ACTING COLLECTIVELY FOR EQUITY (ACE)

PUBLIC HEALTH EQUITY THROUGH IMPROVED WATER, SANITATION AND WASTE MANAGEMENT IN MARADU, KERALA

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EXECUTIVE SUMMARY

Effective water and waste systems are essential for the growth of a healthy and vibrant community. Even when such effective systems are in place, equal access may not exist. When equal access to clean water, sanitation systems, and effective waste management is not in place, communities suffer from economic inequity and disparities in public health.

India's small and mid-size cities, such as Maradu, are experiencing rapid growth, and maintaining clean water and sanitation is an ongoing challenge. The quality and extent of the water and waste systems may be very low in cities that have not begun to invest in sanitation infrastructure early on in their growth. The population's demand for water and waste systems already exceeds the capacity of the existing systems in place and the demand is increasing as the population grows. Water, air and trash pollution tends to increase with population density, all of which threaten environmental and human health. Often, cities do not have the funding to address all of their sanitation needs which leads cities to focus their attention on less complex issues, neglecting larger systematic sanitation problems. This cycle of neglect leads to inequities in the access to safe, healthy, and sufficient sanitation systems. Poor communities are often the most vulnerable populations because they have limited access to sanitary environments.

Maradu is a rapidly growing municipality outside of the city of Kochi in Kerala, India. The town's tropical wet climate and proximity to Kochi have made it a desirable destination for migrating populations. The current population growth rate in Maradu is a leading cause of the stress on the municipality's water and waste infrastructure. Undefined infrastructure capacity, pollution, lack of resources, and the newness of the municipal government exacerbates challenges related to sanitation.

The goal of Acting Collectively for Equity (ACE): Public Health Equity through Improved Water, Sanitation and Waste Management in Maradu, Kerala is to promote public health equity through improved water and sanitation systems in Maradu, India. The objectives of the report are to:

1. Provide information to improve access to clean drinking water
2. Provide information to improve management of wastewater systems
3. Provide information to improve management of solid waste systems

An interdisciplinary group of graduate students from the University at Buffalo (UB), State University of New York, USA prepared this report on behalf of the town of Maradu and the Center for Science and Environment (CSE), a non-profit organization facilitating sanitation planning efforts in Maradu. Development of the report was funded in part by the University at Buffalo Community of Excellence in Global Health Equity.

Working in partnership with the town government, Suchitwa Mission, CSE, and the College of Engineering in Trivandrum, the UB team conducted field research in Maradu in early 2016. The report was completed (at UB) in 2016, and reviewed by CSE and the Town of Maradu (TBC).

The findings in the report are based on multiple sources of data, including quantitative, spatial, and qualitative data. Quantitative data includes secondary sources of town-scale data from Census of India, the Swachh Bharath Town-wide Survey, which was collected (but not processed) by the local government as of January 2016. Quantitative data was also collected through a household survey in Ward 4, conducted by the University at Buffalo. Spatial data includes a town-wide map prepared using Geographic Information Systems (GIS). Qualitative data includes 24 interviews with local government officials and staff, and 47 interviews with adult representatives of households residing in Ward 4 in Maradu. Additional qualitative data collected includes photo documentation and drawings of neighborhood conditions and household practices related to sanitation systems.

Based on this data, and through this report, the students aim to aid the Municipality of Maradu in the preparation of their City Sanitation Plan, a government-mandated document that describes how the town will achieve comprehensive city sanitation. Each town has been mandated through the National Urban Sanitation Policy (NUSP) to create a City Sanitation Plan (CSP) for which the town can follow. NUSP describes the City Sanitation Plan as a "vision document on sanitation with 20 to 25 years horizon with short term town level action plans for 5 years to achieve sanitation goals" (Government of India 2008). NUSP provides detailed guidelines on what should be included for municipalities going through the planning process. This report, which includes six sections, provides information about current sanitation conditions in Maradu, and concludes with sanitation system precedents as well as recommendations for action. Although the planning area for the report is the town of Maradu, the report highlights conditions and opportunities within Ward 4, one of the towns' 33 wards. After detailed investigation, Ward 4 presents itself as a site for implementing some of the recommendations presented in this report.

The following findings suggest that despite many challenges, the town is poised to improve public health equity through improved sanitation.

DRINKING WATER

Adequacy of Treatment

Household drinking water is treated regularly before consumption indicating the awareness of potential pathogens. Drinking water is retrieved from several sources including on site wells and piped in from the Kerala Water Authority.

Frequency of Delivery

Some families must wait to be connected to water and fear inconsistency in supply and therefore dig supplemental wells.

WASTEWATER

Access to Toilets

A high percentage of households have access to private toilets preventing open defecation.

Septage Management

Construction and maintenance of septic tanks is not regulated by the local municipality despite large percentages of septic tank use by households. This can result in ground water contamination due to leaking septic tanks engaging with a high ground water table.

Collection Efficiency

Storm water drains also carry grey water and frequently become clogged with debris that washes off the streets. Clogging leads to flooding and standing water creating a breeding ground for mosquitos that potentially carry and spread disease.

Extent of Cost Recovery

Maradu allocated 2.5 crore rupees for drainage maintenance in the 2014-15 fiscal year indicating there is an awareness of and willingness to address drainage issues.

SOLID WASTE

Available Information

The full extent of waste production is unknown making it difficult to form decisions surrounding the future management of solid waste.

Insufficient Infrastructure

Due to the lack of capacity at existing disposal facilities, informal public dumping sites occur in undesirable locations throughout the entire town.

Persistent practice of the daily outdoor incineration of solid waste is believed to be linked to the poor respiratory health of local residents. The study conducted in Ward 4 revealed that 27% of households dump their waste in nearby canals. Considering Maradu is surrounded by waterways there is a high possibility that this practice is being carried out across Maradu. This could lead to severe degradation in the quality of the waterways.

Positive Waste Management Practices

Existing practices like composting and waste collection by Kudumbashree, a profitable enterprise, are positive methods of waste disposal that can be expanded upon in the future.

The report concludes with 28 ideas for improving public health, water and sanitation systems. These ideas are intended for implementation over a 15 year horizon. The recommendations are outlined here for reference.

Recommended Ideas for Maradu	
Category and Recommendation	
Data Collection	1. Use citizen science to map roads, buildings, and public facilities
	2. Assess existing drinking water infrastructure
	3. Finalize the locations of ward-level solid-waste aggregation sites
	4. Generate data concerning solid waste collection by Kudumbashree and the system of primary collection of solid waste
	5. Identify high contamination areas of waterways through testing conducted in partnership with schools or Inland Waterway Authority
Wastewater	6. Establish a temporary septic treatment and disposal site as part of a phased sanitation stratgey
	7. Promote a comprehensive faecal sludge management system
	8. Implement procedures for the regular maintenance of drainage systems
	9. Develop and create sanitation facilities for underserved areas

Recommended Ideas for Maradu	
Freshwater Supply	10. Enhance existing drinking water infrastructure to ensure high quality and adequate water supplies
	11. Supplement the public water supply with private water sources through public-private partnerships
	12. Promote commercial and industrial on-site water recycling systems to conserve freshwater resources
	13. Encourage planting of vegetation that restores riparian zones along all waterways in the Municipality
Solid Waste	14. Verify the best solid waste treatment facility, prioritizing engineering standards and high capacity
	15. Enhance funding for solid waste management through innovative autogenous strategies and by seeking external aid
	16. Use information gathered on primary collection of solid waste to improve the effectiveness of the Kudumbashree program
	17. Provide sufficient amount of garbage receptacles per ward and work with Clean Kerala to ensure a suitable collection method of garbage bins is maintained
	18. Implement joint municipal agreements to foster sharing of solid waste infrastucture
	19. Segregate hazardous waste/universal waste/household waste
	20. Investigate and implement solid waste reduction strategies
Community-based Initiatives	21. Reinstate the City Sanitation Task Force to catalyze the ward-level sanitation coalition and to create governance structure transparency for the residents of Maradu
	22. Establish ward-level community coalitions that promote public awareness and guide actions related to sanitation and public health equity
	23. Initiate and promote neighborhood clean-ups
	24. Provide signage or symbology for educational and instructional purposes
	25. Design and distribute brochures to households about sustainable practices that promote sanitation
	26. Sponsor school competition programs for water quality and sanitation solutions
	27. Identify opportunities for public green spaces in residential neighborhoods
	28. Design public recreational green and blue spaces between neighborhoods and canals

This report is intended to be a resource for the town of Maradu as the local government embarks on efforts to improve sanitation and public health for Maradu residents. The support brought through public and private partnerships as well as an informed community will be invaluable in the success of the CSP. The UB team encourages the use of the information in this report by Maradu local government and town stakeholders for the purpose of promoting public health equity and strengthening the pillars of a successful City Sanitation Plan.

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1. INTRODUCTION

1.1. HEALTH EQUITY AND SANITATION

Much of what contributes to the quality of life in a town are the underlying water and waste management systems. Quality water and waste systems provide resources such as clean drinking water, proper septic management, and sufficient waste disposal. In developing cities, the infrastructure for these systems struggles to keep up with the pace of population growth. As gaps in infrastructure grow, the price of providing these systems increases. As a result, lower socioeconomic classes have inadequate access to these systems due to a lack of financial capacity, resulting in disparities in health equity.

Health equity is a state where every resident in a community has a fair opportunity to live a long, healthy life. In such a community, health is not compromised because of an individual's or group of individuals "race, ethnicity, gender, income, sexual orientation, neighborhood, or other social condition" (Boston Public Health Commission). Health inequities often result from an uneven distribution of resources and services. For example, low-income individuals living in informal settlements, or slums, experience worse living conditions as a result of the high overall rate of population growth in Maradu (Maradu Municipality 2015). These conditions, which include water stagnation and the presence of insects and rodents, increase vulnerability of the poor towards disease. Improving sanitation conditions related to wastewater, water, and solid-waste systems is an important step to achieving the highest attainable standard of health—a fundamental right for every human being.

1.2. MOTIVATION AND CLIENT

In 2008, the Ministry of Urban Development launched The National Urban Sanitation Policy-NUSP (Government of India 2008) to address issues related to sanitation, resulting from India's rapid urbanization. The policy requires that states produce strategies to improve sanitation conditions statewide. Consequently, municipalities, including Maradu, were charged with developing documents titled City Sanitation Plans (CSPs), comprehensive plans developed in order to improve sanitation at the town-level to "promote social, economic, and physical well-being of all sections of the population" (Maradu Municipality 2015). CSE and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) began a nationwide process in 2014 to assist municipalities in multiple states to draft plans for improving sanitation. Currently, Suchitwa Mission, CSE, and GIZ are working with the Municipality of Maradu to update and fill in the gaps in

their City Sanitation Plan. The authors of this report at the University at Buffalo (UB), in cooperation with CSE, Suchitwa Mission, and the Maradu Municipality, are supporting the effort to improve Maradu's City Sanitation Plan.

In January 2016, with support from the UB Community of Excellence in Global Health Equity (CGHE), the UB School of Architecture and Planning launched a transdisciplinary practicum course—also called a studio— to assist with the Maradu CSP process. The studio faculty convened students across a range of disciplines in collaboration to prepare this report. The UB studio worked with a number of international partners, including Suchitwa Mission, which functions as the Department of Sanitation for the state of Kerala, Centre for Science and Environment (CSE), and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). This report is intended to serve as a technical assistance report for the CSP planning process for the Municipality of Maradu. Maradu can, if it chooses, incorporate the data from the report into its CSP, or adopt the report as an annexure or addendum to its CSP.

1.3. VISION, GOALS, AND OBJECTIVES

The vision of this report is to provide information that contributes to the development of Maradu's City Sanitation Plan, which, in turn advances the public health, water, wastewater, and solid-waste systems that improve equity in health and well-being. Achieving this vision involves providing the necessary information to ensure proper quality and quantity of water is provided to residents, and wastewater systems and solid waste systems are in place to ensure the equitable distribution of health outcomes in Maradu.

This planning report has three overarching objectives focused on clean water, wastewater, and solid waste systems, as outlined below. Although the goals and objectives are presented distinctly, many are, in fact, related.

1. Provide information to improve Maradu's access to clean drinking water
    - Gather primary data (e.g. Ward 4 household surveys and stakeholder interviews) and secondary data (e.g., Swachh Bharath Town-wide Survey, policy documents, finance data, and photos) related to drinking water and water quality
    - Map municipal- and household-level water systems and practices
    - Diagram the water-supply process and related government structure

- Identify opportunities and gaps in the City Sanitation Plan regarding water systems
- Provide precedents, alternatives, and recommendations on access to drinking water

2. Provide information to improve Maradu's management of wastewater systems
    - Gather primary data (e.g. Ward 4 household surveys and stakeholder interviews) and secondary data (e.g., Swachh Bharath Town-wide Survey, policy documents, finance data, and photos) related to management of wastewater systems
    - Map municipal- and household-level wastewater systems and practices
    - Diagram the wastewater process and related government structure
    - Identify opportunities and gaps in the City Sanitation Plan regarding wastewater systems
    - Provide precedents, alternatives, and recommendations on management for wastewater systems
3. Provide information to improve Maradu's management of solid waste systems
    - Gather primary data (e.g. Ward 4 household surveys and stakeholder interviews) and secondary data (e.g., Swachh Bharath Town-wide Survey, policy documents, finance data, and photos) related to management of solid waste systems
    - Map municipal-level and household-level solid waste systems and practices
    - Diagram the solid waste process and related government structure
    - Identify opportunities and gaps in the City Sanitation Plan regarding solid waste systems
    - Provide precedents, alternatives, and recommendations on management of solid waste systems

1.4. PLANNING PROCESS, AREA, AND METHODS

The process for completing this report included early scoping conversations among UB faculty and partner organizations in India, specifically CSE and Suchitwa Mission (in summer 2015), to determine a community site

(a municipality) where UB could most effectively support ongoing work. Following scoping conversations, partners collectively selected Maradu as a site for the studio. The UB studio team conducted field visits to Maradu, India in January 2016 to begin work with community stakeholders and for data collection in partnership with the College of Engineering, Trivandrum. Data analysis and drafting of the report by the studio team was completed at the University at Buffalo. Drafts of the planning report were reviewed by the Center for Science and Environment, Suchitwa Mission, and town officials prior to being finalized (TBC).

This geographic focus for this report is the area ensconced within the boundaries of the town of Maradu. The Municipality of Maradu is comprised of 33 wards (figure 1).[1] To attain the objectives outlined above, the report required a planning process that included gathering data; mapping infrastructure systems; analyzing baseline public-health, water, wastewater, and solid-waste systems data; interviewing stakeholders; pinpointing strengths and weaknesses of the systems; and synthesizing this information into recommendations for the Municipality and other stakeholders.

The findings in the report draw on multiple sources of data, including quantitative, spatial, and qualitative data, to document conditions in the town. Quantitative data includes secondary sources of data from Census of India, the Swachh Barath Town-wide Survey, which was collected (but not processed) by the local government as of January 2016. Spatial data includes a town-wide map prepared using Geographic Information Systems (GIS) and geo-referenced by GPS points collected during field visits. Qualitative data includes 24 interviews of local government officials, staff, and community stakeholders conducted by team members.

To efficiently obtain an illustrative amount of data for the Municipality the team also gathered additional data in Ward 4. Ward 4 was selected because it illustrates many of the topographical features and planning challenges shared by the larger town: for example, it has limited to no land available for development and is bounded on one side by a canal (figure 2). Importantly, Ward 4 was also selected due to a strong willingness from the ward leaders to partner with the studio.

The partnership with Ward 4 leaders made it possible for the UB team to collect comprehensive data in a short period of three weeks. Data in Ward 4 was collected through surveying, mapping and diagramming of households in Ward 4. Ward 4 data collection used a three-pronged approach. One focus

[1] Wards are a division of a town for representative, electoral, or administrative purposes. Prior to 2010, the town was demarcated into 22 wards. The re-designation of wards poses a significant challenge in reconciling current spatial data with historic census data.

was deploying a reliable household survey tool to evaluate a wide range of questions related to household health status, healthcare access, and questions related to food, water, wastewater, solid waste, and toilet access. Out of the 101 households approached in Ward 4, 89 households (86%) agreed to participate in the survey. Second, was conducting deeper interviews with a subset of these 89 households to understand their sanitation-related experiences, and to probe them about potential solutions. And, finally, the team manually mapped the position of every house in Ward 4 and diagrammed interior and exterior spaces.[2]

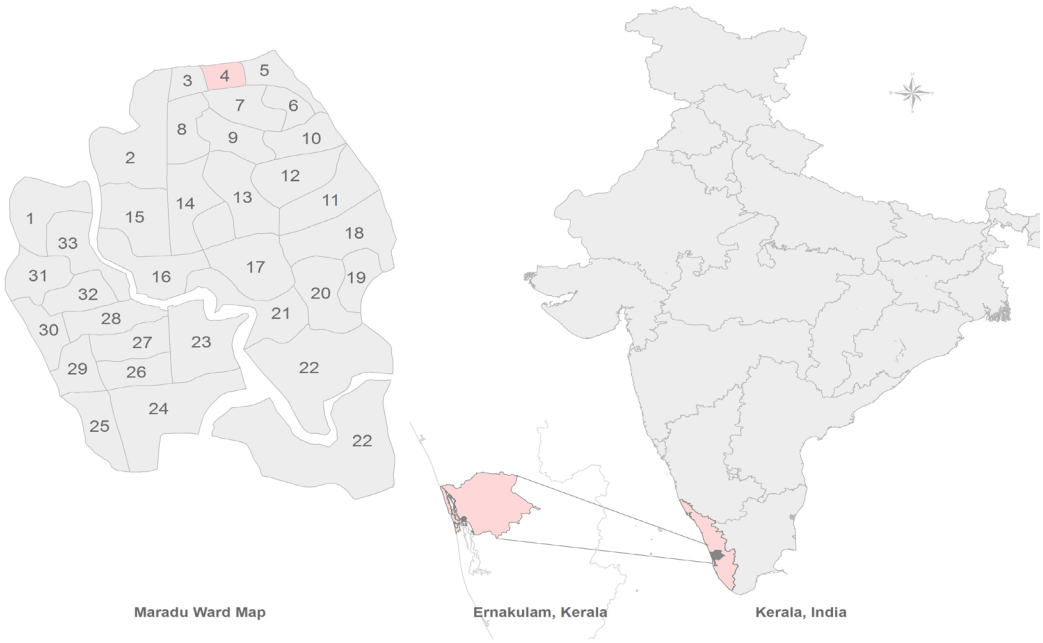
Through this report, the students aim to aid the Municipality of Maradu in the preparation of their City Sanitation Plan, a government-mandated document that describes how the town will achieve comprehensive city sanitation. This report, which includes six sections, provides information about current sanitation conditions in Maradu, and concludes with precedents of how other communities have promoted sanitation as well as recommendations for action in Maradu.[3]

This report, although comprehensive, was constrained by the limited time available for the overall project. The bulk of the project—from initiating conversation with partner organizations to completion of report—was completed in less than ten months. The UB team hopes that work completed through this studio project can be continued and amplified by local partners—such as the Maradu Municipality, possibly with assistance from local universities such as the College of Engineering, Trivandrum—with this report as a baseline for future action.

[2] Ward 4 data was collected in coordinated teams to minimize burden on the households. Surveying, interviewing, and diagramming occurred simultaneously, and with permission of household residents.

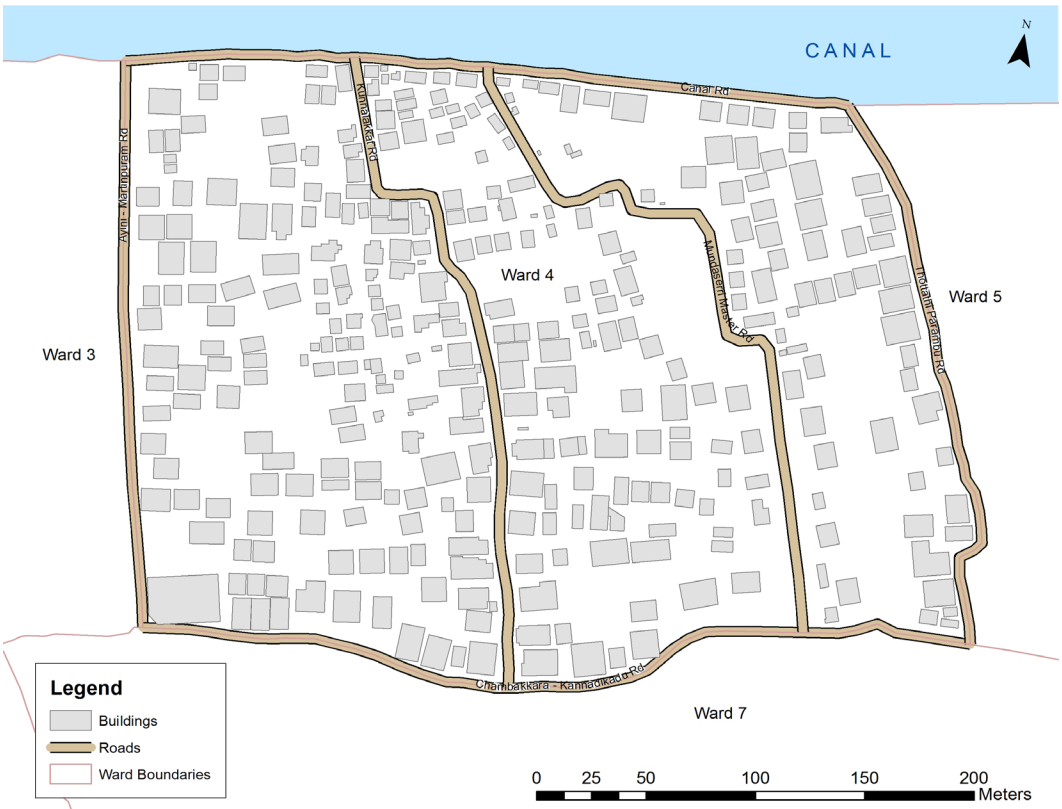
[3] Although the planning area for the report is the town of Maradu, the report highlights conditions and opportunities within Ward 4, one of the towns' 33 wards, which was the site of deeper exploration, and may offer a site implementing pilot projects.

Figure 1: Maradu's Location



Source: Maradu's Location [Map] Data Layers: Census 2011: State and District boundaries; Maradu Municipality: Maradu Ward boundaries. Map by Samantha Bulkilvish in 2017. Using ArcGIS Desktop 10.3. Redlands, CA: ESRI, 2014.

Figure 2: Layout of Maradu's Ward 4



Source: Detailed map of Maradu's Ward 4 [Map] Maradu Municipality: Maradu Ward boundaries, Google Maps: Roads. Map by Samantha Bulkilvish in 2016. Using ArcGIS Desktop 10.3. Redlands, CA: ESRI 2014.

Source: University at Buffalo

2. CONTEXT FOR PUBLIC HEALTH IN MARADU

2.1. GEOGRAPHY AND DEMOGRAPHIC PATTERNS

2.1.1. GEOGRAPHY

Located on the southwestern coastal plains of India in the state of Kerala, Maradu is one of the thirteen municipalities that comprise the Ernakulam District (Ernakulam District Administration). Maradu is situated between the Arabian Sea to the west and the Western Ghats (Sahyadri) mountain range to the east, the latter protects the area from the hot, dry winds from the north. As a result, Maradu experiences a pleasant year-round climate, save for the heavy rainfall season (table 1). The bulk of rainfall is received between the months of May and December as a result of the monsoon seasons, often resulting in significant flooding (Department of Tourism 2013).

The town encompasses 12.35 sq. km. of area. Due to its central geographic location within the Ernakulam District, Maradu is conveniently accessible by multiple railway stations (Department of Tourism 2013) to the Cochin International Airport, and by water transport, due to the town's proximity to Periyar and Muvattupuzha rivers (State Water Transport Department). The close proximity to many waterways adds an additional level of complexity to the municipalities sanitation services.

Maradu is a unique town in the way that natural and built environments are integrated. Residents can find themselves racing through traffic in an autorickshaw,[4] as well as admiring the picturesque landscape of the backwaters – or naturally occurring water canals - flowing throughout the area.

2.1.2. DEMOGRAPHICS

According to the 2011 Census of India, Maradu had 11,065 households and a population of 44,704 people (Census of India Organisation 2011). Between the years 1991 and 2011, Maradu saw an annual population growth rate of 1.23%, resulting in an increase of 9,709 residents (Census of India Organisation 2011). Maradu's male and female populations are virtually an even split, with women just slightly outnumbering men. Females comprise 50.3% of the population (22,528), whereas males make up 49.6% (22,176) (Girija, S.P. et al. 2011). The gender distribution in the population is especially important because the National Urban Sanitation Policy- NUSP has a "special focus on hygienic and affordable sanitation facilities for the urban poor and women" (Government of India 2008).

[4]Autorickshaws are a common mode of public transportation in Maradu.

Similar to other municipalities in the Ernakulam District, Maradu has a highly literate population. A significant majority 88.5% (39,565) of the town's population older than age seven is literate. In fact, literacy rates are higher than in India (63.0%) (figure 3) (Girija, S.P. et al. 2011). Importantly, unlike many parts of the world, the distribution of males and females within the literate population is roughly equal. Women comprise 49.9% (19,730) of the literate population and men comprise 50.1% (19,835) (Girija, S.P. et al. 2011).

Legally protected groups are a small minority in Maradu. Individuals belonging to scheduled castes (SC),[5] who are legally regarded as socially disadvantaged, represent 8.8% (3,939) of Maradu's population. Scheduled tribes (ST),[6] tribes that are listed in the Eighth Schedule of the Indian Constitution and recommended for special help in education and employment, comprises 0.6% (261) of Maradu's population. The scheduled caste and tribe population is much smaller in Maradu compared to the entirety of India, where the percentages are 16.6% and 8.6%, respectively (figure 4) (Girija, S.P. et al. 2011).

Employment rates in Maradu are fairly low. Total number of workers in Maradu, including "main," those who had worked for more than 183 days in the current year, and "marginal," those who had worked less than 183 days in the current year, constituted 37.8% (16,903) of Maradu's population, while non-workers constituted 62.2% (27,801) (figure 5) (Government of India 2001). These levels of employment are relatively similar to the country as a whole.

Compared to India as a whole, Maradu has a diverse representation of religions. India is largely comprised of Hindus (79.8%), whereas Maradu has a more even distribution between Hindus (49.2%), Christians (35.7%), and Muslims (14.9%) (figure 6) (Girija, S.P. et al. 2011). The diversity of religious faiths contributes to a rich multicultural ethos in Maradu.

2.1.3. POPULATION GROWTH

Maradu's population is expected to triple in the next fifteen years. By the year 2031, population is projected to increase to 110,635 people, based on natural growth, migration, and floating populations (Department of Town and Country Planning). This annual population growth is equivalent to a high of 4.64% between the years 2011 and 2031 (figure 7). This projection is based on a hypothetical scenario presuming that migration to Maradu is unhindered. However, if growth management tools are deployed, growth can be managed – or at the least accompanied by a concomitant increase in infrastructure (McNicoll 1984).

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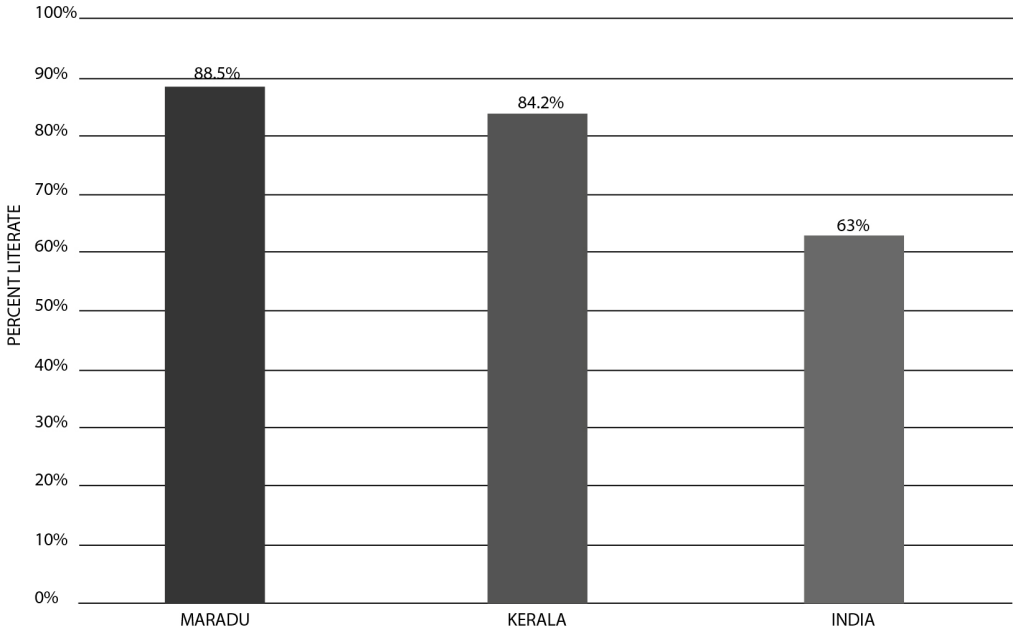
[5] Scheduled castes (SC) are among the most disadvantaged socio-economic groups in India. Article 341 of the Indian Constitution expressly specify which castes are deemed as such. Governement of India. "Scheduled Castes List." from http://socialjustice.nic.in/sclist.php

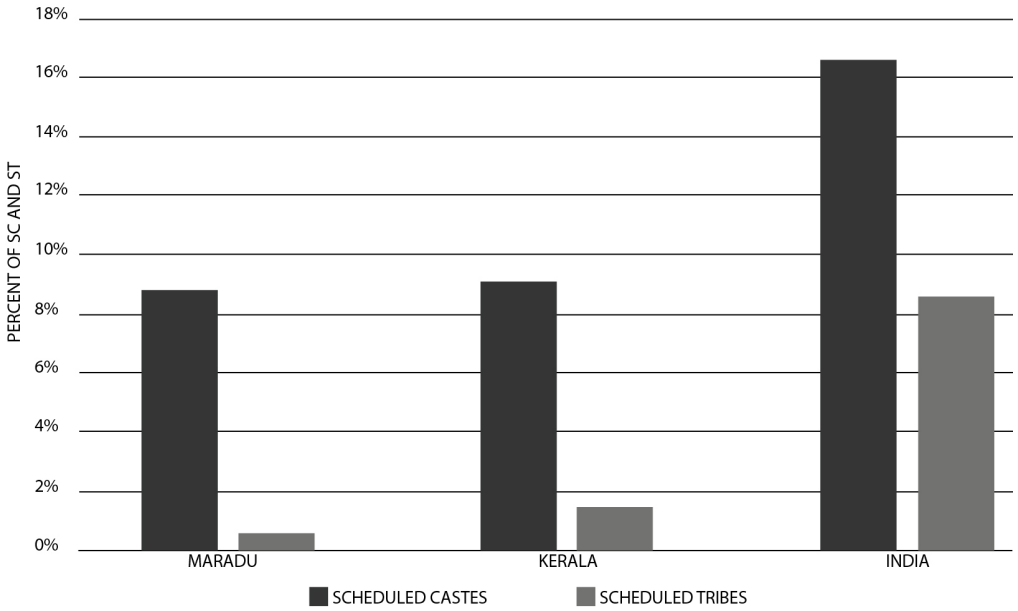
[6] Scheduled tribes (ST) are among the most disadvantaged socio-economic groups in India. Article 342 of the Indian Constitution specify which tribes are deemed as such. Government of India. "Definition." from http://tribal.nic.in/Content/DefinitionpRofiles.aspx.

Figure 3: Literacy Rates



Source: Census of India Organization. (2011). The Indian Census.

Figure 4: Disadvantaged Low-income SC and ST Populations



Source: Census of India Organization. (2011). The Indian Census.

Table 1: Key Geographic Features

Area	Annual Rainfall	Min. Temperature	Max. Temperature
12.35 sq. km.	3,098 mm (122 in)	22 degrees-Celsius	35 degrees-Celsius

Source: Census of India Organization. (2011). The Indian Census.

Growth of Maradu can be attributed in part to location within the Kochi Metropolitan Area (KMA), among the fastest-growing regions in the country. The regional growth can be accredited to economic reforms in India introduced by the Central Government in the mid-1990s. Reforms included the deregulation of markets, greater foreign investment, a reduction in import tariffs, and reduction of taxes (Sharma 2008). Similar to other parts of Kerala, tourism is one of the dominant drivers of Kochi's local economy. The KMA ranks first in the total number of domestic tourists visiting Kerala. As a result, the service sector has seen significant growth, bringing about rapid commercialization, and thus, the KMA has grown into the commercial capital of Kerala. In effect, towns within the KMA, such as Maradu, are absorbing the spillover of this growth. The population growth is creating major difficulties. Services required by cities, such as sewerage, water, and trash collection, are not keeping pace with the rate of population growth. If not adequately addressed, the rate of population growth will further stress the sanitation conditions in Maradu.

2.2. GOVERNANCE AND INSTITUTIONAL FRAMEWORK IN MARADU

2.2.1. POLICY MAKING AND GOVERNANCE STRUCTURES

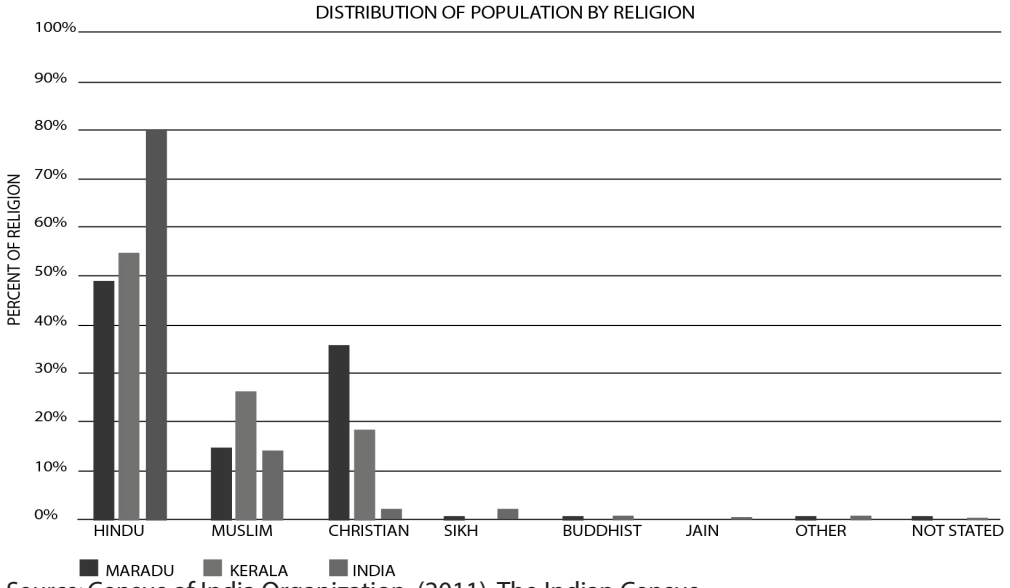
Governments at all levels are making an effort to provide a policy framework for improving sanitation in Maradu. At the national level, the central Government of India is concerned about the detrimental effect of poor sanitation on people's wellbeing, and has made sanitation a priority, requiring states and local governments to follow suit. Policies, plans, guidelines, programs, and funding mechanisms to promote urban sanitation are already in place at multiple levels of government.

Decentralization of the Indian government, which transfers power to urban local bodies (ULBs) and rural panchayats through the 74th Amendment, established the current legal environment for sanitation in ULBs such as Maradu. The 12th Schedule of the 74th Amendment gave Urban Local Bodies (ULB's), governing bodies responsible for functions delegated by state government, a number of responsibilities including providing sanitation for water, and solid waste-management in the interest of public health (table 2). The Kerala Municipality Acts were a direct follow-up to the 74th Amendment, affirming the redistribution of these responsibilities and providing additional requirements regarding the level of performance required through rules and

Figure 5: Work Status

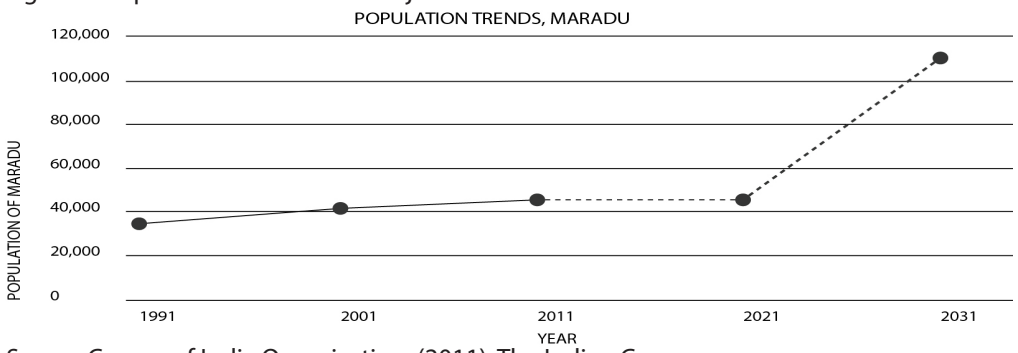
Source: Census of India Organization. (2011). The Indian Census.

Figure 6: Religious Background



Source: Census of India Organization. (2011). The Indian Census.

Figure 7: Population and Growth Projection



Source: Census of India Organization. (2011). The Indian Census.

standards (Ministry of Law and Justice 1992). The 74th Amendment and Kerala Municipality Acts affirm that it is a legal obligation for Maradu to supply clean water, provide adequate sanitation, and manage solid waste within town bounds.

Historically, ULBs have lagged in meeting these obligations, so, central and state governments have supplied policy goals for cities to meet, regulations through policy, guides and manuals for education, programs to facilitate implementation, and funds for expanding and upgrading infrastructure. One of the major pieces of central-level administration is the National Urban Sanitation Policy (NUSP) of 2008. The NUSP outlines the nation's sanitation agenda and encompasses broad aspects of urban sanitation with a specific focus on eliminating open defecation in cities (Government of India 2008). This national policy encourages town-wide approaches to sanitation that encompass all aspects of town sanitation by establishing frameworks for the drafting of state sanitation strategies and town sanitation plans. The NUSP is affirmed by the Kerala State Sanitation Strategy (KSSS), which describes a strict organizational scheme, from the state level to the ULB level, for establishing governance bodies to oversee solid-waste management at each level (Deutsche Gesellschaft für Technische Zusammenarbeit 2008). Governance bodies to be established include a City Sanitation Task Force, supported by City Sanitation Cells at the local level, which are responsible for launching the City 100% Sanitation Campaign, approving the CSP, and overseeing the implementation of sanitation strategies. Any recommendations in this report would be implemented, in part, through the establishment and functioning of such governance structures in Maradu.[7]

2.2.2. NATIONAL, STATE AND LOCAL POLICY INITIATIVES TO IMPROVE HEALTH EQUITY THROUGH SANITATION

Several state- and central-level sanitation and public-health programs operate for the benefit of Maradu residents. These include the Swachh Bharath Mission, Suchitwa Mission, and the Kudumbashree State Poverty Eradication Mission. Swachh Bharath Mission (SBM) is a central government program dedicated to the elimination of open defecation, eradication of manual scavenging, increased utilization of modern and scientific municipal solid waste-management practices in the public and private sector, effective behavioral change of healthy sanitation practices, and heightened awareness about sanitation and its linkage with public health. SBM also authorizes the conduct of extensive assessment surveys to document and monitor sanitation conditions. The SBM Town-wide survey data was used to document conditions in Maradu.

[7] Maradu had established a City Sanitation Task Force (CSTF) in June 2015. However, due to recent ULB elections the membership of the CSTF has to be reappointed and reconvened. This report can provide impetus for reconvening the CSTF.

Table 2: Responsibilities of the Municipality

1.	Urban planning including town planning
2.	Regulation of land-use and construction of buildings
3.	Planning for economic and social development
4.	Roads and bridges
5.	Water supply for domestic, industrial and commercial purposes
6.	Public health, sanitation conservancy and solid waste management
7.	Fire services
8.	Urban forestry, protection of the environment and promotion of ecological aspects
9.	Safeguarding the interests of weaker sections of society, including the handicapped and mentally retarded
10.	Slum improvement and upgradation
11.	Urban poverty alleviation
12.	Provision of urban amenities and facilities such as parks, gardens, playgrounds
13.	Promotion of cultural, educational and aesthetic aspects
14.	Burials and burial grounds, cremations, cremation grounds and electric crematoriums
15.	Cattle pounds; prevention of cruelty to animals
16.	Vital statistics including registration of births and deaths
17.	Public amenities including street lighting, parking lots, bus stops and public conveniences
18.	Regulation of slaughter houses and tanneries

Source: Government of India. (1949) "Twelfth Schedule Article 243W."

Suchitwa Mission is Kerala's state-level sanitation agency and as such plays a key role in drafting the Kerala State Sanitation Strategy. The Suchitwa Mission also oversees the implementation of the state's Total Sanitation Campaign and Malinya Mukta Keralam Action Plan, initiatives aimed at improving sanitation practices related to human excreta (Suchitwa Mission). Suchitwa Mission provides technical support for sanitation programs and projects, and oversees allocation of state funds to local self-government institutions for sanitation programs. Suchitwa Mission provided on-the-ground support for the preparation of this report. The KSSS calls for funding for ULB implementation of sanitation solutions through Suchitwa Mission via a dedicated State Urban Sanitation Fund (SUSF) within the budget of Suchitwa Mission (Policy 2008). As such, the Municipality of Maradu will likely look to Suchitwa Mission as one source of funding for implementing the ideas presented in the Maradu CSP and this report.

The Kudumbashree State Poverty Eradication (KPSE) Mission aims to alleviate poverty among women by developing a women-centered community structure for service delivery of government programs and encouraging women's civic engagement. The KSPE Mission implements a number of different programs, including the Thelima-Solid Waste Management program, in which women entrepreneurs participate in the outsourcing of town waste collection. In Maradu, this program facilitates household collection of plastic waste by women entrepreneurs.

2.2.3. MARADU URBAN LOCAL BODY ADMINISTRATIVE STRUCTURE

The local government of Maradu, which until 2010 was a panchayat, was reclassified as an urban local body in response to the intense urban growth. The town's administrative structure includes elected officials (councilors) who guide policy and administrative staff who implement policy by running day-to-day operations. Councilors represent each of Maradu's 33 wards. Residents from each ward elect their councilor. The councilors then elect a chairperson, an appointed position, to lead the town council, the highest elected body in the town. The chairperson leads a Steering Committee, a small group of elected officials and administrators, to coordinate tasks among elected and administrative representatives. To address specific areas of concern (e.g. finance, welfare, and health), councilors form standing committees (table 3). These standing committees are monitored, and have their work coordinated by the Steering Committee.

The Standing Committee for Health with the Standing Committee for Public Works provide policy directions for urban sanitation in Maradu and oversee projects pertaining to water supply, drainage, sewerage, and other matters of infrastructure. Maradu's Health Department executes the day-to-day matters of sanitation and implements the directives of the standing committee, while the Engineering Department has the responsibility of administering Public Works projects. Efforts for improving sanitation may necessitate creating an inter-departmental/committee task force to increase efficiency in implementation, promote enforcement of policy and regulations, and make best use of funds available for sanitation.

As a municipality, Maradu has a legal responsibility to maintain adequate urban sanitation for its residents. This responsibility is independent of any programs run by or aid received by higher levels of government, such as state and central governments. Although the town may utilize programs and funds from higher levels of government, it is imperative that Maradu become more self-sufficient in generating steady funding earmarked for the provision of sanitation services.

The Municipality of Maradu operates a modest, but growing, budget to execute its administrative responsibilities. In 2014-15, the town's receipts were 24.3 crore rupees. A modest proportion of the budget is estimated to be spent *directly* on water and waste water systems[8] (13%), solid waste[9] (2%), and public health[10] efforts (4%). For example,10,93,950 rupees was allocated to health-related programs and an additional 8,95,308 rupees for ayurvedic and homeopathic services. Special funding in the amount of 15,44,840 rupees was also allocated to services related to poverty alleviation. Multiple welfare programs are in place to assist special populations with health care and sanitation needs including welfare of the aged, welfare programs for physically/mentally challenged, welfare programs for the destitute, women's welfare and special child welfare program.

[8] These include fund numbers: 220110200, 230500300, 230500400, 230511100, 250400800, 250400801, 250501609, 251200801, 251200802, 251202501, 252201501, 253200401, 410310200, 410320300, 460600300. The percentage is higher than prior years due to drainage expenditures.

[9] This includes fund numbers: 250400104, 250400901, 251200901, 251200902, 251202601, 253301801.

[10] This includes fund numbers: 230800600, 250400208, 250400209, 250401100, 250401201, 250401203, 250401205, 250401206, 250401301, 250500601, 250500700, 250500800, 250500902, 251101901, 251102001, 251102002, 251200101, 251200301, 251201401, 251201801, 251202001, 251202101, 251202401, 251300501, 251300601, 251300602, 251300701, 251400101, 251400102, 251400201, 251410101, 251420101, 251420201, 253104001, 260200101, 311100100.

Table 3: Role of Standing Committees of Maradu Municipal Government

Standing Committee for Finance	Shall supervise the utilization of the budget grants and watch carefully the timely assessment and collection of taxes, fees, rents, and other sums due to the Municipal Council
Standing Committee for Development	Shall deal with matters of agriculture, soil conservation, social forestry, animal husbandry, dairy development, minor irrigation, fisheries, small-scale industry, co-operation and institutional finance and shall prepare the development plans for the Municipal Council integrating the proposals of other Standing Committees
Standing Committee for Welfare	Shall address matters relating to the welfare of women and children, development of scheduled castes and scheduled tribes, social welfare, social security pension and financial assistance, poverty alleviation, slum improvement and public distribution system
Standing Committee for Health	Shall deal with the matters of public health and health services, sanitation, and control of dangerous or offensive trade
Standing Committee for Works	Shall deal with matters of public works, housing, town planning including regulation of building constructions, environment, electricity, water supply, drainage and sewerage
Standing Committee for Education, Arts and Sports	Shall deal with matters of education, art, culture and sports

Source: State of Kerala. (1994). Kerala Municipal Act & Rules.

2.3. PUBLIC HEALTH CONDITIONS AND HEALTHCARE DELIVERY IN MARADU

Increased population demands and inadequate infrastructure, in rapidly growing urban areas such as Maradu, have led to concerns about public health equity. Increased generation of solid-waste is a problem, as is contamination of food and water sources. These trends have led to a larger prevalence of infectious and non-communicable diseases. Infectious diseases that were previously controlled by public health practices are re-emerging. Measures of the impact of various diseases and associated morbidity and mortality and population attributable risks can be used to assess the impact of these factors on the population of Maradu. Innovative and effective preventive and curative measures must be incorporated into the current primary health care system in Maradu. The healthcare sector of Maradu can be improved to broaden the availability and quality of its physical infrastructure, its human resources, and services to meet growing demands, with a focus on accessibility and availability of care, especially for the poor and disadvantaged members of the community.

As per the District Medical Health Officer, sanitation issues are most prevalent in the socially disadvantaged groups and migrant populations due to overcrowded living conditions. As a result, there is a greater prevalence of malaria and higher risk for dengue fever, tuberculosis, and leprosy among these populations. Accredited Social Health Activist (ASHA) workers are constantly circulating within communities to identify any health problems and report it back to the Primary Health Clinic (Medical Officer 2016).

Common communicable diseases that are increasing in Maradu include leptospirosis, typhoid fever, and viral and bacterial upper-respiratory infections, such as bronchitis. Water-related and diarrheal conditions such as acute dysentery and hepatitis A are less common . Pulmonary diseases such as asthma, tuberculosis, emphysema, and allergic bronchospasm are increasing , likely due to increased incidence of cigarette smoking and air pollution. Mental illness is more commonly diagnosed and treated by a team of mental health professionals who are available in Maradu one week per month. With the increased use of motorized vehicles and higher use of alcohol consumption in the population, trauma-related injuries are on the rise and require ongoing surveillance and treatment. Due to successful previous public health efforts such as high vaccination rates and preventative services, residents are living longer and rates of chronic diseases, such as obesity, hypertension and a variety of cancers are becoming more prevalent. These diseases require intensive

education and lifestyle modifications to prevent complications leading to increased morbidity and mortality. Primary care services in Maradu focus on immunization and educational programs in the preventive treatment and maintenance of good health outcomes (Medical Officer 2016).

Maradu has fairly robust public health and healthcare systems. There are a variety of private and governmental facilities that focus on primary prevention as well as medical management. Public health programs and services in Maradu are rendered by the Primary Health Clinic (PHC) and its sub-centers of the Kerala Health Services Department. The PHC provides primarily outpatient clinic services and has a 24-bed unit for short-term inpatient treatment. Secondary- and tertiary-care facilities (medical schools and government hospitals) are available for treatment of sicker patients. The PHC and the five smaller sub-centers provide immunizations, screening programs, and disease-specific education and management programs in Maradu (Medical Officer 2016). A household survey was conducted in Ward 4 by the team from University at Buffalo. The responses received from the household survey in Ward 4 (table 4) are representative of the health inequities facing Maradu. Only 38-percent of survey respondents have health insurance and nearly half of the children under five have a cough, possibly due to the incineration of trash or cooking methods used inside the home.

2.4. CONCLUSION ON PUBLIC HEALTH EQUITY

Maradu faces multiple public health challenges. Many of these health challenges are related to rapid population growth, and economic inequities within the population. Urbanization causes increased use of water, and increased generation of liquid and solid waste, which in turn leads to a higher likelihood for unsanitary conditions. These unsanitary conditions place those with fewest economic resources at the greatest risk. Without proper action, health inequities will continue to increase among disadvantaged populations.

Table 4: Health Conditions in Ward 4

Household Characteristics	Percentage (%) of Household Representatives who said 'Yes'
Own house	77.00
Health insurance	38.00
Children <5 years, with cough	42.00
Children <5 years, with fever	30.00
Children <5 years, with diarrhea	00.00
Obtain food from within the ward	62.00
n = 89	

Source: University at Buffalo. (2016). Household Sanitation Survey, Ward 4, Maradu, Kerala.[11a]

[11a] To better understand the complex variables related to household health status, health care services and availability, sources of food and water, and local waste-management practices, as noted earlier, the studio team developed and deployed a household survey. Out of the 101 households approached in ward 4 in Maradu, 89 households (86%) agreed to participate in the survey.

Source: University at Buffalo

3. DRINKING WATER AND WASTEWATER

3.1. INTRODUCTION: SETTING THE SCENE ON SANITATION

3.1.1. RELATIONSHIP BETWEEN WATER, SANITATION, AND HEALTH

Water is one of the most valuable resources that exists on our planet, and is essential for life's needs including drinking, cooking, bathing, cleaning, agriculture, business, and industry. The public sector is responsible for provision of water as a basic service; when the public sector fails individuals must rely on alternative sources. Access to adequate, clean, and affordable drinking water along with collection and treatment of contaminated waste water is necessary to promote good health and to prevent illness and disease. Systems and policies that ensure provision of water and management of waste water remain weak in Maradu.

Effective and equitable sanitation systems involve affordable, accessible, and clean water supplies in conjunction with the protection and preservation of surface and groundwater sources. Oftentimes, town planners prioritize supplying water over treating wastewater. However, poor management of wastewater systems, such as septic tanks, results in wastewater inevitably entering streams, lakes, and rivers, and seeping into the ground, with the potential to contaminate drinking water and freshwater sources.

Contamination from septic tanks makes surface and groundwater unsafe to drink and pose a threat to the health and wellbeing of residents. High nitrate levels accompanying high concentrations of enteric viruses and protozoa in feces make treatment of wastewater and drinking water challenging. Under such conditions greater amounts and more varieties of chemical disinfectants are required to kill pathogens that develop resistance to standard treatment. Ingestion of contaminated waters that do not receive proper physical and chemical treatments can be debilitating, if not deadly, as contaminants are linked with gastrointestinal and diarrheal disease. Enteric infections caused by contaminated waters are highly correlated with gastrointestinal complications, poor nutrient absorption, and slow childhood development and have a profound negative impact on global mortality. Children and immuno-depressant individuals in particular are especially sensitive to pathogens found in contaminated waters (Sanathanam Needhidasan 2014).

Contaminated water sources decrease the amount of clean drinking water available for consumers and impedes access to clean water for lower-income populations. As greater volumes of surface and groundwater become

contaminated, cities and towns must source clean water from farther distances where the cost of pumping water as well as building and maintaining pipelines increases. Moreover, poor maintenance of infrastructure, due to budgetary and staffing constraints, result in leakages that amount to approximately 20% of the water supply provided, which further inhibits the delivery of sufficient water to consumers (Maradu Municipality 2015). Inequities in access to clean drinking water worsen as wealthier populations can afford to pay for the water supplied by the Kerala Water Authority, and the less fortunate populations utilize secondary water sources like bore wells that are easily contaminated and have the potential to cause diseases.

Progress toward improved sanitation in India demands a tremendous amount of capital, water, construction, labor, and energy. Although many Indian cities and towns are in the process of developing sanitation systems, their growth is simply outpacing the availability and quality of infrastructure. Strengthening India's, and Maradu's, sanitation systems requires identifying baseline conditions and deficiencies related to drinking, surface, ground, and wastewater systems in order to close sanitation gaps. Effective and equitable solutions must provide sufficient, affordable, and clean drinking water in conjunction with collection, treatment, and disposal of wastewaters to the population in its entirety.

3.1.2. INDIA'S SANITATION SITUATION AT A GLANCE

Among India's greatest challenges are an insufficient drinking water supply and unequal access to good sanitation. An improved sanitation system encompassing supply of clean drinking water and effective treatment of wastewater is fundamental in supporting the health and well-being of India's rapidly growing population. India's water crisis is predominantly a human-made problem. Remarkably poor water management, corruption, unenforced laws, and industrial and human wastes have created an insufficient water supply and have even rendered the water that is available unusable due to contamination. Projected population growth in India is predicted to only accelerate this national water crisis (Brooks 2007).

Improper wastewater management further exacerbates stress on the country's water sources. Throughout India, 36.4-percent of households have flush or pour-flush toilets connected to a piped sewer system, septic tanks, or are connected directly into drains (table 5) (Census of India Organisation 2011). The country's water quality is further compromised by unsanitary open-

Table 5: Public participation in different wastewater disposal methods

Wastewater Disposal Method		Percentage of Households (%)
Flush or Pour-flush Toilets	Piped sewer system	11.90
	Septic tank	22.20
	Other system (e.g. flushed to street, yard, or drain)	2.30
Latrines	Pit latrine	9.40
	Other latrine to open drain	0.50
	Open defication (no latrine)	49.80

Source: Census of India Organization. (2011). The India Census.

bottom pit latrines that allow septic waste to discharge directly into the shallow groundwater system (Census of India Organisation 2011). Growing poverty and income inequality have also resulted in the development of slum populations that have aggravated the problems in sanitation. The 2011 Indian census shows that nationally, 49.8-percent of households report defecating in open spaces such as open fields, brush, rivers and railway tracks. Even where sanitation access is available, many residents use toilets that are not connected to underground sewerage, and in areas fortunate enough to have sewerage networks, much of the waste fails to reach treatment plants (McClatchey and Elledge 2013).

Improper septic management has resulted in as much as 80% of India's surface water becoming contaminated by pollutants from septic waste (Narayanan). Nitrate levels in groundwater across the country currently exceed 45 milligrams per liter, which indicates sewage contamination. Sewage contaminated waters pose a public health threat in ingestion of enteric pathogens that cause diarrheal disease, which is the third leading cause of childhood mortality in India and is also responsible for thirteen percent of yearly deaths in children under five (Lakshminarayanan and Jayalakshmy 2015). Contaminated waters necessitate more energy and resource-intensive water treatment to make the water safe to drink, resulting in more expensive water for consumers.

3.1.3. MARADU'S SANITATION SITUATION AT A GLANCE

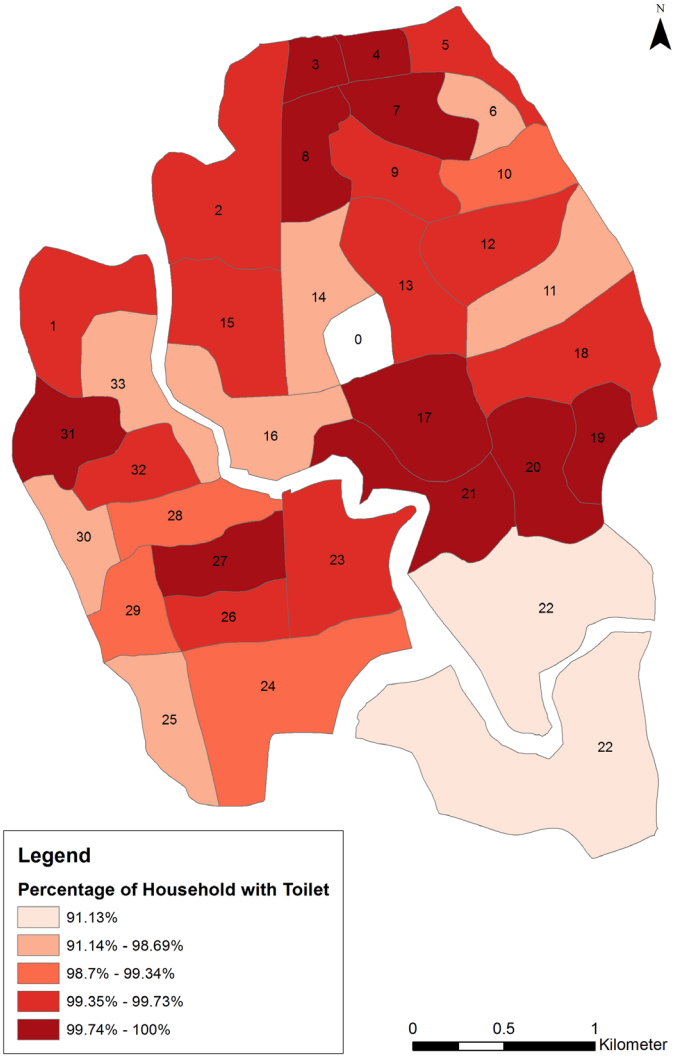
The suburban town of Maradu in Kerala, India, is currently developing a comprehensive sanitation strategy to address many of the same unfavorable conditions that affect the entire country. Improving the supply of water will meet the demand of the growing population and promote good health and

Table 6: Maradu's existing sanitation facilities and disposal methods

Availability of Toilets	Percentage of Households (%)
Households with toilets	99.23
Households without toilets	0.77

Source: Swachh Bharath Mission (Urban). "Baseline Survey-2015, Household Survey Format (Detailed)." Government of India, 2015.

Figure 8: Percent of households in Maradu with toilets by ward



Source: Percent of Households in each Ward with a Toilet [Map] Data Layers: Maradu Municipality: Maradu Ward boundaries; Swachh Bharath Baseline Survey: Number of households, Number of Toilets. Map by Samantha Bulkilvish in 2016. Using ArcGIS Desktop 10.3. Redlands, CA: ESRI, 2014.

well-being for the residents of Maradu. Table 6 shows baseline conditions are fairly good. Of the households surveyed by the Swachh Bharath Mission, 99.23-percent have toilets. What the City Sanitation Plan will support is the percentage of those toilets that are properly disposing of waste, in order to protect drinking water supplies through the prevention of groundwater contamination. Figure 8 shows the spatial distribution of households with toilets and show areas in the South and West that may require additional toilets.

3.2. WATER RESOURCES

Maradu has access to potable and non-potable water. Potable water is water that is free of impurities, bacteria, and contamination, and non-potable water is water that requires treatment prior to human consumption. Non-potable water is further characterized as wastewater, which is comprised of kitchen and bath wastes ("greywater"), toilet wastes ("blackwater"), and runoff from precipitation ("stormwater"). Potable water seldom exists in natural reservoirs, necessitating water treatment for human consumption. Non-potable waters in Maradu exist in two main environmental reservoirs: surface water and groundwater. Homes in the town of Maradu receive public drinking water at an average frequency of six hours per day (Maradu Municipality 2015). To account for unmet water demands, residents of Maradu are turning to low-quality groundwater sources that are salinized and likely contaminated with septic waste. The contamination of ground and surface waters by industrial and domestic waste is a growing concern in the town. Industrial contamination of surface waters occurs via dumping of industrial waste into water bodies and by accumulation of residual contaminants in stormwater runoff that drain into surface waters.

Domestic sources are contributing to water pollution as well through open defecation, spreading of manure on fields, and having toilets directly connected to drains leading into surrounding waterbodies. A detailed study of one neighborhood in the town, Ward 4, reaffirms the threat from poor waste water management.[11b] In Ward 4, toilet connections to storm-water drains allow for untreated septic waste to combine with storm-water and greywater, which then discharges directly into surface waters (University at Buffalo 2016). Of the toilets in Ward 4, 94% are connected to a septic tank (University at Buffalo 2016). However, the highly dense development pattern of Maradu and high groundwater table suggest that there is inadequate spacing between septic tanks for water to be properly treated by a drainage field. When functioning properly, drainage fields filter septic effluent before discharging into ground and surface waters. Without proper drainage fields, effluent is more likely to enter into ground water and surrounding surface waters.

[11b] To better understand the complex variables related to household health status, health care services and availability, sources of food and water, and local waste-management practices, as noted earlier, the studio team developed and deployed a household survey. Out of the 101 households approached in Ward 4 in Maradu, 89 households (86%) participated in the survey.

3.2.1. SURFACE WATER

As noted earlier, Maradu is surrounded by water and the Periyar River, Muvattupuzha River, Vembanad Lake, Arabian Sea, and numerous inland canals provide the town with multiple surface water sources. Surface waters account for 40% of the surface area governed by the Greater Cochin Development Authority (GCDA) where Maradu is located. The Periyar River is the longest river in the state of Kerala, with a total length of 244 km, and flows north, originating in the hills of Western Ghats (Shyam 2013). The Periyar is perennial or has continuous flow through all sections of the stream bed year round, and is the source of drinking water for several surrounding towns. Damming operations in Idukki, an eastern district of Kerala, also generate a source of electrical power from the Periyar River. Vembanad Lake is the largest lake in Kerala, at just over 96.5 km in length, and accounts for 5% of the area of the state of Kerala and almost 30% of the state's surface water resources (Shyam 2013). The lake faces a major ecological crisis and has been reduced to 37% of its original area because of Wellington Island and Cochin Port development (Shyam 2013). Maradu's close proximity to the Arabian Sea allows for easy access to salinized groundwater. Numerous canals in Maradu, both human-made and natural, allow for inland navigation and irrigation, but as automobiles have emerged as the dominant form of transportation many canals have been narrowed to accommodate wider roads for cars and construction projects along the banks.

The surface waters in Maradu are both visibly and chemically polluted. The canals and waterways are visibly polluted with waste from local commercial, industrial, and residential establishments. According to the Ward 4 Household Sanitation Survey, 27% of households reported disposing their food, plastic, cardboard, and other wastes by throwing it directly into canals or surface water bodies (University at Buffalo 2016). Surface waters are also chemically polluted by the combined wastewater from toilets, drains, and overland runoff. Surface waters that are receiving high volumes of combined and polluted wastewater are also the source from which water is drawn for treatment and distribution as drinking water. As the surface waters become more polluted, drinking-water treatment becomes more challenging and costly.

3.2.2. GROUND WATER

Groundwater is easily accessible throughout the town of Maradu due to a high groundwater table and a generally flat terrain ranging from one to four meters above sea level. Although estimates of ground water for Maradu are not

available, the net groundwater availability for the larger Ernakulam district is 557.35 million cubic metres annually (Shyam 2013). Maradu lies above a laterite formation that forms an aquifer; water can be pumped from semi-confined secondary pores in the underlying aquifer. Residents access groundwater via private and public wells and tube well/borehole sources that tap into shallow aquifers below the ground surface. Government programs for public wells and ponds require that water sources are consistently maintained so that the public can access water during shortages (Standing Chair Public Works 2016).

Groundwater sources in shallow aquifers can sustain domestic dug wells, they yield one to six cubic meters per day. These shallow sources are underneath secondary fractured crystalline aquifers and may yield up to four liters of groundwater per second. In the shallow phreatic[12] zone, which is 3.4 to 14.8 meters below ground level, the depth to water in wells ranges from 1.82 to 12.05 meters below the ground level with an average yield of 12 to 20 cubic meters per day (Shyam 2013). The average pre-monsoon depth to water in Maradu is two to five meters, while the average post-monsoon depth to water is zero to two meters. The long-term availability of water in dug wells is controlled by rainfall recharge and return seepage from canal flow and irrigation (Shyam 2013).

Water-quality sampling indicates that the groundwater in many of the aquifers is low in mineralization and is generally fit for all domestic, industrial, and agricultural purposes. However, the Ernakulam District serves as the industrial capital of Kerala, and consequently experiences industrial pollution of groundwater within 80 meters of industrial dumping sites (Shyam 2013). Additionally, foul odors and suspected faecal contamination further undermines the utilization of groundwater resources in Maradu.

Despite the salinization of groundwater, Maradu residents use groundwater for non-drinking purposes, including bathing, laundry and watering plants. The Ward 4 Household Sanitation Survey revealed approximately 20% of respondents use tube wells or boreholes, and approximately 20% of respondents use a protected dug well (University at Buffalo 2016). In most cases, boiling water effectively kills enteric organisms found in sewage-contaminated waters, but boiling does not remove mineralization or metals.

[12] Also known as the zone of saturation, this an aquifer where relatively all pores and fractures are saturated with water.

3.2.3. GROUNDWATER DEVELOPMENT

Supplementary groundwater development is possible in many areas of Maradu due to the favorable underlying geology. Crystalline aquifer dug wells can be constructed wherever sufficient weathered thickness of the saturated zone is available, and low-yielding wells may be revitalized by deepening wells to the entire thickness of the weathered zone. Bore wells are feasible in crystalline areas with deep fractures and tube wells are feasible through tapping 15 to 20 meters of aquifer material with 3.1 millimeter slot size and gravel pack. Laterite terrain dug wells are feasible with depth 10 to 16 meters and diameter of 2 to 4 meters and depth 6 to 8 meters at 1.5 to 3.0 meters diameter in valley areas. In coastal alluvium dug-wells, depths of 4 to 7 meters and diameters of 1.5 to 2.0 meters are appropriate wherever saturated thickness is 5 meters or more (Shyam 2013). Insufficient and unreliable municipally provided water causes residents to rely on groundwater sources on a daily basis. Overutilization of groundwater sources can lead to rapid depletion of groundwater resources within the shallow aquifer systems.

3.3. POTABLE DRINKING WATER

For water to be considered safe for human consumption or use, it must be potable, or free of impurities, pollution, and pathogens. Potable water does not naturally exist in many areas of the world, including India, and is only found in glacial waters and freshwater lakes. Water treatment is thus an essential part of creating potable water prior to delivery as drinking water. In 2014, the Municipality spent 2,392,092 rupees on providing potable water to the public, which is treated and delivered by the Kerala Water Authority.

3.3.1. WATER PROVIDERS, INFRASTRUCTURE, AND MAINTENANCE

According to the Kerala Municipality Act of 1994, Chapter XVI, Section 315, the Kerala Water Authority (KWA) is responsible for the supply of water, and sewerage services. At present, KWA responsibilities include the planning, design, construction, implementation, operation, and maintenance of water supply systems. There are currently no private vendors of drinking water (Engineer 2016). There are 42,000 consumers of drinking water in Maradu, many of whom are without access to adequate amounts of drinking water (Engineer 2016). At present, the KWA's Maradu subsection office supplies only 86% of the demand of drinking water for the town of Maradu (Maradu

Municipality 2015). About 80% of respondents to the Ward 4 Household Sanitation Survey receive their primary source of water from municipal water mains that provide water directly into the household (table 7) (University at Buffalo 2016). According to the draft Maradu CSP, potable water is available to residents at an average frequency of seven hours per day (Maradu Municipality 2015) KWA engineers report that the limited water supply may be explained in part by staffing shortages in the KWA Maradu subsection office (Engineer 2016). The cost of publicly supplied drinking water for Maradu is determined by KWA. The water tariff for domestic, commercial, institutional, and industrial connections is 20 rupees for the initial 5-10 kiloliters of water per month. Each additional kiloliter consumed costs 4 rupees (table 8) (Maradu Municipality 2015).

To meet the growing demand for safe drinking water, two water-supply schemes have been implemented in Maradu and the surrounding panchayats. The initial scheme that provided water to Maradu was the 1995 World Bank-aided scheme, which relied on drawing water from the Periyar River to Aluva Water Works, a drinking-water-treatment plant in Aluva. After multiple augmentations spanning the last 50 years, the treatment plant has a current capacity of 225 million liters per day, yet, Maradu was still allocated an insufficient supply of drinking water (Engineer 2016) (Kerala Water Authority and Jawaharlal Nehru National Urban Renewal Mission).

The length of the water supply main from the Periyar River to Aluva Water Works is 34 kilometers, and the supply main from the intake point at Piravom to the Kundanoor Treatment Plant is 22 kilometers (Maradu Municipality 2015). The distribution network of the World Bank-aided scheme in its entirety spans 223 kilometers (Kerala Water Authority and Jawaharlal Nehru National Urban Renewal Mission). Frequent pipe bursts during the 10-year construction of the 22-kilometer stretch of piping from Pazoor to Maradu proved to be an enormous and expensive challenge in providing an adequate supply of drinking water to the residents of Maradu and the surrounding municipalities (Kerala Water Authority and Jawaharlal Nehru National Urban Renewal Mission).

In response to the unmet water demand, a new scheme, the Jawaharlal Nehru National Urban Renewal Mission Scheme (JNNURM), was implemented. The JNNURM scheme draws water from the intake source at Piravom from the Muvattupuzha River and is piped to the Kundanoor Treatment Plant, which is located within Maradu (figure 9). The plant was commissioned in February 2016 and has an initial capacity of 100 million liters per day. Although the capacity

Table 7: Drinking water conditions in Ward 4

Household Characteristics	Percentage (%) of Household Representatives who Resonded 'Yes'
Drinking water piped into household	82.00
Drinking water treated before consumption	96.00

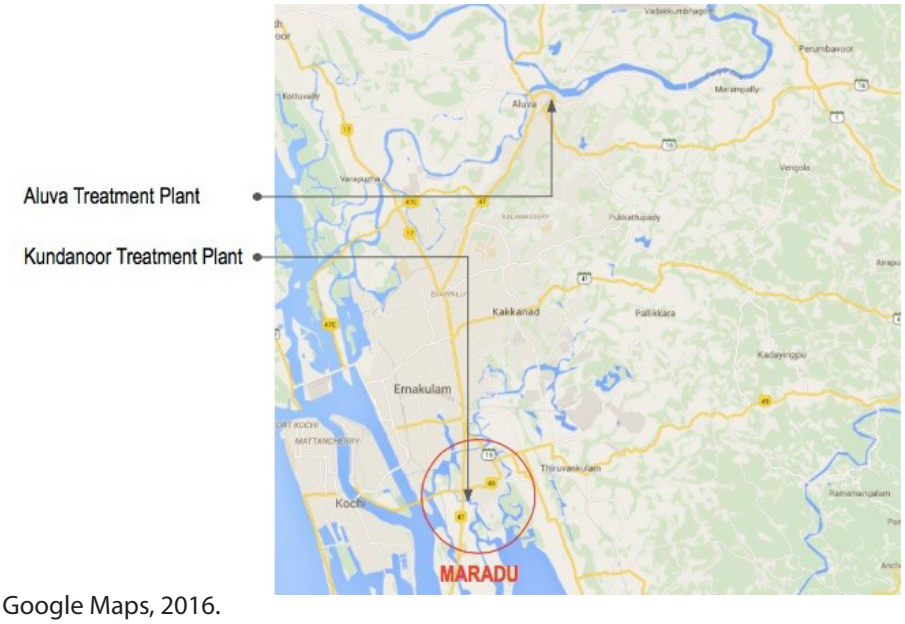
Source: University at Buffalo. (2016). Household Sanitation Survey, Ward 4, Maradu, Kerala.

Table 8: Kerala Water Authority tariff structure

Consumption level (per month)		Fixed Tariff	Variable Tariff
Domestic	Up to 5,000 litres	Nil	Rs. 4.00 per 1,000 litres with Minimum Rs. 20.00
	Above 5,000 up to 10,000 litres	Nil	Rs. 20.00 plus Rs. 4.00 per 1,000 litres in excess of 5,000 litres
	Above 10,000 up to 15,000 litres	Nil	Rs. 40.00 plus Rs. 5.00 per 1,000 litres in excess of 10,000 litres
Non-Domestic	Up to 15,000 litres	Rs. 50/-	Rs. 15 per 1,000 litres with Minimum Rs. 150/-
	15,000 to 30,000 litres	Rs. 50/-	Rs. 225 plue Rs. 21.00 per every 1,000 litres in excess of 15,000 litres
	30,000 to 50,000 litres	Rs. 50/-	Rs. 540 plues Rs. 28.00 per every 1,000 litres in excess of 30,000 litres

Source: Kerala Water Authority. (2014). Services, Water Tariff. Retrieved from https://staging.kwa.kerala.gov.in/index.php?option=com_content&view=article&id=93&Itemid=100

Figure 9: Location of drinking water plants in proximity to Maradu



Source: Google Maps, 2016.

of the Kundanoor Treatment Plant is less than that of the former Aluva Plant, due to proximity, a greater amount of water can be allocated to the Maradu Municipality at a lower cost (Kerala Water Authority and Jawaharlal Nehru National Urban Renewal Mission , TNN 2014).

The water-supply system that currently services households in Maradu is roughly 50 years old, and approximately 40% of the pipes still need to be renovated to carry the amount of water that meets Maradu's demand. To efficiently supply water to the growing population, repairs and enhancements need to be made to the distribution network in order to account for the larger capacity of water and to provide enough pressure to pump water to households. Further challenges to provision of adequate drinking water include the loss of water (and revenue) from illegal water connections. These physical and commercial losses, including water from public taps, account for roughly 20% of the water being supplied. In response to these losses, the Maradu Municipality has closed many of the public taps in Maradu (Kerala Water Authority and Jawaharlal Nehru National Urban Renewal Mission, Maradu Municipality 2015).

3.3.2. DRINKING WATER QUALITY

Residents in Maradu appear to be concerned about the quality of water they receive, and engage in practices to mitigate the negative impacts of poor quality water. In Ward 4, for example, a majority of residents report treating their drinking water at the household prior to consumption (table 9). Over 85% of respondents reported boiling their water prior to consumption (University at Buffalo 2016). To be sure, without water quality samples collected from households, or publicly accessible water quality sampling data from the local water authority, the behavioral practice of treating drinking water does not entirely confirm if customers in Maradu are receiving unsafe or poor quality drinking water.

Table 9: Drinking water treatment methods used in Ward 4

Method of Treatment	**Percentage of Respondents (%)**
Boil	85.00
Bleach/Chlorine treat	3.00
Water filter	3.00
Electronic purifier	12.00
n = 89	

Source: University at Buffalo. (2016). Household Sanitation Survey, Ward 4, Maradu, Kerala.

3.4. WASTEWATER

Wastewater is non-potable water that has been used in homes or by industries and businesses and must not be reused or discharged back into water sources without treatment. Following a precipitation event, stormwater that runs off of roads, parking lots, rooftops, and other surfaces combines with household and industrial wastewater in drains where the combined wastewater contains organisms and compounds that are harmful to both surface waters and to the public. Wastewater from homes is comprised of human waste, oils, detergents, and soaps, and wastewater from business and industries is composed of solvents, lubricants, petroleum, and agricultural chemicals. Without wastewater infrastructure to deliver combined wastewaters to treatment plants or other treatment facilities, wastewaters inevitably make their way back into surface waters, which are later sourced for drinking water treatment.

As noted earlier, contaminants in waste water are dangerous for human health. In addition, high concentrations of nitrate and phosphorus from human wastes has a negative impact on natural marine ecosystems. This nutrient addition results in a "bloom," or great increase, in plant life growing on water surfaces, a process known as "eutrophication". The high density of plant life on water surfaces then blocks sunlight from penetrating the water, negatively impacting the photosynthetic growth of plants in lower depths of the water column. When the surface plants die, they sink and begin to decay, consuming large amounts of oxygen and releasing carbon dioxide into the water. The resulting conditions are referred to as "anoxic," or oxygen-devoid, waters that result in loss of marine life, decreased biodiversity, and disrupt the functioning of the ecosystem. Health problems can arise due to improper drinking water treatment of eutrophic waters.

3.4.1. WASTEWATER GENERATION AND MANAGEMENT

A main generator of wastewater in the town of Maradu are private toilets. Humans generate about 100-500 grams of wet weight of feces and 1-1.3 liters of urine per person per day (Pepper, Gerber et al. 2015). The survey indicates that 99% of households in the town of Maradu have their own toilet (Swachh Bharath Mission 2015).

In Ward 4, a neighborhood adjacent to a canal, 95% of residents have their own private toilet, and about 25% of households discharge wastewater from toilets directly into the drains that flow into the neighboring canal (figure 10,

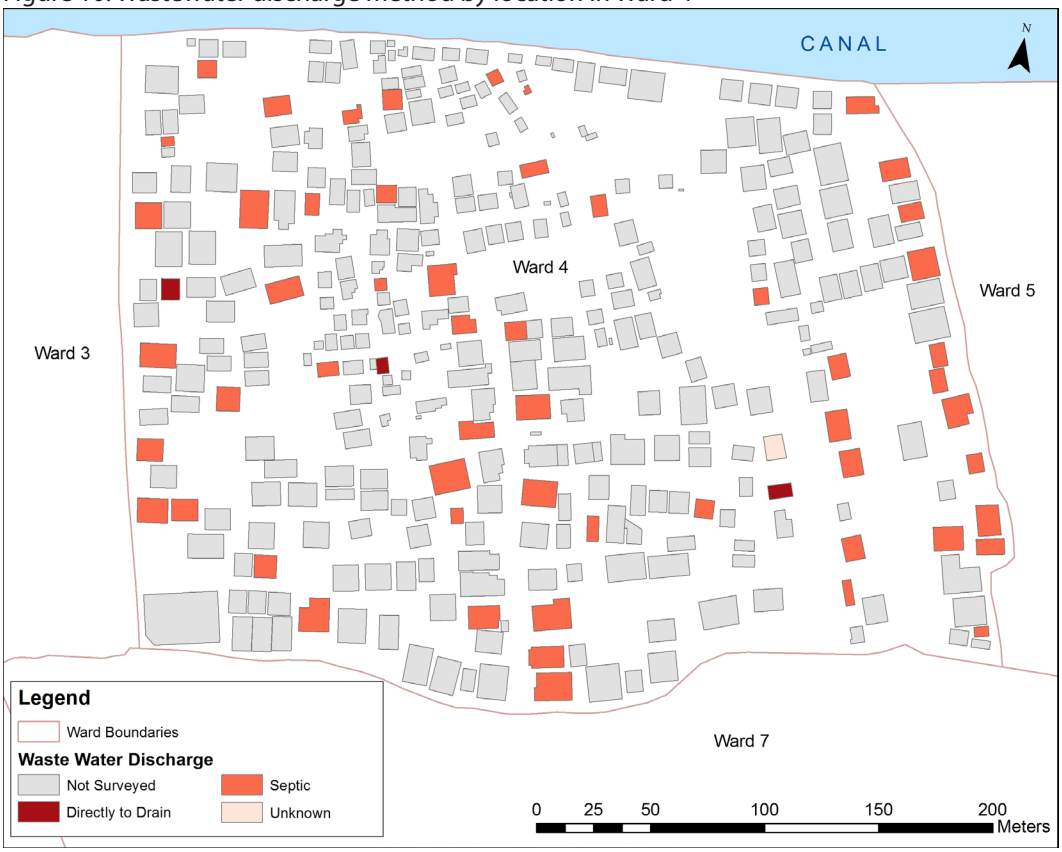
table 10) (University at Buffalo 2016). A majority (81%) of Ward 4 households utilize septic tanks, but many of these households rarely participate in the regular maintenance and desludging of their septic tanks, which can lead to leakages of effluent into the groundwater supply (University at Buffalo 2016). For most family sized septic tanks, proper maintenance requires desludging at a frequency of every 3 to 5 years. Nearly half of the households (47%) of Ward 4 respondents reported that they could not recall the last time their septic tank had been cleaned (University at Buffalo 2016). This implies a limited amount of knowledge about wastewater management practices in the town.

To prevent open defecation in public areas, the public must also have access to public toilets. There currently is a pay-and-use toilet at Maradu Junction, and the agency that built the toilet is also in charge of maintenance. Currently the agency spends 30000-40000 rupees on maintenance, but earnings from toilet use range from 200-3000 rupees, which indicates a major loss in profit (Engineer 2016). There are plans in place for building more public toilets in Maradu, specifically at Kundanoor Junction; however, a lack of available land further constrains the Municipality from constructing additional public toilets. Nonetheless, open defecation does not appear to be as grave a problem in Maradu as it is in other parts of India.

3.4.2. WASTEWATER MANAGEMENT ORGANIZATIONS

The Kerala State Pollution Control Board (KSPCB) oversees wastewater quality which includes septic wastewater. However, this agency does not have information regarding septic or latrine systems in the town of Maradu. In large parts of the interiors of Maradu, human excreta directly enter the open drains, and about 41% of households discharge to septic tanks (Swachh Bharath Mission 2015). Septic tank sludge is collected by private septic servicers with the help of a septic vacuum tanker at the expense of the homeowner. Residents (in Ward 4) report that septic tank servicing is an intrusive, loud, and dirty process often involving jackhammering concrete slabs around the septic tank, an annoyance and disturbance to both residents and neighbors (University at Buffalo 2016). In combination with a lack of a town sanitation and wastewater strategy, improper septic maintenance further contributes to a failing wastewater management system.

Figure 10: Wastewater discharge method by location in Ward 4



Source: Waste Water Discharge method by location in Ward 4 [Map] Data Layers: Maradu Municipality: Maradu Ward boundaries; Household Sanitation Survey: Flush or Pour Flush Toilet. Map by Samantha Bulkilvish in 2016. Using ArcGIS Desktop 10.3. Redlands, CA: ESRI, 2014.

Table 10: Wastewater discharge method prevalence in Ward 4

Wastewater Discharge Method	Percentage of Households (%)
Routed	17.00
Handled septic tanks	81.00
Filtered through soak pits	1.00
Sent directly to drains	25.00
n = 89	

Source: University at Buffalo. (2016). Household Sanitation Survey, Ward 4, Maradu, Kerala.

3.4.3. DRINKING WATER CONTAMINATION CONCERNS

As noted earlier high concentrations of nitrates and other contaminants, including bacteria and viruses, from septic waste pose a challenge to effective wastewater and drinking water treatment. Treating contaminated water involves both physical and chemical removal methods to remove contaminants to make water safe to discharge into surrounding water bodies and more advanced treatment to make water safe to drink again. Physical removal relies on additions of coagulants to make large suspended solids stick together, followed by flocculation to agitate the mixture, then settling to allow heavier, larger solids to sink to the bottom where they can be removed before the remaining effluent is filtered in the last stage of physical treatment. Not all microbial pathogens are effectively removed in the primary physical treatment process, although primary sedimentation is effective for the removal of larger pathogens such as helminths eggs, solid-associated bacteria, and some viruses. Removal of solids in activated sludge during flocculation typically removes 90% of enteric bacteria and 80-99% of enteroviruses and rotaviruses. Nearly all (90%) of Giardia and Cryptosporidium can also be removed (table 11) (Pepper, Gerber et al. 2015).

Following physical treatment, chemical disinfectants are added to kill bacteria and viruses that are not removed during physical treatments. Chemical disinfectants include chlorine, chloramine, ozone, UV light, and chlorine dioxide. However, some organisms (for example, Cryptosporidium) have become resistant to chlorine, requiring additional chemical disinfectant addition, including more chlorine or other types of disinfectants. The use of large amounts of chemical disinfectants in drinking water also have a negative impact on our health as excess chlorine can combine with organic material in water to form trihalomethanes that can cause liver, kidney, and central nervous system problems and are linked to an increased lifetime cancer risk. Moreover, high nitrate levels, bacteria and viruses from sewage require more types of chemical disinfectants are required in greater amounts, making drinking water treatment more expensive, resulting in more expensive drinking water for the consumer.

Pathogenic microorganisms are almost always present in wastewater and pose a major threat to the health of the residents of Maradu. Large numbers of pathogenic microorganisms may be excreted by both asymptomatic and symptomatic individuals, and the concentration of enteric pathogens in wastewater varies depending on the incidence of infection in the community

Table 11: Pathogen removal during sewage treatment

	Enteric Viruses	Salmonella	Giardia	Crypto-sporidium
Concentration in raw sewage (per liter)	10^5-10^6	5,000-80,000	9,000-200,000	1-3,960
Primary treatment[a] (% removal)	50-98.30	95.80-99.80	27-64	0.70
Number remaining (per liter)	1,700-500,000	160-3,360	72,000-146,000	NA
Secondary treatment[b] (% removal)	53-99.92	98.65-99.99	45-96.7	NA
Number remaining (per liter)	80-470,000	3-1,075	6,480-109,500	NA
Secondary treatment[c] (% removal)	99.98-99.99	99.99-99.995	98.50-99.99	2.7[d]
Number remaining (per liter)	0.007-170	0.000004-7	0.099-2,951	NA

[a] Primary sedimentation and disinfection.
[b] Primary sedimentation, trickling filter or activated sludge, and disinfection.
[c] Primary sedimentation, trickling filter or activated sludge, disinfection, coagulation, filtration, and disinfection.
[d] Filtration only.

Source: Pepper, I., C. Gerber, and T. Gentry. (2015). Environmental Microbiology, Third Edition.

Table 12: Typical Composition of Untreated Domestic Wastewater

Contaminants	Low Concentration (mg/L)	Moderate Concentration (mg/L)	High Concentration (mg/L)
Solids, total	350	720	1,200
Dissolved, total	250	500	850
Volatile	105	200	325
Suspended solids	100	220	350
Volatile	80	164	275
Settleable solids	5	10	20
Biochemical oxygen demand	110	220	400
Total organic carbon	80	160	290
Chemical oxygen demand	250	500	1,000
Nitrogen (total as N)	20	40	85
Organic	8	15	35
Free ammonia	12	25	50
Nitrates	0	0	0
Nitrites	0	0	0
Phosphorus (total as P)	4	8	15
Organic	1	3	5
Inorganic	3	5	10

Source: Pepper, I., C. Gerber, and T. Gentry. (2015). Environmental Microbiology, Third Edition.

Table 13: Estimated Levels of Enteric Organisms in Sewage and Polluted Surface Water in the U.S.

Organism	Concentration (per 100mL)	
	Raw Sewage	Polluted Stream Water
Coliforms	10^9	10^5
Enteric viruses	10^2	1-10
Giardia	10-10^2	0.1-1
Cryptosporidium	1-10	0.1-10^2

Source: Pepper, I., C. Gerber, and T. Gentry. (2015). Environmental Microbiology, Third Edition.

the socio economic status of the population, time of year, and per-capita water consumption (Pepper, Gerber et al. 2015). The peak incidence of many enteric infections is seasonal and the highest incidence generally occurs in the late summer and early fall. Pathonogenic contamination into drinking water sources can cause disease from the ingestion of microorganisms including E Coli, Giardia, Cryptosporidium, Hepatitis A, and helminthes (worms) (Pedersen 1997).

Enteric infections are closely correlated with gut complications, including poor nutrient absorption, weak immunal response, stunted growth, and impaired cognitive function. Key knowledge gaps exist about the mortality and morbidity burden of the pathogens (including viruses, bacteria, and parasites) that cause these diseases and about the environmental factors that increase their incidence (Foundation). Compared to the industrialized world, concentrations of enteric pathogens are much greater in sewage in the developing world (table 14) (Pepper, Gerber et al. 2015). Safety norms in India have set a limit of 10 FC (faecal coliforms) per 100 milliliters, although the World Health Organization recommends that no faecal coliforms should exist in potable water (Snyder).

3.5. DRAINAGE

3.5.1. NATURAL DRAINAGE

The water of the Ernakulam District drains into the Periyar River and its tributaries in the north as well as the Muvattupuzha River in the south. Grey and black wastewater runoff, as well as storm water from local precipitation contribute to the small canals within Maradu's watershed. However, the reduced capacity of the canals results in overflow and flooding during the high-precipitation events of the monsoon seasons. The elevated level of surface bodies coupled with compromised drainage systems results in unsanitary flooding that is difficult to divert back into larger water bodies, allowing stagnant water to accumulate on local landscapes. Stagnant waters contain pathogens that are dangerous if ingested by humans or animals and provide environments for mosquitoes to breed.

Table 14: Incidence and concentration of enteric viruses and protozoa in feces in the U.S.

Pathogen	Incidence (%)	Concentration in Stool (per gram)
Entroviruses	10 - 40	10^3 - 10^8
Hepatitus A virus	0.10	10^8
Rotavirus	10 - 29	10^{10} - 10^{12}
Giardia	3.80	10^6
	18 - 54[a]	10^6
Cryptosporidium	0.60 - 20	10^6 - 10^7
	27 - 50[a]	10^6 - 10^7
[a] Children in day care centers.		

Source: Pepper, I., C. Gerber, and T. Gentry. (2015). Environmental Microbiology, Third Edition.

Table 15: Microogranisms typically found in untreated domestic wastewater

Type of Organism	Concentration (per ml)
Total coliforms	10^5 - 10^6
Fecal coliforms	10^4 - 10^5
Fecal streptococci	10^3 - 10^4
Enterococci	10^2 - 10^3
Shigella	Present
Salmonella	10^0 - 10^2
Clostridium perfringens	10^1 - 10^3
Giardia cysts	10^{-1} - 10^2
Cryptospridium cysts	10^{-1} - 10^1
Helminth ova	10^{-2} - 10^1
Enteric virus	10^1 - 10^2

Source: Pepper, I., C. Gerber, and T. Gentry. (2015). Environmental Microbiology, Third Edition.

3.5.2. HUMAN-MADE DRAINAGE

The drainage system in Maradu is a combined system that carries wastewater, including black water, grey water, and storm water, from the source to outfalls along small canals and larger water bodies via an incomplete system of open and closed drains. Drains are made of concrete, approximately 1 meter deep, and are covered by concrete slabs. Frequent blockages from garbage, however, result in regular removal of the concrete covers, leaving large sections of drains open. The prevalence of existing open drainage, which are often used for dumping of waste, undoubtedly poses a public health challenge to the safety and wellbeing of the residents. Open drains pose a risk for small children and animals falling into the drains, animals drinking contaminated waters and carrying disease, and providing breeding ground for mosquitos.

Maradu has an approximately-75% coverage of drains. However, hard evidence regarding the layout and mapping of the drainage network is unavailable or non-existent (Maradu Municipality 2015). Staff at an environmental engineering company, KITCO, which is in the process of constructing a Detailed Project Report (DPR) of the overland flow drainage system in Maradu, report the presence of areas with inadequate drainage (not enough capacity), improper linkages, and even some areas with zero drainage in Maradu (Senior Consultant 2016). In a similar vein, the Chairperson of the Public Works Standing Committee (PWSC) of Maradu reports that at least 10 of the town's 33 wards have incomplete or no drainage. Lack of a plan for town-wide drainage and canals, lack of integration of the existing drainage, and inadequate design of the existing drains further limits the functionality of the greater drainage network (Government of Kerala 2016). The municipal government is aware of the significant need for drainage in the town. In 2014, over 25 million rupees were allocated to drainage expenditures and since then the town government appears to have begun improving the drainage network.

3.6. CONCLUSION

Maradu is surrounded by water on all sides which is a benefit and detriment to the future of Maradu's water quality. Many households treat their drinking water before they consume it. This indicates that there already is an awareness of the potential health hazards that accompany the consumption of contaminated water. A high percentage of households in Maradu have access to a private toilet that they regularly use, curbing open defecation.

Throughout Ward 4, open storm water drains are improperly cared for, which leads to clogging, flooding and standing water. Standing water creates a breeding ground for mosquitos that potentially carry and spread disease. The Municipality does not enforce regulated construction and maintenance of septic tanks. The lack of regulation places no pressures on homeowners to properly care for their septic tanks and ensure they are properly emptied at regular intervals of time. The process of emptying the tanks has been described as noisy and inconvenient. Improper maintenance can lead to sub-standard septic tanks that cause ground water contamination due to leakage engaging with the high ground water table. Maradu allocated 2.5 crore rupees for drainage maintenance in the fiscal year of 2014-2015. The initiative shown by the Maradu Municipality budget allocations indicates that there is an awareness of and willingness to address drainage issues.

Source: University at Buffalo

4. SOLID WASTE MANAGEMENT

4.1. INTRODUCTION: SETTING THE SCENE ON SOLID WASTE MANAGEMENT

The municipal government and residents of the town of Maradu are working diligently to create a cleaner town as a means to improve public health. A key challenge in maintaining a clean town is the accumulation of solid waste. Solid wastes are materials that are discarded or abandoned by their users. These materials are "what [people] discard, [following] a product of a series of processes which includes utilization and depletion of limited resources." (Suchitwa Mission August 2015). Household solid waste[13] includes, but is not limited to, wet waste such as kitchen, food, and garden waste; dry waste such as plastic, paper, glass, cloth; electronic waste such as computers and mobile phones; hazardous waste such as batteries, light bulbs, and paints; and bio-waste such as diapers, sanitary napkins, and injection needles (table 16). In addition, industries and commercial enterprises can also generate solid waste, some of which may be hazardous to human health. To achieve a good quality of life and public health, management of solid waste must remain a priority.

4.1.1. SOLID WASTE MANAGEMENT AND PUBLIC HEALTH

Management of solid waste is crucial for ensuring health of residents. Inappropriate management of solid waste – such as through burning of trash or dumping of solid waste into water bodies – poses health risks (Suchitwa Mission 2015). In particular, burning of trash produces air pollutants, including dioxins, nitrogen oxides, volatile organic compounds, and particulate matter, which are hazardous to health. Some of these pollutants bio-accumulate in plants and animals, which when consumed by humans are hazardous. Ash generated from burning of trash, which residents may scatter in their yards or bury, also contains concentrated levels of pollutants.

Table 16: Solid waste classification and examples by Suchitwa Mission of Kerala

Wet Waste	**Dry Waste**	**E-Waste**	**Bio-Waste**
Discarded fruit scraps	Paper cups	Keyboards	Mediciens
Garden waste	Plastic bottles	Batteries	Syringe
Egg shells	Tires	Light bulbs	Sanitary napkins

Source: Suchitwa Mission (2015). An Approach Paper for Sustainable Management of Waste. Suchitwa Mission Local Self Government Department: 108.

[13] According to some definitions, solid waste also includes faecal sludge; for the purpose of this report, faecal sludge is discussed in the section on wastewater management.

Suchitwa Mission cautions that adverse impacts of burning may include cancers, skin disorders, liver problems, and impairment of endocrine, reproductive, immune, and respiratory systems (Suchitwa Mission 2015). Interviews with ASHA workers in Maradu suggest that pulmonary diseases (including tuberculosis and asthma) are a problem in the town (ASHA Worker 2016), which may result from air pollution from cooking smoke, vehicle exhaust and solid waste incineration. Poor management of e-waste, one of the fastest growing types of solid waste, also poses a hazard for public health. E-waste is not only non-biodegradable, but leaches toxins when exposed to the extreme levels of heat common in Maradu (Sanathanam Needhidasan, et al. 2014). Chemicals from e-waste may infiltrate the water table, which could have damaging effects on the water supply for the Municipality.

4.2. EXISTING SOLID WASTE CONDITIONS AND PRACTICES IN MARADU

4.2.1. TYPES AND QUANTITY OF SOLID WASTE IN MARADU

A variety of solid waste is generated in the town of Maradu although definitive town-wide quantitative data on the magnitude of solid waste is limited. Field observation in the town of Maradu and survey data collected in Ward 4 suggests that solid waste is a growing problem (figure 11, figure 12). In Ward 4, a majority (57.30%) of survey respondents report that their household discards solid waste daily, 34.83% once a week, and the remaining at a lower frequency.[14] The composition of this discarded solid waste poses both environmental and public health challenges. A significant majority of households (83.15%) in Maradu's Ward 4 report routinely discarding packaging for food (83.15%) and for drinks (59.55%) (table 17). In addition to impacting the magnitude of solid waste generated, this composition of solid waste may also reflect shifts in the food supply and dietary patterns, that may negatively impact health outcomes in Maradu in the long run. In addition to food-related waste more than half (53.93%) of the Ward 4 households surveyed report discarding plastics and nearly a quarter (22%) report discarding e-waste. E-waste will especially pose a challenge in the future as electronic manufacturing is one of the fastest growing industries globally, and a great deal of e-waste from developed nations ends up in India as well.

[14] University at Buffalo. (2016). Household Sanitation Survey, Ward 4, Maradu, Kerala.

4.2.2. SOLID WASTE MANAGEMENT PRACTICES AND INFRASTRUCTURE

While the magnitude of solid waste is increasing and the composition of solid waste is changing in Maradu, infrastructure for managing solid waste is not keeping pace. In Kerala, the responsibility for managing solid waste rests with the municipal government of Maradu, which is mandated by the state of Kerala to provide arrangements for the removal of solid waste and rubbish from private premises and government-owned property. However, the municipal government of Maradu has minimal infrastructure for minimizing, recycling, reusing, or disposing of solid waste generated by residents and businesses. With somewhat limited information, we detail the practices and infrastructure by which solid waste is generated by households and businesses, and ultimately managed by the municipal government in Maradu. To illustrate solid waste management practices by households we use Ward 4 as an illustrative case study.

Table 17. Solid waste discarded by households in Ward 4

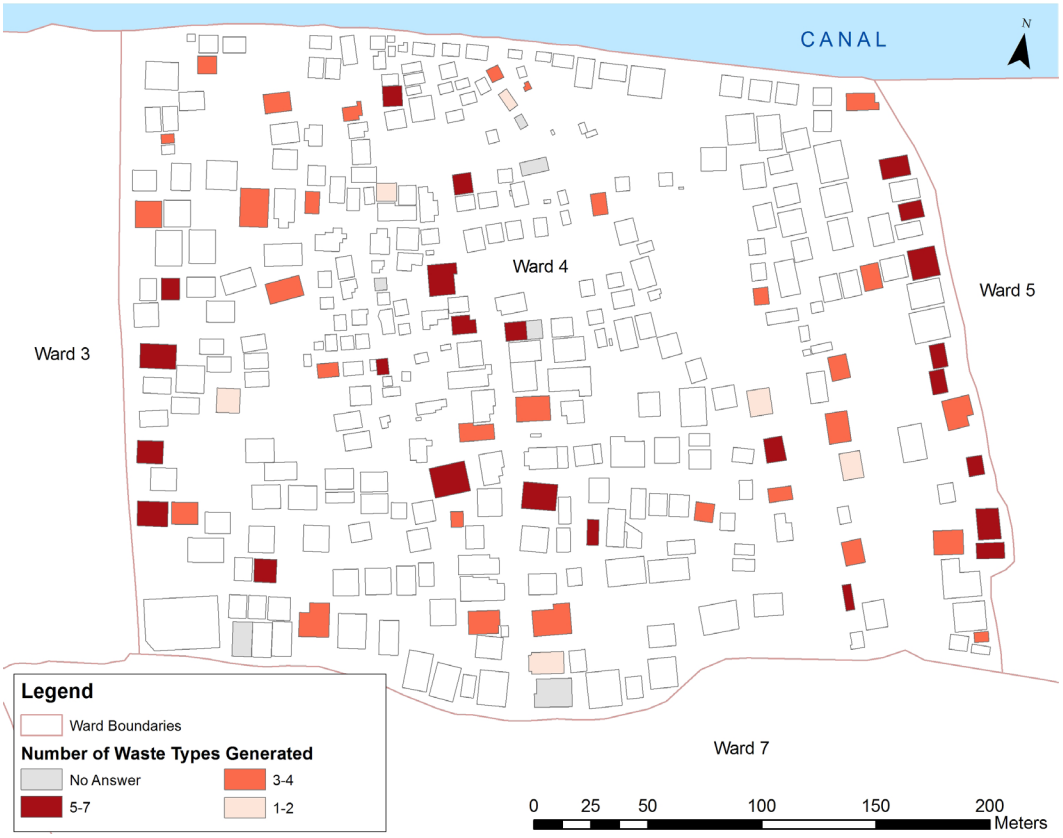
Types of Solid Waste	**Percentage of Respondent Households (%) reporting 'yes'**
Food Waste	95.51
Packaging for Food	83.15
Paper and Cardboard	75.28
Packaging for Drinks	59.55
Plastics	53.93
E-Waste	22.47
Agricultural Waste	3.37
Diapers	17.98
Other Types	5.62
n = 89	

Source: University at Buffalo. (2016). Household Sanitation Survey, Ward 4, Maradu, Kerala.

Figure 11. Informal solid waste dumping site in Maradu

Source: University at Buffalo

Figure 12: Waste generated by households in Maradu's Ward 4



Source: Waste generated by households in Maradu's Ward 4 [Map] Data Layers: Maradu Municipality: Maradu Ward boundaries; Sanitation Household Survey: Please tell me which of these are in the typical solid waste from your household. Map by Samantha Bulkilvish in 2016. Using ArcGIS Desktop 10.3. Redlands, CA: ESRI, 2014.

On-site Household Solid Waste Management Practices

Households in Maradu are engaging in diverse waste management practices despite limited town-wide infrastructure. Household waste, both degradable and non-degradable waste is often separated at the source (Health Inspector, Kochi Corporation 2016). In Ward 4, household representatives report the following common waste management practices: incineration (58%), dumping into canals (27%), collection by ragpickers (23%), dumping in vacant lots (11%), composting (11%), and depositing waste in a pit (10%). Although many household practices, such as incineration, are hazardous to health and strongly discouraged by Suchitwa Mission, many respondents reported that their households engage in the ecologically and public-health friendly practice of composting (table18). The residue from composting processes can be used as [fertilizer] to enhance gardening for fresh food (Health Inspector, Maradu Municipality 2015).The potential for increasing composting remains high: although nearly 95% of households report generating food waste routinely only 11% compost routinely (University at Buffalo 2016).

Municipal Support for At-Source Household Solid Waste Management Practices

The municipal government of Maradu, supported by Suchitwa Mission, encourages at-source waste management by supporting biogas (methane) collection, biopotting, pipe composting, and bucket composting (Health Inspector, Maradu Municipality 2015). The municipal government has distributed 166 biogas units, 215 biopots, and even more composting buckets in Maradu (Health Inspector, Maradu Municipality 2015).

Biogas units use an air tight chamber, which holds bacteria that aid decomposition of solid waste. Household waste and greywater is added through a chute on the side of the tank. Bacteria break down the waste and releases methane and carbon dioxide, which can be used as fuel. The organic leftovers of the process are used as compost (Varma unknown) Suchitwa Mission provides a subsidy to households for the purchase of a biogas plant.

Table 18: Solid Waste Disposal Practices in Ward 4

Type of Solid Waste Disposal Practice	**Survey Respondents Whole Households Use Practices**	
	Number	**Percentage (%)**
Incinerate solid waste	51	58.62
Dump into adjacent canal	24	27.27
Give to ragpicker	21	23.86
Dump solid waste in vacant lots	11	11.36
Compost solid waste	10	11.24
Deposit waste in pit	9	10.23

Source: University at Buffalo. (2016). Household Sanitation Survey, Ward 4, Maradu, Kerala.

The subsidy is for 5000 rupees or 50 percent of the price of the biogas unit, whichever is less (Vasuki 2015).

Bucket composting requires few, low cost materials. The system consists of a plastic, 50-liter bucket fitted with a lid containing 20-25 holes, each of a 2 cm diameter. A plastic net or screen is fitted under the lid to cover the holes to prevent insects from entering the bucket. Biodegradable waste is added to the bucket in addition to government-approved aerobic inoculums. The waste is layered with old compost to ensure the microorganisms that assist with decomposition are not lost and that composting is efficient. A bucket typically fills up in 25 to 30 days when used by a family of five. Once the contents are decomposed sufficiently they serve as a usable soil amendment or fertilizer (Vasuki 2015).

Municipal officials suggest a need for more education for the proper and greater use of these technologies to increase waste reduction (Health Inspector, Maradu Municipality 2015). As more households adopt on-site environmental and public health friendly waste reduction technologies, practices that are hazardous to residents' health will likely reduce.

Infrastructure for Managing Solid Waste Away from Homes

Solid waste is collected and stored at several disposal sites throughout the town of Maradu. The municipal government of Maradu is responsible for ensuring that the solid waste is transported to a treatment plant. The pathway of solid waste is complicated and unclear due to limited data (figure 13). Solid waste collection from wards to disposal sites occurs inconsistently. Still, it is clear that solid waste moves in and out of the town of Maradu's neighborhood, in large part due to the entrepreneurial activity of neighborhood workers and ragpickers.[15] In particular, Kudumbashree workers facilitate waste collection and disposal within wards. Kudumbashree workers are largely responsible for collecting plastic waste, and in the future they are also expected to collect food waste which some hope to use for making compost to sell for an additional profit (Kudumbashree 2016). Residents pay about 50 rupees for solid-waste collection from their homes by Kudumbashree workers (Kudumbashree Supervisor 2016).[16] Interestingly, municipal officials report that Kudumbashree workers have ceased operations in Ward 4 due to insufficient amounts of trash to sustain the program (Kudumbashree 2016). This may also be due to ragpickers competing for the same plastic resources in Ward 4.

[15] Rag pickers are small-business entrepreneurs who collect plastics throughout neighborhoods and commercial businesses and sell plastic to recycling/landfill centers.

[16] Kudumbashree workers are disadvantaged women who are employed through the Kudumbashree programme jointly run by the Governement of Kerala and the National Bank of Agriculture and Rural Development. The programme is designed to help women support themselves and their families.

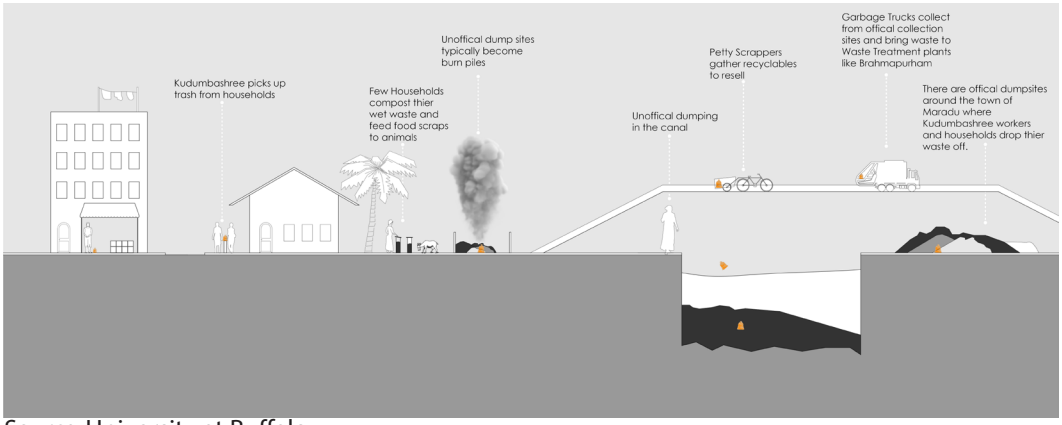
Waste that is not recycled or composted on-site is collected by Kudumbashree workers for transport to waste aggregation disposal sites throughout the town (Kudumbashree 2016). There are between six and eleven such waste aggregation disposal sites in Maradu (Health Inspector, Maradu Municipality 2015). Each site has a shed constructed of corrugated metal where bags of waste can be stored until the Municipality arranges the waste to be transported to a larger facility (figure 14).

Ideally, waste is trucked from waste aggregation sites in Maradu to the Brahmapuram solid waste plant in Kochi for treatment and disposal (Health Inspector, Kochi Corporation 2016) (Health Inspector, Maradu Municipality 2015). The plant, run by Kochi Corporation, receives 30 to 40 truckloads of waste from all over the Kochi region each day, including the town of Maradu. Transferring waste from the town to a solid waste treatment plant may involve contractual agreements with private firms or agreements with quasi-governmental entities such as the Clean Kerala Company Limited, a state-wide organization that helps facilitate the recycling of plastic and e-waste (Solid Waste Treatment Plant Coordinator 2016). Private organizations are also contracted to remove the waste from the disposal sites and transport the waste to be processed. The private companies charge the Municipality 2 rupees per kilo for waste removal (Health Inspector, Maradu Municiplaity 2016).

Plans are in the idea stages to figure out a way for the waste processing plants to use the decomposing plastic as construction material. According to waste treatment facility managers, only 40% of the plastic waste Kochi currently produces is of a high enough quality to be recycled into other plastic products (Solid Waste Treatment Plant Coordinator 2016, Solid Waste Treatment Plant Manager 2016). The plastic that has been collected in Maradu is slated to be moved to a location[17] of a proposed shredding system where the plastic will be mixed with asphalt to aid in improving road surface stability (Health Inspector, Maradu Municipality 2015, Kudumbashree Supervisor 2016). Though there is a site designated for a shredding facility in the southern part of Maradu the availability of land for solid waste management facilities is constrained by the growing population in the town.
Aside from limited availability of infrastructure within the town, management of solid waste from Maradu is also complicated because of policies that extend beyond the boundaries of the town and the surrounding state of Kerala. The neighboring state of Tamil Nadu, where there is limited solid waste management infrastructure, has banned entry of plastic waste from outside its state borders (Inspector 2016). The ban disallows municipal governments in the state of Kerala to access waste management facilities in the adjacent state of Tamil Nadu.

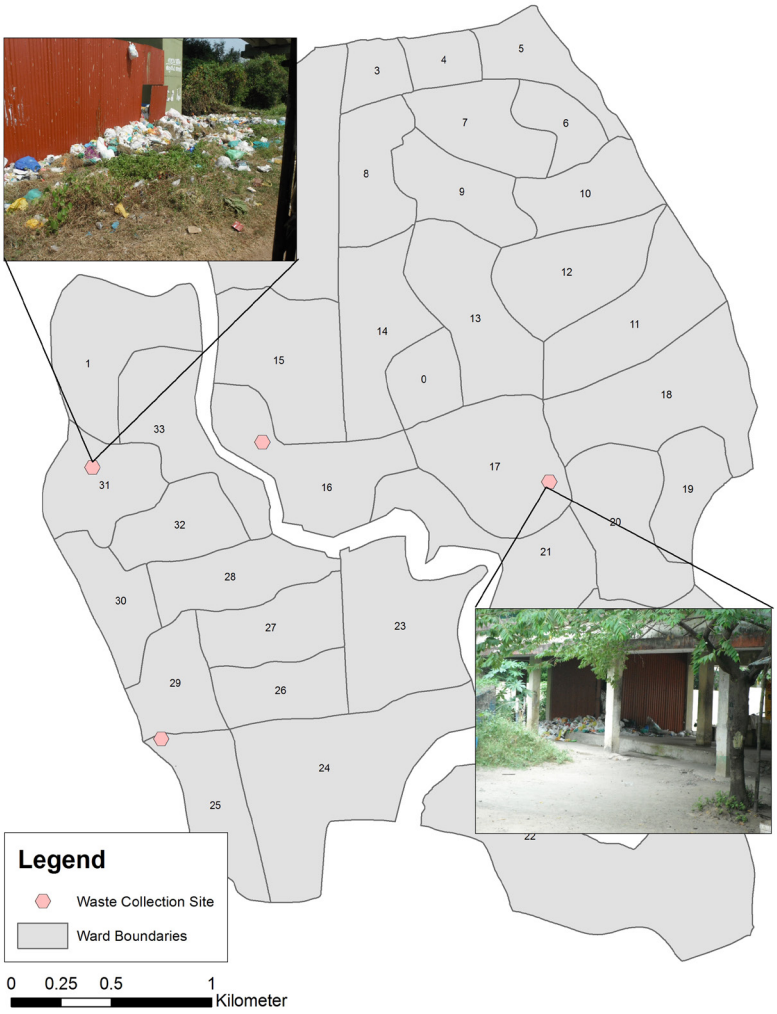
[17] This location is near the Gregorian School.

Figure 13: Pathways of Solid Waste



Source: University at Buffalo

Figure 14: Waste Aggregation Sites



Source: Waste Aggregation Sites [Map] Data Layers: Maradu Municipality: Maradu Ward boundaries; GPS points collected in Maradu: Waste Collection Sites. Map by Samantha Bulkilvish in 2016. Using ArcGIS Desktop 10.3. Redlands, CA: ESRI, 2014.

4.2.3. CURRENT PUBLIC FUNDING FOR SOLID WASTE MANAGEMENT

Although the need for solid waste management is increasing in Maradu, the municipal budget allocations for the implementation of sanitation programmes have not kept pace. Funding for solid-waste management has been made available to ULBs from higher levels of government. Grants have been approved for solid waste management improvements through the 12th, 13th and (current) 14th Finance Commissions, which make recommendations for the transfer of funds between the Central and State governments (Central Pollution Control Board). These funds are filtered to lower levels of government through various programmes administered by a number of government agencies at the central and then state level. Through the 12th Finance Commission grants alone, the Ministry of Urban Development has facilitated allocations of nearly 25 billion rupees to ULBs for improving Solid Waste Managment (SWM) (Central Pollution Control Board).

Beginning in 2005, the Ministry of Urban Development, Government of India, launched the Jawaharlal Nehru National Urban Renewal Mission (JnNURM), which included the Urban Infrastructure Development Scheme for Small & Medium Towns (UIDSSMT) (Central Pollution Control Board). These programmes were major initiatives that provided funds to state governments for their use and for distribution to large ULBs for town modernization including SWM improvements. These programmes were closed in 2014. However, states may still be able to access assistance from the Housing and Urban Development Corporation Limited (HUDCO), a central government agency which provides financial and technical assistance including for integrated SWM systems.

In their State Sanitation Strategy, 2008, the State of Kerala envisions funding for ULB implementation of SWM solutions to occur through Suchitwa Mission. Kerala has proposed the establishment of a dedicated State Urban Sanitation Fund (SUSF), which would be set up under the budget of Suchitwa Mission (Ministry of Urban Development 2015). The Kerala Sustainable Urban Development Project (KSUDP) has also had a hand in providing funding for SWM, having served as the nodal agency for distribution of JnNURM funds (Satish). Funds would be aggregated from the state, supplemented by provisions from Ministry of Urban Development, and allocated for urban sanitation management, planning, communication, monitoring, etc (Ministry of Urban Development 2015). The State planned on allocating an initial sum of 10 crore rupees for the 2014-15 budget year (Ministry of Urban Development

2015). In the Kerala State Annual Action Plan, 2015-16, ULBs are encouraged to explore other possibilities to raise revenue for public works, including SWM, through various schemes such as improving billing and collection systems, public mobilization, and private partnership. The Kerala State Sanitation Strategy has mandated that ULBs earmark a percentage of their own resources towards creating and maintaining sanitation infrastructure, and documenting verifiable results of such efforts (Ministry of Urban Development 2015). This data will be used by the State in the qualifications for Open Defecation Free (ODF) status (Ministry of Urban Development 2015).

The Maradu Municipality budget includes funds for Kudumbashree Employment Programs, Sanitation and Waste Management, Organic Manure Production and encouragement of Biogas production. The Kudumbashree programme has received a 77% increase in funding from the Municipality between the years of 2013 and 2014. Though there is funding available for the programme, inconsistent funding affects the Kudumbashree programme for solid waste collection in the wards. The Municipality also budgets funding for encouraging the use of bio-gas; in fact, in 2012, over 9 million rupees were dedicated to this effort. However this program was not sustained in later years. Revisiting the budget to encourage bio-gas is an important strategy for the future.

4.3. CONCLUSION

Overall, solid waste management is a growing challenge in Maradu with significant potential to harm public health. Solid waste management is undermined by a number of inter-related factors including illegal dumping, lack of enforcement to prevent dumping, inconsistent and insufficient municipal services, and limited availability of space or resources to improve or create new waste management facilities.

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Source: University at Buffalo

5. SYNTHESIS

5.1. STRENGTHS, WEAKNESSES, OPPORTUNITIES, THREATS (SWOT)

After careful examination of the current conditions in Maradu in the areas of drinking water, wastewater, and solid waste management a strengths, weaknesses, opportunities and threats (SWOT) analysis was conducted to help better formulate meaningful and impactful recommendations. The strengths are positive characteristics of Maradu that will continue to help promote public health equity into the future. Weaknesses are conditions and/or practices in Maradu that prevent it from meeting national sanitation standards. Opportunities are factors that will help propel Maradu forward with a successful City Sanitation Plan. Lastly, threats are factors that might inhibit Maradu from reaching success in terms of public health equity.

5.1.1. STRENGTHS

Maradu boasts an attractive tropical climate and proximity to Kochi making it an extremely desirable place for migrating populations to live. Maradu's location within the Kochi metropolitan area, one of the fastest growing regions in the country, draws tourists and rapid commercialization to support the growing population. The beautiful location, surrounded by water on all sides, also makes it an attractive place for residents and visitors to participate in recreation activities on the water and to admire the natural surroundings. Maradu's high literacy rates indicate the importance of education to its residents. Along with education the residents appear to have access to health care facilities and focused primary care because they are living longer and have top rated public health indicators. Additionally, ASHA workers provide community outreach to help reinforce the cultural importance of cleanliness. Municipal government is active and consists of an elected representative from each ward as well as opportunities for equal representation amongst genders. The local government is committed to implementing good sanitation practices: household water is regularly treated, 99% of households have access to a private toilet, and an established Kudumbashree program assists with solid waste collection from households and other establishments. Lastly, residents have ample opportunity for involvement through regular meetings held within each ward.

5.1.2. WEAKNESSES

The largest weakness is that there are a lot of unknowns. There is limited spatial data available, as well as limited quantitative data making it difficult to adequately make decisions. The current drinking water, wastewater, and solid waste infrastructure is inadequate for the rate at which the population is growing. The rapid urbanization is causing increasing population densities and unregulated growth which host many sanitation issues.

- Inconsistent water supply to households is magnified by failing drinking water infrastructure resulting in a loss of an invaluable resource.
- Infrequent and insufficient septage management leads to untreated effluent seeping into the high water table and surrounding waterbodies.
- Unreliable waste collection services and insufficient monitoring of waste disposal facilities leads to waste disposal practices that have harmful health implications.
- Burning of waste causes respiratory issues.
- Dumping of waste in public spaces causes the contamination of soil and pollution of waterways. Dumping also can clog waterways and drainage creating prime breeding conditions for disease carrying insects.
- With limited monetary resources and insufficient administrative oversight these issues have the potential to continue to worsen.

5.1.3. OPPORTUNITIES

There is a strong government interest in promoting healthy living. It is possible to create and implement simple mechanisms for data collection and monitoring of water usage and waste generation to aid in future decision making. Additional sources of funding to support waste, water, and health initiatives are not out of reach and can be found through state government, non-profit organizations and collaborations with private corporations or entities. There are also opportunities to utilize the emphasis placed on education in Maradu by creating educational materials regarding waste, water, and health initiatives to share in schools and at community meetings. Opportunities also arise from the rapid population growth. These include having an expanding work force, more job opportunities, and an increased market to drive the local economy.

There are also opportunities to improve existing infrastructure instead of starting from scratch. Repairing the existing expansive water supply system will cut down on costs and allow for expansion of the system to meet the needs of

the growing population. There is an opportunity to enhance the initiative to collect rainwater from existing drainage points on houses in order to cut down on the dependency of municipal water.

Facilitated conversation and financial contributions can help with the creation of a scientific waste treatment facility that can support Maradu or a larger area's solid waste processing. By entering into a long term contract with a waste removal company, the removal of waste would be guaranteed to occur on a regular basis. Monitoring waste disposal/collection sites regularly will prevent overflow of waste into neighboring properties or waterways. Opportunities also lie within existing waste collection infrastructures. The potential of the ragpickers and Kudumbashree workers can be met by bolstering employment opportunities and ensuring there is no overlap in collection efforts. Additional opportunities are discussed in detail within the recommendations section of this report.

5.1.4. THREATS

The threats to Maradu's success in creating a City Sanitation Plan that will lead to public health equity are few but powerful. By attending to these threats the Maradu Municipality will be able to overcome them.

- The Municipal government is fairly new, and has limited ability to control what happens outside of its borders (e.g. population spillover from Kochi).
- The Municipality is facing economic challenges.
- Homeowners and other stakeholders interviewed provided contradicting information regarding solid waste management practices and wastewater disposal.
- The cleaning of septic tanks and disposal of sewage is unregulated.
- There is a proliferation of plastic packaging due to changing food preferences.
- Waste disposal habits are poor and lead to the illegal dumping of waste into canals and waterways, onto vacant land, and burning of waste.
- The improper disposal of solid waste also leads to compromised infrastructure.
- Existing solid waste treatment facilities lack sufficient capacity and are not up to current standards leading to contamination of ground water sources.
- Drains clogged with solid waste become impassable for water and lead to flooding.

The recommendations presented in the next section seek to minimize these threats if not eliminate them all together.

5.2. CONCLUSION

As outlined in this section, Maradu has numerous strengths but also faces numerous challenges. Rapid urbanization, high population density and inadequate infrastructure all contribute to the imbalance between supply and demand of limited natural resources, especially clean air, clear water and clean sanitary conditions. The poor disproportionately suffer from inequities in access to these natural resources. Maradu has taken preliminary steps to mitigate these inequities through strong representative government, public works and welfare programs. The Municipality must continue to find sustainable solutions that are affordable, equitable and inclusive in order to effectively address the current conditions in Maradu. Drawing on the information presented in this report, the subsequent section outlines ideas for the future to improve management of water and solid waste with an intent to improve public health through private and public partnerships and the active participation of community members.

Table 19. Strengths, Weaknesses, Opportunities, Threats (SWOT) Analysis

Strengths *Positive characteristics*	**Weaknesses** *What is missing or needs improvement?*
1. Attractive tropical climate and proximity to Kochi make a desirable place to live for migrating populations; 2. Surrounded by water on all sides allowing for recreational activities and direct connection to the natural environment; 3. High value placed on education resulting in highly literate community; 4. Kochi metropolitan area is among the fastest-growing regions in the country, drawing tourists and rapid commercialization to support the growing population; 5. Top-rated public health indicators for long life; 6. Accessible healthcare facilities and focused primary care 7. Community outreach by ASHA workers; 8. Cultural standard of cleanliness; 9. Active municipal government with elected representatives; 10. Opportunity for equal representation of gender in government; 11. Local government commitment to implementing good sanitation practices; 12. Household drinking water treatment regularly conducted; 13. 99% household access to private toilets; 14. Kudumbashree Program organizes solid waste collection; 15. Wards hold regular meetings that residents are able to attend.	1. Infrastructure inadequate for rate of population growth; 2. Limited spatial data available; 3. Limited quantitative data available to aid decision makers; 4. Disadvantaged populations experiencing worse health outcomes and disparities in access to healthcare; 5. Rapid urbanization is causing increasing population densities and unregulated growth; 6. Inconsistent water supply to households; 7. Failing drinking water infrastructure; 8. Infrequent/inadequate septage management- flooding and a high water table contributes to untreated effluent entering water bodies; 9. Limited monetary resources; 10. Insufficient administrative oversight; 11. Insufficient monitoring of waste disposal facilities; 12. Unreliable waste collection services; 13. Current practices have harmful health implications • burning causing respiratory issues • dumping contaminates soil and water • dumping causes clogged waterways and drainage creating prime conditions for the breeding of disease-carrying insects

Table 19. Strengths, Weaknesses, Opportunities, Threats (SWOT) Analysis

Opportunities *What will help propel Maradu?*	**Threats** *What might get in the way?*
1. Strong government leadership to promote healthy living; 2. Creation of simple mechanisms for data collection to monitor waste generation; 3. Establish alternative funding sources for waste, water, and health initiatives • State government sources • Non-profit ogranizations • Collaborations with private corporations/entities 4. Acknowledge the existing waste separation practices at the household level; 5. Utilize the emphasis placed on education in Maradu by creating educational materials regarding waste, water, and health initiatives; • To share in schools • To share at community meetings 6. Rapid urbanization and population growth; • Increased work force • Increased job opportunities • Increased market for supply and demand 7. Bolster infrastructure; • Repair existing water supply infrastructure and enhance to meet population needs • Collect rainwater from house's existing drainage points • Ensure scientific waste treatment facility • Long-term contract with waste-removal company • Monitoring system to prevent the overflow of waste disposal/ collection sites • Fully utilize the employment potential of ragpickers and Kudumbashree for solid waste collection	1. Municipal government is fairly new, and has limited ability to control what happens outside of its borders (e.g. population spillover from Kochi); 2. Economic challenges; 3. Contradicting information from homeowners and stakeholders interviewed regarding solid waste management practices and wastewater disposal; 4. Unregulated septic tank cleaning and sewage disposal; 5. Proliferation of plastic packaging due to changing food preferences; 6. Poor waste disposal habits • Illegal dumping into canals and waterways • Illegal dumping into vacant land • Burning of waste 7. Compromised infrastructure due to improper waste disposal practices • Existing waste treatment facilities lack sufficient capacity and are not up to current scientific standards • Drains clogged with solid waste become impassable for water

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Source: University at Buffalo

6. RECOMMENDATIONS

Based on this report's assessment and analysis of Maradu's current water and waste systems, a set of twenty-eight recommendations have been developed.

These recommendations aim to achieve the following goals:

- Provide information to improve access to clean drinking water
- Provide information to improve management of wastewater systems
- Provide information to improve management of solid waste systems

Development of these recommendations was guided by a mission to provide information that contributes to the development of the Maradu City Sanitation Plan (CSP). These recommendations have the capacity to serve as a catalyst for Maradu to increase health-equity-consciousness in city planning efforts.

The recommendations are categorized into five groups: (I) Data Collection, (II) Wastewater Strategies, (III) Fresh Water Supply, (IV) Solid Waste Strategies, and (V) Community-Based Initiatives.

In recognition of meeting the goals of the CSP certain actions must be completed before other strategies are able to be deployed. Prioritization of the recommendations were determined from our field observations, and our estimate of urgency. The time in which the action will take to complete – short, medium, and long term, as well as the estimated cost were also taken into consideration. The CSP is a living document and may need to be evaluated frequently to determine if the timeline given to each recommendation is accurate and if the goals of the CSP are being met.

Within each category, the recommendations have been prioritized according to urgency and feasibility (a combination of cost and time) for inclusion in the CSP (tables 20, 21, 22). Urgency is rated on a scale from one to five, one being very urgent and five representing a recommendation that can slowly unfold. The cost and timeline information are described in detail for each recommendation.

D**ATA COLLECTION**

1. USE CITIZEN SCIENCE TO MAP ROADS, BUILDINGS, AND PUBLIC FACILITIES

Narrative/ Rationale:
Maradu currently lacks an adequate supply of geographic maps. In order to aid in future development projects, it is necessary to establish comprehensive and accurate maps of infrastructure and amenities in Maradu. To do so, the Municipality can utilize OpenStreetMap (OSM), a free open-source mapping website. Anyone with internet access can create an account and add geographic data. Map data contribution can be performed based on personal knowledge of an area. For example, an editor of the map can place objects such as schools, hospitals, restaurants, shopping centers, bus stops, public toilets, and existing drainage systems into the OSM database. Users of OSM may collect map data through ground surveys, GPS devices, and aerial imagery. In combination with the mapping data provided by the UB team, this process will allow for rapid creation of maps that can aid in implementation of other recommendations.

Implementation Information:
Who: Ward-specific community coalitions
Urgency: 2
Timeline: Short-term
Cost: No-cost
Examples: See 1-3 below

1. The Challenges and Prospect of OpenStreetMap in Bangladesh
   Link: http://ieeexplore.ieee.org.gate.lib.buffalo.edu/stamp/stamp.jsp?tp=&arnumber=6164857
2. Crisis Mapping the 2010 Earthquake in OpenStreetMap Haiti
   Link: http://search.proquest.com.gate.lib.buffalo.edu/docview/1690497435?pq-origsite=summon
3. Tutorials can be found here:
   Link: https://www.youtube.com/watch?v=P8qKaL9IGjk
   Link: https://www.youtube.com/watch?v=tXDWxGUp8N0

2. ASSESS EXISTING DRINKING WATER INFRASTRUCTURE

Narrative/ Rationale:
The Kerala Water Authority supplies drinking water to 86% of Maradu households at an average frequency of seven hours per day. To ensure the needs of current and future populations of Maradu are met an assessment of the current system is needed. An accurate understanding of the current supply and demand will help inform expansion in the future.

Baseline information would require an assessment of pipe data regarding:
- Internal and external diameter
- Length
- Roughness value
- Connectivity
- Age
- Material
- Lining and year of lining

It is also important to gather and derive data pertaining to accurate, representative loads of water and the spatial distribution of the load throughout the network model. This data includes measurements of flow metering, water consumption records, telemetered system flows and estimates of consumer consumption. After identifying problematic areas repairs and enhancements should be conducted as necessary in order to reduce water leakages or unaccounted-for-water (UFW). Finally, using the information gathered, evaluate for and develop a hydraulic model specific to measured parameters, in order to maintain necessary pressure in the pipes and convert the intermittent supply to a 24/7 supply. To ensure future accuracy of the hydraulic model regular updating, maintenance, and re-calibration to reflect physical changes in the network should be conducted. If population projections are put in consideration, the model will enable Maradu to meet future water demands.

Implementation Information:
Who: Kerala Water Authority
Urgency: 1
Timeline: Immediate
Cost: ~9 Lakh

3. FINALIZE THE LOCATIONS OF WARD-LEVEL SOLID-WASTE AGGREGATION SITES

Narrative/ Rationale:
Several locations in Maradu serve as secondary storage facilities, or aggregation sites for solid waste. The solid waste collected by the Kudumbashree is taken to these locations before Clean Kerala collects the waste and transports it to a solid-waste disposal facility. The location of four similarly-sized holding facilities is known and documented in a Geographic Information Systems (GIS) map using Global Positioning System (GPS), although the total number of official aggregation sites is unknown. All are constructed from four sheets of corrugated metal and are either placed under a bridge for protection from the elements or have a slanted roof made from the same corrugated metal. After verifying the locations of all the aggregation sites the Maradu Municipality can begin to address underserved areas, ensure proper maintenance of the storage facilities, and guarantee proper storage and collection of waste in order to prevent overflow into canals, drains, and neighboring land.

Implementation Information:

Who: Kudumbashree (initial data collection) and Maradu Municipality - Standing Committee for Welfare (decide whether or not an additional holding facility would need to be constructed), Standing Committee for Works (Construction of additional holding facilities)

Urgency: 1

Timeline: Immediate (Initial location data collection), Short-term (Analysis for additional aggregation sites needed lead by CSP task force)

Cost: Data unavailable to estimate (initial fact finding mission requires limited resources; collecting knowledge from the Municipality and Kudumbashree. If there is need for additional waste aggregation sites then there would be a cost in constructing those holding facilities)

Figure 15. Waste aggregation site overflow in Maradu

Source: Photo by Kenzie McNamara

4. GENERATE DATA CONCERNING SOLID WASTE COLLECTION BY KUDUMBASHREE AND THE SYSTEM OF PRIMARY COLLECTION OF SOLID WASTE AS A WHOLE

Narrative/ Rationale:
There are significant gaps in knowledge regarding the efficacy of the Kudumbashree program as it is currently employed in the primary collection of solid waste in Maradu. The gap in data concerns the quantity of waste collected by Kudumbashree workers versus the amount of waste generated within the Municipality. This can measure the program's efficacy, in addition to poverty alleviation, the program could be used to achieve greater recovery of solid waste. It is also unclear which areas of the Municipality are adequately serviced or not. Reasons for lack of service are also not understood, though it is apparent that Kudumbashree workers are being laid off. The role of rag pickers within the process of waste collection in Maradu is an area that warrants further investigation.

Filling the knowledge gap requires establishing a policy to require Kudumbashree workers to record the amount of solid waste collected. The policy may read as follows:

> "The Urban Local Body recognizes Kudumbashree workers as formal maintainers of solid waste collection in each of Maradu's Wards. A record of solid waste collection is set forth to be utilized by the Kudumbashree workers as a means to account for the solid waste being generated by each household. The worker will utilize the template for recording required information. The document is to be used for recording the appropriate activity bi-weekly and subsequently submitted to the Maradu Municipality Public Health Department. Questions regarding the form or process are to be directed to the Public Health Department."

Maradu Municipality has designated waste aggregation sites where Kudumbashree workers take solid waste, especially plastic. While the waste is held at these sites, there is no existing mechanism to measure nor record the amount of solid waste at these locations. For each full cart transported to the collection site workers may be required to record the number of full or half full carts brought to the collection site. Maradu Municipality officials benefit from knowing the frequency of which solid waste is being collected and generated. Using the existing labor force (e.g., the Kudumbashree) who currently collect the solid waste, a mechanism or process may be put in place

to record the amount of plastics collected by cart and record drop off locations. Once the amount of solid waste generated is recorded, public health officials can correlate areas where illnesses are prevalent with areas where solid waste is improperly disposed of in methods such as burning and dumping. To ensure accuracy in accounting for the amount of solid waste collected, Maradu Municipality may specify push cart size and additional equipment.

Implementation Information:
Who:Town Council writes and adopts policy. Public Health Department and Kudumbashree implements the procedures specified in the policy.
Urgency: 1
Timeline: Immediate
Cost: Low-cost
Example: See 1 below

1. Kudumbashree workers take carts to each household in their respective wards and collect the household solid waste. Once the cart reaches capacity the worker records the information. This information is recorded for each full or half-full cart taken to the waste aggregation site. The policy developed under the assumption that all use the same size cart.

(EXAMPLE) Name: Ms. Sunitha Amarpreet			
Worker ID#: 11867		Cart ID#: 1911	
Date	Cart # for Week	Full/Half-full	Cart Dimensions
20/04/2016	1	Half-full	Standard

Figure 16: Kudumbashree workers with collection cart

Source: Photo by Mariel Vilella from Tangri, Neil. "Waste Pickers Lead the Way to Zero Waste." Retrieved from: http://www.no-burn.org/downloads/ZW%20Pune.pdf

5. IDENTIFY HIGH CONTAMINATION AREAS OF WATERWAYS THROUGH TESTING CONDUCTED IN PARTNERSHIP WITH SCHOOLS OR INLAND WATERWAY AUTHORITY

Narrative/ Rationale:
Fertilizer, sewage, and solid waste is regularly dumped into the natural waterways. Pollution, specifically nitrogen loading, leads to eutrophication which can make waterways effectively uninhabitable for native fauna. Problem areas can be identified by testing for harmful bacteria, nitrogen and phosphorous loading, heavy metals, VOC's and other harmful substances. Data identifying high contamination areas allows for targeted remediation initiatives that could minimize the effects these pollutants on the residents that use them. The Inland Waterway Authority (IWA) may already have the data to identify high contamination areas. Collaboration between the Maradu Municipality and the IWA would help begin the remediation process.

If the data identifying high contamination areas does not exist, collaborating with local schools to test surface water/ecologies/fauna for harmful substances would be the next step. The Municipality could then issue public notice of contamination for the safety of the public and begin the remediation process. The IWA could provide equipment to schools for testing. The collected information can then be analyzed and provided to the Municipality for further action.

Implementation Information:
Who: Inland Waterway Authority and/or local schools
Urgency: 3
Timeline: Immediate
Cost: Data unavailable to estimate

WASTEWATER STRATEGIES

6. ESTABLISH A TEMPORARY SEPTIC TREATMENT AND DISPOSAL SITE AS PART OF A PHASED SANITATION STRATEGY

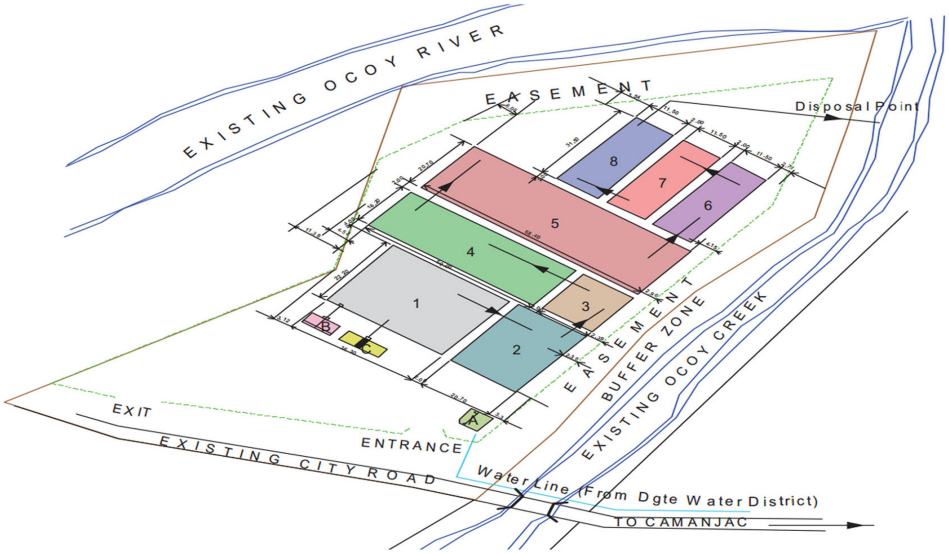
Narrative/ Rationale:
Without a designated site for septic disposal, waste that is pumped from septic tanks in Maradu is illegally dumped into surface waters and marshy lands. A temporary septic disposal site is necessary to properly treat septic waste

while a permanent waste water treatment plant that services the surrounding municipalities is designed and constructed.

A list of temporary septage treatment methods that require little energy and chemical inputs are described below. Each method stabilizes the septage by killing the pathogens present and by removing excess water. Stabilized, treated septage can then be safely disposed of by land application, landfilled, or added into soils.

i. Lagoon Treatment: Utilizing a combination of anaerobic and aerobic lagoons in combination with maturation ponds and constructed wetlands, lagoon treatment facilities can be constructed and operated inexpensively to treat septage without energy or chemical inputs. In lagoon treatment systems, the majority of the biochemical oxygen demand (BOD) and total suspended solids (TSS) are removed in anaerobic digestion in anaerobic lagoons. These 3 meter deep lagoons allow for the solids to be detained for 60 days, which allows adequate time for a removal efficiency of 60-75%. This proposal has the highest septic load capacity of the proposed treatment methods but requires a large amount of land and space. The City of Dumaguete, Philippines has developed a successful lagoon treatment system that requires no energy or chemical inputs and discharges treated effluent into the Ocoy River (see Figure 17).

Figure 17: Lagoon treatment system from City of Dumaguete, Philippines



Source: Robbins, David M. (2007). Septage Management Guide for Local Governments. Retrieved from: https://www.rti.org/pubs/septage_management_guide_1.pdf

ii. Lime Stabilization: Lime stabilization involves the addition of hydrated lime (calcium hydroxide) to septage to form a product that is appropriate to dispose of on land or for use as a fertilizer. The process requires 12-20 kilograms of hydrated lime for every 4,000 liters of septage. After the hydrated lime and septage are mixed together, the pH is raised to 12 and held for a detention time of a minimum of 30 minutes. The lime stabilizes the septage, kills pathogens and reduces odors. This proposal may be the easiest to implement at the neighborhood scale, requires the least land for treatment, and has the capacity to treat neighborhood load. Lime stabilization can be performed in either of the following ways:

- Addition of lime directly into septic vacuum trucks (only if the tanks are stainless steel)
- Lime Stabilization pits: Typical pits are dug directly into the ground and lined with 30 or 40 ml plastic. Pits are 3 meters wide, 4 meters long, and 1.5 meters deep and can hold approximately 40,000 liters of septage. A manual for construction and use of lime stabilization pits can be found: http://www.slideshare.net/MagnusMurray/lime-stabilized-construction-a-manual-and-practical-guide

Figure 18: Lime stabilization pit

Source: Robbins, David M. (2007). Septage Management Guide for Local Governments. Retrieved from: https://www.rti.org/pubs/septage_management_guide_1.pdf

Implementation Information:
Who: ULB, Engineering Sector (feasibility studies), public health sector (regular lab analysis of septic residuals to ensure pathogen removal)
Urgency: 1
Timeline: Immediate (research, feasibility studies, project bidding, and temporary treatment site construction).
Cost: Varies based on selected method and septic load. Cost analysis should be conducted along with feasibility studies.
Example: See 1 below

1. Natural treatment facility options requiring little energy and chemical input have been utilized across the globe.
   Link: https://www.rti.org/pubs/septage_management_guide_1.pdf

7. PROMOTE A COMPREHENSIVE FAECAL SLUDGE MANAGEMENT SYSTEM

Narrative/ Rationale:
Centre for Science and Environment has categorized faecal sludge management into three stages: (1) containment, (2) emptying, (3) transportation, treatment and disposal.

Septic tank construction standards are codified in Part IX of the 1983 National Building Code of India. Verifying that the existing codes meet contemporary standards is a first step. Authorities can train masons in the design and construction of a tank that meets the aforementioned standards. Providing a process of licensure for these construction professionals, in tandem with providing and implementing an inspection process would be an effective way to ensure these codes are followed. In addition, the Municipality could provide a list of approved vendors to the town's residents.

Regulating private cleaners is crucial to the effectiveness of a septage management system. By building a private-public partnership between the Municipality and the masons constructing the septic tanks as well as the private cleaners of the tanks it would result in: 1) access to improved service for residents, 2) a method to monitor and regulate emptying activities, and 3) private cleaners are introduced to new markets and formal employment, in effect making them aware of safe sites for faecal sludge disposal. (http://www.downtoearth.org.in/coverage/urban-shit-53422) Providing a process of licensure/training for these professionals, while concurrently developing

inspection and registration processes for their tankers would help mitigate health risks posed by contamination. These practices could be coupled with a reorganization of existing payment structure (monetary disincentivization) to eliminate financial benefit of unsanitary dumping.

Faecal sludge treatment and/or recycling enhancements need to accompany the proposed solutions around collection, transport and disposal. Suresh Rohilla, programme director of urban water management at CSE, advocates for the use of decentralized wastewater treatment systems, which can be implemented at the household, schoolwide, or colony-scale. An example of such a system is provided by the Aravind Eye Care Hospital at Abhishekapakkam in Puducherry. If a community-level solution is not feasible, then independent septage treatment plants can be set up and maintained by charging a user fee.

Encouraging household and/or individual recycling strategies, such as composting toilets and the use of bio-manure in agriculture, could minimize sludge generation and, therefore, necessitate less treatment capacity. Providing adequate sewage treatment capacity for sanitary disposal would need to be prioritized before proposed collection and disposal could be enforced. Temporary measures may facilitate smoother transition to a comprehensive sewage treatment plant for Maradu.

Implementation Information:
Who: Municipality & State (would be more effective the wider its adoption because workers would have more incentive to get licensed and it would reduce potential for contractors to just refuse to work in Maradu)
Urgency: 1
Timeline: Immediate
Cost: High-cost
Example: See 1 below

1. The Centre for Science and Environment (CSE) has performed extensive research on how to make the necessary improvements to these processes including financial management, construction and operation of waste management facilities and all the necessary data that needs to be collected before this process can even begin.
   Link: http://www.downtoearth.org.in/coverage/urban-shit-53422
   Link: http://www.cseindia.org/userfiles/document_sm.pdf
   Link: http://www.downtoearth.org.in/blog/how-to-reinvent-the-sanitation-wheel-53507
   Link: http://wateraidindia.in/wp-content/uploads/2016/01/Faecal-Sludge-Management-Report.pdf

8. IMPLEMENT PROCEDURES FOR THE REGULAR MAINTENANCE OF DRAINAGE SYSTEMS

Narrative/ Rationale:
The town of Maradu has open and closed drainage systems that collect stormwater runoff. The clogging of these drains leads to stagnant water build up, breeding mosquitoes and other pathogens. Maradu Municipality could enact two options dependent upon feasibility and affordability to address stagnant water build up.

1. Community driven programs, run by ward councilors or a community coalition, may encourage the maintenance of drainage systems. The ward councilors could propose the cleaning of drains during the ward sabah meetings, through which residents would learn the proper method of cleaning the drains. Consequently, the residents clean their drains during a selected day of every month. This low cost recommendation requires the active participation of residents in ward sabah meetings, or the spread of this information to residents who do not attend the meetings.
2. The Public Works department and the Health department in the Maradu Municipality could work closely together to set up a system to monitor open and closed drains to ensure they remain clean. The Public Works department could lead the charge of mapping the current drainage infrastructure, and identifying problem areas along the way. This could occur using OpenStreetMap (OSM), which was recommended previously. The Health department could have access to these same mapping resources and could deploy sanitation workers to address the areas where drains are clogged. These tasks could increase the efficiency of the Public Works and Health departments which may already be spread too thin.

Implementation Information:
Who: Ward Councilors or Public Works and Health departments
Urgency: 2
Timeline: Immediate
Cost: Data unavailable to estimate

9. DEVELOP AND CREATE SANITATION FACILITIES FOR UNDERSERVED AREAS

Narrative/ Rationale:
The creation of sustainable sanitation facilities that includes toilets with proper waste disposal, and water to properly wash clothes and wash hands will decrease water contamination from human excreta and the spread of disease. Public facilities should be created in areas where toilet usage is lower according to the Swachh Bharath Town-wide Survey. Education on the importance of better hygiene practices and encouragement of toilet facility usage should be done at schools. If children go to school and utilize sanitation facilities, they will be more inclined to bring these good practices home. Incentivization of toilet usage as an alternative to open defecation practices is also important.

Implementation Information:
Who: Public-private partnership entities and Maradu Municipality
Urgency: 3
Timeline: Medium-term
Cost: Data unavailable to estimate
Examples: See 1-6 below

1. Eram Scientific Solutions Delight E-Toilet
   Link: http://borgenproject.org/self-maintained-delight-toilets-in-india/
   Link: http://www.eramscientific.com/?q=productoftheyear
2. Alternative to open defecation: get paid to use the toilet
   Link: http://sanitation.indiawaterportal.org/english/node/2898
3. Anganwadi toilets encourage behavior change for children
   Link: http://www.thealternative.in/business/10-toilet-designs-for-rural-india/
4. Low Cost toilets
   Link: http://www.gramalaya.in/pdf/appropriateLowcost_toilet_technology.pdf
5. 50,000 rupees for 1 toilet
   Link: http://www.thealternative.in/business/10-toilet-designs-for-rural-india/
6. Locally built green toilet facilities
   Link: http://inhabitat.com/locally-built-green-toilet-facilities-provide-safe-sanitation-for-india/

FRESH WATER SUPPLY

10. ASSESS AND ENHANCE EXISTING DRINKING WATER INFRASTRUCTURE TO ENSURE HIGH-QUALITY AND ADEQUATE WATER SUPPLIES

Narrative/ Rationale:
In order to meet the needs of current and future populations of Maradu, assessments and enhancements of the current system are needed. After collecting baseline information repairs and enhancements should be conducted as necessary in order to reduce water leakages or unaccounted-for-water (UFW). Using the information gathered, evaluate for and develop a hydraulic model specific to measured parameters, in order to maintain necessary pressure in the pipes and convert the intermittent supply to a 24/7 supply. To ensure future accuracy of the hydraulic model, regular updating, maintenance, and re-calibration to reflect physical changes in the network should be conducted. If population projections are put in consideration, the model will enable Maradu to meet future water demands. A written Project Proposal and Detailed Project Report (DPR) for water system improvements would require information in the following format:

- Qualifications - of the project manager and lead agency
- Background - information needed to be collected (outlined below)
- Methodology - how information will be collected and enhancements will be made
- Work schedule - projected timeline of project
- Proposal statement - what will be done
- Costs - Projected costs
- Results - an excerpt on desired outcome for the project
- Conclusion

It is also important to gather and derive data pertaining to accurate, representative loads of water and the spatial distribution of the load throughout the network model. This data includes measurements of flow metering, water consumption records, telemetered system flows and estimates of consumer consumption.

Implementation Information:
Who: Kerala Water Authority and Maradu Municipality (Standing Committee)
Urgency: 1
Timeline: Immediate
Cost: ~18 Lakh
Example: See 1 below

1. Badlapur transformation of intermittent water supply to continuous through development of a hydraulic model.
   Link: http://www.sswm.info/sites/default/files/reference_attachments/DAHASAHASRA%202008%20Model%20for%20Transforming%20Intermittent%20into%20Continuous.pdf

11. SUPPLEMENT THE PUBLIC WATER SUPPLY WITH PRIVATE WATER SOURCES THROUGH PUBLIC-PRIVATE PARTNERSHIPS

Narrative/Rationale:
Municipalities face challenges that lead to the unsustainable exploitation of water resources, which include rising demand due to increased urbanization, lagging investment in the water sector, and inefficiencies in the current infrastructure. International precedents of public-private partnerships (PPPs) suggest they help address these challenges through investment and improved efficiency. Maradu experiences difficulties meeting its water supply needs; shortages and inconsistencies in the supply received are systemic. Large corporations and other organizations within the Municipality may play a role to ameliorate this problem both for their sustainability and that of Maradu. Maradu has great potential to take advantage of and benefit from PPPs. Maradu Municipality may cooperate with various international and domestic companies and non-governmental organizations to pool resources; increasing investment to develop and improve water infrastructure and supply. PPPs will enable these companies and organizational entities to benefit from increased and an improved municipal water supply including the town as a whole.

Implementation Information:
Who: Maradu Municipality, other entities, international aid and development organizations
Urgency: 2
Timeline: Short-term to Medium-term
Cost: Data unavailable to estimate, Toolkit cost: 35USD
Examples: See 1-2 below

1. Tool Kit for Public-Private Partnerships in Urban Water Supply for the State of Maharashtra, India

   The Asian Development Bank (ADB) in a joint initiative with the Government of India published (2011) a toolkit for public-private partnerships (PPPs) in urban water supply and sanitation for the state of Maharashtra, India. The toolkit aims to support relevant entities and stakeholders in the state to develop PPP projects for water supply and sanitation. This initiative studied PPP structures and their applicability in selected sample cities, then developed proposed term sheets, which were identified based on feasibility for implementation. The toolkit is expected to help stakeholders in the state develop PPP projects in water supply and sanitation and to serve as reference for similar cities in India. The toolkit consists of (1) PPP toolkit for the water supply and sanitation sector, (2) details of PPP structures, (3) case studies of PPP in Maharashtra, and (4) term sheets.

2. Please contact the Public-Private Partnership in Infrastructure Resource Center (PPPIRC) and/or the Asian Development Bank (ADB) to seek assistance related to such a program.

   Link: http://ppp.worldbank.org/public-private-partnership/library/urban-water-toolkit-maharashtra-india

   Link: http://www.adb.org/publications/toolkit-public-private-partnerships-urban-water-supply-state-maharashtra-india

12. PROMOTE COMMERCIAL AND INDUSTRIAL ON-SITE WATER RECYCLING SYSTEMS TO CONSERVE FRESHWATER RESOURCES

Narrative/ Rationale:

Large amounts of freshwater are consumed by commercial and industrial institutions, which also generate an abundance of gray water. On-site water recycling is an effective approach to reducing the impact these institutions have on the water supply. Recycled water may be utilized for a multitude of household, municipal, industrial, and commercial uses to reduce the increasing need for freshwater.

In order to reduce the quantity of freshwater these institutions are using, Maradu Municipality could develop guidelines that outline how to safely engage in water-recycling. Guidelines on using the recycled water should include a risk management framework, managing health risks, managing

environmental risks, monitoring, and consultation and communication. Maradu Municipality could promote engagement in on-site water recycling by providing incentives in the form of tax alleviations or subsidies.

Implementation Information:
Who: Public Health Department, Engineering Division
Urgency: 4
Timeline: Immediate
Cost: High-cost (initial large investment by industrial/commercial institutions but incentives should pay for the system after ~15 years)
Examples: See 1-2 below

1. The Australian Government developed the National Guidelines for Water Recycling: Managing Health and Environmental Risks as a reference supply, use, and regulation of recycled water schemes. The guidelines consist of a framework for management of recycled water quality and use, management of health risks in recycled water, management of environmental risks in recycled water, monitoring, and consultation and communication.
   Link: http://www.environment.gov.au/system/files/resources/044e7a7e-558a-4abf-b985-2e831d8f36d1/files/water-recycling-guidelines-health-environmental-21.pdf

2. Sample policy for a recycled water supplier:

   The organisation or partnership supports and promotes the responsible use of recycled water and the application of a management approach that consistently meets the National Guidelines on Water Recycling, as well as recycled water user and regulatory requirements. See next page.

To achieve this we will:

- Recognize the paramount importance of protecting public and environmental health
- Maintain communication and partnerships with all relevant agencies involved in management of water resources, including waters that can be recycled
- Engage appropriate scientific expertise in developing recycled water schemes
- Recognise the importance of meeting community expectations and ensuring resident participation in decision-making processes
- Manage recycled water quality at all points along the delivery chain from source to the recycled water user
- Use a risk-based approach to identify and control potential threats to water quality
- Integrate the needs and expectations of users of recycled water, communities, other stakeholders, regulators and employees into the various planning processes
- Establish regular monitoring of control measures and recycled water quality
- Establish effective reporting mechanisms to provide relevant and timely information
- Promote confidence in the recycled water supply and its management
- Develop appropriate contingency planning and incident-response capability
- Participate in and support research and development activities to ensure continuous improvement and understanding of recycled water issues and performance
- Contribute to the development of industry regulations and guidelines and standards relevant to public health and the water cycle
- Continually improve current practices by assessing performance against corporate commitments and stakeholder expectations.
- Recycled water management systems consistent with the National Guidelines on Water Recycling will be implemented and maintained to effectively manage the risks to public and environmental health.

All managers and employees involved in the supply of recycled water are responsible for understanding, implementing, maintaining and continuously improving the recycled water management system. Membership and participation in professional associations dealing with management and use of recycled water is encouraged.

Signed by responsible officer(s), dated

13. ENCOURAGE PLANTING OF VEGETATION THAT RESTORES RIPARIAN ZONES ALONG ALL WATERWAYS IN THE MUNICIPALITY

Narrative/Rationale:
Waterfront lands, also known as riparian zones, play an integral role in providing clean water for communities and healthy habitats for wildlife. Many species rely on these habitats for survival and their flourishing existence has a direct impact on human well-being and quality of life.

The importance of healthy riparian zones should be shared with citizens including what a healthy riparian zone looks like, how they function, and the benefits of making improvements to the existing riparian zone. This information could be shared through community meetings or pamphlets outlining simple improvements. Workshops targeted toward landowners along the waterways can guide them in restoring healthy riparian zones by providing them with restorative plants. This restoration further reinforces the role of waterways as an asset to the community. The ward-level coalitions that promote awareness and guide action could promote comprehensive approaches to healthier waterways.

Implementation Information:
Who: Ward Counselors and Community Coalitions
Urgency: 5
Timeline: Immediate
Cost: Low-cost
Examples: See 1-2 below

1. The Buffalo Niagara RIVERKEEPER through their Living Shorelines Program helped riparian land owners return the shoreline to a healthy riparian buffer restoring its beauty and improving habitat through educational workshops and carefully selected plantings.
   Link: http://bnriverkeeper.org/?s=riparian

2. Riparian buffer zones offer many benefits including increased habitat for animals, habitat for pollinators, protection from flooding, as well as food and habitat for aquatic species.
   Link: http://www.agroforestry.net/the-overstory/105-overstory-167-riparian-buffer-zone-restoration-for-food-security

SOLID WASTE STRATEGIES

14. VERIFY THE BEST SOLID WASTE TREATMENT FACILITY, PRIORITIZING ENGINEERING STANDARDS AND HIGH CAPACITY

Narrative/ Rationale:
Examine Brahmapuram and other Solid Waste Management (SWM) facilities in conjunction with Clean Kerala to identify an existing facility that has the following qualities: (1) a large capacity, (2) a reasonable travel distance from Maradu, and (3) meets specifications for SWM Facilities outlined by The Ministry of Environment, Forests, and Climate Change, Government of India. If none of the facilities meet the specifications, work with a facility, selected for its proximity to the Municipality, to meet the proper engineering standards and to increase capacity.

As the population of Maradu grows land availability will be at a premium and the amount of waste will continue to grow. Land may not be available for the expansion of SWM facilities and therefore will need to be utilized most efficiently. Following the engineering guidelines introduced by the Government of India for SWM the Municipality ensures that they are being responsible stewards to the land and the surrounding populations. The specifications ensure leaching will not occur into local water sources and that resources generated from the landfill, like methane, can be captured and utilized to generate electricity to run the facility.

Implementation Information:
Who: Maradu Municipality and Clean Kerala
Urgency: 1
Timeline: Short-term to Medium-term
Cost: Medium-cost
Example: See 1 below

1. Specific guidelines for properly engineered solid waste management facilities are outlined in the Solid Waste Management Rules provided by the Ministry of Environment, Forest, and Climate Change part of the Government of India (2016).
   Link: http://www.indiaenvironmentportal.org.in/files/file/Solid%20Waste%20Management%20Rules,%202016.pdf - Ministry of Environment and Forests. 2016. Solid Waste Management Rules, Schedule I. pg 65-68

15. ENHANCE FUNDING FOR SOLID WASTE MANAGEMENT THROUGH INNOVATIVE AUTOGENOUS STRATEGIES AND BY SEEKING EXTERNAL AID

Narrative/ Rationale:
One of the major roadblocks to implementing solid waste management (SWM) improvement projects is the lack of funds available to the Municipality. These funds may be found or raised from either internal or external sources. Maradu may raise or conserve funds on their own through creative financing by utilizing techniques such as public-private partnerships (PPPs) and effective administration of user fees. Alternatively, the Municipality may seek grants from higher levels of government or apply for aid from private sources. Regardless of the method employed, it is imperative that Maradu become more financially secure in order to better supply much needed SWM services to residents.

User fees are a good way to recover some of the cost of providing SWM services. It has been reported that the Kudumbashree already employ a form of the user fee system, though it is unclear if this system is being exploited to its full advantage. If properly administered with appropriate rates set, accompanied by a high fee collection efficiency, user fees should account for the entire cost of operation and management for collection, transport, and disposal of solid waste. If a satisfactory collection service is regularly provided, residents may be willing to pay a well-set user fee with little hesitation. The rate of a monthly user fee could be on a sliding scale dependent on income. Poor households may be levied a smaller fee than wealthier households who in turn may not pay as much as shops or offices. Large commercial establishments may pay the most. A portion of the fee could be retained by the Kudumbashree worker but the rest may go to funding other steps of the transport and disposal of solid waste. This system should be assessed as part of Recommendation 20.

PPPs can effectively reduce the cost of service provision. Privatizing services such as street sweeping or waste collection and transport, the Municipality can save money and boost service quality by leveraging the competitive nature of the open market. Also, because private contractors do not need to pay workers government salaries, their cost of operation will be less, improving efficiency. Data from 2006 has shown that Bangalore saved 50% of the cost of SWM services by privatizing 61 contracts and Hyderabad saved 65% by privatizing 161 contracts (Figure 19). There are numerous types of contracts available, but performance-based service contracts ensure the private partner performs to an adequate level of service.

It is also important that the Municipality become aware of and take advantage of all available government funding. Funding should be mainly expected from state sources but the central government may initiate financing plans periodically. There may be grants and aid packages issued by the state and central governments, though these may be aimed at specific types of projects such as funding for composting or waste-to-energy initiatives. Though relying on government funding is necessary at present, it would be beneficial for Maradu to seek to become as financially independent as possible in the future.

Implementation Information:
Who: Maradu Municipal Council
Urgency: 1
Timeline: Immediate
Cost: Low-cost to Medium-cost

Figure 19: Street sweeping in Hyderabad

Box 4.4 Street Sweeping in Hyderabad

Unit Area
In Hyderabad, a yardstick of 500 meters road length per one sanitary worker is used. A team of 15 female workers for street sweeping, 3 male workers for carrying the street sweepings in handcarts to the secondary waste storage depot, and 1 supervisor is assigned per unit area of 8 kilometers' road length.

Contracting Model
Using the state's minimum wage structure, requirements for tools and equipment, and a reasonable profit margin for the contractor, a unit cost of Rs 48,853 per month per 19 sanitation workers for cleaning the streets during the day and Rs 69,250 per month per 19 sanitation workers for cleaning of important roads at night was calculated. Contracts were prepared for 161 packages to cover approximately 75 percent of the city roads, measuring 2,238 kilometers in road length; 1,928 kilometers were assigned for day sweeping, and 310 kilometers were assigned for night sweeping. Only one unit will be allotted to each contractor.

A team of street sweepers in Hyderabad is assigned a per unit area of 8 kilometers of road length. (Photo by the Centre for Environment Education)

Source: Centre for Environment Education.

Source: Zhu, Da and World Bank Institute. (2007). Improving municipal solid waste management in India a sourcebook for policymakers and practitioners. Washington, D.C. World Bank.

16. USE INFORMATION GATHERED ON PRIMARY COLLECTION OF SOLID WASTE TO IMPROVE THE EFFECTIVENESS OF THE KUDUMBASHREE PROGRAM IN MARADU

Narrative/ Rationale:
More comprehensive and efficient solid waste collection may be achieved by reforming the Kudumbashree program. Kudumbashree leadership who, upon obtaining all necessary information from Recommendation 19, may analyze the data along with other information currently at hand, such as municipal spending related to the Kudumbashree program. This will grant the Municipality the information to make necessary changes to the Kudumbashree program to provide enhanced primary collection services. Enhancements will be most effective if they focus on ensuring waste collection occurs for all households and businesses and that collection of further types of waste occurs. In order to increase waste recovery for all of Maradu, it is important to ensure collection services accommodate all houses and businesses within the Municipality. Once service exists for the whole Municipality, participation may be encouraged by aligning the service fee to client income and demonstrating benefits of the service.

Plastics predominate Kudumbashree collection. In select instances, wet waste is collected for compost. Plans have been expressed to expand the practice of collecting organic matter for compost to reduce informal dumping, the attraction of vermin, and the spread of disease. Collection of compost will also provide a modest income for Kudumbashree workers who may sell the final product. Other types of waste may be collected if treatment can be provided, further reducing informal disposal and the diffusion of pollution.

Implementation Information:
Who: Maradu Municipal Council
Urgency: 2
When: Immediate
Cost: Low-cost to Medium-cost: Variable depending on improvement strategy(s) selected

17. PROVIDE SUFFICIENT AMOUNT OF GARBAGE RECEPTACLES PER WARD AND WORK WITH CLEAN KERALA TO ENSURE A SUITABLE COLLECTION METHOD OF GARBAGE BINS IS MAINTAINED

Narrative/ Rationale:
Currently, Maradu is lacking a sufficient number of garbage receptacles for waste disposal. As a result, waste is disposed of by incineration and illegal dumping, causing poor respiratory health and clogging of waterways, respectively. By ensuring proper coverage of waste receptacles, Maradu can cut down on the amount of incineration and illegal dumping that is occurring. Kudumbashree workers can disperse garbage receptacles throughout each ward in Maradu. However, it's necessary that these new receptacles are properly serviced to prevent overflow. This can be attained by working with Clean Kerala to ensure a proper service schedule is created. Collection of each garbage receptacle will take place once a week, and the schedule can be adjusted as necessary to make certain that waste is efficiently removed.

Implementation Information:
Who: Kudumbashree workers and Clean Kerala
Urgency: 2
Timeline: Immediate to Short-term
Cost: Data unavailable to estimate

18. IMPLEMENT JOINT MUNICIPAL AGREEMENTS TO FOSTER SHARING OF SOLID WASTE INFRASTRUCTURE

Narrative/ Rationale:
The current waste management infrastructure is inadequate for the growing populations of people in Maradu and the surrounding area. While community led efforts to encourage people to properly dispose of their solid waste and waste water may impact behavior change the ultimate change must be in the infrastructure to support these new behaviors. Large infrastructure projects necessary for urban sanitation often exceed the feasibility of individual municipalities like Maradu to undertake. Sizable operations pay less per unit of waste than small operations because the cost of overhead operations scales disproportionately. To solve this, nearby municipalities and/or corporations often team together to construct landfills and other regional sanitation facilities.

Maradu may work with other nearby ULBs such as Kochi to find the means necessary to realize the plastic shredding facility currently being planned. A partnership with Kochi in which Maradu shreds some of their plastic, in addition to their own, in return for partial financial support from Kochi may grant Maradu the means to realize the project. A similar strategy may be employed to establish a temporary or permanent liquid waste treatment facility.

Implementation Information:
Who: Maradu Municipality Council
Urgency: 2
Timeline: Immediate
Cost: Data unavailable to estimate

19. SEGREGATE HAZARDOUS WASTE/UNIVERSAL WASTE/HOUSEHOLD WASTE

Narrative/ Rationale:
Segregation of household wastes from hazardous and universal wastes is important in improving solid waste management in Maradu. Segregation of these wastes will protect surface and groundwater supplies and soils from contamination, and will reduce the volume of waste that require landfilling. Segregation of household, universal, and hazardous waste should be practiced at the household, commercial, and industrial level. The public health sector may consider issuing a list of constituents that classify wastes as universal or hazardous. A specialized unit of the Sanitation Task Force could be created to oversee segregation and disposal of classified wastes and to enforce compliance with proper segregation and disposal procedures. The Task Force may consider distribution of proper collection bins for large hazardous waste producers such as businesses and industries. Standardized descriptive labels should be issued along with collection bins and should list a phone number to call to have the Task Force pick up the collection bins when they become full. The ULB should select a protected temporary collection site for bins until a hazardous waste landfill is constructed. Collection of hazardous and universal wastes will be at the expense of the generator and fines should be issued by the Task Force for failure to comply with proper segregation practices or improper disposal. Best management practices should be evaluated by the engineering sector to determine if recycling of hazardous waste is suitable and to decide where residual wastes may be disposed of. A specialized, permanent hazardous waste landfill will be the terminal acceptor of the segregated wastes.

Implementation Information:
Who: ULB, Sanitation Task Force, Public Health Department, and Engineering Sector
Urgency: 3
Timeline: Immediate (Provision of specialized collection bins and select temporary collection site) and Long-term (construction of hazardous waste landfill)
Cost: Medium-cost (salary for additional employees as specialized Sanitation Task Force unit, specialized bins and labels) and High-cost (construction of a hazardous waste landfill)

20. INVESTIGATE AND IMPLEMENT SOLID WASTE REDUCTION STRATEGIES

Narrative/ Rationale:
An efficient way to ameliorate problems related to solid waste in Maradu may be to simply reduce the production of waste that needs to be disposed of in a landfill. Reduce, reuse, and recycle are three primary methods employed to minimize solid waste arriving in landfills. These strategies will lessen the burden of collecting, transporting, and treating solid waste by lessening the amount of waste to be handled to a more manageable size. Reducing waste generation also means that fewer resources are consumed.

Strategies for waste reduction fall into two categories; those requiring policy and those requiring other forms of ULB support or action. Policy options typically require producers to take responsibility of the post-consumer stage of their product. These approaches to policy are termed Extended Producer Responsibility (EPR). EPR policies mandate tasks such as segregated collection, reuse, recycling, and/or storage and treatment. Specific EPR policies that may be useful in Maradu include quotas in which the Municipality requires packaging for specific product types to be made of a set percentage of recycled material, product bans where products made with certain harmful materials are banned from being sold within the Municipality, product charges in which an eco-tax is levied on products made with undesirable materials raising cost and reducing consumption, and collection systems that require the producer of a product to take back packaging and/or used products such as batteries.

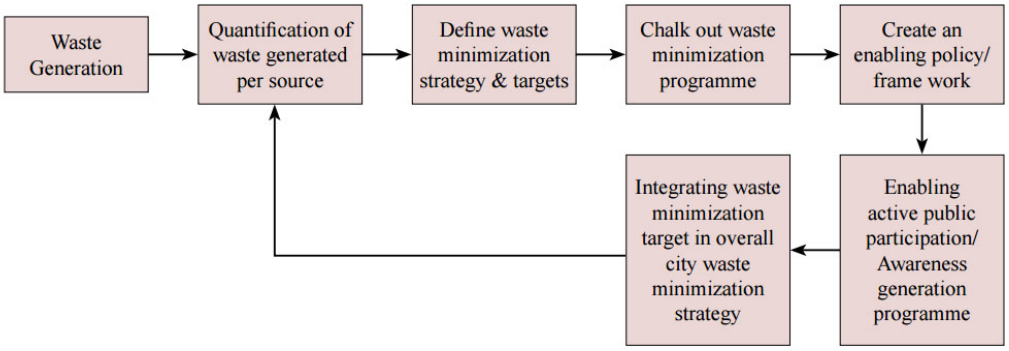
Waste minimization programs that may be implemented with other forms of municipality support include composting programs that remove organic waste from the municipal waste flow, encouraging local businesses to take back recyclable products, and programs that educate local businesses and industry

on how to reduce waste generation through efficient material usage. Waste minimization programs succeed most when developed with expert advice and stakeholder input. Seeking support from the state in the form of buttressing policy or providing funds further promotes the success of such initiatives.

Implementation Information:
Who: The Maradu Municipal government
Urgency: 3
Timeline: Immediate
Cost: No-cost to Low-cost
Examples: See 1-2 below

1. Steps for municipalities to take in producing waste reduction strategies
   Link: http://www.indiaenvironmentportal.org.in/files/file/municipal%20solid%20waste%20management.pdf
2. TerraCycle, collects difficult to recycle waste and reuses, recycles, or upcycles it into usable products. Their collection programs promote recycling and can act as a fundraiser for the Municipality.
   Link: https://www.terracycle.com/en-US
   Link: https://www.terracycle.com/en-US/brigades/haincelestial

Figure 20: Developing a Waste Minimization Program for Municipalities



Source: Central Public Health and Environmental Engineering Organisation. (2014). Municipal Solid Waste Management Manual. Government of India. Ministry of Urban Development. Retrieved from http://www.indiaenvironmentportal.org.in/files/file/municipal%20solid%20waste%20management.pdf

COMMUNITY-BASED INITIATIVES

21. REINSTATE THE CITY SANITATION TASK FORCE TO CATALYZE THE WARD-LEVEL SANITATION COALITION AND TO CREATE GOVERNANCE STRUCTURE TRANSPARENCY FOR THE RESIDENTS OF MARADU

Narrative/ Rationale:
The City Sanitation Task Force could be reinstated to take responsibility for and support sanitation efforts in Maradu on the larger town scale and in the individual wards. The City Sanitation Task force could lead the effort to create ward-level sanitation coalitions, providing guidance on how residents can appoint leaders and create sanitary environments in their communities. The City Sanitation Task Force could also be responsible for diagramming the governance structure related to drinking water, wastewater, liquid waste, solid waste and recycling. It is important for residents and leaders to understand the organizational structure and functions of the ULB to ensure sanitation plan implementation. A chart of the organizational structures could allow for clear understanding of the governing systems. Residents must understand organizational structures so that if issues arise in the operation of the system, the residents can be empowered to notify the proper section of the ULB.

Implementation Information:
Who: Maradu Municipality, City Sanitation Task Force
Urgency: 1
Timeline: Immediate
Cost: Low-cost

22. ESTABLISH WARD-LEVEL COMMUNITY COALITIONS THAT PROMOTE PUBLIC AWARENESS AND GUIDE ACTIONS RELATED TO SANITATION AND PUBLIC HEALTH EQUITY

Narrative/ Rationale:
Collective efforts from residents would make healthy sanitation solutions and daily practices more sustainable for the town of Maradu. A community coalition could be responsible for sanitation and public health equity in three ways: (1) generate campaigns to educate the community about sanitation and public health equity, (2) identify areas in neighborhoods that do not comply with existing water, wastewater, and solid waste laws, and (3) represent ward-level sanitation concerns to the Municipality as well as clarify the intentions and regulations of the Municipality for the town residents.

This coalition could consist of three coalition heads, including the ASHA worker, sanitation engineer, and representative from the Public Health Centre (PHC), as well as up to six individuals from the local ward. The ASHA worker assigned to each ward is already tasked with holding awareness meetings with residents and reporting health concerns to the ward Councilor. As a part of these awareness meetings the sanitation engineer and the representative from the PHC can be on hand to address technical questions the residents may have about health and sanitation. The local ward members assigned to the coalition would be responsible for portraying the concerns of the ward and making decisions on specific campaigns the coalition should pursue. The local resident members of the coalition could receive specific training and education about sanitation and public health equity by the Municipality as well as other organizations to ensure they are representing the community in the best way possible.

Alternating campaigns accompanied by monthly meetings to educate the community about the relationship between sanitation and public health could be conducted. At the public meetings discussions about specific ward performance in terms of sanitation would be guided by the coalition and information on where improvement is still needed within the ward would be collected. This information could be combined into a quarterly report. The community coalition could use this report and other relevant resources to present information to their communities to show areas of improvement over time to encourage their residents to continue to make improvements to their waste and sanitation practices. This group would report to the ward councilor on a regular basis by sharing their quarterly report. The ward councilor could mediate between the larger Municipality and the local residents when the coalition is in need of resources and support for events or community clean-ups.

Implementation Information:
Who: Maradu Municipality, ward councilors, ward residents
Urgency: 3
Timeline: Immediate
Cost: Low-cost
Example: See 1 below

1. The report, "Community Approaches to Total Sanitation", created by UNICEF, gives examples from Sierra Leone, India, Zambia, and Nepal of community members improving the sanitation of their local environment. The document includes "The Essential Elements of Community Approaches to Total Sanitation" to give communities direction on how to begin the process of creating a total sanitary environment. UNICEF also references the "Handbook on Community-Led Total Sanitation" which describes strategies for local governments to sensitively encourage community sanitation efforts.

23. INITIATE AND PROMOTE NEIGHBORHOOD CLEAN-UPS

Narrative/ Rationale:
This recommendation proposes that the community sanitation coalition initiate and promote neighborhood clean-ups. Collective and local efforts from the ward could promote good trash disposal and recycling behavior in the community by rewarding those who participate with a free bus pass or other type of incentive. Community clean-ups could be scheduled and organized by the ward community sanitation coalition at local ward meetings as a regular monthly event or as a part of a holiday celebration like Gandhi Jayanthi. Residents of each ward would volunteer to spend certain days or a certain amount of each day picking up trash in streets, drains, and open spaces in the ward. These clean-up initiatives could occur as often as necessary depending on the number of residents that are willing to participate. Any potential equipment needed for clean-ups could be provided by the Municipality of Maradu or the Kudumbashree.

Implementation Information:
Who: Maradu Municipality, Kudumbashree, ward residents
Urgency: 3
Timeline: Immediate
Cost: Low-cost

24. PROVIDE SIGNAGE OR SYMBOLOGY FOR EDUCATIONAL AND INSTRUCTIONAL PURPOSES

Narrative/ Rationale:
This recommendation proposes that the community sanitation coalition provide signage/symbology for educational and instructional purposes. This symbology/signage could serve several roles for the community. It could inspire and remind the community to care for their physical environment in the form of public art through wall murals and posters. It could also instruct the community on how and where to dispose of their waste or collect their plastic recyclables. The signage/symbology should occur in all Maradu wards and should be posted on high traffic streets. These murals could be painted by local schools as part of an art course or by a professional local artist. A formal and instructional type of signage could be paid for and installed by the Maradu Municipality.

Implementation Information:
Who: Maradu Municipality Standing Committee for Welfare & Standing Committee for Education, Arts and Sports, local school children, local artists
Urgency: 4
Timeline: Immediate
Cost: Low-cost
Examples: See 1-2 below

1. Figure 21: An example of a community mural
   Link: http://www.belfastcity.gov.uk/News/News-7107.aspx
2. Figure 22: An example of a instructional signage
   Link: http://www.fm.uci.edu/units/recyling-refuse.html

Figure 21: Community mural in City of Belfast, Ireland

Source: Belfast City Council. (2013). Community mural brightens up west Belfast. Retrieved from: http://www.belfastcity.gov.uk/News/News-7107.aspx

Figure 22: Instructional signage

Source: UCI Facilities Management. (2016). Recycling & Refuse. Retrieved from http://www.fm.uci.edu/units/recycling-refuse.html

25. DESIGN AND DISTRIBUTE BROCHURES TO HOUSEHOLDS ABOUT SUSTAINABLE PRACTICES THAT PROMOTE SANITATION

Narrative/ Rationale:
Currently Maradu Municipality has limited educational programs addressing sanitation practices for their residents. Brochures about proper waste practices will identify official dumping sites, available subsidies for waste management, and sustainable practices around solid waste. The brochures will address various sanitation issues in Maradu. This is a low-to-medium cost recommendation that requires a set schedule of distribution, perhaps bimonthly. These brochures could be produced by Maradu Municipality and distributed by the Kudumbashree. Measuring the success of this intervention is necessary to assess its potential utility. One way of measuring the effectiveness of these brochures might be by conducting surveys to an illustrative sample every year, and utilizing existing subsidies through sponsorships in the brochures.

The educational brochures could be distributed on a month to month basis and might contain information regarding: cover-biogas, biopot, composting, rainwater collection/filtration, terraced gardening, composting, composting toilet, biogas, specifics of septic treatment, community opportunities for involvement, opportunities to participate in classes given in the community, creation of a community garden and subsidies available to private residences.

Implementation Information:
Who: Maradu Municipality and Kudumbashree
Urgency: 5
Timeline: Immediate
Cost: Low-cost
Example: See 1 below

1. A sample tri-fold brochure that prints on standard sized paper can be used as a template for additional brochures (Figure 23).

Figure 23: Sample tri-fold brochure about composting

Source: University at Buffalo. (2016). Studio Planning and Design for Global Health Equity.

26. SPONSOR SCHOOL COMPETITION PROGRAMS FOR WATER QUALITY AND SANITATION SOLUTIONS

Narrative/ Rationale:
Sanitation and water-related issues continue to persist in communities, disproportionately more in disadvantaged communities that experience worse health outcomes related to sanitation and water concerns. School-sponsored programs, such as competitions, may foster curiosity and educate the next generation to pay more attention to sanitation and water quality. These programs may generate a cascading effect to encourage community ownership in addressing problems related to public health and sanitation.

In Maradu there are five primary schools, three middle schools, and four secondary/senior secondary schools. These schools may implement water and sanitation related competitions to foster results similar to those of the Socio-Economic Unit Fund (SEUF) School Health Clubs (SHC) competition programs. We propose that the competitions be continuously initiated during each school term in varying levels of scope and scale. The school competitions may be scaled-up and conducted between different schools. It is important to implement pilot programs to test the feasibility and success of this program, to ensure cooperation between the municipal government, schools, and involved groups, and to continually re-evaluate these competitions to ensure sustainability and effectiveness.

Implementation Information:
Who: Maradu grade schools (faculty and administration), Maradu Municipal government (education officials), community groups, and students
Urgency: 5
Timeline: Immediate
Cost: 3,000-15,000 rupees
Examples: See 1 below

1. Socio-Economic Unit Foundation's (SEUF) School Health Club Programme (SHC), believes that children have potential to affect changes in their families. To date, SEUF has organized 1,230 SHCs in Kerala, and their activities have been well received and supported by Parent-Teacher Associations (PTAs) with the support of Primary Health Centres (PHCs).

SHCs focus on three areas of action: (1) Facilitating discussion to generate awareness on issues related to health, sanitation, and hygiene (e.g., assemblies, expert guest-lectures, and informational posters in schools), (2) Forming healthy habits (e.g., maintaining clean spaces/facilities in schools, maintaining and cleaning community taps, and healthy habit campaigns), and (3) Disseminating knowledge and practices about sanitation (e.g. SHC members and sanitation programmers work with local government to visit poor neighborhoods, participate in community cleaning, and encourage children to discuss these topics with family).

A specific SHC initiative involves competitions for school children and teachers to promote awareness about hygienic habits related to water and sanitation through essay writing, elocution, drawing, songs, and skits. PTAs and other groups such as merchant associations sponsored the SHC programs and provided prizes for most participants.

Please contact Kochurani Mathew of SEUF to seek assistance related to these programs.

Link: http://kerala.ngosindia.com/socio-economic-unit-foundation-thycaud/

27. IDENTIFY OPPORTUNITIES FOR PUBLIC GREEN SPACES IN RESIDENTIAL NEIGHBORHOODS

Narrative/ Rationale:
Throughout Maradu, households use open spaces for dumping and burning solid waste. These open spaces are in very close proximity to residential areas and are often used as an extension of neighboring home owners property. By distinguishing the land from surrounding properties using signage and human-scale amenities, (e.g., park benches, trash receptacles, and/or playgrounds with multiple entry points), residents are less likely to dump waste in public spaces and parks. Maradu Municipality should define the public space and provide a suitable recreational environment for residents.

A pilot program could be initiated in any of the available public spaces within Ward 4. There are several public access points available to community members and surrounding neighbors so there is no exclusivity to availability and open entrance. There are a few public incineration sites that require cleaning that is primarily performed by sanitation workers under the Health Department.

There is no signage indicating restrictions on public dumping nor is there any indication that these vacant lands are public space. To define this space or any residual space in the town as public recreational land, the Municipality may incorporate amenities such as park benches, gardens and/or playground equipment to the space for all residents to enjoy.

Implementation Information:
Who: Public Health Department (sanitation workers for initial cleaning/ maintenance)
Urgency: 5
Timeline: Immediate
Cost: Low-cost
Example: See 1 below

1. In Jagraon, a rural Municipality further north in Punjab with a similar population numbering over 40,000, the municipal government successfully transformed an unsightly dumping area into a pocket park consisting of 2.5 acres of green space with playground amenities. The transformation cost the Municipality 35 lakh rupees.

Figure 24: An empty lot in Maradu, currently used for burning trash and parking unused vehicles

Source: Photo by University at Buffalo

28. DESIGN PUBLIC RECREATIONAL GREEN AND BLUE SPACES BETWEEN NEIGHBORHOODS AND CANALS

Narrative/ Rationale:
Promoting the public use of canals, rivers, and other waterways provides opportunities for recreational events that include picnicking, fishing, boating, walking, and playing. Bringing people to the canals could also be a reminder for the potential of inland water transportation. With crowded roads water transportation could be quicker and less resource intensive. Maintenance of existing canal walls and development of green spaces and seating areas could encourage residents of Maradu to spend more time outside appreciating their environment and their neighbors as well as traveling on the water. Public efforts to beautify these areas may lessen the prevalence of dumping and polluting in the waters. Involving community members as a whole is likely to increase civic pride to invest in sanitation efforts. A new emphasis on the water may also spur business for water taxis or ferries from smaller municipalities to Kochi.

Examples of initiatives include creation and maintenance of public seating areas and docks that act as transportation hubs, promoting recreational uses such as floating docks, fishing, and growth of edible vegetation and ornamental foliage. These revitalization efforts will improve the environment, community spaces, and overall quality of life for residents.

Implementation Information:
Who: Maradu Municipality - Standing Committee for Works
Urgency: 5
Timeline: Immediate
Cost: Data unavailable to estimate
Examples: See 1-2 below

1. A design concept found in Izmir, Turkey, seen in Figure 25 is a relevant precedent. Urban designers at iyiofis, in collaboration with the Izmir University of Economics have created the Think Micro project. A series of small floating modular and multifunctional spaces designed to line the city's waterfront. These spaces may be used as floating docks and piers to act as social gathering places and facilitate fishing and recreation. The project highlights the use of local small-scale improvements that increase communal interaction and civic pride.

2. Another example of this concept was created by the Ministry of Environment and Water Resources in Singapore; the Public Utilities Board (PUB), a water agency created to manage the water supply, water catchment area and sewerage. PUB launched the ABC Waters program (Active Beautiful Clean waters for all) in 2006. ABC Waters program promotes water cleanliness and conservation, which involves beautifying the banks of the Kallang River by planting willow trees and flowering shrubs. Floating docks, boardwalks, and walkways facilitate community and recreational activities along the waterfront. A waterwheel centerpiece draws attention to the beautiful waterway.

Figure 25: Think micro project on the coastline of Izmir, Turkey

Source: Project for Public Space. Think Micro: Izmir, Turkey. Retrieved from http://www.pps.org/places/lqc/think-micro/

Table 20. Recommendations Key: Urgency

Recommendations Key: *URGENCY*	
How soon should this recommendation be set in motion?	1-5 scale; 1 being "very soon" and 5 being "it can wait"

Table 21. Recommendations Key: Timeline

Recommendations Key: *TIMELINE*	
Term	**Timeframe**
Immediate (I)	0-12 months
Short-term (S)	1-3 years
Medium-term (M)	3-5 years
Long-term (L)	5-15 years

Table 22. Recommendations Key: Cost

Recommendations Key: *COST*	
Term	**AMOUNT**
Actual extimate of cost ($*)	Derived from precedent research
Low-cost ($)	0 - 2 million rupees
Medium-cost ($$)	2 - 5 million rupees
High-cost ($$$)	5 - 15 million rupees
Data not available (DNA)	Unable to determine cost due to unavailable data

Table 23. Recommended Ideas for Maradu

Category and Recommendation		Urgency	Time	Cost
Data Collection	1. Use citizen science to map roads, buildings, and public facilities	1	S	$*
	2. Assess existing drinking water infrastructure	1	I	$
	3. Finalize the locations of ward-level solid-waste aggregation sites	1	I	DNA
	4. Generate data concerning solid waste collection by Kudumbashree and the system of primary collection of solid waste	1	I	$
	5. Identify high contamination areas of waterways through testing conducted in partnership with schools or Inland Waterway Authority	3	I	DNA
Wastewater	6. Establish a temporary septic treatment and disposal site as part of a phased sanitation stratgey	1	I	DNA
	7. Promote a comprehensive fecal sludge management system	2	I	$$$
	8. Implement procedures for the regular maintenance of drainage systems	2	I	DNA
	9. Develop and create sanitation facilities for underserved areas	3	M	DNA
Freshwater Supply	10. Enhance existing drinking water infrastructure to ensure high-quality and adequate water supplies	1	I	$*
	11. Supplement the public water supply with private water sources through public-private partnerships	2	S-M	DNA
	12. Promote commercial and industrial on-site water recycling systems to conserve freshwater resources	4	I	$$$
	13. Encourage planting of vegetation that restores riparian zones along all waterways in the municipality	5	I	$

Category and Recommendation		Urgency	Time	Cost
Solid Waste	14. Verify the best solid waste treatment facility, prioritizing engineering standards and high capacity	1	S-M	$$
	15. Enhance funding for solid waste management through innovative autogenous strategies and by seeking external aid	1	I	$-$$
	16. Use information gathered on primary collection of solid waste to improve the effectiveness of the Kudumbashree program	2	I	$-$$
	17. Provide sufficient amount of garbage receptacles per ward and work with Clean Kerala to ensure a suitable collection method of garbage bins is maintained	2	I-S	DNA
	18. Implement joint municipal agreements to foster sharing of solid waste infrastructure	2	I	DNA
	19. Segregate hazardous waste/universal waste/ household waste	3	I	$$
	20. Investigate and implement solid waste reduction strategies	3	I	$
Community-based Initiatives	21. Reinstate the City Sanitation Task Force to catalyze the ward-level sanitation coalition and to create governance structure transparency for the residents of Maradu	1	I	$
	22. Establish ward-level community coalitions that promote public awareness and guide actions related to sanitation and public health equity	3	I	$
	23. Initiate and promote neighborhood clean-ups	4	I	$
	24. Provide signage or symbology for educational and instructional purposes	4	I	$
	25. Design and distribute brochures to households about sustainable practices that promote sanitation	5	I	$
	26. Sponsor school competition programs for water quality and sanitation solutions	5	I	$*
	27. Identify opportunities for public green spaces in residential neighborhoods	5	I	$
	28. Design public recreational green and blue spaces between neighborhoods and canals	5	I	DNA

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