexure I further claims that “drainage should also be focused upon.”


251 Barakat, 2012.

This approach contrasts with that of Karaikal District, which will be discussed later.
finalized between the District Collector and NGOs. In two government orders passed after G.O.Ms.No.25 and before the signing of MOUs, Nagapattinam District was earmarked ₹1.4 million per month for five months in order to provide water to temporary shelters, and millions of rupees that were to be used for water supply in part.

Turning to the MOU, it is a 10-page document. It commences with a two-page preface for District Collectors outlining the process for selecting and approving NGOs, and eight pages follow that constitute the actual binding MOU agreement between the District Collector and NGO(s). First off, the MOU promises a free permanent house to all affectees (as per G.O.Ms.172) who agree to be resettled outside of the 500 meter CRZ, while:

Those who do not choose to do so [relocate outside of the CRZ] will be permitted to undertake the repairs on their own in the existing locations, but they will not be eligible for any assistance from the Government.

G.O.Ms.No172 was particularly confusing because the CRZ was defined as 200 meters at that time, but was eventually altered to a more considerable distance of 500 meters. After heeding the bounds of the CRZ’s 500 meter buffer, the MOU explicitly, yet arguably ambiguously, detailed all responsibilities and expectations of both the District Collector (‘First Part’) and NGOs (‘Second Part’) “to support rehabilitation and reconstruction initiatives in partnership with the Government of Tamil Nadu” according to “the guidelines specified by the Government of Tamil Nadu.”

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Not only has the CRZ been amended no less than 19 times since its inception in 1991, but frequent changes to the CRZ after the tsunami imposed modifications in the reconstruction process and were a source of contestation between the Government of Nagapattinam District and Sneha, which disbursed funds to affectees to rebuild in situ.

256 Government of Tamil Nadu, 2005a: preface.
The stipulated guidelines obligated the District Collector to provide the land required for reconstruction at no cost to NGOs. The District Collector was first responsible for selecting and securing sites for housing reconstruction, of which payment was conducted via the newly appointed Additional Collector housed in the Revenue Department. Subsequently, the District Collector ensured site preparation and infill (if necessary) in panchayat areas through village-level ‘Union Engineers’ working as either Block Development Officers or Additional Block Development Officers (BDOs and ABDOs), in the Municipality through ‘Municipal Engineers,’ or in either jurisdiction with engineers from TDIU—which has general authority over reconstruction activities across the district. Next, the prepared, developable land was presented to NGOs to erect an agreed upon number of permanent houses in a layout comprising:

> [A]ssociated infrastructural facilities such as Water Supply, Sanitation, Waste Water / Solid Water Management, Rain Water Harvesting facilities, other ecological features, Roads, Community Centres, School Buildings, Fish and Farm Produce Market Yards, Village Information / communication Centres, etc. . . . in consultation with the beneficiaries especially women

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257 Land for reconstruction was okayed by the District Collector and then purchased by the Government of Tamil Nadu (if land was owned privately or by a temple), or in most cases, land already owned by the state was transferred to the Revenue Department and then authorized for housing reconstruction. Ownership of all land was vested with the Government of Tamil Nadu before permitting NGOs to construct infrastructure, and land ownership remains with the Government of Tamil Nadu to this day. However, inhabitants of post-tsunami houses possess the right to petition for a patta, which grants them ownership of only the housing unit. Furthermore, it is illegal to sell such houses until a period of 30 years has passed. Although the regulation is in place, some post-tsunami houses have been rented (which is also forbidden) or even sold via informal, illegal agreements.

258 M. Senthilkumar (2011), Executive Engineer at TDIU, Nagapattinam District, personal interview.


The practice of site selection and preparation differed in Karaikal District, which will be discussed later.

Interestingly enough, while the provision of water infrastructure on behalf of NGOs appears to be explicit in both G.O.Ms.No.25—which codified the MOU model—and in two sections of the MOU, the MOU goes on to contradict itself and its parent directive by claiming that “The FIRST PART [government] undertakes the responsibility of providing water [original capitalization].”

In practice, the MOUs required NGOs to construct ‘disaster resistant’ houses along with sewerage infrastructure (i.e., either a septic tank or leach pit). The stipulation of ‘rain water harvesting’ translated to conveying water from the flat roofs of houses to pipes that transport it to the subsurface (i.e., groundwater recharging in actuality). Lastly, NGOs were obligated to build a community hall at each settlement, with additional facilities, such as livelihood training centers, anganwadis, and parks for children being optional.

According to the MOU, the construction of all housing and infrastructural amenities by NGOs, taking place on government-chosen and prepared land, must be jointly inspected by the District Collector and the respective NGO(s) “at such periodicity as may be found convenient and expedient . . . preferably once in a fortnight.” Upon completion of all MOU-defined tasks by an NGO(s), the District Collector was to inspect the settlement and, upon satisfaction, “take ownership of the building and infrastructure” from the NGO(s) with a “handing / taking

260 Ibid.: sec. 1.

261 Houses were to be constructed according to guidelines put forth in a text provided to NGOs. Thus, houses had to meet certain requirements for risk reduction from cyclones and earthquakes (e.g., plinths, lintels, and other reinforcement beams). The only requirement for sewerage was that the septic tank or leach pit must meet the following minimum dimensions: 1.5 meters in depth and 1.5 by 0.75 meters in width. [Senthilkumar, 2011. Government of Tamil Nadu and UNDP India (2007), Guidelines for reconstruction of houses affected by tsunami: general and public buildings (RCC) (Chennai: Disaster Management and Mitigation Department, Revenue Administration, Government of Tamil Nadu).]


In practice, inspections were the responsibility of Union Engineers (BDOs/ABDOs) or Municipal Engineers. While the MOU states that inspections should take place biweekly, SAC meetings—administered by the District Collector—stated that they should occur weekly, while later SAC meetings called for ‘at least’ weekly inspections, and still later meetings ordered inspections to be verified with submitted reports. [Government of Nagapattinam, 2007. Government of Nagapattinam, 2006b.]
over certificate in writing and signed by both the parts.”263  Next, the District Collector delegated tasks to the concerned government department that must lay water pipes, establish water access points, connect the settlement to a water supply (all aforementioned tasks the responsibility of TWAD), connect houses to electricity, build roads, and undertake any final sewerage, drainage, or physiographic corrections. At this point, the settlement was complete, individual houses were allocated to pre-selected beneficiaries via a lottery, site occupation was allowed, and (re)construction of the settlement concluded. One notable caveat is that, in the “unlikely event” of non-completion of work by an NGO(s), the District Collector (TDIU in practice) was to take over the settlement “under ‘as is where is’ condition sans any liability,” complete all unfinished work that was the responsibility of the NGO(s), and then resume the reconstruction process as per the MOU.264

Thus, the short 10-page MOU that forges the foundation for all post-tsunami housing reconstruction in Nagapattinam District has been narrated. While the subsequent chapter will detail the current water situations in the post-tsunami settlements, some general outcomes for water will be described here and connected to the MOU-based reconstruction process. Firstly, the iteration of water provision being a responsibility of NGOs (in G.O.Ms.No.25 and the MOU) was initially a cause for uncertainty. As stated by Dhurairaj, the head of an international NGO branch that constructed settlements in both Nagapattinam and Karaikal Districts:

I was under the impression that we [the NGO] would have to build water infrastructure, but the MOU eventually said that all water supply


Incompletion of work by NGOs was not rare, and the TDIU was left responsible for a considerable amount of unforeseen work. For example, original records from TDIU reveal that a total of 2,932 septic tanks or leach pits in 11 post-tsunami settlements were left undone by NGOs, including three sites in this study: all 186 septic tanks in Akkaraipettai, all 222 tanks in Andana Pettai, and 487 tanks in New Nambiyar Nagar. Some of the sewerage facilities have been built by TDIU, work is ongoing at other settlements, while ground has yet to be broken after several years of residency at other settlements. [Government of Nagapattinam TDIU (2011), “Table: RGRP construction of septic tank and leach pits (NGOs have not constructed).”]
infrastructure was to be taken care of by the government. This basically means street pipes [in Nagapattinam District]. How can an NGO be expected to know where to lay pipes when we don’t know where the water source will be or where exactly roads will be placed by the government. Anyway, it’s the government’s job to provide water and it would be too expensive for NGOs to be expected to do so. However, if an NGO wanted to provide water infrastructure, which wasn’t required of them, then they didn’t have to get permission and it wasn’t really inspected. Everything was a scramble and it [water infrastructure] wasn’t required of us.265

While the misunderstanding was clarified among all parties, it sheds light on three issues: (1) all public water taps and underground infrastructure were borne of the Government of Tamil Nadu (specifically, the TWAD branch located in Nagapattinam District); (2) the government (Nagapattinam District and the State of Tamil Nadu through TWAD and as creator of the MOU)—and therefore not NGOs—is almost solely responsible for the post-tsunami water situation; and (3) any water infrastructure introduced by NGOs was above and beyond their duties and was likely uninspected by the District government since doing so was unrequired.

Addressing points one and two above, it was the District government that selected the sites for reconstruction and ensured site preparation for development; it was the State government (i.e., TWAD) that implemented all water infrastructure; and it was the State government that retroactively decided that drainage—a lack of which induces the flooding of water access points and promotes water quality hazards—should not ‘be focused upon’ (as proclaimed in the State’s G.O.Ms.No.25). In fact, although the State-drafted MOU required

265 Dhurairaj, 2011.

NCRC (2005), based on a workshop held on March 24, 2005, is in agreement with Dhurairaj. NCRC states that “the dividing line between who is responsible for infrastructure and for common provisions (such as sanitation) in the habitats and to what extent is not clear.” Furthermore, NCRC notes that “no milestones are clearly laid,” and that “Technical Guidelines are kept out of the purview” of the MOU. Even more damning, the document postulates that the Government of Nagapattinam is lacking in transparency as to what investments they are responsible for, while insisting transparency from NGOs, and that “The MOU reads like the Government is sub-contracting the construction of the houses to the NGOs. The spirit of partnership is no where reflected in the MOU.” Moreover, not only did the Government of Nagapattinam, as well as the Government of Karaikal, sub-contract reconstruction activities to NGOs, but NGOs in turn subcontracted the actual construction to private entities. This arrangement has fashioned an arena across both districts in which the governments blame NGOs for shortcomings and NGOs blame private contractors for shortcomings. [NCRC (2005), Comments on the MOU on public private partnership towards tsunami rehabilitation (Nagapattinam: NCRC): p. 1.]
‘waste water management,’ ‘sanitation,’ and ‘other ecological features,’ the State of Tamil Nadu later rebuffed the stipulations:

Drainage would have been ideal, but no funds were available [to Nagapattinam District]. Furthermore, proposals were sent [for drainage]. . . but those funds were denied by the state because there wasn’t a mitigation culture. They thought we [Nagapattinam District] just wanted to raise expenditures for non-essential and unnecessary purposes. They thought that the money would be wasted and that we just wanted more funds. . . . it didn’t matter because there were no clauses for soil and site drainage.266

Information imparted by the former District Collector of Nagapattinam was not only upheld by Gunaseelam, Ezhilan, and Senthilkumar (all State and District officials privy to the reconstruction process), but they buttressed the State’s rejection of funds for drainage claiming that it is not only ‘too costly,’ but also redundant because the ‘soil is sandy,’ ‘percolation is good in coastal areas,’ and there exists ‘natural drainage.’267 However, as postulated in Chapter 2, soil in the study area exhibits a moderate composition of clay (hampering percolation), the sites are generally flat (negatively influencing drainage), and waterlogging is extremely common (thus inundating water access points, stimulating seepage from sewerage infrastructure, and further contaminating groundwater that is harnessed by households). Compounding matters, the drainage situation was not aided by a government order that exempted Nagapattinam District from acquiring wetlands and marshy areas for housing reconstruction. Thus, although “orders were issued to the effect that the wet lands should not be acquired,” the “eventuality to acquire wet lands” was deemed “unavoidable” in Nagapattinam District, and therefore the jurisdiction

266 Radhakrishnan, 2012a.

267 Ezhilan (2011), Assistant Engineer of Rural Water Supply and Tsunami Sewerage Projects at TWAD, personal interview.


Senthilkumar, 2011.
was granted an “exemption from obtaining . . . wet lands for the purpose of construction of permanent shelters for the use of Tsunami affected victims.”

Therefore, to take stock of the previous paragraph, the post-tsunami water scenario is a product of the District and State governments, owing to their choice and preparation of land, provision of water infrastructure, and insistence that drainage was both too expensive and physiographically unwarranted. A single caveat is that NGOs were responsible for sewerage infrastructure, much of which is inadequate, low quality, and allows seepage into the groundwater—especially in times of waterlogging. Therefore, while the respective governments are (essentially) wholly responsible for the water situation, sewerage infrastructure introduced by NGOs (or left incomplete) undoubtedly problematized the waterscape.

Being that the provision of water infrastructure was the responsibility of TWAD, it is interesting to highlight their operational practices and standards. According to the minutes of the SACs, TWAD was to “synchronize” their provision of the “basic amenity” of “drinking water” with the completion of the settlements. Thus, as soon as NGOs completed their mandatory work, and sometimes in the meantime, TWAD was to arrange for and undertake construction for the provision of water. However, TWAD soon fell behind schedule, perhaps owing to miscommunication, mismanagement, an overabundance of work, the forces of weather, or a combination of these and other factors. Sluggish work on behalf of TWAD—whether due to external dynamics or fault of their own—provoked the following stern orders from the District Collector: “The TWAD board is instructed to take immediate action” and “TWAD board is instructed to speed up their work and given [sic.] water supply in all the sites” (the second order was repeated in every subsequent SAC meeting until the meetings ceased in late December.

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While physical, quality-based outcomes directly related to the blunt demands can only be speculative, it would not be incorrect to assume (informed by post-tsunami reconstruction in Sri Lanka and Indonesia) that such statements catalyze a ‘rhetoric of returns’ in which actors are pressed to generate tangible ‘outputs’ that can be viewed, enumerated, and reported. However, the quality of such rapid output is often low and substandard. Thus, the possibility that pressure to produce water pipes and taps visible to the naked eye ultimately resulted in more shoddy infrastructure (than what may have otherwise been built) remains open to speculation.

Turning to guidelines, G.O.Ms.No.25 and the MOU explicitly state that all work must be executed in line with ‘certain standards,’ which were never made clear to the reader and may not have been articulated to NGOs. However, in terms of water (and after much investigation), the standards upheld were the preexisting standards set by TWAD for all of their water infrastructure provision and supply, and by the Central Public Health and Environmental Engineering Organisation (CPHEEO), an agency of the Government of India. Thus, in terms of density of water taps and accessibility, all post-tsunami settlements were to be provided a minimum of one public tap per 30 houses, as explained by Ragunath, a TWAD regional Executive Engineer:

> We have norms that we must follow. The norms are set by the Government of Tamil Nadu and TWAD must follow them when executing all schemes. The norm for public fountains is one tap per 150 people, which is equal to 30 houses. We provided that norm to all tsunami hamlets. We provide per that norm to conserve scarce resources.

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272 Kennedy et al., 2009.

Kennedy et al., 2008.

Similarly, articulating a goal of speed failed to secure desired outcomes after an earthquake in Dhamar, Yemen. [Barakat, 2012.]

273 Ragunath, 2011.
Additionally, the District Collector instructed the Union and Municipal Engineers overseeing “all habitations” to “assess the number of public taps and capacity of OHTs [overhead tanks] per requirement of LPCD [liters per capita per day] in consultation with TWAD . . . and finalise.”

Thus, not only were there to be a minimum of one tap per 30 houses, but LPCPD supply standards set by CPHEEO were to be met, and the capacity of OHTs (the equivalent of ‘water towers’) to supply that volume standard was to be checked. Hence, all infrastructure provided by TWAD should have been designed to dispense a quantity of no less than 135 LPCPD in Nagapattinam Municipality, and no less than 40 LPCPD in panchayat administrated territories. Suffice it to say that the standards for LPCPD are poorly met at the study sites in Nagapattinam District, which will be discussed further in Chapters 5-6.

Turning to the temporal transmission of water to public taps, CPHEEO clearly recommends that:

Piped water supplies should be designed on continuous 24 hours basis to distribute water to consumers at adequate pressure at all points. Intermittent supplies are neither desirable from the public health point of view nor economical.

However, despite nationally-defined guidelines that “intermittent supplies should be discouraged,” TWAD only designed “for our norms of providing water for eight hours per
day. All places should get water for eight hours each and every day.”

Thus, the health risks, economic advantages, and even the environmental benefits of a continuous supply were not achieved or even strived for.

Government officials offered several hypotheses when they were asked why post-tsunami settlements in all de jure territories of the District were experiencing substandard quantities of volume (as per CPHEEO standards) and only one water availability window of roughly 1-2 hours per day (not a continuous supply or even TWAD’s eight-hour norm). First off, Ragunath places the blame on additional public taps (beyond TWAD’s 1:30 house ratio) and local water politics:

There are more public fountains than the norm because some local bodies put in extra taps, that was not done by us. Sometimes local bodies put in extra taps for their own whims and fancies and to get votes. Now more people are drawing more and more water with only the same resources available. What this means is that any variation in getting eight hours per day of water and enough quantity is due to too many public taps. This makes the time and quantity very less. . . . [Also,] panchayat masters and local tank operators may be closing the valves on the tanks early to save money.

Ragunath’s argument does hold ground. Most households at the study sites enjoy a density of less than 30 households per public tap. This is attributable to local governments and residents themselves penetrating underground pipes to create additional taps (in the latter case because a greater quantity of water than what is being realized under ‘normal’ arrangements is required). Chandrasekharan, the Municipal Commissioner of the City of Nagapattinam, concurs with

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278 Ragunath, 2011.

279 It is accepted that a continuous supply of water, on average, results in less water usage by volume. Given a continuous supply, consumers take only what is needed as is needed. In contrast, the maximum amount of water is customarily taken in cases of limited hours, leading to wastage when excess water is poured out to retrieve the maximum amount of (fresher) water during the next availability window. [McKenzie and Ray, 2009. P. Dasgupta (2006), “Household water services in incomplete markets: managing water stress for the urban poor,” in Managing water resources: policies, institutions, and technologies, (eds.) V. R. Reddy and S. M. Dev (New Delhi: Oxford University Press).]

280 Ragunath, 2011.
Ragunath and also posits issues related to infrastructural capacity, infrastructural design, elevation, and insufficient revenue. Chandrasekharan laments:

Anything less [the time water is available and quantity delivered] is due to the size of the tank, pressure, elevated areas, and places being on the tail end of pipes, . . . Public fountains in the Municipality are free and there are 680 public fountains that we know of, in addition to 7,500 individual connections. Those are only official numbers, there are actually more due to illegal connections. CPHEEO standards are difficult to achieve with little revenue sources from public fountains, and harder to achieve with so many unknown illegal connections.281

In fact, Chandrasekharan goes on to imply that shortages of water at public taps and the cumbersome task of acquiring water from such taps is a strategy for “motivating people to get personal connections to raise revenue.”282

Finally, and most indifferently, Kandaswamy, the former Tsunami Relief and Rehabilitation Coordinator for Nagapattinam District, defended the government and deflected any shortcomings squarely on the shoulders of post-tsunami settlement inhabitants:

The government’s job is only to provide the specified required amount of water per head per day. We are only required to provide drinking water, other things such as washing and bathing must be obtained by their own means.283

The most striking facet of Kandaswamy’s statement is its flagrant inaccuracy: CPHEEO’s minimum standards for LPCPD encompass several classifications of water usage. Thus, drinking water comprises only three liters of the LPCPD standards, while the remainder is divided among units for cooking, bathing, flushing toilets, gardening, and other domestic purposes. When asked how residents, many of whom are poor (rendering well and handpump installation economically infeasible) or live in areas with unsatisfactory groundwater or no surface water, should exploit water for ‘other things such as washing a bathing,’ Kandaswamy

281 Chandrasekharan (2011), In Charge and Municipal Commissioner of Nagapattinam Municipality, personal interview.

282 Ibid.

283 Kandaswamy (2009), former Tsunami Relief and Rehabilitation Coordinator, Nagapattinam District, personal interview.
stated: “I agree with you, it is a very pathetic situation. But what am I supposed to do?” To this end, some panchayats, for example in Akkaraipettai and Uzhuvar Nagar, provided handpumps to help relieve issues of water scarcity.

Lastly, it is interesting to observe the efforts of NGOs, in terms of water, that exceeded the requirements outlined in the MOU. Most NGOs did provide additional amenities for relieving the water situation. For example, most houses at the study sites were provided 500-liter tanks (on the roof) for storing water. Some households were even provided in-house piping (to the kitchen and bathroom) that was connected to the tanks. The objective was that households were expected to carry water to the roof, fill the tank, and thus enjoy a modified form of in-home water access. Furthermore, the tanks could be connected to electric or diesel-powered borewells for a more steady supply. Other households were provided with taps in the kitchen and bathroom, but they were not connected to any source of water and were meant to facilitate an individual water connection if the household chose to pay the connection fee. Unfortunately, as a result of a shortage of water and lack of interest or funds to apply for an individual connection, the pipes remain dry and most are cracked, rusted, and defunct. Many household also deemed carrying water to rooftop storage tanks undesirable, leaving them unutilized or, at best, sitting in the front or back yards of houses to store untreated water for bathing and laundry. Additionally, NGOs provided a small water filtration unit (a pitcher equipped with a carbon filter) to all households in Akkaraipettai and New Nambiyar Nagar. Some households used the filtration units for a few months, but then ceased usage when the units either broke or households failed to find new filters for the units.

What is perhaps most interesting is the case of on-site water treatment centers introduced by NGOs. In Nagapattinam District, village-scale water treatment centers were erected at

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284 Ibid.

285 The connection fee is ₹2,000 in Nagapattinam Municipality, with a flat rate of ₹40 per month for water. [Chandrasekharan, 2011.]
Andana Pettai and Samanthanpettai. Beginning with the successful venture at Andana Pettai, the treatment facility was conceived with joint funds from the constructing NGO and panchayat: the NGO provided the tanks, filtration, and reverse osmosis infrastructure, and the panchayat built the physical structure that houses the treatment and operation mechanisms. An elderly resident of Andana Pettai operates the plant during the settlement’s fluctuating 1-2 hour water availability window, charging ₹2 per vessel—revenue that is handed over to the panchayat less a small, token salary for the operator.

Interestingly enough, the treatment center at Andana Pettai does not supplement lean flows of piped water from the panchayat. Rather, it secondarily treats a portion of the water that arrives to the water tower, bequeathing residents a choice between free water from public taps or affordably priced water from the same source that has been treated a second time. Besides the limitation of not introducing additional quantities of water to the population, the treatment center is inaccessible to a substantial number of houses given that the settlement is bifurcated by a national highway (making the distance too great for many on the east side). Still, the treatment center can be considered a success story in that it is sustainable (has been running for more than three years), is adequately maintained (the NGO remains active by regularly providing new filters and performing maintenance), establishes a small revenue stream for additional investments, provides employment to a settlement resident, and dispenses water of a much higher quality than what would otherwise be available.286 Thus, while NGOs were not required to construct any water infrastructure whatsoever in accordance to the MOU, some NGOs went above and beyond their minimum requirements to positively impact the water scenario of post-tsunami settlements, albeit with assistance of the panchayat.

286 J. Francis (2011), water treatment center operator at Andana Pettai, personal interview.

M. Jayaraman (2011), President of panchayat at Andana Pettai, Nagapattinam District, personal interview.

Personally conducted water quality tests revealed that water dispensed by the treatment center is biologically safe and exhibits better chemical results than tests performed at the public taps.
Turning to the water treatment center at Samanthanpettai, the case should be perceived as a failure of Nagapattinam Municipality to capitalize on valuable infrastructure provided at will to the tsunami-affected community, and partly a failure of settlement residents and the constructing NGOs to instill community ownership of said infrastructure. As mentioned in Chapter 2, a state-of-the-art ‘Dr. Water’ treatment center, equipped with microfiltration and ultraviolet disinfection, was constructed on the behalf of two NGOs that were allotted funds from UNICEF. However, despite chronic water quality and quantity hardships, the completed ‘Dr. Water’ plant was never connected to a stream of water, and it has endured rapid dilapidation ever since.

To begin with, the NGOs failed to garner community ownership of the infrastructure. This was in part because unelected leaders of Samanthanpettai strongly rejected the NGOs’ assistance in developing and implementing a model for plant operation (by a settlement resident), unit pricing, and ensuring revenue for maintenance—a model paralleling the arrangement at Andana Pettai and other small-scale water treatment centers the world over. Instead, the resolution was that the NGOs instructed settlement leaders on how to run the 65,000 liter per day plant and then left it in full care of the same settlement leaders. Here it must be noted that the groundwater exceeds TDS limits for microfiltration, decreeing connection to a (less sullied) government-provided water stream necessary for plant operation, a component which has proven futile. With the NGOs out of the picture and (poorly) trained individuals in charge of the plant, the Municipality has evaded all responsibilities for the treatment center by shrouding itself behind the MOU, traditional legal protocols, and administrative hierarchies. According to

287 L. Peter (2011), Director at Real Plan, personal interview.
S. Sankaran (2011), former village leader at Samanthanpettai, personal interview.
P. Vijayan (2011), Project Team Leader at Water Health International, personal interview.
Vijayendran (2011), current village leader at Samanthanpettai, personal interview.
Municipal office holders, any obligation by the Municipality to even acknowledge the treatment center is obstructed for two reasons. First, the NGOs were not granted ‘official’ permission to construct the plant, and second, the NGOs failed to properly hand the plant over (with an official ‘handover certificate’) to the government before ceasing their work at Samanthanpettai. Bunking the first assertion, as imparted earlier by Dhurairaj, NGOs did not need permission to build water infrastructure because such infrastructure surpassed the requirements of the MOU. Refuting the second claim, while NGOs were required to transfer ownership of all infrastructure to the District Government in accordance with Section 14 of the MOU (concluding their tasks and allowing the government to implement water supply, roads, electricity, and eventually allot houses), transference or non-transference was ultimately a moot point. George offers an explanation referring to the case of Dr. Water at Samanthanpettai:

The act of handing over doesn’t matter when it comes down to it. The government had a checklist and they were supposed to make sure that the NGOs handed everything over to them. In the end, it doesn’t really matter because the government took possession of all work and then handed over the houses to the people, so the government automatically assumed ownership of the plant when they took possession and should therefore maintain it.

Moreover, it appears that the treatment center languishes in legal gridlock. Municipal Commissioner Chandrasekharan proclaims that:

I know nothing about Dr. Water not working. Nothing has been brought to my attention by the 11th Ward during our monthly meetings. I cannot simply fix a problem when nobody has told me about it and when a proper request has not been submitted that can then be followed up and budgeted.

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289 Chandrasekharan, 2011.


290 George, 2011.

291 Chandrasekharan, 2011.
Meanwhile, Murugaian, Municipal Counsel of the 11th Ward representing Samanthanpettai and the surrounding area, disagrees with Chandrasekharan’s ignorance of Dr. Water’s inoperability. Murugaian contends that he has requested a connection to water on many occasions:

Every monthly meeting I fight with the Municipal Chairman [Commissioner] and say that the 11th Ward needs Dr. Water connected. The Chairman says ‘Wait, I’ll solve the problem.’ But then the next month I have to go through the same process. Finally, after six months of asking, I walked out of one of the monthly meetings because I was so upset. Now I attend all the meetings, but I dropped the issue. . . . Samanthanpettai people didn’t even request me [as their Counsel] to connect Dr. Water to municipal water, but I did anyway. I am a power man, so they must do one thing. Samanthanpettai people must be giving me a proper request and then I will be giving a proper request to the Chairman. This is how it must be done. Anyway, now I dropped the issue after many hard works.292

Thus, it appears that Dr. Water’s fate has been sealed first by the NGOs not being granted permission to erect the facility (a position that has been deflated), second by a stipulation in the MOU that demands an official handover certificate for all NGO-constructed infrastructure (which legally fails to hold ground since the government takes ownership of all infrastructure before houses are allotted to beneficiaries), and lastly by being hostage to rigid administrative protocols and hierarchies that can deny requests from below with impunity. At this juncture, Dr. Water has fallen so deep into disrepair that it would require considerable toil from outside water engineering experts in order to resurrect the plant’s operability, connection to a piped water stream notwithstanding. All this to the chagrin of parched settlement residents and scarce resources that appear to have been wasted in the venture.

292 Murugaian, 2011.

Murugaian’s claim that residents of Samanthanpettai never requested Dr. Water to be connected was refuted by numerous interlocutors. Soman, a resident of Samanthanpettai, claims that he and others have implored Murugaian on several occasions to connect the treatment center to a water supply. However, they argue that Murugaian sidesteps the issue, fails to relay the events of monthly Municipal meetings, and simply tells residents that it will be in operation ‘soon.’
Table 4.1 presents a breakdown of MOU-determined responsibilities for water infrastructure provision, as well as current roles for supply, treatment, and maintenance.

Table 4.1: Water Provision, Supply, Treatment, and Maintenance in Nagapattinam District

<table>
<thead>
<tr>
<th></th>
<th>Municipality</th>
<th>Panchayats</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Provision</strong></td>
<td>TWAD constructed water towers, sumps, pipelines, and public taps</td>
<td>TWAD constructed water towers, sumps, pipelines, and public taps</td>
</tr>
<tr>
<td><strong>Supply</strong></td>
<td>TWAD supplies water from Kollidam to a central sump in Velepalayam (in Municipality); the Municipality purchases the water from TWAD and distributes to public taps*</td>
<td>TWAD supplies water from Kilvelur and Kollidam to local water towers and sumps in panchayats; panchayats purchase the water from TWAD and distribute to public taps</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>TWAD treats in Velepalayam sump using silver ionization</td>
<td>Kollidam: TWAD treats in main sumps using silver ionization and distributes to local water towers and sumps; some panchayats secondarily treat with sodium hypochlorite in their local water towers and sumps Kilvelur: TWAD treats in sump in Kilvelur with sodium hypochlorite and distributes to local water towers and sumps; some panchayats secondarily treat with sodium hypochlorite in their local water towers or sumps</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>TWAD maintains only main sump and main pipeline; Municipality maintains water towers, other sumps, small pipelines, and public taps^</td>
<td>TWAD maintains only main sumps and main pipelines; panchayats maintain local water towers and sumps, small pipelines, and public taps</td>
</tr>
</tbody>
</table>

* The Municipality also has an infiltration well near the Odacherry River. For this source, the Municipality built and maintains all infrastructure, and is also in charge of treatment and supply (TWAD has no responsibilities). The quantity from this source is marginal and supplies only two wards (which were not sampled in the study). Therefore, this source is not included in the table.

^ Although the Municipality and panchayats are required to maintain public taps, many households pool funds to fix small problems because it resolves problems more quickly and they feel that they cannot rely on the local governing body. Some NGOs built water infrastructure (e.g., on-site treatment centers) for post-tsunami settlements. In such cases, the infrastructure is maintained either by the NGO (if it remains active in the community) or has been handed over to the local governing body. TWAD has no responsibilities for such infrastructure.

TWAD = Tamil Nadu Water Supply and Drainage Board
It is now useful to review additional oversights during the reconstruction process, as well as pressures upon that process. First off, the former District Collector humbly admits that:

All of the water ‘solutions’ were short-sighted and not visionary. The government and NGOs were rushing development in order to finish the reconstruction, there was no cohesion or long-term planning.293

The former quote can be used as a segue to inform the remainder of this section. Beginning with the choice of sites for housing reconstruction (and the amenities escorted along with the houses), there was no site selection committee—as existed and will be illustrated in the case of Karaikal District—comprised of members that oversaw the process from their unique, professional viewpoints. Thus, public health officials and representatives from TWAD, TNEB, and other pertinent agencies were not constituents in the site selection process, which may have attenuated post-reconstruction issues. Rather, the Revenue Department chose the land in accordance to CRZ regulations, received approval from the District Collector (who first okayed the sites with the Municipality or respective panchayat), and then made arrangements for purchase. Thus, as declared by the Executive Engineer of TDIU: “geography wasn’t a concern because the government would prepare the land and it would be inspected,” thereby rectifying any precursory issues.294

Succeeding site selection, the model for reconstruction called upon numerous government agencies (beyond the introduction of NGOs) to execute separate but interrelated and often overlapping tasks. Given the scale of reconstruction and number of agencies involved—not to mention government officials being moved to other posts in the meantime, thus introducing new officials in the midst of reconstruction—it shall come as no surprise that the dissection of roles cultured a level of confusion, blurriness, and gave way to finger pointing later on. For example, in Uzhuvar Nagar, water pipes were laid by TWAD but were irrevocably damaged shortly thereafter when TNPWD mobilized heavy machinery to construct internal roads.

293 Radhakrishnan, 2012a.
294 Senthilkumar, 2011.
(several leach pits were also damaged, but were built a second time by the NGO). As for pointing fingers, many government officials adopted the blame game during the interview process, with shortcomings often blamed on other departments or directed at officials who no longer worked in the respective agency. What is interesting is that the division of reconstruction roles across agencies was not practiced in Karaikal District, where a single agency was in charge of all non-NGO reconstruction activities. Furthermore, meetings akin to the SAC meetings in Nagapattinam District were not held in Karaikal District, likely a result of having a primary agency in charge of all government reconstruction activities and thus overriding the necessity to coalesce all concerned actors on a weekly basis.

A paucity of inspections may also be culpable in generating lackluster outcomes. Despite calls for biweekly (in MOUs) and then ‘at least weekly’ inspections accompanied with hard copy documentation (in SACs), inspections were conducted much less often. According to Dhurairaj:

Government officials and panchayat officials, being the BDOs, and even beneficiaries from the affected communities formed local monitoring teams. The teams were supposed to come every week to observe the construction progress, but they were coming only 2-3 times in a month at the most.295

Furthermore, water infrastructure was never formally inspected. The agencies in charge of inspection—namely the BDOs, ABDOs, and TDIU—were only responsible for confirming site preparation before allowing NGOs to begin construction, and later for certifying the structural quality of housing and sewerage infrastructure built by NGOs.296 Water was the sole responsibility of TWAD, and it was not inspected by an outside agency or considered holistically as a crucial component among several interdependent components.

Pressures, both unanticipated and those exerted from above, placed additional stress upon the reconstruction process and quality of infrastructure. Inflation in the price of inputs such as

295 Dhurairaj, 2011.

296 Senthilkumar, 2011.

Pattabaraman (2010), Junior Engineer at TDIU, Nagapattinam District, personal interview.
cement powder, bricks, sand, and iron weighed heavily on the budgets of the government and NGOs, which led them “to do some cost cutting.” Budgets had been forecasted and approved before the rise in prices, rendering active budgets short of the actual funds required for reconstruction, while still being held to the same level of standards and output. For example, the price of bricks doubled, iron rose from ₹23 to ₹53 per kilogram, and the price of cement powder rose from ₹180 to ₹280 per 50-kilogram sack. One of the most visible outcomes of stretching deficient funds across more expensive inputs is the prevalence of deteriorating cement structures, particularly the interior and exterior walls of houses, septic tanks, and leach pits. In an effort to save money, the cement to sand ratio was reduced to 1:6 from the usual 1:4 or 1:5, which resulted in the less durable infrastructure.

Compounding the unforeseen pressures of rising material prices, the District Collector explicitly ordered all reconstruction actors to speed up their work, a direct product of combined pressure from the state government, media, donors, and affectees to ‘see’ results. A survey of the SAC meeting minutes reveals, above all else, a veritable rhetoric of returns in which rapidity in the fabrication of visible outputs—presumably at the cost of quality—while attempting to satisfy unrealistic deadlines was the modus operandi. In fact, the very first SAC meeting in June

297 Radhakrishnan, 2012a.

298 Dhurairaj, 2011.

Radhakrishnan, 2012a.

A. M. Doss (2009), Project Coordinator of tsunami reconstruction at Development Alternatives, personal interview.

299 Dhurairaj, 2011.

V. Mukhundan (2011), contracted construction laborer at a post-tsunami settlement, personal interview.

Doss, 2009.
2006 convened with the unequivocal goal to “achieve the target of completing construction at the earliest.”300 The explicit demand for speed did not subside in future meetings.

A few months after the first SAC meeting, the District Collector ordered all actors “to concentrate more on non-started items and also to show adequate progress,” whilst being sure to “speed up the work and complete before the onset of monsoon in October 2006.”301 Thus, not only was a completion date explicitly articulated, but a stated goal of producing visible results was also brandished. The order was repeated verbatim in every subsequent SAC meeting through October, and was then reconceived sans the October 2006 deadline through December 2006. Next, the date for completing all work was established as “on or before 31st March 2007,” with the goal of beginning non-started items and showing adequate progress remaining intact.302 In the final SAC meeting before the March deadline, the District Collector “insisted” on meeting the target date;303 the deadline was not satisfied, yet remained in the minutes of every meeting until May 14, 2007 (even though the March date had expired), when a new, quickly approaching and woefully unrealistic May 31st target date for completing all reconstruction was instituted.304 Interestingly enough, the May 2007 completion date was reinforced verbatim up until the meeting of July 23, at which the date was altered to July 15th—a date that had already passed.305 As the SAC meetings in July 2007 came to a close, TWAD had already been singled out to ‘take immediate action’ months earlier in March, the most recent July 15th deadline had passed before it was even set, and in the following month of August TWAD was “instructed to speed up their

301 Ibid.: minutes of 09/01/2006.
303 Ibid.: minutes of 03/26/2007.
304 Ibid.: minutes of 05/14/2007.
work and given [sic.] water supply in all the sites.”—an order that was repeated until the SAC meetings ceased in late December 2007.306

Despite the amended deadlines, reconstruction of the post-tsunami settlements did not officially end until late 2009 or early 2010 (when all of the newly constructed settlements had been populated or at least partially populated). However, in actuality, reconstruction is ongoing as TDIU is still building sewerage infrastructure left incomplete by NGOs in panchayat areas. Furthermore, TWAD is currently building a sewage treatment plants for three settlements in the Municipality that were provided with no sewerage infrastructure whatsoever, and various government agencies are struggling to locate funds to complete houses left incomplete or unstarted by NGOs. Thus, reconstruction persists against the overt backdrop of numerous deadlines, leaving the stated goal of speed either not serving its purpose and/or having assisted in the generation of lower quality infrastructure (than what may have otherwise been produced).307

Adjusting the focus to a larger scale, there were several additional factors that shaped the reconstruction process and its outcomes for water in Nagapattinam District. First off, the magnitude of the disaster was unexpected, the extent of damage demanded sui generis approaches, and solutions were stymied by geographic and political pragmatics. Radhakrishnan argues that, second to the scale of the disaster, “the linearity [or ‘thinness’] of the district was the biggest obstacle,” which problematized the availability of land for reconstruction.308 Moreover, the availability of land was further complicated by regulations and uninformed, devolution-impaired decisions inflicted by the State of Tamil Nadu. Radhakrishnan laments:

307 The detriment of setting deadlines was also visible in the case of the Dhamar earthquake in Yemen. [Barakat, 2012.]
308 Radhakrishnan, 2012a.

Radhakrishnan and other government officials in both Nagapattinam and Karaikal Districts readily admit that Karaikal District’s shape and greater availability of land contributed to a less complex resettlement and reconstruction canvas.
Land was at a premium because much of the district was destroyed due to its geographic linearity. There was not enough space to put up such a large concentration of new houses, and the CRZ regulations from the Center [State of Tamil Nadu] made it problematic to try to run full-fledged reconstruction. The CRZ caused constraints and so did other centrally made decisions [by the State of Tamil Nadu] that should have been made locally. Many environmental decisions and policies are made at the state level and don’t allow latitude for local problems. . . . Local decisions should be made by local people and local panchayats, when it moves up to higher levels we lose grassroots solutions.309

The construction of a total of 78 new settlements in Nagapattinam District was not only constrained by geographies and scalar politics, but it was further hampered by interim elections and what Radhakrishnan refers to as the ‘imaginary fears’ of affectees:

Elections took place during this time period [in the midst of reconstruction] and people were unsure as to how the outcomes would change reconstruction and the promises made to them previously. . . . There was pressure of imaginary fears of the people that they wouldn’t get a house at all since the one year anniversary of the tsunami had passed without a single house being built. They were losing their faith in government. Also, the people had no livelihood for six months so there was lots of time for people to get agitated, organize, and spread imaginary fears. For example, people thought that tourism activities would replace their original land, which to this day has not occurred. They didn’t want to be left out of the housing scheme. They had imaginary fears, even though I assured them otherwise that they would get houses. However, fears built up and people demanded a site so that they would not be left out of free housing. There may have been better land available if more time passed, but people demanded land soon so we finalized it and gave it to them. Now some people are unhappy about the land they themselves demanded. For example, Andana Pettai people demanded the land they are on even though they were very aware that it flooded every year even before the tsunami.310

Thus, the scale of the event, geographic and political factors, interim elections, and the appeasing of ‘imaginary fears’ collectively impacted the reconstruction context in terms of both the availability and choice of land (i.e., land that may have not been chosen).

Digging deeper into the nature of the reconstruction politics, the structure and genuine effort of the government must be examined. Government workers in India are notorious for departmental loyalty and strictly following orders—daring not sway from the demands of higher-

309 Ibid.
310 Ibid.
This deference not only fashions an intractable hierarchy, but it also restricts the capacity of subordinates to voice and potentially activate alternative solutions, perhaps impeding staff from acting the role of a whistleblowing Ibsenian Dr. Stockman. Furthermore, the rigidity of subservience appears to generate indifferent attitudes among government workers, encompassed by a multitude of interview responses such as ‘it was not within my power,’ ‘I couldn’t do anything about it,’ ‘I was just following my superior,’ and ‘I was just doing my job.’ Radhakrishnan brings such a contention to life in the following passage:

The entire reconstruction process was not given the importance it was due. It was put through strenuous approvals through various government levels, but not for reconstruction purposes, only for following rules and to do your job. Thus, there was an absence of a meaningful “mitigation culture,” and in future efforts “we need to move to a higher plane, to an ecosystem approach where we are trying to address long-term problems,” rather than simply pushing papers for the sake of performing work. George, whose NGO continues to engage coastal communities to this day, condemns the government even more harshly:

Reconstruction results seem helter skelter and not an improvement of the previous scenario. The government had funds to produce better, more well planned, and more sustainable results, but they chose not to. They intentionally got the bare minimum done and swept the rest under the rug.

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Wood also evidences that governmental departments in Tamil Nadu do not work in concert, enforce conflicting policies, and compete for scarce funds made available at higher levels.


“An enemy of the people” is an acclaimed play that was originally published in 1882. It tells the story of Dr. Stockman, who goes against his superiors to warn townspeople of a public health hazard.

313 Radhakrishnan, 2012a.

314 Ibid.
The reason is that the government doesn’t want transparency and strict guidelines or standards because that is not in the government’s interest. Instead, they work off monetary kickbacks and by just sliding by, so less transparency, less spotlight, and an absence of standards fits within their modus operandi.315

Therefore, the outcomes of reconstruction for the water sector were subjugated by a systemic ‘business as usual’ approach—one that failed to break the inflexible tradition of hierarchy and transcend paper pushing in order to instigate meaningful reforms.

In terms of the political culture, and societal culture more broadly, there exist both implicit and explicit preferences for technocratic solutions. Therefore, when it comes to formulating a solution, Western, technical, and engineering-oriented remedies are generally favored. However, an Indian reliance on engineered solutions often folds when confronted with inappropriate geographies, ensuring proper usage, operation, and maintenance, shortcomings in cost recovery and investment, and a lack of political capacity for management (i.e., technical ‘solutions’ often fail when inserted into anthropogenic systems).316 Thus, despite the conspicuous technical ‘solutions’ of pakka houses, piped water supplies, on-site water treatment centers, and proper sewerage facilities, in practice the ‘solutions’ bordered on lackluster or even flopped as a result of geographic underpinnings, community usage, and government capacity and mismanagement. Interestingly enough, several government officials in both Nagapattinam and Karaikal Districts doubled down by replying that the two greatest lessons learned for responding

315 George, 2011.

316 For example, not touching on cost recovery and not considering larger scales, a water tower operator being sick, attending a wedding, leaving town, not explicitly told to do something that should be done routinely, a lapse in salary, broken or missing parts or tools, caste, and his/her grudges or forgetfulness often stand in the way of a study site receiving or not receiving water on any given day. Likewise, solid waste is seldom removed from leach pits and drainage is habitually clogged (sometimes intentionally) with little maintenance from the government and community. A recent article (Trevelyan, 2012) published in a leading Indian newspaper corroborates these assertions and offers candid narrations of technical ‘solutions’ meeting their fate when confronted with human systems. Furthermore, Chattopadhyay (2001) argues that water and sanitation infrastructure designed for application in Western contexts is impractical and often fails in India. [J. Trevelyan (2012), “The enigma of Indian engineering,” The Hindu, 20 June 2012, accessed 12 July 2012, http://www.thehindu.com/opinion/lead/article3547601.ece. S. Chattopadhyay (2001), “A practical approach to water supply and sanitation in Asian cities,” Building Issues 11(2).]
to future disasters are (marginally paraphrased): (1) not to expect ‘such a huge problem in the future’ owing to the ‘new technology that has been implemented;’ and (2) ‘in the future’ the government will use ‘different,’ ‘new,’ and ‘modern’ technologies to ‘fix the problems of the past.’ Thus, the method of Nehruvian technocracy, serving to suppress indigenous knowledge and discount nonstructural solutions in the process, remains alive and robust.  

Finally, before switching gears to Karaikal District, the affectees inhabiting the newly constructed housing settlements cannot escape without some form of liability. That is, the affectees themselves complicated the reconstruction process and co-constructed the current water fabric in which they reside. First off, theft and destruction of infrastructure on the part of affectees is commonplace. For example, doors and taps were stolen from community latrines in Andana Pettai, empty houses in Andana Pettai were raided by residents already residing there, and the Dr. Water treatment center in Samanthanpettai was plundered for valuable pipes and fittings, while children use it as a playground and damage it in the process. George upholds such claims: “The communities are also at fault. They have sold taps, pipes, and other structures and then complain when things don’t work and want the NGOs and government to come and fix it.”

Doss, the Project Coordinator of an NGO that constructed three housing settlements, further documents the phenomenon:

We have had lots of problems with theft. Pumps and generators were stolen, handpump handles were missing from handpumps, construction materials and equipment went missing, and the people’s goats would eat the trees we planted.

In addition to marginalizing indigenous knowledge and flying in the face of nature—as argued by McHarg (1969) and demonstrated by Mileti (1999)—technocracy serves to subjugate nonstructural mitigation. Non-structural or ‘soft’ approaches to mitigation are paramount for effective coastal hazard management in general (Psuty and Ofiara, 2002), and have been recommended for reconstruction after the tsunami in particular (Olsen et al., 2005). Furthermore, such approaches reduce human-environment interaction and have been recognized as more sustainable. [Olsen et al., 2005. N. P. Psuty and D. D. Ofiara (2002), Coastal hazard management: lessons and future directions from New Jersey (New Brunswick: Rutgers University Press). D. Mileti (1999), Disasters by design: a reassessment of natural hazards in the United States (Washington DC: Joseph Henry Press). McHarg, 1969.]

George, 2011.

Doss, 2009.
Still others place blame on affectees not appreciating the freely provided infrastructure and services, and for essentially being free riders on the system. For example, a TDIU official argues:

The big problem is that no people [in the post-tsunami settlements] are paying taxes. The villagers will not pay taxes, but they need and request services. Low education, no family planning, overpopulation, and taxes are the problems. We cannot provide water for so many people with no money.  

Chidambaram, a resident of Velankanni who hires several affectees as laborers on his aquaculture farms, concurs:

For these people everything is free. Water is free, electricity is free, the house was free, rice and wheat are free, and even their TV was free. It is difficult to get such people to work hard and use things properly because they think everything should be free to them and that everything is owed to them. Because of that, they are not willing to pay for public services and they won’t assume responsibilities for improving what the government is already giving them free of cost.

While there are likely threads of truth in what the previous two individuals contend, the situation is also a product of the ineffective method of ‘provision and adoption,’ rather than instilling ownership, that was practiced. NGOs and the government simply handed over infrastructure to affectees assuming that usage, maintenance, and investment would automatically ensue in a desirable manner. However, as George posits, the affectees were whisked away to a new way of life, and adjustment to this new mode of existence is an ongoing process:

They are not used to having community-based infrastructure and are learning from scratch, it will take some time. They need to learn to treat things as community property rather than individual property. They have a lack of civic sense and fail to realize that each of their actions impacts other people and leads to other outcomes and actions. The post-tsunami

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321 Chidambaram, 2011.

Color televisions were provided free of charge to all ration card holders of Tamil Nadu by Karunanidhi, the previous Chief Minister.
folk are used to caring only about their house, but not the greater community.\textsuperscript{322}

George expounds by elucidating the case of drainage infrastructure:

They used to live in less dense housing areas with better drainage through soil and topography. Now, the houses are extremely close and drainage canals are a novel technology. They are not used to other people’s flux flowing in front of their house and especially not used to the stench. Thus, one cannot blame them for covering the ditches with sand or cement. They are in a transitional phase and it will take time for them to realize that if everybody takes care of the drainage then it will work for everybody.\textsuperscript{323}

Government officials are now privy to the fact that instilling ownership in gratis-provided infrastructure to individuals and the community is paramount. Officials spoke candidly about the need for ‘deep advocacy,’ and the necessity to ‘teach’ people how to properly use the infrastructure. In fact, officials from TWAD and TDIU both stated one of the chief goals of future reconstruction should be to ‘ensure usage of the infrastructure,’ thus ‘saving it from being a waste.’ While the focus of government officials remains on ‘teaching,’ others have suggested a demand-driven approach, as conveyed in this colorful quote by Ganapathi, a Special Correspondent for \textit{The Hindu} and self-proclaimed environmental activist:

Coca Cola went to the villages and stirred up a demand for Coca Cola even though there was no need for it. However, there is a need for clean water and toilets and there is actually a benefit from them, but for some reason we are failing in building a demand. The same goes for cell phones and TVs. People think cell phones are necessary and they’ll even wake up in the middle of the night just to charge them, similarly, they will pay rupees 125 per month to the cable company and not think twice. But when it comes to building a demand for clean water and toilets the government and NGOs have failed.\textsuperscript{324}

\textsuperscript{322} George, 2011.

\textsuperscript{323} Ibid.

\textsuperscript{324} V. Ganapathi (2011), Special Correspondent for \textit{The Hindu} and researcher at EXNORA, personal interview.

Furthermore, it is argued that the absence of a concerted demand by the citizenry of India for an adequate quality of water at a sufficient quantity leads to the government assuming that the populace has low expectations and is satisfied with the status quo. This in turn fosters low expectations for water service delivery on the behalf of the people, fashioning a vicious cycle. [Bajpai and Bhandari, 2001.]
Therefore, concluding the discussion on civic responsibilities for the water scenario, while there surely exist lags in affectees perceiving infrastructure as community-owned organisms, there was also a failure on the behalf of NGOs and the government to foster a sense of *communitas*, to instill ownership in infrastructure provided, and to relay the benefits of such infrastructure in a way that induces demand.

### 4.4 The reconstruction process in Karaikal

The model for reconstruction in Karaikal District is essentially a mirror image of that utilized in Nagapattinam District. However, the management of certain aspects, water included, were conducted in different ways by different authorities. First off, regarding administrative changes, the Department of Revenue was given a facelift and renamed to the Department of Revenue and Disaster Management, a name that sticks to this day. Secondly, an almost identical MOU (conceived in GO.Ms.No.29) was enacted on March 15, 2005 by the Union Territory of Puducherry. Just as its counterpart in Tamil Nadu, the MOU was to be implemented by District Collectors, as contracts between District Collectors and NGOs, throughout the territory.

The establishment of the TPIU at the state level and the TDIU at the district level in Tamil Nadu was paralleled by the creation of the Project Implementation Agency (PIA) in the Union Territory of Puducherry. The PIA was established in May 2005 in G.O.Ms.No.57, and it varied from its counterpart agencies in Tamil Nadu. Rather than launching agencies at the district level that are nested in a higher state agency as occurred in Tamil Nadu, the PIA is an agency of the Union Territory with appointed officials working directly at the district level (i.e., only one agency with no lower level agencies at sub-levels). The PIA accepted, released, and monitored funds for NGO-assisted reconstruction projects, and was also slated to complete all

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mandatory work left incomplete by NGOs—just as were the responsibilities of the TDIU in Nagapattinam District. Moreover, and most significant in variance, the PIA was designated as the single agency for completing all government-based reconstruction in the newly constructed post-tsunami housing settlements. Thus, the PIA was responsible for implementing all water pipelines and taps, internal roads, and electrical infrastructure, as well as site preparation. A single caveat is that PWDP was tasked to construct water towers to serve new post-tsunami settlements that could not be serviced by existing infrastructure (not all sites required new water towers, only those situated too great of a distance from existing water towers). This caveat aside, the single agency approach in Karaikal District is distinct from the collaborative governance system practiced in Tamil Nadu and Nagapattinam District, in which separate departments (e.g., TWAD, PWD, TNEB, and BDOs/ABDOs) were responsible for their niche roles.

Turning to the MOU, its conception was not the first option floated for responding to the tsunami. However, as shared by the Executive Tahsildar, the magnitude of the event ultimately pressed for a novel model for reconstruction:

> It was the first time we had such a big problem. At first we just thought to give land to the tsunami-affected peoples under a current scheme, the Land Grant Scheme, which already existed. Then, as we saw the gravity of the problem and as NGOs approached us, we decided to go for the government giving the land and the NGOs giving the houses.

Thus, the MOU model was implemented in Karaikal District, and it was virtually identical to its counterpart in Nagapattinam District.

The Puducherry-designed MOU—with boiler plate text essentially indistinguishable from its counterpart in Tamil Nadu—begins by explicating its formation:

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327 Danabal (2011), Junior Engineer at PIA, Karaikal District, personal interview.

T. Murugesan (2011), Executive Tahsildar at Revenue and Disaster Management Department, Karaikal District, personal interview.

Government of Puducherry, 2005b.

328 T. Murugesan, 2011.
Non Governmental Organizations, Voluntary Agencies and individuals have come forward to assist the Government in the mammoth task of rehabilitating the thousands of families in the 22 affected revenue villages. The Government have considered these offers from such agencies and have decided to set out the framework for their coordination with the Administration for permanent relocation and rehabilitation of the affected families.329

Next, the MOU lays out the respective roles and responsibilities of the two parties (respective District Collector and NGO(s)), as well as stipulations that must be followed. Chief among the stipulations was that the MOU must heed the 500 meter CRZ/CMZ established in G.O.Ms.No.101.330 While the Government of India drafted guidelines for coastal buffers, states and union territories have the power to enforce CRZs idiosyncratically; that being said, both Tamil Nadu and Puducherry settled on 500 meters. While a higher population combined with an elongated shape and scarce amounts of land made resettlement in accordance with the CRZ difficult in Nagapattinam District, a smaller population confined in a more compact, circular shape with a greater availability of westward land made resettlement in Karaikal District less complicated.331 Thus, most post-tsunami settlements were simply shifted 500 meters west flanked by a newly constructed road that tracks the coast parallel.

Government responsibilities began with the selection, purchase, and preparation of land for resettlement. In Karaikal District, a ‘site selection committee’ was established, which differs greatly from the site selection process in Nagapattinam District. Murugesan of the Revenue and Disaster Management Department describes the process:


The active CRZ when the MOU was created was only 200 meters. However, the MOU accommodated the 500-meter CRZ when it was altered in G.O.Ms.No.101. The MOU declares that restrictions are imposed on the location of post-tsunami housing as regulated in the CRZ, thus allowing it to morph along with changes to the CRZ. [Government of Puducherry, 2005a: sec. 5.]

331 Radhakrishnan, 2012a.

Laltinkhuma, 2011.

T. Murugesan, 2011.
A Site Selection Committee was formed made up of nine officials: District Collector as the Committee Chairman, Deputy Collector, Commissioner of [Karaikal] Municipality, Executive Engineer of PWD, Irrigation and Public Health section of PWD, Building and Roads section of PWD, Executive Engineer of the Electricity Board, Medical Superintendent, and a Commune Panchayat representative. First, the Site Selection Committee would visit unoccupied land to see if it was suitable for development. All members of the Committee had to approve the land based on their own relevant background. If all found it suitable, then the Revenue Department would transfer the land if it was government-owned land, or approach the owners—usually individuals or temples—to purchase the land. Then it was ready for preparation and landfill [read as ‘infill’].

As explained above, the PIA was responsible for purchasing and preparing all land, which sometimes entailed infill. As in Nagapattinam District, the land was then transferred to NGOs allowing for the satisfaction of their compulsory responsibilities. However, it shall be quickly mentioned that all land “will remain in the name of the Government,” meaning that, in the end, land is owned by the government with only the houses owned by affectees (the same practice as was applied in Nagapattinam District). According to G.O.Ms.No.89, all land for reconstruction had been “taken possession in Karaikal District” and was “ready for construction of houses to the tsunami affected victims” in July 2005.

With sites having been prepped, the stage was set for NGOs to fulfill their requirements of post-tsunami reconstruction, which mimicked the responsibilities for which NGOs were held accountable in Nagapattinam District. NGOs entered into agreements with the District Collector (via the MOU) to “construct 100 houses or more,” or to “construct less than 100 houses” upon meeting additional requirements (funds had to be deposited with the government). The

332 T. Murugesan, 2011.

Notice how this more comprehensive approach for site selection contrasts with that in Nagapattinam District, where the District Collector—with various gradations of input from other officials—finalized the reconstruction sites.


NGOs were also held to “proper and quality construction of houses and other facilities” that were to be “disaster resistant.”

Accompanying the houses were ‘other facilities,’ which the MOU articulates as:

Community infrastructure such as roads, water supply, health facilities, noon meal centre, internal roads, drains, anganwadi, net mending halls, fish auction halls, fish drying and curing yards, playground, library, information centre, etc should be designed and provided for the entire habitation; or they [NGOs] shall bear the proportionate cost.

The requirement for community infrastructure raises two issues: (1) it claims that NGOs are responsible for the provision of water infrastructure; and (2) the mentioning of sewerage is completely absent (in fact, sewerage is not cited in the entire MOU). Just as in the case of Nagapattinam District, this led NGOs to initially believe they were responsible for providing water supply infrastructure, but this was clarified during the signing of the MOU, when it was made apparent that provision of water was a task reserved for the PIA.

Furthermore, sewerage, in the form of a septic tank or leach pit, was denoted as the responsibility of constructing NGOs. In practice, NGOs were required to build the agreed upon number of houses complete with sewerage, anganwadis, and community halls, while a smattering of NGOs provided additional facilities such as playgrounds, libraries, and medical centers.

Lastly, the MOU proclaims, “the Government desires” NGOs to “takes up such work [sic.] . . . comprehensively following certain standards.”

Disaster resistant’ houses were defined by the Government of Puducherry as being earthquake and cyclone resistant, and was architecturally demonstrated in prototypical housing designs provided to NGOs. As in Nagapattinam District, this effectively meant including beams to increase the strength of the brick and cement houses. [Dhurairaj, 2011. Government of Puducherry, 2005a.]


Danabal, 2011.

Dhurairaj, 2011.

Doss, 2009.

never defined numerically or descriptively, the MOU states, “there will be continuous quality checks by teams consisting of Government [officials], NGOs and experts.” According to both the PIA Junior Engineer and the Junior Town Planner, such inspections were to be conducted by the PIA “daily or at least weekly.” However, inspections realistically occurred weekly or every 10 days as imparted by Dhurairaj and Doss, whose NGOs constructed a total of four post-tsunami settlements (1,009 houses) in Karaikal District. Intermediate inspections aside, a final inspection was conducted by the PIA when NGOs completed their mandatory work. Upon a satisfactory review, NGOs officially transferred ownership of the infrastructure to the government and their work was complete. Next, the PIA was to implement water supply, drainage, roads, and electricity. After the introduction of this infrastructure, the reconstruction process for that settlement was complete, and “allotment of houses to the beneficiaries” was “decided by the Government on a rational basis.” The ‘rational basis’ was “to allot the plots by drawl of lots to the beneficiaries in a transparent manner”—typically with the accommodation of housing relatives in adjacent houses.

Turning the focus to water, ambiguities exist in the MOU, the foremost being that Section 7 denotes water supply, as well as drainage and internal roads, as NGO designated tasks—

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340 Ibid.: sec. 4(h).
341 Danabal, 2011.
342 Dhurairaj, 2011.
343 Notice that drainage was provided in Karaikal District, differing from the non-provision of such infrastructure in Nagapattinam District. Furthermore, it is worth noting that, after much observation and formal interviews with dozens of households, flooding is considerably less of a problem in Karaikal District.
345 Government of Puducherry, 2005e: sec. 3.
actuality, all are responsibilities of PIA. Just as this was misstated in Nagapattinam District, the misstatement was replicated in Karaikal District, but was clarified when NGOs signed the binding MOUs.\footnote{Danabal, 2011. Dhurairaj, 2011. Doss, 2009.} Furthermore, the MOU leaves sewerage infrastructure—which necessarily impacts water quality—completely absent; however, this was later conveyed as a responsibility of NGOs during the signing of the MOU. It shall also be reiterated that inspections by the PIA occurred less frequently than was stipulated.

As for the standards of water infrastructure, while none were specified in Section 7 of the MOU, the PIA adhered to current benchmarks that are perceived as acceptable by the Town and Country Planning Department. Thus, the PIA provided individual taps to all houses in Karaikal Municipality, and public taps in \textit{panchayat} areas of Karaikal District owing to constraints in supply capacity.\footnote{Chidambaranathan, 2011. Danabal, 2011. Murugan, 2011. A. Murugesan, 2011.} A maximum density was not set for public taps, but in general the results fared better than the household density of 30 pursued in Nagapattinam District. Households with individual taps in the Municipality are charged ₹50 per quarter, while in \textit{panchayat} areas public taps are free and availing an individual connection costs households ₹10 per month along with a non-refundable ₹250 ‘security deposit’ (e.g., a one-time connection fee).\footnote{Government of Puducherry (2010), “G.O.Ms.No.61 dated 22/01/2010.” A. Murugesan, 2011. Tamaraiselvan (2011), Commissioner of Kottucherry Commune \textit{Panchayat}, personal interview.} While many households with individual taps do not pay the scheduled ₹10 or 50 charge, Chidambaranathan,
Junior Engineer of water supply at PWDP, assures that PWDP will not shut off water to non-paying households because “water is a human right.”

In terms of water supply, a standard of three water availability windows per day in the Municipality and two per day in panchayat areas was practiced, the latter a function of limited infrastructural capacity in rurally defined areas. However, although post-tsunami settlements in panchayat areas have water dispensed twice per day (in line with the standard), most settlements in the Municipality only receive water twice per day, leaving availability one window short of the Municipal standard (in this study, only Paravaipettai and Vettakaramedu—which are more centrally located and thus closer to the source node—enjoy three windows). In a candid interview, Chidambaranathan claimed, “every pipe [in the Municipality] gets water three times per day for the exact amount of hours [stipulated by PWDP];” however, after being prompted, he retreated and admitted that “discrepancies are there due to houses being at tail ends.” The Municipal Commissioner also acknowledged the shortcoming; after first claiming that “All locations in the Municipality get water three times per day,” further probing caused him to back off and state, “Oh, well that’s because they’re near the edges of Municipal limits, they’re at the tail ends.” Lastly, it shall be reiterated that the existence of availability windows is contrary to the goal of continuous supply set by CPHEEO and the Ministry of Urban Development.

349 Chidambaranathan, 2011.
350 Chidambaranathan, 2011.
351 Chidambaranathan, 2011.
352 Veerasamy, 2011.
The volume of water supplied shall also come under scrutiny. According to CPHEEO and government officials, the same LPCPD requirements in Nagapattinam District are to be upheld in Karaikal District. Thus, the LPCPD standard is 135 in the Municipality, and 40 in panchayats. While residents of post-tsunami settlements do not enjoy 135 liters per day (although they do receive more than their counterparts in Nagapattinam Municipality), Rajasekharan, Executive Engineer of PWDP in Karaikal District, contends, “we are supplying more than 135 LPCPD, which is above our duty.” However, a poor cost recovery structure aside, Rajasekharan’s claim is a raw number that fails to control for UFW water leaking from pipes, and merely reports the volume of water pumped to the main sump divided by the total population. Thus, such a claim loses credibility when considering UFW, the social hydrology (e.g., allocation of water), taps near the end of supply lines, and ultimately the amount of water that is actually dispensed to consumers at consumption points. In panchayat areas, Murugan, Junior Engineer of Water Supply and Maintenance in Kottucherry Commune Panchayat, divulges that his agency is likely not meeting its 40 liter per capita standard. However, Murugan evades responsibility by proclaiming, “here water is not a problem because all houses have their own handpump or borewell,” therefore, “they just need a little bit of water from us for drinking.” The contention that ‘all houses’ have private infrastructure to obtain supplemental supplies is patently false.

There are concerns over the PIA’s provision of water infrastructure. After the PIA laid water pipes, they were next handed over to PWDP for maintenance and supply in the

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354 Rajasekharan (2011), Executive Engineer of Water Supply Sub-Division of PWDP and IPH, personal interview.

355 Rajasekharan, 2011.

356 Murugan, 2011.
Municipality, and to respective panchayat bodies in rural areas. This surfaces two notorious issues in Kottucherry Commune Panchayat. First off, Tamaraiselvan, Commissioner of the de jure territory, discusses the case of Akkam Pettai, a settlement of 100 houses:

PIA built the 10 pipes [public taps] in Akkam Pettai, but PIA didn’t properly hand over the blueprints and diagrams of the settlements, so we had no technical data on where the water pipes were laid or any dimensions. Yet we were required to maintain the infrastructure without knowing about the layout and we didn’t even know who built what—the NGO or PIA. We had to go digging around to look for water pipes. We eventually got it worked out with PIA, but you can see how difficult the situation was since it’s [maintenance] our job but we didn’t know what to do.357

Similarly, Kottucherry Commune Panchayat was left in the balance in the case of Mandapathur, a settlement comprising 100 houses. The constructing NGO provided underground water pipes and individual taps to every house, which far exceeded their MOU requirements. The PIA authorized the NGO’s venture and absolved itself of any water-related tasks for the site. Murugan, Junior Engineer in charge of water supply and maintenance for the Panchayat, describes what ensued:

The NGO gave all the houses in Mandapathur individual water pipes [taps]. However, the pipes were too thin and there wasn’t enough pressure and supply, so they didn’t work, no water came out. By that time PIA had completed the site so the Commune Panchayat was left in charge of all infrastructure. We had to lay all new pipes and put in four street pipes for the residents at our own cost. That is all we could afford because it was not a job we expected to do, it was PIA’s. Eventually, PWD built a new water tower next to the site in 2009 to alleviate water problems, and in January 2010 it was completed and water was coming out of it. At that time we put in six more street pipes so now there are 10 street pipes for the 100 houses, but it took a long time and was too much work.358

In the two cases recounted, Akkam Pettai and Mandapathur, it becomes apparent that—akin to Nagapattinam District—multi-layered tasks and the provision and subsequent handing over of infrastructure for other agencies to maintain are not without problems. Furthermore, referring to Mandapathur, the fact that water infrastructure introduced by NGOs was not subject to

357 Tamaraiselvan, 2011.
358 Murugan, 2011.
inspection by the PIA (as it was deemed above and beyond their responsibilities) may have everything to do with the failure of individual tap provision, genuine benevolence on the part of the NGO notwithstanding. For, as Danabal, Junior Engineer of the PIA declares, “If an NGO wanted to build water infrastructure they could and it was included in the plan, but it was not checked for quality.”

The case of Mandapathur proffers insight on the (unrequired) provision of water infrastructure by NGOs. It shall be mentioned that numerous NGOs (for example, in Paravaipettai, Kilinjilmedu, Kizhakasakudimedu, and Amman Kovil Pathu) provided 500-liter tanks on the rooftops of houses they constructed, often equipped with in-house piping. Furthermore, the constructing NGO at Paravaipettai actually laid all the underground water pipes and provided individual taps connected to the rooftop storage tanks, thus relieving PIA of any responsibilities for the settlement’s water needs. Although the water pressure was not great enough to reach the tanks, households simply bypassed the tanks and were able to obtain water closer to the ground level, while others installed pumps allowing the rooftop tanks to be utilized. In fact, the setup of underground pipes, individual taps, and, in some cases, the rooftop tanks, is still operational in Paravaipettai to this day. Such efforts by NGOs are complemented by the construction of on-site water treatment centers in Kizhakasakudimedu and Amman Kovil Pathu.

Beginning with Kizhakasakudimedu, a settlement of 200 houses lying near the northern boundaries of the Municipality, PIA provided individual taps to all houses in accordance with the ‘standards’ exercised in municipally delineated areas. However, upon occupying the settlement, residents soon found that close to half of the taps failed to dispense even a single drop of water. While some families were fortunate to have selected (through lottery) houses with functioning taps (particularly on the north and east edges of the site, which are closer to the tower that supplies water), many others selected houses with dry taps as a function of exceedingly low pressure. Some families dug three feet deep holes to intercept the pipeline at a lower level;

359 Danabal, 2011.
others were granted limited amounts of water from neighbors or relatives who lived at the site; others were forced to invest in private handpumps or borewells; while still others chose to maintain residence at the pre-tsunami location. Ultimately, given the PWDP’s longstanding failure to rectify the partially non-existent supply, two of the constructing NGOs stepped forward and built an on-site water treatment center well after their reconstruction roles had passed.

The treatment center harnesses groundwater, pre-treats it with light soda ash (to soften the water and neutralize the pH), and then runs it through reverse osmosis mechanisms. The plant is in full operation and is operated by a resident, Devi, who runs a petty shop roughly 100 feet from the plant. Devi turns on the plant every morning and turns it off in the evening. Residents seeking water readily find Devi accessible at her petty shop and pay ₹1 for each kadam. The model for operation, being run through a petty shop, renders accessibility a non-burdensome task and also facilitates record keeping. Devi’s records report that revenue averages ₹500-600 per week, with a representative from one of the constructing NGOs coming weekly to collect the revenue. Of the revenue, Devi is salaried ₹1,200 per month, and the remainder is deposited into a bank account and used for maintenance. The NGO brings soda ash and filters as needed, and Devi has been trained to add the pre-treatment medium and wash the filters. While residents of Kizhakasakudimedu are still pleading for water to be supplied to their individual taps—as should be and as is the PWDP’s responsibility—the reverse osmosis plant is a comforting supplement and is able to allay the residents’ water woes for the time being.

Interestingly enough, what likely ensured the project’s success was the lack of any necessary assistance from the government. The treatment center utilizes groundwater, meaning that it does not require connection to a PWDP pipeline, the NGO remains active in overseeing long-term cost recovery, operation, and maintenance, and Devi looks after day to day operations. A non-reliance on the government, which undoubtedly aided project success, contrasts greatly with the case of an on-site water treatment center in Amman Kovil Pathu.

A reverse osmosis treatment center was erected in Amman Kovil Pathu by the constructing NGOs. The treatment center was built along with the houses and was meant to
provide residents with an additional source of water—other than their individual taps—that was passed through extra treatment processes. However, after lingering for several years, the plant remains locked and has yet to dispense a single drop of water. Unfortunately, after speaking with all concerned government officials, it appears that the reverse osmosis plant has met its death sentence. Just as responsibility for the plant in Samanathanpettai (Nagapattinam District) rested upon a handover certificate and was jockeyed from one individual or department to the next, the plant at Amman Kovil Pathu has been dealt a similar fate. Beginning with the PIA, Danabal, who appears to know nothing of the plant, contends:

The RO plant in Amman Kovil Pathu, I don’t know about that. If there is any problem it is with the Municipality and PWD, they are in charge of the infrastructure now and they only must supply water to it.360

Williams, the Deputy Director of Planning for Karaikal District, echoes Danabal’s statement virtually word for word. After admitting, “we don’t know about the RO plant and why it was never put to use,” Williams contests, “the PWD approves all connections, it’s as simple as that.”361 However, the PWDP rejects having any authority over the treatment center. Chidambaranathan, Junior Engineer of water supply, ricochets responsibility back to the PIA, reverts to the weak ‘handover certificate’ defense, and casts off all tasks associated with NGO-introduced infrastructure:

PIA is responsible for all tsunami hamlets, we don’t know the facts about it [the RO plant at Amman Kovil Pathu]. The RO plant was never handed over to PWD. Even if it was, the RO plant was built by an NGO and I only supply public water and maintain public pipes and standposts. So, who will maintain it? I only supply natural water and maintain public infrastructure, so it is not my job.362

360 Ibid., 2011.

361 S. Williams (2011), Deputy Director of Planning for Karaikal District, personal interview.

362 Chidambaranathan, 2011.
Rajasekharan, Executive Engineer of water supply and Chidambaranathan’s superior, goes on to shift responsibility to the constructing NGOs (even though the government took ownership of all infrastructure as outlined in the MOU) and the Municipality:

It [the treatment center] is up to the Municipality and municipal officials, not us [PWD]. It was the NGOs’ job to connect it to the water supply, and for that they needed our permission. After that, the plant needed to be properly handed over to the Municipality. If it was not connected to the water supply or properly handed over by the NGOs then it is up to the Municipality to connect it to the water supply by asking us for permission.363

Turning to the Municipality, the vortex of finger pointing and shirking responsibility continues. Veerasamy, Commissioner of Karaikal Municipality, unsurprisingly absolves himself of duty and asserts that responsibility lies with PWDP and the residents of Amman Kovil Pathu:

First off, Amman Kovil Pathu hamlet is already supplied good water to every house by PWD, so they are being taken care of. Second, PWD is responsible for all water issues, not the Municipality. In terms of getting the plant running, the populations at Amman Kovil Pathu must submit a request to PWD and then it is their job to take care of a water connection. That is how the chain is working.364

Thus, the water treatment center, built at considerable cost, remains dry, unutilized, and has fallen victim to the notorious ‘handover certificate’ phenomenon (the defense of which has already been soundly dismantled) and government agencies failing to take ownership. Ultimately, post-reconstruction governmental processes stymied NGOs’ additional efforts to guarantee potable water.365

Just as in Table 4.1, Table 4.2 outlines the provision of water infrastructure in Karaikal District, as well as responsibilities for supply, treatment, and maintenance.

363 Rajasekharan, 2011.
364 Veerasamy, 2011.
365 Mulvany (2011b), focusing on memories of disaster in Puducherry, argues that, despite its inoperability, residents of Amman Kovil Pathu remain fond of the water treatment center, are proud of its existence in their settlement, and refer to it ‘our’ facility. [A. Mulvany (2011b), “The new fisher ‘habitats’ of Pondicherry: post-disaster housing rehabilitation in the Union Territory of Pondicherry,” paper presented at Moynihan Conference on Post-Disaster Recovery (Syracuse: Moynihan Institute of Global Affairs at the Maxwell School, Syracuse University).]
Table 4.2: Water Provision, Supply, Treatment, and Maintenance in Karaikal District

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Commune <em>Panchayats</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Provision</strong></td>
<td>PWDP constructed water towers, tanks, and sumps (if necessary); PIA constructed pipelines and individual taps</td>
</tr>
<tr>
<td><strong>Supply</strong></td>
<td>PWDP harnesses groundwater from Nedangadu Headwalls, conveys it to a central sump in Nehru Nagar, and distributes to local water towers and then to individual taps</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>PWDP treats water with sodium hypochlorite in sump at Nedangadu Headwalls and again in sump at Nehru Nagar</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>PWDP maintains all infrastructure except individual taps, which are the responsibility of households*</td>
</tr>
</tbody>
</table>

* PWDP only maintains infrastructure built by PWDP or the PIA, excluding individual taps. PWDP claims that they are not responsible for maintaining infrastructure built by NGOs or infrastructure introduced by the residents of post-tsunami settlements. PWDP states that maintenance of such infrastructure is the responsibility of households, NGOs, the post-tsunami settlement as a whole, or the Municipality.

PWDP = Public Works Department of Puducherry

PIA = Project Implementation Agency

After surveying the reconstruction process for water in Karaikal District, it is constructive to compare and contrast such practices across both districts. First off, many of the hurdles that emerged in Nagapattinam and Karaikal Districts are analogous. For example, NGOs and governments in both locales encountered dramatic rises in infrastructural inputs and some NGOs left houses and sewerage incomplete and thus did not fully satisfy the MOU (although this was less frequent a problem in Karaikal District). Additionally, the failure to draft and sign handover certificates—whether the blame rests upon NGOs or the respective government—appeared in both jurisdictions. Furthermore, intractable issues related to technophilia, deference to higher
level officials, and multi-layered reconstruction and maintenance processes that spawned a canvas of finger pointing proliferated in both political units.\textsuperscript{366}

Comparison aside, there exist several notable discrepancies between water elements of reconstruction in the two districts. Foremost, while Karaikal District was impacted by the tsunami at a similar rate as Nagapattinam District, after accounting for the variable of area, \textit{ceteris paribus}, the scale of magnitude was less in Karaikal. Thus, the literal number of houses, roads, water infrastructure, and other services that needed to be rebuilt or restored was comparatively less in Karaikal District. Moreover, it has been posited by officials in both districts that Karaikal had more green space available for resettlement and reconstruction purposes, and that Karaikal’s more circular shape (as opposed to the elongated, linear shape of Nagapattinam) facilitated a less complex resettlement scenario. Second, in Nagapattinam District, site selection was overseen by the District Collector, and was financially and legally secured by the Revenue Department. This contrasts markedly with Karaikal District, where a nine-person site selection committee was formed with each member providing input and representing their field of expertise (e.g., water supply, public health, and roads). Thus, while one cannot say for certain that the site selection process in Karaikal is responsible for engendering ‘better’ outcomes, the enhanced, multi-filtered scrutiny likely steered resettlement away from land that is less desirable for large-scale development.\textsuperscript{367}

\textsuperscript{366} For the sake of brevity and because much of this was detailed in the case of Nagapattinam District, an existence of such systemic issues shall be taken for granted in Karaikal District. However, for the sake of mounting a modest defense, a preference for technocracy was made lucid by Danabal (PIA), Veerasamy (Municipal Commissioner), and T. Murugesan (Revenue and Disaster Management Department); subservience surfaced among Danabal, Veerasamy, and Chidambaramanathan (PWDP); and placing blame on others was palatable throughout the narration of the water treatment center at Amman Kovil Pathu and additionally by Danabal and Premanand (Town and Country Planning Department).

\textsuperscript{367} It shall be noted here that, based on household interviews and several years of observation, both flash flooding and waterlogging are less common in Karaikal District compared to Nagapattinam District. One can speculate that a more thorough site selection process may be a factor.
Furthermore, and most influential, was the administrative organization of reconstruction activities in the two districts. A collaborative governance approach was exercised in Nagapattinam District, whereas a quasi-stand-alone agency approach was utilized in Karaikal District. Thus, while site preparation (BDOs/ABDOs and TDIU), successive inspections (BDOs/ABDOs and TDIU), and numerous reconstruction roles (e.g., TWAD, TNPWD, and TNEB) were strewn across several agencies in Nagapattinam, almost all activities in Karaikal—including the lion’s share of water infrastructure—were conducted solely by the PIA.

Additionally, the TDIU was a district level sub-department of the State of Tamil Nadu’s TPIU, whereas the PIA was an agency of the Union Territory of Puducherry that operated at the district level. Thus, the organizational structures for managing and implementing post-tsunami infrastructure across the two districts differ fundamentally, and the political scale at which they occurred (district versus union territory level) should not go unnoticed. Therefore, one can rightly assume that the singularity of responsibility in Karaikal District (and perhaps its closer link to a higher political level) led to a sharper definition of tasks and fostered a ‘cleaner’ canvas of responsibility. On the contrary, the dissection of roles across multiple departments in Nagapattinam District, combined with the need to be granted funds (via numerous requisitions accompanied by itemized budgets) from higher level state agencies, likely confounded reconstruction processes and propagated outcomes that may have been enhanced given an alternative organizational structure (perhaps akin to that in Karaikal).

In distinguishing reconstruction processes in Karaikal District from those in Nagapattinam District, it must be noted that all sites have drainage—introduced by the PIA—in Karaikal, while it is a rarity to exhibit even partial drainage coverage in Nagapattinam. The

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368 Davidson et al. (2007) argue that the organizational structure for managing reconstruction activities—referring to both the government and NGOs—is the single biggest determinant of reconstruction success. [Davidson et al., 2007.]

369 Only one study site in Karaikal District (Vettakaramedu) has partial drainage coverage. However, the site is mostly covered and only two small side streets (encompassing a total of four houses) are without service. In Nagapattinam District, only two study sites enjoy partial drainage coverage, and that level of coverage is considerably less compared to Vettakaramedu in Karaikal District. To be
establishment of drainage has serious implications, ultimately arranging for the structural conveyance of precipitation and grey water away from settlements, which contributes to a more hygienic water quality scenario. Lastly, an equivalent of SAC meetings was not practiced in Karaikal District, which presents issues of transparency. Thus, while a public record of statements by the District Collector, succinct orders to government agencies and NGOs, and a delineation of distinct tasks to specific agencies is available in Nagapattinam District, a similar document is absent in Karaikal District. Reconstruction outcomes notwithstanding, the formation of a public forum with published minutes is laudable in Nagapattinam District, and it offers a level of transparency that is wholly lacking in Karaikal District.

4.5 Of infrastructure, funds, and ‘hard’ paths

In the years following the tsunami, water has cropped up as a significant component of reconstruction, yet high ranking government officials possess few feasible solutions. Munusamy, the current District Collector of Nagapattinam District readily admitted, “You have come to study a topic that is in very poor condition here and that we don’t spend much money on.” Magnifying the urgency, the Municipal Commissioner of Nagapattinam commented on the awakening of tsunami affectees to pressure for better water services:

You have come at the correct time to discuss such [water] works. Now people are demanding for works, complaining about works, and submitting petitions to many government offices for works. It is seven years later [since the tsunami], but still problems are there.

Yet, as exigencies mount, viable solutions among government officials remain remote. The consensus is that aged water supply infrastructure must be replaced or augmented, and proper

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370 T. Munusamy (2011), District Collector of Nagapattinam, personal interview.

371 Chandrasekharan, 2011.
sewerage and drainage infrastructure must be introduced. According to the District Collector of Karaikal, a former medical doctor:

The main problem with water supply is that all the infrastructure is 40 years old, but it was only built for 30 years of usage. The pipes are perforated and very small, so there is not enough pressure. We do not have proper sewage or drainage systems—mainly septic tanks and above ground channels—so groundwater is tainted by leaking septic tanks, open air defecation, and other dirty water, and all of that gets into the perforated pipes. On top of that, people are drinking groundwater directly. Because of these issues, we have a lot of cases of diarrhea, especially right now in the monsoon season, so we must over-chlorinate the water.  

Amidst the struggle to maintain satisfactory water supply with outdated infrastructure to the tune of a decade, proposals by Karaikal District targeting the problem have been handily rejected by the Government of Puducherry. For example, most recently in 2009, two project proposals for additional water supply infrastructure, citing pressing water needs, increases in population, and a system that has outlived its time-horizon, were rejected by the Union Territory of Puducherry. The justification was a lack of funds at both the Union Territory and Central Government levels, as well as a gap in backing from the National Bank for Agriculture and Rural Development (NABARD) and the Housing and Urban Development Corporation (HUDCO). Thus, Karaikal District persists with antiquated infrastructure while simultaneously confronting critical water needs; meanwhile, no substantial remedy is in sight.

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372 Laltinkhuma, 2011.

373 Government of Karaikal (2009a), Proposed water supply scheme for Karaikal central zone (Karaikal: Water Supply Sub-Division of PWDP and IPH).


Furthermore, a complementary proposal for an underground sewerage system was submitted along with the two water supply proposals. It was also denied funding. [Government of Karaikal (2009c), Estimate for underground sewerage system for Karaikal Town, Puducherry (Karaikal: Water Supply Sub-Division of PWDP and IPH).]

374 Chidambaranathan, 2011.
The condition of water supply infrastructure in Nagapattinam District fares no better. The infrastructure being utilized was sanctioned in 2003 (before the tsunami), built from 2004-2007, commenced operation shortly thereafter in 2007, and is designed to be in operation until at least 2031. Although demand has already outstripped the relatively new infrastructure’s 22.5 million liter p/d capacity (not controlling for UFW), Ragunath states jarringly:

We must live with this system until 2031 [time-horizon]. In order for it to work, we must hold back demand within these supply scheme limitations. People should only use the good [treated] water for drinking and cooking, never for bathing. People should use shallow handpumps and borewells for all other purposes besides consumption. We must hold back demand of treated water by using handpumps and borewells for most purposes. This is to conserve the good water from the system.

Therefore, according to Ragunath—a high ranking official from TWAD in Nagapattinam District—as well as comparable statements by officials from PWDP and Kottucherry Commune Panchayat in Karaikal District, the ‘soft water path’ advocated by Falkenmark (2009), Kundu and Thakur (2006), Pearce (2004), Gleick (2003 and 2002), and other water experts is being perverted in order to cope with infrastructural and economic-induced scarcity. Moreover, the

375 Ragunath, 2011.
376 Ibid.


This approach also flies in the face of ‘integrated water resources management’ (IWRM) and the more nuanced ‘integrated water resources and land-use management’ (IWRLM), which call for the coordinated participation of all stakeholders—especially on the behalf of women—and an equitable distribution of water resources at the basin scale.
brunt of such a mal-aligned path will be borne by the vulnerable and poor—residents of newly
constructed post-tsunami settlements predominantly included—who are least capable of
adjusting to its harshness and who already pay more for water than the middle class and
wealthy. 378 While the soft path does aim to curb the demand for limited water resources on an
ever thirstier planet, it seeks not do so on the backs of its poorest consumers. Rather, the
exploitation of further resources (i.e., supply-side or ‘hard’ path approach) is eluded by
increasing the efficiency and productivity of existing water usage practices—primarily in the
agricultural and industrial sectors, the two largest global water users bar none—and by attuning
allocation of the social hydrology more equitably.

While the tsunami ushered in unparalleled levels of Western-style development coupled
with increased levels of piped water connectivity, the existing water supply infrastructure—
which was insufficient antecedent to the tsunami and fails to satisfy the LPCPD requirements of
the CPHEEO at the post-tsunami settlements—was not improved or supplemented. 379 All this
while the tsunami triggered the central and state governments to release funds that were
previously off limits, NGOs to bring in unprecedented monies, the World Bank to allot funds for
water and sanitation projects (which Radhakrishnan argues failed), and a veritable tabula rasa
for long-term, sustainable development. However, despite post-tsunami injections, a grave
outlook looms vis-à-vis aged, incapacitated infrastructure, shortfalls in funding and cost
recovery, and increases in population and demand. Unfortunately, the ominous predicament
promises to be of real dimensions for the residents of post-tsunami settlements for the
foreseeable future, with methods of a perverted soft water path either being exercised or favored

378 Black and Talbot, 2005.

Ruet, Saravanan, and Zehra, 2002.

379 The situation mirrors a case that played out in Bangalore, where the provision of new piped
water supplies to the poor, or ‘the cart,’ was placed in front of implementing adequate infrastructure that
could actually deliver the service, or ‘the horse.’ [M. Ranganathan, L. Kamath, and V. Baindur (2009),
“Piped water supply in greater Bangalore: putting the cart before the horse?,” Economic & Political
Weekly 44(33).]
in the years to come. The result will likely be a permanent, slowly unfolding manmade disaster of social, political, and environmental proportions.

4.6 Revenue- and ‘sight’-based approaches to reconstruction

Accompanying the resettlement and reconstruction processes emerged mechanisms for socially engineering the spatial organization of affectees and their activities. Whether planned or stumbled upon by the two geographies of inquiry, what have accrued are notions of ‘seeing like a state’ à la Scott’s (1998) classic case study of Nyerere’s policy of ujamaa in Tanzania. Specifically, Nyerere’s element of ‘villagization’ in which “peasants were . . . shifted to poor soils on high ground . . . where the land was unfamiliar,” a draconian move that Scott postulates “set the stage for disaster.” The case of Tanzania, which Scott characterizes as ‘high modernism’ in practice, not only reveals that bureaucratic planners are often incapable of knowing what is best for the people being (forcibly) rearranged, but also that levying taxes and increasing revenue are commonly concealed motives being pursued in the name of development, modernity, and extension of public utilities. The case of Nyerere’s Tanzania and Scott’s wisdom can be applied to the fashioning of permanent housing settlements and their supply of water after the tsunami in the districts of Nagapattinam and Karaikal.

Beginning with enhanced ‘vision’ of the populations residing in post-tsunami settlements, the gridded layouts facilitate the literal sight that governments—panchayats or municipalities—have over their citizenry. Prior to the tsunami, houses were scattered, less geometrically organized, and more irregular in terms of plot size and shape. However, the wave of post-

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Bentham’s ‘panopticon’ (conceived in 1787)—an architectural structure enabling governments and institutions to see their citizens and control their behavior—also applies in this situation. As argued by Foucault (originally published in 1975), “Whenever one is dealing with a multiplicity of individuals on whom a task or a particular form of behavior must be imposed, the panoptic schema may be used. It is—necessary modifications apart—applicable to all establishments.” [J. Bentham (1995), The panopticon writings, (ed.) M. Bozovic (London: Verso). M. Foucault (1995), Discipline & punish: the birth of the prison (New York: Random House, Inc.): p. 205.]
tsunami reconstruction whisked affectees away from this familiar mode of existence into Western-style latticed arrangements. Furthermore, the houses were numbered and, during allotment, the heads of household were registered (by name and ration card number) and legally attached to the houses in government accounts. Thus, governments now know exactly where families reside, are easily able to identify and access the household, and are equipped to levy taxes and fees (see Fig. 4.1). This is not mere speculation, as the SACs in Nagapattinam District affirm this contention textually:

The RDO’s [sic.] shall issue joint pattas to the beneficiaries in the name of husband and spouse once the relinquishment obtained from the beneficiaries is written. . . . The Municipal Commissioner’s/BDO’s/EO’s [sic.] shall assign numbers to all houses and ensure House Taxes collected from all the beneficiaries within their jurisdiction.381

Likewise, the tactic of seeing like a state ensued in Karaikal District. While there is no equivalent of SAC minutes in Karaikal District (a flagrant example of non-transparency), a PWDP official made clear that:

These [post-tsunami settlements] are all new hamlets and they are in the process of being regularized. The system and fees are being updated, but it will take some time to update because the hamlets are so new.382

Thus, the introduction of house taxes, a new concept for most affectees, is already underway or is in the process of being conceived. For some, house taxes are/will be accompanied by additional fees for water and electricity. It is important to note that house taxes represent an indirect tax on water because a portion of revenue goes toward the cost of supplying water as well as maintaining roads and other public amenities. For example, in rural areas of Karaikal District, commune panchayats provide water to public taps at free of cost, but a portion of house taxes help pay for water supply. Similarly, panchayats and municipalities in Nagapattinam District purchase water from TWAD and in turn ensure revenue in the form of house taxes.


This announcement was repeated in all subsequent SAC meetings.

382 Chidambaranathan, 2011.
Furthermore, individual taps in any jurisdiction entail direct costs (in the form of a connection fee and monthly or quarterly charges), which are still accompanied by mandatory house taxes.

Figure 4.1: Spatial (re)organization
Numbered houses in Andana Pettai are methodically laid out in a gridded pattern, allowing each house to be individually recognized.

At the study sites in Nagapattinam Municipality, two sites, namely New Nambiyar Nagar and Saveriyarkovil, have yet to encounter any house taxes or fees for utilities, whereas houses in Samanthanpetta are charged a hefty ₹350 biannually in house taxes. In rural Nagapattinam District, all of the study sites have witnessed charges in the form of house taxes: houses in Akkaraipettai pay ₹110 per year; houses in Theti pay ₹225 per year; houses in Andana Pettai are charged ₹220 per year (which houses without pattas refuse to pay); and houses in Uzhuvar
Nagar pay ₹55 per year—even though they do not possess pattas (thus lacking official ownership status) and therefore are not be required to pay the fees according to law.

The situation is similar, but more convoluted, in Karaikal District. First off, two of the study sites, Mandapathur and Vettakaramedhu (the former in panchayat territory, the latter in the Municipality), have not experienced any charges—yet the majority of sites have. Regarding house taxes and fees for utilities: some houses in Kizhakasakudimedu receive bills for water supply, but they refuse to pay; houses in Amman Kovil Pathu are charged ₹50 per month for water (although many do not pay) and were informed by government officials that house taxes will be levied soon, but residents do not know when or at what rate; and houses in Kilinjilmedu receive electricity bills (some pay, while others do not) and were charged a one-time fee of ₹350 in 2009 to have meters placed on their individual taps (however, they were cognizant of the purpose of the fee, and it took six months for the meters to actually be installed).

The final two study sites in Karaikal District, Paravaipettai and Akkam Pettai, are unique cases in the arena of house taxes and fees for utilities. The residents of Paravaipettai remain perplexed and misinformed about charges for which they are responsible. At first, residents claimed they were promised by government officials that all SC settlements would not be required to pay house taxes, water, or electrical fees—an erroneous assertion that many residents take at face value to this day.383 In actuality, what played out is that six of the 22 houses had legally recognized electrical connections (by the Electricity Board) before the tsunami, and, for some unknown reason, they have not been held responsible for paying electrical charges after in situ reconstruction was completed. On the other hand, the 16 remaining houses, which were provided with new electrical connections during reconstruction, have been receiving bills for electrical usage on a quarterly basis. Similarly, some houses in Paravaipettai receive water bills

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383 This assertion was swiftly rejected by the PWDP, which claims that all domestic water consumers (and the same goes for electricity) are charged the same rate irrespective of whether they are SC or below the poverty line. Rates only vary for commercial and industrial consumers. [Chidambaranathan, 2011. Government of Puducherry, 2010.]
from PWDP biannually at ₹120, while other houses enjoy their water free of charge. Amidst confusion, Selvaraj, an unelected representative of Paravaipettai, probed the government and offers insight on the discrepancies:

All will eventually have to pay for water and also the house taxes and electricity too. When this will take effect is a question. I found out all the information about the fees one day when trying to pay my electricity bill at the government office. I hadn’t received a bill, so I went to ask about how much I owed. The man at the office said I need not pay anything. He said that sometime in the future they will prepare a bill for electricity for the six houses [that are not charged for electrical usage] and also figure out water fees and house taxes. Some people in the settlement have not paid a single paisa [paisa is literally one hundredth of a rupee, but is synonymous with the term ‘money’ and is used here to denote a miniscule amount] in water fees and nobody has paid house taxes, but I found out that this will eventually change too. This was announced as a warning on local TV, the radio, and through megaphones on autos that are coming to the area giving announcements. When the water fees and house taxes will begin and how much they will be is unknown, but it will happen sometime. So far, I’ve lived in my house for four years and haven’t paid a paisa for house taxes, water, or electricity. I just hope they are not building up and that I get a shock.384

While the quagmire surrounding house taxes and utility fees continues in Paravaipettai, the residents of Akkam Pettai are having fees held against them as leverage. For example, a resident of Akkam Pettai received a bill at his house for ₹100, but he did not understand the charges. Upon visiting the Kottucherry Commune Panchayat office, he was informed that the bill is a yearly charge for water. The government official stated that he did not have to pay the bill. However, he was warned that if he requires a marriage, birth, or death certificate (or other vital documents from the government), he will not be able to attain them until he clears the charges and perhaps pays additional fees. Finding this practice intriguing, I followed up with an official of the Panchayat who stated, off the record, that the allegation is true and that ‘the tsunami-affected peoples are not paying for many works,’ so it is a way ‘to guarantee money when they have official work that needs to be done.’

384 Selvaraj (2011), unelected representative at Paravaipettai, personal interview.
The installation of water meters by the PWDP in Karaikal Municipality shall also bear scrutiny as a method utilized to monitor the activities of affectees and levy charges. The volumetric measurement of water usage is novel concept in India, as the standard is to charge a flat fee for individual water connections or to earmark a portion of house taxes towards the costs of water supply. However, in 2009, the Government of Puducherry and Karaikal Municipality began a campaign to measure the usage of water at the household scale and to charge accordingly. One year later, the passing of G.O.Ms.No.61 by the Government of Puducherry in January 2010 established a new, non-graduated tariff schedule of 50 paise (½ rupee) per 1,000 liters to take effect immediately in all of its municipalities.385 According to the legislation, bills are to be calculated quarterly, with a minimum charge of Rs50 per quarter.386 Asked why the change was implemented, Chidambaranathan of the PWDP stated that, “Meters have been put on for revenue purposes, to catch people using too much water.”387

As for the introduction of water meters, the case of Kilinjilmedu was cited earlier, in which houses were charged Rs350, oblivious as to why at the time, for the installation of meters on their individual taps. Meters were also installed in 2009 on all individual taps at Amman Kovil Pathu, Kizhakasakudimedu, and Vettakaramedu (only households in Kilinjilmedu were forced to pay for their meters, while meters were installed free of charge at the other three sites), leaving only Paravaipettai sans meters at the present. Interestingly enough, the meters do not work, have yet to register any volumetric measurement, and have never even been checked by PWDP officials—all this despite being connected to pipelines for three years. Although the government order enforcing meterage has been in place for more than two years and meters have been physically administered for three years, A. Murugesan, Assistant Engineer of PWDP, assures that metered charges will materialize in the near future: “This is coming. This is going

386 Ibid.
387 Chidambaranathan, 2011.
under a regularization process and it will take some more time to administer the new scheme. However, nothing has come of G.O.Ms.No.61 other than hardships on the behalf of post-tsunami settlement residents.

In addition to being inoperable, the meters are also wreaking havoc on the water scenario faced by the residents of newly constructed post-tsunami settlements. When meters were first installed, residents were bewildered and somewhat fearful: how do they work? What if they do not work? How much will water cost? Who is responsible if they break? However, such puzzlement took a back seat to real issues confronted during the next water window. What transpired was that water pressure was fundamentally altered for the worse by the introduction of the new contraptions. The water stream thinned, and taps that used to dispense enough water to fill a kodam in one or two minutes now took closer to three, four, or five minutes or longer. In fact, water pressure was constricted so acutely that some taps in Kilinjilmedu, Kizhakasakudimedu, and Amman Kovil Pathu went completely dry—not a single drop of water would trickle from the previously operable taps.

It did not take long for outright subversion to emerge. Households, hypothesizing that the only new variable affecting pressure was the meters, soon developed methods to circumvent the burdensome technology. During the dry time—that is, not during a water availability window—one by one, street by street, settlement by settlement—households began intercepting their pipe before the meter (by puncturing the pipe and jamming in a rubber hose), in effect accessing water before it has a chance to pass through the meter (see Fig. 4.2). While this has proven the preferred method of technological subversion, others have simply removed the meter (by cutting the pipe before the meter and thereafter converting the open end into a tap), and still others have simply damaged the meter until pressure was restored. The result in all cases was that pressure was restored, although some argue that the original pressure was not fully realized.

Meanwhile, PWDP remains ignorant of the fact that meters are being tampered with and that

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388 A. Murugesan, 2011.
they represent a formidable encumbrance on pressure. After a discussion with the Assistant Engineer on meters resting inoperable for several years, I inquired as to why meters are hindering water pressure, invoking the following response:

Any change in pressure is due to improper meter maintenance by the household. All pipes, including the meter fitting, are 15 millimeters in diameter. Maybe the needle that spins inside to get the reading is slowing down the pressure. I honestly don’t know, nobody has ever asked such questions before. But no complaints are there, if anybody made a complaint we would fix it immediately.389

At any rate, what has cropped up in Karaikal Municipality is a bungled migration from a flat fee structure to volumetric charges for individual taps, with the victims being the residents of post-tsunami settlements, as well as the tax base at large given the thus far wasteful spending.

![Bypassed water meter](image)

**Figure 4.2: Bypassed water meter**

This water meter in Amman Kovil Pathu has been bypassed in order to regain lost pressure. The pipe was intercepted before the meter, and a rubber hose has been jammed in to direct the flow of water into containers.

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389 A. Murugesan, 2011.
In Nagapattinam Municipality, Chandrasekharan, the Municipal Commissioner, is also wielding water in post-tsunami settlements as a medium to increase the government coffers. It was already posited in Section 4.3 of this chapter that shortages of water at public taps and the tiring task of acquiring water from such taps is being utilized as instruments for “motivating people to get personal connections to raise revenue.”\textsuperscript{390} This was also buttressed in Section 4.3 by Pattabaraman of the TDIU, who flatly stated that the “big problem” is that no affectees “are paying taxes . . . but they need and request services,” thereby making it difficult to “provide water for so many people with no money.”\textsuperscript{391} However, while difficulties in financing water supply and a tight fiscal squeeze are all too real in the districts of Nagapattinam and Karaikal, the governments seem to be overlooking the fact that affectees—despite the nonpayment by some—are surrendering more in house taxes, water fees, and electrical charges than ever occurred before the tsunami. Furthermore, the governments boldly ignore that households are simultaneously paying for water in other ways. Besides traversing long distances to gather water—shouldering heavy containers and encountering numerous opportunity costs in the process—individuals and communities readily finance much of the maintenance of water infrastructure, tasks primarily designated as those of the governments. ‘When there are small problems, we fix them ourselves because we can’t count on the government and the government will take too long—it’s easier and faster to do it ourselves,’ voice the residents of all the study sites. Thus, when a public tap breaks, households chip in to buy a new tap; when there are not enough taps, a plumber is paid to install a two-way tap; and when pressure is too low, households pay to dig a hole, have the pipe intercepted at sub-surface level, and for the hole to be lined with cement (see Fig. 4.3).

In conclusion, what remains perhaps most striking are neither the concept of seeing like a state (or panopticism) in practice nor the tapping of newly created settlements for revenue, but the sheer level of irregularity, lack of transparency, and inefficiency that characterized the

\textsuperscript{390} Chandrasekharan, 2011.

\textsuperscript{391} Pattabaraman, 2010.
Figure 4.3: Water access modification
This innovative example of a structural coping mechanism was adopted in Saveriyarkovil to resolve issues of low water pressure. The brick and cement structure was paid for by pooled funds from households using the tap. The phenomenon is not uncommon at the study sites in Nagapattinam and Karaikal, although this specific example is better engineered than most (many similar structures have no cement lining or are much more rudimentary).

processes. In employing methods for sight and revenue, a complete disregard for standardization was and is rampant. The outcomes speak for themselves: one study site in Nagapattinam Municipality pays house taxes at the considerable rate of 750 per annum, while two sites in the Municipality pay absolutely nothing; some households without pattas in rural Nagapattinam District are forced to pay house taxes, while others without pattas have been allowed to escape the tax. Meanwhile, no study sites in all of Karaikal District pay house taxes, but there are
rumblings that house taxes will surface at some (though not all) of the sites. In Karaikal Municipality, some households receive water bills, while others have experienced no charges—and of those receiving bills, the rates range from ₹50 per month to ₹120 every six months (not the standard ₹50 per quarter according to G.O.Ms.No.61 and the PWDP). Similarly, the households at one study site in Karaikal Municipality were forced to pay ₹350 each for water meters, while three additional sites were provided meters at no cost and one site remains without meters altogether. Analogously, some households in Karaikal Municipality receive electricity bills, whilst others have received no bills and have enjoyed the service gratis for years. Of the two rural study sites situated in Kottucherry Commune Panchayat, one site has experienced no charges, while some at the other site have received peculiar bills for water. The lack of uniformity not only brings forth issues of transparency (which fuel misinformation and rumors among settlement residents), but it also surfaces questions on fairness and equality. Across the sites, why are households classified in the same typology (e.g., municipality, no patta, and individual tap) exploited for revenue at different rates while still others are not charged at all? At the site scale, why are some households charged for water or electricity while identical households at the very same site are not called upon to contribute to the government bankroll whatsoever?

There are likely no simple answers to the previous queries, but it essentially comes down to ineptitude and capacity to ‘capitalize’ on the ‘opportunities’ that were presented to the governments in Nagapattinam and Karaikal Districts. Incompetency, disorganization, and the political capital to actually do it right appear to have botched the seizing of avenues for statecrafting and revenue streams. While the governments have increased revenue and gained sight over the populations affected by the tsunami, its haphazard nature is more than palatable and borders on disturbing. Rather than implementing a systematic scheme, the process has run amok in a non-uniform, piecemeal, and at best grossly unfair manner. Lastly, I am not arguing that taxes are unwarranted and that constituents should be provided water or electricity for free. In fact, even the IWRM/IWRLM and leading scholars argue that monetizing water consumption
equitably and in a way that subsidizes the subaltern (i.e., not privatization) is a fundamental method for managing scarce resources—not to mention that it is demonstrably evident that cost recovery and financing of the water sector in India is poor at best. Rather, such price structures must be aired openly, transparently, and equitably in a manner that is uniform across space and different socioeconomic classes.

4.7 Conclusion

Nagapattinam and Karaikal both confronted the titanic task of reconstructing after the 2004 tsunami. Moreover, both districts operationalized nearly identical MOUs in order to manage the process. However, tasks reserved for the governments were conducted under a single agency in Karaikal as opposed to a collection of agencies in Nagapattinam. It is argued that Karaikal’s single agency approach produced comparatively better and more consistent outcomes for water vis-à-vis Nagapattinam’s multi-layered, collaborative approach. That being said, discrepancies in infrastructural output exist across both locales, with standards for water frequently unattained (e.g., quantity and hours of availability). Furthermore, because the MOUs declared all water infrastructure as a government responsibility, such infrastructure introduced by NGOs was left for affectees and/or NGOs to manage and maintain with little governmental assistance or cooperation. Thus, rather than absorbing such infrastructure as means for supplying supplemental and improved resources, the governments often shirked responsibilities claiming they had satisfied their requirements of the MOUs—not to mention their allegation that NGOs failed to properly hand over water infrastructure. The result is that much infrastructure aimed at alleviating water issues sits unutilized at the cost of wasted funds, wasted efforts, and stymied development.

Other similarities between Nagapattinam and Karaikal include the instrumentalization of ‘sight’- and revenue-based approaches of reconstruction. The employment of such methods reveals a case of government-planned statecrafting in response to a large-scale catastrophe. Furthermore, supply-side approaches to water reconstruction and management were practiced in
both *de jure* territories, which questions to what extent the severity of long-term, intractable development issues were contemplated. Lastly, major differences between the political units include a more informed site selection process in Karaikal and greater transparency via public SAC meetings in Nagapattinam. Speaking on the latter, it is interesting to note that increased transparency did not appear to affect results, although it did serve as a window into the complexity and (often) disorder behind post-disaster planning.392

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392 This complexity, chaos, and confusion buttress the need for a more enhanced framework for reconstruction (e.g., the one presented in Chapter 8).
CHAPTER V: HAZARDOUS WATERSCAPES AND MECHANISMS FOR COPING

This chapter describes both the physical and social products of water-based reconstruction in the study sites. The status of water quality, pressure, and quantity are narrated, and accompanying each discussion are accounts of coping mechanisms developed in order to circumvent their shortcomings. Next, conflicts arising from access to water and unique cases of ‘colonizing’ water resources are communicated. The chapter concludes by indicating discrepancies between Nagapattinam and Karaikal, but argues that affectees in both locales are unable to fully remedy the water scenario. Thus, affectees are restrained by the newly fabricated waterscape and are ultimately forced to assimilate.

5.1 Introduction

Seven years had passed since the tsunami unexpectedly ravaged coastal South India. Citizens awoke to a cool morning breeze. It was cloudy; it was the monsoon season; it rained that day—a welcome reprieve from the sun that ordinarily scorches the region. The anniversary of the tsunami was marked with prayers, flowers, and speeches, and newspapers articles commemorated the day by recounting the stories of survivors and presenting snapshots of the contemporary lives of affectees. One article in particular stuck out.

On December 26, 2011, The New Indian Express, in an article entitled “Better amenities amidst bitter memories,” chronicled a tale of successful resettlement and reconstruction in Nagapattinam District. According to the article, a rosy post-tsunami existence prevailed for all affectees:

Today, though the painful memories of the tidal attack still continue to haunt the affected families, there is perceptible improvement in their lifestyle.

Death and destruction apart, the tsunami aftermath has brought a lot of positive changes in the lifestyle of coastal communities.

Tsunami-hit hamlets have undergone total transformation of infrastructure development. Fishing harbour, fish landing centres, fish auction halls,
cold storage facilities and fish drying yards have virtually wiped the scars of tsunami destruction.

Many villages are equipped with new school buildings, vocational course institutes, computer training institutes, knowledge centres, water purification plants, multi-purpose halls, community halls, metal roads and new bridges.

The affected families have been provided with new houses and the fishermen have become proud owners of fibreglass boats. Many fishermen have bought big steel boats utilising the subsidised loans provided by banks.

Prior to the tsunami, women of the area did not know anything other than fish vending. Now, through SHGs [self-help groups], they handle hi-tech fish dryers, make footwear and leather articles, pickles, coir products, ready-made garments, roofing tiles, bricks, hollow blocks, candles, perfumes, agarbathis [incense for devotional purposes], paper cups, palmleaf products and the list is endless.

Children have access to better education. . . . The Government High School at the worst-hit Akkaraipettai is producing brilliant results in public examinations.393

Temporarily retreating from its patronizing language, the article briefly mentions that “tones of discontent” exist as a result of permanent houses being “located far away from the sea” and “water-logging problems during the rainy season.”394 However, the article brushes the all too real concerns aside in its closing paragraph: “Despite these voices of discontent, seven years after the tsunami, the fishing villages have undergone a positive transformation.”395

Nobody wishes the article a truism more than the affectees themselves. However, the facts on the ground are far from what was deceptively reported. In reality, a ‘transformation’ did take place, but its composition more aptly mirrored a ‘disaster after the disaster.’ Scholars have applied the concept of ‘disaster after the disaster,’ or ‘disaster within disaster,’ to denote post-disaster processes of anthropogenic origin that exacerbate the impacts of the initial disaster event. Poor resettlement and reconstruction practices, a paucity of healthcare, and the prevalence

394 Ibid.: p. 2.
of conflict, neo-liberal approaches, unemployment and loss of livelihood, and governmental mismanagement coalesce to produce a second disaster that sometimes overshadows the preceding event—particularly when they generate intractable, life-altering scenarios. Disasters after the disaster have been detailed after the earthquake in Kutch, Gujarat by Virmani (2008), Hurricane Katrina both by Adams, van Hattum, and English (2009) and Button and Oliver-Smith (2008), the Haiti earthquake by numerous reporting agencies, and theoretically by Schuller (2008). Adding to the discourse, this chapter will document (descriptively) the post-tsunami scenario in Nagapattinam and Karaikal Districts in reference to water.

This chapter will use quotes from settlement inhabitants and photos of the situations described to report frankly on the current water canvases in the newly constructed post-tsunami settlements. Furthermore, strategies operationalized for adaptation, modification, resistance, and what are collectively best described as coping mechanisms will be documented. As will be demonstrated, life in the post-tsunami settlements revolves around water, a contention upheld by Uma, who states, “first, I give preference to water, then I do my other tasks;” Ambika, who argues, “my day and life are controlled by water;” and Usha, who says, “water only comes for one hour, so I must concentrate 100% on that or else I won’t have enough water for the day.”

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S. Virmani (2008), Disasters within disaster: failed interventions we can learn from (Bhuj: Hunnarshala Foundation).

397 All quotes from interlocutors of the study sites who do not possess an official position (e.g., a position in the panchayat) are given pseudonyms and shall therefore remain anonymous.
5.2 Quality

The quality of water in the study area has already been described as abject in Chapter 2, the result of both natural (e.g., iron, dissolved solids, and fluoride) and anthropogenic (e.g., nitrates and raw sewage, agro-industrial chemicals, and saline intrusion) causes. Furthermore, even piped water—often treated via shock chlorination, which can result in harmful disinfection byproducts and is insufficient for water with high TDS—habitually fails to arrive safely to consumers at the end of distribution lines. Penetrating deeper, the quality of water in the post-tsunami settlements and methods for adjusting to the abysmal context will be detailed.\(^{398}\)

Perhaps the best place to begin is with a discussion of time. It shall come as no surprise that the quality of water exhibits a temporal dimension. In the monsoon season, while the quantity of water supplied increases, the contaminant load—particularly bacterial \textit{flora} and contaminated groundwater seeping into cracked pipes during the non-supply time—also increases. The result, according to Ishweri of Andana Pettai and the residents of all study sites, is that:

The pipes are empty for 23 hours. Before the water comes you can hear ‘poof-poof’ air sounds, then the water comes, but it is brown and murky at the beginning of water coming. We just let the water flow until it becomes clear, or sometimes we use it to water the plants.\(^{399}\)

While the practice of not consuming the front-end of water supplies is surely beneficial, outbreaks of diarrhea, fevers, chills, and skin rashes—not limited to the monsoon season—are a fixture of everyday life, especially among the children and elderly. In fact, there was a recent (2011) water-related outbreak of diarrhea in Vettakaramedu, as imparted by Lakshmi:

Six months ago many people had \textit{joram} [‘fever’ in Tamil], loose motions [diarrhea], and so many health problems. When we visited the GH

\(^{398}\) A quantitative discussion of quality, as well as pressure, quantity, and other water-related variables, will take place in Chapter 6. Thus, this chapter will narrate salient water-based issues across the study sites, while the subsequent chapter will examine such issues quantitatively and at several scales.

\(^{399}\) The ‘poof-poof’ sounds described by Ishweri are products of dry pipes during non-supply windows. The sounds, common across all sites, are a sensory reminder of pipes being tainted as a result of no pressure for a majority of the day and low pressure during supply windows.
[government hospital] the doctor told us that poor water quality was the main problem. He told us to boil the water and to complain to the government about the water. We complained to our local leaders and they contacted the PWD and the Collector’s Office by letter. The government came and cleaned the tank [water tower], but said that the major problem was that we broke the pipes to get water due to low pressure. He said that the broken pipes allowed dirt and dirty water to enter the pipes, but we have to do it in order to get water.400

Since the root of water quality rests upon the infrastructure and water supply regime, it is useful to discuss the multilayered system that guides water to the sites.

First off, the quality of water at the study sites is a function of the initial quality of water supplied by TWAD, PWDP, and panchayats. I was authorized to test three main nodes that supply water to a total of five of the 14 study sites (I was not permitted to test the other nodes). In Nagapattinam Municipality, water was tested at the sump in Velepalayam, which is the node that distributes water to the entire Municipality, including the sites of Saveriyarkovil, New Nambyiar Nagar, and Samanthanpettai. The tests confirmed the presence of fecal coliform (two H₂S strip tests were conducted, both positive), and that the levels of pH, hardness, chlorides, and alkalinity exceeded the desirable limits set by the BIS (see Table F.1 in Appendix F).

Furthermore, tests were conducted in Kottucherry Commune Panchayat at Kunjimani Thidal and Nanavaickal, the nodes that supply water to Akkam Pettai and Mandapathur, respectively. The tests in rural Karaikal District revealed that both sources tested positive for fecal coliform (two H₂S strip tests were conducted at each node, all four positive). Furthermore, Nanavaickal’s levels of pH, hardness, and alkalinity exceeded BIS desirable limits, and the levels of hardness, chlorides, alkalinity, and iron also exceeded BIS standards at Kunjimani Thidal (see Table F.1 in Appendix F). In fact, hardness and chlorides even surpassed BIS permissible limits at Kunjimani Thidal, and no tests at any of the three source nodes detected a trace of total residual chlorine (TRC). While I was denied access to other relevant supply nodes, the data demonstrate that the

400 In the region, use of the term joram in Tamil and ‘fever’ (use of English term by Tamil speakers) is extremely fluid. Joram and fever can describe the physical condition of an increase in body heat, but are more often used describe any type of illness, such as the common cold, headaches, and not feeling well in general.
initial quality of water already failed to meet acceptable standards—fecal coliform the most dangerous in the immediate term—and quality deteriorated after being dispensed from the main supply nodes as a function of additional factors (see the tables in Appendix E).

Once water has been released from supply nodes, it must travel through aged pipes that have loose fittings and are fractured (or ‘perforated’ as Laltinkhuma terms). Thus, the quality of water diminishes as groundwater and waterlogging on the surface level, both tainted with sewage from shoddy septic tanks, leach pits, and OAD (it is a rarity for residents of the post-tsunami settlements to use the latrines provided), seep into the pipelines.401 It is worth reiterating that a non-continuous supply and lack of pressure compounds the situation. As pipes go dry for a majority of the day (exhibiting flow only during scheduled availability windows), external fluids and solids are able to penetrate the pipeline and further adulterate the water supply. Also, the non-continuous supply fails to properly flush the system, especially near the endpoints. Furthermore, the prevailing low in-pipe pressure is insufficient for mitigating further tainting: when pressure in the pipe is greater than pressure outside of the pipe, the introduction of external constituents is mitigated, with the opposite holding true in this case.402 It is here that the absence of TRC must be revisited, because its deficiency can permit degradation of quality proliferated by broken pipes and low in-pipe pressure. TRC travels with water during its lengthy journey from the location of treatment to endpoints, serving to kill bacteria encountered along the way. An absence of TRC allows water to pick up and transport bacteria to endpoints, rather


Chinn, 2009.


402 A quote from a report by the Ministry of Urban Development (2011) crystallizes points argued in this paragraph: “In a continuously pressurised distribution system, contaminants surrounding the pipelines cannot penetrate even if there are breaks in the pipes and joints. Without continuous pressure, street run-off, drainage water, raw sewage from adjacent sewer lines and leaky septic tanks get sucked into the water mains.” [Ministry of Urban Development, 2011: p. 48.]
than eliminating bacteria with its residual capacity. With the exception of one, results from 75 chemical tests conducted at taps in the study sites, as well as tests performed at the three main supply nodes, all reveal that TRC was undetectable (see Appendices E and F). The BIS sets a standard for TRC of 0.2 mg/l, yet—sans one that exceeded the limit, which poses its own risks—all tests established an absence of the bacterial mitigating chemical.

During the course of travel through inferior pipelines, water is raised to water towers in local areas for purposes of supply and pressure, where it is then conveyed through the last leg of pipelines to its endpoints. Thus, the cleanliness of water towers shall also be scrutinized. In the study areas, water towers, which accumulate legacies of sediments and other impurities over time, are to be cleaned methodically by Nagapattinam Municipality or the respective panchayat every 15-30 days in Nagapattinam District, and every six months by PWDP or the respective panchayat in Karaikal District. The Commissioner of Nagapattinam Municipality describes the process:

Water tanks [towers] are cleaned every 15 days, we’ve been doing that for the past five years. We have two tank operators and a watchman at all tanks. They are responsible for cleaning, but others help if more labor is needed. There is a notice board on each of the tanks displayed that tell when the tank needs to be cleaned next.

Similarly, Jayasankar, a Lab Assistant at PWDP, outlines the process in Karaikal Municipality:

Tanks [water towers] and sumps are cleaned twice per year at the same time. There is no particular date to clean. There are dates painted on the pillar of the tank that state the last time it was cleaned. When it gets close to six months we tell our superior and he gives an order to clean the tank. After cleaning the tank, we paint the date at eye level on the pillar for future reference. Mazdoor [multipurpose staff] workers of the PWD clean

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403 The single test to reveal a presence of TRC was at a public tap in Akkaraipettai. The water tower had just been cleaned, which entails scrubbing the interior walls with chlorine powder—hence the likely source of chlorine. The test revealed a TRC level of 1.0 mg/l, which is injurious and five times higher than 0.2 mg/l standard set by the BIS.

404 The virtual nonexistence of TRC upholds contentions by Chaplin (1999) that the politics of sanitation in India bend towards the reactive (as opposed to the preventive), and that the possibility of massive outbreaks of disease is very real.

405 Chandrasekharan, 2011.
the tanks along with a few private hired helpers, such as plumbers and people who work with water. The tanks and sumps are cleaned in one day. It takes from 8am until 6-7pm with a total of about 25 workers. The sumps are cleaned first, and then the tanks. An advertisement is given to the city the day before on the local TV channel and All India Radio. The advertisement says that there will be a water supply disruption the following day due to maintenance works. Water is supplied the day of cleaning from 6-8am, but then the cleaning takes place all day and water will not come until the following day.406

Lastly, Sankar, a *panchayat* President overseeing the study sites of Akkaraipettai and Andana Pettai in Nagapattinam District, describes the cleaning process:

> Cleaning the water tanks [towers] in the *panchayat* is under my authority. The tanks are cleaned every month by two workers from the village that are hired by the *panchayat* to clean the tanks, repair water lines, and fix handpumps provided by the *panchayat*. They do these tasks under my direction. The tanks are cleaned by first opening the drain pipe, then removing the sludge, then scrubbing the inner walls with an iron brush, and then rinsing the inside with clean water. Then, we fill the tank and add some chlorine to the water. Cleaning the tank takes half a day.407

Therefore, the cleaning of water towers, if done properly and according to schedule, should maintain the initial quality of water supplied, which tests reveal is already substandard.

However, the cleaning of water towers occurs much less than what is required and what is reported by government agencies. Revisiting Sankar’s contentions, Rajjilakshmi, a resident of Akkaraipettai who lives just 15 feet from a water tower, argues that, “He [Sankar] is telling lies. The tank is cleaned only once every six months at best and it only takes a couple hours.” Worse yet is the case of Samanthanpettai, located in Nagapattinam Municipality, as recounted by Palmani:

> The tank [water tower] wasn’t cleaned for six months and the water was dirty. We told the Municipality to clean the tank to no avail. Then we got fed up and 10 of us cleaned the tank ourselves. We told the local leaders we were going to do it and they allowed us. They just watched us clean the tank but didn’t help. Since then we’ve cleaned the tank five times. We clean [the tank] once every two months. There is 30 centimeters [one foot] of sludge at the bottom of the tank each time, it’s fully black.

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406 Jayasankar, 2011.

407 Sankar, 2011.
Thus, the cleanliness of water towers has been called into question, causing several government officials to yield from their claims on the actual timeliness of cleaning water towers. After mild probing, the Commissioner of Nagapattinam Municipality readily admitted that:

> Even though the tanks are cleaned every 15 days, sometimes they are not cleaned properly and sometimes 30 days goes without cleaning, it happens. Sometimes people complain that the tank is not clean and that dirty water, insects, or worms are coming.\(^{408}\)

Adding insult to injury, Jayasankar of the PWDP acknowledged that “there is no penalty” for the non-cleaning of water towers, while Ragunath of TWAD stated, “There is no punishment, so much punishment is not here. Nobody will get sacked for not cleaning a tank.”\(^{409}\) Furthermore, V. Murugan of Kottucherry Commune Panchayat claimed, “There will be no penalty to the individual who was supposed to clean the tank, but we will take immediate action to ensure the tank is cleaned at the earliest.”\(^{410}\)

When considered collectively, the quality of water is a function of multilayered processes: methods of treatment and the initial quality of water in main distribution nodes; travel from distribution nodes through broken pipes compounded by a non-continuous supply and low pressure; insertion into unclean water towers; and finally conveyance through compromised pipes to the endpoints. Ultimately, the residents of post-tsunami settlements are forced to consume substandard water, with individuals from Saveriyarkovil, New Nambiyar Nagar, and

\(^{408}\) Chandrasekharan, 2011.

\(^{409}\) Jayasankar, 2011.

\(^{410}\) Ragunath, 2011.

It is worth mentioning that water dispensed during water windows directly following the cleaning of water towers is of very poor quality. Residents shared time after time that water is brown (from sediments scrubbed off the interior of the tank) and tastes and smells of bleach (from the chlorine used for cleaning). Thus, residents refuse to drink the water supplied immediately following the cleaning of water towers. Rather, they choose to consume the previous day’s water or groundwater until the next water availability window.
Samanthanpettai regularly witnessing organisms swimming in their water after two or more days of storage. Subramanian, a resident of Samanthanpettai, spoke animatedly on the subject:

Puuch, puuch ['Insects and fish, insects and fish’ in Tamil]! Puuch irukku ['Insects and fish are there’ in Tamil; said vigorously while bending index finger, a non-verbal expression to designate small organisms]! After two days there are small bugs and animals swimming in the water! This is happening too much, and then the water goes for wastage.411

Subramanian’s quote, buttressed by personal observations and testimonials at other study sites, confirms the Commissioner of Nagapattinam Municipality’s admission that ‘dirty water’ with ‘insects’ and ‘worms’ is in fact true.

Once water has arrived to endpoints, it encounters several additional deteriorating influences, the foremost being flooding and waterlogging, particularly during the monsoon season (see Fig. 5.1). Public taps are typically surrounded by stagnant water because the ground is relatively low owing to a high magnitude of foot traffic, an artifact attributable to the water retrieval process (see Fig. 5.2). Not only does floodwater threaten to seep into supply pipes, but it does so while inundating poorly built sewage infrastructure and harboring human excreta and solid waste that dots the landscape.412 In addition to penetrating water pipes, floodwater is also kicked up as water seekers trudge to, from, and around the taps—their kodams indiscriminately speckled with droplets of the cocktail. Nalini, a resident of New Nambiyar Nagar crystallizes the myriad opportunities for post-point contamination poignantly:

It is difficult to get water in times of waterlogging. I have to walk to the standpost with my vessels, and I also have to hold up my sari so it doesn’t wet. In the journey, I have to be careful not to step on rocks and garbage that are under the water. When I get to the tap it is difficult to wash the vessel because it just gets dirty from sitting in the dirty water and mud. I

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411 The term puuch can refer to an insect, worm, small fish, and other small organisms. Here, Subramanian indicated (via a translator) that he thinks insects and/or fish are present in the water. I have personally observed such creatures in stored drinking water at the study sites, but I was not able to make a positive identification.

412 Woodson, 2010.

M. Black and B. Fawcett (2008), The last taboo: opening the door on the global sanitation crisis (Sterling: Earthscan).
Figure 5.1: Serial flooding
Flash flooding and prolonged waterlogging, primarily during the monsoon season, represent formidable foes to water quality, not to mention hygiene, mobility, and quality of life. Here, waterlogging is visible in New Nambiyar Nagar (A), Saveriyarkovil (B), Andana Pettai (C), and a septic tank is completely surrounded by water in New Nambiyar Nagar (D), serving to complicate the already low quality.

have to be careful not to get the dirty water in the clean water that I get from the teru [‘street’ in Tamil] pipe. Also, the hose falls in the dirty water and we try our level best to rinse it off, and childrens [sic.] are playing in the dirty water. They think they are having fun, but they don’t realize that it’s not clean and that they are splashing into the good water. Then, I have to walk back home with the vessels, but sometimes I can only carry one vessel instead of two because I have to hold my sari and watch out for rocks and garbage under the water. It is a hectic situation at the tap for all the ladies.

Nalini’s vivid narration of gathering water from public taps during the monsoon season is all too real of an event at the study sites, although it is more characteristic of sites in Nagapattinam District where both flooding (amplified by lack of drainage) and public taps are more common.
Figure 5.2: Flooding of access points
These taps, all in New Nambiyar Nagar, are surrounded by water. Some taps are only accessible by jamming rubber hoses into the supply pipe, which unavoidably flop into the floodwater from time to time. One tap (top center) is completely submerged, and the inserted hose barely extends from the floodwater. Such is the paltry condition for obtaining water for 2-3 months of the year at most post-tsunami settlements.

Hardships during the dry and ‘normal’ (time between the monsoon and dry seasons) periods also exist. First off, although the contaminant load is less during the dry season, the concentration of contaminants is higher as a result of lower volumes of water supplied. Furthermore, the dry and ‘normal’ periods are when families, if the option is available, are forced to rely more heavily on untreated sources of water. Owing to lower volumes of piped water supplies in the non-monsoon seasons, families are driven to consume water from handpumps and borewells, which are shallow (harnessing the less naturally filtered water close to the surface)
and notorious for sheltering bacteriological contaminants. Secondly, most government water taps are perpetually open throughout the year: there is no valve to turn them off and on. Thus, the taps, or what are perhaps better described as ‘open pipe endpoints,’ allow precipitation, dirt, airborne particulate matter, *flora* and *fauna*, and the elements broadly defined to enter. Even worse, many of these ‘open pipe endpoints’ have been equipped with rubber hoses to facilitate the direction of water into containers more easily. However, the ends of hoses, which come into contact with floodwater during the monsoon season, regularly rest on the moist ground or in puddles of water that surround the taps throughout the year. Across time, mud-laden puddles surround the taps, naturally pooling in the concave, foot-trodden ground that envelops them. These ephemeral, yet virtually permanent, pools are filled by the brown, murky water that is released at the beginning of water windows (in the wait for the flow to become clear); *kodams* being rinsed before their filling (with the rinse-water thrown next to the tap); and water inadvertently falling to the ground as one full vessel is removed to be replaced a few seconds later with an empty vessel.

Drainage also increases the risk for post-point contamination. A lack of drainage prevails in Nagapattinam District, thereby resulting in serial flooding and generating numerous opportunities for unhygienic environments. At the other end, an existence of drainage infrastructure in Karaikal District also contributes to water quality hazards. The location of taps

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Black and Talbot, 2005.


Furthermore, a buffer of 100 feet should exist between groundwater sources and septic tanks or leach pits. When possible, the groundwater source should also be placed uphill of sewerage infrastructure. The buffer is impossible to satisfy at the study sites as a result of high housing (and therefore sewerage) densities. Thus, the furthest handpump or borewell from sewerage infrastructure that I was able to measure was 30 feet. Also, while mild undulations are present, the sites are generally flat and rarely allow for the uphill placement of groundwater sources. [Philip, 2012. Woodson, 2010.]
near drainage infrastructure that is often intentionally obstructed by anthropogenic waste makes the collection of safe water treacherous (see Figs. 5.3 and 5.4).

Figure 5.3: Drainage issues
Drainage ditches have been intentionally blocked by bricks in Vettakaramedu (A), cement in Akkaraipettai (B), sand in Samanthanpettai (C), and by solid waste in Mandapathur (D).

Lastly, the storage of water, a necessary practice dictated by a non-continuous supply and meager quantities, engenders additional prospects for post-point contamination. Storage, typically for close to 24 hours in Nagapattinam District (and sometimes for several days when water fails to arrive), fosters microbial growth and a further deterioration of water quality in bacterial terms.\footnote{D. Lantagne and T. Clasen (2011), \textit{Project report: assessing the implementation of selected household water treatment and safe storage (HWTS) methods in emergency settings} (London: London School of Tropical Medicine and Hygiene).} Furthermore, water is removed cup by cup from storage vessels with hands

that may not have been washed, especially among thirsty children returning home from school or playing a game of cricket with friends. At any rate, numerous hands are dipped into water storage containers each day in order to obtain water for consumption, serving to problematize the already poor water quality scenario.415


415 In a survey, Nath (2000) found that 68% of households in rural India take water from storage vessels in the manner described above. Furthermore, Nath confirms that “repeated hand contact with drinking water during collection, storage and serving” increases the risk for post-point contamination. [K.
Water quality tests uphold these assertions on water handling (see Table 5.1). Of the randomized household samples at Kizhakasakudimedu and Andana Pettai, 22 came from the treatment centers that serve the sites. Although tests revealed that water from the treatment centers was negative for fecal coliform (see Appendix E), 13 of the 22 samples (59.1%) tested positive in the household—a clear product of contamination during retrieval, transportation, storage, and serving processes. Analogous results were demonstrated when water from government taps that tested negative for fecal coliform was subsequently checked in the household. Of the 16 samples fitting these criteria, nine samples (56.3%) tested positive at the household scale, again owing to post-point contamination.416

Table 5.1: Post-Point Contamination

<table>
<thead>
<tr>
<th>Safe water source</th>
<th>Samples in household</th>
<th>Safe samples in household</th>
<th>% Safe in household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe water source - treatment centers</td>
<td>22</td>
<td>9</td>
<td>40.91%</td>
</tr>
<tr>
<td>Safe water source - govt. taps</td>
<td>16</td>
<td>7</td>
<td>43.75%</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>16</td>
<td>42.11%</td>
</tr>
</tbody>
</table>

* Safe water defined as an absence of bacteria

Observed collectively, geographies adjacent to the taps, as well as the taps themselves, permanently complicate the quality of water, with numerous opportunities for post-point contamination layered on top. First off, the initial quality of water is already substandard.


416 More than 16 government taps tested negative for fecal coliform, but sampled households that utilize those taps were consuming other sources of water, such as groundwater, pre-packaged water, and water from treatment centers.
Moreover, such quality is secondarily deteriorated by inadequately maintained infrastructure, and the entire canvas is exacerbated by serial monsoon flooding. Yet—unfortunately—few coping strategies, let alone those that amount to long-term solutions, are available to the residents of post-tsunami settlements.

The first and perhaps best method for ensuring potable water is through on-site treatment centers, although this does not address post-point contamination and storage hazards. However, as was reported in the previous chapter, two of the four treatment facilities remain unutilized, thus preventing residents of Samanthanpettai and Amman Kovil Pathu from accessing relatively safer water. As for sites without treatment centers, the facilities are costly and difficult to fund sans external assistance, rendering them financially infeasible for the most part. The result is that households must rely on water provided by the government and untreated groundwater, both of which generally fail to meet acceptable water quality standards. It must be reiterated that the mere existence of on-site treatment centers—which are dispensing water of good quality—do not guarantee that the water, after being placed into (possibly dirty) kodams, trekked back to the home, stored for hours/days, and consumed piecemeal by dipping in cups, will retain its initial quality. Recall (in Table 5.1) that close to 58% of safe water dispensed from treatment centers and government taps underwent post-point contamination by the time of consumption. Thus, anthropogenic contamination remains a formidable hazard, implying hygiene education, behavior modification, and point-of-use disinfection as avenues for intervention.

Ultimately, residents are forced to implement rudimentary strategies to manage the situation. For example, residents let dirty water run from the pipe at the beginning of water windows, walk gingerly to avoid splashing, lay stepping stones to walk in and out of the puddles that inundate taps, and limit storage—which is often beyond their control because of shortages in

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417 The two treatment centers in operation at Kizhakasakudimedu and Andana Pettai tested negative for fecal coliform and passed all BIS standards for chemical constituents, validating the treated water safer compared to water provided by the governments at the two sites.
supply. Other than on-site treatment centers, HWT can represent a simple, time-tested method for eliminating bacteriological contaminants from drinking water. HWT will be detailed in Chapter 7 (see Table 7.1), but for now, suffice it to say that 35 of 169 (20.7%) sampled households in Nagapattinam District and 30 of 131 (22.9%) households in Karaikal District practice methods of HWT. Of the 65 sampled households engaging in HWT, 64 boil their water and one filters their water. However, HWT exhibits serious limitations at the study sites, with only 26 of the 65 (40%) households performing HWT processes producing water free of bacteria (Chapter 7 will expound upon the success of bacterial eradication via HWT). A final method for overcoming water of poor quality is to purchase prepackaged water, typically in 20-liter jugs at an expense of ₹20-30. This method, labeled by scholars as an ‘unimproved source,’ does deliver water that is superior to government-provided water and untreated groundwater. However, of the seven sampled households that consume pre-packaged water, only three (42.9%) tested negative for fecal coliform, which suggests issues of unhygienic handling practices and/or poor initial water quality.

A final, more civically active, method of striving for enhanced water quality is to file complaints with the government. While most water-related complaints pertain to quantity (usually when water fails to arrive for several days), residents of the post-tsunami settlements have made objections over water quality to their respective governments. One instance, during an outbreak of diarrhea in Vettakaramedu that was mentioned earlier, prompted the PWDP to clean the water tower serving the site. However, the PWDP swiftly deflected the issue upon the

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418 Interviewees claim that they increase HWT practices during the monsoon season, during which sickness, especially among children, increases.

419 I consume the same pre-packaged water when I live in the study region. Moreover, all 16 tests I performed on the water revealed that it was negative for fecal coliform and exhibited better results compared to government-provided water for all chemical constituents. In fact, the results were similar to parallel tests of Aquafina and Kinley, two reputable water bottlers in India.

420 While I tested numerous pre-packaged waters from several distributors—all negative for bacteriological contaminants—the trade is unregulated, meaning that vendors at the study sites may be distributing water that is not potable.
residents (a seemingly reflexive action), branding it a result of households intercepting pipes at subsurface levels, which households defend as a necessary action. Residents of Samanthanpettai, in a case also referenced earlier, lodged complaints on the cleanliness of their water tower. However, Nagapattinam Municipality took no action, which led residents to decide to clean the tank themselves—a task they have since performed several times. Likewise, residents of Samanthanpettai have pleaded with Murugaian, their Municipal Counsel, to connect the on-site water treatment center to a municipal stream, a request that has long been neglected. Furthermore, residents of all 14 study sites have made verbal, written, or in-person complaints to unelected leaders, *panchayats*, municipalities, and the PWDP. However, problems persist despite the tiresome legwork, causing many to brand the act of filing complaints as woefully unproductive.

Given the points above, now is a fitting time for a discussion on why some residents of the post-tsunami settlements are hesitant to file complaints. First off, residents postulate that making complaints is a ‘waste of time’ because, in the end, the problems are rarely rectified, leading Siva of Uzhuvar Nagar to state that “it doesn’t matter if we complain, nobody will help and nobody cares about our problems.” In cases when complaints do produce results, it is often after residents voice their concerns numerous times by visiting numerous officials, rendering the extent of work and length of time required for rectification to materialize extremely burdensome. For example, Punita of Mandapathur discloses that she submitted a letter to the local *panchayat* President in complaint of water quality and pressure, which was signed and forwarded to Kottucherry Commune *Panchayat*. Punita contends that “this was done 10 times” until action was finally taken. Yogapriya, the *panchayat* President of Mandapathur, says, “I listen to the complaints of Akkam Pettai people because I also live here. I complain to the water master all the time, but I get no responses.”

Furthermore, during the complaint process, government

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421 Yogapriya (2011), President of *panchayat* at Mandapathur, Kottucherry Commune *Panchayat*, personal interview.
officials quickly turn the problems back on persons lodging complaints, claiming that they are providing ‘good water’ and that the problems have been manufactured by the residents themselves—a stance that does not sit well with the residents of the study sites. Residents also posit that even when they wish to share a concern with government officials, they often do not know who to contact, leaving them feeling helpless.

In a more disturbing case, renters are fearful of lodging complaints because they are partaking in an illegal activity (according to government orders, post-tsunami houses are not to be rented or sold), and because they are viewed as ‘outsiders’ by the settlement community at large. Even more distressing, several interviewees stated that they are not only apprehensive, but genuinely frightened of making complaints. Lakshmi of Akkam Pettai declares:

I complained to the [Kottucherry Commune] Panchayat and to PWD officials who were here fixing a broken pipe. I told them that the water is brown and not good. They said they would look into it, but they never did anything about it. I don’t want to complain again because I don’t want to put our family at risk and I don’t want to make the situation worse than it already is.

Adding to the sentiment, Nagoreammal of Amman Kovil Pathu claims, “I’m too scared to talk to the local leaders and give work requests. I am a minority [Muslim], so if I complain I’ll be ignored and it might start trouble.”

Ultimately, residents of the post-tsunami settlements are jaundiced by the lack of results secured by the predominantly ill-fated complaint process. Adding insult to injury, Vikas, a resident of Samanthanpettai, is perturbed at having to pay taxes for such poor service: “We all pay our taxes [₹700 per annum], but we don’t see any results. Water is a big problem here and the problems never get fixed even when we complain.” Ultimately, the popular action when confronting water issues is to fix the problems at the levels of household and settlement. Residents prefer to introduce temporary fixes, intercept water lines, dig holes to access water at subsurface levels, hire plumbers with pooled funds to rectify small problems, and seek water from other parts of the city—often at a considerable distance. As a resident from Saveriyarkovil makes clear, “It’s easier and faster to fix small problems ourselves. The government won’t help,
so it’s better to do it ourselves.” Concluding this passage on barriers to lodging complaints, Evangeline of Andana Pettai claims that her family’s approach is not to complain to the *panchayat*, rather, “we just adjust to the problems.”

5.3 Pressure

A discussion on water pressure at the study sites is situated between the sections on quality and quantity because all three are inextricably interwoven. Pressure serves to degrade both quality and quantity: it has already been noted that low in-pipe pressure allows impurities to enter underground pipes, and low pressure also manifests itself in a weak stream, making the acquisition of sufficient quantities either impossible or onerous.

First off, pressure exhibits temporal attributes. Pressure is lowest at the beginning and end of water availability windows, while it reaches its height during the middle of windows. Interestingly enough, this assertion does not hold in the case of individual taps in Karaikal Municipality, where pressure actually increases near the end of the window. This is due to some households obtaining a desired amount of water and then closing their taps, which allows the velocity of the remaining flow to be spread across fewer taps, thereby increasing the pressure. Also, in general, the pressure at individual taps in Karaikal Municipality is less compared to other study sites (all of which were provided public taps). The lower pressure is a result of the flow being spread across scores of taps (e.g., 268 in Kilinjilmedu and 122 in Amman Kovil Pathu), as opposed to the flow being divvied among a smaller amount of public taps (e.g., 10 taps in Akkam Pettai). However, it should be articulated that this does not translate to more water per capita at public taps, as they are shared by many households. Pressure also varies throughout the year. Pressure is lowest during the dry season, picks up in the ‘normal’ time, and reaches its peak in the monsoon season—variability that is mirrored by the quantity of water obtained during the three time periods.

Pressure also demonstrates spatial attributes. Taps nearest to water towers exhibit greater pressure than those located further from water towers and those on tail ends. Pressure not only
decreases solely as a function of increased distance, but it also because taps further up the line remove water from a rationed supply that has less and less water behind it to induce pressure—a classic etiology associated with the serial and branched distribution networks applied in India (see Fig. 5.5).\textsuperscript{422} For example, at the site scale in Karaikal Municipality, while three water availability windows are enjoyed in Vettakaramedu and Paravaipettai—which are located closer to the main sump—the other three sites in the Municipality only experience two windows, a phenomenon that can be attributed to the design of supply pipes compounded by reduced pressure from up-pipe taps ‘stealing’ water from those below. Furthermore, at the intra-site scale, variability in pressure as a function of relative distance from the local water tower is palpable. Elucidating the point, taps on the southeast side of Kilinjilmedu receive water before and exhibit greater pressure than those on the north and northwest fringes; taps positioned in the northeastern section of Amman Kovil Pathu dispense water at a higher rate than those in the south and southwest; taps situated on the south side of Akkam Pettai deliver water more slowly compared to those on the north side; taps located on the eastern block of New Nambiyar Nagar release water faster than taps to the west; and in Andana Pettai, which is bisected by a national highway, the water tower was erected on the west side, thus providing water first and fastest there relative to its eastern counterpart. Collectively, these examples of discrepancies in pressure are a function of situational geography \textit{vis-à-vis} the location of the respective water tower in real space. Keeping on topic with two unique cases, taps on the north and northeastern edges of Kizhakasakudimedu dispense water, while the remaining taps remain dry—unable to eke out a single drop; and the settlement of Akkaraipettai is serviced by three water towers, each supplying water to taps at varying rates (the tower furthest east is the largest and typically induces the greatest flow rate). Residents of the study sites are privy to the fact that pressure demonstrates

\textsuperscript{422} Ministry of Urban Development, 2011.

Chinn, 2009.

Bhave, 2003.
spatial variability, often pointing out, in the words of Prema of Amman Kovil Pathu, “people on that side are able to get more water than us because the pressure here is very less.”

Figure 5.5: Design of water distribution networks
This schematic depicts (a) serial, (b) branched, and (c) looped networks. Serial and branched networks, which are inferior, are the most commonly used designs in India. Looped networks are preferable because they are able to exert pressure from more than one direction and they foster continuous in-pipe flow, thus flushing the far reaches and therefore aiding water quality.


Pressure is highly variable and manifests itself in the length of time taken to fill a kodam. For example, the number of seconds taken to fill two standard size kodams (a volume of 30 liters) is as low as 33 and 35 seconds (0.91 and 0.86 l/s) at two separate public taps in Akkaraipettai, but is as appallingly time consuming as 1,419 seconds (0.02 l/s) at a public tap in Mandapathur, and 894 and 861 seconds (both 0.03 l/s) at two separate individual taps in Amman Kovil Pathu. The result is that much time is wasted during the water retrieval process, and that
supply infrastructure problematizes the already inequitable social-hydrology, in effect dictating the winners and losers in its allowance of water.

Coping mechanisms pertaining to low pressure are concentrated on modifying the height at which water is dispensed at the endpoints. Elementary laws of physics decree that a lower tap height relieves water of its arduous travel to a higher altitude, thus allowing it to be released from a relatively lower height at a faster rate—a concept that does not escape the residents of post-tsunami settlements. Therefore, the predominant method utilized for increasing pressure in the post-tsunami settlements is to manually saw taps at a level that is closer to the ground, which is visible in several photos in Fig. 5.2. However, even the lowering of taps to near surface levels has proven futile at many of the study sites, prompting more dramatic modifications. Ultimately, holes have been dug and numerous taps have been lowered to sub-surface levels in order to induce flow, with the flow rate after the severe modification still remaining painfully slow (see Fig. 5.6). Worse yet, the low pressure persists so acutely that small containers must be filled at sub-surface levels and then hoisted to ground level in order to fill _kodams_ in a one-by-one, piecemeal effort—a laborious task indeed (as seen in photos ‘A’ and ‘C’ in Fig. 5.6). However, the flow of water still tapers off and frequently ceases, forcing residents to suck on the end of the hose in order to encourage flow, essentially siphoning water from the pipeline. Yet, the hardships to do not cease. During the monsoon season, the holes fill with precipitation and floodwater, causing water quality issues at best, and effectively shutting down taps for days or weeks at a time at the worst (see Fig. 5.7). Vani, a resident of Kizhakasakudimedu, testifies that this is the case:

In rainy seasons the hole fills up with water and makes it very difficult to get water. I have to scoop out the water from the hole, but it soon fills up with water again. Sometimes I use this water for cleaning and bathing, but not for drinking. Sometimes I have to stop using my pipe and get vessels from a neighbor’s pipe if they have water to spare.

Supplementing the discussion of low pressure is the case of meters installed by PWDP in Karaikal Municipality, which was described in Chapter 4. Suffice it to say that the meters,
which have never been operationalized by PWDP, complicate the pressure scenario and impel households to bypass the meters in order to regain lost pressure (as portrayed earlier in Fig. 4.2).

Figure 5.6: Water pressure

In order to access water, taps have been lowered to sub-surface levels at Saveriyarkovil (A), Akkaraipettai (B), and Kizhakasakudimedu (C). In photo ‘C’, a young girl is forced to fill small a container with water and then pour it into a larger container at surface level.

Residents of the study sites submit complaints to concerned government agencies in a last ditch effort. It was previously posited as to why individuals shy away from lodging complaints, but they have been made nonetheless. Sangeeta of Akkam Pettai complained to the panchayat, but was summarily rebuffed:

I complained to the panchayat that the pressure at my tap is too low and that sometimes no water comes. They said that there was breakage in the
underground pipe when the road was built and that it would be too
difficult to identify where the breakage is and too expensive to tear up the
road. So, they told me to use a different tap. They don’t realize that other
people don’t want me to come to their tap and that other taps have the
same problem.

Nisha, a resident of Amman Kovil Pathu, encountered a similar problem, and she did not
envision the situation improving in the short-run:

I complained one month ago that pressure is low. The government said a
pipe was broken between the tank and the settlement, but they didn’t fix it.
Now, MGR Nagar [a separate, adjacent post-tsunami settlement] was
empty for the past one year, but now it is filling up with people. The
pressure is getting less because they use the same tank [water tower] as us.
Now the same water is being used by 250 houses instead of 125, so
pressure and quantity are decreasing.

Figure 5.7: Water pressure and the monsoon
Access to water at this sub-surface tap in Saveriyarkovil has been obstructed by
recent monsoon rains, rendering it useless until the rains subside.
In an effort to put forward a positive case of lodging complaints, Aanandi of Akkaraipettai recounts how she contacted a superior official in order to restore pressure:

I was getting water from a hole below ground level. I told about pressure problems to Sankar [panchayat President], but the problem was fixed only after going next to K. A. Jayapal [State Fisheries Minister who lives near Akkaraipettai]. He reminded Sankar to fix it and then it was fixed after a few days. Sankar promised to fix it, but he didn’t fix until I contacted Jayapal.

In the end, informed by dozens of interviews with interlocutors, complaints over the abominably low pressure are generally destined for vain outcomes, not to mention that the infrastructure and supply regime upon which pressure depends are ersatz configurations to begin with. Ultimately, the most immediate and rewarding method for increasing pressure remains to lower the height of taps, even if that translates to digging holes in an effort to intercept pipes at sub-surface levels.

5.4 Quantity

The trifecta of salient issues perturbing the waterscapes of post-tsunami study sites, including quality and pressure, will be closed with a discussion on quantity. Securing an adequate quantity of water is a daily battle, but the crusade is most difficult in the dry season. During this time of year, interlocutors argue that they obtain roughly 50% less water when contrasted with the monsoon season. Moreover, as imparted by numerous interviewees, the dry season is when the consumption of water increases—particularly for drinking and bathing—leading to an amplification of water deficits. For example, as attested to by Selvi, a resident of Saveriyarkovil, “In the rainy season I get 7-8 pots of water [per day], sometimes I get so much that I don’t use it all. In the dry season I only get about 3-4 pots of water, but that is when I need water the most.”

Furthermore, at a finer temporal scale, quantity is low at the beginning and

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423 Ruet, Saravanan, and Zehra, 2002.

424 For additional perspective, a resident of Mandapathur claims that her household obtains ‘about five pots’ per availability window in normal times, but ‘only two pots in the dry season,’ while a resident of Kilinjilmudume estimates that she is able to collect six kodams during each water availability window during the monsoon season, but only four kodams per window during the dry season.
end of each water availability window, owing to pressure being low at the beginning, picking up in
the middle, and tapering off near the end. Spatial attributes of quantity also exist, primarily an
artifact of pressure, relative distance from the water tower, and location along the pipeline, which
was already discussed in the previous section. The result is that the allocation of water is biased
towards taps closer to the respective water tower, with volumes dispensed at further taps
decreasing as distance increases.

Water availability windows also complicate the water quantity scenario. Not only do
they anchor water gatherers to the household during prescribed time periods, but they also
ascribe opportunity costs and conflict with the performance of necessary, often gendered
domestic tasks. Water availability windows occur in the morning (with sites that have two
windows experiencing a second window in the afternoon, and sites with three windows enjoying
a short window of availability at midday), which conflicts greatly with ablutions, cooking
breakfast, dressing children for the day, and heading off to work or school. Akila, a 16-year old
resident of Akkaraipettai, states, “I leave for school at 9am and I want to bathe and eat before.
But mom and I are too busy getting water, so sometimes that’s not possible. Dad also has to
leave for work, so it is very difficult.” A fellow resident of Akkaraipettai, Geetha, raises similar
concerns:

I want water to come in the evening. In the morning we are busy cooking,
eating, going to work, and I’m going off to college. We are all busy in the
morning, so water should come in the evening. Then it would be less
stressful and less tension because we would already have water when we
wake in the morning. Too many thanni [‘water’ in Tamil] problems are
there, romba kashtam [‘very difficult’ in Tamil]. But we cannot survive
without water, so we must get it when it is coming.

Symmetrical anxieties were enunciated across all of the study sites, with no option available
other than obtaining the much needed water as it is made available. Lastly, discussing the
confliction of water windows with daily life, residents of Theti, a Muslim site, distress over the

major cities,” Economic & Political Weekly 42(3).
timeliness of water availability during the holy month of Ramazan (Ramadan), as shared by Nada:

During Ramadan fasting water comes from 8-9am [the normally scheduled time of the supply window]. The time is bad because that is when people are going to work and school, and also that is not when we need water at that [Ramadan] time. We eat during the night and very early in the morning when it is still dark, so that is when we need the water. People who are home at that time [8-9am] want to be sleeping and want to be in bed without interruption, but we must wake up to get water. Some of us stay awake until the water comes and then go to sleep, but that is not what we want.426

Thus, the incongruency of water windows with daily tasks (e.g., cooking, bathing, and getting ready for work and school) and culture (water’s intersection with social, religious, and domestic rhythms) continues to influence the existence of post-tsunami settlement life. However, the indispensability of water (at an adequate quantity) compels residents to synchronize their lifecycles around availability windows, lest they be left with no water.427 The claim is bolstered by Rama of Amman Kovil Pathu, who contends, “That is when water comes so we must get it at that time. What to do? There is no other go.” The contention is especially relevant in Nagapattinam District, where water arrives but once per day, permitting a single opportunity for fetching water.

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426 Post-fieldwork, I was informed by members of the panchayat—confirmed by residents—that the water window during the last Ramadan was changed to 6:30-8am when possible. According to the informants, the window was ‘pre-poned’ about ‘half of the time.’ The individual in charge of the local water tower lives in Theti and was able to turn on the valve at the new time; however, this was only effective when the tank had already been filled by TWAD, which did not always occur. The earlier window, albeit not achieved 100% of the time, was greatly appreciated by the residents. [I. H. Kareem (2012), Treasurer of panchayat at Theti, personal interview. Sundarmurthy (2012), President of panchayat at Theti, personal interview. Thajudeen (2012), Vice President of panchayat at Theti, personal interview.]

427 Several residents of Vettakaramedu and Paravaipettai expressed that the three water availability windows experienced at their sites enable them to work outside of the home. Residents stated that they are able to leave for work early and skip the first two windows (in the morning and at midday), but return home in time for the third and final window. Without that last window, state single parents working outside of the home and households with both heads engaged in outside work, they would not obtain any water and would either be forced to forsake paid employment or work fewer hours.
Density at public taps is another obstacle in the quest for attaining adequate quantities of water. While residents of sites in Karaikal Municipality enjoy individual taps, residents in rural areas of Karaikal District and all sites in Nagapattinam District must gather water from public taps. While some public taps are shared by less than 10 households, others are shared by 15, 30, and even 100+ households (see Fig. 5.8). Thus, the quantity of water dispensed by taps is divided among the number of households utilizing the tap, which triggers issues of equality, equity, and biased social hydrologies. Gomathy, a resident of Samanthanpettai, states, “We have a very crowded tap with 16 houses, and we only get water for one hour per day, so I don’t get enough water. We barely survive each day.” Furthermore, when individuals from relatively crowded taps travel to more distant taps in order to obtain greater quantities, they are often shooed away and told to ‘get water from your own tap.’ Water gatherers at less crowded taps do not wish to share their less partitioned quantities of water, which they feel they are entitled to as a function of the proximal location of their house, serving to reify the unequal distribution of water.

Further complicating the quantity of water is the sporadic nature of its availability, which wreaks havoc on the lives of post-tsunami settlement residents. While water is scheduled to arrive at pre-defined availability windows either once, twice, or thrice per day, it is common for water not to arrive—sometimes for several days consecutively. For example, in summer 2011 at Vettakaramedu, water failed to arrive for six consecutive days. Residents were forced to walk upwards of one mile to obtain piped water and to bathe and do laundry in a nearby canal. On the second day, PWDP dispatched a tanker lorry to service the site. Households were able to obtain 2-3 kodams of water each; this amount sufficed for consumptive purposes, while the canal met other needs until water finally arrived four days later. Similarly, in September 2011, while attempting to measure flow rates and gather samples for water quality testing in New Nambiyar Nagar and Saveriyarkovil, I witnessed the failure of water to arrive for three days (Theti was simultaneously not supplied water for two days). Water was dispensed on September 15th, but was not dispensed again until September 19th, prompting residents to walk and bicycle 1-2 miles
Extreme density is visible at this public tap that dispenses water for only one hour per day in Akkaraipettai.

to retrieve water for consumption, and to use a nearby pond—located adjacent to the area used for OADU—for bathing, laundry, and washing dishes. Nagapattinam Municipality did not dispatch a tanker lorry.

The absolute availability of water resources is a reason for intermittent water supplies. However, a more immediate reason is a shortage of electricity. A shortage of electricity is a regular component of Indian life, evidenced by 650 million in North India being without electricity for several days in July 2012 (which became an international news story) and regularly scheduled ‘power cuts’ in the study area. A function of insufficient generation of
electricity and infrastructure not working at capacity, Nagapattinam District exercises scheduled electrical outages on a daily basis from 6-8am. Additionally, random, non-scheduled outages occur frequently throughout the day and last from a few minutes to tens of hours. Furthermore, during the dry season—when both electricity and water demand reach their peak—and partially during my fieldwork in the non-dry season, power outages in Nagapattinam District were scheduled from 8-10am, 2-4pm, and 6:30-7:30pm, and random outages occurred in the meantime. The result, which should come as no surprise, is that water is not able to be supplied during electrical outages, which produces grave situations during the dry season. Engines at pumphouses lose power, hindering the conveyance of water across space, and pumps beneath water towers, which harness water to higher altitude tanks allowing it to be supplied to subsurface pipes with pressure, are paralyzed. Ultimately, when water windows conflict with power outages, whether scheduled or random, water fails to arrive and residents must wait until the following day to access water—a hopeful scenario that may or may not materialize. Furthermore, while some residents of the study sites have installed borewells in order to supplement inadequate quantities of piped water, their pumps operate via electricity and are therefore rendered inoperable during electrical outages, reducing borewells to mere aggregates of metal and plastic. In the end, quantity is rigidly dependent upon electricity, with few economically feasible options for both settlement residents and local governments. For now, seeking temporary sources of water and playing a dangerous ‘electricity waiting game’ are the only accessible alternatives for residents of the study sites.

Suffice it so say that water insecurity, an etiology of temporal and spatial ramifications, availability windows, density at public taps, and erratic supply regimes compounded by electrical outages, remains a perverse phenomenon at the post-tsunami study sites. Before turning attention to coping mechanisms, which amount to little more than satisficing, Devika, an elderly resident of Kizhakasakudimedu, communicates the degree of the situation broadly:

We do not get enough water, but somehow, by God’s grace, we survive. I have to walk far to get enough water and then carry it home. I am 57 years old, so it is very difficult and my knees and back ache. Luckily,
only two people live in our house, so we don’t need a huge quantity. We could not survive if there were more people living in the house. Even with two people we have to limit our usage. Water has control of my life.

Several mechanisms for coping with an insufficient quantity of water have been implemented at the study sites, although most constitute temporary fixes and none serve to purge the issue of existence. The foremost method for adapting to meager supplies of water is storage. Water gathered during pre-defined windows is stored in an assemblage of *kodams*, large cooking vessels, buckets, tanks designed for storing water, and even fishing coolers (see Fig. 5.9).428

![Picture of storage methods]

*Figure 5.9: The storage of water*

The storage of water is an archetypal fixture of post-tsunami settlement life. Here, water is stored in an unused bathroom (A), an unused kitchen (B), and in a storage tank provided by the constructing NGO (C).

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428 A resident of Amman Kovil Pathu went so far as to build a closed cement tank for the sole purpose of storing water.
Water is typically stored in bathrooms, which remain unused according to cultural-religious rationale, or in kitchens, which are employed as storage areas for sundries since cooking is performed outside (kitchens do not have ventilation, which is required when cooking with wood and kerosene as fuel). The storage of water not only allows households to ‘see’ the quantity of water that must be rationed until the next availability window, but it also hedges against the possibility that water may not arrive during the next window. The storage of water is so common at the study sites that virtually 100% of sampled households articulate that they store water on a daily basis. In fact, only three of the 300 sampled households state that they do not store water; all three households are in Akkam Pettai, and all three rely exclusively on privately constructed borewells.

Another method for attaining greater volumes of water entails individuals searching for resources away from their prescribed public tap (and even away from their individual tap when that source fails to dispense adequate quantities). It was already mentioned that seeking water from other taps, be it in the same settlement or at taps located outside of the settlement, is a setting for confrontation. Individuals doing so are commonly harassed and told to obtain water from their own source. Still, being that water fails to arrive in sufficient quantities or fails to arrive altogether, it is common for residents of New Nambyar Nagar, Uzhuvar Nagar, Saveriyarkovil, Andana Pettai, Akkaraipettai, and Kizhakasakudimedu to walk or bicycle up to 1.5 miles to obtain water, only to turn around and lug the heavy ‘blue gold’ back home. Interestingly enough, a unique case of obtaining water from abandoned houses has emerged at Kilinjilmedu. With an occupancy rate of 83.75%, 52 houses remain unoccupied. However, many of the individual taps at the unoccupied houses dispense water. Thus, families allotted

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429 Unfortunately, when water does arrive during the next availability window, the balance of stored water is poured out (i.e., not consumed) and is effectively wasted. However, some individuals pour the water near plants or trees in an effort to help them grow.

430 Bapat and Agarwal (2003) document the same issue in Pune and Mumbai. That being said, residents of the study sites often have relatives, friends, or neighbors who accommodate them or who are willing to part with a kodam of water. [Bapat and Agarwal, 2003.]
houses with low pressure taps, as well as those who seek to double their quantity of water, gather water simultaneously from their own tap and a nearby unoccupied house, as explained by Elangovan:

The pressure at our pipe is very less. Our children get whatever water comes to our pipe, and my wife goes to the [empty] neighbor’s house and gets water there. In this way we are able to get enough water. I don’t know what we will do if the neighbors move into the house, we will have to adjust.

In addition to searching for external sources of water, numerous constituents of public taps have developed queuing systems in order to avoid conflicts and apportion water woes more smoothly. Queuing systems are flexible, differ across taps, and demonstrate temporal characteristics. That is, the queuing systems are not static (they can be changed from day to day based on the availability of water and individual water needs), not all taps practice a system and each system is organized differently, and queuing systems are most prevalent during the dry season (when quantities are stressed) and tend to dissolve during the monsoon season (when quantities increase). Examples of queuing systems include: a member of each household sharing the tap takes two kodams and then all members take an additional kodam one-by-one until the water window closes; half of the households sharing a tap retrieve water today, and the other half fetches water the following day (meaning that households gather water every other day); each household takes as much water as is needed, but the last to get water on a given day is the first to get water the following day; and those who most urgently need water (based on work and domestic schedule, family size, and amount of water obtained the prior day) receive water first. These organic systems for distributing limited quantities of water in a more equal and pacific manner have proven efficacious, with many individuals noting that obtaining water no longer ‘affects me mentally.’ However, queuing systems are not a panacea; conflicts still erupt as relatively older individuals and those who allege superiority (often through class, family ties, or social status) avow that they deserve water first.

Modifying the usage of piped water supplies and transferring usage to other freely available sources (e.g., surface water and rainwater) are two further approaches utilized for
managing deficiencies in quantity. Curbing the usage of water, particularly during the dry season and when water fails to arrive, is widely practiced across the study sites. A number of families shared that they are forced to curtail the frequency of bathing, cleaning, and washing laundry in order to conserve scarce quantities of piped water. Selvanayi, a resident of Kizhakasakudimedu, makes this apparent:

We are six people in this house. We cannot afford to put in a borewell, so we have to make due only on the pipe water that is coming. Sometimes there is not enough water, so I have to give preference to my twin babies. I only bathe if there is water remaining and after the others bathe before me. Still, there is a shortage of water and I cannot do laundry every day, I have to do it every two or three days because the quantity is so low.

Priya of Andana Pettai agrees with Selvanayi, noting:

My husband only bathes in the morning, but he wants to bathe twice in a day. Our kids only bathe once in every two days. Also, I have to hold back on washing garments and cleaning the floors. We must adjust water usage and only use it for drinking and cooking when there is not enough water. If we were able to get just two more vessels of water per day then we could fix all of this.

Relegating bathing, laundry, and even dish washing to bodies of surface water, such as nearby ponds, rivers, and canals, is yet another method for coping with water scarcity. While some sites, such as Amman Kovil Pathu, Kilinjilmedu, Samanthanpettai, and Theti, are not located near bodies of surface water, residents of Andana Pettai, New Nambiyar Nagar, and Saveriyarkovil, utilize ponds located near their sites in times of distress, while residents Uzhuvar Nagar and Akkaraipettai use nearby rivers, and inhabitants of Vettakaramedu make use of a nearby canal. Furthermore, some residents supplement insufficient quantities of government-provided water by catching rainwater, which is used for bathing, laundry, post-defecation ablutions, and watering plants. Preethi, a resident of Kizhakasakudimedu, demonstrated how she directs precipitation from her roof into buckets (which she uses to wash laundry), while Ranjini of Saveriyarkovil discloses:

I collect rainwater during the rainy season to bathe, wash laundry, and to wash after [using] the toilet. Some people say that I am crazy and that what I am doing is dirty, but I think the water is pure. I am an elderly person, so I can’t get much water because it is too heavy to carry from the
Thus, the practice of modifying water usage—whether through conservation, performing water-based tasks sparingly, or by tapping into freely available sources, has been demonstrated as a coping mechanism of primacy.

Residents of the post-tsunami study sites also employ coping mechanisms that entail financial investment. However, as a circumstance of cost, such methods are only implemented in dire times or by households that possess the requisite resources. In times of dire necessity—typically when water has not arrived for several days with no response by the government—it is common for a portion of a post-tsunami settlement (or the entire settlement) to pay for a tanker lorry to service the site (see Fig. 5.10). Tanker lorries extract water from borewells in rural areas and transport it to communities in need—for a price, of course. Sometimes local governments dispatch and pay for tanker lorries to alleviate localized water emergencies, but it is customary for households, on their own, to pool funds in order to have water physically brought to their settlement. Natarajan, a resident of New Nambiyar Nagar, claims that he and his neighbors have called upon tanker lorries several times: “When water isn’t coming for many days we call a tanker lorry. The water comes from Kilvelur [a rural area in west-central Nagapattinam District] and costs ₹850 for 12,000 liters.” On a smaller scale, it is common for thirsty households to purchase water from entrepreneurial middlemen, who purchase large amounts of groundwater or tanker lorry water (usually 500-1,000 liters) to sell in smaller increments at a profit. Ox-drawn wagons hauling tanks brimming with water ply the parched settlements vending water on a unitized basis. Residents simply flag down the carriage, fill their containers with water, and pay the standard price per vessel, typically ₹3. It must be noted that such sources of water—both tanker lorries and water vended from bullock carriages—are not only relatively expensive, but demonstrate no water quality control measures whatsoever.

Other methods of investing in water security include purchasing pre-packaged jugs of water (known colloquially as ‘can water’), and installing a borewell or handpump (known colloquially as an ‘adi-pump’). ‘Can water,’ analogous to the jugs of water present at business
Tanker lorries transporting water, such as this one in Nagapattinam District, are part and parcel of life in India, a progeny of insufficient government supplies. Tanker lorry water is extracted from the ground and is not treated; in fact, the trade is not even regulated. It is argued by numerous government officials that such water need not be treated because it is ‘good water,’ ‘sweet water,’ ‘it comes from the hills,’ and ‘it comes from rural areas.’ Tanker lorry water generally comes from Kilvelur in Nagapattinam District, and Nedangadu Commune Panchayat in Karaikal District.

Offices in the West, costs ₹20-30 per 20-liter unit. Only seven of the 300 sampled households purchase ‘can water’ on a regular basis (it was cited earlier that water from four of these sources tested positive for fecal coliform, although this may be a function of unhygienic storage practices). More expensive yet, a considerable number of households have invested in either borewells or handpumps (see Fig. 5.11). While costs vary, after speaking with three plumbers, parts and labor for installing a borewell amount to roughly ₹3,000 to upwards of ₹5,000, while a handpump costs, on average, ₹1,500-2,500. These means of harnessing groundwater alleviate issues of water scarcity and provide a measure of convenience by affording access to water both when it is desired (i.e., not in pre-set windows) and on the premises. However, it must be mentioned that the water is untreated, comes from shallow sources (where water is more likely to
Figure 5.11: Private handpumps

Water is being retrieved from a privately installed handpump in Saveriyarkovil. Several neighbors are permitted to use this source of water freely, especially when water fails to arrive and for washing laundry.

be contaminated), and borewells cannot function during electrical outages—which severely limits the coping arrangement. That being said, numerous residents of the study sites vehemently stated that they could not survive if they did not have access to a borewell or handpump. Chellarisi of Akkam Pettai contends:

We do not get enough water. Only because we have a borewell do we get enough water, without the borewell we would only have pipe water and we couldn’t survive. I have a one month old baby, so I need lots of water and I must keep the house clean. I don’t know what would happen if we didn’t have the borewell, it would not be a good situation.
In a display of camaraderie, water from privately owned borewells and handpumps is often shared with neighbors and relatives, although feuding sometimes causes access to be withheld. Furthermore, several panchayats have provided handpumps in the post-tsunami settlements. Sankar, the panchayat President at Akkaraipettai, contends, “The panchayat has supplied many handpumps to the settlement. We have provided one handpump for every 30 houses.”

Similarly, North Poiganallur Panchayat provided two handpumps at Uzhuvar Nagar. Local governments have also introduced handpumps at other settlements, but they have since fallen into disrepair or been raided for their parts, rendering them inoperable.

Cost is not the only barrier to introducing borewells and handpumps, whether privately or by the government. Geographic underpinnings weigh upon the quality of sub-surface water at the site-specific scale, and can therefore prevent the introduction of such coping devices. For example, residents of New Nambiyar Nagar and Andana Pettai voiced that they would like to install borewells or handpumps, but that the quality of the water—described as ‘too salty,’ ‘brown,’ or ‘not good’—prohibits them from doing so. Thus, not only is cost a formidable obstacle to implementing methods for groundwater extraction, but the quality of groundwater present in micro-geographies can also disallow the practice—even when the cost of investment is feasible.

A truly innovative case of coping with scarce quantities of water takes place in Akkaraipettai, and may be expressed with the moniker ‘thanni’ [‘water’ in Tamil] and the tower’ or ‘pani’ [‘water’ in Hindi] and the pebble.’ In 2008, during a strenuous time of meager water supplies, a system was devised to measure the water level in one of the water towers serving Akkaraipettai. Day in and day out, residents would wait for water during the allotted water availability window, often to no avail, prompting male residents to ascend the ladder attached to

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431 Sankar, 2011.

This statement is true, but the ratio of handpumps to houses is moderately exaggerated and closer to one handpump for every 40-50 houses.
the water tower. The vantage point enabled them to peer in to see if the tank was full: if the tank was full, they would be supplied water that day, if the tank was empty, families would make plans to secure water by other means. After making do with this arrangement for several months, an idea was sprung to tie a stone to one end of a string, and a fishing float (placed inside the tank) to the other end of a string. Through the contraption, the float would rise if the tank was full, in turn lowering the stone which dangles visibly from the side of the water tower, and the float would rest on the bottom of the tank if it was empty, thereby raising the stone (see Fig. 5.12). The system—which resembles the method used to determine the amount of gasoline in the tanks of automobiles—was a success and its usage continues to this day. In fact, the float system is being exploited at the other two water towers serving Akkaraipettai, and residents claim that other post-tsunami settlements located in rural areas have caught wind of the innovation and have also put it into practice. Now, Rajjilakshmi, who lives just 15 feet from the water tower, monitors the level of the stone throughout the day; she describes the process vividly:

I look at the stone many times in a day, I can see it easily through my door. If the stone is near the top, I don’t bother waiting for water and instead I can put my effort to do other tasks and wait until the tank is full. I look at the stone first thing in the morning and several times throughout the day. Other Akkaraipettai people also see the stone and some call me [by cell phone] to ask where the stone is, so everybody knows the water situation. The panchayat water service man knows that we did this and he is okay with it. Sometimes he calls me and asks where the stone is. If the tank is empty sometimes he turns on the pump from his location to fill it up if he has water. We have control of the valve at the bottom of the tank, so whenever it’s full we turn on the valve to get water. We always wait for the tank to be full so that everyone can get water. If it’s only half full then there won’t be enough water for everybody because it won’t be shared equally. But, if we haven’t gotten water for 2-3 days and the tank is only half full then we turn on the valve anyway because we need the water. We can notice a big difference in pressure from when there is a full tank or a partially full tank. The stone helps us a lot, there is less tension here now. It does not fix the problem, but it allows us to know the situation so we can make other plans and so we don’t have to waste time waiting for water.

The float system, blossomed by Rajjilakshmi’s candid narration, is a classic case of innovation in the throes of adversity. Furthermore, her determination to share lean quantities of water equally
is positive in this age of conflicts over resources, especially in a region notorious for contestations over water.

Figure 5.12: Float system
The water tower serving the northwest section of Akkaraipettai (left) is equipped with a float system in order to gauge the level of water. The stone hanging from the side of the water tower (circled in red on right) is raised or lowered depending on the amount of water present in the tank. In the photo (right), the tank is half full; the tank is full when the stone reaches a level roughly two feet below the blue line.

Finally, while complaints have been lodged regarding quality and pressure-related malfeasances, complaints over insufficient quantities, particularly when water fails to arrive for several days, top the list. However, raising grievances has neither proven an effective coping mechanism nor an avenue to compel local governments to provide greater quantities of water. At best, complaints elicit local governments to dispatch a tanker lorry to sites that have not received water for several days, as occurred in Vettakaramedu in a case highlighted earlier. However, settlements typically must go without water for 2-4 days, and the scenario must be
brought to the government’s attention (in this way, complaints do sometimes secure results). Although tanker lorries are (on certain occasions) sent to sites, they dispatched only in times of impending crisis and possible upheaval, and such actions are merely stopgap measures that do nothing to erode underlying issues of agency supply, infrastructure, and capacity.

Other than dispatching tanker lorries, there has been little acquiescence on the behalf of governments to supply greater quantities of water, leaving the inhabitants of post-tsunami settlements to wallow in the status quo or, when possible, to attempt to rectify quantity-related problems themselves. For example, Balakrishnan and Vijayarani, residents of two separate houses sharing the same public tap in Saveriyarkovil, iterated a circuitous account of demanding greater volumes of water. Their public tap, shared by 16 households, failed to dispense water, a condition they attributed to low pressure and broken underground pipes. When digging a hole to intercept the pipe at a subsurface level proved futile, the collective households demanded Viji, their local unelected representative, to contact officials at Nagapattinam Municipality. After hearing no response and suffering several days of groveling for water at other taps and trekking one mile for water, the sharers of the tap decided to take further action. According to Balakrishnan, “Representatives of five families from the tap went to the Municipal Office to tell about quantity problems. We told them there is leakage that is causing a shortage of water.” Granted only lip service and struggling with the same situation for several more days, Vijayarani claims, “Eight people from the teru [‘street’ in Tamil] pipe went to the Collector’s Office with a letter saying that there is no water due to breakage. We even followed up two more times.” However, no action was taken, and the households were thrusted to resolve the issue through their own means. The households pooled funds to hire a plumber and two laborers to fix the pipe during the dry time (not during a water window). The plumber and his hired hands tore up the ground, sawed off a section of the broken pipe, laid a new plastic pipe with a tighter fitting, and fashioned an access point below ground level in a hole that was lined with cement. The cost, according to the two interlocutors, was ‘about ₹90 per household,’ a substantial amount for many residents of the post-tsunami study sites.
The case of (multiple) formal complaints lodged in Saveriyarkovil opens a revisiting of the rationale by residents for not requesting assistance from local governments. As has been evidenced throughout this chapter, lodging complaints requires considerable time and effort (often involving travel by bus, bicycle, or foot), and the results are generally nonexistent or delayed at best. Add to that the families who rent houses or wish not to create problems for their family (whether this fear is real or perceived), and the predominant response to grappling with water woes is to fix problems themselves (when possible), and to live with the problems as permanent fixtures of their lives through adjustment, acclimation, and acculturation.

5.5 Conflicts and the colonization of water

Owing to socially and environmentally-constructed scenarios documented in the previous three sections, water has emerged as a source of confrontation at the study sites, despite the establishment of queuing systems and laudable efforts (such as that described by Rajjilakshmi in Akkaraipettai) to share water equally. Conflicts over water are common at the study sites, and they exhibit temporal, situational, and density-related properties.432 Temporally, while conflicts can erupt at any time, they are most common during the summer, when pressures decrease, quantities supplied diminish, water is more likely not to arrive (a factor of limited resources and electrical capacity), and consumers warrant greater demands. Situationally, conflicts can arise at any time of the year when water is scarce, water windows unexpectedly begin late or end early, individuals cut in line, refuse to heed the queuing system, or usurp more than their fair share, and when individuals have pressing concerns and therefore argue that they are entitled to more water.

or should be granted water first. In terms of density, conflicts are non-existent in Karaikal Municipality (where households were provided individual taps), are infrequent at public taps with low densities, and are most common at public taps serving large numbers of households.

Conflicts generally constitute heated arguments, although those arguments can fashion permanent friction and can even disturb residents psychologically. In rare cases, arguments explode physically, leading to the hurling of others’ *kodams*, and in even rarer cases to the extremes of hair pulling and shoving. In an attempt to bring some of the causes for conflict to life, Harini of Saveriyarkovil talks of a consistent troublemaker:

> House number XXX [retracted to retain anonymity] fights all the time, it’s her character. She is supposed to get water from a different pipe, but she always comes here and starts problems. She is known as *amma* [‘mother’ in Tamil], she thinks it is a sign of respect, but we use it secretly as a joke. People both laugh and are scared when they hear the name being said. She fights with people daily, and sometimes the veins in her neck and forehead pop out because she yells so loud.

Supplementing Harini’s account, it appears that ‘troublemakers’ populate many of the sites, with Sana of Theti describing how “one lady always takes water first ever day, and she fights when she isn’t able to get water first,” and a resident of New Nambiyar Nagar claiming, “One lady fights daily with everybody, especially in the dry season. She is a bitter woman looking for a fight.” Furthermore, Malathi, a resident of Mandapathur, identifies individuals using the areas surrounding public taps as laundry centers as instigators:

> Some people wash their garments at the [water] pipe. They take too much water and they keep taking water in the middle of the queue to wash their garments. This stops others from getting enough water, but they don’t care. We need water too and we also have to wash our garments. This is the cause of many fights here in Mandapathur.

As for another case of situational conflicts, Bharathi of Akkam Pettai describes the situation when there is no electricity:

> There are many houses here that only use borewells or that mainly use borewells. But when there is no electricity these people crowd the pipes

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433 I witnessed numerous heated arguments during pre-dissertation field visits and formal fieldwork, and two cases of physical conflict: one in New Nambiyar Nagar and one in Saveriyarkovil.
and take water. This creates fights because it means that we are not able to get as much water as we planned. This happens too much.

Lastly, numerous households at settlements located in Karaikal Municipality voice that they are satisfied with having been granted individual taps because prior to the tsunami they too were forced to retrieve water from public taps—which often involved witnessing and participating in conflicts. Divya, a resident of Paravaipettai, voices such concerns:

> There are problems here, but the best change [from prior to the tsunami] is that we have our own [water] pipe. Before the tsunami, I had to get water at a street pipe with 30 or 40 houses. Daily there were arguments and it really affected me mentally, believe me. I get nervous just remembering the tension. Now, we all have our own pipe and it is better. We don’t fight and I am in a better mental state now.

While the inhabitants of sites located in Karaikal Municipality, as well as the few households that have invested in individual taps at other sites, enjoy lives free from conflict, the tumult continues. Unfortunately, the combination of limited supplies, infrastructural shortcomings, and lack of response by the respective governments provide scant hope of such conflicts dissipating in the short-run, and perhaps arguably in the long-run.

The ‘colonization’ of water access points is a final phenomenon that must be observed, as it serves to perturb the already unbalanced social hydrology. In Akkam Pettai, a unique case of claiming private rights to public water access points has emerged. The public taps at the site were built near the streets, but are located roughly five feet away from the streets in residents’ yards. While the preponderance of households allow neighbors to enter their yard in order to access water (see Fig. 5.13), others have erected fences in order to control who is permitted access to the indispensable resource—in effect colonizing access points as their own, and discretionarily allowing, or disallowing, access to water. At least three public taps in Akkam Pettai have been colonized, with the outcomes causing agony among nearby households that must walk farther to access water (not to mention that the density at those further taps has been artificially increased) or who are only allowed access when the colonizing household is home. Chitra expresses her concerns:
Figure 5.13: The ‘decolonization’ of water
This public tap in Akkam Pettai has been modified with a hole cut in the corrugated steel in order to extend accessibility to all households on the street. However, other households have erected impervious fences in an effort to authorize greater quantities, command control of access, and prevent intruders.

They [the family that colonized the nearest public tap] don’t allow us to use the pipe even though everybody knows the pipe is for everybody. They only let their relatives and friends use the pipe. It’s not fair. I have to walk 100 meters to another tap, but they [at the other tap] tell me to get water from a different pipe because the amount of water is less when I come.

Umarani finds her family in a similar, albeit slightly better, predicament:

My neighbor [who colonized the nearest public tap] allows us to use the pipe. But, when they are gone to a wedding or when they visit relatives or if they are not home during the water time then they lock the gate [tie it shut] and don’t allow us inside. Then we have to go to a pipe that is far away. I don’t like to go to the other pipe. People don’t like it when I
come to their pipe, but they understand the situation. I also have to carry the water back home, which is more difficult.

Although the taps are clearly public utilities, not to mention that the property on which they are situated is owned by the Government of Puducherry as (stipulated in the MOU), households engaging in this unequal practice argue that, “it [the public tap] is in my yard,” and “I don’t want people on my property and inside my fence.” Only time and methods of conflict resolution will abet such unfortunate scenarios, but, for now, the case persists as a prime example of resource control amidst scarce supplies.

5.6 Discrepancies between Nagapattinam and Karaikal

In keeping with a comparative focus, a basic contrast between Nagapattinam and Karaikal Districts will be delivered. Beginning with potability, poor water quality prevails in both locales. Furthermore, the same issues—namely temporal, spatial, compromised pipes, unclean tanks, post-point contamination, and consuming untreated groundwater—are present in each district. As for water quality tests performed at taps and in households, the results are complex and partially contrarian. Therefore, quality will be analyzed in the subsequent chapter where it will be accompanied by original quantitative data. In terms of pressure, identical issues—temporal, spatial, and lowering tap heights in order to augment pressure—exist in both supra-sites. However, it shall be noted that pressure tends to be greater in Nagapattinam District and rural Karaikal District (which are served by public taps) when compared to sites positioned in Karaikal Municipality (which are served by individual taps). This attribute is a consequence of the number of taps present, each of which consumes a portion of the pressure. However, it is important to posit that, while sites with individual taps, on average, enjoy less pressure, the quantity obtained by each household is greater owing to a factor of lower densities.

Quantity is an issue that plagues both Nagapattinam and Karaikal District, compounded by temporal and spatial issues, supply windows, density, insufficient supply regimes, and

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434 Government of Puducherry, 2005a, sec. 4(f).
electrical outages. That being said, more availability windows in Karaikal District (all sites in Nagapattinam District are supplied water once per day, while all sites in Karaikal District are supplied water two or three times per day), combined with lower densities in Karaikal Municipality (a function of individual taps) engender greater quantities of water on a per capita basis in Karaikal District. Furthermore, electrical outages are less common in Karaikal District. Although Nagapattinam District has scheduled outages throughout the year—which are lengthened during the dry season and periods of high demand—Karaikal District is provided electricity 24-hours per day, with occasional random power outages (which also occur in Nagapattinam District) taking place from time to time. Thus, electricity’s unique domination over water supply and quantity is less glaring in Karaikal District.

Lastly, the coping mechanisms outlined in this chapter, whether amounting to adaptation, modification, outright subversion, or filing complaints, are practiced in both locales. That being said, the extent of practice remains a function of the magnitude and frequency of the respective problems, gradients which tend to reign more extreme in Nagapattinam District (as will be evidenced in the next chapter). Interestingly enough, one caveat involves water improvements, which are more common in Karaikal District compared to Nagapattinam District (see Table G.1 in Appendix G). Water improvements are defined here as installing a borewell or handpump, upgrading from a public to individual tap, installing in-house piping, or connecting a rooftop tank to in-house pipes. Most households in Karaikal District were already provided with individual taps, meaning that there are fewer opportunities for upgrades as per the definition of water improvements (i.e., the option to advance to an individual tap is removed). Furthermore, individual taps reduce the urgency of undertaking improvements since they eradicate issues of distance, high densities, and conflict. However, 45.8% of households in Karaikal District executed water improvements contrasted with only 21.9% in Nagapattinam District. This variance is even more contradictory given that Karaikal District exhibits a lower mean total household income (see Table 2.3).
5.7 Conclusion

This chapter illustrated the newly fabricated waterscapes in Nagapattinam and Karaikal Districts. The discussion was substantiated with observational and government interview data, as well as the firsthand accounts and lived experiences of affectees. Several shortcomings in reconstruction outcomes were uncovered relating to water quality, quantity, and pressure. Affectees absorbed and sometimes surmounted these inadequacies by establishing an array of organic coping mechanisms. To that end, it is contended: (1) the coping mechanisms fail to fully remedy the water scenario; (2) much of the waterscape remains beyond the control of the subjects; and (3) the governments are ultimately deficient in responding to the needs of their citizens (e.g., a history of unresolved complaints). While the issues confronted in Nagapattinam are generally more common and severe than those in Karaikal, the end result is that affectees in both locales are forced to acculturate to the post-tsunami landscape.

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435 This descriptive chapter will be complemented by the subsequent chapter, which employs empirical, quantitative data to examine such issues. Thus, see Chapter 6 as well as Appendices H and I.
CHAPTER VI: DEVELOPMENT OF A CONTEXTUALIZED WATER POVERTY INDEX

6.1 Introduction

It is estimated that one billion of the world’s population lack access to ‘improved’ sources of drinking water. However, the oft quoted figure surges when one incorporates measures such as quality, quantity, distance traveled to obtain water, density at access points, and the frequency at which water is actually available. The inclusion of these parameters begins to paint a more complete and accurate picture of the prevailing waterscape at a given scale, not to mention that it problematizes the unidimensional definition of access to improved (read as ‘safe’) water. Furthermore, parameters such as those mentioned above can be used to assess water scenarios in a multi-dimensional fashion, in essence creating indicators of water poverty. Moreover, a systematic collection of data that captures several aspects of a water situation can be


Improved sources are defined by the UN, WHO, and others as treated or protected sources of water (e.g., piped water or deep tube-wells).

437 The limits of measuring access to safe water simply as access to an improved source can be exposed at the study sites. All of the houses at the study sites have access to either a public or individual tap that dispenses treated water. Hence, in theory, every household has access to safe water according to the UN and WHO, not to mention that all houses in post-tsunami settlements categorically count towards the MDG for improving access to water. However, such a black and white definition obfuscates the reality that water is not always available from the taps, which thereby requires individuals to consume water from unimproved sources and constitutes the arrangement as only a pseudo-improved source. Furthermore, the measurement boldly assumes that water dispensed from the taps is automatically free of pathogens, an assumption that does not hold in the cases of Nagapattinam and Karaikal (see Appendices C-E). Thus, access to safe water is not continuously provided and, on the average, the quality of water is not actually safe.


used to deconstruct complex, interrelated issues of water poverty and assist in the prescription of structural and management-based remedies.

The construction of a set of indicators—in this case, molded into a composite WPI—can assist in the identification and reduction of ‘water poverty.’ The term water poverty acknowledges links among socioeconomic status, access to water resources, and human development broadly defined (see Fig. 6.1). Heterogeneous degrees and patterns of access to water are writ large upon the landscape, and cases of water shortage and poverty are recognized as mutually reinforcing. Ahmad (2003) describes the situation:

[E]conomic and social vulnerabilities feed on one another . . . people cannot address one vulnerability (lack of water) as they are afflicted with another (lack of money) and because they cannot address the former they will have even less of the latter; thus, their poverty trap becomes more and more entrenched.439

While the subaltern likely possess more capacity than Ahmad seems to suggest, his point is well taken and is upheld by Turton (1999), who argues that natural resource control, particularly over water, is associated with socioeconomic status and is especially intractable in cases of low adaptive capacity.440 Collectively, the assertion is that it is difficult to live happily, healthily, and predictably while in a state or process of water poverty. Conversely, it is contended that individuals and communities with access to water at a sufficient quantity, quality, and in a less burdensome arrangement are better equipped to satisfy health needs, attend work more frequently, harness water for livelihood purposes, develop human capital, and transfer the opportunity costs of meeting water needs to more economically and socially productive ventures.


Falkenmark (2009) also argues that “water quality degradation makes it impossible . . . to get out of the poverty trap,” thereby adding quality to access and quantity as components of the poverty thumbscrew. [Falkenmark, 2009: p. 74.]

Therefore, I have developed a contextualized WPI in order assess the level of water poverty at the study sites and to identify the most urgent areas for intervention.

![Graph showing correlation between access to water and income](image)

**Figure 6.1: Correlation between access to water and income**


### 6.2 The water poverty index and its critiques

The WPI is a composite index conceived by Sullivan in 2000; it was subsequently expanded in 2001.\(^441\) The WPI has since been deployed for international comparisons, adapted for agriculture, irrigation, and water management, and received a fair amount of criticism.\(^442\)

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\(^{441}\) Sullivan, 2001.


Lawrence, Meigh, and Sullivan, 2002.
The original WPI comprises five indicators: resources, access, capacity, use, and environment. Each indicator is linearly interpolated to range from 0-100 based on set standards. The indicators can both be viewed individually and combined to produce a single supra-indicator (i.e., the WPI). Through these lenses of measurement, a snapshot of the water scenario, or a barometer of water poverty, is determined at a pre-defined scale. In addition to facilitating visual representation (e.g., spider/radar diagrams and choropleth maps), the WPI can be exploited for several practical purposes:

- to identify complex problems that are interrelated, multilayered, or cumulative;
- to compare two or more sites uniformly;
- to examine multiple scales;
- to establish baselines for temporal comparison (e.g., pre- and post-disaster or pre and post intervention);
- to allow governments, NGOs, and private entities to monitor and evaluate the ‘success’ of their projects—especially if targets or standards are set for each indicator;
- to more efficiently allocate scarce funds and capital to the most deserving geographic areas or water poverty indicators (i.e., evidence-based decision-making);
- to reduce spatial inequities and heterogeneous patterns of development;
- and the WPI’s diagnostic and prescriptive capabilities can ultimately be used to inform policy.

While most WPIs have been conducted at the national scale, experts concur that smaller scales, such as the sites included in this study, form the most appropriate level of inquiry because finer-scaled data is more precise and less likely to mask variability. Furthermore, as scale


Sullivan, Meigh, and Lawrence, 2006.
decreases, additional issues germane to the daily life of the population being examined become visible, which is complemented by the ability to incorporate such issues into the WPI by performing fieldwork. Based on a thorough review of the literature, the only WPIs calculated at a relatively small scale (i.e., not the national scale) were village level pilot studies in Sri Lanka, Tanzania, and South Africa; a regional WPI was also calculated in Benin. Interestingly enough, all of these studies utilized the classic WPI indicators, therefore neglecting to introduce novel indicators designated as significant by the populations being studied. Thus, the caveats of scale and coarseness of data on one hand, and the inclusion of locally relevant indicators on the other, will be addressed in this study. Additionally, while the original WPI weights indicators equally, this study adopts several schemes. Besides equal weighting, indicators will be weighted in correspondence to their level of importance or difficulty as reported in household surveys and according to my expert judgment (i.e., advised by observations, fieldwork, and the literature).

The parallel schemes will posture the classic weighting system vis-à-vis a system informed by subjects that live in, cope with, and manage the context, as well as one founded on field experience complemented by the literature. The three modes of weighting will be compared for analytical purposes.

Before constructing the WPI, critiques of composite indices must be posited. On the positive side, composite indices can be utilized to measure a breadth of phenomena, with prime examples comprising the Drastic Index for groundwater quality, Disaster Risk Index (DRI) and

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Sullivan et al., 2003.

444 CEH and UKDFID, no date.

Heidecke, 2006.

Sullivan et al., 2003.

445 Mayoux and Chambers, 2005.


Social Vulnerability Index (SoVI), Human Development Index (HDI) and Gender Development Index (GDI), and the Dow Jones Industrial Average (DJIA). Furthermore, composite indices facilitate the presentation of complex, multi-dimensional phenomena in a straightforward manner, suitting diverse audiences from laypersons to policymakers to experts. The ability to rank and compare scales of inquiry, galvanize public interest, allocate resources more judiciously, and other functions listed earlier also render composite indices useful and inherently pragmatic. Lastly, with respect to the WPI, its flexibility means that it can be adapted to fit various contexts by adding or eliminating indicators and their parameters, by altering indicators and parameters to coincide with local standards or project objectives, and by tweaking the weight scheme to reflect prevailing societal expectations or configurations.

Positives aside, scholars have posited formidable critiques of the WPI, particularly in terms of the robustness of data, scale of analysis, substitutability of indicators and their values across space, and (seemingly arbitrary) weighting. Keeping these challenges in mind, this study’s methodology avoids such pitfalls. First, I collected data at the household scale, in effect ensuring robustness through direct dialogues with those being studied. Accuracy was further confirmed by observations across four calendar years and via peer debriefings with engineering and sociology experts in the region. Second, composite indices often aggregate data in order to (homogenously) describe larger scales, thereby serving to conceal variability at lower levels—especially at rural-urban scales and among the poor. In an attempt to account for variability, this study utilizes data acquired through randomized samples at the household level (i.e., the lowest

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scale) to portray each post-tsunami settlement. Such hamlets, in an effort to avert communal tensions, were populated in line with pre-tsunami settlement patterns and attributes of livelihood, religion, and caste. Thus, household data remain representative when extrapolated to the site scale because the sites are relatively homogeneous (similar people were purposefully settled together *en masse*). Third, the sample sets are analogous in that they comprise marginalized populations that were affected by the same disaster (i.e., they share a set of lived experiences). Furthermore, the study populations were secondarily settled into unique, yet similar, post-tsunami settlements. Thus, indicators and their values can be compared across space because the sites are demographically and structurally alike, not to mention that comparable water-based issues, such as quality, quantity, and availability, are salient across all of the sites. Lastly, as touched upon earlier, the weighting of indicators will be executed equally (as is normally performed in the construction of WPIs), in conformity with the significance or difficulty of each indicator as reported in surveys, and according to my own expert judgment.

### 6.3 Components and calculation of a contextualized index

This study in Nagapattinam and Karaikal Districts significantly modifies the classic WPI in order to fit the Indian and post-tsunami settlement contexts. Therefore, while the conceptual framework and the construction of ‘water poverty snapshots’ remain the same, several indicators were introduced in an attempt to increase the scope and suitability of the WPI at the study sites. The inclusion of additional indicators is premised upon much inquiry and deliberation. Ultimately, an indicator was incorporated only when it satisfied the following conditions: (1) it was articulated by households, without prompting, as creating hardships or hazards in water provision and/or consumption; (2) it was independently observed and thus validated as a

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447 See the survey instrument in Appendix B, the number of samples from each site in Table 3.1, and the intra-site distribution of samples in Appendix C.

448 For example, indicators such as distance to access point, density at access point, and windows of water availability encompass nuanced inclusions that are specific to the waterscapes of the study sites.
hardship or hazard; and (3) it has been denoted in the academic literature as a significant element of proper water provision. Having fulfilled these provisos, this study’s modified WPI subsumes 10 indicators. Each indicator and their parameters were measured as precisely as possible in either quantitative or discrete, qualitatively categorized terms. Following is the list of indicators accompanied by explanations of their linear interpolation (recall that rationale for the inclusion of each indicator and units of measurement were outlined in Chapter 2):

- **Distance** \( (D_i) \): At the study sites, some residents must walk to community water taps while others possess individual taps on their premises. The Sphere Project (2004), writing on post-disaster and emergency situations, argues that distance to water access points should be less than 500 meters, while UNHCR (2007), speaking of the same contexts, states that the distance should be less than 200 meters or “a few minutes walk.”\(^{449}\) Meanwhile, the Ministry of Urban Development of the Government of India affirms that “100 per cent individual piped water supply” should be the norm “for all households including informal settlements,” thus proclaiming that the distance should be zero.\(^{450}\) Since 500 meters is too prohibitive a distance considering that water is only available in limited timeframes (i.e., not enough trips can be made when the distance is combined with short windows of availability), the threshold was set at 200.01 meters. This distance accounts for availability windows and the level of infrastructural scarcity, which forces a preponderance of households to trek to public taps. Therefore, the following calculation is used at the household scale:

\[
D_i = \left[ \frac{(200.01 - d_i)}{200.01} \right] \times 100
\]

*Ergo*, a distance of zero translates to an indicator score of 100, while 200 meters approaches 0 and distances greater than 200 meters are recorded as 0. Next, the

\(^{449}\) UNHCR, 2007: p. 257.


household scores are averaged to generate a single score for each site. The remaining indicators are standardized and expressed at the site-scale in same fashion.

- **Hours of availability (H):** Total hours of water availability determine the amount of time households can retrieve water from access points; obviously, more hours of availability are preferable to fewer hours. The threshold was set at 24 hours because a continuous supply is both the international ‘golden standard’ and what residents of the study sites desire. Furthermore, the CPHEEO (1999) recommends that water should be supplied on a “continuous 24 hours basis,” the Ministry of Urban Development (2011) entitled an entire section of their report “Why cities should deliver continuous water supply,” and McKenzie and Ray (2009) also make the case for continuous supply in India. The literature all cite the economic and public health benefits of an uninterrupted supply regime. Therefore, the following calculation is used at the household level:

  \[ H = \left( \frac{h}{24} \right) \times 100 \]

- **Windows of availability (W):** Water should be supplied throughout the day; however, it is only made available in pre-defined windows. The greatest number of windows exhibited per day among all sampled households is three, whilst the lowest is zero. Thus, a max-min equation is utilized, which is the method employed in the figuring of almost all indicators in the original WPI. Three windows, albeit sub-optimal, achieves 100 and the minimum of zero windows scores 0:

  \[ W = \left( \frac{(w - w_{\text{min}})}{(w_{\text{max}} - w_{\text{min}})} \right) \times 100 \]

- **Density (De):** Despite the Ministry of Urban Development’s (2011) call for all households in India to possess their own connection, such a configuration is far from

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reality. Rather, residents thronging public standposts is the norm. TWAD follows a standard of 150 persons per access point in all of its projects, which it executes pragmatically as 30 households per tap (thus, TWAD assumes a household size of five). Furthermore, the Sphere Project (2004) states that there should be no more than 250 persons per tap, while UNHCR (2007) argues that a density of 80-100 persons is preferable, with 200 being the maximum. Applying TWAD’s assumed household size of five, Sphere’s recommendations convert to a maximum density of 50, and UNHCR’s preferred and maximum recommendations convert to 20-25 and 40, respectively. Therefore, TWAD’s density was heeded not only because it was the standard set during reconstruction processes, but also because it falls conveniently between the preferred and maximum densities set in other publications. The following calculation is used at the household scale; notice that a density of one—the minimum—is awarded a score of 100, while a density of 30 approaches 0 and densities beyond 30 are recorded as 0:

\[ D_e = \frac{31 - d_e}{30} \times 100 \]

- **LPCPD (L):** Access to an adequate quantity of water is (essentially) recognized as a universal human right. While the Governments of Nagapattinam and Karaikal are both required to supply 135 LPCPD to municipal areas and 40 to *panchayat*-administered areas, a standard of 50 was used. Rijsberman (2006) and Gleick (1998 and 1996), two

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453 Chandrasekharan, 2011.
Ragunath, 2011.
Sphere Project, 2004: p. 65.
Rajasekharan, 2011.
internationally renowned water experts, set 50 LPCPD as the minimum standard for meeting consumption, sanitation, and cooking needs.\textsuperscript{456} Furthermore, the same standard is used in the original WPI. Thus, 50 LPCPD is earmarked as the quantity required to attain 100. LPCPD is calculated at the household level and accounts for total household population ($hp$); note that achieving a score greater than 100 is barred:

$$L = \left[ \left( \frac{l}{hp} \right) / 50 \right] \times 100$$

- **Flow rate ($P$):** Flow rate is used as a surrogate for pressure, which has the potential to negatively impact water quality.\textsuperscript{457} The flow rates (l/s) of taps utilized by every sampled household were recorded, but raw time (seconds) taken to dispense 30 liters is used in the calculation. A modified max-min formula was used with 33 seconds constituting the fastest (i.e., minimum) time taken to fill vessels amounting to 30 liters. The Sphere Project (2004) states that the minimum flow rate (i.e., maximum time) at public taps should be three minutes per 20 liters, which converts to 270 seconds for 30 liters.\textsuperscript{458} Thus, the maximum was set at 271 seconds, allowing a time of 270 seconds to earn a score just above 0:

$$P = \left[ 1 - \left( \frac{p - p_{min}}{p_{max} - p_{min}} \right) \right] \times 100$$

\textsuperscript{456} Rijssberman, 2006: p. 10.

\textsuperscript{457} Ministry of Urban Development, 2011.

\textsuperscript{458} Sphere Project, 2004: p. 63.
• **Conflicts over water (Co):** This indicator is difficult to gauge. Obviously, an absence of conflicts in a given time period is optimal (i.e., score of 100), while accruing conflicts eventually moves towards a grade of 0. However, prescribing that tipping point is inherently subjective. After parsing interviews with hundreds of subjects and carefully reviewing the literature, I decided to peg 12 conflicts per year, or one per month, as the rate at which a household achieves 0.\(^{459}\) Thus, a household involved in no conflicts in the past year earns 100, while 11 conflicts approaches 0:

\[
Co = [1 - (co / 12)] \times 100
\]

- **Capacity (Ca):** This indicator incorporates three parameters: income, education, and resources, the latter possessing several sub-parameters.
  - Income (I), and socio-economic status more broadly, is strongly associated with vulnerability, capacity, resiliency, and the ability to cope with emergency situations—particularly when confronting issues related to water and disasters.\(^{460}\)

Total monthly household income \((i)\) was applied in a modified

\(^{459}\) Bapat and Agarwal, 2003.

Crow and Sultana, 2002.

Sneddon *et al.*, 2002.


Conversations with subjects revealed that they expect conflicts to arise from time to time (e.g., monthly), and that such a rate is manageable or ‘tolerable.’ However, subjects tended to report that conflicts psychologically affect them when the incidents escalated to monthly and especially when they occurred daily or weekly.


max-min equation. A monthly income of ₹10,000 was set as the amount required to obtain a score of 100. This amount was not the highest reported income, but it signifies relative affluence in the study sites and also surpasses ‘one lakh’ (₹100,000) per annum, which is recognized as a respectable income in India. The minimum was set at ₹850, which is the lowest reported monthly household income. Thus, while disallowing scores that exceed 100, income is calculated at the household level as:

\[ I = \left( \frac{i - i_{\text{min}}}{i_{\text{max}} - i_{\text{min}}} \right) \times 100 \]

- Education (E) is recognized as a component of adaptive capacity, an avenue for vulnerability reduction, and a means for managing stresses upon and shocks to domestic systems. Furthermore, level of educational attainment has been used in composite indices by Meher, Patra, and Sethy (2011), Sharma and Patwardhan (2008), Birkman and Fernando (2007), Cutter,


Income is also a component of the original WPI’s indicator for capacity.

461 Margai, 2010.


Adger et al., 2004.


Education is also a component of the original WPI’s indicator for capacity.
Educational attainment is measured as the highest grade level completed by an individual residing permanently in the household. Grade 12 is the point at which 100 is achieved because that is the level when the germ theory, knowledge on water quality, hygiene, and sanitation, and other general knowledge have been imparted. Thus, the following equation is utilized with the ability to score greater than 100 disallowed:

\[ E = (e / 12) \times 100 \]

- Resources \((R)\), the final component of capacity, encompasses five sub-parameters: assets, investments, social networks, kinship, and time living at residence. The five elements are summed in order to gauge household ownership of a basket of resources. Assets \((a)\) are a proxy for wealth and represent capital that can be used to cope with stresses and water issues broadly defined; they can also be converted to cash in times of need. The assets component is modeled after Peacock, Killian, and Bates’ (1987) Domestic Assets Index, Bolin’s (1976) Family Recovery Model, and Belcher’s (1972) Cross-Cultural Household Level-of-Living Scale. A total

\[ \text{Assets} \]

\[ \text{Investments} \]

\[ \text{Social networks} \]

\[ \text{Kinship} \]

\[ \text{Time living at residence} \]

\[ \text{Total} \]

References:


of 12 commonly owned assets were included in this sub-parameter. Investments \( (i) \) that improve the water situation or quality or aesthetics of the homestead encompass the second component. Investments are evidenced by Oliver-Smith (1991 and 1992) and Coburn, Leslie, and Tabban (1984) as both determinants of successful reconstruction and indicators of capacity.\(^{464}\) A maximum of four investments are included in this sub-parameter. Social networks \( (n) \) foster connectivity and serve as arteries for seeking information and support during crises.\(^{465}\) A maximum of three networks akin to civic, trade, religious, and NGO affiliations are allowed in this parameter. Kinship \( (k) \) is the fourth aspect of the resources component. Nearby kin represent informal networks that complement more formalized social networks. Kinship is limited to five relatives (household scale) that live within a one

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\(^{464}\) Oliver-Smith, 1992.

The amount was decided based on the law of diminishing marginal returns, thus leading to the postulation that benefits begin to decay after the existence of a few proximally located relatives. The distance of one kilometer was chosen because it covers a distance that the entire household can walk during times of emergency while also carrying children and items necessary for survival (i.e., accessibility). The final sub-parameter is the time (in months) subjects have populated their residence \((m)\). Experience living in newly occupied space is crucial because it facilitates place-based knowledge on what to expect across time, and it also affords better command over the situation. For example, a longer residence bestows an understanding of the seasonal availability and variability of water, the frequency and magnitude of floods, the level of government involvement, and it also bequeaths time to adapt to and modify the water situation \textit{in toto}. In this study, time is measured as having lived in the house for: less than six months, 6-11.99, 12-17.99, 18-23.99, and 24 months or longer. The time periods correspond to scores of 0, 0.25, 0.5, 0.75, and 1 out of 1, respectively.

As noted above, the five sub-parameters sum to a total of 25 and the complete resources parameter is formulated as:

\[
R = [(a + i + n + k + m) / 25] \times 100
\]

Collectively, the three parameters of income, education, and resources are summed and weighted equally to produce the final indicator of capacity:

\[
Ca = (I + E + R) / 3
\]

- **Access to unimproved sources** \((U)\): Access to additional sources of water beyond government-provided taps is a crucial coping mechanism. This indicator is classified in a graded, aggregate scheme at the household level: is there access to an additional source of water \((as recorded as: \text{no} = 0, \text{yes} = 100)\); is the source greater than 100 feet from
sewerage infrastructure (s recorded as no = 0, yes = 100); an affirmative response meaning that a supplemental improved source exists in addition to a government tap (tr recorded as no = 0, yes = 100). Thus, the equation for unimproved sources is:

\[ U = (as + s + tr) / 3 \]

- **Water quality (Q):** This indicator consists of two parameters: the quality of water at government-provided taps (which considers the initial quality), and quality in the household (which incorporates quality at the point-of-use). In both cases, water is deemed safe if there is an absence of fecal coliform and unsafe if there is a presence (see Tables 3.1 and 3.2 for the number of samples and Appendices C and D for results).

Quality at taps (qt) includes the variables number of negative samples (qt\(_n\)) and total samples (qt\(_t\)), and quality in the household (qh) comprises the number of negative samples (qh\(_n\)) and total samples (qh\(_t\)). qt and qh are weighted equally. Thus, the superequation is \[ Q = qt + qh \] and final equation is:

\[ Q = [(qt\(_n\) / qt\(_t\) x 100) + (qh\(_n\) / qh\(_t\) x 100)] / 2 \]

After accounting for all 10 indicators, the abridged WPI equation (weighted equally) for each site is expressed as:

\[ WPI = [Di + H + W + De + L + P + Co + Ca + U + Q] / 10 \]

After substitution, the final WPI equation becomes:

\[
WPI = \frac{[(200.01 - di) / 200.01 x 100] + [h / 24 x 100] + [(w - w\text{-}min) / (w\text{-}max - w\text{-}min) x 100] + [(31 - de) / 30 x 100] + [(l / hp) / 50 x 100] + [(1 - (p - p\text{-}min) / (p\text{-}max - p\text{-}min)) x 100] + [(1 - (co / 12)) x 100] + [(i - imin) / (i\text{-}max – i\text{-}imin) x 100] + (e / 12 x 100) + [466 Sewerage infrastructure can negatively impact water quality. Thus, it is widely accepted that sewerage infrastructure—particularly septic tanks and leach pits, which are the predominant infrastructure at the study sites—should be located a minimum distance of 100 feet from borewells, handpumps, and surface waters. [Philip, 2012. Woodson, 2010. Chinn, 2009.]

467 Given the units of measurement and all additional sources of water revealed by surveys, the possible outcomes for as, s, and tr are (respectively): 100-0-0 for borewells, handpumps, and surface water; 100-100-0 for rainwater; and 100-100-100 for water from on-site treatment centers and pre-packaged water.
\[ ((a + i + k + n + m) / 25 \times 100) / 3 + [(as + s + tr) / 3] + [(qt_a / qt \times 100) + (qh_a / qh \times 100)] / 2 \] / 10

6.4 Analysis and discussion

This section examines the outputs of the contextualized WPI in its application to the 14 study sites. The caveats of individual indicators are also divulged. Moreover, three weighting schemes are considered (equal, survey, and expert) and analyses are executed at the site, district, and rural-urban scales. Each weighting scheme is accompanied by a discussion of its unique results.

The first WPI weights each component equally, meaning that all 10 indicators account for 10% of the final water poverty score. Several observations can be gleaned at the indicator level of the site scale (see Table 6.1).\(^{468}\) In terms of distance, a Karaikal District bias is apparent. The top four scores are all located in Karaikal Municipality, where individual taps are the norm and thus the distance of zero generates the maximum score of 100. Kizhakasakudimedu—located in Karaikal Municipality—is an outlier in these terms because close to half of the taps fail to dispense water, which forces such households to traverse a longer distance to access water at an on-site treatment center. Hours of water availability reveals much variation with the highest score roughly five times the lowest. Samanthanpettai figured the poorest because water is only provided for one hour per day, and Kizhakasakudimedu also fared poorly because many of the taps fail to dispense water (such taps were afforded a score of 0). Number of windows per day indicates a rigid Karaikal District bias—all seven sites in Karaikal ranked at the top, while the bottom is comprised of sites all located in Nagapattinam. The whole of sites in Karaikal District enjoy either two or three windows per day, while those in Nagapattinam are sanctioned only one. Interestingly enough, Kizhakasakudimedu’s defunct taps brought the site’s score closer to 33.3 (i.e., the grade reserved for one window), while the existence of a few irregular

---

\(^{468}\) Note that Table 6.1 provides a rudimentary sensitivity analysis because it presents each indicator individually with possible results ranging from 0-100. Thus, if the total weight was assigned to any indicator (thus weighting all remaining indicators at 0), then the output would be the results listed under each indicator exactly.
Table 6.1: WPI – Site Scale (Equal Weight)

<table>
<thead>
<tr>
<th>Distance ($D_i$)</th>
<th>Hours Available ($H$)</th>
<th>Windows ($W$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 – AKP (K)</td>
<td>20.6 – Vettakaramedu (K)</td>
<td>100 – Paravaipettai (K)</td>
</tr>
<tr>
<td>100 – Paravaipettai (K)</td>
<td>13.7 – Akkam Pettai (K)</td>
<td>100 – Vettakaramedu (K)</td>
</tr>
<tr>
<td>100 – Vettakaramedu (K)</td>
<td>13.0 – NNN (N)</td>
<td>66.7 – Akkam Pettai (K)</td>
</tr>
<tr>
<td>99.7 – Kilinjilmedu (K)</td>
<td>11.2 – Mandapathur (K)</td>
<td>66.7 – AKP (K)</td>
</tr>
<tr>
<td>92.6 – Samanthanpettai (N)</td>
<td>10.4 – Paravaipettai (K)</td>
<td>66.7 – Kilinjilmedu (K)</td>
</tr>
<tr>
<td>91.9 – Akkaraipettai (N)</td>
<td>10.2 – Saveriyarkovil (N)</td>
<td>66.7 – Mandapathur (K)</td>
</tr>
<tr>
<td>91.2 – Theti (N)</td>
<td>8.3 – AKP (K)</td>
<td>38.1 – Kizhakasa. (K)</td>
</tr>
<tr>
<td>90.3 – Akkam Pettai (K)</td>
<td>8.3 – Kilinjilmedu (K)</td>
<td>36.9 – NNN (N)</td>
</tr>
<tr>
<td>89.4 – Uzhuvar Nagar (N)</td>
<td>7.9 – Akkaraipettai (N)</td>
<td>35.9 – Saveriyarkovil (N)</td>
</tr>
<tr>
<td>89.0 – Mandapathur (K)</td>
<td>7.1 – Theti (N)</td>
<td>33.3 – Akkaraipettai (N)</td>
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<td>6.3 – Uzhuvar Nagar (N)</td>
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<td>5.3 – Andana Pettai (N)</td>
<td>33.3 – Samanthanpettai (N)</td>
</tr>
<tr>
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<td>4.2 – Kizhakasa. (K)</td>
<td>33.3 – Theti (N)</td>
</tr>
<tr>
<td>80.8 – Kizhakasa. (K)</td>
<td>4.2 – Samanthanpettai (N)</td>
<td>33.3 – Uzhuvar Nagar (N)</td>
</tr>
<tr>
<td>range = 19.2</td>
<td>range = 16.4</td>
<td>range = 66.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Density ($D_e$)</th>
<th>LPCPD ($L$)</th>
<th>Flow Rate ($P$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 – AKP (K)</td>
<td>99.6 – Vettakaramedu (K)</td>
<td>74.5 – Akkaraipettai (N)</td>
</tr>
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<td>97.3 – Paravaipettai (K)</td>
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<td>25.8 – Kizhakasa. (K)</td>
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<th>Capacity ($C_a$)</th>
<th>Unimproved Sources ($U$)</th>
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<tr>
<td>100 – AKP (K)</td>
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<tr>
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Table 6.1 (cntd.)

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<td>34.7 - Kilinjilmedu (K)</td>
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<td>56.5 - Saveriyarkovil (N)</td>
<td>33.3 - Akkam Pettai (K)</td>
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<td>91.7 - Andana Pettai (N)</td>
<td>55.1 - Theti (N)</td>
<td>33.3 - Uzhuvar Nagar (N)</td>
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<td>54.9 - NNN (N)</td>
<td>29.6 - Mandapathur (K)</td>
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<table>
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<th>WPI</th>
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<td>68.6 - Paravaipettai (K)</td>
</tr>
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<td>1.9 - Saveriyarkovil (N)</td>
<td>43.5 - Saveriyarkovil (N)</td>
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</table>

*range = 43.3  range = 25.9  range = 85.7*

WPI = Water Poverty Index

LPCPD = Liters Per Capita Per Day

AKP = Amman Kovil Pathu

NNN = New Nambiyar Nagar

(K) = located in Karaikal District
Table 6.1 (cntd.)

(N) = located in Nagapattinam District

Note: Maximum is 100 and minimum is 0 for WPI and all indicators

taps in Saveriyarkovil and New Nambiyar Nagar (both in Nagapattinam District) that continually dispense water pulled the sites’ scores above the demarcation for a single window.

Density also reveals a bias towards Karaikal District, and even more so towards the Municipality. The top five ranked sites in the density indicator are all in Karaikal District, and the top four comprise sites in the Municipality that possess individual taps. Kizhakasakudimedu was yet again an anomaly (owing to the fact that myriad households with inoperable taps must crowd the on-site treatment center), while Akkaraipettai in rural Nagapattinam District scored the poorest with a figure half that of the top four. LPCPD, like windows, is an extremely spatially, or jurisdictionally, skewed indicator. The top seven sites are all located in Karaikal District and the remainder are situated in Nagapattinam District. Vettakaramedu and Paravaipettai are the only sites that experience three water availability windows and they simultaneously possess individual taps, so their top ranks should perhaps be anticipated.

Uzhuvar Nagar performed the worst as individuals realized less than half the quantity of the top six sites.

Flow rate is extremely variable (range of 71.0) and is an etiology of the individual versus community tap dichotomy. The top seven sites retrieve water from public taps, while the bottom three obtain resources from individual taps. Generally speaking, pressure from the source node was either divided among a large number of individually provided taps, or it remained greater at a fewer amount of public taps (the result of a lesser extent of divvying). Conflicts demonstrate a Karaikal District bias: the top five sites are both located in Karaikal Municipality, and more importantly they possess individual taps (where conflicts over water resources are nonexistent).
Residents of Kizhakasakudimedu obtain water either from individual taps or the on-site treatment center; however, the latter is accomplished in a non-contentious manner, which resulted in a relatively high performance. The indicator of capacity correlates with data presented in Chapter 2 on income and education (see Table 2.2) and distance relocated from pre-tsunami location (see Table 2.3). For example, Vettakaramedu exhibited the lowest level of educational attainment, a relatively low total household income, and the new site was resettled the furthest from its original site—which negatively affected the network and kinship components of the capacity indicator. Therefore, it shall come as no surprise that Vettakaramedu scored the lowest in terms of capacity. Conversely, Akkaraipettai, the top performer, demonstrated the highest income, a relatively high level of education, and was reconstructed in situ—thus, preexisting networks and kinship ties were preserved.

Next, the unimproved sources indicator reveals several insights. First off, the existence of treatment centers in Kizhakasakudimedu and Andana Pettai drives the sites to the top. The sites not only have access to a supplemental source of water, but the sources also satisfy the latter two indicator components: the water is treated and the distance from sewerage infrastructure at the points of treatment were fulfilled. That being said, owing to relative location, the treatment facility in Andana Pettai is inaccessible to some households in the settlement while the facility in Kizhakasakudimedu is more accessible—hence the higher score in Kizhakasakudimedu. Akkaraipettai performs well because the panchayat provided numerous handpumps for community use and several households consume prepackaged water. Three of the bottom four sites (Theti is the exception) exhibit either no access to surface water (or nearby surface water has been deemed unfit for use) and/or the groundwater is considered unfit, thus permitting few opportunities for secondary sources of water. In the case of Paravaipettai, the site lacks access to surface water and no handpumps or borewells have been introduced even though the groundwater could be utilized for non-consumptive purposes. Residents report that they are sanctioned three water windows per day and are therefore able to attain sufficient quantities of water; thus, there is presently no demand for access to supplemental sources. With
Paravaipettai’s score of 0, access to unimproved sources is the most variable indicator with a range of 85.7.

Lastly, quality is the second most variable indicator (range of 71.4) and it indicates two dichotomies. The top seven sites are all located in either Karaikal Municipality or panchayat-administered areas of Nagapattinam District (only Kizhakasakudimedu falls outside of the two binaries). Bacteriological water quality tests conducted at both taps and in households (see Appendix C and D) reveal that water in Karaikal Municipality is superior compared to its rural counterpart, and that the opposite holds true in Nagapattinam District, where sites located in panchayat territories outperform those situated in the Municipality. While the former case meshes with conventionally held wisdom, the latter requires explanation. As documented in Chapter 4 (see Table 4.1), much water provided to sites in rural Nagapattinam is doubly treated: TWAD treats the water (using silver ionization) before it is supplied to local towers and sumps, and from there many panchayats secondarily treat the water with chlorine before supplying it to their jurisdictions. Conversely, TWAD treats water under the same process before it is provided to Nagapattinam Municipality; however, the water does not undergo further treatment. Ultimately, Paravaipettai, where all taps tested negative for fecal coliform and close to half of the households consume safe water, scored the highest. Andana Pettai ranked second with 80% of taps free of bacteria and many households consuming safe water from the treatment center. The seventh site from the bottom (Samanthanpettai) exhibited only one safe tap, while all taps at the bottom six sites tested positive for bacterial contamination, which was reified in quality at the household level.

Having reviewed each indicator, the composite index compresses the totality of data into a final WPI score for each site (see Table 6.1). Biases at the Karaikal Municipality and District scales are evident in many indicators and thus manifest in the total WPI. The four highest ranked sites are located in Karaikal Municipality and all seven of the sites situated in the de jure District are represented in the top eight—a spatially lopsided outcome indeed. Kizhakasakudimedu was an outlier in many indicators and thus failed to enter the top half, although it still outperformed
all sites in Nagapattinam District except Andana Pettai. While Andana Pettai broke the 50\textsuperscript{th} percentile—owing to relatively high scores in quality and unimproved sources (which were aided by the supply of relatively safe tap water and the provision of a treatment center)—the remaining six sites in Nagapattinam District brought up the rear.

Next, it is useful to observe caveats of and interrelations among the 10 indicators—some of which were visible at the site scale, others which will emerge in subsequent analyses at the district and rural-urban scales. Beginning with distance, density, conflicts, and flow rate, all are, to greater or lesser extents, a function of the prevalence of individual or community taps. Households with individual taps (i.e., primarily located in Karaikal Municipality) achieve ratings of 100 each for distance, density, and conflicts. On the other hand, households that utilize shared taps (i.e., all sites in Nagapattinam District and those in rural Karaikal District) are subject to greater distances and densities as well as opportunities for conflict. Furthermore, as previously mentioned, flow rate is influenced by the number of taps prevailing at a site. Thus, on the average, sites comprised of individual taps exhibit lower flow rates while those with community taps enjoy greater flow rates. However, while the indicator score for flow rate is often lower at sites predominantly composed of individual taps, the arrangement is preferable and correlates to higher scores in the distance, density, and conflict indicators. The number of water availability windows also demonstrates a caveat in that all sites in Nagapattinam District are provided water once per day while five sites and two sites in Karaikal District are dispensed water twice and thrice per day, respectively. Unimproved sources is a function of palatable groundwater at the micro-geographical level; the government-provision of community-based handpumps (for example, in Akkaraipettai and Uzhuvar Nagar); access to relatively clean surface water; and the existence of treatment centers. Unfortunately, residents of the study sites exert little control over most of these factors. Lastly, LPCPD is associated with distance, hours of availability, density, and flow rate, while quality is primarily a function of political geography (water administered by Karaikal Municipality or \textit{panchayats} in rural Nagapattinam District) and access to a treatment center.
After assessing the indicator level of the site scale, final WPIs, and caveats of the composite indicators, it is also useful to examine larger scales of inquiry. Observed collectively, the sites in Karaikal District outstripped those in Nagapattinam in many indicators, and this pattern ultimately manifested in the final WPI scores (see Table 6.1). This bipartite, although not strict, phenomenon also transpired prominently at the district scale (see Table 6.2). Nagapattinam District outperformed its counterpart in only two of the 10 indicators, namely flow rate and capacity. Thus, after aggregating data at the district scale, Karaikal’s superiority in the other eight indicators—especially windows and LPCPD—pulled the district 10 points ahead of Nagapattinam. This range is the greatest of all scales presented in Table 6.2, which suggests that location in either district, ceteris paribus, is a significant determinant of discrepancies in water poverty.

Table 6.2 also presents rural-urban analyses, which take place at two scales. At the intra-district scale, rural Nagapattinam surpasses urban Nagapattinam by 4.3 in the final WPI, which defies conventional wisdom on rural-urban disparities in development. Each locale leads in five indicators; however, the double-treatment of water in rural Nagapattinam combined with its greater access to unimproved sources (a treatment center in Andana Pettai and panchayat-provided handpumps in Akkaraipettai and Uzhuvar Nagar) add to the rural WPI. Conversely, the relatively poor quality of water and scarce access to unimproved sources (a function of less or decidedly polluted surface water and groundwater often deemed as unusable) in municipally-defined sites hindered the WPI of urban Nagapattinam. On the other hand, analysis at the same scale in Karaikal conforms to the notion of an urban hierarchy. The sites in urban Karaikal outperformed rural delineated sites in seven of 10 indicators, thus rural Karaikal scored 6.5 points less than its urban counterpart. Quality constituted a major factor: not a single access point in rural Karaikal tested negative for fecal coliform—which carried over to the household tests—while urban Karaikal performed the best (61.2) of all aggregate sample sets represented in Table 6.2. Furthermore, while flow rate was higher in rural sections of the district (a result of public taps), a preponderance of individual taps in the Municipality produced higher scores in
distance, density, and conflicts. Thus, the provision of individual taps ‘harmed’ urban households in terms of flow rate, but the configuration simultaneously provided benefits that more than made up for the encumbrance.

Table 6.2: WPI – District and Rural-Urban Scales (Equal Weight)

<table>
<thead>
<tr>
<th></th>
<th>Distance (Di)</th>
<th>Hours Avail. (H)</th>
<th>Windows (W)</th>
<th>Density (De)</th>
<th>LPCPD (L)</th>
<th>Flow Rate (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>District - Naga.</td>
<td>89.3</td>
<td>7.7</td>
<td>34.2</td>
<td>71.8</td>
<td>61.2</td>
<td>47.3</td>
</tr>
<tr>
<td>District - Karaikal</td>
<td>94.2</td>
<td>11.0</td>
<td>72.1</td>
<td>87.4</td>
<td>91.2</td>
<td>28.2</td>
</tr>
<tr>
<td>Rural - Naga.</td>
<td>90.2</td>
<td>6.6</td>
<td>33.3</td>
<td>73.6</td>
<td>57.2</td>
<td>44.2</td>
</tr>
<tr>
<td>Urban - Naga.</td>
<td>88.1</td>
<td>9.1</td>
<td>35.4</td>
<td>69.5</td>
<td>66.7</td>
<td>51.3</td>
</tr>
<tr>
<td>Rural - Karaikal</td>
<td>89.6</td>
<td>12.4</td>
<td>66.7</td>
<td>78.1</td>
<td>87.8</td>
<td>52.8</td>
</tr>
<tr>
<td>Urban - Karaikal</td>
<td>96.1</td>
<td>10.4</td>
<td>74.3</td>
<td>91.1</td>
<td>92.6</td>
<td>18.3</td>
</tr>
<tr>
<td>Rural - Total</td>
<td>90.0</td>
<td>8.6</td>
<td>44.4</td>
<td>75.1</td>
<td>67.4</td>
<td>47.1</td>
</tr>
<tr>
<td>Urban - Total</td>
<td>93.1</td>
<td>9.9</td>
<td>59.7</td>
<td>83.0</td>
<td>82.9</td>
<td>30.7</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Conflicts (Co)</th>
<th>Capacity (Ca)</th>
<th>Unimproved Sources (U)</th>
<th>Quality (Q)</th>
<th>WPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>District - Naga.</td>
<td>79.0</td>
<td>56.0</td>
<td>25.5</td>
<td>21.5</td>
<td>49.3</td>
</tr>
<tr>
<td>District - Karaikal</td>
<td>91.4</td>
<td>52.8</td>
<td>35.3</td>
<td>29.7</td>
<td>59.3</td>
</tr>
<tr>
<td>Rural - Naga.</td>
<td>82.8</td>
<td>55.6</td>
<td>36.7</td>
<td>31.8</td>
<td>51.2</td>
</tr>
<tr>
<td>Urban - Naga.</td>
<td>73.9</td>
<td>56.5</td>
<td>10.5</td>
<td>7.8</td>
<td>46.9</td>
</tr>
<tr>
<td>Rural - Karaikal</td>
<td>70.6</td>
<td>53.5</td>
<td>31.5</td>
<td>4.2</td>
<td>54.7</td>
</tr>
<tr>
<td>Urban - Karaikal</td>
<td>99.8</td>
<td>52.5</td>
<td>36.9</td>
<td>39.9</td>
<td>61.2</td>
</tr>
<tr>
<td>Rural - Total</td>
<td>78.7</td>
<td>54.9</td>
<td>35.0</td>
<td>22.6</td>
<td>52.4</td>
</tr>
<tr>
<td>Urban - Total</td>
<td>90.0</td>
<td>54.0</td>
<td>27.0</td>
<td>27.9</td>
<td>55.8</td>
</tr>
</tbody>
</table>

WPI = Water Poverty Index
LPCPD = Liters Per Capita Per Day

Note: Maximum is 100 and minimum is 0 for WPI and all indicators
Lastly, analysis was performed at the scale incorporating all rural and urban sites in the study. The urban scale led in seven of 10 indicators, which constructed a score 3.4 points higher than the rural scale. Therefore, the notion of urban superiority was upheld. However, I argue that, in this specific case, the results at this scale are not a good measure. The outputs are a product of better performing rural sites and worse performing urban sites in one locale combined with superior urban sites and relatively inferior rural sites in another locale. Consequently, the data ultimately generated WPIs closer in range than when the rural-urban scales are observed independently at the intra-district scale. Thus, while the aggregate rural-urban scale warrants analysis, I argue that it is less insightful when compared to the same scale at the intra-district level. However, what this reveals is that it is imperative to examine all scalar possibilities—only by doing so can such subtleties be discerned.

In addition to the equally weighted scheme, a second system was utilized corresponding to the significance or difficulty of each indicator as reported in household surveys (see Table 6.3). In the culmination of the survey, each household was asked to rank the top three indicators in terms of the importance or adversity they posed. At the beginning of the study, I asked respondents to rank all 10 indicators, but this became complex and I noticed that subjects struggled after the first few indicators were distinguished. Thus, I decided to ask respondents to ordinally identify only the top three indicators, which removed the fuzziness and seemingly random ranking that cropped up after the first few indicators were chosen. In observing the survey-determined weights, what is most interesting is that capacity was not indicated by any of the 300 households as an indicator of significance. This exposes a possibility of at least four issues. First, perhaps I was not able to translate, convey, or adequately explain what was meant by capacity in the survey. Second, it is possible that, with no intent of condescension, subjects failed to grasp the theoretical concept of capacity. Third, subjects may have downplayed the external abilities or abstract role of capacity by instead focusing on more tangible components of the waterscape (e.g., problems that are better able to be seen or felt, such as quantity and distance). Lastly, and perhaps most provocative, it must be questioned whether capacity is as
important a factor as the literature decrees. At any rate, capacity was assigned a weight of 0 (thus eliminated from the survey-based weighting scheme), and quality and quantity topped the list and comprise 50.3% of the final WPI.

Table 6.3: WPI – Site Scale (Weights Reported in Survey)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Survey weight</th>
<th>WPI - survey weight</th>
<th>WPI - equal weight</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality (Q)</td>
<td>0.2583</td>
<td>73.5 - Paravaipettai (K)</td>
<td>68.6</td>
<td>4.9</td>
</tr>
<tr>
<td>LPCPD (L)</td>
<td>0.2448</td>
<td>62.7 - AKP (K)</td>
<td>62.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Distance (Di)</td>
<td>0.1303</td>
<td>62.1 - Vettakaramedu (K)</td>
<td>62.9</td>
<td>-0.8</td>
</tr>
<tr>
<td>Flow Rate (P)</td>
<td>0.1095</td>
<td>57.2 - Kilinjilmedu (K)</td>
<td>59.4</td>
<td>-2.2</td>
</tr>
<tr>
<td>Hrs. Avail. (H)</td>
<td>0.0870</td>
<td>55.7 - Andana Pettai (N)</td>
<td>55.7</td>
<td>0</td>
</tr>
<tr>
<td>Unimp. Sources (U)</td>
<td>0.0517</td>
<td>52.4 - Akkuraptai (N)</td>
<td>52.4</td>
<td>0</td>
</tr>
<tr>
<td>Conflicts (Co)</td>
<td>0.0505</td>
<td>52.0 - Akkam Pettai (K)</td>
<td>56.4</td>
<td>-4.4</td>
</tr>
<tr>
<td>Windows (W)</td>
<td>0.0359</td>
<td>50.4 - Mandapathur (K)</td>
<td>53.0</td>
<td>-2.6</td>
</tr>
<tr>
<td>Density (De)</td>
<td>0.0320</td>
<td>49.0 - Kizhakasa. (K)</td>
<td>52.8</td>
<td>-3.8</td>
</tr>
<tr>
<td>Capacity (Ca)</td>
<td>0</td>
<td>48.6 - Theti (N)</td>
<td>47.9</td>
<td>0.7</td>
</tr>
<tr>
<td>sum = 1</td>
<td>46.0 - NNN (N)</td>
<td>47.8</td>
<td>-1.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>44.4 - Samanthanpettai (N)</td>
<td>49.3</td>
<td>-4.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>41.6 - Saveriyarkovil (N)</td>
<td>43.5</td>
<td>-1.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>39.3 - Uzhuvvar Nagar (N)</td>
<td>48.8</td>
<td>-9.5</td>
<td></td>
</tr>
</tbody>
</table>

WPI = Water Poverty Index
LPCPD = Liters Per Capita Per Day
AKP = Amman Kovil Pathu
NNN = New Nambiyar Nagar
(K) = located in Karaikal District
(N) = located in Nagapattinam District

Note: Maximum for both WPIs is 100

In examining the survey weighted WPI, it must first be mentioned that differences between sites at the indicator level are proportionally maintained, which results in the same
ranking of sites within each indicator (see Table H.1 in Appendix H). However, while such discrepancies are preserved, the summation of the newly weighted indicators has the potential to reduce or exacerbate such differences in the total scores. Thus, the order of sites has the ability to change in the final WPI.

After implementing the respondent-advised weighting scheme, range at the site scale increased by 9.1 compared to the equally weighted WPI (see Table 6.3). Furthermore, the WPI of nine sites decreased, while two remained unchanged and only three increased. The average decrease was 3.54 and the average increase was 2.0, so, observed in toto, the 14 WPIs are relatively lower vis-à-vis the equally weighted scheme. Moreover, the results reveal that residents perceive themselves (and their settlements) as worse off through their personal lenses versus what is portrayed by the optics of the classically weighted WPI. This is significant because it seriously questions whether an equally weighted WPI is capable of sufficiently capturing contextualized, place-based settings.

At the site scale, the order jostled and only two sites—Paravaipettai and Kilinjilmedu—retained their original ranking (this is aptly illustrated later in Fig. 6.2). Additionally, Akkaraipettai entered the top half, primarily due to the site exhibiting comparatively safe water quality and the top ranking in flow rate (the fourth highest weighted indicator). Thus, two sites in Nagapattinam District surpassed the 50th percentile (as opposed to only one in the equal weight), causing Karaikal District to have only seven of the top nine WPIs instead of seven of the top eight. The worst performing site also changed. Uzhuvar Nagar assumed the spot due its lowest score in LPCPD and relatively poor water quality.

While changes in rankings occurred at the site scale, no changes took place at the district and rural-urban scales (see Table 6.4). In fact, all four scales of inquiry were preserved in terms of ranking, although the range increased in each case. Moreover, all sample sets—whether defined by district or type of administration—scored lower in their final WPI than they did under the equally weighted scheme. Thus, just as occurred at the site scale, the survey weights also
calculate final WPIs that pronounce all categories of inquiry as worse off compared to the equal weight scenario (which is exhibited later in Fig. 6.3).

Table 6.4: WPI – District and Rural-Urban Scales (Weights Reported in Survey)

<table>
<thead>
<tr>
<th></th>
<th>Distance (Di)</th>
<th>Hrs. Avail. (H)</th>
<th>Windows (W)</th>
<th>Density (De)</th>
<th>LPCPD (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>District - Naga.</td>
<td>11.63</td>
<td>0.67</td>
<td>1.23</td>
<td>2.30</td>
<td>14.99</td>
</tr>
<tr>
<td>District - Karaikal</td>
<td>12.28</td>
<td>0.95</td>
<td>2.59</td>
<td>2.80</td>
<td>22.33</td>
</tr>
<tr>
<td>Rural - Naga.</td>
<td>11.75</td>
<td>0.58</td>
<td>1.20</td>
<td>2.35</td>
<td>13.99</td>
</tr>
<tr>
<td>Urban - Naga.</td>
<td>11.48</td>
<td>0.79</td>
<td>1.27</td>
<td>2.23</td>
<td>16.33</td>
</tr>
<tr>
<td>Rural - Karaikal</td>
<td>11.68</td>
<td>1.08</td>
<td>2.40</td>
<td>2.50</td>
<td>21.48</td>
</tr>
<tr>
<td>Urban - Karaikal</td>
<td>12.52</td>
<td>0.90</td>
<td>2.67</td>
<td>2.92</td>
<td>22.66</td>
</tr>
<tr>
<td>Rural - Total</td>
<td>11.73</td>
<td>0.74</td>
<td>1.60</td>
<td>2.40</td>
<td>16.49</td>
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<tr>
<td>Urban - Total</td>
<td>12.13</td>
<td>0.86</td>
<td>2.15</td>
<td>2.66</td>
<td>20.29</td>
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<td>max = 13.03</td>
<td>max = 8.70</td>
<td>max = 3.59</td>
<td>max = 3.20</td>
<td>max = 24.48</td>
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<table>
<thead>
<tr>
<th></th>
<th>Flow Rate (P)</th>
<th>Conflicts (Co)</th>
<th>Unimproved Sources (U)</th>
<th>Quality (Q)</th>
<th>WPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>District - Naga.</td>
<td>5.18</td>
<td>3.99</td>
<td>1.32</td>
<td>5.55</td>
<td>46.9</td>
</tr>
<tr>
<td>District - Karaikal</td>
<td>3.09</td>
<td>4.62</td>
<td>1.83</td>
<td>7.67</td>
<td>58.1</td>
</tr>
<tr>
<td>Rural - Naga.</td>
<td>4.84</td>
<td>4.18</td>
<td>1.90</td>
<td>8.21</td>
<td>49.0</td>
</tr>
<tr>
<td>Urban - Naga.</td>
<td>5.62</td>
<td>3.73</td>
<td>0.54</td>
<td>2.01</td>
<td>44.0</td>
</tr>
<tr>
<td>Rural - Karaikal</td>
<td>5.78</td>
<td>3.57</td>
<td>1.63</td>
<td>1.08</td>
<td>51.2</td>
</tr>
<tr>
<td>Urban - Karaikal</td>
<td>2.01</td>
<td>5.04</td>
<td>1.90</td>
<td>10.30</td>
<td>60.9</td>
</tr>
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<td>Rural - Total</td>
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<td>3.98</td>
<td>1.81</td>
<td>5.83</td>
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<tr>
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<td>3.36</td>
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<td>1.39</td>
<td>7.19</td>
<td>54.6</td>
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<tr>
<td></td>
<td>max = 10.95</td>
<td>max = 5.05</td>
<td>max = 5.17</td>
<td>max = 25.83</td>
<td>max = 100</td>
</tr>
</tbody>
</table>

WPI = Water Poverty Index
LPCPD = Liters Per Capita Per Day
Note: Capacity not included because survey weight is 0
Lastly, an expert-based weighting scheme was implemented (see Table 6.5; also see Table H.2 in Appendix H for results at the indicator level, in which differences are proportional to those of the equal and survey weighted WPIs). The weights are informed by my observations across four calendar years, 300 household surveys, 74 qualitative interviews, FGDs, interviews with more than two dozen government officials, and the academic literature. It should be noted that the weight ascribed to each indicator was decided blindly, meaning that the weights and outputs of the other two schemes were not considered.

Ultimately, I concentrated 25% of the expert weight each in the indicators of quality and LPCPD. Access to a sufficient quantity of safe water is crucial in terms of health and supporting domestic cycles and livelihoods (all of which impact quality of life). Furthermore, I apportioned 12.5% of the weight to unimproved sources given that government supplies often fail to arrive or do so in deficient quantities. Thus, the possession of a back-up and/or supplementary source warrants stress. I also assigned 12.5% of the weight to capacity. Greater incomes are means for improving the waterscape, whether that constitutes the introduction of a borewell or handpump, upgrading to an individual tap, or financing other water improvements. Likewise, education provides basic knowledge (e.g., the germ theory) that can be harnessed to create a more hygienic environment—this is especially appropriate given the pervasive issues of poor water quality and post-point contamination. Last of the capacity components, formal and informal networks and living at the site for longer durations—which bestows knowledge on what to expect in terms of water issues and thereby cultivates the proliferation of nuanced coping mechanisms—should not be understated. I chose to demote the weights of density, flow rate, and conflicts (to 3.5%, 3.5%, and 2%, respectively) because they are all a function of individual taps and thus collectively represent outcomes created by the same phenomenon. Distance is also a function of individual taps. However, it was rated at 7% because shorter distances afford convenience, enable more roundtrips to retrieve scarce resources within limited availability windows, and cut down on opportunity costs. Finally, the windows indicator was weighted at 2% because it is associated
with quantity (which is more important in the end) and since hours of availability is a similar—
albeit distinct—measure.

Table 6.5: WPI – Site Scale (Expert Weight)

<table>
<thead>
<tr>
<th>Expert weight</th>
<th>WPI - expert weight</th>
<th>WPI - equal weight</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality (Q)</td>
<td>0.25</td>
<td>66.9 - Paravaipetrai (K)</td>
<td>68.6</td>
</tr>
<tr>
<td>LPCPD (L)</td>
<td>0.25</td>
<td>61.9 - AKP (K)</td>
<td>62.3</td>
</tr>
<tr>
<td>Capacity (Ca)</td>
<td>0.125</td>
<td>58.5 - Vettakaramedu (K)</td>
<td>62.9</td>
</tr>
<tr>
<td>Unimp. Sources (U)</td>
<td>0.125</td>
<td>56.9 - Kilinjilmedu (K)</td>
<td>59.4</td>
</tr>
<tr>
<td>Distance (D)</td>
<td>0.07</td>
<td>55.8 - Andana Pettai (N)</td>
<td>55.7</td>
</tr>
<tr>
<td>Hrs. Avail. (H)</td>
<td>0.07</td>
<td>51.1 - Kizhakasa. (K)</td>
<td>52.8</td>
</tr>
<tr>
<td>Density (De)</td>
<td>0.035</td>
<td>50.3 - Akkaraipetrai (N)</td>
<td>52.4</td>
</tr>
<tr>
<td>Flow Rate (P)</td>
<td>0.035</td>
<td>48.7 - Akkam Pettai (K)</td>
<td>56.4</td>
</tr>
<tr>
<td>Conflicts (Co)</td>
<td>0.02</td>
<td>47.5 - Mandapathur (K)</td>
<td>53.0</td>
</tr>
<tr>
<td>Windows (W)</td>
<td>0.02</td>
<td>46.0 - Theti (N)</td>
<td>47.9</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
\text{sum} & = 1 \\
41.6 & \text{- NNN (N)} \\
40.9 & \text{- Samanthanpetrai (N)} \\
38.2 & \text{- Saveriyarkovil (N)} \\
35.9 & \text{- Uzhuvular Nagar (N)} \\
\end{align*}
\]

range = 31.0 range = 25.1

WPI = Water Poverty Index
LPCPD = Liters Per Capita Per Day
AKP = Amman Kovil Pathu
NNN = New Nambiyar Nagar
(K) = located in Karaikal District
(N) = located in Nagapattinam District

Note: Maximum for both WPIs is 100

Significant differences exist between the expert weighting scheme and its two counterparts (see Table 6.5 and later Table 6.7 for variations in weights). First off, no indicators were weighted at 10%, which is the uniform level utilized in the equally weighted system. In
fact, two indicators—quality and LPCPD—each comprise 25% of the total weight, and four indicators are weighted at either 3.5% or 2%. Similarly, although the weights for quality and quantity are analogous to those in the survey weighted scheme, noticeable differences are present. For example, capacity was eliminated in the survey-informed WPI while the expert scheme weighted capacity at 12.5%; the expert weighted WPI assigned a rate for unimproved sources that is more than double that of the survey-aligned WPI; and the expert weighted system prescribed a weight for flow rate at less than 1/3 that of the survey weighted scheme. Furthermore, the survey weight for conflicts is more than two and a half times the same in the expert scheme and, from the same vantage point, the weight for distance approaches double that of its contemporary.

As demonstrated in Table 6.5, range at the site scale increased by 5.9 when the expert and equally weighted arrangements are compared. Only one site’s WPI increased (by a barely noticeable 0.1), while the WPIs of the remaining 13 sites decreased at an average of 4.67. Thus, when juxtaposed with the uniformly weighted scheme, the expert system portrayed sites as worse off, which mirrors the results of the survey-informed weights. Moreover, the order of sites changed in the final WPI (which is visualized later in Fig. 6.2). Just as occurred under the survey weight, Akkaraipettai rose two places in ranking, meaning that Nagapattinam District has two sites ranked in the top half as opposed to only one. Furthermore, Kizhakasakudimedu fared better, which is attributed to the site’s highest score in access to unimproved sources (due to the existence and accessibility of its treatment center). Identical to what occurred in the survey weight, Uzhuvvar Nagar fell two places to exhibit the worst overall score, which is linked to the site’s poor performance in LPCPD and quality. At the district and rural-urban scales, all outcomes were maintained in terms of rankings (see Table 6.6). However, the difference in WPI at each scale increased compared to the equal weight WPI, and all sample sets are worse off under the expert-determined weight (which can be viewed later in Fig. 6.3).
Table 6.6: WPI – District and Rural-Urban Scales (Expert Weight)

<table>
<thead>
<tr>
<th></th>
<th>Distance (Di)</th>
<th>Hours Avail. (H)</th>
<th>Windows (W)</th>
<th>Density (De)</th>
<th>LPCPD (L)</th>
<th>Flow Rate (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>District - Naga.</td>
<td>6.25</td>
<td>0.54</td>
<td>0.68</td>
<td>2.51</td>
<td>15.31</td>
<td>1.65</td>
</tr>
<tr>
<td>District - Karaikal</td>
<td>6.60</td>
<td>0.77</td>
<td>1.44</td>
<td>3.06</td>
<td>22.80</td>
<td>0.99</td>
</tr>
<tr>
<td>Rural - Naga.</td>
<td>6.31</td>
<td>0.46</td>
<td>0.67</td>
<td>2.58</td>
<td>14.29</td>
<td>1.55</td>
</tr>
<tr>
<td>Urban - Naga.</td>
<td>6.17</td>
<td>0.64</td>
<td>0.71</td>
<td>2.43</td>
<td>16.67</td>
<td>1.80</td>
</tr>
<tr>
<td>Rural - Karaikal</td>
<td>6.27</td>
<td>0.87</td>
<td>1.33</td>
<td>2.74</td>
<td>21.94</td>
<td>1.85</td>
</tr>
<tr>
<td>Urban - Karaikal</td>
<td>6.73</td>
<td>0.73</td>
<td>1.49</td>
<td>3.19</td>
<td>23.14</td>
<td>0.64</td>
</tr>
<tr>
<td>Rural - Total</td>
<td>6.30</td>
<td>0.60</td>
<td>0.89</td>
<td>2.63</td>
<td>16.84</td>
<td>1.65</td>
</tr>
<tr>
<td>Urban - Total</td>
<td>6.52</td>
<td>0.69</td>
<td>1.19</td>
<td>2.91</td>
<td>20.72</td>
<td>1.07</td>
</tr>
</tbody>
</table>

max = 7

<table>
<thead>
<tr>
<th></th>
<th>Conflicts (Co)</th>
<th>Capacity (Ca)</th>
<th>Unimproved Sources (U)</th>
<th>Quality (Q)</th>
<th>WPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>District - Naga.</td>
<td>1.58</td>
<td>7.00</td>
<td>3.19</td>
<td>5.37</td>
<td>44.1</td>
</tr>
<tr>
<td>District - Karaikal</td>
<td>1.83</td>
<td>6.60</td>
<td>4.42</td>
<td>7.42</td>
<td>55.9</td>
</tr>
<tr>
<td>Rural - Naga.</td>
<td>1.66</td>
<td>6.95</td>
<td>4.59</td>
<td>7.95</td>
<td>47.0</td>
</tr>
<tr>
<td>Urban - Naga.</td>
<td>1.48</td>
<td>7.06</td>
<td>1.32</td>
<td>1.95</td>
<td>40.2</td>
</tr>
<tr>
<td>Rural - Karaikal</td>
<td>1.41</td>
<td>6.69</td>
<td>3.94</td>
<td>1.04</td>
<td>48.1</td>
</tr>
<tr>
<td>Urban - Karaikal</td>
<td>2.00</td>
<td>6.56</td>
<td>4.61</td>
<td>9.97</td>
<td>59.0</td>
</tr>
<tr>
<td>Rural - Total</td>
<td>1.57</td>
<td>6.86</td>
<td>4.37</td>
<td>5.64</td>
<td>47.4</td>
</tr>
<tr>
<td>Urban - Total</td>
<td>1.80</td>
<td>6.75</td>
<td>3.37</td>
<td>6.96</td>
<td>52.0</td>
</tr>
</tbody>
</table>

max = 2

max = 12.5

max = 25

max = 100

WPI = Water Poverty Index
LPCPD = Liters Per Capita Per Day

Lastly, it is useful to observe the three schemes side by side (see Appendix I for visual representation via spider diagrams). As is evident in Table 6.7, distinguishable differences exist among indicator weights. Furthermore, Figure 6.2 clearly depicts the reorganization that occurred under the three diverse configurations. There was much shuffling of sites between the
Table 6.7: Comparison of the Three Weighting Schemes

<table>
<thead>
<tr>
<th></th>
<th>Equal weight</th>
<th>Survey weight</th>
<th>Expert weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality (Q)</td>
<td>0.1</td>
<td>0.2583</td>
<td>0.25</td>
</tr>
<tr>
<td>LPCPD (L)</td>
<td>0.1</td>
<td>0.2448</td>
<td>0.25</td>
</tr>
<tr>
<td>Distance (Di)</td>
<td>0.1</td>
<td>0.1303</td>
<td>0.07</td>
</tr>
<tr>
<td>Flow Rate (P)</td>
<td>0.1</td>
<td>0.1095</td>
<td>0.035</td>
</tr>
<tr>
<td>Hrs. Avail. (H)</td>
<td>0.1</td>
<td>0.0870</td>
<td>0.07</td>
</tr>
<tr>
<td>Unimproved Sources (U)</td>
<td>0.1</td>
<td>0.0517</td>
<td>0.125</td>
</tr>
<tr>
<td>Conflicts (Co)</td>
<td>0.1</td>
<td>0.0505</td>
<td>0.02</td>
</tr>
<tr>
<td>Windows (W)</td>
<td>0.1</td>
<td>0.0359</td>
<td>0.02</td>
</tr>
<tr>
<td>Density (De)</td>
<td>0.1</td>
<td>0.0320</td>
<td>0.035</td>
</tr>
<tr>
<td>Capacity (Ca)</td>
<td>0.1</td>
<td>0</td>
<td>0.125</td>
</tr>
</tbody>
</table>

*sum = 1 sum = 1 sum = 1*

equal and survey weights and the equal and expert weights. However, the survey and expert weights essentially mimic each other, with only one site having changed rank and the remaining 13 sites maintaining their ranks. This is particularly intriguing because the weights of two schemes, other than for quality and LPCPD, are dissimilar. Thus, although the survey and expert weights vary, they ultimately served to fashion analogous total WPIs. Furthermore, it is interesting to note that the two modified schemes both generated greater variation among sites and indicated higher levels of water poverty (i.e., lower WPI scores) compared to the classically weighted scheme (although the range of the expert weight was less variable than that of the survey weight). These outputs are significant because they indicate that the relative and actual levels of water poverty are greater through the lenses of those who are most familiar with conditions on the ground—the study populations and the expert. Finally, Figure 6.3 captures differences at the district and rural-urban scales. While all weighing schemes produce the same rankings, the two modified schemes both portray all sample sets as worse off and claim that the relative difference between each scale of analysis is greater. Thus, the survey and expert weighted schemes, which are informed by extensive place-based knowledge, generate snapshots
that suggest the uniformly weighted scheme may not accurately interpret the actual level of water poverty.

![Comparison of Weighting Schemes – Site Scale](image)

**Figure 6.2: Comparison of three weighting schemes (site scale)**

### 6.5 Conclusion

I have constructed a contextualized WPI in order to examine the outcomes of post-tsunami reconstruction processes in South India. Furthermore, the locally, situationally adapted WPI was deployed at several scales and analyzed using three distinct weighting permutations. The instrument was able to crystallize complex, often mutually reinforcing problems by
Comparison of Weighting Schemes – District and Rural-Urban Scales

<table>
<thead>
<tr>
<th></th>
<th>Equal Weight</th>
<th>Survey Weight</th>
<th>Expert Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>District - Naga.</td>
<td>49.3</td>
<td>46.9</td>
<td>44.1</td>
</tr>
<tr>
<td>District - Karaikal</td>
<td>59.3</td>
<td>58.1</td>
<td>55.9</td>
</tr>
<tr>
<td></td>
<td>range = 10.0</td>
<td>range = 11.2</td>
<td>range = 11.8</td>
</tr>
<tr>
<td>Rural - Naga.</td>
<td>51.2</td>
<td>49.0</td>
<td>47.0</td>
</tr>
<tr>
<td>Urban - Naga.</td>
<td>46.9</td>
<td>44.0</td>
<td>40.2</td>
</tr>
<tr>
<td></td>
<td>range = 4.3</td>
<td>range = 5.0</td>
<td>range = 6.8</td>
</tr>
<tr>
<td>Rural - Karaikal</td>
<td>54.7</td>
<td>51.2</td>
<td>48.1</td>
</tr>
<tr>
<td>Urban - Karaikal</td>
<td>61.2</td>
<td>60.9</td>
<td>59.0</td>
</tr>
<tr>
<td></td>
<td>range = 6.5</td>
<td>range = 9.7</td>
<td>range = 10.9</td>
</tr>
<tr>
<td>Rural - Total</td>
<td>52.4</td>
<td>49.7</td>
<td>47.4</td>
</tr>
<tr>
<td>Urban - Total</td>
<td>55.8</td>
<td>54.6</td>
<td>52.0</td>
</tr>
<tr>
<td></td>
<td>range = 3.4</td>
<td>range = 4.9</td>
<td>range = 4.6</td>
</tr>
</tbody>
</table>

Figure 6.3: Comparison of three weighting schemes (district and rural-urban scales)

capturing a snapshot of each site at both the indicator and total WPI levels. This facilitated ‘apples to apples’ comparisons at the site scale, and the same assessments were accomplished when data were aggregated at district and rural-urban scales. The operationalization of the WPI confirmed my qualitative observation (i.e., data presented in Chapter 5) that issues of, inter alia, quality, quantity, and conflict reign pervasive at many of the study sites. Moreover, the WPI validated my contention that—at the district scale and for the most part the site scale—Karaikal
is better off in many respects compared to Nagapattinam. Furthermore, the WPI established that sites in rural Nagapattinam District performed better than their urban counterparts. This phenomenon is counterintuitive and such a discrepancy may not have been unearthed unless field-based data collection and scalar analyses were undertaken.

In terms of utility and functionality, the WPI’s simplistic nature, ability to support multi-scalar analyses, applicability in several spheres, and suitability for visualization (see Appendix I) render it a useful instrument. Ultimately, the WPI has several practical uses. Governments, whether national, state, district, or local, can harness the WPI in order to evaluate the success of projects (both post-disaster and ‘normal’), allocate scarce resources more efficiently, and implement evidence-based policies. On the latter two points, governments, NGOs, and private entities can therefore utilize the device to reduce spatial inequities and heterogeneous patterns of development. Additionally, the WPI and its snapshots can form baselines for making temporal comparisons, such as after interventions from a subsequent disaster, post the implementation of a ‘normal’ project, or to monitor developmental change over time. Lastly, the contextualized WPI introduced in this paper incorporated original data at the household scale, and it was also advised by field observations and interviews with those living in and managing the contexts. A WPI advised by such a scale, data set, and insights delivers not only the ‘what’ of problems, but also the ‘how’ and ‘why.’ In the end, it is the how and why that are intrinsically significant for understanding unique problems and developing informed courses of action.

The three competing weight schemes presented in this study surface the longstanding discourse on proper weighting techniques. The weighting of composite indices, and in any instance when multiple factors must be considered, is a highly subjective and contentious arena. Moreover, this is a dilemma that will likely go unresolved—experts will continue to both refine and debate weighting schemes. No weighting assignment is perfect, and seemingly miniscule alterations have the potential to mask or overexaggerate the study problem(s)—sometimes to the end of inadvertently causing harm. Thus, at the end of the day, an index should comprise only a portion of the policy and decision-making calculus.
Bearing in mind the above points, I argue that an equally weighted WPI is a good starting point for the examination of post-tsunami water issues in Nagapattinam and Karaikal. However, the equal weight scheme ultimately (and ironically given that it is multi-dimensional) treats all indicators as pseudo-monoliths, meaning that it does not account for the prevalence, uniqueness, severity, or significance of each indicator. Thus, I contend that the survey and expert weights, while imperfect, more adequately capture the extent of water poverty at the study sites. The two modified permutations are better equipped to tell the ‘real story’ because they are imbued with the vantage point of the populations coping with the conditions on one hand, and observations across space and time, interviews with the study populations and government officials, and the literature on the other. Therefore, while the survey and expert-based weighting schemes are admittedly imperfect, they arguably produce outcomes that are closer to the sentiments and realities that are experienced in real space. It is worth noting that the two schemes converge in their products, albeit for different reasons. While this does not necessarily signify higher levels of accuracy, the two modes were founded on localized background information and thus there appears to be merit in varying the WPI scheme away from one of equal weight and towards one that is more contextualized. A refined scheme that is derived from a robust combination of field observations, inputs from the study populations, and upheld by the literature may be called for.

Lastly, while I argue that the survey and expert weighted WPIs performed more accurately in this study, a similar project might demand a very different scheme. For example, the same study comparing post-tsunami reconstruction across India, Sri Lanka, and Indonesia may exhibit vastly different weights given the boundless possibility of observations, dialogues, and severity and prevalence of issues that could emerge across the diverse settings. Thus, while no weighting scheme is universally applicable in all cases and at all scales, value exists in tailoring weighting arrangements in order to attain a more holistic snapshot of the study problem.
CHAPTER VII: BOILING AS A METHOD OF HOUSEHOLD WATER TREATMENT

7.1 Introduction

The poor nature of water quality in Nagapattinam and Karaikal Districts has already been established in Chapters 5 and 6. In general, piped water supplies are laden with fecal coliform and fail to meet standards set by the BIS and WHO, with quality further deteriorating as a result of retrieval, storage, and serving processes. Therefore, HWT, promoted by bodies such as the WHO’s International Network on Household Water Treatment and Safe Storage (HWTS), has been touted as a practical method for ensuring potable water among populations confronting issues of water quality—the study sites certainly fitting this category. Boiling water is the most dominant method of HWT, with 21% of all households in low and middle income countries boiling their water at the global scale, including 10.4% of the whole of India.469 Clasen (2009), a professor of water, sanitation, and health at the London School of Hygiene and Tropical Medicine, comments on the comprehensiveness of such a technique:

Boiling or heating with fuel is perhaps the oldest means of disinfecting water at the household level. If practised correctly, boiling is also one of the most effective, killing or inactivating all classes of waterborne pathogens, including bacterial spores and protozoan cysts that have shown resistance to chemical disinfection and viruses that are too small to be mechanically removed by microfiltration. Heating water to even 55 °C has been shown to kill or inactivate most pathogenic bacteria, viruses, helminths and protozoa that are commonly waterborne. Moreover, while chemical disinfectants and filters are challenged by turbidity and certain dissolved constituents, boiling can be used effectively across a wide range of physical and chemical characteristics.470

Many households in the study sites practice HWT to some extent, with boiling encompassing the primary method. Thus, the rate and results of boiling water in the study sites, followed by the

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efficacy, barriers to, and caveats of its practice will be examined. The chapter ends with recommendations for improving and scaling up boiling and other methods of HWT.

### 7.2 Rate and results of household water treatment

HWT has already been recognized as a coping mechanism in the face of poor water quality in Chapter 5. At the study sites, a sampling of 300 households revealed that 35 of 169 (20.7%) households in Nagapattinam District and 30 of 131 (22.9%) households in Karaikal District engage in some method of HWT for a total of 21.7% (see Table 7.1). Moreover, the results of HWT are quite alarming: of the 35 households practicing HWT in Nagapattinam District, 16 samples tested negative for fecal coliform; likewise, 10 of 30 samples in Karaikal District tested negative for fecal coliform. The aggregate result is that only 26 of 65 (40%) households utilizing HWT generated water free of bacterial contamination, whereas the outcome should theoretically be closer to 100%. That being said, households engaging in HWT are clearly more likely to consume potable water than those who drink water directly from the tap: 35 of 235 (14.9%) households not utilizing HWT exhibited potable water compared to 40% among those that practice HWT; and only 21.7% of households practice HWT, yet they comprise 42.6% of the tests negative for fecal coliform. Thus, while HWT is facilitating improved, albeit lackluster, results, issues of efficacy—particularly when considering a method that can virtually guarantee water free of bacteria—come to the forefront. Therefore, pretexts for the lower than expected proportion of negative tests, as well as barriers to and caveats of practicing HWT will be examined next.

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471 Of the 65 households practicing HWT, 64 boil their water and one filters their water.

472 The figure of 40% resembles Clasen et al.’s (2008) study in rural Vietnam in which a presence of fecal coliform was found in 37% of surveyed households that boiled their water. [T. Clasen et al. (2008), “Microbiological effectiveness and cost of boiling to disinfect drinking water in rural Vietnam,” *Environmental Science & Technology* 42(12): p. 4258.]
Table 7.1: Household Water Treatment at the Study Sites

<table>
<thead>
<tr>
<th></th>
<th>Nagapattinam</th>
<th>Karaikal</th>
<th>Total</th>
<th>% Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households practicing HWT</td>
<td>35 / 169</td>
<td>30 / 131</td>
<td>65 / 300</td>
<td>21.67%</td>
</tr>
<tr>
<td>Households not practicing HWT</td>
<td>134 / 169</td>
<td>101 / 131</td>
<td>235 / 300</td>
<td>78.33%</td>
</tr>
<tr>
<td>Households practicing HWT with safe water *</td>
<td>16 / 35</td>
<td>10 / 30</td>
<td>26 / 65</td>
<td>40.0%</td>
</tr>
<tr>
<td>Households not practicing HWT with safe water</td>
<td>13 / 134</td>
<td>22 / 101</td>
<td>35 / 235</td>
<td>14.89%</td>
</tr>
<tr>
<td>Safe water from HWT households of all safe water</td>
<td>16 / 29</td>
<td>10 / 32</td>
<td>26 / 61</td>
<td>42.62%</td>
</tr>
</tbody>
</table>

n = 300

* Safe water defined as an absence of fecal coliform

HWT = Household Water Treatment

Note that households practicing HWT revealed samples free of fecal coliform only 40% of the time, yet were 25.11% more likely to exhibit safe water relative to households not practicing HWT.

7.3 Efficacy, barriers, and caveats of boiling

I begin this section by deconstructing the efficacy of boiling water in the study area (i.e., why much boiled water fails to reach a safe standard). Next, several barriers to and cultural rationale for not boiling water will be posited, which will be accentuated by caveats that accompany the process. The segment on barriers and caveats resembles Wellin’s (1955) classic case study “Water boiling in a Peruvian town,” in which various socio-cultural justifications for boiling or not boiling water were teased out through methods of ethnography and observation.473

Opening with efficacy, there are two primary hypotheses for why boiled water failed to fully eliminate fecal coliform from drinking water at the study sites. Excluding the sole household that filters its water (which tested negative), 25 of 64 (39.1%) households that boil

their water produced water free of *Escherichia coli*. Informed by much observation, the principal factor impeding higher rates of successful bacterial elimination pertains to the activity of boiling as practiced in the household. After observing seven households boil their water (without cueing), it became apparent that households do not actually boil their water. Rather, they simply heat the water, which households report as *sooru thanni* (‘boiled water’ in Tamil). Households tend to ‘boil,’ at one time, enough drinking water for the day (typically 10 liters) in a metal container. The time taken to boil 10 liters of water is considerable, often entailing close to 15 minutes. Water boilers, generally the female heads of household, have multiple tasks to tend to—including cooking, which requires the stove or hearth space occupied by water being heated—engendering water boilers to remove water from the heat source (whether fueled by propane, kerosene, or biomass) as soon as it is subjectively deemed hot enough. The result is that water rarely reaches boiling point, let alone having been brought to a rapid boil for several minutes, which is recommended by experts—especially when one knows that the water is likely contaminated. While heating water can kill microorganisms, elimination is not guaranteed unless water is brought to a sustained rolling boil. Secondly, efficacy is compounded by methods of storage and serving. Whether water is boiled properly or not, storage in containers that may be contaminated (especially prolonged storage, which is common) and serving by dipping cups and hands (both of which may be contaminated) into the storage container present hazards for post-treatment contamination. Taken collectively, insufficient boiling practices combined with methods of storage and serving render boiling less efficient than it otherwise should be.

Assuming issues of efficacy can be surmounted (an assumption postulated for the sake of discussion), several barriers exist, *ceteris paribus*, for households taking up boiling as a method

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of HWT. First off, many households not engaging in boiling are under the impression that water provided by the government is automatically ‘good water’: if it comes from a pipe and has been treated then it must be safe. Furthermore, several households subscribe to the argument that nobody in their household is sick, so the water must be safe; in other words, if the water is contaminated then, using syllogism, members of the household would be ill. This assumption is best brought to life by Rekha, a resident of New Nambiyar Nagar:

You do not know what you are talking about [in response to me stating that the water is contaminated]. Pipe water is nalla, romba nalla [‘good, very good’ in Tamil]. It’s super. If there are krimi [‘bacteria’ or ‘germs’ in Tamil] in the water then I would be sick right now. Krimi illah [‘there are no bacteria/germs’ in Tamil]. I’m not sick, so the water is safe. You are wrong [said chuckling].

Contentions of this nature are not restricted to the study sites in South India, as Wellin (1955) reported similar responses during fieldwork in Peru.\textsuperscript{475} Somewhat related, knowledge on the benefits of boiling water appear to be absent among some members of the post-tsunami settlement communities. For example, Paliammal, a resident of Amman Kovil Pathu, claims:

I boil my water every day, but some people here do not believe that it is healthy. They say that people who boil their water get sick more often and people who drink water directly stay healthier. I tell them that they’re wrong, but they don’t believe me and they’ll never change. I am the leader of 37 women in a microcredit group in this area. I tell them to boil their water, some listen and some don’t. Even if they know that it is healthier many still don’t do it. What to do?

Not only does Paliammal’s quote correspond with Wellin’s (1955) observation that “the people of Los Molinos equate health with unboiled water” and infirmity with boiled water, but it surfaces issues of resisting the practice even when its benefits are known.\textsuperscript{476} This assertion is buttressed by an elderly resident of Kilinjilmedu who refuses to boil her water despite her spouse having died of cholera, and by numerous households that were shown (colorfully and odorously

\textsuperscript{475} Wellin, 1955.

\textsuperscript{476} Ibid.: p. 85.
with jet-black, sulfur-laden vials) that their drinking water tested positive for fecal coliform, yet state vehemently that they do not intend to boil their water or practice any form of HWT.477

Assuming that residents of the study sites can be persuaded that boiling water provides health benefits, and assuming that its efficacy can be improved, several barriers to adoption still exist. When such hitches are removed, barriers in the form of time (or opportunity costs), monetary costs, and preferences in consumption reign formidable. Beginning with time, it was already cited that boiling water, typically in large volumes, requires considerable time, a contention upheld by Adair-Rohani (2011) in Uganda, Clasen et al. (2008) in Vietnam, and Wellin (1955) in Peru.478 Moreover, Poulos et al. (2012), in a conjoint analysis survey in Andhra Pradesh, India (the state bordering Tamil Nadu), report that time required to treat water in the household was a major factor in households determining whether the intervention was worthwhile.479 Furthermore, during peer debriefing sessions with MacDonald and Philip, who study participatory HWT interventions, it was stated that residents of a target population in Chennai, Tamil Nadu, voiced a preference for quicker methods of HWT. Observed pragmatically at the study sites, the burden of boiling water—a gendered chore profoundly impacting women—competes with myriad tasks that must be conducted concurrently: gathering water, cooking breakfast, feeding children, getting children and adults ready for school and work, cooking lunch and packing it for those going to school and work, bathing, washing dishes and laundry, cleaning the house, and the list goes on. Without allotting time for relaxation, the

477 Similarly, Wellin discusses the habits of ‘Mrs. E.,’ who is “convinced of the value of boiling the drinking water, yet does not do so.” [Ibid.: p. 86.]


Clasen et al., 2008.


list of ‘duties’ performed by women permits little time for boiling water, particularly when considering that a pot of water takes up all or half of the stove or hearth space, thereby restricting space available for cooking. Thus, it is no wonder why the time and opportunity costs attributed to boiling water led Suneetha to cease the practice of boiling in less than one week: “It [boiling water] became too troublesome and took too much time. I have other things to do.” Lastly, a majority of the households at the study sites use biomass fuel for cooking, which translates to a necessity of supplemental stores of fuel if households choose to boil their water. The chore of gathering biomass for fuel, an activity reserved for women and children, imposes additional time and opportunity costs, especially during the monsoon season when dry brush is scarce.

The monetary costs associated with boiling water also present a significant obstacle, a liability attested to by Clasen et al. (2008) in Vietnam, Gilman and Skillicorn (1985) in Bangladesh, and Wellin (1955) in Peru. In fact, in neighboring Bangladesh, it was revealed that families in the lowest income quartile that boil their water are forced to utilize 22% of their fuel for boiling, and that boiling increases household expenditures by 11%—a price few can afford. Echoing the first figure, it is estimated that “1/5 of the total end-use of energy for households in developing regions [globally] was for water heating alone.” At the study sites, electing to boil water either entails searching for biomass fuel more frequently or for longer durations, or the purchase of greater quantities of propane or kerosene. At last check in January 2012, propane was available from private vendors at the rate of ₹420 for a 31.24 pound canister (the rate is variable). However, the use of propane also requires a stove, costing roughly ₹600-

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480 Clasen et al., 2008.


482 Adair-Rohani, 2011: p. 11.
900, and a deposit to the vendor amounting to several hundred rupees. Collectively, the three costs often price out the residents of post-tsunami settlements. Furthermore, propane is in high demand, meaning that many vendors are not taking new orders and that there is often a delay of 1-2 weeks from when an empty tank can be replaced with a full tank. Kerosene is used by some households, although propane (when economically feasible) is preferred and biomass is practiced most widely. Kerosene is only available at government ration shops at the rate (as of January 2012) of ₹15.5 per liter (the use of kerosene for cooking also requires a stove with an attachment for pumping the fuel). Suffice it to say that the costs of boiling water—whether defined as the time required to gather biomass fuel or the monetary costs associated with using propane or kerosene—render the practice of boiling water either meddlesome or costly at the study sites.

Lastly, preferences relating to the physical properties of water further inhibit the procedure of boiling. Individuals from the study sites, as did those in Wellin’s (1955) case study, voiced *ad infinitum* that they do not enjoy drinking boiled water.\(^{483}\) Residents complained that the ambient air temperature, whether outside or in the confines of the home, is generally hot, and that consuming hot water is inimical to natural cooling processes. While boiled water can be left to cool, doing so requires roughly two hours (given 10 liter batches). Thus, the time of day that water arrives (on the average, between 6-8am) does not allow for water to be boiled, cooled, and then consumed before beginning the day, not to mention that it would not be cooled to a point that children and adults could take it with them to school or work. Additionally, interlocutors object to the aesthetics of boiled water, with Jancy of Paravaipettai disclosing, “I don’t want to boil my water. I don’t like boiled water, I just don’t like it. It tastes bad.” Jancy’s opinions are shared by many, and are a result of the de-oxygenation of water that occurs during the boiling process, as well as the condition of the pots used. The pots used for boiling have often suffered heavy usage, leach a metallic flavor, and food films or particulates present in the pots sully the taste of the water (e.g., from cooking rice). Even when a vessel is

\(^{483}\) Wellin, 1955.
used only for the purpose boiling water, individuals claim that a metallic tincture is palpable, and that the taste is aesthetically unpleasant and ‘not pure tasting’—not to mention that many remain adverse to consuming hot water in the first place.

In addition to the efficacy of boiling water and barriers to doing so, several caveats must be teased out. A chief caveat is of temporal nature: few households that self-report as water boilers exercise the practice continually. Rather, while a minority of boilers fulfill the task uninterruptedly, the majority boil water only during the monsoon season or when an individual in the household is ill. Just as certain foods, such as mangoes and jackfruit, produce heat, while others, such as bananas and curd, cool the body, hot water is accepted as a heating agent during the relatively chilly monsoon season, thereby generating a temporal spike in the number of boilers. During fieldwork, the common response was affirmative when households were asked if they boil their water. However, when asked for a sample of the water for testing purposes, more often than not, there was no boiled water to be tested—which was perpetually qualified through the explanation that the household does boil water for drinking, but only during the monsoon. Interlocutors commented that, during the monsoon, temperatures plummet, winds increase (which disturb their ears), rain prevails, and the interior of their homes are cool and moist—all of which are abated by consuming hot, boiled water.

Similarly, the consumption of boiled water is reserved temporally, or perhaps situationally, for the ill. Individuals who boil water for the ill acknowledge its safety relative to non-boiled water, and allopathic doctors and ayurvedic praxes instruct parents to boil water for their children when they suffer sickness. However, what transpires is that water is boiled while individuals are ill, but the practice is terminated once individuals recover. Thus, rather

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484 The conception of ‘hot’ and ‘cold’ foods is both a cultural convention and practiced clinically in the form of ayurveda, a traditional system of medicine based in Hinduism that dates back to the Vedic period.

485 Wellin (1955) uncovered the same practice in Peru, where traditionally held beliefs “dictate unboiled water for the healthy and boiled water only for the sick.” [Ibid.: pp. 91-92.]
than boiling water daily, which would decrease the incidence of waterborne diseases overall and could have possibly prevented the malaise that triggered the short-lived episode of boiling to begin with, households engage in routinized cycles of boiling and not boiling as a function of real or perceived illness. Therefore, the temporal nature of boiling, whether observed during the monsoon or in sickness, loses it preventive edge and is demoted to a reactive, as opposed to a proactive, mechanism.

Besides the temporal, the consumption of boiled water also demonstrates a selective dimension. Among households that boil, it is common for only a portion of the household to consume the treated water. For example, water is typically boiled for the sole purpose of children to drink, while the remainder of the household consumes water directly from the tap. This system is practiced among boilers who acknowledge that heat kills germs, yet opt not to compel the entire household to consume the water that they appraise as relatively safer. Likewise, it is common for only elderly members of the household to consume boiled water, which is primarily a function of the elderly subscribing to the premise that consuming cold items, such as ice cream, chilled beverages, items stored in a refrigerator, and exposure to cold airs, instigate illness. For example, if an individual is observed drinking cold water today and is infirm tomorrow, the cause, according to many (the elderly in particular), was the unwise consumption of chilled water. This dichotomy of hot and cold water is not based on microbes, but instead on traditionally held beliefs rooted in popular conventions and ayurveda. Thus, predicated on relative interpretations of disease origins, the elderly are more likely to consume boiled water, while other members of the household tend to consume non-boiled water.

Manikandan, a 73-year old resident of Uzhuvar Nagar, upholds this claim: “I drink hot water. Cold water causes joram [‘fever’ in Tamil]. My daughter-in-law boils water every day for me. I drink the boiled water, but only me in this house.” Therefore, based on observations and hundreds of dialogues, it is clear that just because a household boils water does not translate to all members consuming the treated water. Rather, it is likely that a subset of the family unit, typically children, the elderly, or one of the heads of household, consume the boiled water.
Furthermore, while rationale stems from foundations of health understanding, the reasoning derives from two camps: the germ theory and a cold-hot binary.

A final caveat concerns the ancillary health impacts of boiling water. At the study sites, most cooking, and likewise the boiling of water, is fueled by biomass, namely shrubs and small pieces of wood collected from the edges of the settlements. Propane is cost prohibitive for the majority of post-tsunami settlement residents, and kerosene, while cheaper, costs more than freely available biomass resources; hence the proclivity of exploiting biomass for fuel. Unfortunately, the use of biomass for cooking and boiling water is associated with increased exposure to air pollution, formaldehyde, acrolein, benzene, toluene, styrene, and particulates comprising a set of the injurious constituents.\textsuperscript{486} Furthermore, air pollution from biomass fuel has been correlated with low birth weights, acute lower respiratory infections (ALRI), cataracts and eye discomfort, chronic obstructive pulmonary disease (COPD), tuberculosis, asthma, lung cancer, and headaches.\textsuperscript{487} Therefore, because boiling necessarily increases the amount of biomass combusted, it is argued that boiling demonstrates a notable drawback, and that its practice may not be as cumulatively healthy as proponents suggest.

Additionally, boiling water is associated with increases in burns and scalds, especially among children.\textsuperscript{488} In fact, in Sao Paulo, Brazil, Rossi \textit{et al.} (1998) found that the heating of

\textsuperscript{486} Adair-Rohani, 2011.


\textsuperscript{487} Adair-Rohani, 2011.


Shaheed and Bruce, 2011.

Smith, 2002.

\textsuperscript{488} Adair-Rohani, 2011.
liquids—water being the most frequent—accounted for 50% of all reported burns.  

Furthermore, 85.6% of burn accidents took place in the home, 80.7% occurred while at least one parent was present, and 50% of the cases were among children age three and under. Thus, the boiling of water escalates the risk of burns in the household, with children, even when parents are present, disproportionately affected. Lastly, in this era of deforestation, manmade climate change, and pursuits for sustainability, the literature contends that increases in boiling amplify both greenhouse gas emissions and unsustainable practices that serve to reduce vegetation cover. However, while this argument is valid, I refuse to hold marginalized populations responsible for processes to which they have either contributed very little or possess few methods for moderating.

7.4 Discussion and recommendations

This section follows Wellin’s (1955) structure by providing recommendations for increasing the efficacy of boiling and scaling up HWT in the study area. Given the data presented in the previous section, it has been demonstrated that boiling water may not be the optimal method for ensuring safe water at the point-of-use. In agreement with the conclusions of Clasen et al. (2008), boiling does improve water quality, but the full risk to waterborne pathogens is not eliminated, and formidable drawbacks emerge. Thus, after accounting for opportunity and monetary costs, popular resistance, practices manifesting as non-continuous and

Clasen et al., 2008.


489 Rossi et al., 1998: 418.

490 Ibid.: 419.

491 It is worth noting is that an increase in kerosene usage (for boiling water) is accompanied by an increase in poisoning incidents among children via the accidental consumption of kerosene. [Adair-Rohani, 2011.]

492 Clasen et al., 2008.
selective, and associated health impacts, the evidence coalesces to classify the method of boiling as seriously limited.

While limitations exist, several insights have been garnered for improving the efficacy of boiling water. First off, proper methods for boiling must be relayed in order to increase the elimination of bacteria. Households tend to heat the water, presuming that the water has been boiled and that microbes have been destroyed. However, while some microbes are killed by heating to 55ºC (131ºF), bringing water to a rapid boil, preferably for several minutes, is the only surefire way to eliminate the full risk. Thus, proper instructions on what constitutes boiling must be imparted to at risk populations, with clear guidelines on producing ‘bubbles’ for several minutes as a visible and auditory cue that water has been brought to a boil (methods for education on HWT will be discussed later in scalability). Furthermore, in order to augment efficacy, as well as whittle the opportunity cost of time, it is suggested that households use pressure cookers to boil water. A pressure cooker, used for cooking rice, potatoes, goat meat, and other foodstuffs, is a common kitchenware in India. Not only would the pressure of the device better ensure the elimination of bacteria (e.g., pressure is used in health settings to sterilize medical instruments), but it would also provide sensory clues (through the ‘whistle’ sounds the cooker emits) that water has been boiled. Furthermore, pressure cookers would reduce the time required to boil water, which has been identified as a major barrier. Lastly, the caveat of burns and scalds would be diminished because pressure cookers contain their contents with sealed lids.

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Clasen, 2009.


494 Philip (2012) argues that the combination of pressure and heat activate a quasi-chemical process that is highly effective in eliminating microorganisms. [Philip, 2012.]
Turning the attention to barriers, which pressure cookers tangentially address, changing the time of boiling may prove helpful. Given that women—the primary handlers of water—are busy in the morning (when water arrives), and in an effort to circumvent the preference of many not to consume hot water, it is recommended that water be boiled in the evening or nighttime. Water that is boiled in the evening would be cooled by morning, allowing for the consumption of treated water throughout the day and for children and adults to carry the water to school and work. Furthermore, it is likely that more adult members of the household are present in the household during the evening/nighttime, permitting the boiler of water to tend to the task while other adults keep watch over the children. In an attempt to cloak the undesirable flavors of boiled water, it is posited that adding natural flavors during the boiling process be practiced. For example, it is common for cumin (known as jeera in the study region), bark from Caesalpenia sappan (a perennial tree with ayurvedic properties known as pathimukham in the study region), and other herbs or spices to be added to water. Additives such as these may make the water more palatable and thus increase the likelihood of consumption among those who are adverse to the unpleasant taste of raw boiled water.

In terms of caveats, while the use of pressure cookers would diminish the hazard of tipping, thus reducing the risk of burns, other caveats can be addressed. First off, the temporal nature of water boiling, particularly during the monsoon season and when individuals are ill, must be expanded. The benefits of boiling water for epidemiological bases—that is, its capacities for disease prevention—must be articulated to at risk populations. Boiling water during the monsoon season, not because the air temperature is relatively cold, but because water quality decreases with the deluge of tainted floodwaters and saturated soils surrounding underground pipes, is a valid practice. However, continuing the practice year-round must be distinguished as a mechanism for improving health throughout the year. Furthermore, communicating that numerous illnesses, which serve to trigger a temporary boiling of water, are an etiology of poor water quality (prima facie), is warranted. Thus, knowledge on waterborne diseases and their manifestations, combined with evidence that the continuous boiling water can
prevent incidents of disease from occurring in the first place, is step towards increasing the scope of boiling. Moreover, since the opportunity cost of boiling water is a major barrier, it may prove effective to couch incidences of disease as opportunity costs themselves (e.g., they keep adults from work, children from school, and make domestic tasks difficult or impossible). Thus, conveying that the opportunity costs of boiling water will be rewarded with fewer cases of sickness may gain traction.495

Lastly, and perhaps the most difficult caveat to address, is pollutant exposure from the combustion of biomass. While propane, a less hazardous fuel in terms of pollutants, is the preferred method for cooking, it remains economically infeasible for most households at the study sites, not to mention the high demand that has brought about limited supplies. Kerosene is costly and more injurious to health than propane, and biomass fuel is the most dominant means of cooking as well as the most dangerous of the three in terms of air pollution. Thus, there are efforts to introduce solar cookers to villages in India, which evade issues of electricity, cost (over time), air pollution, and deforestation and climate change.496 While the prospect of solar cookers is gaining a foothold, impediments remain in design, capacity of energy storage, and popular acceptance. Nonetheless, solar cookers are an avenue being vigorously explored in India, and their contribution to reducing exposure to air pollution, including while boiling water, deserve to be highlighted.

Scalability is a sphere much researched in the realms of health intervention, technological dissemination, and HWT. Scholars agree that education, sensitization, or advocacy campaigns are crucial components of introducing technologies and sanitary practices, but that such ventures

495 Communicating the benefits of boiling to populations exposed to poor water quality will be discussed shortly in scalability.


often fail to gain a footing or peter out over time. Thus, Lantagne (2011) argues that scaling up HWT requires the selection of an effective and (culturally and geographically) appropriate method. Lantagne also contends that education be disseminated in order to ensure correct and consistent use by the target population, and that the selected method be available on a long-term, sustainable basis.\footnote{Lantagne, 2011.} Furthermore, scholars have suggested holding workshops in the target community, working through local health clinics, performing continued monitoring and evaluation, and that intervening officials exercise a prolonged exposure (e.g., not one-off education sessions).\footnote{S. Chankova, L. Hatt, and S. Musange (2012), “A community-based approach to promote household water treatment in Rwanda,” \textit{Journal of Water and Health} 10(1).} Through these approaches, target populations are more likely to modify their behaviors (especially when the HWT medium is easy to perform and locally sourced), and professionals can oversee the practice of HWT, evaluate its efficacy, gain acceptance (through repeated site visits), and incorporate user feedback. Furthermore, the method of ‘provision and adoption’ is eluded with methods of building rapport and instilling value and ownership.

While the approaches outlined above are widely accepted and practiced to some extent by health professionals and NGOs, the format for conducting such campaigns must be detailed. First of all, a survey or pilot-study should be conducted in order to identify the best method for HWT given the initial quality of water, cultural and economic attributes of the target population, and HWT practices that are sustainable and minimally intrusive in the daily lives of those who will treat the water. Conducting pre-intervention field visits also allows for inputs from the

\footnote{Clasen, 2009.}
\footnote{W. P. Schmidt and S. Cairncross (2009), “Household water treatment in poor populations: is there enough evidence for scaling up now?” \textit{Environmental Science & Technology} 43(4).}
\footnote{M. M. Stevenson (2008), \textit{Monitoring effective use of household water treatment and safe storage technologies in Ethiopia and Ghana} (M.S. Thesis, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology).}
\footnote{Moll \textit{et al.}, 2007.}
target population to affect HWT design, with FGDs representing a possible medium. After a method for HWT is chosen, information on waterborne diseases and their manifestations, the benefits of HWT, and demonstration of the selected HWT strategy (and its prototype, if applicable) should be carried out via workshops in an interactive format. To increase authenticity or legitimacy, workshops should be performed in coordination with or after having been granted approval from village leaders or persons highly respected by the target population. For visible effects, I recommend using H$_2$S strip tests, as well as other titration methods, in workshops to visualize the obvious differences between contaminated, untreated water (jet black after the H$_2$S test) and safe water that has been treated (clear after the H$_2$S test), thereby ‘showing’ the benefits of HWT. Throughout the process, members of the target community should partake in demonstrations and be encouraged to provide improvements and feedback, which can foster the voluntary operationalization of the selected method.\footnote{499} Proper HWT strategies should be textualized and pictoralized (in the vernacular) on placards or posters that can be hung in the home. This method enables consistent public health messaging and strategy retention among the target population. For example, with reference to boiling, placards should display bubbles rolling in the water vessel along with a message stating that the bubbles should be sustained for three minutes.\footnote{500} After the HWT intervention has been executed, weekly check-ups at the household scale—slowly tapered off to monthly and (possibly) yearly visits—should be carried out; such visits can be aided by representatives of the target population.

\footnote{499} It may be appropriate to have the target community elect representatives or form a ‘HWT Supervisory Committee.’ These bodies can record suggestions and complaints, report to intervening officials, implement survey instruments, and perform other logistical functions. Furthermore, the bodies may serve to instill ownership and control of HWT processes, as well as popularize HWT strategies and therefore promote its scalability.

\footnote{500} Three minutes could also be expressed in cultural or domestic terms, such as the length of time taken to perform a common task.
Regular checks can galvanize fellowship among all members of the venture and assist in solidifying HWT as a long-term, and hopefully permanent, practice.\textsuperscript{501}

In addition to demonstrations, cueing materials, and follow-ups, education on related hygiene and sanitation practices, which further deteriorate the already poor level of water quality, must be relayed (see Table 5.1). Keeping public taps and their environs clean and dry, washing collection vessels with soapy water, the mal-effects of storage and curtailing its practice (when possible), proper serving procedures (by not dipping hands in the storage vessel), and not reusing plastic beverage bottles, which leach toxic chemicals over time and are difficult to clean given their narrow necks, constitute a poignant list for education. Knowledge dissemination on the benefits of such practices will help to maintain the initial quality of water (thereby reducing the amount of microbes that must be removed via HWT) and curb incidents of post-HWT contamination.

As for selecting a method for HWT, there is no universally optimal option given the variability in target populations, available resources, and consumer preferences. When executed properly, boiling is effective in eliminating pathogens, yet its efficacy (39.1\% elimination of bacteria) and drawbacks at the study sites have been underscored in detail. Turning to other approaches, Hunter (2009) demonstrated in a meta-analysis regression of 67 studies on HWT that chlorine tablets (and the same goes for Aquatabs, sodium hypochlorite, and sodium dichloroisocyanurate) were less effective in eliminating microorganisms than other HWT methods (boiling was not considered).\textsuperscript{502} Furthermore, consumers, those in the study area in

\textsuperscript{501} The doling of rewards for adhering to learned behaviors is sometimes applied. However, this practice can backfire, thereby threatening to create conflict and division among the target population. If a reward system is practiced, then consider a common reward for the entire population, such as a well, books for a library, or other community-owned resources, which may prove more appropriate and less divisive than individual rewards.


Methods of ‘shock chlorination’ are hindered by turbidity and high TDS counts.
particular, often find the taste of chemically treated water undesirable and ‘unnatural,’ as several interviewees declared. Therefore, there is a tendency for individuals to resist the consumption of chemically treated water on aesthetic bases. Hunter also found that solar disinfection (SODIS) is less effective than other HWT strategies, not to mention that SODIS takes several hours to perform and thus exhibits dramatic time constraints.\textsuperscript{503} Hunter’s study revealed that ceramic filters, followed by biosand filters, were the most effective methods of HWT, and Mwabi \textit{et al.} (2011) demonstrated in a comparative study of four HWT methods (including biosand), that sliver impregnated ceramic filters were the most effective in removing bacteria (boiling was not considered in either study).\textsuperscript{504} However, ceramic filters are easily broken, and both ceramic and biosand filters occupy considerable space in the home—particularly when considering scarcity of space in small post-tsunami dwellings. Furthermore, peer debriefing sessions with MacDonald and Philip and their forthcoming publication indicate that households in a peri-urban Chennai slum were averse to biosand filters. In the design and implementation of biosand filters, households resisted usage because the biofilm or ‘dirty’ layer (the principle component for removing pathogens) emitted a foul odor.\textsuperscript{505} Thus, while methods of HWT reduce the presence of microorganisms, they do so at different rates and may be opposed by target populations for reasons manifold. Ultimately, pilot studies must be conducted in order to identify the most

\textsuperscript{503} Hunter, 2009.


Hunter, 2009.

Hunter warns that the efficacy of biosand filters reported in his study may be unreliable. Hunter claims that his methodology is sound, but that too few empirical, field-based studies on the efficacy of biosand filtration exist, few of those available are blinded, and the duration of the studies is relatively short. Thus, Hunter warns the audience that biosand filters may or may not be as efficient as reported in his meta-analysis.

efficacious, contextualized, and culturally acceptable method that is able to be sustained over the long-term.

Lastly, focusing on the study area, the governments of Nagapattinam and Karaikal must be criticized for their role in water quality. HWT would not be required, or at least would not be as prominent an issue, if the governments provided potable water from the outset. In Nagapattinam District, water taken directly from government-provided taps tested positive for bacteriological contaminants in 31 of 40 (77.5%) samples; in Karaikal District, 23 of 35 (65.7%) samples tested positive (see Appendix D). The result is that 72% (54 of 75 samples) of water provided to the study sites is tainted with fecal coliform before it reaches the household, with quality deteriorating post facto. Furthermore, all samples taken from treatment-supply nodes at Velepalyam, Nanavaickal, and Kunjimani Thidal (which supply water to five of the study sites) tested positive for bacteria before the water even began its journey to endpoints (see Appendix F). Likewise, chemical tests at the supply nodes also failed standards set by the BIS (see Appendix F). Thus, the governments must execute enhanced disinfection methods, repair pipelines and supply infrastructure, clean water towers more frequently, ensure continuous supply, and imbue water with the recommended dosage of TRC. While HWT can counteract deficiencies in government treatment and supply, the extent of HWT required is a function of initial quality, and risks must be eliminated as one cannot expect all households to practice HWT. Moreover, the necessity of HWT is a chief artifact of inadequate government supplies, which, if improved, could diminish the urgency of HWT, save households time and resources, and reduce the disease burden.

7.5 Conclusion

This chapter has examined the boiling of water as a method of HWT. The rate and efficacy of boiling, barriers to and caveats of engagement, and recommendations for improving and scaling up its practice (as well as the trajectory of other HWT methods) have been detailed, though non-exhaustively. While boiling water is scientifically proven to eliminate bacteria, data
from the field demonstrate that the pragmatics of boiling inhibit the total destruction of pathogens. Furthermore, evidence from the field and literature indicate an array of cultural, economic, and health-based factors that impinge the acceptability and scalability of boiling.

Confronted with limitations, actors have turned to full-fledged campaigns seeking to operationalize and increase the practice of boiling and other methods of HWT. If interventions are conducted, it is argued that prior exposure to the target community—in the form of observations, FGDs, and surveys or pilot studies—is vital. Pre-intervention exposure allows for identification of the problem, water quality testing across competing HWT approaches, input from the target population, rapport building, and ultimately a more culturally and geographically informed method for HWT. Just as boiling exhibits limitations, chlorination, filters, and other HWT mechanisms may also underperform (in terms of efficacy) or be resisted by the target population. Therefore, selection of the most effective method that is appropriate, accessible (physically and economically), and sustainable over the long-term is imperative. Furthermore, for monitoring, evaluation, and adherence to the HWT method, a presence in the target population well after the intervention is crucial. Lastly, while professionals possess engineering knowledge on HWT, success is contingent upon the heterogeneous bloc of water treaters and consumers that must operationalize and adapt to HWT processes. Therefore, a participatory approach (enacted at the earliest possible stage) is fundamental, and input from the bottom cannot be disregarded—this is indispensable when foreign or ‘outside’ populations are leading the intervention. The introduction of HWT methods is best perceived as a collaborative venture with all parties on an equal footing and all participants possessing valuable niche knowledge.
CHAPTER VIII: A FRAMEWORK FOR INTEGRATING WATER COMPONENTS OF DISASTER RECONSTRUCTION

8.1 Introduction

On December 26, 2004, a massive earthquake struck off the southwest coast of Sumatra, Indonesia. The earthquake generated towering waves that, when subsided, triggered the most extensive reconstruction project in India’s history. The tsunami also ushered in the opportunity, external assistance, and consensus support (both political and popular) necessary for the construction of improved infrastructure on such a large scale. In this setting, the reconstruction processes in the water sectors of Nagapattinam and Karaikal Districts and the organizational structures that oversaw their execution were analyzed from a longitudinal, triangulated perspective. This examination was founded on, inter alia, more than three years of field observations, household, government, and key informant interviews, primary documents, water quality tests, and the conceptualization of a new WPI metric. Ultimately, this dissertation produced an authoritative account of pervasive outcomes that transpired as a result of such processes and, moreover, their ramifications for affectees in terms of water quality, quantity, accessibility, and a host of other critical indicators. Therefore, informed by the corpus of this dissertation study, I call for additional research on the water-disaster interface that warrants water components of disaster reconstruction the attention they merit. Such research is imperative in order to avert, or at least minimize, the reification of similar outcomes in the future.

Insight gained from this comparative geographic inquiry can be harnessed to inform future reconstruction processes in the water sector. Thus, this concluding chapter proceeds by arguing: (1) the literature on water components of reconstruction is scarce, ultimately leaving water elided in frameworks for reconstruction; (2) water elements of reconstruction processes are treated as ‘normal’ water projects, yet they are inherently unique and thus differ from such projects; and (3) therefore, a first-of-its-kind framework seeking to close these gaps is required.
8.2 Need for a framework

Reconstruction comprises several distinct components (e.g., housing, transportation, employment, sanitation, and water), yet scholars have paid little attention to the water component. The role of water in reconstruction is significant because safe water is not only essential for promoting public health, but is also critical for reducing the impacts of future disasters (e.g., mitigation and vulnerability reduction), building capacity and resilience, and addressing a wide range of socioeconomic inequities. Thus, a framework accounting for water elements of reconstruction will not only expand the scope of the disaster literature, but it will also speak to issues of public health and development broadly defined.

A review of the literature on water components of disaster reconstruction was posited in the introductory chapter (see Section 1.3). The review demonstrated marked gaps and an urgent need for more informed scholarly research on the provision and long-term impacts (both social and physical) of such infrastructure. The survey not only revealed how the literature fails to sufficiently address these pressing issues, but it also established water as virtually non-existent among vital elements of reconstruction. Thus, water remains elided in disaster reconstruction despite a modest suite of publications probing the water-disaster interface—comprised of both case studies and theoretical inquiries and composed by social scientists, engineers, governments, and NGOs—and a set of frameworks developed for managing and/or evaluating post-disaster processes. It is evident that the literature does not grant water the attention it demands, and the following gaps reign supreme:

- publications tend to focus on the exigency of meeting water needs during and in the immediate aftermath of disasters (i.e., the response phase), but neglect to consider

506 Noji, 2005.
PAHO, 2002.
permanent post-disaster water infrastructure and its latent impacts on affectees in the long-run;

- the preponderance of publications have been written by NGOs and governments, thus demonstrating a paucity of independent scholarly work (furthermore, such parties rarely critique their projects and instead prefer to laud themselves for a ‘job well done’—both actions being counterproductive);

- publications that model for vulnerability reduction of water distribution systems do so in the pre-disaster context, thereby discounting reconstruction and the impacts of introducing new infrastructure to disaster-affected populations;

- and frameworks for reconstruction treat water components superficially with the assumption that they have already been included with housing, ultimately leaving water omitted (i.e., water is neither a constituent of frameworks nor listed as a determinant or indicator of project ‘success’).

Ergo, on the whole, the literature concentrates primarily on water as it relates to immediate response, casually glossing over water components of reconstruction in the long-term. To compound matters, due to gaps in the reconstruction literature, actors are forced to consult literature outside of the disaster arena when implementing water-based projects. In turn, this practice reifies the tendency for newly introduced infrastructure to be conceived sans a disaster lens (i.e., executed as a ‘normal’ water project). Thus, there is a propensity to return to the pre-disaster status quo—a protraction of the disaster cycle by disregarding vulnerability reduction of the community and their systems—and a failure to anticipate the cascade of long-term effects caused by the introduction of new infrastructure to unique, affected populations.

Despite what the literature articulates, observations from the field indicate that water projects triggered by reconstruction processes not only depart from immediate response, but they also vary from ‘normal’ water projects in several discernible ways. First, the subjects (or beneficiaries) have been affected, if not traumatized, by a hazard event, rendering them different
Second, post-disaster water projects differ in that they have recovery and rehabilitation components, are part of a larger disaster mitigation and reconstruction plan (i.e., scale), and likely have different funding and organizational structures (a progeny of scale and the introduction of external actors). Furthermore, resettlement is more often invoked, which necessarily induces land-use change, hydrological perturbations, and the uprooting of people, consequently disturbing physical and social systems. Lastly, the milieu of the post-disaster political atmosphere—with reconstruction actors held accountable by donors for ‘outputs,’ short-term socio-political rewards for speedy reconstruction, pressure exerted from the media, and conspicuous affectees wallowing in transitional shelters—exudes a temporal dimension that engenders post-disaster water projects exceedingly more urgent when juxtaposed with ‘normal’ projects. Thus, due to time constraints, a (stated or unstated) ‘rhetoric of returns’ often takes root in which the quality of infrastructure loses superiority to rapid, measurable ‘progress.’

Each of these variances entails a range of socio-physical corollaries that collectively distinguish post-disaster water projects from ‘normal’ ones. ‘Normal’ projects are generally modest and specific; for example, connecting a community to a water supply, increasing accessibility, or improving existing water quality. However, post-disaster water projects are generally more capital-intensive, larger in scale, and possess a combination of the aforementioned variables layered on top, rendering them much more complicated than their normal-time counterparts. Given the dissimilarities between post-disaster and ‘normal’ water projects, there is both theoretical and practical value in analyzing and implementing such projects differently, which is woefully lacking in the present. A framework that accounts for

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507 Ingram et al., 2006.
Oliver-Smith, 1991.
Scudder and Colson, 1982.
Prince, 1920.
these discrepancies has the ability to avoid pervasive issues that are likely to emerge during and after project implementation. For example, in the case of post-tsunami Nagapattinam and Karaikal, problems include the organizational structures that oversaw reconstruction, inconsistencies across space, intractable issues of quality and quantity, and organically-derived coping mechanisms developed to overcome reconstruction shortcomings. Furthermore, a review of Cyclone Thane in Chapter 2, the most recent disaster to impact the region, revealed similar issues and buttressed the need for a framework. Ultimately, a framework is called for that heeds the distinct nature of the post-disaster water canvas, closes gaps in the literature, and recognizes embedded problems from the outset.

8.3 The framework

I have developed a novel framework that recognizes, rather than stymies, the uniqueness of post-disaster waterscapes fabricated by reconstruction processes. The framework comprises six components that should be addressed during such processes. All of the components (or issues that can be traced back to the components) affect water reconstruction and the possibility of generating negative externalities. The components of the framework and issues linked to the components have been observed in the field and reported by subjects as factors that problematize their daily lives. Furthermore, the components are present in the literature across space, time, and type of disaster. Lastly, the framework acknowledges each component as significant in how it differs from ‘normal’ water projects and, therefore, how its implications must be considered during reconstruction (see Table 8.1). The six components are: the nature and needs of subjects; existence of recovery and rehabilitation components; scale; funding and organizational structure; resettlement; and temporal constraints.

The first constituent of the framework is the nature and needs of the subjects. Populations affected by disasters are more vulnerable than the subjects of ‘normal’ water projects. Such populations have been traumatized by an external stimulus and have experienced dramatic human and capital loss. Furthermore, in the fog of shock, affectees tend to gravitate
### Table 8.1: A Framework for Integrating Water Components of Disaster Reconstruction

<table>
<thead>
<tr>
<th>Difference from 'normal' water projects</th>
<th>Implications to consider in implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nature and needs of subjects</strong></td>
<td>-Subjects have been traumatized by a hazard event and experienced extreme human and capital loss</td>
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<tr>
<td></td>
<td>-Subjects have multiple competing needs—water constituting only one</td>
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<td></td>
<td>-Community participation is vital for incorporating these nuances</td>
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<tr>
<td><strong>Recovery and rehabilitation</strong></td>
<td>-The project should establish pre-disaster levels at a minimum and should strive to improve upon the pre-disaster scenario</td>
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<tr>
<td></td>
<td>-The project should facilitate future development and assist in reestablishing critical systems</td>
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<tr>
<td></td>
<td>-Water allows for development and itself embodies a system of centrality</td>
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<tr>
<td><strong>Scale</strong></td>
<td>-The project scope involves more than simply improving water supply or access and is therefore more capital-intensive</td>
</tr>
<tr>
<td></td>
<td>-Each water component is a subset of a larger multi-dimensional project, and each project is a subset of a larger mitigation and reconstruction plan</td>
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<tr>
<td></td>
<td>-Decisions for water may degrade, contest, or increase the vulnerability of other project components and vice versa—thus, a systems approach is required</td>
</tr>
<tr>
<td><strong>Funding and organizational structure</strong></td>
<td>-Disasters introduce a spectrum of local, national, and external actors</td>
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<td></td>
<td>-Actors and their funds influence the organizational structure and blur both reconstruction responsibilities and the meaning of development</td>
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<td></td>
<td>-A cogent structure that (explicitly) includes water, articulates specific responsibilities, and sets minimum standards is required</td>
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<tr>
<td><strong>Resettlement</strong></td>
<td>-Resettlement is more often invoked, which necessarily perturbs social and environmental systems</td>
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<td></td>
<td>-Increased opportunities for development are compounded by increased opportunities for failure</td>
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<td></td>
<td>-Site choice should not be driven by ease of development, but by popular representation that contemplates sustainable access to water services</td>
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<tr>
<td><strong>Temporality</strong></td>
<td>-A rush to rehouse affectees stimulates rapid development and prototypical, top-down approaches</td>
</tr>
<tr>
<td></td>
<td>-Such approaches can prevent the consideration of geo-social intricacies, disallow popular input, and serve to generate inferior outcomes</td>
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<tr>
<td></td>
<td>-Two temporal (and possibly conflicting) goals exist: to introduce water services quickly in the short-term, and to ensure that the method is viable for the long-term</td>
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<tr>
<td></td>
<td>-Actors should eschew unsustainable, decontextualized methods of water provision that are more likely to materialize when confronting time constraints</td>
</tr>
</tbody>
</table>
towards short-term remedies and those that mirror the pre-disaster scenario (i.e., conservative coping strategies) in place of approaches that consider the holistic long-term.\footnote{R. Dynes and E. Quarantelli (2008), “A brief note on disaster restoration, reconstruction and recovery: a comparative note using post-earthquake observations” (Newark: Preliminary Paper #359, Disaster Research Center, University of Delaware).} However, a return to the status quo (along with its vulnerabilities) may prove unfavorable in the long-run—especially from a disaster planning perspective. Furthermore, issues of ‘stated’ versus ‘felt’ needs, in which affectees concur with what outsiders stipulate is needed rather than articulating the real, felt needs of the community, is common.\footnote{Scudder and Colson, 1982.} Thus, water projects must be conducted tactfully in order to perpetuate neither victimhood nor dependency (i.e., the ‘Samaritan’s’ dilemma or principle of ‘do no harm’). Disaster-affected populations exhibit myriad competing needs, including water, food, shelter, health resources, and livelihood, not to mention that critical systems, such as kinship networks, domestic cycles, and income streams, have been disrupted. Thus, water-based reconstruction must recognize the distinct nature of disaster affectees and implement projects that account for their uniqueness. Reconstruction actors, particularly in terms of water, should garner popular input at the earliest possible stage, and such input should rise above tokenism (i.e., information dissemination) to allow for genuine control over the process and its outcomes.\footnote{H. Naraindas (2010), “‘Build back better’ and the psychic economy of want,” paper presented at Workshop on Natural Disasters and Public Memory in South Asia (Iowa City: University of Iowa).} However, mutual goals must be established that seek to regenerate

\footnote{A. George (2008), “‘What is’ and ‘what ifs’ of post-tsunami response: perspectives for the future,” paper presented at International Conference on Re-Examining Disaster, Recovery and Reconstruction: Social Science Perspectives on the Tsunami (New Delhi: Centre of Social Medicine & Community Health, Jawaharlal Nehru University).}
benign features of the pre-disaster water canvas while refashioning other aspects in order to reduce vulnerability, aid capacity and resilience, and ultimately fashion a safer and more accessible waterscape.

Next, water components of reconstruction projects inherently possess recovery and rehabilitation elements. As Bolin and Stanford (1991) argue, reconstruction “incorporates the notion that disasters interrupt ongoing social trends, often either accelerating or decelerating them.” Therefore, the goal of reconstruction is not simply to rebuild, but to do so in a manner that is relatively safer, initiates avenues for livelihood, and plants the seeds for immediate and long-term development. A clear path for transcending the pre-disaster settlement pattern is imperative, but such an approach must be activated with meaningful participation of the affected community. The approach must instill ownership, cultivate communitas, and aid in the reestablishment of critical systems. Ultimately, potable water that is accessible at an adequate quantity must be recognized as a vital component of recovery and rehabilitation and fundamental for returning to a state of normalcy. Thus, the introduction of an enhanced water supply configuration enables the completion of domestic tasks, permits cultural activities, supports livelihood ventures, promotes public health and productivity, and constitutes a healthier nature-society relationship. In the absence of a reliable water supply regime, recovery and rehabilitation


Cuny, 1983.

are perturbed, critical systems are difficult to reestablish, and instances of dependency may be preserved rather than dissolved. A lack of water impedes all avenues of recovery, so its promotion to a prominent facet of post-disaster reconstruction is essential.

Issues of scale heavily influence the post-disaster sphere and water projects in particular. Firstly, scale establishes water components of reconstruction as larger in scope and more infrastructure-intensive than ‘normal’ water projects. Second, post-disaster water projects are nested within an individual, multi-dimensional project (e.g., the construction of a new post-disaster housing colony equipped with roads, electricity, sewerage, etc.), and that project is nested within a larger reconstruction and mitigation plan. Thus, water may not receive the attention it warrants since it comprises merely one of many components of each project, and each project is part and parcel of a broader process. As a result of this multi-scalar paradigm, decisions for one aspect of reconstruction or mitigation may serve to degrade or contest other features of the reconstruction plan. For example, a choice not to provide drainage may increase the probability of flash flooding and waterlogging, not to mention that such hazards could taint water supplies and inundate sewerage infrastructure. Conversely, a conscious choice to shunt water away from a site may increase the vulnerability of a neighboring or downstream settlement, perhaps affecting their waterscape. Thus, decisions cannot be made in a vacuum and an integrated, systems-based approach accounting for the interdependency and cumulative effects of all reconstruction components is required.\footnote{R. Haigh and D. Amaratunga (2010), “An integrative review of the built environment discipline’s role in the development of society’s resilience to disasters,” \textit{International Journal of Disaster Resilience in the Built Environment} 1(1). D. McEntire, C. Crocker, and E. Peters (2010), “Addressing vulnerability through an integrated approach,” \textit{International Journal of Disaster Resilience in the Built Environment} 1(1).}

Water must comprise an explicit component of each project and be addressed in the larger plan for reconstruction and mitigation.

Funding and the organizational structure also weigh upon the post-disaster water sphere. Disasters, especially when large in magnitude, rouse media attention, which in turn unleashes the introduction of a spectrum of actors—local, national, and international, governmental and non-governmental—equipped with various streams of funding. The presence of a diverse set of actors (and their much needed funds) serves to shape the reconstruction canvas and ultimately generates a model for reconstruction, which may be top-down or bottom-up, donor- or affectee-driven. However, what often accompanies the milieu are blurred lines of who is in charge (e.g., the government, NGOs, or is it a public-private partnership?) and who holds responsibility for specific components of reconstruction. Furthermore, actors may prioritize certain sectors while neglecting others and donors may harbor stated or unstated agendas. As for organizational pragmatics, the overarching reconstruction plan may be executed as a collection of independent projects that may or may not be unified under a common vision. Moreover, the building of a single settlement may involve several distinct actors, each with their own responsibilities (i.e., one each for water, housing, drainage, and so forth). Therefore, in terms of water, it is crucial to, inter alia, set minimum standards for supply mechanisms, denote a type of access point (e.g., public or individual taps), and set a maximum density at water access points. An absence of standards has the propensity to result in ad hoc, fragmented projects with varying types and levels of water infrastructure across space. This can spawn fissures between communities who view their contemporaries as having been left unfairly better off. To that end, the meaning of development should not be decided by each actor separately, but should instead be codified in order to produce similar results that fit within a cogent reconstruction plan. Thus, while funding and external assistance are vital to the reconstruction process, the organizational structure needs to be consistent and authoritative in order to produce similar results across projects, with quality strived for over quantity. Nowhere is this more evident than when observing outputs in the water sector, as it is difficult to live happily and healthily in the absence of a suitable waterscape.

Resettlement is more often invoked in post-disaster projects compared to ‘normal’ water projects. Resettlement is a complex, transformative process that is as much social as it is
physical and technical. While resettlement may eliminate constraints and usher in opportunities to address deep-seated problems, it is frequently overshadowed by issues of uprootedness, loss of identity, and resistance.\textsuperscript{514} In fact, scholars have gone so far as to posit resettlement as a ‘social disaster,’ noting that the impacts of resettlement may be worse than the disaster itself.\textsuperscript{515} It is common for sites to be chosen because the land is cheap, flat, and easily developable, yet such characteristics rarely translate to optimal locales for resettlement. Therefore, it is essential that affectees participate in site choice, thereby instituting proactive site selection in an effort to negotiate the risks and rewards of resettlement. Furthermore, resettlement (to green-field spaces in particular) necessarily perturbs social, economic, and environmental systems—with alterations in vegetation cover, land-use, and hydrology collectively impinging the provision of water. Speaking pragmatically, resettlement to land with a high water table may provide ease of access to groundwater, but such a context may also flood sewerage infrastructure and promote stagnation after periods of rain. Similarly, resettlement to land with poor access to groundwater and surface water may disallow social, cultural, and economic practices, thereby limiting the productivity (both socially and economically) of the settlement at large. Ultimately, sites lacking proper water provision and access exhibit a propensity for abandonment. Resettlement should


Oliver-Smith, 1991.


\textsuperscript{515} Cernea, 2000.

Partridge, 1989.


Oliver-Smith (1991) notes that affectees, when faced with a choice between the ecological hazard of occupying the original site and the social hazard of resettlement, prefer the former because the consequences of the latter may be much worse. [Oliver-Smith, 1991.]
only be invoked when necessary, and sites selection should be based on a host of factors—relative safety from hazards, sustainable access to water, connectivity to nodes of employment, and proximity to the original site reigning paramount.

Lastly, *temporal constraints* are often confronted due to the urgency of the post-disaster sphere. Speaking frankly, the (stated or unstated) effort to ramp up reconstruction activities can be perceived as rational given the critical eye of the media, desire for donors to ‘see’ outputs, and the conspicuousness of scores of affectees reeling in transitional settlements. Therefore, reconstruction actors, beholden to funders, driven by pathos, and often instructed by governments to do so, are motivated to produce quick, visible, and numerable outputs (i.e., to demonstrate ‘progress’ on the landscape). While this veritable ‘rhetoric of returns’ may achieve the short-term goal of service restoration, it often precludes the long-term goal of implementing infrastructure that is viable and sustainable. Thus, the rhetoric of returns converts to a practice that rewards physical outputs, but fails to contemplate the quality, appropriateness, and durability of the infrastructure. In the end, rapid development forged by temporal constraints comes at a cost. These costs frequently manifest in the form of top-down and/or contractor-driven approaches, a failure to garner popular input or consider geo-social intricacies, and the production of proto-typical, technocratic, and ‘foreign’ infrastructure. The result is not only the introduction of sub-standard infrastructure, but that historical and indigenous approaches to water management are disregarded. Thus, for the sake of speed, there is a proclivity to adopt unsustainable water supply arrangements rather than fashioning contextualized and socially, economically, and environmentally sustainable infrastructure. Ultimately, the affected population is left to assimilate to the level of health, quality of life, and social hydrology fabricated by the new regime. Thus, affectees are forced to adapt to, cope with, and modify such configurations, often lacking the political capital to mount a swift and targeted rebuke. Meanwhile, the reconstruction actors have long departed and are now at the epicenter of the next disaster, more than likely reproducing the same layout for an altogether different set of affectees. And so the cycle goes on, seemingly for perpetuity.
8.4 Conclusion

Water components of post-disaster reconstruction are unique and demand specialized attention. Therefore, water projects cannot simply be inserted into the post-disaster sphere and treated as ‘normal’ projects, which is the current practice. While ‘normal’ projects may involve improving existing water quality or increasing accessibility, post-disaster projects are much larger in scope and are necessarily influenced by the constituents that comprise the framework. Hence, such projects vary distinctly and thus require a nuanced approach. To that end, a first-of-its-kind framework has been developed in order to bring attention to the water-disaster interface.

The framework moves beyond immediate response—the dominant arena of inquiry at the intersection of water and disaster—and carves out water projects in the reconstruction sphere as distinct by identifying six key factors: the nature and needs of the subjects; the existence of recovery and rehabilitation components; scale; funding and organizational structure; resettlement; and temporal constraints. I argue that heeding the framework will assist in the aversion—or at least minimization—of common project failures, such as culturally and geographically insensitive arrangements, inconsistencies across space, and the generation of outputs that exacerbate poverty and dependency. I also contend that the framework can be operationalized independently or conjoined with existing frameworks, and that it exhibits diagnostic, management, and evaluative potential because: it identifies issues of centrality that might otherwise be ignored, directs reconstruction actors to avoid such issues, and provides a checklist of fundamental concerns that should be addressed. That being said, the framework is

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516 For example, in the case of post-tsunami Nagapattinam and Karaikal, resettlement processes informed by the framework may have reduced risk to flooding, which is currently affecting water quality and access. Likewise, the framework’s attention to recovery and rehabilitation may have improved outputs in the water sector. Water service was not effectively restored/established and thus it inhibits long-term recovery and development. Furthermore, relief aid and the organizational structures utilized in Nagapattinam and Karaikal failed to adequately recognize water and either failed to set or satisfy standards for water. Perhaps the framework could have guided reconstruction actors to create relatively superior outcomes.
novel and necessitates refinement. Therefore, more longitudinal studies documenting the successes and failures of post-disaster water projects must be conducted in order to improve its applicability.

Finally, it should be noted that all reconstruction processes occur within distinct socio-cultural, politico-economic, and environmental contexts. Thus, place- and systems-based approaches that consider cumulative effects in local nature-society relationships should be employed. The components of the framework are common across space, time, and disaster, but addressing the components and formulating solutions to their associated risks should be determined by local geographies. Therefore, three suggestions are posited in order to increase the framework’s functionality and efficacy: (1) manage reconstruction processes at the smallest scale that captures the entire problem (i.e., application of Ostrom’s principle); (2) empower local decision-makers; and (3) incorporate meaningful popular participation at the earliest possible stage.
APPENDIX A: QUALITATIVE HOUSEHOLD INTERVIEW INSTRUMENT

Date: __________________
Name of settlement: _____________________________________________

BACKGROUND
1. Name: ____________________________________________________________ (male / female)

2. Age: ______

3. Pre-tsunami location: ____________________________________________ . Distance from pre-tsunami location: ______ . What ties does your household maintain with the pre-tsunami location (e.g., still maintain a house there, visits to damaged house, visit family or friends still residing there)?

4. Which entity constructed the houses: ________________________________

5. Total number of houses constructed: ______

6. When were the houses completed: _____ . When did you occupy your house: _____ .

7. Individual houses OR blocks of flats (circle).

8. Is there a head of the settlement: ______ . If so, how was that person chosen?

9. Prevailing employment characteristics of the settlement: ____________________________

10. Number of persons working in your household (paid and unpaid): ______ . What is their occupation(s)?
WATER

11. Who is the provider of piped water: _____________________________. Are they maintaining the infrastructure? Explain.

12. Is there a person in charge of water for your settlement or for the panchayat? If so, how was that person(s) chosen?

13. Do availability windows conflict with the household’s daily schedule (e.g., constrict mobility, education, and employment opportunities)? Explain.

14. Has a queuing system been established: _____. If so, how was it developed and how does it function?

15. For what purposes are different sources of water (e.g., piped, groundwater, surface water) used?

16. Does your household boil water or use any other treatment mechanisms? If so, what types of water do you boil/treat and for what purposes?

17. Describe any issues of water quality (e.g., taste, color, odor)? Have there been any outbreaks of disease or skin ailments that have been linked to water quality?

18. Is there a volumetric cost or initial or recurring connection fee for water? If so, explain.

19. Describe any issues of water pressure?

20. Is the quantity of water obtained enough to meet daily household needs? Explain.

21. What methods have been employed to cope with or modify water scarcity, access, pressure, or fees (e.g., storage, limit usage, queuing system, digging of sub-surface holes, intercepting the pipes, protests, complaints)?

22. Is there a difference in quantity of water obtained during the wet and dry seasons? Likewise, do pressure and other attributes of water vary?

23. Besides community taps, what other infrastructure was provided with the house or settlement (e.g., treatment center, in-house pipes, overhead tanks, handpumps)? Are they operable and are/were they utilized? Explain.
24. Have any complaints about water been filed? If so, in what manner, to which entity, and what was the result?

25. Rate your satisfaction with the water scenario between 0-10 (where 0 is lowest and 10 is highest: _______. Explain.

26. Describe the water source, quality, quantity, and access at the pre-tsunami settlement?

27. What are the differences between the pre- and post-tsunami settlements (both good and bad)?

28. Do you feel that the current water situation is an improvement compared to the pre-tsunami context? Explain.

29. Additional comments on water not probed thus far?
SEWERAGE

30. Do you have: septic tank (individual, joint, or community); leach pit; OR piped sewerage connection (circle).

   a. If a septic tank or leach pit, has it been filled or blocked: ________. If so, how many months did it take to fill/block: ________.

   b. If a septic tank, have you had it pumped: _________. If so, who pumped it and what was the cost?

   c. If a leach pit, do you wait for the filled portion to dry and then empty it: _______. How much time passes between the cycles: ________.

   d. If a piped sewerage connection, is the system operable, is/was it utilized, and is it adequately maintained by the governing body? Explain.

31. Are the washroom and toilet one room or two separate rooms?

32. Is, or has there been, any visible seepage/leaking of the sewerage infrastructure? Does the infrastructure get inundated during the monsoon season? Explain.

33. Does the bathroom have a water access point: _______. If so, does it function: ________.

34. Does your household currently use the toilet regularly: yes / no (circle). Do all people in the household use the toilet? Is it used all year round (i.e., during dry and monsoon seasons)?

   a. If yes, what water is used to flush the toilet: ______________________

   b. If not, was it used initially and why did the household cease usage?

   c. If not used regularly, is it used in emergencies, during sickness, or when privacy is required (especially by women in the household)?

   d. If not, is lack of water a hindrance?

   e. If not, is adequacy or quality of infrastructure a hindrance? Explain.

   f. If not, where does the household ‘go to the bathroom’? Has this led to any problems (e.g., during the monsoon, privacy, security, disputes with private landowners)?

   g. Are there other hindrances to usage (e.g., tank/pit is full, facilities inoperable, location of infrastructure, issues of culture or purity)?

   h. If not, what would need to be altered in order for you to use the infrastructure?

   i. If not, for what is the bathroom used (e.g., storage, puja room): ________________
35. How do issues related to sewerage infrastructure differ during the wet and dry seasons?

36. Who is responsible for maintaining the sewerage infrastructure? Is it being maintained? Explain.

37. Have any complaints about sewerage infrastructure been filed? If so, in what manner, to which entity, and what was the result?

38. Rate your satisfaction with the sewerage scenario between 0-10 (where 0 is lowest and 10 is highest): _______. Explain.

39. Describe the toilet and sewerage situation at the pre-tsunami settlement?

40. What are the differences between the pre- and post-tsunami settlements (both good and bad)?

41. Do you feel that the current sewerage situation is an improvement compared to the pre-tsunami context? Explain.

42. Additional comments on sewerage issues not probed thus far?
**DRAINAGE**

43. What is the method of drainage: none; dug ditches; concrete canals (circle).

44. Who is responsible for maintaining drainage infrastructure? Have they cleaned it and how often? Have the residents or outside volunteers ever cleaned the infrastructure?

45. Are there problems draining domestic water (i.e., washroom, sink, and laundry water)?

46. Are there problems draining rainwater? Does your roof leak?

47. Are there anthropogenic causes for drainage blockage (e.g., garbage, plastic refuse, and intentional blockage with sand or cement)? If intentional blockage, why?

48. How do issues related to drainage differ during the wet and dry seasons?

49. Is flooding common: yes / no (circle).
   a. If yes, how often and how much precipitation is needed to induce flooding?
   b. If yes, how high has the water reached (use physical marker)?
   c. If yes, has water surrounded the house requiring you to walk through the water for entry?
   d. If yes, has water entered the house: ______. If yes, how many times: ______.
   e. If yes, have you ever been forced to temporarily relocate: ______. How many times: ______. For how long and where did you stay?
   f. If yes, how has flooding affected daily household tasks, mobility, and education and employment opportunities?
   g. If yes, what has the government done to mitigate and/or respond to flooding?
   h. If yes, what have you and/or the residents done to mitigate and/or cope with flooding?

50. Drainage is clogged: never; sometimes; often; almost always (circle).

51. Is stagnation/waterlogging a problem in ‘normal’ times and/or during the wet season? If so, are there problems of stench, mosquitoes, outbreaks of disease, or other problems? Explain.
52. How has drainage or flooding affected water access and quality? Which of these problems exist: waterlogged access points, forced closing of access points, contaminated water, or other problems? Explain.

53. How has drainage or flooding affected sewerage infrastructure? Which of these problems exist: seepage, flooded septic tank or leach pit, flooded toilet pan, or other problems? Explain.

54. Have any complaints about drainage been filed? If so, in what manner, to which entity, and what was the result?

55. Rate your satisfaction with the drainage scenario between 0-10 (where 0 is lowest and 10 is highest): ______. Explain.

56. Describe the drainage situation at the pre-tsunami settlement (i.e., was there drainage infrastructure and was it effective)? Was flooding common?

57. What are the differences between the pre- and post-tsunami settlements (both good and bad)?

58. Do you feel that the current drainage situation is an improvement compared to the pre-tsunami context?

59. Additional comments on drainage issues not probed thus far?
WRAPUP

60. Do you feel safer from hazards (e.g., floods, cyclones, tsunamis, outbreaks of disease) in the post-tsunami settlement compared to the pre-tsunami settlement? Explain. Would you rather live at the previous settlement or the current settlement and why?

61. Out of the all topics probed (water, sewage, and drainage), is there anything else you would like to add?

62. Issues related to water, sewage, and drainage have been probed. Rank the three issues from most problematic to least problematic. Explain why you chose that ranking.

1.

2.

3.

63. What participation/inputs were you sanctioned in the resettlement and reconstruction processes? Likewise, in terms of water, sewage, and drainage?

64. If you were given more participation/input power, what would you have suggested or demanded during the resettlement and reconstruction processes? Likewise, in terms of water, sewage, and drainage?
APPENDIX B: HOUSEHOLD SURVEY INSTRUMENT

Date: _________________
Name of settlement: ________________________________________

1. Times of water availability:
   - Window 1: _________________
   - Window 2: _________________
   - Window 3: _________________
   - Total hours available per day: _________________

2. How many households share the access point: ______

3. Household population (permanently residing in the house): ______

4. Volume of water household obtained today: ___________ liters.

5. Has your household been involved in any conflicts over water: _______. If so, how many times
   in the last year: _______. Describe the conflicts. Do the conflicts have a seasonal dimension?
   [Conflicts defined as heated arguments and anything beyond.]

6. Total monthly household income: ₦ ____________

7. Highest level of education completed by an individual residing permanently in the household:
   __________

8. a. Which of the following does your household possess (circle; max = 12 because no households
    exceeded 12 even with the inclusion of ‘other’ assets):
    
    boat/cart/work implements/petty shop    electrical connection
    motorcycle                             livestock
patta and/or house insurance  gas connection

TV  radio/cassette/CD/DVD player

phone (mobile or landline)  refrigerator

air conditioner  vehicle (automobile or motorcycle)

other (e.g., electric rice grinder, sewing machine, invertor, computer)

b. Has your household (circle; max=4):

added on to your house (concrete or masonry only)

built a fence OR overhang OR shed (concrete or thatch)

planted trees OR a garden OR flowers

installed a borewell or handpump OR upgraded to an individual tap OR installed in-house piping OR connected a rooftop tank to in-house pipes

c. List membership in the household of any civic, trade, religious, or cooperative organizations (e.g., labor union, SIFFS, SHG, Lion’s Club, microcredit, cooperative bank)? (max = 3).

d. How many relatives (household scale) live within 1 kilometer: ______ (max = 5).

e. How many months have you occupied the house: <6; 6-11.99; 12-17.99; 18-23.99; 24 and above (circle).

9. Besides government-provided water, does your household have access to another source of water (e.g., treatment center, well or handpump, pond, tanker lorry, packaged water)? _________. If yes, is the supplemental source treated: _________.

10. Does your household boil or treat the water used for consumption: yes / no (circle).

11. Distance of piped water access point from household: ________ meters. Does distance create any problems in terms of access or quantity (e.g., long turnaround time does not allow you to retrieve as many vessels as are needed)?

12. Time taken to attain 30 liters of water: _____________ seconds.
13. Result of bacteriological water quality test: ________ (+ or -)

14. Of the following items, rank the three most important for your household (1-3 with 1 being most important): *

   Distance to access point _____
   Total hours of water availability _____
   Number of availability windows per day _____
   Number of households sharing access point _____
   Water quantity _____
   Pressure _____
   Water quality _____
   Conflicts over water _____
   Availability of other sources of water _____

* Note that this question formed the basis for the survey weighted WPI presented in Chapter 6.
APPENDIX C: BACTERIOLOGICAL SAMPLES – HOUSEHOLD

Table C.1: Bacteriological Presence-Absence at Household Scale

<table>
<thead>
<tr>
<th>Location</th>
<th>No. of samples</th>
<th>No. of neg. samples</th>
<th>No. of pos. samples</th>
<th>% Safe water *</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>21</td>
<td>7</td>
<td>14</td>
<td>33.33%</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>21</td>
<td>5</td>
<td>16</td>
<td>23.81%</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>37</td>
<td>4</td>
<td>33</td>
<td>10.81%</td>
</tr>
<tr>
<td>Samanthanpetta</td>
<td>26</td>
<td>4</td>
<td>22</td>
<td>15.38%</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>26</td>
<td>1</td>
<td>25</td>
<td>3.85%</td>
</tr>
<tr>
<td>Theti</td>
<td>23</td>
<td>7</td>
<td>16</td>
<td>30.43%</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>15</td>
<td>1</td>
<td>14</td>
<td>6.67%</td>
</tr>
<tr>
<td><strong>Total Nagapattinam</strong></td>
<td><strong>n = 169</strong></td>
<td><strong>29</strong></td>
<td><strong>140</strong></td>
<td><strong>17.16%</strong></td>
</tr>
<tr>
<td><strong>Karaikal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>18</td>
<td>1</td>
<td>17</td>
<td>5.56%</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>19</td>
<td>6</td>
<td>13</td>
<td>31.58%</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>24</td>
<td>5</td>
<td>19</td>
<td>20.83%</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>21</td>
<td>6</td>
<td>15</td>
<td>28.57%</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>18</td>
<td>2</td>
<td>16</td>
<td>11.11%</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>15</td>
<td>7</td>
<td>8</td>
<td>46.67%</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>16</td>
<td>5</td>
<td>11</td>
<td>31.25%</td>
</tr>
<tr>
<td><strong>Total Karaikal</strong></td>
<td><strong>n = 131</strong></td>
<td><strong>32</strong></td>
<td><strong>99</strong></td>
<td><strong>24.43%</strong></td>
</tr>
<tr>
<td><strong>Total all sites</strong></td>
<td><strong>n = 300</strong></td>
<td><strong>61</strong></td>
<td><strong>239</strong></td>
<td><strong>20.33%</strong></td>
</tr>
</tbody>
</table>

* Safe water defined as an absence of bacteria
Following are maps of the stratified random sampling of households at all 14 sites. In addition to representing the samples, the symbology depicts whether drinking water in the sampled households tested positive or negative for bacteriological contaminants.

Consult this legend for all maps:

**REPRESENTATION OF HOUSEHOLD SURVEYS**

- Red circle: Sampled household, positive bacteriological test
- Green circle: Sampled household, negative bacteriological test
I. NAGAPATTINAM DISTRICT

Figure C.1: Akkaraipettai – bacteriological presence-absence at household scale
21 sampled households; 7 negative and 14 positive tests.
Figure C.2: Andana Pettai – bacteriological presence-absence at household scale
21 sampled households; 5 negative and 16 positive tests.
Figure C.3: New Nambiyar Nagar – bacteriological presence-absence at household scale
37 sampled households; 4 negative and 33 positive tests.
Figure C.4: Samantha Pettai – bacteriological presence-absence at household scale
26 sampled households; 4 negative and 22 positive tests.
Figure C.5: Savertiyarkovil – bacteriological presence-absence at household scale
26 sampled households; 1 negative and 25 positive tests.
Figure C.6: Theti – bacteriological presence-absence at household scale
23 sampled households; 7 negative and 16 positive tests.
Figure C.7: Uzhuvan Nagar – bacteriological presence-absence at household scale
15 sampled households; 1 negative and 14 positive tests.
II. KARAIKAL DISTRICT

Figure C.8: Akkam Pettai – bacteriological presence-absence at household scale
18 sampled households; 1 negative and 17 positive tests.
Figure C.9: Amman Kovil Pathu – bacteriological presence-absence at household scale
19 sampled households; 6 negative and 13 positive tests.
Figure C.10: Kilinjilmedu – bacteriological presence-absence at household scale
24 sampled households; 5 negative and 19 positive tests.
Figure C.11: *Kizhakasakudimedu* – bacteriological presence-absence at household scale
21 sampled households; 6 negative and 15 positive tests.
Figure C.12: Mandapathur – bacteriological presence-absence at household scale
18 sampled households; 2 negative and 16 positive tests.
Figure C.13: Paravaipettai – bacteriological presence-absence at household scale
15 sampled households; 7 negative and 8 positive tests.
Figure C.14: Vettakaramedu – bacteriological presence-absence at household scale
16 sampled households; 5 negative and 11 positive tests.
APPENDIX D: BACTERIOLOGICAL SAMPLES – WATER ACCESS POINTS

Table D.1: Bacteriological Presence-Absence at Government-Provided Access Points

<table>
<thead>
<tr>
<th></th>
<th>Govt. taps sampled</th>
<th>Govt. taps neg.</th>
<th>Govt. taps pos.</th>
<th>% Safe water *</th>
<th>Other sources sampled (# neg. / # sampled) ▲</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>40.00%</td>
<td>---</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>80.00%</td>
<td>1 / 1</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>9</td>
<td>0</td>
<td>9</td>
<td>0.00%</td>
<td>---</td>
</tr>
<tr>
<td>Samanthanpettai</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>16.67%</td>
<td>---</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0.00%</td>
<td>---</td>
</tr>
<tr>
<td>Theti</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>40.00%</td>
<td>---</td>
</tr>
<tr>
<td>Uzhuvar Nagar v</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0.00%</td>
<td>0 / 1</td>
</tr>
<tr>
<td><strong>Total Nagapattinam</strong></td>
<td>n = 40</td>
<td>9</td>
<td>31</td>
<td>22.50%</td>
<td>---</td>
</tr>
<tr>
<td><strong>Karaikal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0.00%</td>
<td>0 / 1</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>60.00%</td>
<td>---</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>40.00%</td>
<td>---</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0.00%</td>
<td>1 / 1</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0.00%</td>
<td>1 / 1</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>100.00%</td>
<td>---</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>40.00%</td>
<td>---</td>
</tr>
<tr>
<td><strong>Total Karaikal</strong></td>
<td>n = 35</td>
<td>12</td>
<td>23</td>
<td>34.29%</td>
<td>---</td>
</tr>
<tr>
<td><strong>Total all sites</strong></td>
<td>n = 75</td>
<td>21</td>
<td>54</td>
<td>28.00%</td>
<td>---</td>
</tr>
</tbody>
</table>

* Safe water defined as an absence of bacteria

▲ Non-government sources supporting the sites were also tested: treatment centers at Andana Pettai and Kizhakasakudimedu, a handpump in Uzhuvar Nagar, and borewells in Akkam Pettai and Mandapathur

▼ A minimum of 5 taps were tested at each site, but Uzhuvar Nagar has only 4 taps total
Following are maps of the stratified random sampling of water access points at all 14 study sites. In addition to representing the samples, the symbology depicts whether sampled access points tested positive or negative for bacteriological contaminants.

Consult this legend for all maps:

**REPRESENTATION OF TESTED WATER ACCESS POINTS**

- Sampled government tap, positive bacteriological test
- Sampled government tap, negative bacteriological test
- Sampled non-government source, positive bacteriological test *
- Sampled non-government source, negative bacteriological test *

* Handpump, borewell, or on-site treatment center
Figure D.1: Akkaraipettai – bacteriological presence-absence at water access points
5 taps sampled; 2 negative and 3 positive tests.
Figure D.2: Andana Pettai – bacteriological presence-absence at water access points
5 taps sampled; 4 negative and 1 positive tests. On-site treatment center test negative.
Figure D.3: New Nambiyar Nagar – bacteriological presence-absence at water access points. 9 taps sampled; all tests positive.
Figure D.4: Samanthanpettai – bacteriological presence-absence at water access points
6 taps sampled; 1 negative and 5 positive tests.
Figure D.5: Saveriyarkovil – bacteriological presence-absence at water access points
6 taps sampled; all tests positive.
Figure D.6: Theti – bacteriological presence-absence at water access points
5 taps sampled; 2 negative and 3 positive tests.
Figure D.7: Uzhuvar Nagar – bacteriological presence-absence at water access points. All 4 taps sampled; all tests positive. Handpump test positive.
Figure D.8: Akkam Pettai – bacteriological presence-absence at water access points
5 taps sampled; all tests positive. Borewell test positive.
Figure D.9: Amman Kovil Pathu – bacteriological presence-absence at water access points
5 taps sampled; 3 negative and 2 positive tests.
Figure D.10: Kilinjilmedu – bacteriological presence-absence at water access points
5 taps sampled; 2 negative and 3 positive tests.
Figure D.11: Kizhakasakudimedu – bacteriological presence-absence at water access points
5 taps sampled; all tests positive. On-site treatment center test negative.
Figure D.12: Mandapathur – bacteriological presence-absence at water access points
5 taps sampled; all tests positive. Borewell test negative.
Figure D.13: Paravaipettai – bacteriological presence-absence at water access points
5 taps sampled; all tests negative
Figure D.14: Vettakaramedu – bacteriological presence-absence at water access points
5 taps sampled; 2 negative and 3 positive tests.
## APPENDIX E: CHEMICAL SAMPLES – WATER ACCESS POINTS

### I. NAGAPATTINAM DISTRICT

Table E.1: Akkaraipettai – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9.25</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>775</td>
<td>650</td>
<td>675</td>
<td>600</td>
<td>625</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>650</td>
<td>587.5</td>
<td>612.5</td>
<td>550</td>
<td>587.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>7.75</td>
<td>6.65</td>
<td>8.86</td>
<td>8.86</td>
<td>8.86</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>1.0</td>
<td>0.25</td>
<td>1.0</td>
<td>1.0</td>
<td>0.25</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>300</td>
<td>312.5</td>
<td>262.5</td>
<td>312.5</td>
<td>337.5</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: Samples 2 and 4 negative for bacteria, remaining samples positive
### Table E.2: Andana Pettai – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Treatment center</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9.25</td>
<td>9.25</td>
<td>8.75</td>
<td>9</td>
<td>9.25</td>
<td>8.5</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>725</td>
<td>700</td>
<td>725</td>
<td>700</td>
<td>675</td>
<td>300</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>987.5</td>
<td>1012.5</td>
<td>1037.5</td>
<td>1012.5</td>
<td>1037.5</td>
<td>312.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>3.32</td>
<td>4.43</td>
<td>5.54</td>
<td>8.86</td>
<td>3.32</td>
<td>4.43</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
<td>0.25</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A_T mg/l)</td>
<td>375</td>
<td>375</td>
<td>362.5</td>
<td>337.5</td>
<td>337.5</td>
<td>162.5</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: All samples negative for bacteria except sample 5
### Table E.3: New Nambiyar Nagar – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>9</td>
<td>8.75</td>
<td>9</td>
<td>8.75</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>700</td>
<td>725</td>
<td>750</td>
<td>725</td>
<td>700</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>487.5</td>
<td>400</td>
<td>437.5</td>
<td>462.5</td>
<td>475</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>3.32</td>
<td>2.22</td>
<td>4.43</td>
<td>3.32</td>
<td>3.32</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>2.0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>262.5</td>
<td>300</td>
<td>300</td>
<td>325</td>
<td>275</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
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</table>

<table>
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<th>9</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>750</td>
<td>800</td>
<td>787.5</td>
<td>750</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>437.5</td>
<td>475</td>
<td>462.5</td>
<td>362.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>3.32</td>
<td>6.65</td>
<td>6.65</td>
<td>6.65</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>2.0</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>312.5</td>
<td>275</td>
<td>300</td>
<td>287.5</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Numbers 1-9 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: All samples positive for bacteria
Table E.4: Samanthanpettai – Chemical Samples (Water Access Points)

<table>
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<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>9</td>
<td>8.75</td>
<td>9</td>
<td>9.25</td>
<td>9</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>787.5</td>
<td>800</td>
<td>800</td>
<td>825</td>
<td>775</td>
<td>812.5</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>400</td>
<td>437.5</td>
<td>425</td>
<td>450</td>
<td>412.5</td>
<td>425</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>6.65</td>
<td>5.54</td>
<td>5.54</td>
<td>5.54</td>
<td>6.65</td>
<td>5.54</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>1.5</td>
<td>1.5</td>
<td>0.5</td>
<td>1.5</td>
<td>0.5</td>
<td>1.25</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>275</td>
<td>312.5</td>
<td>300</td>
<td>312.5</td>
<td>312.5</td>
<td>300</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-6 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: All samples positive for bacteria except sample 5
Table E.5: Saveriyarkovil – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9.25</td>
<td>9.25</td>
<td>9.25</td>
<td>9.5</td>
<td>9</td>
<td>8.75</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>675</td>
<td>625</td>
<td>825</td>
<td>750</td>
<td>675</td>
<td>900</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>250</td>
<td>375</td>
<td>350</td>
<td>337.5</td>
<td>400</td>
<td>437.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>4.43</td>
<td>3.32</td>
<td>3.32</td>
<td>3.32</td>
<td>3.54</td>
<td>5.54</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
<td>1.5</td>
<td>1.5</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>212.5</td>
<td>300</td>
<td>350</td>
<td>312.5</td>
<td>275</td>
<td>325</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-6 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: All samples positive for bacteria
### Table E.6: Theti – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>675</td>
<td>725</td>
<td>700</td>
<td>750</td>
<td>725</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>437.5</td>
<td>437.5</td>
<td>450</td>
<td>475</td>
<td>412.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrites (NO₃⁻ mg/l)</td>
<td>5.54</td>
<td>5.54</td>
<td>4.43</td>
<td>3.32</td>
<td>3.32</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>1.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A_T mg/l)</td>
<td>275</td>
<td>325</td>
<td>312.5</td>
<td>312.5</td>
<td>293.8</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: Samples 4 and 5 negative for bacteria, remaining samples positive
Table E.7: Uzhuvar Nagar – Chemical Samples (Water Access Points)

<table>
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<tr>
<th></th>
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<th>4</th>
<th>Handpump</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>8.5</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>1100</td>
<td>1100</td>
<td>1025</td>
<td>925</td>
<td>1075</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>675</td>
<td>662.5</td>
<td>650</td>
<td>650</td>
<td>837.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>6.65</td>
<td>4.43</td>
<td>6.65</td>
<td>4.43</td>
<td>5.54</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>0.75</td>
<td>1.5</td>
<td>1.5</td>
<td>1.75</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₅ mg/l)</td>
<td>362.5</td>
<td>437.5</td>
<td>400</td>
<td>412.5</td>
<td>350</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂- mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-4 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: All samples positive for bacteria
## II. KARAIKAL DISTRICT

Table E.8: Akkam Pettai – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Borewell</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH</strong></td>
<td>9</td>
<td>8.75</td>
<td>8.5</td>
<td>8.5</td>
<td>8.5</td>
<td>8.75</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td><strong>Hardness</strong> (CaCO₃ mg/l)</td>
<td>775</td>
<td>825</td>
<td>837.5</td>
<td>825</td>
<td>850</td>
<td>1200</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td><strong>Chlorides</strong> (Cl mg/l)</td>
<td>512.5</td>
<td>550</td>
<td>562.5</td>
<td>500</td>
<td>587.5</td>
<td>712.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Nitrates</strong> (NO₃⁻ mg/l)</td>
<td>7.75</td>
<td>7.75</td>
<td>7.75</td>
<td>8.86</td>
<td>6.65</td>
<td>7.75</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td><strong>Fluoride</strong> (F⁻ mg/l)</td>
<td>2.25</td>
<td>1.0</td>
<td>1.5</td>
<td>1.0</td>
<td>2.0</td>
<td>1.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Alkalinity</strong> (A₇ mg/l)</td>
<td>300</td>
<td>262.5</td>
<td>250</td>
<td>287.5</td>
<td>250</td>
<td>337.5</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td><strong>Iron</strong> (Fe mg/l)</td>
<td>0</td>
<td>1.0</td>
<td>0.5</td>
<td>0</td>
<td>1.0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>TRC</strong> (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: All samples positive for bacteria
### Table E.9: Amman Kovil Pathu – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th><strong>BIS desirable</strong></th>
<th><strong>BIS permissible</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH</strong></td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>425</td>
<td>400</td>
<td>500</td>
<td>350</td>
<td>350</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>512.5</td>
<td>562.5</td>
<td>537.5</td>
<td>487.5</td>
<td>487.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>6.65</td>
<td>8.86</td>
<td>7.75</td>
<td>5.54</td>
<td>3.32</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>287.5</td>
<td>325</td>
<td>287.5</td>
<td>275</td>
<td>250</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: Samples 1, 2, and 4 negative for bacteria, remaining samples positive
Table E.10: Kilinjilmedu – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>475</td>
<td>375</td>
<td>400</td>
<td>425</td>
<td>400</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>487.5</td>
<td>537.5</td>
<td>625</td>
<td>625</td>
<td>575</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>6.65</td>
<td>7.75</td>
<td>7.75</td>
<td>7.75</td>
<td>7.75</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>300</td>
<td>287.5</td>
<td>250</td>
<td>275</td>
<td>287.5</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: Samples 1 and 4 negative for bacteria, remaining samples positive
Table E.11: Kizhakasakudimedu – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Treatment center</th>
<th>BIS desir-</th>
<th>BIS permiss-</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>325</td>
<td>375</td>
<td>275</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>487.5</td>
<td>612.5</td>
<td>537.5</td>
<td>650</td>
<td>550</td>
<td>150</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>7.75</td>
<td>9.97</td>
<td>13.29</td>
<td>13.29</td>
<td>11.08</td>
<td>5.54</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A_T mg/l)</td>
<td>337.5</td>
<td>312.5</td>
<td>337.5</td>
<td>325</td>
<td>350</td>
<td>75</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps
BIS = Bureau of Indian Standards
TRC = Total Residual Chlorine
Note: All samples positive for bacteria except treatment center
Table E.12: Mandapathur – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Borewell</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.75</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>8.75</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>550</td>
<td>525</td>
<td>625</td>
<td>525</td>
<td>600</td>
<td>675</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>350</td>
<td>325</td>
<td>337.5</td>
<td>350</td>
<td>375</td>
<td>487.5</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>3.32</td>
<td>4.43</td>
<td>5.53</td>
<td>4.43</td>
<td>5.53</td>
<td>38.76</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>0</td>
<td>0.5</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>312.5</td>
<td>325</td>
<td>287.5</td>
<td>262.5</td>
<td>300</td>
<td>300</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: All samples positive for bacteria except borewell
### Table E.13: Paravaipettai – Chemical Samples (Water Access Points)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>450</td>
<td>500</td>
<td>475</td>
<td>400</td>
<td>500</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>562.5</td>
<td>537.5</td>
<td>525</td>
<td>487.5</td>
<td>525</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>4.43</td>
<td>4.43</td>
<td>4.43</td>
<td>5.54</td>
<td>6.65</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₇ mg/l)</td>
<td>325</td>
<td>287.5</td>
<td>312.5</td>
<td>312.5</td>
<td>362.5</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: All samples negative for bacteria
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th><strong>BIS desirable</strong></th>
<th><strong>BIS permissible</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH</strong></td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td><strong>Hardness (CaCO₃ mg/l)</strong></td>
<td>375</td>
<td>325</td>
<td>375</td>
<td>375</td>
<td>350</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td><strong>Chlorides (Cl mg/l)</strong></td>
<td>525</td>
<td>550</td>
<td>537.5</td>
<td>512.5</td>
<td>525</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Nitrates (NO₃⁻ mg/l)</strong></td>
<td>5.54</td>
<td>6.65</td>
<td>6.65</td>
<td>7.75</td>
<td>8.86</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td><strong>Fluoride (F⁻ mg/l)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.25</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Alkalinity (A₁ mg/l)</strong></td>
<td>262.5</td>
<td>287.5</td>
<td>275</td>
<td>325</td>
<td>312.5</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td><strong>Iron (Fe mg/l)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>TRC (Cl₂⁻ mg/l)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Numbers 1-5 represent samples from government taps

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: Samples 3 and 5 negative for bacteria, remaining samples positive
### APPENDIX F: BACTERIOLOGICAL AND CHEMICAL SAMPLES – SUPPLY NODES

Table F.1: Supply Node Samples – Bacteriological and Chemical

<table>
<thead>
<tr>
<th>Bacteria (H₂S)</th>
<th>Velepalayam</th>
<th>Kunjimani Thidal</th>
<th>Nanavaickal</th>
<th>BIS desirable</th>
<th>BIS permissible</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9</td>
<td>8.5</td>
<td>8.75</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Hardness (CaCO₃ mg/l)</td>
<td>550</td>
<td>675</td>
<td>525</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Chlorides (Cl mg/l)</td>
<td>325</td>
<td>1287.5</td>
<td>225</td>
<td>250</td>
<td>1,000</td>
</tr>
<tr>
<td>Nitrates (NO₃⁻ mg/l)</td>
<td>6.65</td>
<td>13.29</td>
<td>13.29</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Fluoride (F⁻ mg/l)</td>
<td>0.5</td>
<td>1.0</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Alkalinity (A₅ mg/l)</td>
<td>262.5</td>
<td>387.5</td>
<td>300</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>Iron (Fe mg/l)</td>
<td>0</td>
<td>1.0</td>
<td>0.25</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>TRC (Cl₂⁻ mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Velepalayam sump is the supply node for Nagapattinam Municipality, where water is received, stored, treated, and supplied to the entire jurisdiction. The node supplies water to the study sites of New Nambiyar Nagar, Samanthanpettai, and Saveriyarkovil.

Kunjimani Thidal is a groundwater extraction, storage, treatment, and supply node in Kottucherry Commune Panchayat (rural Karaikal District). The node supplies water to Akkam Pettai.

Nanavaickal is a groundwater extraction, storage, treatment, and supply node in Kottucherry Commune Panchayat (rural Karaikal District). The node supplies water to Mandapathur.

BIS = Bureau of Indian Standards

TRC = Total Residual Chlorine

Note: Two bacteriological tests were performed at each node, all six were positive.

Note: I was not authorized to test nodes that supply water to the remaining study sites.
# APPENDIX G: WATER IMPROVEMENTS

Table G.1: Water Improvements at Household Level

<table>
<thead>
<tr>
<th>Location</th>
<th>Water improvements</th>
<th>No water improvements</th>
<th>% Water improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nagapattinam</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkaraipettai</td>
<td>15</td>
<td>6</td>
<td>71.43%</td>
</tr>
<tr>
<td>Andana Pettai</td>
<td>0</td>
<td>21</td>
<td>0.00%</td>
</tr>
<tr>
<td>New Nambiyar Nagar</td>
<td>2</td>
<td>35</td>
<td>5.41%</td>
</tr>
<tr>
<td>Samantha Pettai</td>
<td>13</td>
<td>13</td>
<td>50.00%</td>
</tr>
<tr>
<td>Saveriyarkovil</td>
<td>2</td>
<td>24</td>
<td>7.69%</td>
</tr>
<tr>
<td>Theti</td>
<td>4</td>
<td>19</td>
<td>17.39%</td>
</tr>
<tr>
<td>Uzhuvar Nagar</td>
<td>1</td>
<td>14</td>
<td>6.67%</td>
</tr>
<tr>
<td><strong>Total Nagapattinam</strong></td>
<td>37</td>
<td>132</td>
<td>21.89%</td>
</tr>
<tr>
<td><strong>Karaikal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akkam Pettai</td>
<td>9</td>
<td>9</td>
<td>50.00%</td>
</tr>
<tr>
<td>Amman Kovil Pathu</td>
<td>12</td>
<td>7</td>
<td>63.16%</td>
</tr>
<tr>
<td>Kilinjilmedu</td>
<td>11</td>
<td>13</td>
<td>45.83%</td>
</tr>
<tr>
<td>Kizhakasakudimedu</td>
<td>11</td>
<td>10</td>
<td>52.38%</td>
</tr>
<tr>
<td>Mandapathur</td>
<td>14</td>
<td>4</td>
<td>77.78%</td>
</tr>
<tr>
<td>Paravaipettai</td>
<td>4</td>
<td>11</td>
<td>26.67%</td>
</tr>
<tr>
<td>Vettakaramedu</td>
<td>0</td>
<td>16</td>
<td>0.00%</td>
</tr>
<tr>
<td><strong>Total Karaikal</strong></td>
<td>61</td>
<td>70</td>
<td>45.80%</td>
</tr>
</tbody>
</table>

* Water improvements defined as installing a borewell or handpump, upgrading to an individual tap, installing in-house piping, or connecting a rooftop tank to in-house pipes
### APPENDIX H: SUPPORTING WATER POVERTY INDEX DATA

#### Table H.1: WPI – Site Scale Extended (Weights Reported in Survey)

<table>
<thead>
<tr>
<th>Distance ($D_i$)</th>
<th>Hours Available ($H$)</th>
<th>Windows ($W$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.03 - AKP (K)</td>
<td>1.80 - Vettakaramedu (K)</td>
<td>3.59 - Paravaipettai (K)</td>
</tr>
<tr>
<td>13.03 - Paravaipettai (K)</td>
<td>1.20 - Akkam Pettai (K)</td>
<td>3.59 - Vettakaramedu (K)</td>
</tr>
<tr>
<td>13.03 - Vettakaramedu (K)</td>
<td>1.12 - NNN (N)</td>
<td>2.40 - Akkam Pettai (K)</td>
</tr>
<tr>
<td>12.98 - Kilinjilmedu (K)</td>
<td>0.97 - Mandapathur (K)</td>
<td>2.40 - AKP (K)</td>
</tr>
<tr>
<td>12.06 - Samanthanpettai (N)</td>
<td>0.91 - Paravaipettai (K)</td>
<td>2.40 - Kilinjilmedu (K)</td>
</tr>
<tr>
<td>11.97 - Akkaraipettai (N)</td>
<td>0.89 - Saveriyarkovil (N)</td>
<td>2.40 - Mandapathur (K)</td>
</tr>
<tr>
<td>11.89 - Theti (N)</td>
<td>0.73 - AKP (K)</td>
<td>1.37 - Kizhakasa. (K)</td>
</tr>
<tr>
<td>11.77 - Akkam Pettai (K)</td>
<td>0.72 - Kilinjilmedu (K)</td>
<td>1.33 - NNN (N)</td>
</tr>
<tr>
<td>11.64 - Uzhuvar Nagar (N)</td>
<td>0.69 - Akkaraipettai (N)</td>
<td>1.29 - Saveriyarkovil (N)</td>
</tr>
<tr>
<td>11.60 - Mandapathur (K)</td>
<td>0.61 - Theti (N)</td>
<td>1.20 - Akkaraipettai (N)</td>
</tr>
<tr>
<td>11.50 - Andana Pettai (N)</td>
<td>0.54 - Uzhuvar Nagar (N)</td>
<td>1.20 - Andana Pettai (N)</td>
</tr>
<tr>
<td>11.21 - NNN (N)</td>
<td>0.46 - Andana Pettai (N)</td>
<td>1.20 - Samanthanpettai (N)</td>
</tr>
<tr>
<td>11.16 - Saveriyarkovil (N)</td>
<td>0.37 - Kizhakasa. (K)</td>
<td>1.20 - Theti (N)</td>
</tr>
<tr>
<td>10.52 - Kizhakasa. (K)</td>
<td>0.36 - Samanthanpettai (N)</td>
<td>1.20 - Uzhuvar Nagar (N)</td>
</tr>
<tr>
<td><strong>max = 13.03; range = 2.51</strong></td>
<td></td>
<td><strong>max = 3.59; range = 2.39</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Density ($D_e$)</th>
<th>LPCPD ($L$)</th>
<th>Flow Rate ($P$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.20 - AKP (K)</td>
<td>24.39 - Vettakaramedu (K)</td>
<td>8.16 - Akkaraipettai (N)</td>
</tr>
<tr>
<td>3.20 - Kilinjilmedu (K)</td>
<td>23.83 - Paravaipettai (K)</td>
<td>6.02 - Akkam Pettai (K)</td>
</tr>
<tr>
<td>3.20 - Paravaipettai (K)</td>
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<td>5.83 - NNN (N)</td>
</tr>
<tr>
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</tr>
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<td>5.54 - Saveriyarkovil (N)</td>
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Table H.1 (cntd.)

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\]

\[
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\]

\[
\text{max} = 25.83; \quad \text{range} = 17.69
\]

WPI = Water Poverty Index
LPCPD = Liters Per Capita Per Day
AKP = Amman Kovil Pathu
NNN = New Nambiyar Nagar
(K) = located in Karaikal District
(N) = located in Nagapattinam District

Note: Capacity not included because survey weight is 0
Table H.2: WPI – Site Scale Extended (Expert Weight)

<table>
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<th>Distance (Di)</th>
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<td>1.33 - AKP (K)</td>
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<td>0.67 - Akkaraipettai (N)</td>
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max = 7; range = 1.35

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max = 3.5; range = 1.75

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<td>6.89 - Theti (N)</td>
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<td>6.77 - Mandapathur (K)</td>
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<td>1.54 - Theti (N)</td>
<td>6.61 - Akkam Pettai (K)</td>
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<td>6.45 - Uzhuvan Nagar (N)</td>
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\[
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\[
\text{max} = 12.5; \quad \text{range} = 10.71
\]

Unimproved Sources (U) | Quality (Q)
------------------------|-------------
10.71 - Kizhakasa (K) | 18.33 - Paravaipettai (K) |
8.13 - Andana Pettai (N) | 12.98 - Andana Pettai (N) |
5.16 - Akkaraipettai (N) | 11.45 - AKP (K) |
4.61 - AKP (K) | 9.17 - Akkaraipettai (N) |
4.34 - Kilinjilmedu (K) | 8.91 - Vettakaramedu (K) |
4.17 - Akkam Pettai (K) | 8.80 - Theti (N) |
4.17 - Uzhuvan Nagar (N) | 8.60 - Kilinjilmedu (K) |
3.70 - Mandapathur (K) | 4.01 - Samanthanpettai (N) |
3.39 - Vettakaramedu (K) | 3.57 - Kizhakasa. (K) |
2.40 - Samanthanpettai (N) | 1.39 - Mandapathur (K) |
0.91 - Theti (N) | 1.35 - NNN (N) |
0.90 - NNN (N) | 0.83 - Uzhuvan Nagar (N) |
0.64 - Saveriyarkovil (N) | 0.69 - Akkam Pettai (K) |
0 - Paravaipettai (K) | 0.48 - Saveriyarkovil (N) |

\[
\text{max} = 12.5; \quad \text{range} = 10.71
\]

WPI = Water Poverty Index

LPCPD = Liters Per Capita Per Day

AKP = Amman Kovil Pathu

NNN = New Nambiyar Nagar

(K) = located in Karaikal District

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APPENDIX I: WATER POVERTY INDICES – SPIDER DIAGRAMS

Note that all diagrams visualizing survey and expert weights are expressed on a logarithmic scale.

Figure 1.1: Spider diagrams – indicators
Figure 1.2: Spider diagrams – sites
Figure I.3: Spider diagrams – districts
Figure I.4: Spider diagrams – rural-urban Nagapattinam
Figure I.5: Spider diagrams – rural-urban Karaikal
Figure 1.6: Spider diagrams – rural-urban total
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