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REPORT

FINAL REPORT

MCC Mozambique Urban Water Supply and Sanitation Evaluation Design Report

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ACRONYMS

AES	Advanced Encryption Standard
AIAS	Water Supply and Sanitation Infrastructure Administration (Administração de Infra-estruturas de Água e Saneamento)
ARA	Regional Water Administration Council (Administração Regional de Águas)
CDC	Centers for Disease Control and Prevention
CBAs	Cost-benefit analyses
CMC-CETA	Cooperativa Muratori E Cementisti-CMC Di Ravenna e CETA – Construções e Serviços, SA
COSDECs	Community Skills and Development Centers
CRA	Water Regulation Committee (Conselho de Regulação de Águas)
DHS	Demographic and Health Survey
DNAAS	National Directorate for Water and Sanitation (Direcção Nacional de Abastecimento de Água e Saneamento)
DNAS-GOH	National Directorate for Water – Hydraulic Works Authority (Direcção Nacional de Águas)
DNGRH	National Directorate for Water Resource Management (Direcção Nacional de Gestão de Recursos Hídricos)
EA	Evaluability Assessment
EB	Pumping Station (Estação de Abastecimento)
EMUSA	Quelimane Municipal Sanitation Company (Empresa Municipal de Saneamento de Quelimane)
EMUSANA	Nampula Municipal Sanitation Company (Empresa Municipal de Saneamento de Nampula)
ERR	Economic rate of return
ETA	Water Treatment Station (Estação de Tratamento de Agua)
FGDs	Focus group discussions
FIPAG	Water Supply Asset Holding and Investment Fund (Fundo de Investimento para o Património de Abastecimento de Água)
GDP	Gross domestic product
GoM	Government of Mozambique
IMAGINE	IMprove the educAtion of Girls In NigEr
INE	National Institute of Statistics (Instituto Nacional de Estatística)
INGC	National Disasters Management Institute (Instituto Nacional de Gestão de Calamidades)
IRB	Institutional Review Board

ITT	Indicator tracking table
JICA	Japan International Cooperation Agency
LCC	Lusaka City Council
LWSC	Lusaka Water and Sewerage Company
LWSSD	Lusaka Water Supply, Sanitation, and Drainage
M&E	Monitoring and evaluation
MCA-M	Millennium Challenge Account Mozambique
MCC	Millennium Challenge Corporation
MISAU	Ministry of Health (Ministério da Saúde)
MOPH	Ministry of Public Works and Housing (Ministério das Obras Públicas e Habitação)
MOPHRH	Ministry of Public Works, Housing and Water Resources (Ministério das Obras Públicas, Habitação, e Recursos Hídricos)
MPR	Mathematica Policy Research
MSW	Municipal solid waste
NPA	National Poverty Assessments
NTF	National training fund
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
QA	Quality assurance
RCT	Randomized controlled trial
RFQ	Request for quotes
SDC	Swiss Agency for Development and Cooperation
TA	Technical assistance
TOR	Terms of reference
TRMM	Tropical Rainfall Measurement Mission
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
VTGF	Vocational training grant fund
WASH	Water, sanitation, and hygiene
WBHO	Wilson Bayly Holmes - Ovcon
WSS	Water Supply and Sanitation

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I. INTRODUCTION & BACKGROUND

A. Country context

Mozambique is one of the poorest countries in the world. It ranks 181 out of 188 countries in the human development index and has the lowest rank among 16 countries in the Southern Africa Development Community (UNDP 2016). The country was destroyed by 26 years of civil war, which ruined much of its water and sanitation infrastructure in both urban and rural areas (PPIAF-World Bank 2009). The country has one of the lowest levels of per-capita water consumption in the world, with an average of 50 liters per day, placing it well below global benchmarks (African Development Bank Group, 2016)). Less than one-third of the population in Mozambique has access to piped water. Paradoxically, even as access to convenient, high quality water is out of reach for much of the urban population, flooding is a major problem, particularly in the north, where rainfall averages 8–9 inches per month between December and March. The challenges of access to clean water and exposure to stagnant water contribute to higher instances of water related diseases such as cholera and malaria and reduce the productivity of people in Mozambique. Women and children are most affected since they are responsible for water collection and household duties.

Poor sanitation is another obstacle for Mozambique. More than half the urban population in Mozambique lacks access to an improved sanitation facility such as a septic tank (Mozambique Post Compact M&E Plan 2018).[1] The poor sanitation infrastructure contributes to poor health and reduced productivity among the population, costing Mozambique around $124 million USD each year, or 1.2 percent of the national GDP, with the economic burden falling most heavily on the poorest (Water and Sanitation Program 2012). Poor hygiene and sanitation conditions coupled with insufficient access to clean water lead to cholera and diarrhea outbreaks. Large investments in infrastructure are needed to ensure that water and sanitation services are safe and affordable to consumers (Farolfi and Gallego-Ayala 2014).

In 2007, the Government of Mozambique (GoM) identified improvements in water and sanitation as central to meeting the Millennium Development Goal of reducing infant and child mortality by 2015. Water improvements are also one of the three pillars of the GoM's sustained growth agenda, part of the 2006–2009 Action Plan for the Reduction of Absolute Poverty II (Millennium Challenge Compact 2007). MCC worked with the GoM to design a project that would address some of the barriers to economic growth caused by the poor condition of water, sanitation, and drainage infrastructure. The compact entered into force in September 2008; however, results of lengthy feasibility studies led to a re-scoping of activities and delayed implementation of the WSS project until September 2011, leaving only two years for the WSS activities to be implemented before the compact ended in September 2013. The project included four main activities: (1) urban water supply, (2) urban drainage and sanitation, (3) capacity-building, and (4) rural water. The details of these activities are elaborated in Chapter II.

[1] Improved sanitation facilities hygienically separate excreta from human contact, such as through flush/pour to piped sewer systems, septic tanks, or pit latrines; ventilated improved pit latrines; composting toilets; and pit latrines with slabs.

B. Objectives of this report

In 2018, MCC contracted with Mathematica Policy Research to evaluate the urban activities under the Water Supply and Sanitation (WSS) Project and the sustainability of the infrastructure investments in the post-compact period. (A separate evaluation of the rural water activity was completed in 2013; see Hall et al. [2014].) Mathematica proposes a mixed-methods ex-post performance evaluation including three components:

1. An **ex-post implementation evaluation** that explores how project funds were used during the compact and whether contractors adhered to the planned designs. The implementation evaluation also provides a deeper understanding of how policy changes affected the WASH sector and helps contextualize the outcome analysis. The ex-post implementation evaluation will draw from primary qualitative data, including key informant interviews, collected from national and local stakeholders and households in Nampula and Quelimane, a review of project documents, and administrative data provided by water and sanitation utilities and government agencies.
2. An **infrastructure assessment** that examines the adequacy of water supply to the system, the degree to which the water supply and drainage infrastructure is maintained, and how well it operates. The infrastructure assessment includes site visits, inspections, review of project design documents, review of maintenance records, and interviews with staff at the various sites to determine the sustainability of the project's investments.
3. An **outcomes analysis** will examine current outcomes that contribute to the cost-effectiveness of the WSS program. The analysis will use administrative data to determine the extent to which outcomes improved over time. These outcomes include the availability and reliability of water services in Nampula throughout the year; flood incidence; and health outcomes (particularly diarrhea and malaria). The outcomes analysis will be complemented by a multi- case study that examines how access to and reliability of water might affect local businesses in Nampula.

In the chapters that follow, we provide context for the evaluation and describe the planned evaluation design in further detail. In Chapter II, we outline the activities of the WSS and the program logic and summarize the literature related to the effects of similar interventions. In Chapter III, we discuss the research questions that our evaluation seeks to answer and describe the evaluation design and data sources that we will use to conduct the evaluation. We conclude in Chapter IV with a discussion of administrative details related to the evaluation. We present the option-period budget in Appendix A.

II. OVERVIEW OF THE COMPACT AND THE WSS PROJECT

A. Overview of the compact

In July 2007, the Millennium Challenge Corporation (MCC) partnered with the Millennium Challenge Account-Mozambique (MCA-M) to implement a five-year, $506.9 million compact designed to increase the country's economic growth and reduce poverty by investing in four project areas: (1) water and sanitation, (2) roads, (3) land tenure, and (4) agriculture. A major investment under this compact was the $203.6 million[2] Water Supply and Sanitation (WSS) Project, which was designed to improve access to safe, reliable water supply and sanitation services to further the compact's overall objectives of increasing the productive capacity of the population in northern Mozambique, thereby increasing household income in targeted districts and reducing poverty and chronic malnutrition, and specifically benefitting women and children (Millennium Challenge Compact 2007).

The compact entered into force in September 2008. The WSS Project was originally intended to improve piped water systems and storm water drainage for approximately 1.6 million urban beneficiaries in three Northern provinces (Cabo Delgado, Nampula, and Zambezia). The original compact included activities in three large cities (Nampula, Pemba, and Quelimane), and five medium sized cities (Montepuez, Nacala, Monapo, Gurúè and Mocuba). Effective storm-water drainage improvements were expected to benefit nearly the entire population of each city by reducing standing water from rain and flooding that leads to water related illnesses such as cholera and malaria, thus contributing to increases in productivity. The improvements in storm drains and water systems were also expected to encourage new business investment, leading to economic growth. The improved access to water, drainage, and sanitation systems was expected to benefit the elderly by reducing water related diseases that compromise their immune systems. MCC further expected that better access to and quality of water would improve child growth rates and reduce mortality among the elderly and children under age 5 (Cronin et al. 2006). In addition, because women and girls are usually responsible for gathering water, providing water sources in closer proximity to women's homes was expected to enable them to engage in productive activities (Millennium Challenge Compact 2007).

WSS project interventions took place between September 2011 and September 2013 after a series of feasibility studies showed that activities had to be reduced due to time and resource constraints. The rescoping reduced the locations (that is, the number of cities) where the interventions would be implemented from eight to four and the number of activities from 16 to 8 due to the cost and feasibility of completing the works before the end of the compact. Section B describes the final activities funded under the MCC WSS activity.

[2] The original compact amount for this WSS Project was $203,585,393 USD. The total amount disbursed was $200,221,661 (Mozambique Post Compact Monitoring and Evaluation Plan 2018). The completion report (2013) cites a budget of $207.4 million as of September 2013 (p. 33).

B. Overview of WSS project activities[3]

1. Urban water supply activity[4]

The final urban water supply activity included four sub-activities in the cities of Nampula, Nacala, and Mocuba. Each sub-activity is described in detail below.

Rehabilitation and expansion of the Nampula city water supply system ($18.3 million). This sub-activity included the rehabilitation and expansion of an existing extraction and pumping station (EB0); rehabilitation and expansion of pumping station ETA1 to restore its nominal capacity; construction of ETA2, including pumping stations and sludge lagoons; and construction of a new clear water reservoir, new transmission main, and new EB5 distribution center consisting of a reservoir to supply zones that had insufficient pressure.

Rehabilitation and expansion of the Nacala city water supply system ($44.2 million). The goal of this sub-activity was to rehabilitate and expand the Nacala water supply system. However, the contract was terminated due to poor contractor performance and the work has yet to be completed.

Rehabilitation of the Nacala Dam ($40.0 million). This sub-activity aimed to rehabilitate the Nacala dam, which had been functioning with deficiencies since the 1980s. The works increased the carrying capacity of the reservoir and rerouted the road to ensure that traffic did not weaken or damage the dam. However, the intended beneficiaries were not reached because the distribution pipeline (part of the water supply system sub-activity) was not completed.

Box II.1. Key WSS Stakeholders

FIPAG, Water Supply Investment Fund (Fundo de Investimento para o Património de Abastecimento de Água), has responsibility for water supply systems in large cities. FIPAG's role for WSS was to support management and construction of the Nampula City Water Supply System.

AIAS, the Water Supply & Sanitation Infrastructure Authority (Administração de Infra-estruturas de Água e Saneamento) with responsibility for water supply in small cities and responsibility for sanitation in all cities. In terms of project areas, this covers water supply in Nacala and Mocuba and sanitation systems in Nampula and Quelimane.

ARA, Regional Water Administration Council (Administração Regional de Águas) with responsibility for the river basins, water availability, dam operation and flood forecasting. WSS worked with ARA Norte and Centre-Norte.

CRA, Water Regulation Committee (Conselho de Regulação de Águas), oversees the direct, indirect, and consultative tariffs for the water and sanitation sectors.

DNGRH-GOH is responsible for maintaining the reservoirs and reinforcing water management in Mozambique.

DNAAS, the Directorate for Water and Sanitation (Direcção Nacional de Abastecimento de Água e Saneamento), provides political, strategic, and planning guidance to the water sector regarding provision of water once it leaves the reservoirs.

EMUSA(NA), the Municipal Sanitation Company in Qualimane and—newly created—in Nampula, manage sanitations systems and public outreach on hygiene and sanitation best practices.

MORPH, the Ministry of Public Works, Housing, and Water (Ministério das Obras Públicas, Habitação, e Recursos Hídricos), provides overall leadership, policy guidance, and decision making in the water and sanitation sector.

[3] The financial figures in this section are drawn from the MCA Mozambique Close-Out Detailed Financial Plan (DFP) 07/09/2014: Disbursements Tab.

[4] All of the budget values that we discuss in this section are taken from the MCA-M C Mozambique Compact Completion Report dated September 2013. In some cases, we have aggregated values for lots 1 and 2 in order to show the total value of the contract. These values do not necessarily reflect the final amount disbersed as we do not have access to that data for individual activities.

Emergency works for Mocuba city water supply system ($4.8 million). This sub-activity provided critical upgrades to an existing low-lift pumping station and an existing water treatment plant. The sub-activity also funded the construction of a new stone maintenance platform in the Lugela River and added two low-lift pumps and two treated water transfer pumps at the main pumping station. These new systems temporarily doubled the volume of water pumped from the river to the city of Mocuba. However, in 2015, flooding significantly damaged the pumping station and adjacent water treatment plant. The low-lift pumps were replaced using funding from the World Bank, but the flood modified the path of the Lugela River, leading to a significant reduction in the amount of water the pumping station can access to service the city. Currently, the pumping station functions at about a quarter of its capacity during the dry season and at half capacity during the rainy season.

In addition, as part of this activity, limited water source investigations were funded for Pemba, Quelimane, Nacala, and Montepuez, but the studies had not been completed at the time of the completion report. We will attempt to locate these reports and review the final versions as part of the evaluation.

Urban drainage and sanitation activity[5]. MCA-M invested $61.2 million in the rehabilitation and expansion of storm-water drainage systems in the northern cities of Quelimane ($36.6 million) and Nampula ($24.6 million). Both sub-activities intended to reduce flooding and stagnant water and contribute to a reduction in water related diseases, including malaria and cholera. The projects targeted four neighborhoods in Quelimane (with more than 200,000 inhabitants) and six administrative neighborhoods in Nampula (with nearly 470,000 inhabitants).

As part of this sub-activity, feasibility studies were completed for the expansion of wastewater treatment, improvements to the piped sewage network, and increasing the usage of septic systems in urban centers and latrines in peri-urban areas. To our knowledge, none of these studies led to actual projects. However, the feasibility studies played a critical role in prioritizing activities both during and after the compact. The GoM and other donors continue to use the studies (which focused on both water supply and sanitation) to guide decisions about investments in the WASH sector. As a result, Mathematica considers these a positive outcome of the program and includes the studies as part of the document review of the evaluation.

The entire urban population of Nampula and Quelimane, as well as a proportion of the peri-urban population whose drainage canals link into the constructed or rehabilitated storm drainage systems, were expected to benefit from the interventions. MCC estimated that approximately 60 percent and 70 percent of the Quelimane and Nampula populations, respectively, would benefit from the sanitation investments.

[5] Throughout the M&E plan and end of compact report, sanitation and drainage are discussed as one activity. We refer to the activity in the same way throughout the report.

Capacity-building activity ($9.6 million disbursed out of $21 million budgeted). This sub-activity provided training and capacity building to the municipalities of Nampula and Quelimane and also to FIPAG, DNA-DAU, DNA-DAR, DNA-GOH to increase the accessibility, reliability, and quality of sanitation and hygiene services in the peri-urban areas. The sub-activity assisted the municipality of Nampula in the establishment of EMUSANA (an autonomous municipal sanitation company) and provided support to both EMUSANA and EMUSA (the existing company in Quelimane) to carry out their function as water and sanitation managers. Project implementers conducted public outreach to improve hygiene practices and constructed low-cost sanitation facilities in markets and supported activities such as drafting legal legislation, developing advocacy and M&E plans, and human resource development plans. One of the key pieces of legislation created the EMUSANA in Nampula to manage sanitation and storm water drainage and formerly recognized EMUSA in Quelimane. Capacity-building activities were delivered primarily in the form of a training workshop and on-the-job training provided by MCA-M technical staff.

Box II.2. Activities completed under Capacity-building

The Advocacy Plan for Water Sanitation and Hygiene Integration to the Municipal Management Structure

The establishment of the Autonomous Municipal Sanitation Company within the Municipality

A Human Resources Development Plan for capacity building and training

Capacity Building in the Municipality for Monitoring and Evaluation

The development of Guidelines for Program Implementation

The Planning and Budgeting for Implementation of the program

Community Mobilization and Hygiene Promotion

While the Mozambique compact was signed in 2007 and entered into force in 2008, the feasibility studies took more time than expected to complete. These studies provided a wealth of important design information, but delayed project activities until 2011. As the figure below shows, implementers only had two years to complete activities. The timeline below highlights the major activities along with the start and end dates for the WSS project.

Figure I.1. MCA-M WSS Implementation Timeline

Activity	Start Date	End Date	2007		2008				2009				2010				2011				2012				2013			
			Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Compact signed	7/13/2007		Δ																									
Compact entry into force	9/22/2008						Δ				Δ				Δ													
Conduct feasibility studies	2009	2011							→	→	→	→	→	→	→	→												
First rescoping request	1/26/2011																Δ											
Second rescoping request	3/29/2011																Δ											
Nampula storm drainage construction	5/1/2011	8/30/2013																Δ	→	→	→	→	→	→	→	→	Δ	
Nacala dam construction	5/26/2011	6/1/2013																Δ	→	→	→	→	→	→	→	Δ		
Nampula water supply construction	8/1/2011	8/31/2013																	Δ	→	→	→	→	→	→	→	Δ	
Quelimane drainage construction	10/24/2011	8/30/2013																		Δ	→	→	→	→	→	→	→	Δ	
Nacala water supply construction	N/A	N/A																			→	→	→	→	→	→		
Capacity building activity	9/1/2012	8/30/2013																						Δ	→	→	→	Δ
Mocuba water construction	9/27/2012	6/20/2013																						Δ	→	→	Δ	
Compact end date	9/21/2013																											Δ

Table II.1 provides a summary of the implementing organizations for each activity/sub-activity, and the number of intended beneficiaries through the end of the compact, after the rescoping activities.

Table II.1. Summary of WSS activities and beneficiaries

Activity and sub-activities	Implementing Entities	Targeted beneficiaries by 2015[a]	Targeted beneficiaries by 2028[b]
Urban water supply			
Rehabilitation and expansion of the Nampula city water supply system ($44.2 million).	FIPAG/CMC-CETA J.V.	29,519	56,595
Rehabilitation and expansion of the Nacala city water supply system	FIPAG/Implementing entity not available for Nacala city water supply.	20,072	
Rehabilitation of the Nacala Dam ($39.9 million).	ARA/ DNA-GOH/WBHO Enterprise/Jefferes and Green	189,382	-
Mocuba water supply sub-activity ($4.8 million).	AIAS/PBG-SA/R.J. Burnside International Limited	-	53,831
Urban drainage and sanitation			
Rehabilitation of storm drains in Nampula ($12.56 million)	AIAS/ Construções Gabriel A. S. Couto, S.A./ Louis Berger	402,928	353,202
Rehabilitation of storm drains in Quelimane ($28.56 million)	AIAS/CETA-CMC J.V./Louis Berger	200,000	161,323
Capacity building			
The establishment of the Autonomous Municipal Sanitation Company within the Municipality Development of various plans as detailed in Box II.2	HYDRCONSEIL and the Swiss Agency for Development and Cooperation (SDC)	FIPAG, DNA-DAU, DNA-DAR, DNA-GOH	FIPAG, DNA-DAU, DNA-DAR, DNA-GOH

[a] From MCC's M&E plan.

[b] From the close-out ERR and MCC's personal communication on March 4, 2019.

Estimates of the number of project beneficiaries are inconsistent across the documents we have reviewed. According to the compact completion report, by 2015 the WSS project would have assisted over 600,000 beneficiaries, or about 40 percent of the initial target of 1.6 million (see Table II.1). The completion report estimates 1,081 million beneficiaries by 2028, whereas the post-compact M&E plan (2018) estimates 780,000 beneficiaries. Table II.1 summarizes the estimated number of beneficiaries expected by 2028.

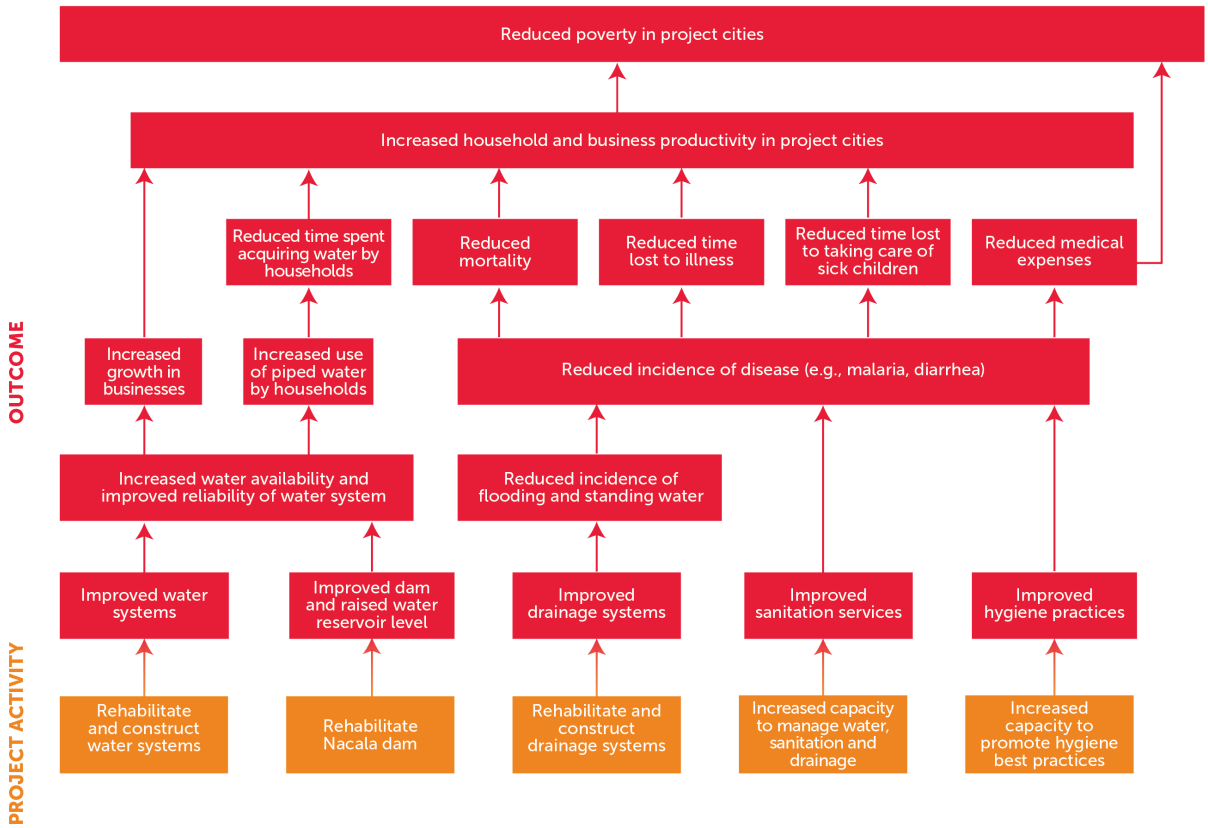
In addition to these beneficiaries, the feasibility studies that were completed under the WSS project continue to benefit the GoM and donors by guiding their investment decisions and helping to prioritize activities in the WASH sector. The reach of these studies contributes additional beneficiaries that can be included in our analysis. Our infrastructure assessment will assess how the government has progressed post-compact and their plans for the future works in Nacala.

C. Theory of change

To guide the evaluation, we have developed a conceptual framework that depicts links in a causal chain as implied in various project documents. Figure II.1 shows this conceptual framework, based on our understanding of project activities after the rescoping.

The conceptual framework begins with the project activities depicted in the bottom row of Figure II.1—specifically, the activities related to water supply (Nampula water supply rehabilitation and construction, Nacala water supply rehabilitation and construction, Mocuba water system repairs, and Nacala Dam rehabilitation and expansion), storm drainage construction and rehabilitation (Nampula, Quelimane), and the technical assistance to AIAS, EMUSA, and EMUSANA. These activities lead to the outputs of new and strengthened water and drainage infrastructure, strengthened capacity to maintain the infrastructure and improve service delivery, and improved hygiene practices depicted in the next level up in the figure. Among the short- and medium-term outcomes, the project was expected to lead to improved water availability and quality water services, and to reduce flooding and standing water. Ultimately, households were expected to benefit from decreased prevalence of water-related diseases and time savings from better access to water, contributing to time and monetary savings that would lead to increased productivity (reflected in the fifth row of Figure II.1). The project's theory of change also hypothesized that if instances of flooding were reduced and local businesses had better and more consistent access to piped water, they would be able to improve customer service, thus increasing economic growth. In addition, the project hypothesized that investors would be more likely to create new businesses if they knew that water infrastructure was in place in the area of investment.

Figure II.1. WSS conceptual framework



D. Cost-benefit analysis and beneficiary analysis

Our review of the economic analysis for the WSS project includes the following four closeout ERR models (which reflect the three rounds of rescoping):

1. Nampula water supply
2. Mocuba water supply
3. Nampula storm water drainage
4. Quelimane storm water drainage

Our review of the ERR calculations for the project shows heterogeneity among the urban areas. It is our understanding that MCC did not conduct an ERR for the Nacala dam sub-activity and did not reestimate the Nacala urban water supply ERR at the end of the compact because the sub-activity was terminated and handed over to the government to complete. Although it is not entirely clear from the project descriptions in the ERR spreadsheets for the two storm water drainage sub-activities, it appears that the benefits of the technical assistance and capacity building sub-activity were not factored into these models. From a summary of the ERRs in the post-compact M&E plan, we infer that the initial ERR grouped all of the activities together rather than considering them separately, with a combined pre-compact estimated ERR of 22 percent for the entire WSS project (including the rural water points sub-activity). As shown in the bottom row of Table II.3, at the end of the compact, MCC estimated that the Nampula storm water drainage sub-activity was extremely cost-effective (estimated ERR of 38.6 percent). The estimated ERR for the Nampula water supply (estimated ERR of 13.4 percent) also surpassed MCC's investment threshold of 10 percent. In contrast, the estimated ERR for Quelimane storm water drainage was just 0.3 percent, and ERR was actually negative (at 2.5 percent) for the Mocumba water sub-activity. In the rest of this section, we review the key elements of the four closeout ERR models. As previously mentioned, the estimated ERR for the entire WSS project (including rural water points) was 22 percent (MCC Compact Closeout Report, 2013).[6]

[6] The closeout estimated ERR for the rural water points was 46.7 percent, making it an extremely cost-effective sub-activity (MCC Compact Closeout report, 2013).

Table II.2. Benefit streams included in closeout ERR analyses[a]

Benefit stream	Percentage of benefits attributable to each benefit stream, by sub-activity			
	Nampula water	Mocuba water	Nampula drainage	Quelimane drainage
Economic benefits of improved water supply				
Monetary savings from use of cheaper water sources	8.6[b]			
Monetized time savings from water collection	8.6[b]			
Value-added of new businesses (previously constrained by the water supply)	87.2			
Health benefits from reduced levels of diarrhea (water) and malaria (drainage)				
Household savings from reduced use of medical care	2.2[c]		29.1	21.2
Household income from reduced child care days	2.2[c]		6.8	8.6
Household income from longer lifespan and reduction in disability	2.0	100	64.1	70.3
Closeout ERR	13.4	-2.5	38.6	0.3

[a] Nacala did not have a closeout ERR due to the implementer's failure to complete the works prior to the end of the compact.

[b] The ERR does not separately identify benefits from lower-cost water sources and time savings.

[c] The ERR does not separately identify benefits from reduced medical care use and reduced child care days.

The benefit streams included in the Nampula water ERR are mostly unfounded and somewhat inconsistent with the sub-activity's rescoped design. As shown in Table II.3, growth in businesses previously constrained by lack of water drives the ERR for this sub-activity, accounting for over 85 percent of the benefits from the upgrades to the water treatment and distribution network. The ERR spreadsheet is not well documented, but it appears to assume that 13 new businesses were created in Nampula in 2011 as a result of project interventions, with 7 new businesses created annually for the next four years (relative to over 650 firms in existence in Nampula at the beginning of the compact, as stated in the ERR). These new businesses are assumed to increase the city's GDP by the ratio of GDP to non-domestic water connections from the previous year (that is, the mean GDP per non-domestic water connection). This approach assumes that new firms are as productive as the average existing firm, which seems overly optimistic. Moreover, there is no justification provided for the number of new firms created each year. Looking back to the document that was the basis for the design of the overarching WSS project, we found no mention of inadequate water supply constraining business growth (although it is certainly plausible).

Household benefits account for a much smaller share of the estimated ERR for the Nampula water supply sub-activity, but it is not clear that they should be included at all. An estimated 8.6 percent of benefits come from household savings from using cheaper water sources and saving time on the collection process; however, this seems to be a holdover from the initial design of the sub-activity, which would have expanded access to the piped water network. Without an expansion in the network, there is no reason to think that the rehabilitations made to the existing network would reduce the cost of water or the time required to collect it, because they do not

change the water sources households use, but instead improve only the availability, reliability, and quality of water provided to households that were already connected to the public network. Health benefits attributable to the Nampula water supply sub-activity are marginal (less than 5 percent of the benefits created by the sub-activity).

The ERR models for the storm water drainage sub-activities in Nampula and Quelimane are almost identical—based entirely on reduced morbidity from malaria—but yield radically different estimates because of differences in population and the costs of the sub-activity in the two cities. Both models assume a number of annual cases that is based on 40 percent of the adult population, 24 percent of the child population, and 99 percent of babies having malaria, although the spreadsheet does not define these age ranges or provide a source for these rates[7]. The rates are then scaled by population, which is just over twice as large in Nampula as in Quelimane. Both models assume that malaria cases are reduced by 50 percent, without providing any references or explanation to justify this assumption. Although standing water is a breeding ground for the mosquitoes that carry malaria, a 50 percent reduction is an incredibly optimistic assumption, because there is a good chance there will still be standing water in the new drains. Moreover, it only takes a tiny amount of standing water for mosquitoes to breed. Even with improved drainage, it is unlikely that mosquitoes would struggle to find a place to lay their eggs, because the drainage is meant to reduce occasional flooding, and the nearby wetlands provide a breeding ground for mosquitos. Despite assuming that 70 percent of the population in Quelimane benefit from the drainage (whereas only 60 percent in Nampula benefit), the fact that there was almost twice as much construction in Quelimane than in Nampula leads to an estimated ERR of essentially zero in Quelimane and over 35 percent in Nampula. Although it is certainly logical that infrastructure serving twice as many people and costing half as much would be more cost-effective, the lack of justification for the health benefits and the assumption that half of malaria cases will be eliminated as a result of improvements to the drainage system brings into question the ERRs.

The ERR model for the Mocuba water supply sub-activity is also based entirely on morbidity reductions (from diarrhea rather than malaria) and suffers from the same weaknesses as the two drainage ERRs. No justification is provided for the assumption that 15 percent of diarrhea cases will be prevented. The ERR model does refer to a Demographic and Health Survey as the source for the share of the population that has diarrhea each year, but it does not cite a specific year; in addition, the rates used in the ERR model seem internally inconsistent (62 percent of adults and children, but only 5 percent of babies, when we would expect lower prevalence among adults, who have built up some immunity).

[7] We believe that the source of these data were key informant interviews conducted by MCC during an in-country mission. The source of the data is not documented in the ERR files.

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III. Evaluability Assessment and Literature Review

A. Literature review

Municipal governments in developing countries often struggle to create a clean and safe environment in which residents and businesses can thrive; the cities participating in the WSS project are typical in this regard. Insufficient quantity, poor quality, and unreliability of piped water are thought to constrain business growth and certainly cause hardships for city residents. Ironically, an overabundance of water—flooding following rains, and stagnant water that has nowhere to drain—also threatens health and productivity. Solid waste management quickly becomes a visible problem, compounding flooding as trash piles up in drains, but is rarely a budget priority—and without resources, it is difficult to collect and dispose of waste or to enforce regulations that are intended to protect people and the environment. The WSS project was intended to help the participating cities overcome these challenges by investing in infrastructure. In this subsection, we review the existing evidence on the two primary drivers behind MCC's estimated economic rate of return for the infrastructure projects: (1) the extent to which improved water services enable firms to grow and (2) the health benefits—and potential unintended consequences—of drainage improvements.[8] We also discuss best practices for municipal solid waste management as the primary focus of the TA sub-activity. After reviewing the existing evidence, we discuss the potential contributions of this evaluation.

1. Summary of the existing evidence and gaps in the literature

Water as a constraint on firm growth. Improving the accessibility and reliability of piped water infrastructure in developing countries is often cited as a precondition for economic growth, particularly in Africa (WWAP 2016). The economic benefits of better piped water services are experienced by many groups, including household members who save time they would otherwise spend collecting water and recovering from waterborne illnesses; health systems, which have fewer patients to serve; and firms that produce goods and services, since water is an important input in many manufacturing processes and services (such as tourism). Both large companies and small- and medium-sized enterprises are positioned to gain from improved water infrastructure through a number of channels, including increased productivity and reduced expenditure on the treatment of employees affected by waterborne illness, reduced cost of water procurement, and averted costs of production disruptions generated by service interruptions, among others (SIWI 2005; Davis et al. 2001). Water infrastructure is also considered a potential requirement to attract new businesses to a region, city, or neighborhood. Mitigating water restrictions may raise locations' appeal to investors or allow water-intensive industries to engage in higher value-added activities (WWAP 2016).

The expectation that water infrastructure can enable firm growth is based at least in part on cross-country regressions that find that macroeconomic growth is positively correlated with water infrastructure (see Esfahani and Ramírez [2003] and Estache et al. [2005] for examples

[8] Drainage can also be an important for preventing damage to infrastructure that can have direct economic costs and also become a drain on productivity if people and goods are not able to freely move through a city. In this literature review, we focus only on the effects of drainage on health, since these other did not factor as much into the estimated economic rate of return for the drainage projects.

specific to Africa). However, cross-country regressions suffer from many potential biases, including the possibility that some factor not included in the model might be influencing both macroeconomic growth and infrastructure. Firm-level evidence can avoid some of these biases, but firm-level data are hard to come by. The limited existing literature on the effects of better water services on firm-level outcomes offers mixed findings on the benefits of improved access and reliability. Escribano et al. (2010) and Moyo (2011) both use firm-level data from the World Bank's Climate Investment Surveys in Africa; the former includes 26 countries and firms in any sector, whereas the latter focuses on manufacturing in just 5 countries. Both papers find important heterogeneities that bear on the relationship between water infrastructure and firm outcomes. Escribano and colleagues find that water infrastructure is not an important constraint for most of the fast-growing countries in Africa (which are limited more by problems dealing with customs when importing or exporting goods), but that in slower-growing countries,[9] water infrastructure is a bottleneck on productivity and on the ability to reallocate resources to more productive uses.[10] Moyo presents data that show the diversity of water infrastructure problems; for example, in Uganda, water is available almost every day but for only a few hours, whereas Tanzania averages almost nine days per month without any water; however, on days when water is available, it is available for almost half the day. Moyo also explores the potential for firms to cope with water infrastructure problems by relying on their own borehole wells, going so far as to suggest that it might be economically advantageous to encourage or even assist firms in countries with serious piped water supply problems to acquire alternative sources such as boreholes. Of the five countries included in the study, the correlation between hours per day without piped water and total factor productivity is only statistically significant in Uganda and Zambia. Islam (2018) is the first study to assess the effects of water shortages specifically on informal firms' productivity. Islam finds that an increase of one standard deviation in the duration of shortages in a month can lead firms to incur an annual average loss of 14.5 percent of monthly sales per worker. The study also finds that the number of shortages per month has no relationship to productivity once the duration of shortages is controlled for. In a case study of micro and small enterprises in two towns in Uganda, Davis and colleagues (2001) compare the outcomes of firms in a town with new piped water supply infrastructure to those for firms in an otherwise comparable town nearby without piped water. They find that although business owners viewed water supply as a binding constraint to their operations, increased access to water did not lead to additional connections or higher water usage, although it generated savings in water costs for some firms (Davis et al. 2001).

In summary, although water infrastructure improvements are widely expected to lead to higher productivity, firm-level evidence is nascent and offers little guidance about whether expected benefits will materialize for businesses located within the reach of specific infrastructure investments. Moreover, although the literature raises the importance of firm characteristics and particular patterns of water supply problems in determining effects, it does not establish which characteristics are most influential. Without better evidence, it is difficult to predict how, how much, and which firms will benefit from water infrastructure improvements.

[9] Mozambique is not included in the study, but it is more similar to countries in the slow-growth group.

[10] It is worth noting, however, that in all of the included countries other than Algeria and Tanzania, electricity is a more important constraint than water.

Health benefits of improved drainage. Drowning may be the most obvious health risk caused by flooding, but the health toll of that immediate hazard might well be dwarfed by longer-term increases in fecal-oral diseases such as cholera, typhoid, and other diarrhea-inducing pathogens, as well as vector-borne diseases like malaria, dengue, and yellow fever (Ahern et al. 2005); unlike drowning deaths, which are relatively easy to count, the health burden of these illnesses is much more difficult to quantify and attribute directly to flooding.

Drainage is recognized as a primary tool for defending against flooding's health consequences, as well as the economic toll. Nonetheless, despite the potential for drainage systems to prevent flooding and protect health, there is very little research quantifying the impacts of drainage systems on health outcomes, and even less that could be considered rigorous evidence. In one of the few studies to attempt to measure health effects of drainage, Moraes and colleagues (2003, 2004) estimated the effects of drainage and simplified sewer systems in informal, low-income neighborhoods in a city of over two million residents in Brazil, comparing neighborhoods that received both drainage and sewerage, drainage only, or neither. The authors' findings suggest that several years after construction, children living in neighborhoods with drainage had less diarrhea infections than those in neighborhoods with neither drainage nor sewer infrastructure, and children in neighborhoods with both had the lowest prevalence rates (ranging from 28 percent of children under 5 years old in the comparison group to 12 percent in the neighborhoods with drainage and 4 percent in the neighborhoods with sewerage and drainage). Similar trends were observed for nematode infections including Ascaris, Trichuris, and hookworm.[11]

Crucially, the drains in the aforementioned studies in Brazil were covered, such that human interaction with the contents of the drain was not possible. In contrast, several studies suggest that open drains create high risks of waterborne diseases. A quantitative microbial risk assessment modeling the risks of exposure to viruses and bacteria in the Bwaise slum of Kampala, Uganda, predicts that exposure to open drainage is the largest contribution to the pooled disease burden from multiple waterborne pathogens, potentially accounting for 50 percent more disease than the next most risky pathway (exposure to grey water in tertiary drains), and far outpacing risks from water stored in the home or collected from unprotected springs, contaminated soil, or tap water (Katukiza et al. 2014). Gretsch and co-authors (2015) also conducted a quantitative microbial risk assessment to evaluate drainage as the source of exposure to fecal contamination for children living in four low-income neighborhoods of Accra, Ghana. In contrast to Katukiza and colleagues, who collected environmental samples and tested for pathogens but relied on assumptions about behaviors that lead to exposure, Gretsch and co-authors collected both environmental samples and primary data on behaviors, such as contact with drains and choice of drinking water source, to calibrate their model. They found that drains' fecal contamination levels were high, regardless of neighborhoods' and drains' characteristics. Frequency of contact with open drains was the primary factor driving risk of exposure to waterborne pathogens (Gretsch et al. 2015).

Several design considerations will influence how drainage effects health. First, despite the best intentions for drainage to prevent flooding, it can be difficult to determine the necessary

[11] Importantly, the parasite outcomes are less subject to bias since they are based on observed pathogens in stool samples as opposed to caregiver-reported diarrhea.

capacity needed to accommodate the rainfall intensity-duration-frequency of the catchment areas. Although existing models may inform this aspect of design, the lack of reliable longitudinal data on rainfall in some areas may lead to the installation of drains that risk being overwhelmed by floods exceeding their carrying capacity. Missing data on runoff creates a similar threat (Parkinson et al. 2007; Parkinson 2002). On a related note, the way water is redirected can reduce the risk of flooding in one area but may increase it in another, shifting health consequences (Jha et al. 2012). Storm drains often carry fecal matter, as documented by the studies cited above and frequently visibly obvious. Clear demarcation of improved drains' direct and indirect areas of influence and assessments of their effect on the distribution of health impacts are needed to fully capture their health outcomes (Parkinson et al. 2007).

Second, management systems for drains and the operational capacity of the organization responsible for maintain the infrastructure can also influence the effect on health. Conventional drain management systems in poor, urban areas face several challenges, including ineffectual drain-cleaning regimes and lack of solid waste management systems. The aforementioned problems are rooted in a number of factors including insufficient resources and manpower, inappropriate equipment, and institutional design (Labite et al. 2010; Parkinson et al. 2007). With regard to the latter, Parkinson (2002) notes that, in some cases, ineffectual management can be traced to the separation of urban drainage authorities from solid waste management departments. It is therefore critical that local urban leaders in developing countries utilize drainage systems as a component of integrated water resource management (Parkinson and Mark 2006; Jha et al. 2012).

Finally, human interactions with drains play a pivotal role in determining the relationship between drain infrastructure and health. As noted by Parkinson et al. (2007), people—particularly those living in the vicinity of drainage systems—often use drains for a variety of unrelated activities, such as irrigation and domestic chores, recreation, and the disposal of fecal material and other forms of waste. Several papers assess how these activities, and their interactions, increase exposure to waterborne pathogens while eroding drainage's functionality in ways that affect health. For example, a quantitative microbial risk assessment aimed at quantifying the health risks of the entire urban water system in Accra, Ghana, found that individuals eating raw vegetables irrigated using drain water are highly exposed to gastrointestinal pathogens such as Ascaris and rotavirus (Labite et al. 2010). The disposal of non-organic and organic waste in drains may affect the drains' microbial load and cause them to become blocked. Blocked drains may fail to effectively channel storm water and, in turn, may result in flooding and the spillage of untreated waste water—factors that are detrimental to health. In the face of these challenges, behavioral change campaigns are considered a key supplement to drainage interventions seeking to improve health (Jha et al. 2012).

In sum, although drains are widely considered a key intervention for reducing the health risks of flooding, research suggests that the construction of drainage systems without complementary institutional and behavioral adaptations may not have positive effects for health. Although literature on drains' impacts is scare, a wide body of work connects negative health effects to drains' design, management, and interactions with human behavior. Research on this topic also suggests that drains' health impacts materialize through different pathways (including direct and indirect exposure) and may vary across space and demographic groups. Understanding

transmission pathways and their particular effects on downstream and proximate populations and children, for example, is key to understanding their implications for health.

Municipal solid waste management. As populations and living standards continue to rise in many developing countries, municipal solid waste (MSW) management has become a focal point of concern (Guerrero et al. 2013). The United Nations lists efficient waste management as a key component of its 11th Sustainable Development Goal focused on making cities safe and inclusive (UN 2018). Developing countries face distinct technical, financial, institutional, economic, and social constraints when attempting to implement successful MSW management (Ogawa 2005). Within Sub-Saharan Africa, for example, the World Bank identified facility overuse, land scarcity, high urbanization and sprawl, and citizen opposition to placing new facilities near their homes as key challenges (Kaza et al. 2018). These constraints are worrisome, as inadequate MSW management is associated with negative impacts on public health and the environment. For example, the burning of waste can result in various respiratory and neurological diseases, toxic runoff from piles of waste leads to water and soil pollution, and the presence of organic waste in waterways reduces available oxygen while simultaneously causing the growth of harmful organisms (Kaza et al. 2018). Poor MSW management has also been linked to economic costs, as the optics of waste buildup are thought to dissuade potential tourism and foreign investment (Ogawa 2005). This is notable for the Mozambican context and for the cities of Quelimane and Nampula in particular, as the country as a whole and those two cities hope to attract more tourism.

Although there is no universal blueprint for achieving efficient MSW management in the developing world's diverse municipalities, existing literature yields a number of best practices. Guerrero and co-authors' (2012) mixed-method study of waste management literature published between 2005 and 2011 suggests that awareness campaigns and institutional knowledge and the availability of necessary equipment play major roles in the successful implementation of widespread waste separation. Additionally, complimentary infrastructure and monetary support from the local and central governments can affect the success of MSW collection and disposal (Guerrero et al. 2012). Kaza and co-authors note that user fees must match residents' ability to pay. With regard to the disposal of MSW, Guerrero and colleagues' (2012) conclusions are consistent with the belief that a strong legal framework on waste regulation and related enforcement mechanisms lead to safer disposal practices. The 2010 formalization of waste pickers in Brazil demonstrates the value in engaging the informal waste management system to increase citizen buy-in and improve collection (Kaza et al. 2018).

With these aforementioned practices in mind, it is important to acknowledge that the current literature has overwhelmingly defined success through a financial lens, often focusing on recovery rates. It is within this gap that our evaluation exists, identifying the indirect relationship of MSW management with sectors of public life such as local business and public health.

2. Policy relevance of the evaluation

Given the dearth of evidence on some of the key assumptions underlying the WSS project logic, anything we learn through this evaluation will add to the literature. In particular, although we cannot do a rigorous impact evaluation of the project, given the lack of a credible comparison group, our planned performance evaluation will provide useful evidence on the effects of better water service on firm growth, the effects of improved drainage on health, and the effects of

technical assistance and autonomy of the solid waste management utility on quality of service delivery, albeit in very particular contexts, as our evaluation focuses on only two cities. Additionally, our evaluation will leverage both quantitative and qualitative data to understand how and why any changes might have occurred. Our evaluation will not only add to the overall evidence base, but will be particularly useful to MCC as one of the first long-term evaluations of the sustainability of infrastructure projects that were implemented early in the organization's history.

Evaluability assessment

The MCC Project Evaluability Assessment tool provides guidance to assess five project dimensions: (1) problem definition and evidence in support of the problem diagnostic; (2) project objectives and theory of change; (3) risks and assumptions, as well as potential risk mitigation strategies; (4) definition of project participants and justification in terms of geographic scope and eligibility criteria; and (5) metrics for measuring results for accountability and learning. Table III.1 summarizes the conclusions from the Evaluability Assessment that Mathematica submitted to MCC in October 2018. In the interest of using the evaluability assessment to guide the design of the evaluation, we focused on the most recent rescoping (August 2011).[12] The complete Evaluability Assessment is included in Appendix X.

Table III.1. Evaluability assessment overview of conclusions

Problem diagnostic
Project objectives and logic
Project documentation only provides a rudimentary project logic with project activities and overarching outcomes. It does not present well-defined causal chains from outputs via short-term outcomes to the overarching outcomes. The EA report, page 61 (Appendix I) presents a conceptual framework for the evaluation that organizes causal chains implied in various parts of project documentation and the economic rate of return (ERR) models. Based on the RFQ and MCC's agreement, Mathematica will assess the cost-effectiveness of the investments in the final report, rather than a full ERR. Our approach to the cost-effectiveness is presented in Chapter IV.
Risks and assumptions
Key risks identified by our analysis are: 1. Mathematica constructed a conceptual framework to depict the project's theory of change after the rescoping activities in 2011. However, project documents do not provide sufficient information on the technical assistance and capacity building projects, so we are unsure of the scope and impact of this activity. 2. We found little or no evidence that businesses in project areas are constrained by lack of access to clean water. As a result, the inclusion of this benefit stream, which accounts for 85 percent of the benefit stream in Nampula, is hard to justify and creates a large risk that the true ERR will be far less than was estimated at the beginning of the project. 3. The measurement for the value of time should be revisited, since several of the assumptions included in the initial ERR calculations assume that any time savings gained by individuals would be used in productive (wage-bearing) activities. However, we know from the literature that time savings can be used in a number of ways, including for leisure. This assumption needs to be built into ERR calculations. We also know that there are gender and age differences in wages in Mozambique that the initial ERR calculations did not take into account. 4. In terms of measuring the incidence and medical costs of water related diseases (malaria and cholera), it is possible that the DHS 2011 data set could have had a large enough sample across the project areas. The WSS project activities had not progressed by the time of DHS data collection in October/November 2011, so the closeout ERR model could use the more updated information. We will also obtain all possible health data from INE; however, we know that INE only has a few data points, which will prevent us from conducting any long-term trend analysis.

[12] It is beyond the scope of the evaluability assessment to judge whether the project's assumptions have been borne out in practice or to reflect on the changes that led to how the project was actually implemented. Mathematica will elaborate on the outcomes of the assumptions in our final evaluation report.

Table III.1 (continued)

Problem diagnostic
Project participants/beneficiaries
Project participants are generally well defined for all three activities that Mathematica will evaluate.
Accountability and learning metrics
Monitoring indicators for processes are well defined.
As a result of three rescoping processes, most output indicators were dropped from the monitoring and evaluation (M&E) plan. However, we recommend exploring the use of several health indicators for the evaluation.

3. Findings from the Mathematica design trip and implications for the evaluation

The Mathematica evaluation team of Audrey Moore, Clair Null, Catalina Torrente and Joe Dalton traveled to Mozambique in October 2018. The results of the mission lead us to focus the evaluation on several key activities that can be assessed in depth. Based on the findings from the evaluation design trip, we will focus our resources on additional data collection and analysis in Nampula (for both water supply and sanitation/drainage) and Quelimane (sanitation/drainage). The evaluation will not conduct additional data collection activities in Nacala or Mocuba, as the works are not benefiting residents of either city, and will not provide adequate lessons to justify the cost, as discussed with MCC. Chapter IV presents our planned evaluation of the interventions carried out in Nampula and Quelimane and describes our approach for collecting data for the evaluation.

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IV. EVALUATION DESIGN

In this chapter, we describe our proposed design for the evaluation of the WSS project. We begin by reviewing the questions the evaluation seeks to address and providing a brief overview of the proposed evaluation design, which includes an ex-post implementation study, an infrastructure sustainability assessment, and a mixed-methods outcomes evaluation. We then describe each element of the design in further detail, including the data on which we will rely and how we will draw on them to answer the evaluation questions.

A. Evaluation questions

Table IV.1 lists the core research questions posed by MCC and explains why each question is important for the evaluation to address. Together, the questions address all layers of the conceptual framework, from the original implementation of the activities (question 1), to whether the activities continue to provide the intended services (question 3), to the full range of outcomes (questions 4–6), and, finally, to whether the investment was cost-effective and what we can learn from the project to improve the design, implementation, or effectiveness of future MCC or government investments (questions 2 and 7, respectively, both of which speak to the ultimate goal of reducing poverty).

Table IV.1. Research questions for the evaluation of the WSS project

Research question	Rationale/justification
1. Was the program implemented according to approved plans and budget?	Implementation of project activities is the first step in the theory of change and is a prerequisite for other steps to unfold. Answering this question is essential to discerning whether lack of impacts may be due to failures in the theory of change (or program logic) and/or to implementation challenges.
2. As implemented, were the activities cost-effective?	This question aims to establish whether impacts of the activities, as implemented, justify the costs. Answering this question provides key inputs for policymakers to decide how to invest limited resources by offering a common metric to compare the returns of potential activities.
3. Are the infrastructure investments operational and being appropriately maintained?	This question aims to assess the project's sustainability and provides the ability to make projections about its long-term costs and benefits.
4. What were the effects of Urban Water Supply Activity on key outcomes (i.e., water supply, water supply reliability, water consumption and/or expenditure, malaria and diarrhea incidence)?	Research questions 4–6 ask about the short- and medium-term effects of each activity on key outcomes. If activities were implemented as planned, determining whether they produced the expected changes on key outcomes is fundamental to testing the theory of change and to answering research question 2. Measuring changes in key outcomes can also point to areas where goals have not been met and further investments are required.
5. What was the effect of Urban Drainage and Sanitation Activity on key outcomes (drainage capacity, flood incidence, flood severity, malaria incidence)?	
6. What was the effect of Capacity-Building Activity on sanitation service delivery?	
7. What lessons can MCC or the GoM apply in future programs to program design, implementation, and sustainment of results?	This question aims to synthesize the lessons drawn from answering questions 1–6. MCC and the GoM can use such lessons to inform the design, implementation, and sustainability of future programs.

In addition to the core questions, MCC also posed more specific questions related to each of the infrastructure investments, the extent to which the infrastructure and TA affected household perceptions and behaviors related to water and drainage, and the current status of the entities that were expected to benefit most from the project: FIPAG, AIAS, and EMUSA(NA). Based on additional information we reviewed for the Evaluability Assessment and learned on the design trip conducted October 13–25, 2018, we also recommend adding two sub-questions related to (1) the effect of the water infrastructure improvements on business growth in Nampula, since this was expected to be the largest economic benefit stream for that sub-activity, and (2) the reasons why Quelimane seems to have a much stronger culture for management of water and storm drainage systems (including stronger political and social institutions) than Nampula, since this difference could have important implications for the sustainability of the infrastructure and benefits in the two cities and could also yield valuable insights about the conditions under which MCC can expect drainage investments to be most cost-effective. The supplemental questions posed by MCC and Mathematica's evaluation team are reflected in Table IV.2, below.

B. Evaluation design overview

To answer the research questions described above, we plan to conduct a mixed-methods ex-post performance evaluation with three components, all of which will feed into the cost-effectiveness assessment. Table IV.2 summarizes which components of the evaluation and data sources will help us answer each of the research questions, highlighting key outcomes for each question.

First, for each activity, we will conduct an **ex-post implementation evaluation** that will (1) explore how project funds were used; (2) explore whether contractors adhered to the as-built designs, how and why changes to the design were made, and our observations of the current state of the infrastructure; (3) help contextualize outcome results by describing the geographic, social, and policy environment in each of the implementation cities; and (4) provide a deeper understanding of how policy changes affected water supply in urban areas and drainage systems in Nampula and Quelimane. The implementation study will draw on interviews with key stakeholders as well as reviews of project and stakeholder documents.

Second, to assess the degree to which the water supply and drainage infrastructure is being maintained and how well it is operating, we will conduct an **infrastructure sustainability assessment** under the guidance of our infrastructure engineering consultant. Through a combination of on-site inspections, review of maintenance records, and interviews with staff from FIPAG, AIAS, AIAS's operator in Mocuba, EMUSA(NA), and ARA, we will identify maintenance successes and shortcomings, and reasons for these shortcomings (such as lack of funding or insufficient technical expertise), as well as potential threats to infrastructure sustainability.

Finally, we will evaluate key outcomes of the project investments using a mixed-methods **outcomes analysis** that will examine current outcomes—and, when possible, changes over time—drawing on administrative data from FIPAG, municipalities, and INE and other national institutes that archive information related to key outcomes. We will also conduct interviews and focus group discussions (FGDs) with municipal officials, health staff, businesses, and households in beneficiary areas to collect outcome measures such as household water usage,

exposure to flooding, and incidence of diseases related to standing or contaminated water, in particular malaria and diarrhea.

To answer question 2 on cost-effectiveness of the WSS project, we will compare cost data collected through our implementation evaluation to the findings of the infrastructure sustainability assessment and the outcomes analysis. The scope of work for this evaluation does not include a formal cost-benefit analysis, but we anticipate that we will have sufficient information about costs and benefits to be able to provide some insights about the validity of some of the assumptions in the original ERR model.

The original evaluation was intended to be conducted in all four cities. However, based on findings from the evaluation design trip in October 2018, it is clear that the investments in the dam and water infrastructure in Nacala have never benefited FIPAG or its customers. This situation remains because the Nacala Dam reservoir is being used below its water design capacity as a result of a failure to connect all of the transmission pipes. Similarly, much of the infrastructure that was built in Mocuba was severely damaged by flooding not long after it was finished, so the compact's investments only benefited the city for a short while. Consequently, for research question 4, on the effects of the urban water supply works, we will focus only on Nampula and not attempt to look at outcomes related to water supply in Nacala and Mocuba, since there are no benefits that could be attributed to the WSS project.

Table IV.2. Evaluation questions and outcomes, designs, and data sources

Research questions and outcomes	Evaluation design component			Data sources
	Implementation evaluation	Infrastructure sustainability assessment	Outcomes analysis	
1. Was the program implemented according to the approved plans and budget?	X			**Key informant interviews** • Former MCC and MCA-M staff • Individuals who were staff at FIPAG, AIAS, and ARA during planning and construction • Municipal officials involved in setting up the EMUSA/NA • Staff at CRA, DNGRH, DNAAS, MORPH • Other donors involved in the water and sanitation section in Mozambique during and since the compact (including those considering funding completion of the Nacala water infrastructure works) **Project documents**, including but not limited to: • Feasibility studies • Infrastructure designs • Engineers' reports • TA-related documents (TOR, reports, etc.)
2. As implemented, were the activities cost-effective?	X	X	X	Costs from MCC and MCA-M documents; outcomes from FIPAG, AIAS, EMUSA/NA, and ARA
3. Are the infrastructure investments operational and being appropriately maintained?		X		**Direct observations of infrastructure** **Key informant interviews** • Management and other staff at FIPAG, AIAS, EMUSA/NA, ARA • Community leaders and/or members in Nampula and Quelimane **Maintenance records** from FIPAG, AIAS, EMUSA/NA, ARA
4. What were the effects of Urban Water Supply Activity on key outcomes?				
Rated capacity to deliver potable water, reliability of abstraction (%), water supply (m^3/day), and reliability (hours per day)		X	X	**FIPAG administrative records**
Nampula only, split by domestic versus commercial, for both the whole city and restricted to EB5 service area: number of connections, water consumption (m^3 billed to customers)			X	**FIPAG administrative records**

Table IV.2 (continued)

Research questions and outcomes	Evaluation design component			Data sources
	Implementation evaluation	Infrastructure sustainability assessment	Outcomes analysis	
Nampula only: Choice of where to source water based on changes in quality of service (including reliability); time spent collecting water (households only); decisions about how much water to use and for what purposes; business investment decisions contingent on water availability, quality, and reliability	X		X	**Key informant interviews** with key businesses **Focus group discussions** with FIPAG customers
Diarrhea incidence			X	**Secondary data sources** including survey data from INE (if sufficiently disaggregated) and health facility records (if available)
5. What was the effect of Urban Drainage and Sanitation Activity on key outcomes?				
Drainage capacity (km of primary, secondary, and tertiary drains) and share of Cement City* and peri-urban areas that benefit from improved drainage		X	X	**Project documents and key informant interviews** with staff of AIAS and EMUSA/NA
Flood incidence and severity (number of hours/days of flooding, area underwater, peak depth of flood water)			X	**Archival research** in municipal records and Instituto Nacional de Gestão de Calamidades **Secondary data** on precipitation from NASA **Photo documentation** of 2019 rainy season **Focus group discussions** with households living near drains and in neighborhoods that previously experienced persistent flooding or stagnant water
Malaria incidence			X	**Secondary data sources** including survey data from INE (if sufficiently disaggregated) and health facility records (if available)

Table IV.2 (continued)

Research questions and outcomes	Evaluation design component			Data sources
	Implementation evaluation	Infrastructure sustainability assessment	Outcomes analysis	
6. What was the effect of Capacity-Building Activity on sanitation service delivery? • EMUSA/NA has a budget and ring-fenced revenue streams • EMUSA/NA staff have technical skills necessary to fulfill their responsibilities • Availability of adequate equipment for trash removal and pit emptying • Frequency of trash collection • Frequency of drain cleaning • Clear responsibilities for enforcement of regulations about emptying latrine pits and septic tanks • Existence of long-term plans for solid-waste management (approved site and funding for additional landfill capacity) • Household familiarity with EMUSA/NA services	X	X	X	**Key informant interviews** with staff of AIAS and EMUSA/NA and municipal officials **Focus group discussions** with households **Administrative data** on trash and drainage maintenance (if available)
7. What lessons can MCC or the GoM apply in future programs to program design, implementation, and sustainment of results? Related supplementary questions: How well are FIPAG and AIAS managing and sustaining WSS interventions? What factors have facilitated or inhibited the effectiveness of FIPAG, AIAS, and EMUSA/NA? What are the prospects for AIAS's future? What factors influence the municipal culture of solid waste management?	X	X	X	All of the above

*Cement City refers to the part of Nampula where the roads and buildings are made of concrete.

The timing of this ex-post evaluation is driven primarily by the parameters of the contract for the evaluation.[13] More than five years have passed since the compact ended, so now the evaluation is being completed as quickly as possible, with data collection scheduled to occur in March of 2019 (see Table IV.3). The table further highlights the time that beneficiaries have been exposed to the interventions and

Table IV.3. Time elapsed between end of WSS activities and data collection for the ex-post evaluation

Activity	Completion/ end of contract	Data Collection	Number of months elapsed
Nampula city water supply system	30-Jun-13	30-Mar-19	69 months
Nampula city storm drains	30-Aug-13	30-Mar-19	67 months
Establishment of the Autonomous Municipal Sanitation Company (EMUSANA)	30-Sep-13	30-Mar-19	66 months
Nacala city water supply system	30-Jan 13	30-Mar-19	75 months
Nacala Dam[a]	30-Jun-13	30-Mar-19	60 months
Mocuba water supply	30-Jun- 13	30-Mar-19	69 months
Quelimane storm drains	30-Aug-13	30-Mar-19	67 months

Note: For calculation purposes, we assume activities were completed (or the contract terminated) on the 30th of the month.

[a] The exposure period for the Nacala Dam refers to the period of time that the infrastructure has been in place and the Dam could have been functioning if the transmission pipes had been put into place. There are currently no beneficiaries from the Nacala Dam since water cannot be pumped to the population.

C. Implementation evaluation

As part of the overall performance evaluation, Mathematica will conduct a mixed-methods, ex-post implementation evaluation. The ex-post implementation evaluation will draw on qualitative data collected through interviews and/or focus groups with key stakeholders as well as information extracted from compact documents. Data collection for the implementation study began during Mathematica's evaluation design trip and will continue in March and April 2019. The implementation study will capture information about initial facilitators of and barriers to implementation, along with perceptions and attitudes about the implemented activities. The implementation study will complement the outcomes analysis by enabling us to explore *how*, *why*, *where*, and for *whom* the estimated changes in outcomes did or did not take place post-MCC compact.

The **implementation evaluation** will focus on answering research question 1, collecting the cost data needed to answer question 2, and providing context that will help us understand the *why* behind questions 3–6 about sustainability and changes in outcomes. For example, we have already learned from FIPAG that during the dry season, the water level in the Nampula dam falls far below the capacity of the treatment plant that was funded through the compact, so in our outcomes analysis we would not expect to see improvements in reliability during the dry season.

[13] MCC contracted with Mathematica Policy Research in April 2018 but the inception mission for the evaluation did not happen until October 2018 to allow MCC's new program manager for the evaluation to participate in the mission, which also needed to occur after elections in Mozambique earlier that month.

We recognize that local organizations cannot control how weather events affect the capacity of the reservoirs, though we will gather information on their process for managing water resources in various scenarios to inform the evaluation. In addition, we anticipate that many of the lessons learned (question 7) will come from this component of the evaluation; this compact was one of MCC's early investments, so it is one of the first for which there is the opportunity to explore long-term sustainability.

1. Data sources

The implementation evaluation relies on primary qualitative data collected from national and local stakeholders and households who remember the construction process, a review of project documents, and observations of infrastructure. Our implementation evaluation will go beyond simply documenting how each activity was implemented, using a political economy lens[14] to explore how implementation was influenced by the context (including the characteristics of the agents and institutions involved). During the evaluation design trip in October 2018, we completed our observations of the water supply infrastructure (including dams) in Nampula, Nacala, and Mocuba and collected photographic evidence of the unfinished works in Nacala. We also conducted preliminary interviews with some key stakeholders, the results of which we will use to further develop our qualitative interview protocols. We will collect additional data in late March to early April 2019, including key informant interviews and focus group discussions as summarized in Section F, below.

- **Former MCC and MCA-M staff (3 and 9 interviews, respectively).** We will interview key staff at MCC and MCA-M because they were responsible for designing the project, overseeing implementation, monitoring and evaluating the project, and gender and social inclusion mainstreaming. Interviews will cover the respondents' roles, their perceptions of successes and challenges, and their expectations of the effects of the project on key outcomes. **FIPAG (1 interview).** We will interview staff from FIPAG because they were responsible for working with MCA-M technicians to oversee the water supply works in Nampula and Nacala. They helped design the water works, put in infrastructure, and continue to maintain the works post-compact. Interviews will cover respondent roles, perceptions of success and challenges, and their perceptions of key outcomes on target beneficiaries.
- **ARA Centre Norte (1 interview).** We will interview ARA Centre Norte staff because of their partnership with MCA-M and FIPAG to redesign and construct the Nacala Dam. ARA Centre Norte was also involved in rehabilitation efforts at Nampula Dam and brings extensive knowledge of the water supply constraints in the Nampula region. We will discuss the role of ARA Centre Norte during the compact, perceptions of success and challenges, and perceptions of key outcomes on target beneficiaries.

[14] "Political economy is concerned with the interaction of political and economic processes in a society: the distribution of power and wealth between different groups and individuals, and the processes that create, sustain and transform these relationships over time". (S. Collinson, Power, Livelihoods and Conflict: Case Studies in Political Economy Analysis for Humanitarian Action, Humanitarian Policy Group Report 13, Overseas Development Institute, 2003).

- **DNGRH-GOH (1 interview).** We will interview the head of the DNGRH-GOH because of their role in managing the reservoirs and hydraulic resources throughout the country. We will discuss their plans for creating new water sources in the region.
- **AIAS (5 interviews)**. We will interview AIAS managers who oversaw the water infrastructure works in Mocuba and the drainage infrastructure in Nampula and Quelimane. AIAS was created on 13th May 2009 through the decree 19/2009 following the approval of the extension of the delegated management framework to secondary public water supply systems in small to medium sized cities and public sanitation on the 9th of May of 2009 through the decree 18/2009. AIAS has since benefited from MCC funding on various WSS projects including: a) Consultancy Services for the preparation of long term and WSS services investment plan; b) Recruitment of TA to strengthen the capacity of the Municipalities of Nampula and Quelimane for the management of the water and sanitation and hygiene Program; c) Quelimane and Nampula Drainage Works. We will also interview the former leadership of AIAS to understand how the new institution was created. We learned during the design trip that there may be overlapping roles and responsibilities and a lack of clarity about the future of AIAS. These interviews will be critical to understanding the role AIAS played in the WSS project and how it continued to operate in the post-compact period.
- **EMUSA/NA (2–4 interviews)**. The EMUSA/NA are business entities created to manage sanitation and the storm drains in Nampula and Quelimane. However, the entities fall under the municipal government and lack their own operating funds. We will interview staff who can speak about the technical capacity sub-activity and how the EMUSA/NA were created.
- **CRA (1 interview).** CRA is the regulatory agency for water and sanitation utilities and plays an important role in setting tariffs. During the design trip, we met with the current CRA president and a CRA board member, as well as the former president of CRA, to understand how the regulator was involved in project selection, including reviewing the feasibility studies during the compact, and CRA's relationship with AIAS.
- **Donors (3–4 interviews).** The World Bank, the Government of the Netherlands, JICA, and UNICEF all play critical roles in continuing to fund activities in the water sector. These donors were also active during the compact and post-compact period. During our design trip, we interviewed World Bank staff with knowledge of the current and previous work in the water and sanitation sector. We will interview current and previous staff in these organizations to obtain their perspectives on the MCC WSS program and to understand the role they played during the compact period, how the MCC feasibility studies contribute to their work, and how MCC interventions have influenced their funding priorities for the future.
- **MORPH (1 interview).** The Ministry of Public Works and Water Resources serves as the main policy and decision-making ministry for water and sanitation in Mozambique. We will interview the former minister who was in office during the compact to understand the role of the ministry in negotiating the compact and setting priorities for project investments.
- **Municipal government (3-4 group meetings and interviews).** The municipal governments in Nampula and Quelimane are responsible for local decision making and priority setting in each of the municipalities served by the WSS project. During the evaluation design trip, we

met with three council members in Nampula who accompanied our team during site visits to the local storm drainage system.

- Households (8 focus groups: 2 with beneficiaries of EB5 and 2 with households in non-EB5 service areas in Nampula, and 2 with members of households that live adjacent to the drains in Nampula as well as 2 in Quelimane, to discuss services provided by EMUSA/NA). We will purposively select the target areas based on MCC interventions and FIPAG's service areas; however, individuals will be selected through convenience sampling. We will invite females from each household to participate in the focus groups since they bear the primary responsibility for water collection decisions. Although the main motivation to conduct focus groups with households is to explore project benefits for the outcome evaluation, participants will contribute to the ex-post implementation evaluation by providing retrospective information related to the construction process and information they received about the works during the compact period. More details on recruitment for the focus groups are provided in Section F, below.

In addition to the interviews and focus group discussions, we will also conduct a desk review of key project documents, including the compact, the M&E plan, feasibility studies, independent engineer's reports, and the close-out report written by MCC and MCA-M. As part of the desk review, we will also extract information on project costs, which we need to answer question 2.

2. Analysis of qualitative data

We will use the framework method to manage and systematically analyze our qualitative data from the interviews/focus group discussions and desk review (Ritchie and Lewis 2003). This method begins with a careful review of the transcribed interview and project documents and includes making initial notes in the margins for the purposes of coding. We will follow four steps to analyze the data (Creswell 2009):

1. **Organize the raw data.** Raw data management is the process of organizing raw data into formats usable for analysis (that is, from audio files to transcripts). During raw data management, we will review all data and eliminate any that are incomplete or not useful to our analysis.
2. **Code data using chunking for initial coding.** This process, often referred to as data reduction, will enable us to read through the interview and focus group transcripts several times and obtain a holistic view of the data. We will use the framework method to organize and analyze themes, patterns, and issues in the data. We will develop a detailed initial coding scheme—a set of themes we might encounter in the transcripts that map to the research questions and conceptual framework. We will also document potential themes, linkages among results, and potential findings. After a review of the first few transcripts, the team will meet to develop the analytic framework of codes that will be applied to the remaining transcripts.
3. **Revise the coding scheme with more detailed coding.** This process involves refining the coding scheme and recoding data as we examine them in greater depth. We will use NVivo software to review and code the transcripts based on the initial codes developed during the chunking process. Use of NVivo software to assign codes to the qualitative data will enable

us to access data on a specific topic quickly and organize information in different ways to identify themes and compile evidence supporting them. As additional themes emerge, we will expand and refine the codes in an iterative process during the coding exercise and subsequent analysis of the coded transcripts. Further, the software will enable us to categorize respondents by gender, age, geographic location, or other salient characteristics to facilitate analysis by subgroup, which will allow us to identify divergent and common perspectives among different groups. For instance, community members in peri-urban areas may have a different view of the benefits or drawbacks of the WSS project relative to community members in Cement City. At the end of the detailed coding process, we will chart the findings into a matrix to strike a balance between reducing the data to a usable amount and retaining the original meaning of the text.

4. **Conclude with data interpretation and writing.** Because we will be analyzing multiple data sources to answer each research question, data interpretation and writing will require **data triangulation** to identify consistency and discrepancies in findings across data sources. This process will help confirm patterns or findings across data sources and identify important similarities and differences among them. For example, we will use triangulation to see whether the condition of infrastructure presented in project implementation reports and utilities' maintenance records aligns with direct observation of the same pieces of infrastructure by our engineering consultant.

D. Infrastructure sustainability assessment

The newly constructed Nacala Dam

An infrastructure sustainability assessment is a study that assesses the health and capability of civil works over time. Under the guidance of our civil engineer, we will conduct an assessment of the sustainability of project infrastructure in Nampula (water supply, drainage, and sanitation) and Quelimane (drainage and sanitation only) to evaluate (1) the extent to which upgrades to and construction of water supply and sanitation infrastructure by the WSS project match what was initially envisioned by the project, (2) the current state of infrastructure and its maintenance, and (3) how well infrastructure is operating and expected to operate in the future. The infrastructure sustainability assessment will draw primarily upon data collected from observations of infrastructure improvements and will be supplemented by key informant interviews and administrative records, summarized in Table IV.4.

Table IV.4. Data sources for the infrastructure sustainability assessment

Data types	Potential data sources
Direct observation	• Direct observation of water supply infrastructure in Nampula, Nacala, and Mocuba, including dams in Nampula and Nacala, conducted in October 2018 by our civil engineer. • Direct observation of storm drainage infrastructure in Nampula and Quelimane (including covered drains in the Cement City and open drains in the peri-urban neighborhoods), completed in October 2018 by our civil engineer. • Direct observation of low-cost sanitation facilities in schools and markets in Nampula and Quelimane, completed in October 2018 by the Mathematica team.
Key informant interviews	• Management and other staff at FIPAG, AIAS, EMUSA, ARA Centre Norte • Staff members of firms and organizations that conducted infrastructure maintenance
Administrative records	• WSS project-planning documents • Maintenance records from FIPAG, AIAS, EMUSA, ARA Centre Norte

Toilets constructed in a market under the MCC project.

We will also conduct observations of a sample of low-cost sanitation facilities constructed in markets and schools in Nampula and Quelimane under the Capacity-Building Activity to verify their construction, whether they are in use, and whether they have been maintained.

To assess whether the infrastructure investments made by the WSS project match what was initially envisioned, we will compare our observations to information about the project's goals obtained from project documentation, such as inception reports provided by contractors and the reference documents created by MCA-Mozambique. Our analysis of the current state of infrastructure will factor in the capacity of the infrastructure to meet anticipated demands; key risks and points of failure; the quality of materials and parts; and the observed capacity, organization, and day-to-day functioning of staff at each site. We will use the project's stated performance targets as benchmarks for this analysis. For example, we will assess the ability of water distribution systems to meet water supply investment targets in each municipality by examining whether the capacity of each critical element of the system—including dams, reservoirs, treatment plants, and pumping stations—can provide or handle the required flow of water.

Civil engineer Joe Dalton assesses the functioning of electronic equipment at the Nacala Dam.

To understand the extent to which maintenance and inspection activities are being regularly performed, we will compare our direct observations to a combination of other data sources. First, we will try to identify any training and maintenance protocols developed during the project, to use as benchmarks against which we can measure the level of maintenance that has occurred. Second, we will triangulate our direct observations with administrative data and information from key informant interviews with stakeholders at utilities and oversight bodies about the maintenance and inspection practices that are being observed. Our assessment of the adequacy of maintenance practices will be based on the types of maintenance and inspections being performed, the presence of records that document maintenance and inspection, and the regularity with which these activities occur. In addition to assessing the current state of infrastructure and its maintenance, we will use the data described above—along with any information about future changes in demand or institutional capacity at key utilities or municipal government bodies—to assess how well the infrastructure will continue to function in the future.

E. Outcomes analysis

The pre-post **outcomes analysis** aims to answer research questions 4, 5, and 6, generating evidence on benefits that will factor into the cost-effectiveness analysis (question 2); we anticipate that our analysis of outcomes will also likely lead to some findings related to question 7 (lessons learned). Ideally, we hope to be able to compare outcomes at a minimum of two points in time—one point before and one point after the infrastructure and TA were completed, that is, on or before 2011 and from 2013 or shortly after, respectively. We will examine changes in water supply, reliability, and consumption; drainage capacity and flood incidence and severity; sanitation service delivery; and health outcomes, including prevalence of diarrhea and malaria and missed workdays due to illness. We will assess change in these outcomes in both Nampula and Quelimane, with the exception of water supply and consumption and/or expenditure, which we will assess in Nampula only. Finally, we also plan to do a case study of water supply and business growth in Nampula, since business growth was the main contributor to the ERR for that sub-activity.

The outcome analysis aims to shed light on potential benefits from the compact; however, in the absence of a comparison group, the best possible design we can propose for an ex-post evaluation requires baseline data collected before the compact that we can compare with data collected after the compact was implemented. In addition to using baseline data, we will aim to document activities other than the compact that were implemented at the same time and that may account for the outcomes observed.

It is our understanding that M&E indicators, as well as most indicators collected as part of the DHS and NPA do not capture data for the neighborhood levels that would be valuable for the evaluation. Because some of the works had the potential to impact some neighborhoods and not

others, access to neighborhood-level data would increase the precision of our analysis and our ability to detect changes attributable to compact activities. Neighborhood-level data would allow the analysis to focus exclusively on households or businesses that plausibly benefited from compact activities, as opposed to including neighborhoods where impacts are highly implausible. FIPAG may not collect these data or the data may not be available for Mathematica to use for the evaluation. If data are not available at the neighborhood level, we could still use data for the cities of Nampula and Quelimane. This approach might obscure the true impacts of the activities, but primary data collection to estimate neighborhood-level effects is prohibitively expensive.

Household focus group discussions will be a key data source for all of the outcomes we plan to analyze. As mentioned previously, we plan to conduct 8 focus groups. The 6 groups with FIPAG customers in Nampula will provide the customer perspective on water supply adequacy and reliability and behaviors related to water consumption, the six groups with households that live along the drains in both cities will provide another perspective on flooding incidence and severity, and the two groups discussing EMUSA/NA services will provide the customer perspective on the management of water and storm drainage systems. We will use a convenience sample based on resources and a desire to get a diversity of perspectives from households in the target neighborhoods. We will prioritize the focus groups that provide the most important perspectives for the design and implementation of the project, and therefore, contribute the most to the evaluation findings. We will leverage all of the groups to collect additional qualitative data on changes in diarrhea and malaria prevalence and severity since prior to the compact.

1. Water supply, reliability, and consumption

For outcomes related to water supply, reliability, and consumption, we are requesting data from local agencies such as FIPAG, INE, and AIAS on the indicators listed in Table IV.5. We hope to obtain data on all of these indicators at a quarterly frequency from 2005 to the present, to capture both the pre- and post-implementation periods (roughly 2005–2010 and 2014–2018, respectively) and seasonal differences. Our focus is on Nampula, and particularly on the neighborhoods served by EB5, since those customers likely experienced a more pronounced improvement in the quality of service they receive from FIPAG. We will also try to obtain data for Nacala in support of the infrastructure assessment and ex-post implementation evaluation.

Table IV.5. Key statistics on FIPAG operations in Nampula and Nacala

Indicator	Definition	Disaggregation levels	Rationale
Water supply[a]	Quantity of water leaving the treatment plant: average cubic meters per day for each quarter OR total cubic meters over the quarter	Separately for Nampula and Nacala	MCC wants to know if the investments are allowing FIPAG to provide more water
Water supply – EB5	Quantity of water passing through EB5 OR cumulatively stored in the reservoir (either average cubic meters per day for each quarter OR total cubic meters over the quarter)	Nampula EB5 service area	MCC wants to know if the investments have improved the availability of water in the part of the city that is expected to have experienced the biggest improvement in water supply
Water supply reliability	Average hours per day (obviously there can be variation within a city in terms of which areas receive water for how long, but we are happy to follow FIPAG's standard method of calculation)	• Separately for Nampula and Nacala • Also limited to just the area served by EB5 in Nampula	MCC wants to know if the investments are allowing FIPAG to provide a better quality of service (related to the supply of water that is available, of course)
Reliability of water abstraction	We are happy to follow FIPAG's standard method of calculating this (we have seen references to reliability as a percentage in some documents, but we are not sure how that is defined)	Nampula only	MCC wants to know if the target that informed the design for the works has been achieved
Total volume billed to customers[b]	Cubic meters per quarter (or per billing cycle if that is easier)	Separately for Nampula, Nacala, and Nacala-EB5 service area; ideally, we would also like to know the total volume billed to customers, split by domestic versus commercial customers (in addition, if data on government consumption are also available, that would be fantastic)	MCC wants to know if households and businesses are actually getting more water thanks to the investments
Number of customers	As recorded in FIPAG's billing database at the end of each quarter; ideally split by type of customer (domestic versus commercial)	• Separately for Nampula and Nacala • Also limited to just the area served by EB5 in Nampula	MCC wants to know if connections have increased since the project (this affects the number of beneficiaries that feeds into their cost-benefit analysis). In addition, we need to know how many customers there are, to be able to interpret trends in the volume billed
Coverage ratio	Percentage of population served by FIPAG's piped network (as calculated by FIPAG)	Nampula: total for the whole city and separately for the area served by EB5	MCC wants to know if the investments have enabled FIPAG to serve a higher share of the city's population

[a] We will also ask ARA for data on the volume of water stored by both cities' dams, which we understand is the main constraint on the quantity of water that FIPAG can supply during the dry season.

[b] Knowing the share of non-revenue water would allow us to infer how much water is going to customers but we would not be able to disaggregate by type of customer, which is why we prefer to have the volume billed.

In addition to the indicators in Table IV.5, we will also investigate whether there have been any updates to the rated capacity to deliver potable water to Nampula and Nacala and from well fields in several other cities where the WSS project drilled new wells (including Metuge well field in Pemba; Licuari, Nicoadala, and Inahne well fields in Quelimane; and Niuhula and Mecuhia well fields in Montepuez). Finally, we will also try to obtain annual data on the volume of maintainable yield of water from ARA Centre Norte (MCC M&E Plan, 2013) and through our qualitative interviews we will explore ARA Centre Norte's view on what a sustainable yield would be. This indicator was reported on through the Indicator Tracking Table from 2014–2018.

2. Flooding

To answer the research question about the effect of the Urban Drainage and Sanitation Activity on flood incidence and flood severity, we will contact the Instituto Nacional de Gestão de Calamidades (INGC) in Mozambique. INGC is responsible for coordinating disaster risk-management actions at the national level. As such, it collects data on rainfall, river flow behavior, and incidence of natural disasters. We will explore the possibility of obtaining data from 2005 to the present for the cities of Nampula and Quelimane. If possible, we will request data on flood severity for the neighborhoods directly targeted by the compact. We are also exploring the possibility of using NASA's Precipitation Measurement Missions data to adjust for the level of flood risk, based on recorded precipitation. We believe the Tropical Rainfall Measurement Mission (TRMM), from 1997 to 2015, may contain such data.

An alternative source of data is ReliefWeb, a humanitarian information outlet at the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). ReliefWeb gathers data from thousands of sources to inform humanitarian relief efforts, including data on floods, flash floods, landslides, and so on. We have located reports about floods in Mozambique from as early as 2013. We are trying to locate reports from before the time of the compact.

We are also making arrangements to obtain photo documentation of flooding (or lack thereof) during this year's rainy season in both Nampula and Quelimane. We will work with AIAS, the municipal governments, EMUSA/NA, and our local consultant to develop a protocol for locations to photograph. We can then use the TRMM data to characterize how effectively storm water is draining out of the cities.

3. Sanitation service delivery

An important determinant of the functionality of the drains is how much solid waste is inappropriately dumped into them. During our design trip, our team photographed the status of the drainage system. We will collect additional data during the rainy season by photographing the runoff into and through the drains during rainfall. The photographs and local consultant observations will allow us to document how well the drains function in each of the cities. We will also interview staff from the EMUSA/NA and the street cleaning women to gather data on how often and how the drainage system is maintained. Many of the indicators we will consider under this category will come directly from EMUSA/NA:

- EMUSA/NA have a budget and ring-fenced revenue streams
- EMUSA/NA staff have technical skills necessary to fulfill their responsibilities

- Availability of adequate equipment for trash removal and pit emptying
- Frequency of trash collection
- Frequency of drain cleaning
- Clear responsibilities for enforcement of regulations about emptying latrine pits and septic tanks
- Existence of long-term plans for solid-waste management (approved site and funding for additional landfill capacity)

In addition to these indicators, the household focus group discussions will help us understand how familiar city residents are with EMUSA/NA services, how well they judge the new utilities to be functioning, and the type of public education (if any) communities received during the compact period.

4. Health outcomes

We have explored several potential data sources for health outcome data, but unfortunately, based on our understanding of when various national surveys were done, it seems that our only hope for a pre-post comparison will be to use data from the National Poverty Assessments (NPA) to assess change in morbidity and missed workdays due to illness. These data were collected by INE in 1996/97, 2002/03, 2008/09, and 2014/15.[15]

Given the paucity of quantitative data on health outcomes, we plan to interview a few long-serving staff at health facilities in each of the two cities to explore whether there are any facility records that might help shed light on any changes in diarrheal and malaria morbidity since prior to the compact. In addition to historical records, we will also ask staff about their subjective impressions of changes in morbidity over time.

5. Business growth

Mathematica will develop a **multi-case study** related to the effects access to quality water can have on the decision making of local businesses to start-up/remain in a region and/or expand their operations. The multi-case study approach considers each business as a "case" and examines it in detail, thus enabling us to describe each unique business experience while still drawing broad conclusions across the selected cases. Information gained from the cases will provide in-depth information on an important outcome that was not specifically called out as part of research question 4 but which we believe is important to investigate, based on the fact that business growth accounted for almost all of the anticipated economic benefits of the investment in the Nampula water system. The cases will be drawn from businesses in Nampula that may have benefited from compact investments (or that may still be constrained by insufficient or unreliable access to water).

[15] Demographic and Health Survey (DHS) data sets are a good source of nationally representative statistics on the prevalence of diarrhea and malaria, but the most recent DHS (2011) was completed before the works were finished. DHS from 1997 and 2003 could be used to characterize diarrheal and malaria morbidity prior to the compact, but the DHS does not have sufficient sample size disaggregated by city.

Selection of local businesses. We will select two businesses that benefit from piped water and two that use boreholes. We will purposefully select the businesses based on a combination of annual profit, number of employees, level of water use, and their location. We will use local business listings to randomly select two businesses from the EB5 neighborhood, one with piped water and one with borehole access. The remaining two cases will be selected from non-intervention areas. We will interview the business manager and the owner when possible. If it is a small, locally owned business, we will identify the main decision-maker to include in the interview. We will have a total of four cases for the study.

Data sources. The multi-case study design will draw on quantitative and qualitative data that we will collect through interviews with local businesses that have access to piped water and boreholes. We plan to conduct one round of data collection, which will include in-depth interviews with the owners of the company and any quantitative administrative data they are willing to share with us on changes in the cost of water, supply of water, consistency of water, and increases/decreases in resources over the last five years. Our analysis will focus on the extent to which extending piped water contributed to changes in the businesses, and the role that water accessibility and quality plays in business decision making. The municipal government maintains a list of businesses for Nampula as does the Provincial Private Sector Federation. We will use these lists to purposefully select the businesses for our case studies. The data sources include the following:

- **Businesses serviced by EB5 in Nampula (2).** We will select two businesses within the EB5 service area that are connected to the piped water system. The purpose of these cases is to understand how water access, quality, and usage has changed since MCC/MCA-M and FIPAG established the EB5 station, which provides piped water to new areas of Nampula. We will explore themes such as consistency of water supply, customer service, changes in water supply, and factors that influenced decisions on where to start up and maintain the business. We want to understand the extent to which having the EB5 pumping station may have contributed to changes in business profits, functioning, and investments. We will conduct an in-depth interview with the business owner and collect administrative data such as billing statements and annual income. This case study will provide Mathematica with insights into the contributions that MCC investments in a new pumping station have made to business establishment and growth.
- **Business served by boreholes in Nampula (2).** We will select two businesses that are serviced by boreholes in Nampula—one in the EB5 neighborhood and one in a non-intervention area. The purpose of these cases is to understand any differences experienced by local businesses that do not rely on piped water. We will explore themes such as the reasons that they continue to receive water from boreholes rather than receiving piped water, consistency of water supply, customer service, changes in water supply, and whether business owners believe access to piped water verses boreholes affects their ability to operate effectively. We will conduct an in-depth interview with the business owners and collect administrative data such as billing statements and annual income. This case study will provide Mathematica with insights into any perceived differences that access to water has on local businesses.

Data analysis. The data analysis will seek to describe the individual investments (cases) and draw broader lessons across them. To describe those included in our sample, we will fully describe the characteristics of each investment and summarize the key findings related to it, organized by topic area (for example, decisions related to location, access to water, consistency of water provision, and challenges). To draw broader lessons across these cases and how they might have been affected by the project, we will draw on the full set of interviews and administrative data and use the key steps below to analyze the data. Specifically, we will use qualitative analysis software to systematically code data and sort them to identify key themes and patterns in the responses. We will follow the qualitative data analysis steps detailed under the ex-post implementation evaluation in Section C, above.

F. Data collection

Table IV.6 presents a comprehensive summary of the qualitative data we plan to collect through interviews and focus group discussions. Many of our respondents will be interviewed about topics that relate to multiple aspects of our design; in the table, we have aggregated all of these so that each respondent is listed only once. In total, we plan to conduct over 50 interviews and 8 focus group discussions.

Table IV.6. Summary of primary qualitative data collection

Data sources	Type of data	Approximate number	Evaluation component	Illustrative areas of focus for interview and focus group protocols
AIAS—Mocuba water	Interview/ meeting	1	• Ex-post implementation evaluation • Infrastructure assessment	• History of AIAS • Relationships with MCA-M, CRA, and government ministries • Deviations from project plans • Implementation barriers and facilitators, including political, institutional, or financial constraints, and quality of the planning process and of human resources
AIAS—Nampula and Quelimane drainage	Interviews Administrative data Photographic observation data	5	• Ex-post implementation evaluation • Infrastructure assessment	• History of AIAS • Relationships with MCA-M, CRA, and government ministries • Main activities that were part of technical assistance sub-activity and perception of strengths and weaknesses in the implementation process • Current role in managing sanitation services in Nampula and Quelimane and how their role has changed since the organization was created in 2011. • Sustainability of AIAS • Factors that facilitate or hinder the organization's ability to support access to sanitation in peri-urban areas and the organization's sustainability • Functioning of management systems for sanitation facilities in (schools) and markets
ARA Centre Norte	Interviews Administrative Data Photos	3	• Ex-post implementation evaluation • Infrastructure assessment	• Current role as manager of dams and water availability • Availability of water in the event of drought • Discussions around Nampula Dam capacity during feasibility studies. • Use of feasibility studies for future work. • Role of ARA Centre Norte during compact • Relationship between ARA and FIPAG
Businesses served by FIPAG and businesses that use private boreholes (not connected to FIPAG's network) in Nampula	Interviews	4	• Outcomes Analysis	• Main factors impacting business productivity and growth • Satisfaction with quantity, quality, and reliability of water available from FIPAG • Pros and cons of using water from FIPAG's network versus other sources (especially boreholes) • Impact of rains/flooding, functioning of drains • Changes in the above in the past decade • Decision-making process for choosing business location

Table IV.6 (continued)

Data sources	Type of data	Approximate number	Evaluation component	Illustrative areas of focus for interview and focus group protocols
Staff from the management firm Collins	Interviews	1–2	• Infrastructure Assessment • Ex-post implementation evaluation	• Contributions to Mocuba water treatment facility • Challenges with existing MCC infrastructure • Sustainability of MCC interventions
CRA	Interviews Administrative data	3	• Ex-post implementation evaluation	• Role in project selection • Relationship with AIAS • Priorities for FIPAG and AIAS (financial sustainability, quality of service, expansion of service)
DNGRH	Interviews	3	• Ex-post implementation evaluation	• Role of departments in the water and sanitation sector • Priority setting and decision making during compact • Use of feasibility studies • Availability of data
DNAS-GOH	Interviews	1	• Ex-post implementation evaluation	• Role of departments in the water and sanitation sector • Priority setting and decision making during compact • Use of feasibility studies • Availability of data
Donors	Interviews	3–4	• Ex-post implementation evaluation	• Other projects that could have influenced WSS outcomes of interest • Factors influencing willingness to fund completion of Nacala works
EMUSA/NA staff	Interviews	4	• Infrastructure assessment • Outcomes analysis	• History of EMUSA/NAs • Current role as manager of the water, sanitation, and hygiene program and how its role has changed • Factors that facilitate or hinder the organization's ability to exercise its role • Relationship with municipal government
FIPAG staff	Interviews Group meeting	4 2	• Ex-post implementation evaluation • Infrastructure assessment • Outcomes analysis	• Role in project design and selection • Deviations from project plans • Implementation barriers and facilitators, including political, institutional, or financial constraints and quality of the planning process and of human resources • Relationships with MCA-M, CRA, and government ministries • Efforts and challenges for infrastructure maintenance • Current condition of infrastructure • Decision-making process for scarce water allocation
Health facilities' staff	Interviews Administrative data	4 (2 in each city)	• Outcome analysis	• Prevalence of water related diseases in Nampula and Quelimane • Main factors driving prevalence and actions required for improvements • Changes in the above in the past decade

Table IV.6 (continued)

Data sources	Type of data	Approximate number	Evaluation component	Illustrative areas of focus for interview and focus group protocols
Households[a] served by FIPAG in Nampula	Focus groups	4	• Ex-post implementation evaluation • Outcomes analysis	• Current availability and quality of water, including water sources used by the household and time to get to water source (if applicable) • Seasonal variation in water availability and quality and implications for household water sources, time spent collecting water, and water consumption • Main factors impacting households' productivity and health outcomes • Changes in any of the above in the past decade • Perceptions of water utility and FIPAG
Households residing near drains in Quelimane and Nampula	Focus groups	4	• Ex-post implementation evaluation • Outcomes analysis	• Impact of rains/flooding, functioning of drains, and perception of changes over the past decade • Solid waste management • Community involvement in infrastructure upkeep
MCA-M staff	Interviews Compact documents Administrative data	9	• Ex-post implementation evaluation • Infrastructure assessment • Outcomes analysis	• Process to design and implement compact activities • Implementation barriers and facilitators, including political, institutional, or financial constraints and quality of the planning process and of human resources • Lessons learned • Relationship with local implementing entities (FIPAG, AIAS, ARA)
MCC staff	Interviews Compact documents Administrative data	3–4	• Ex-post implementation evaluation • Infrastructure assessment • Outcomes analysis	• Process to design and implement compact activities • Implementation barriers and facilitators, including political, institutional, or financial constraints and quality of the planning process and of human resources • Lessons learned
Ministry of Health (MISUA)	Interview Administrative data	1–2	• Ex-post implementation evaluation • Outcomes analysis	• Prevalence of water related diseases in Nampula and Quelimane • Main factors driving prevalence of disease and actions required for improvements • Changes in the above in the past decade
MORPH (former Minister during Compact)	Meeting	1	• Ex-post implementation evaluation	• Role of the ministry in negotiating the compact • Lessons learned from compact experience • Priority setting and decision making during compact • Use of feasibility studies
Municipal government	Group meetings and interviews	4	• Ex-post implementation evaluation • Infrastructure assessment	• History of EMUSA/NA • Relationship with MCA-M, AIAS, EMUSA/NA, government ministries related to drainage and sanitation • Sustainability of EMUSA/NA

Table IV.6 (continued)

Data sources	Type of data	Approximate number	Evaluation component	Illustrative areas of focus for interview and focus group protocols
Provincial Directorate of Public Works, Housing and Water Resources	Interview Administrative	2	• Ex-post implementation evaluation	• Role in the water and sanitation sector • Priority setting and decision making during compact • Use of feasibility studies • Availability of data

[a] Household members will be invited as part of a convenience sample. We will invite females from the household since they bear the primary responsibility for water collection decisions.

As highlighted in Table IV.6, we will use four main sources of data for the performance evaluation: key informant interviews, focus group discussions, observations, and administrative data. The following section provides a brief description of how we will identify participants and conduct each of these different types of data collection.

1. Key informant interviews

As identified in Table IV.6, we plan to conduct approximately 30–35 interviews with key stakeholders involved in the WSS project. We will use the information we gathered during the design trip, including meetings with many of the key organizations, to develop protocols for these interviews. Since we will be dependent on key informant recall, we will use anchoring techniques such as critical incidents to anchor the discussion to particular incidents that remind participants of where they were during the time or of activities that took place in 2011–2013. We will also provide summary information to stakeholders prior to the interview and request permission to follow up with them should we have questions or gain further insight through other interviews and focus groups. These techniques will allow us to triangulate the information we gather to paint a more accurate picture of what took place during the compact implementation period.

2. Focus group discussions

As described in Section C, above, we propose to conduct approximately 8 focus group discussions with various types of households. As with the key informant interviews, we will use the information we gathered during the design trip to develop and refine our discussion protocols. The FGDs will be led by our local consultants, who bring familiarity with the populations and culture of the target participants. We will hold FGDs with the following groups:

- One focus group with middle- to high-income families in the Nampula EB5 service area[16]
- One focus group with low-income families in the Nampula EB5 service area
- Two focus groups with households in Nampula non-EB5 service areas
- Two focus groups with households along the storm drain systems in Nampula
- Two focus groups with households along the storm drain systems in Quelimane

Successful focus groups require careful and purposeful selection of participants to gather quality data on the study themes. Mathematica will follow these steps to recruit participants for the proposed focus groups:

a. **Create a pre-screening tool for participant selection**. Focus groups are most successful when all participants contribute to the discussion. Our proposed focus groups require participants who share specific characteristics, such as living along an MCC-constructed storm drain or living in neighborhoods serviced by EB5, or those who can provide our team with perspectives on access to quality water and sanitation systems. We also know that

[16] We will use socio-economic data from the municipalities to define household income thresholds and use the thresholds to randomly select households.

populations in the target areas vary by socio-economic status, languages, and ethnic backgrounds, which may affect their perspectives.

b. **Pre-screen participants.** To ensure a strong mix of characteristics among our focus groups, we will create a pre-screening tool that collects information on participants. This information includes data on characteristics such as location, socio-economic status, type of water access, type of sanitation, and willingness to participate in a focus group. Our local consultant will visit every Nth household (to be determined based on the number of households in the neighborhood) to apply the pre-screening tool.

c. **Select participants.** Mathematica will review the pre-screening data and select 8–12 participants for each focus group. We will then select a convenient location based on the location of the participants and invite the final group to the discussion.

There is no definite way to determine the proper sample size to gain significant insights into qualitative themes. The literature focuses on "reaching a point of saturation," which means that during data analysis, researchers determine that the same themes are recurring and that no new insights will come from conducting additional interviews or focus groups. We have elected to conduct 8 focus groups based on the time and resources available for the evaluation. However, if we find that saturation is not reached based on these initial numbers, we will use our local consultant to conduct additional interviews and focus groups with specific populations.

3. Observation of infrastructure

During the design trip, the Mathematica team, including our civil engineer, visited all the MCC investment sites, conducted observations of the infrastructure, documented the current status of the works, and assessed the sustainability. To complete the observation analysis, our civil engineer will review the "as-built" design documents and compare those to what we saw in the field and to other documents, such as the engineering final report.

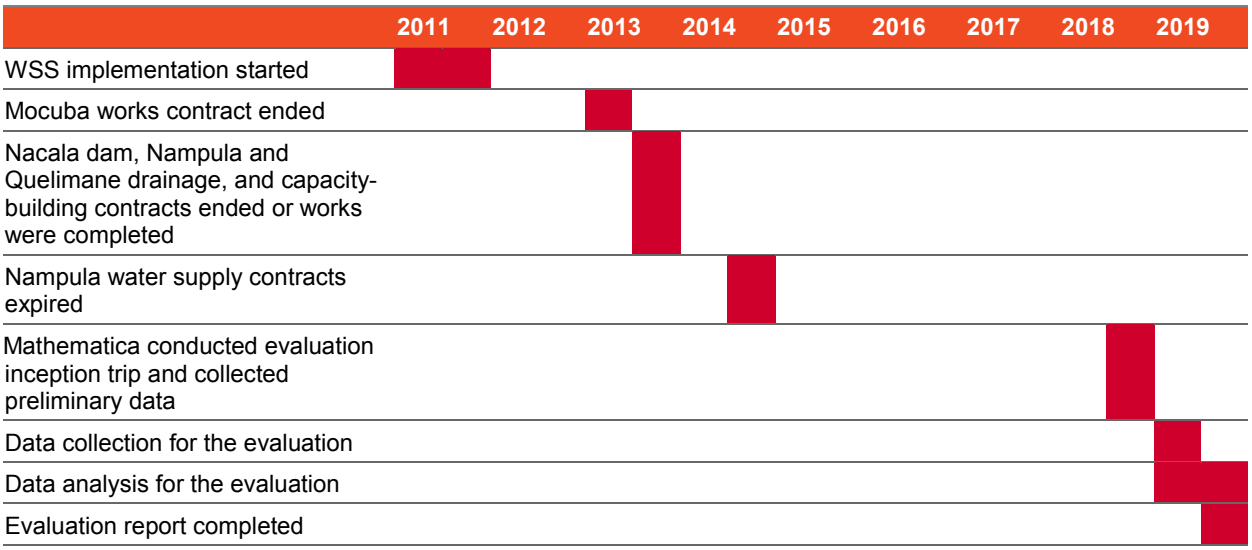
We will also conduct observations of the storm drains in Nampula and Quelimane during the rainy season. We will document the water flow through the streets and drainage system through pictures and direct observations conducted by our local consultant. These observations will allow us to assess the functioning of the drainage system during the flooding season.

4. Timeline

All additional primary data collection for the process evaluation, outcomes analysis, and case studies will take place in spring 2019 (see Figure IV.1). Analysis of secondary data sources will take place in summer and fall 2019. The final report will be concluded in October 2019. Overall, data collection and analysis for this ex-post implementation evaluation will take place five to six years after compact activities were completed or contracts expired.[17]

[17] The contract for Mocuba works was the first to expire, in second quarter 2013; the contract for Lot 1 of the Nampula water supply works was the last to expire, in the second half of 2014 (MCA-Mozambique: Compact Completion Report 2013).

Figure IV.1. Timeline of key project, evaluation, and report activities



G. Challenges and limitations to data analysis

The ex-post nature of this evaluation presents a number of challenges and limitations for data collection and analysis. Here we highlight several of them and our plan for mitigating them:

1. **Lack of baseline data for many outcomes.** The data collected under the compact do not always provide baseline values or consistent data across the time period of implementation. Our design trip revealed that little data were collected in the post-compact period. However, our meetings with FIPAG and INE highlighted that there are data available for the time period in which we would like to analyze outcomes; we are optimistic that we can obtain these data through data use agreements. If we are unable to get these data, we will use national statistics and qualitative interview and focus group data to show how the project may have contributed to improved outcomes over time.
2. **Inability to attribute changes in outcomes to the WSS project.** Even for those outcomes for which we have baseline data, there is no comparison group against which to gauge changes in outcomes due to other factors; therefore, we have no way of knowing what would have happened in the absence of the WSS project and, thus, how much of any changes we do observe can be attributed to the project versus other factors. We will use triangulation between all our data sources to construct the most plausible explanations for any observed changes, and use contribution analysis to confirm or revise the project logic and show any potential changes to outcomes.
3. **Long recall period.** It has been five years since MCA-M closed and the contractors all moved on to other jobs. We may encounter difficulties locating some of the people we would like to interview; even when we are able to connect with those on our list of respondents, we will be asking them to remember events that occurred quite long ago, so their recollections might be incomplete or inaccurate. Our team brings extensive experience working with and understanding project implementation. We will use anchoring techniques to remind interviewees of where they were and what activities were taking place during that time period to ground their responses. We will also share summary information in advance of the

interviews so that respondents will have primed their recall before the interview or focus group. We will pre-screen participants and try to identify strong candidates, as well as participants who knew each other during the project activities, so that we build on information gleaned in each interview to help tailor the next one. This process will improve the quality of the qualitative recall data. Finally, we will request permission from the participants to follow up post-interview with a phone call or email to them so that when we learn new information from another respondent, we can triangulate it with earlier respondents, potentially jogging memories and fleshing it out.

4. **Respondent Bias.** Respondent bias is a general research terms that refers to factors that may influence a participants responses to a survey or interview question. These factors can lead to nonrandom deviations of the answers from the true value (http://methods.sagepub.com/reference/encyclopedia-of-survey-research-methods/n486.xml, cited in February 2019). Our team brings extensive experience dealing with respondent bias on evaluations. We will follow a series of steps to mitigate this issue on our evaluation. First, we will triangulate our data. We will ask the same questions across respondent groups and stakeholders and collectively analyze the data to create a picture of the situation, while recognizing the different perspectives each stakeholder may bring to the table. Second, we will use quantitative data (when possible and relevant) to document and ground the qualitative responses. Finally, we will ask the same question in different ways to each stakeholder and then compare the answers during analysis to look for consistency and accuracy in the responses.

H. Ensuring high quality data

To implement our ex-post performance evaluation, we will draw on various data sources that cut across project activities, follow an integrated data collection plan that ensures we efficiently collect valid and reliable data, and institute protocols to safeguard data quality. Following approval of the Evaluation Design Report, MPR staff and our consultants will conduct two to three weeks of data collection, which will include key informant interviews, FGDs, direct observation of storm drain function during the rainy season, and collection of administrative data. We know from experience that after a compact ends, the incentives for key informants to engage with evaluators weaken. However, we believe that we established strong working relationships with relevant stakeholders during our evaluation design trip. Drawing on these established relationships will help us mitigate the challenges of acquiring access to administrative data and key stakeholders for interview.

Our outcomes analysis will rely on administrative data obtained from the water and drainage utilities, city and local government, and MOPH and MISAU. During the evaluation design trip, we met with staff at INE, who shared a series of annual reports so that we could review the data they collect. Upon approval of the evaluation design, we will submit a data sharing agreement to the INE director, who agreed to give us access to the databases used to compile the annual report. We are also working with FIPAG to try to gain access to customer billing data in support of the evaluation. FIPAG has agreed to provide our team with all of the MCC indicator ITT data; however, they are unwilling to share additional data with our team until they review our evaluation design and understand how we will use the data. To ensure data quality, we will cross-check key indicators with data from externally validated organizations and review the methodologies for each data source.

The Mathematica team will conduct all interviews and focus groups in Mozambique. All interviews will be conducted in Portuguese and transcribed by a local organization. Throughout the process, we will review field notes and provide regular feedback to ensure that our research is responsive and adaptive to the emerging findings. Our instrument and protocol development will follow key data quality practices, including seeking input from MCC and local stakeholders to ensure that the questions are thorough and appropriately framed and targeted. We will pilot a sample of interview protocols to pre-test questions and ensure that the field procedures are effective before making final revisions to the protocols and conducting the interviews. We will ensure that data from the interviews are correctly transcribed and cleaned for coding and analysis. Since our team speaks Portuguese, we will limit translation of interview and focus group transcripts.

The success of the evaluation depends on the collection of qualitative data that are valid, accurate, and useful. We plan to rely on interviews with key stakeholders and FGDs, in which we will need to elicit potentially sensitive information. In a complex system with several layers of accountabilities and incentives, interview subjects may be reluctant to share honest opinions that could be perceived as being critical of or unfavorable toward the project, peers, or supervisors. Focus groups could tend toward "groupthink" if not carefully facilitated to draw out quieter members and elicit diverse opinions. To mitigate these risks, we will follow best practices for gathering qualitative data, including ensuring confidentiality, as well as recording (where appropriate and possible) and transcribing all interviews so that the analysis can be done using raw data rather than notes taken during sessions. We will strive to put our informants at ease, probing carefully without resorting to asking leading questions. To further minimize this risk to data quality, we plan to implement the following data quality controls:

- Work with local consultants who have experience working among diverse populations in urban and peri-urban areas of northern Mozambique
- Set interviewer recruitment and evaluation standards
- Create instruments in Portuguese
- Pre-test and pilot to ensure the effectiveness of field protocols and instruments
- Set up teleconference meetings with the Mathematica team in the field to discuss challenges encountered in the field.
- Review transcripts with audio to ensure proper transcription

V. ADMINISTRATIVE

A. Summary of IRB requirements and clearances

Mathematica is committed to protecting the rights and welfare of human subjects and will obtain approval from an institutional review board (IRB) for relevant research and data collection activities. IRB approval requires three sets of documents: (1) a research protocol, in which we describe the purpose and design of the research and provide information about our plans for protecting the confidentiality and human rights of study participants, including how we will acquire consent for their participation; (2) copies of all data collection instruments and consent forms that we plan to use for the evaluation; and (3) a completed IRB questionnaire that provides information about the research protocol, how we will securely collect and store our data, our plans for protecting participants' rights, and any possible threats to participants resulting from any compromise of data confidentiality. We anticipate that this study will qualify for expedited IRB review as it presents minimal risk to participants. IRB approval is valid for one year; we will submit annual renewals for subsequent year approvals if needed.

In addition, we will ensure that the study meets all U.S. and Mozambique research standards for ethics, in consultation with MCC. We will submit the research protocols and instruments to our U.S.-based IRB and the local IRB in Mozambique (if required). We will work with our local consultant to obtain permits or clearances from the relevant national and/or local government offices before starting field work. If either the U.S. IRB or the local IRB recommends changes to protocols or instruments, the local consultants, MCC, and Mathematica will work together to accommodate the changes and all parties will agree on the final protocols before the start of data collection.

B. Data protection

Mathematica and its consultants adhere to the highest standards of collecting and maintaining data in an ethical and confidential manner. Prior to commencing work, the local consultants who will be conducting interviewers and moderate focus groups will be trained regarding protocols, human subjects protection, and the specific requirements of this study. The data collection process will incorporate the elements of good consent practices in a culturally relevant context. We will obtain oral consent from all respondents in Portuguese or English (depending on the respondent's language preference) before beginning the interviews/focus groups. Before interviewing any respondent, the interviewer will provide a description of the study and its purpose, our procedures, and confidentiality safeguards, and will request verbal consent to proceed. The consent language for the semi-structured qualitative interviews and focus group protocols will be similar. For focus groups, we will add an additional statement with a request for participants not to share anything discussed during the focus group with anyone outside of the group. All interviewees and focus group respondents may choose not to participate.

Interviewers and moderators will ensure respondents have privacy in participating in interviews (although privacy will not be possible for focus groups), and will maintain control of all protocols and audio recordings during field work. Interviews and focus groups will be recorded, with the recordings stored on secure password-protected computers that only the data

collection and study team can access. We will transfer the final transcripts to the Mathematica office electronically via email, using WinZip or a similar tool for encryption during transfer. In Mathematica's offices, all electronic data pulled from the file transfer site will be password protected and saved on secured servers. Reports will not identify participants by name or provide other information that would enable respondents to be identified.

For all Mathematica projects, all electronic data are encrypted both in transit and at rest. Sensitive data are stored (segregated) into a designated encrypted project folder that is secured with AES 256-bit encryption. Access is restricted through the use of access control lists. Access to the project folder is authorized by the project director on need-to-know and least-privilege bases. Data stored in the designated restricted folder are easily identifiable to authorized staff for data return or destruction purposes. Project staff are instructed to maintain all files with confidential data in these project-specific, encrypted folders on the Mathematica network. In addition, Mathematica utilizes a host-based intrusion detection system and firewall provided by Symantec Endpoint Protection.

C. Preparing data files for access, privacy, and documentation

After producing the final report, we will explore the possibility of preparing corresponding de-identified data files and codebooks that MCC can make available to the public. We budgeted 16 hours to complete this task and do not expect it to be extensive. We will not collect any survey data, and our ability to produce public use files from the administrative and qualitative data we collect will be limited. We will redact the qualitative transcripts and de-identify administrative data files and manuals according to the most recent guidelines set forth by MCC. The public use data files will be free of personal or geographic identifiers that would allow users to directly identify individual respondents or their households and we will remove or adjust variables that could introduce reasonable risks of deductively disclosing the identity of individual participants. Mathematica will remove all individual identifiers, including names, addresses, telephone numbers, and any other similar variables. We will also remove unique and rare data using local suppression, replacing those observations with missing values instead. If necessary, we will also use top and bottom coding, setting upper and lower bounds to remove outliers and collapsing any variables that could make an individual highly visible by means of geographic or other factors into less easily identifiable categories. We will explore whether we are able to manage the data perturbation necessary to ensure respondent confidentiality without significantly degrading the data so they are still useful to the public.

D. Dissemination plan

To ensure that the results and lessons from the evaluation reach a wide audience, we will work with MCC to increase the visibility of the evaluation and to target the findings to relevant policymakers and practitioners in the WASH sector. We have already developed relationships with key project stakeholders during our design assessment trip, including staff from MORPH, DNGRH, DNAAS, FIPAG, AIAS, EMUSA(NA), ARA, and CRA. We will share our final evaluation design report with these and other project stakeholders, including Mozambican government officials, to inform and engage them in the evaluation process and solicit their feedback. We will present our evaluation design to staff from MCC and project stakeholders either in person or remotely. After completing the final report, we will present findings in person

to MCC in Washington, DC. The final evaluation report will be available online on the MCC website within six months of its submission.

We expect the broader research community to have strong interest in the findings from the evaluation. To facilitate wide dissemination of findings and lessons learned, we will collaborate with MCC and other stakeholders to identify additional forums—conferences, workshops, and publications—in which to disseminate the results, and we will encourage other donors and implementers to integrate the findings into their programming. For example, in addition to the project's final report, we will develop a policy issue brief summarizing and visualizing key findings for a broader audience of readers and stakeholders.

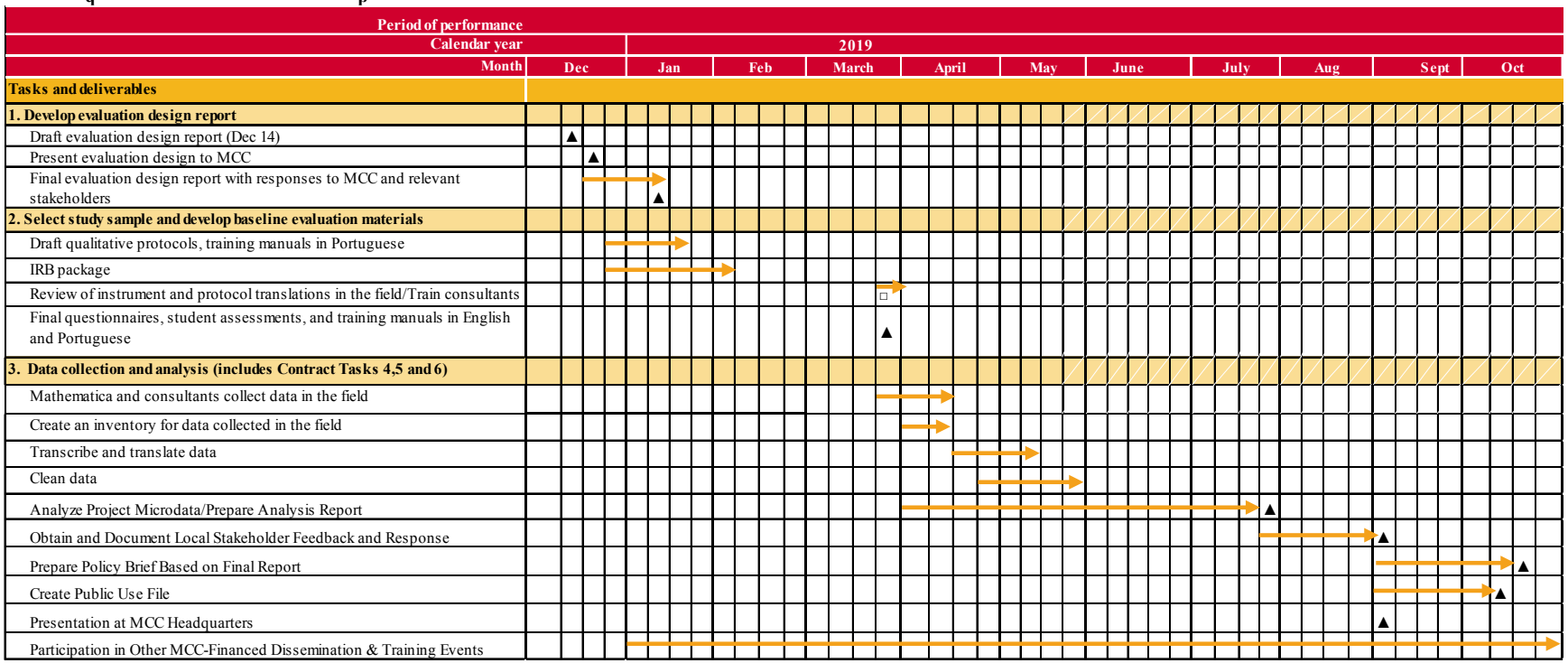
E. Evaluation team roles and responsibilities

Our team will contribute extensive experience and expertise to meet MCC's evaluation needs. **Dr. Audrey-Marie Moore** leads the team as the program manager and oversees the design and implementation of the evaluation. She assumes primary responsibility for coordinating deliverables and for ensuring the on-time completion of tasks within budget and with high quality. She is also the qualitative methods expert for the data collection activities and evaluation. **Dr. Clair Null** serves as the senior evaluation expert, responsible for the technical and methodological leadership of the evaluation. **Mr. Joe Dalton** serves as the senior water and sanitation expert consultant and is supporting the assessments of water and drainage infrastructure. **Dr. Catalina Torrente** is the team's analysis/evaluation expert. Dr. Torrente supports Drs. Moore and Null in the technical design process and in data collection and analysis. **Mr. Anselmo Feleuane** and **Mr. Cesar Cossa** are in-country qualitative evaluation consultants who work closely with Mathematica and local stakeholders to organize data collection logistics and support data collection, including by conducting key informant interviews and FGDs and compiling secondary and administrative data. **Ms. Raquel af Ursin and Ms. Irina Cheban** serve as research analysts and support the team with the design of the qualitative assessment, including instrument development and data collection. **Mr. Evan Fantozzi** manages the project internally for Mathematica and supports research tasks.

F. Evaluation timeline and reporting schedule

Figure V.1 presents our evaluation activities, including instrument development and data collection, administrative and qualitative data analysis, report writing, and dissemination for the final report. We will closely monitor risks to completing deliverables on time, including the political and economic environment in Mozambique. If any factors will affect our evaluation timeline, we will discuss them in advance with MCC.

Figure V.1. Mozambique data collection workplan



▲ Report/deliverable

REFERENCES

African Development Bank Group. "AIKP Water Supply and Sanitation Needs Model (WSS)." January 2016. Available at http://infrastructureafrica.opendataforafrica.org/AIKPWSSNM2016/aikp-water-supply-and-sanitation-needs-model-wss-2016. Accessed February 15, 2019.

Ahern, Mike, and Sari R. Kovats. "Global Health Impacts of Floods: Epidemiologic Evidence." *Epidemiologic Reviews,* vol. 27, 2005, pp. 36–46.

Bartlett, S. "Climate Change and Urban Children: Impacts and Implications for Adaptation in Low- and Middle-Income Countries." *Environment & Urbanization,* vol. 20, no. 2, 2008, pp. 501–519.

Davis, J., A. Kang, J. Vincent, and D. Whittington. "How Important is Improved Water Infrastructure to Microenterprises? Evidence from Uganda." *World Development,* vol. 29, no. 10, 2001, pp. 1753–1767.

Douglas, I., K. Alam, M. Maghenda, Y. McDonnell, L. McLean, and J. Campbell. "Unjust Waters: Climate Change, Flooding and the Urban Poor in Africa." *Environment and Urbanization,* vol. 20, no. 1, 2008, pp. 187–205.

Escribano, A., J. Guasch, and J. Pena. "Assessing the Impact of Infrastructure Quality on Firm Productivity in Africa: Cross-Country Comparisons Based on Investment Climate Surveys from 1999 to 2005." IDEAS Working Paper Series from RePEc, 2009.

Esfahani, Hadi S., and Maria T. Ramírez. "Institutions, Infrastructure, and Economic Growth." *Journal of Development Economics* vol. 70, no. 2, 2003, pp. 443–477.

Estache, A., B. Speciale, and D. Veredas. "How Much Does Infrastructure Matter to Growth in Sub-Saharan Africa?" Washington DC: Mimeo, World Bank, 2005. Available online. Accessed December 13, 2018.

Fletcher, T., W. Shuster, W. Hunt, R. Ashley, D. Butler, S. Arthur, S. Trowsdale, S. Barraud, A. Semadeni-Davies, J. Bertrand-Krajewski, P. Mikkelsen, G. Rivard, M. Uhl, D. Dagenais, and M. Viklander. "SUDS, LID, BMPs, WSUD and More – The Evolution and Application of Terminology Surrounding Urban Drainage." *Urban Water Journal,* vol. 12, no. 7, 2014, pp. 1–18.

Gretsch, S., J. Ampofo, K. Baker, J. Clennon, C. Null, D. Peprah, H. Reese, K. Robb, P. Teunis, N. Wellington, H. Yakubu, and C. Moe. "Quantification of Exposure to Fecal Contamination in Open Drains in Four Neighborhoods in Accra, Ghana." *Journal of Water and Health*, vol. 14, no. 2, 2015, pp. 255–266.

Guerrero, L., G. Maas, and W. Hogland. "Solid Waste Management Challenges for Cities in Developing Countries." *Waste Management*, vol. 33, no.1, 2013, pp. 220–232.

Hammond, M., A. Chen, S. Djordjević, D. Butler, and O. Mark. "Urban Flood Impact Assessment: A State-of-the-Art Review." *Urban Water Journal,* vol. 12, no. 1, 2013, pp. 1-16.

Islam, Asif. "The Burden of Water Shortages on Informal Firms." World Bank Policy Research Working Paper #8457, 2018. Available at https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-8457.

Jha, A., R. Bloch, and J. Lamond. *Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century* (World Bank e-Library). Washington, D.C.: World Bank, 2012.

Katukiza, A., M. Ronteltap, P. Steen, J. Foppen, and P. Lens. "Quantification of Microbial Risks to Human Health Caused by Waterborne Viruses and Bacteria in an Urban Slum." *Journal of Applied Microbiology,* vol. 116, no. 2, 2014, pp. 447–463.

Kaza, S., L. Yao, P. Bhada-Tata, and F. Van Woerden. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Urban Development Series. Washington, DC: World Bank, 2018

Labite, H., I. Lunani, P. Van Der Steen, K. Vairavamoorthy, P. Drechsel, and P. Lens. "Quantitative Microbial Risk Analysis to Evaluate Health Effects of Interventions in the Urban Water System of Accra, Ghana." *Journal of Water and Health,* vol. 8, no. 3, 2010, pp. 417-430.

MCC Compact Closeout Report – Mozambique. Washington D.C.: Millennium Challenge Corporation, 2013.

Moraes, L., J. Cancio, S. Cairncross, and S. Huttly. "Impact of Drainage and Sewerage on Diarrhoea in Poor Urban Areas in Salvador, Brazil." *Transactions of the Royal Society of Tropical Medicine and Hygiene,* vol. 97, no. 2, 2003, pp. 153–158.

Moraes, L., J. Cancio, and S. Cairncross. "Impact of Drainage and Sewerage on Intestinal Nematode Infections in Poor Urban Areas in Salvador, Brazil." *Transactions of The Royal Society of Tropical Medicine and Hygiene,* vol. 98, no. 4, 2004, pp. 197–204.

Moyo, Busani. "Do Water Cuts Affect Productivity? Case Study of African Manufacturing Firms." *Water SA,* vol. 37, no. 3, 2011, p. 349.

Ogawa, Hisashi. "Sustainable Solid Waste Management" Presented at the 7th ISWA International Congress and Exhibition, Parallel Session 7, "International Perspective." Kuala Lumpur, Malaysia, 2005.

Parkinson, Jonathan. "Urban Drainage in Developing Countries—Challenges and Opportunities." *Waterline*s, vol. 20, no. 4, 2002, pp. 2–5.

Parkinson, Jonathan, and Ole Mark. "Urban Stormwater Management in Developing Countries." *Water Intelligence Online*, vol. 5, 2006.

Parkinson, J., K. Tayler, and O. Mark. "Planning and Design of Urban Drainage Systems in Informal Settlements in Developing Countries." *Urban Water Journal,* vol. 4, no. 3, 2007, pp. 137–149.

SIWI. "Making Water a Part of Economic Development: The Economic Benefits of Improved Water Management and Services." Stockholm International Water Institute, 2005.

UN. "Accelerating SDG 11 Achievement: Policy Brief in Support of the First SDG 11 Review at the UN High-level Political Forum 2018." New York: United Nations, 2018. Available at https://sustainabledevelopment.un.org/content/documents/194452018_HLPF_Thematic_Review_of_SDG_11_UNHabitat_12_June_2018_original.pdf. Accessed December 13, 2018.

United Nations World Water Assessment Programme (WWAP). "The United Nations World Water Development Report 2016: Water and Jobs." Paris: UNESCO, 2016.

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APPENDIX A

BUDGET

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Table A.1. Mathematica Cost to Complete Budget by task, Labor and ODC

Task	Task Description	(a) Current Contract			(b) Reported/Invoiced through 11/30/2018			(c) Estimated Budget to Complete			(d) Total (b+c)		
		Labor	ODC	Total	Labor	ODC	Total	Labor	ODC	Total	Labor	ODC	Total
1	Assess Evaluation Plan	$31,496	$1,401	$32,897	$41,188	$1,630	$42,819	$0	$0	$0	$41,188	$1,630	$42,819
2	Develop Evaluation Design Report	$127,742	$36,260	$164,002	$127,197	$30,898	$158,095	$59,851	$13,526	$73,377	$187,048	$44,423	$231,472
3	Develop Evaluation Materials	$63,383	$3,916	$67,299	$956	$37	$993	$35,556	$2,707	$38,263	$36,512	$2,744	$39,256
4	Supervise Data Collection	$45,599	$58,417	$104,016			$0	$39,491	$25,463	$64,954	$39,491	$25,463	$64,954
5	Develop Final Report	$89,012	$39,345	$128,357			$0	$106,888	$15,967	$122,855	$106,888	$15,967	$122,855
6	Disseminate Final Report	$21,391	$896	$22,287			$0	$16,744	$758	$17,502	$16,744	$758	$17,502
Total Estimated Amount		**$378,622**	**$140,235**	**$518,858**	**$169,342**	**$32,565**	**$201,907**	**$258,530**	**$58,420**	**$316,951**	**$427,872**	**$90,986**	**$518,858**

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