INFLUENCE OF THE ENABLING ENVIRONMENT ON DRINKING-WATER PROGRAMS: QUALITATIVE AND QUANTITATIVE ANALYSES

Edema Ojomo

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Approved by:

Jamie Bartram

Bruce Gordon

Jackie MacDonald-Gibson

Mark Sobsey

Frank Webb

ABSTRACT

Edema Ojomo: Influence Of The Enabling Environment On Drinking-Water Programs: Qualitative And Quantitative Analyses
(Under the direction of Jamie Bartram)

Accounting for drinking-water quality, approximately 1.8 billion people lack access to safe drinking-water, increasing their risk of diarrheal diseases. To remedy this, Sustainable Development Goals, particularly target 6.1 to "achieve universal access to safe and equitable water" by 2030, were established. It is believed achieving this will require an enabling environment. However, the enabling environment for drinking-water programs is ill-defined. The term "enabling environment" is increasingly used in the drinking-water field but its meaning is vague and its influence on drinking-water programs has not been determined. The purpose of this dissertation is to clarify the meaning of the enabling environment and investigate its influence on drinking-water programs. I use the institutional analysis and development framework to explain the enabling environment. Key informant interviews are carried out to determine the influence of the enabling environment on drinking-water programs, specifically household-water treatment and safe storage (HWTS) programs and climate change adaptation of drinking-water systems. Additionally, multiple regression analyses are conducted to determine the significance of enabling environment variables on expenditures on drinking-water systems, a proxy for decision-making about providing access to drinking-water.

I find that the enabling environment is the blend of formal rules, informal rules, and the physical environment that impact the capacity of individuals and organizations to achieve their

objectives. All enabling environment elements—formal rules, informal rules, and the physical environment—were found to influence the drinking-water programs analyzed; however, their relative degree of influence varied. In the HWTS study, informal rules (e.g. cultures), were found to determine adoption of HWTS practices more than formal rules (e.g. policies). Formal rules had a greater impact on decisions to adapt drinking-water systems to climate change than informal rules. Formal and informal rules about partnerships were a recurrent theme in both studies. Regression analyses showed that policies supporting user participation and cross-sectoral partnerships had significant effects on expenditures on drinking-water systems regardless of rural or urban setting.

I show that actors involved in drinking-water programs will benefit from shaping an enabling environment that facilitates access to drinking-water. This enabling environment will resemble one that is collaborative with clearly defined leadership.

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CHAPTER 1: INTRODUCTION

1. Exploring the Enabling Environment for Drinking-Water Programs

1.1. Defining the Enabling Environment for Drinking-Water Programs

Recent decades have seen dramatic changes in the way development initiatives are defined and approached. The 1960s and 70s focused on training and provision of tools and equipment for individuals in key positions, a movement labeled "technical assistance" and later "technical cooperation." Eventually, focus shifted to developing "organizational capacities" and building a sense of "ownership" in recipient countries in addition to increasing technical capacities (DFID, 2002; UNDP, 2002; OECD, 2008). Subsequently, development actors shifted focus away from project characteristics and training towards features of the target environments that impact the sustainability of development programs (Brinkerhoff, 2004). The shift brought about a new concept in the development community—the enabling environment. This concept broadly denotes the environment within which actors perform and the conditions of this environment that impact the capacity of actors to carry out activities. The term "enabling environment" is increasingly used, especially in the drinking-water field, as can be seen in the growing number of publications on the enabling environment for drinking-water programs (examples include Johnson and Perez, 2002; EAWAG, 2005; Adank et al., 2013); however, efforts to explore its meaning have been minimal and, as a result, it is currently a vague concept that is often imprecisely defined (Konig, et al., 2013). Varied interpretations may lead to confusion during discussions and/or false expectations, which if reduced or eliminated, could aid in more effective delivery of services in different areas of development intervention, including the drinking water sector.

With the increasing interest in the concept of the enabling environment and the increasing number of publications that call for the implementation of programs in an enabling environment (e.g. Brinkerhoff, 2012, Zearly, 1993, Haddad, 2013, Loza, 2004, United Nations, 2015), it is important to determine what the enabling environment for drinking-water programs is; if and what elements of the enabling environment impact drinking-water programs; and possible reasons why they have an impact, as these could improve implementation practices. This assessment will improve the understanding of the term and findings will assist drinking-water program stakeholders in determining what elements of the enabling environment are broadly associated with specific drinking-water programs, given the growing importance of the enabling environment. The understanding of the enabling environment for drinking-water programs is particularly important given the commitment to pursue "policy coherence and an enabling environment for sustainable development at all levels" in the achievement of the Sustainable Development Goals (SDGs), including SDG target 6.1 to "achieve universal and equitable access to safe and affordable drinking water for all" by 2030 (United Nations, 2015, p. 31).Target 6.b of the SDGs, highlights a means of implementation to facilitate achievement of SDG target 6.1 which is an environment that supports and strengthens community participation in water management. In addition to this, achieving SDG 6 (ensure water and sanitation for all), will require an enabling environment that includes strong leadership, clear roles and responsibilities, and supportive policies (United Nations, 2015). The achievement of the drinking-water target of the SDGs has implications for public health and economic development; therefore, it is important that if this achievement is, even partly, dependent on the enabling environment, a better grasp of this environment is achieved.

1.2. Investigating the Enabling Environment and its Influence on Drinking-Water Programs

According to the World Health Organization (WHO) and United Nations Children's Emergency Fund (UNICEF) Joint Monitoring Programme Report (2015), more than 650 million people in the world, majority of whom reside in low-income countries, lack access to improved drinking water sources, that is, sources "that, by nature of their construction, are protected from outside contamination, particularly fecal matter." National and global analyses accounting for drinking water quality have shown that people with "improved" drinking water do not necessarily have access to a water source that is microbiologically safe to drink (Bain, et al., 2012; Baum, et al., 2014; Onda, et al., 2012). In 2012, there were approximately 842,000 diarrheal deaths as a result of inadequate water, sanitation, and hygiene (WaSH) practices worldwide and approximately 380,000 of these deaths were children under the age of five (Prüss-Üstün, et al., 2014). Consuming unsafe water also has adverse effects on school attendance and economic development, as illnesses like diarrhea lead to high rates of school absenteeism, missed workdays, and increased expenditures on healthcare (Hutton & Haller, 2004; Monse, et al., 2013). Additionally, lack of access near the home increases time spent collecting water, which contributes to decreased school attendance and a reduction in other productive activities (Hutton & Haller, 2004; Hutton, et al., 2007; Sorenson, et al., 2011).

Considering the implications unsafe drinking-water has on public health and economic development, it is important that resources being put towards achieving universal access to safe drinking-water are not wasted. One way to ensure effective use of resources is to improve the understanding of the conditions, including the enabling environment, that will foster the achievement of universal access to safe drinking-water. To improve understanding of the enabling environment and determine if, and how, this environment influences drinking-water programs, I conduct qualitative analyses to determine the factors that facilitate the implementation of two drinking-water programs and a quantitative analysis to support the findings. The qualitative analyses examine decisions to employ household-water treatment and safe storage (HWTS) practices and to adapt drinking-water systems, specifically piped water systems, to climate change. These were selected because they represent programs in which the main decision-makers are different, the number of people affected by the decisions made are vastly different, and the organizations that implement these programs vary. Therefore, the specific enabling environment factors that are influential, if they indeed are, may vary. This approach is intended to produce a more comprehensive understanding of the enabling environment. The quantitative study looks at the influence of the enabling environment on expenditures on drinking-water systems, which is a proxy for decision-making about increasing access to drinking-water sources. The findings from these three studies will help clarify the impact the enabling environment has on drinking-water programs.

1.2.1. Rationale for Investigating the Enabling Environment for Climate Change Adaptation

Water resources (surface water and groundwater) and drinking-water infrastructure have been, and continue to be, adversely affected by the changing climate (IPCC, 2014). This is particularly true of coastal areas where it is believed the impacts of climate change will be greater due to the susceptibility of these areas to additional climate impacts like sea level rise, storm surges, and cyclones (EPA, 2015). Additionally, coastal areas are particularly important because of their economic significance and high population. Three-quarters of all large cities are located on the coast and more than 40% of the global population resides within 100km of the coast (UNEP, UN-HABITAT, 2005; UN, n.d.). With the effects climate change is projected to have on drinking-water systems (resources and infrastructure), water quality and quantity could be threatened, as experts believe that the undesirable impacts of climate change on freshwater systems outweigh the benefits (IPCC, 2014). To deal with the impacts climate change will have on drinking-water systems, effective adaptation of these systems needs to be carried out to ensure that efforts made to increase access are not futile. Adaptation is particularly important because few drinking-water systems are resilient to climate change (Howard, et al., 2007).

Adaptation to climate change is dependent on a number of conditions including high costs of adaptation (estimated by the World Bank (2009) to be billions of dollars a year for low-income countries) and other conditions which may include the enabling environment. However, these conditions are not well known and understood, particularly for drinking-water systems in low-income countries. Most of the literature on enablers and barriers to climate change adaptation focuses on high-income countries (examples include Bierbaum et al., 2012, Hunt and Watkiss, 2011, Jantarasami et al., 2010, Lawrence et al., 2015, and Measham et al., 2011). With the projected impacts climate change will have on water systems and on low-income countries (IPCC, 2015), research specific to low-income countries is warranted, since almost half of the world's population (3.45 billion people) resides in low- and lower middle income countries (World Bank, 2015). This research has implications for the goal of universal access. With the changing climate, the ideal solution to lack of access to safe drinking-water is to ensure universal access to safe and climate-resilient water supplies However, achieving this will require shaping conditions, such as the enabling environment, that are favorable to the building and maintenance of these systems (World Bank, 2010). In the meantime, individuals must obtain their water from unimproved and/or climate vulnerable sources.

1.2.2. Rationale for Investigating the Enabling Environment for Household Water Treatment and Safe Storage Programs

Household water treatment and safe storage (HWTS) options like boiling, chlorination, and filtration provide feasible interim solutions for managing water safety at home while access to improved and safe water sources is increased and/or while water quality is compromised, even if temporarily. HWTS options do not increase access, rather they provide an alternative for dealing with the safety aspects of water collected from sources not close to the home, water from unimproved sources, and water contaminated by a number of factors including flooding from climate disasters. HWTS interventions have been demonstrated to yield improvements in drinking water quality and reductions in diarrheal disease (Sobsey, et al., 2008; Clasen, et al., 2007). However, there have been studies that show that HWTS practices are not as effective in diarrheal disease reduction as is often claimed, especially when assessed over periods longer than those typical of HWTS studies (Boisson, et al., 2013; Hunter, 2009). The success of HWTS interventions in preventing disease is a function of many factors, including efficacy of the practiced method at removing or inactivating pathogens of concern, rates of consistent and correct use, and the presence of other pathogen exposure routes (Enger, et al., 2013; Brown & Clasen, 2012).

Despite evidence that HWTS practices can be effective in reducing diarrheal diseases when used correctly and consistently, centuries of practice by individuals, and years of advocacy and implementation efforts by non-governmental organizations (NGOs), HWTS practices, except boiling, are yet to achieve scale (Clasen, 2008). There is limited research on ways to scale-up and sustain HWTS practices and limited understanding of the factors that influence people's decisions. Most research on choices to treat water at home or to select particular treatment methods focus mainly on individual and demographic characteristics (e.g. EAWAG SANDEC, 2002, POUZN, 2007, and SODIS, 2007). Research on individual and demographic factors in addition to community level factors such as the context within which HWTS interventions are being carried out is limited (e.g. Clasen 2008). A comprehensive assessment on conditions that drive scale-up and sustainability of HWTS practices will provide information on the influence of the enabling environment, if there is one, on people's decisions to adopt and continue to use HWTS products and technologies.

1.2.3. Rationale for the Quantitative Analysis

Quantitative studies can support and strengthen the conclusions made by qualitative analyses by determining if the probability of coming to these conclusions when a suitable sample size is analyzed. For example, certain factors may be determined to influence outcomes qualitatively but quantitative studies aid in giving confidence that the conclusions made through the qualitative studies were not random occurrences and help determine the magnitude of the effect of these factors on the outcomes. The implementation of drinking-water programs, whether HWTS programs or climate change adaptation, has costs that are incurred by a wide range of stakeholders, including governments, private sector organizations, NGOs, and consumers. It has been estimated that universal access to improved drinking-water sources would cost billions of dollars per year from 2015 to 2030 and these costs are not incurred equally by all countries owing to a number of factors, including population size (e.g. China's population is 1.3 billion while Cape Verde's population is about 500,000 (World Bank, 2016)) and current access to drinking-water which hints at past expenditures in providing access (Hutton and Varughese, 2016).

Studies have analyzed household (Soares, et al., 2002) and national (Bain, et al., 2013; Luh & Bartram, 2016) determinants of access to improved drinking-water sources or change in access to improved drinking-water sources over time. Luh and Bartram (2016) found no correlation between nine country characteristics, one of which was official development assistance, and normalized rate of change in access over time. Bain et al. (2013) also found no association between the volume of aid and progress. The same conclusions were drawn by Botting et al. (2010) and Wolf (2007) when gross domestic product (GDP) per capita was controlled for.

The enabling environment includes formal rules such as policies. This is one point of agreement in the literature on the enabling environment. Studies on national conditions have focused on socio-economic characteristics and not on policies. Policies are more proximal determinants of commitments and decision-making about access to drinking-water sources. By assessing the role of policies and regulations, which are proxies for decision-making at the national level, about drinking-water systems, insight into the role of the enabling environment can be acquired.

The focus on the enabling environment in the SDGs[1] makes clarifying the enabling environment for drinking-water programs necessary because of the implications drinking-water has on public health and economic development and because a better understanding of the enabling environment and how it influences drinking-water programs can lead to more effective allocation of resources towards the important elements.

1.3. Purpose and Research Questions

The purpose of this dissertation is to develop a working definition of enabling environment and examine the influence of the enabling environment on decisions about drinking-water programs. To achieve this, I use mixed methods research to explore the concept of the enabling environment, the influence of this enabling environment on climate adaptation and HWTS programs, and the extent to which different factors of the enabling environment influence drinking-water system expenditures. By using mixed methods, I approach the dissertation from multiple views, thereby providing a more complete perspective. Specifically, I achieve this by answering the following questions:

1. What is the enabling environment for drinking-water programs and what elements does it comprise?
2. Does the enabling environment influence scale-up and sustainability of HWTS practices? If it does, what elements of the enabling environment influence scale-up and sustainability of HWTS practices?
3. Does the enabling environment influence climate change adaptation of water systems in low-income coastal countries? If it does, what elements of the enabling environment influence adaptation of water systems, specifically piped water systems?

[1] There is a commitment to pursue an enabling environment. This environment is one with strong leadership, clear roles and responsibilities, and supportive policies.

4. What country-level enabling environment factors influence expenditure on drinking-water systems?

To answer these questions, I (a) used the Institutional Analysis and Development (IAD) framework to analyze the concept of the enabling environment and to build a framework for diagnosing the enabling environment for drinking-water programs; (b) conducted interviews with key informants in HWTS programs to determine enablers and barriers to the scale-up and sustainability of HWTS programs; (c) conducted interviews with key informants in drinking-water programs, specifically water utilities and government officials involved in climate change to determine enablers and barriers to adaptation of drinking-water systems to climate change; and (d) performed multiple regressions to determine the association between enabling environment variables obtained from the Global Analysis and Assessment of Sanitation and Drinking Water (GLAAS) dataset, and expenditures on drinking-water systems.

1.4. Structure of the Dissertation

This dissertation is divided into seven chapters (Figure 1). The next four chapters detail the studies carried out, current knowledge on those areas of research and the results from those studies. The sixth chapter addresses the lessons learned about the enabling environment from all the studies and the connections between the studies. The seventh and last chapter concludes the dissertations with major findings and implications of the research carried out.

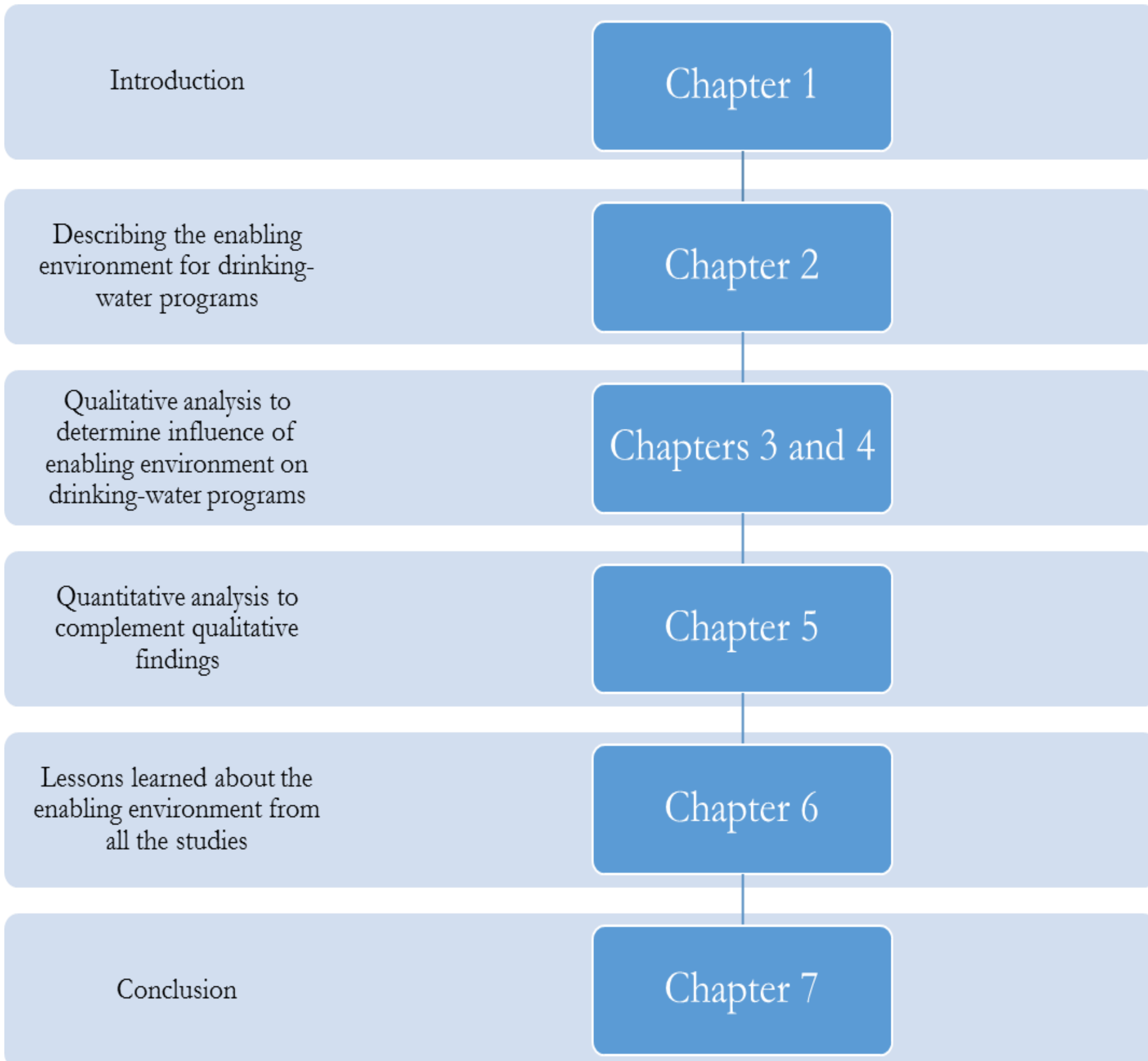

Figure 1.1: Structure of the dissertation

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CHAPTER 2: THE ENABLING ENVIRONMENT FOR DRINKING WATER PROGRAMS: DESCRIPTION AND DIAGNOSTIC FRAMEWORK[2].

1. Introduction

With the inception of the Sustainable Development Goals (SDGs) in 2015, drinking water practitioners are exploring ways to ensure universal access to safe water in a sustainable fashion because hundreds of thousands of people die from diarrheal diseases that result from unsafe water, inadequate sanitation, and poor hygiene practices every year (Prüss-Üstün, et al., 2014). There have been dramatic changes in the way development initiatives are defined and approached. The 1960s and 70s focused on training and provision of tools and equipment for individuals in key positions, a movement labeled "technical assistance" and later "technical cooperation" to imply a change in towards more equal partnership between donor and recipient countries (GSDRC, 2009). Eventually, focus shifted to developing "organizational capacities" and building a sense of "ownership" in recipient countries in addition to increasing technical capacities (DFID, 2002; UNDP, 2002; OECD, 2008). Each of these has been a focus of activity for development organizations. Subsequently, development actors shifted focus away from project characteristics and training towards features of the target environments that impact the success of development programs (Brinkerhoff, 2004). The shift brought about a new concept in the development community – the "enabling environment."

The meaning of enabling environment is vague and it is often imprecisely defined, despite its increasing use (FAO, 2013). The enabling environment is broadly described as the context within which actors perform and programs are developed and implemented; although these contexts vary,

[2] This chapter will be submitted to the World Development journal.

for example depending on the sector employing the term, definitions vary and remain broad and lacking in detail even when employed by authors working in the same sector (EAWAG, 2005; Johnson & Perez, 2002; WSP, n.d.). This may be because "like much of the vocabulary of international development and assistance discourse, the term exhibits an apparent clarity that masks the underlying complexity inherent in the conceptual territory it subsumes" (Brinkerhoff, 2004, p. 1). Additionally, the term is more recent than many other international development terms and has not been the subject of rigorous analysis in the drinking water field.

Target 6.1 of the SDGs is to "achieve universal and equitable access to safe and affordable drinking water for all" by 2030 (UN, 2015, p. 6). According to the United Nations (UN, 2015, p. 29), one of the ways in which effective implementation will occur is in the presence of an enabling environment and there is a commitment to pursue "policy coherence and an enabling environment for sustainable development at all levels" in the achievement of the SDGs. However, it is unclear what this enabling environment would look like for the SDG targets.

Within the drinking water field, the enabling environment is defined in various ways[3] and while a perfect definition, agreed upon by everyone, may not be possible, it is important that the meaning of the term, as it relates to drinking water programs, is explored. Different interpretations may lead to poor communication between stakeholders which if eliminated, could aid in more effective delivery of water services. With the increasing use of the term, practitioners, policy makers, researchers, and other actors in the drinking water sector may be well served by some clarification.

This paper clarifies the meaning of the enabling environment as it relates to drinking water,

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[3] Johnson & Perez (2002) define it as those organizational and/or social structures that, when established, will sustain the implementation of programs and determine the scale of the public health impact of those programs; Water and Sanitation Program of the World Bank (2008) defines it as the policy, institutional and financial framework that is necessary for sustaining and replicating large scale sanitation programs.

assesses the enabling environment for drinking water programs, and proposes a diagnostic tool for examining the enabling environment that will assist organizations during program planning and implementation. The Institutional Analysis and Development (IAD) framework is used to analyze the enabling environment for drinking water programs and as a guide for systematically defining the enabling environment for drinking water programs. The IAD framework is used because it facilitates a comprehensive analysis of the elements present in all human systems, the values of which differ from one system to another. Additionally, the framework is well-established and has been used in diverse fields to analyze institutions.

2. Defining the Enabling Environment for Drinking Water Programs Using the Institutional Analysis and Development Framework

2.1. Building the Foundation for the Enabling Environment Definition

Table 1 provides a sample list of definitions used in different sectors and shows the parts that generally comprise an enabling environment definition. The bolded, italicized, and underlined words in the table represent the elements, impacts, and objectives, respectively.

Table 2.1: Definitions of the enabling environment broken into elements, impact, and objectives

Source	Field	Definition
UNDP, 2008	Capacity Development	"**the broader system within which individuals and organizations function** and one *that facilitates or hampers* their <u>existence and performance</u>"
Johnson & Perez 2002	Rural water supply and sanitation	"**those organizational and/or social structures** that, when established, *will sustain* the <u>implementation of programs</u> and *determine* the <u>scale of the public health impact of those programs</u>."
Winpenny 1994	Water resource management	"the creation of **general conditions** for *encouraging* the <u>more economically rational use of resources such as water</u>."
Thindwa et al. 2003	Civic engagement	"A **set of conditions** - often inter-related - *that impact* on the <u>capacity of citizens and civil society organizations to engage in development processes in a sustained and effective manner, whether at the policy, program or project level</u>.
Water and Sanitation Programme (WSP) of the World Bank	Handwashing and rural sanitation	"the **policy, institutional and financial** framework that is *necessary* for <u>sustaining and replicating large scale sanitation programs</u>"
Christy et al. 2009	Business	the set of **policies, institutions, support services and other conditions** that together *create* the general business setting where <u>enterprises can be started and thrive</u>

* Bolded items are the factors, italicized items are the suggested impact, and underlined items are the objectives

Based on Table 1, definitions of the enabling environment generally have three parts: the objective of the program for which the enabling environment is being assessed, the impact of the environment on the objective, and the elements of the enabling environment, that is, components that make up the enabling environment (Table 1). It is, therefore, based on these parts that we develop a definition of the enabling environment for drinking water.

Definitions of the enabling environment are dependent on the objective a proposed program. This is because an environment may be simultaneously enabling for one program, e.g. a drinking water program, and disabling for another program, e.g. an irrigation program. The specificity of the objective is directly linked to the specificity of the conditions that are assumed to impact the achievement of that objective. Some definitions of the enabling environment (Table 1) list precise enabling environment elements that are believed to aid in achieving the desired objective (e.g. Johnson and Perez, 2002 and WSP, n.d.) while others are not precise about the elements (e.g. UNDP, 2008). For this paper, the enabling environment is defined and assessed in relation to achieving the objective of *improving access to and use of safe and sustainable drinking water*.

Numerous publications describe the impact of the enabling environment as facilitating (e.g. Johnson and Perez, 2003, Winpenny, 1994); however, the enabling environment is sometimes described in terms of conditions that influence, that is either hinder or facilitate, these outcomes (e.g. Thindwa et al., 2003, e.g. UNDP 2008). The reason for this is an environment can be facilitating at one time but hindering at another; or a positive condition may unintentionally cause adverse consequences. For these reasons, an enabling environment is one that impacts the capacity of individuals and organizations to carry out their responsibilities and achieve their objectives.

The final part of the definition that needs clarification is the elements. This is the most difficult to clarify because there is a need to be comprehensive without being overwhelming. Brinkerhoff (2004, p. 3) notes "getting more specific about the enabling environment requires ... elaborating a comprehensive set of influential environmental factors …" Since the enabling environment is understood as the context within which actors perform; for drinking water programs it is then important to ask what contextual conditions impact the capacity of actors to achieve their desired outcomes? There are three contextual conditions, henceforth called elements, highlighted in the enabling environment literature: formal rules, informal rules, and the physical environment. However, they are rarely listed collectively.

Formal rules are written, created, communicated, and enforced by official entities such as police, courts and judges (Soysa & Jutting, n.d.). They set the boundaries for action, assign roles to different actors, and establish the guidelines for engagement and relationships between individuals and organizations that influence objectives. They include policies, regulations, standards, laws, and formal guidelines. Formal rules generally have predictable outcomes; however, they do not generate the exact same outcomes everywhere and every time (Soysa & Jutting, n.d.). One reason for this is the existence of informal rules.

Informal rules typically represent unwritten and socially-shared guidelines that are enforced outside official channels (self-enforced, enforced by community chiefs, etc.) (Soysa & Jutting, n.d.). Informal rules, like formal rules, govern the behaviors, modes of operation, relationships, and mandates of individuals and organizations (UNDP, 2008). They include social norms, culture, religious beliefs and power relations. For drinking water programs, informal rules are particularly relevant because even if access to drinking water systems is achieved, use and maintenance of these systems can be influenced by informal rules.

For the purposes of this paper, the physical environment includes both the natural environment (climate, water resources, etc.) and the built environment (road networks, etc.). The physical environment is given less consideration in publications on the enabling environment than formal and informal rules because it is not always applicable to a specific objective. For example within the context of empowerment of women (Kardam, 2005) or civic engagement (Thindwa, et al., 2003), it is rarely discussed. However the influence of climate, land-use, groundwater levels and other physical environment components on drinking water programs makes the physical environment important to consider when analyzing the enabling environment for drinking water programs.

Formal, informal rules, and the physical environment contribute, in differing degrees depending on the situation, to the success of drinking water programs. These enabling environment elements impact the success of interventions. For example, the financial capacity of an organization may be low in a country with high corruption and stringent import regulations whereas the capacity of that organization may be sufficient in another country with the same available resources where there is low corruption and there are favorable tax regulations. Additionally, these elements cannot be adequately approached in isolation of one another; because interactions among them (section 2.2) can play an important role in determining whether an environment facilitates or hinders desired objectives.

Now that the foundations for the enabling environment definition have been built, a framework, which can aid in comprehensively assessing the enabling environment, it will be used to fully develop the definition of the enabling environment using the information from this section as the groundwork.

2.2. Using the Institutional Analysis and Development Framework to Comprehensively Analyze the Elements of the Enabling Environment

A framework can be used to systematically and comprehensively determine elements that influence the success of drinking water programs. Such frameworks help to identify the elements that influence program implementation and the relationships between these elements, the understanding of which is essential for diagnostic inquiry (Ostrom, 2011). Therefore, an existing framework, the Institutional Analysis and Development (IAD) framework (Figure 1) is used to assess the enabling environment drinking water programs. The framework is a product of many social scientists who have, over the past 25 years, participated in the Workshop in Political Theory and Policy Analysis (Polski & Ostrom, 1999). The framework can be used to analyze and design policy interventions across diverse fields. The IAD framework is versatile and widely accepted; it has been applied successfully to evaluation in a diverse range of settings and sectors (Ostrom, 2011). The framework has been used to analyze fisheries policies (Imperial & Yandle, 2005), co-management measures (Whaley & Weatherhead, 2014), and general policy analysis and design (Polski & Ostrom, 1999). The IAD framework emphasizes contextual factors and does not assume that one factor is preferred or more important that another. It helps to generate questions that need to be addressed during analysis, thereby ensuring a comprehensive approach that systematically organizes the relationships among different elements of the enabling environment: formal rules, informal rules, physical environment.

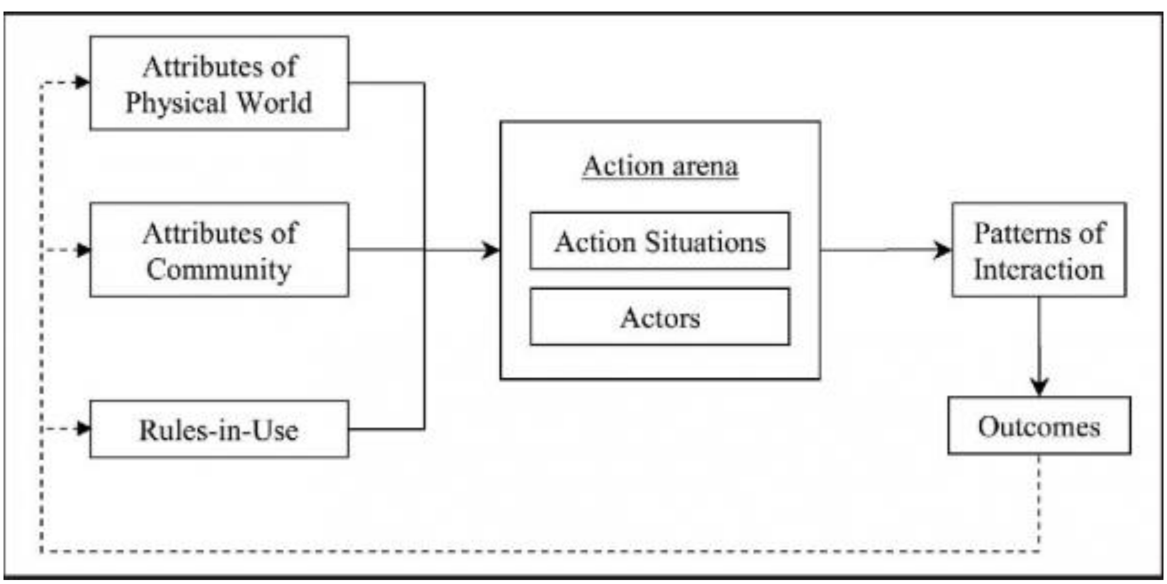

Figure 2.1: The Institutional Analysis and Development framework, adapted from Ostrom (2011)

The IAD framework has the following components: the external variables, the action situation, interactions, and outcomes. The components used are the external variables, actors within the action situation, interactions, and outcome. The other part of the action situation—positions, information, control, and net costs and benefits—are not used in this paper because they are related to analyzing actors and the actions they carry out based on a their position. This assessment is not an actor analysis and as a result this in-depth study of actors is left out of this section. In addition to its widespread use and acceptance, the IAD was also chosen for this analysis because the *external variables* components of the IAD framework mirror the enabling environment elements—formal rules, informal rules, and the physical environment—identified in the preceding section.

The external variables include the "biophysical environment", "rules-in-use", and "attributes of the community" as named in the IAD framework. Henceforth, these external variables are called the physical environment, formal rules, and informal rules, respectively and will be identified as the enabling environment elements. These elements directly or indirectly influence and/or are influenced by a group of *actors* that are involved in a specific drinking water program. The actors are included in the analysis of the enabling environment because they can shape the enabling environment; therefore, identifying them can aid in more effective assessment of the enabling environment. There are *interactions* between actors that influence the outcomes of programs and these interactions can be influenced by the enabling environment, such as public-private partnership (PPP) which may be governed by regulations. For example, the public-private partnership act of 2013 in Kenya states that one such arrangement between the private sector organization and the contracting authority (a government body) is the management contract in which the private party is responsible for management and performance of a specified obligation for a period not exceeding

10 years (Republic of Kenya, 2014). *The outcomes* are the consequences of the actions of these actors as they work within the boundaries of the enabling environment.

Figure 2 represents the IAD framework as applied to drinking water programs. Drinking water specific examples are presented under each element. The framework has also been modified to show a clear demarcation between the enabling environment elements and other elements (actors and outcomes) that will help in outlining the enabling environment for drinking water programs.

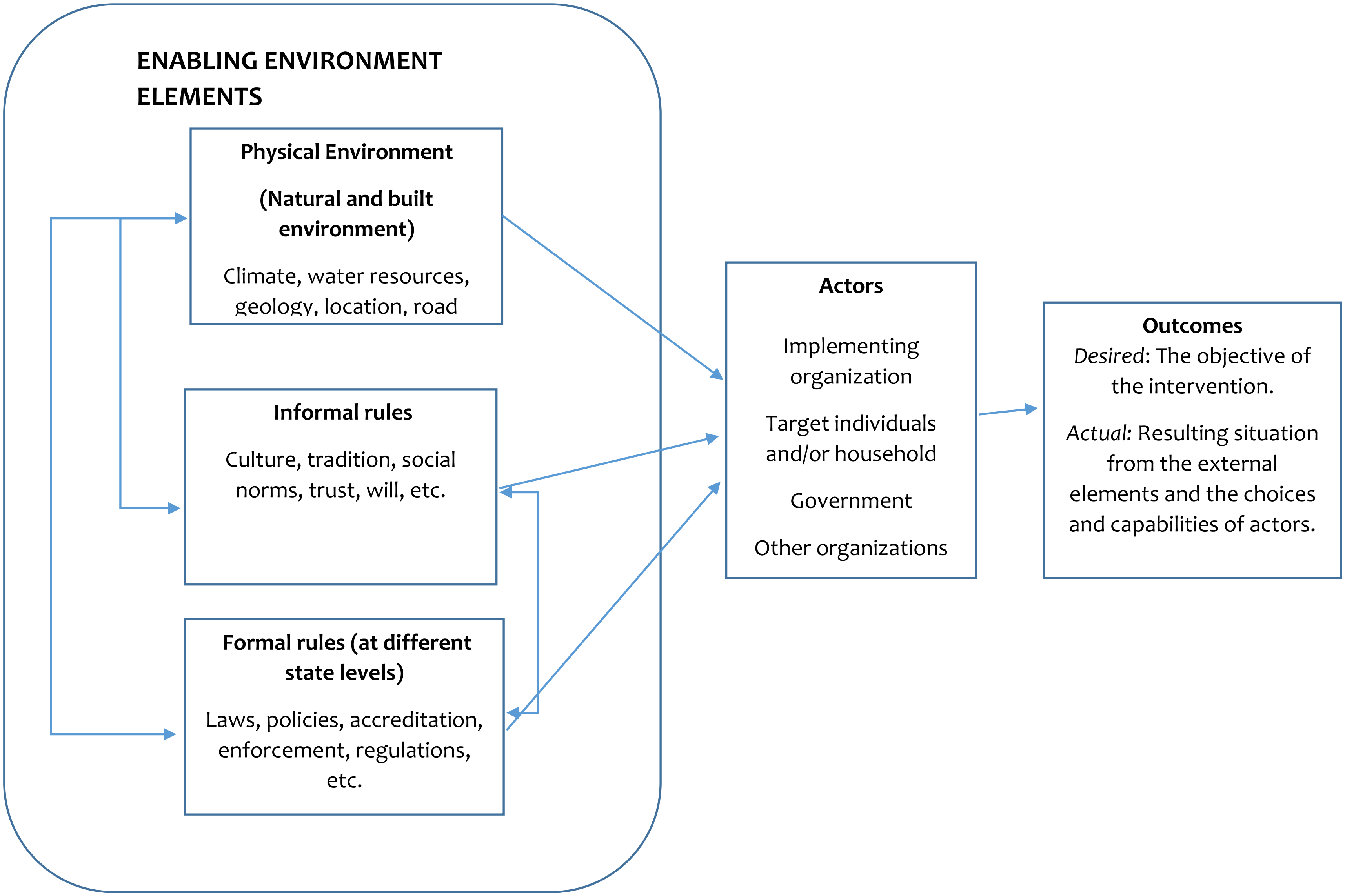

Figure 2.2: Framework for identifying relevant elements and sub-elements that influence drinking water programs and the interactions between these elements. Developed based on the IAD framework. The arrows represent the interactions among different elements.

2.2.1. The Enabling Environment Elements for Drinking Water Programs

The Enabling Environment Elements

This section describes the enabling environment elements with regard to drinking water programs and provides examples of how these elements have influenced drinking water programs, access to and/or use of drinking water systems.

The physical environment element of the enabling environment is important because a hostile environment or natural disaster can reduce or eliminate access to water supply infrastructure. For example, in 2004, floods in Bangladesh caused contamination of water sources, posing a health risk to the population and reducing access to existing water systems (Sirajul, et al., 2007). By understanding this environment, implementers can make the right decisions about the types of water technologies to promote and the most effective location for infrastructure. While the physical environment can sometimes be altered by human activities (e.g. urban development of a forest area), sometimes it cannot (e.g. lands with boundaries with the ocean cannot be made land-locked). Although, the physical environment cannot always be modified, it is important that it be considered as part of the enabling environment during planning and implementation because the physical environment can affect other elements of the enabling environment. An example of this is building regulations (formal rules) for countries are sometimes based on location, climate, and common natural disaster. In Florida, construction is prohibited within 50ft of the mean high water line at any coastal location (International Code Council, 2014).

Formal rules can include sub-national, national, and international rules that govern decision-making. Important regulatory policies to consider for drinking water programs include import regulations and standards for foreign products (Johnson, et al., 2008), water policies that guide organizational participation (Government of Ghana, 2007), and regulations on NGO registration

(Brinkerhoff, 2004). In 1994, Uganda developed a Water Action Plan (WAP) that outlined a framework for integrated water resource management process and defined roles and responsibilities of key stakeholders. This plan has fostered stakeholder participation and promoted decentralization which has facilitated local level involvement (Jønch-Clausen, 2004). Although country specific rules are important, international policies can influence country decision making as well, such as recognition of access to safe water as a human right which prompted nations to put into law the right to safe water (Otieno, 2015; UN, 2002). In terms of *formal rules*, the presence of favorable policies, regulations, and standards is insufficient. Implementation of these policies, enforcement of regulations, and accountability of government officials are critical to ensuring that desired outcomes occur. In Buea, Cameroon, laws exist to protect source waters but the limited capacity to enforce these laws allows pollution of water sources and illegal construction of buildings within zones not designated for infrastructure (Folifac, et al., 2009). It is, therefore, necessary to understand that managing implementation is just as important as designing good policies. The policy implementation process calls for "consensus-building, participation of key stakeholders, conflict resolution, compromise, contingency planning, and adaptation." (Brinkerhoff & Crosby, 2002, p. 6). One way to push forward the implementation process is to determine stakeholder interests and set incentives for performance within formal policies and ensure that these are enforced. For example, in Kenya, the private sector organizations involved in promoting household water treatment are granted importation waivers of foreign-produced products for proven household water treatment technologies (WHO & UNICEF, 2011).

Whether formal rules facilitate achievement of objectives is as much a question of policy implementation effectiveness as the *informal rules* in place (Soysa & Jutting, n.d.). Therefore, even though informal rules can be hard to understand and measure, they are as important as formal rules. For example, in 1942, a cholera epidemic struck Hsi-ch'eng, a rural Chinese market town and the town's residents expended most of their efforts to fight the diseases based on their traditional understandings of the nature of disease and curative methods. Their methods included eliminating all sour fruits, confections, egg plants and some other foods from their diets and improving moral behaviors to please the gods. Residents also eliminated dirt and animal feces on the streets to make the air and ground clean for the gods. Although they carried out some measures known scientifically to improve sanitation and mitigate cholera, the reasoning was not scientific but rather cultural. Western medical facilities were present in the town; however, these facilities were largely ignored or inconsistently used and when they were used, this was in conjunction with cultural practices. This shows that to effectively introduce new systems and knowledge, it is beneficial to recognize that individuals respond according to their cultural beliefs (Hsu, 1955).

Table 2 lists some sub-elements found in the literature. These sub-elements are examples of formal rules, informal rules, and the physical environment.

Table 2.2: Sub-elements of the enabling environment in the literature

Elements	Examples of elements	Publications that cite element examples
Formal rules	Policies	UNDP, 2008; Johnson & Perez, 2002; Thindwa et al., 2003; Brinkerhoff, 2004; PATH, n.d.; Bartle 2012; Christy et al., 2009; GWP, 2013;
	Laws and Legal framework	UNDP, 2008; Thindwa, 2003; EAWAG, 2005; Bartle, 2012; GWP, 2013
	Institutional arrangements	EAWAG, 2005; Johnson & Perez, 2002; PATH, n.d.; Christy et al., 2009; GWP, 2013;
	Regulations	Johnson & Perez, 2003; Bartle, 2012
Informal rules	Cultural practices	Thindwa, 2003; Brinkerhoff, 2004; PATH, n.d.,
	Social norms	UNDP, 2008;
	Power relations	UNDP, 2008;
Physical	Climate	Fioramonti and Kononykhina, 2015

environment	Location	Fioramonti and Kononykhina, 2015
	Infrastructure (e.g. road networks, schools, etc.)	Brinkerhoff, 2004; Hodgman, 2011

Interactions between the Enabling Environment Elements

In addition to considering the enabling environment elements discussed above, implementers may benefit from examining the interactions between these elements. Even within a particular element, for example formal rules, there are interactions to consider. According to Ostrom (2010), decisions made about rules at one level are usually based on a structure of rules on another level. For example, sub-national regulations are dependent on national level policies. In the United States, for example, states must adhere to the protection of water sources under federal protection in accordance with the Clean Water Act and can only make modifications to the regulations if these modifications are more stringent than that of the federal regulations (Environmental Law Institute, 2013). Thus rules at different state levels may need to be considered depending on the level at which the program is being carried out. Leković (2011) notes that formal and informal rules can be complementary or competing and thus the combination of both can either facilitate or hinder the achievement of objectives. Corruption, for example, is an informal institution that generally hinders the achievement of policy objectives. There also exists interactions between formal and informal rules and the physical environment. For example, some coastal cities set "distance to the coast" regulations for the construction of infrastructure, which can influence the types and location of drinking water infrastructure (see Florida example in section 3.1.i). All these impact the types of programs that should be carried out and the effectiveness of those programs. It is, therefore, important to consider how these three elements may interact and how that interaction affects the programs.

2.2.2. *Actors and Their Interactions with the Enabling Environment*

Knowing the actors involved in drinking water programs and their interactions is important to understanding and improving the enabling environment (Ostrom, 2011). This is because informal rules are specific to different actors and formal and informal rules are enforced by some of these actors. There are numerous actor analysis models available (e.g. CAP-NET 2005, IFC, 2007, NETSSAF 2008, Rietbergen-McCracken et al., 1998, SSWM, n.d.) that can assist implementers in identifying the relevant actors. This paper does not focus on that; rather it emphasizes the importance of actors for understanding the enabling environment based on the influence they have on the enabling environment.

Actors interact, sharing ideas and interests, with the goal of achieving their own objectives. Sometimes, these objectives are complementary and at other times they are conflicting. Generally, actors find a broad common goal (e.g. community investment, public health, environmental stewardship, etc.) and build from this to develop partnerships (IFC, 2007). Although these partnerships can be voluntary, they can also be mandatory, that is guided by formal rules, and have ruling guidelines that set the roles and responsibilities of different actors. For example, in Ghana, the government will, where feasible, enter into contracts which articulate roles and responsibilities of public and private operators to manage water systems (Government of Ghana, 2007). One of the key actors in any drinking water program is the government (IFC, 2007). Governments set the national and sub-national policies that guide if and how implementers carry out activities (see public private partnership act in section 3). In some cases, community leaders enforce social norms and thereby influence whether and how communities accept different safe drinking water practices (Pejovich, 1999). In addition to knowing and understanding what the enabling environment elements are, drinking water program planners and implementers may be well served to know other actors that can, if necessary, modify the enabling environment elements.

2.2.3. Defining Desired Outcomes

The outcome of a drinking water program is dependent on the enabling environment, the actors, and the interactions that occur between and within these elements of the framework. However, by defining desired outcomes at the beginning of a program, a process that can be recurrent, implementers can determine what enabling environment elements may influence those desired outcomes and carry out activities to shape the enabling environment, when possible, because the interactions among the enabling environment and actors may create unintended outcomes that may be beneficial or detrimental. This can cause the final outcome to be similar to the desired outcome.

Based on the foundation for building the enabling environment and the identification of the relevance of actors and interactions using the IAD framework, we define the enabling environment as *the blend of formal rules, informal rules, and the physical environment that impact the capacity of individuals and organizations to increase access to and use of safe and sustainable drinking water sources.*

3. Enabling Environment Diagnostic Tool

The discussion above on the use of the IAD framework shows how the proposed enabling environment elements relate to drinking water programs. It also shows how these elements have influenced drinking water programs; however, the extent to which they impact drinking water programs varies. A diagnostic tool can aid drinking water program implementers in determining which elements influence their specific program objectives by highlighting constraints and enablers to the achievement of their program objectives, identifying ways the constraints can be eased, and proposing where resources should be put in terms of making needed changes to enhance the enabling environment. This tool can be used prospectively for shaping the enabling environment for a planned project or retrospectively for determining what the enabling environment would be for a completed or an already started project; this will help in making modifications to projects not yet completed and in informing future program planning.

The diagnostic tool (Figure 3) is useful for gathering information to comprehensively fill out the framework (Figure 2). By using this tool, information on which identified elements will impact the program, which actors that control certain elements, and what stages in the implementation process the identified elements are important can be obtained. This information can assist implementers in putting together effective strategies to modify the environment, if needed.

The first step in diagnosing the enabling environment is to clearly define program objectives and program plans to achieve the objectives. This will help implementers conduct a more accurate assessment of the enabling environment elements that may influence the achievement of these objectives than if the objectives were not defined or not specific? The ways in which these elements may affect the program at the planning, implementation, and post-implementation stages should then be identified. Knowing the elements and how they will influence the program is beneficial;

implementers will be also served with determining ways these elements can be modified to facilitate the achievement of program objectives if they are hinder program goals. To do this, the actors that can most readily modify them or influence the elements be determined. The last step in the process is the identification of means by which the enabling environment can be enhanced, if needed. This diagnostic tool can be used before the start of a program; it is also beneficial during implementation as additional elements not recognized during the preliminary assessments are identified.

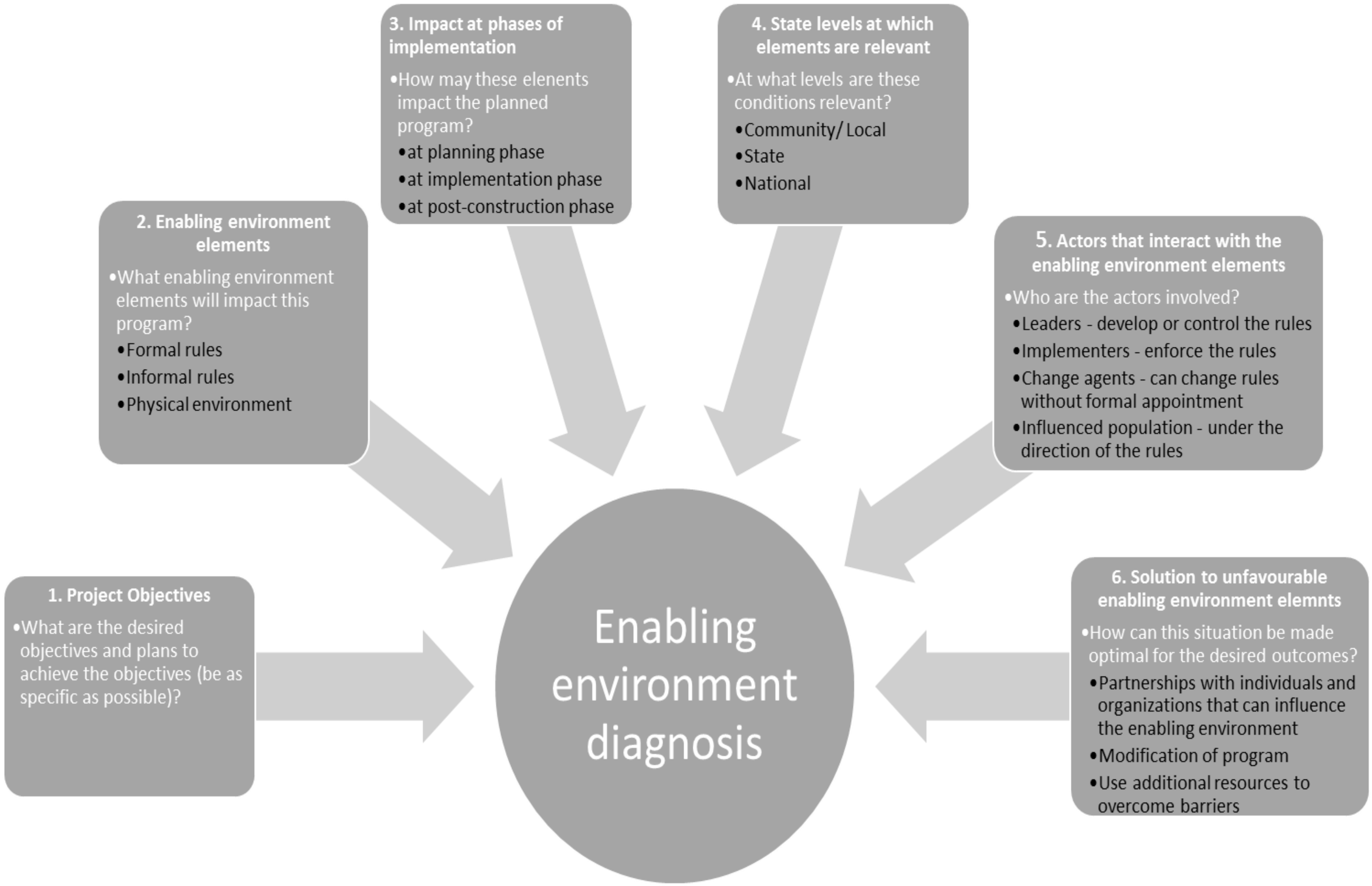

Figure 2.3: Tool for diagnosing the enabling environment of drinking water programs

We use a case study of a sustainable water management project in Salamieh district in Syria to illustrate the use of the diagnostic tool in comprehensively assessing the enabling environment for the project. This is a retrospective analysis. The information presented for this analysis was obtained from Al-Zein (2015) case study report on this project. The goal of the project was to lessen the negative impacts of water shortage in the district such as poor crop yields and low income. This was achieved through improved productivity and efficiency of water use by employing modern irrigation systems, particularly drip systems. The project included interventions to assist farmers in implementing water saving irrigation measures. Farmers from 120 villages were targeted for the intervention. Although this case study focuses on the use of water for irrigation, it mirrors drinking-water projects focused on improving access to safe drinking-water as new technologies and measures are introduced to a community. This case study was chosen because it provided details on the specific interventions carried out, the results, and the challenges faced which enables the accurate use of the diagnostic tool.

Figure 4 shows the sample project objective and plan for the program. Two specific plans in each of the shaded boxes are used to illustrate the use of the diagnostic tools (Table 3). Figure 3 and Table 3, together, represent the use of the diagnostic tool to analyze the enabling environment for this project. Figure 3 shows the first step of the diagnostic tool which is to define project objectives and plans to achieve the objectives.

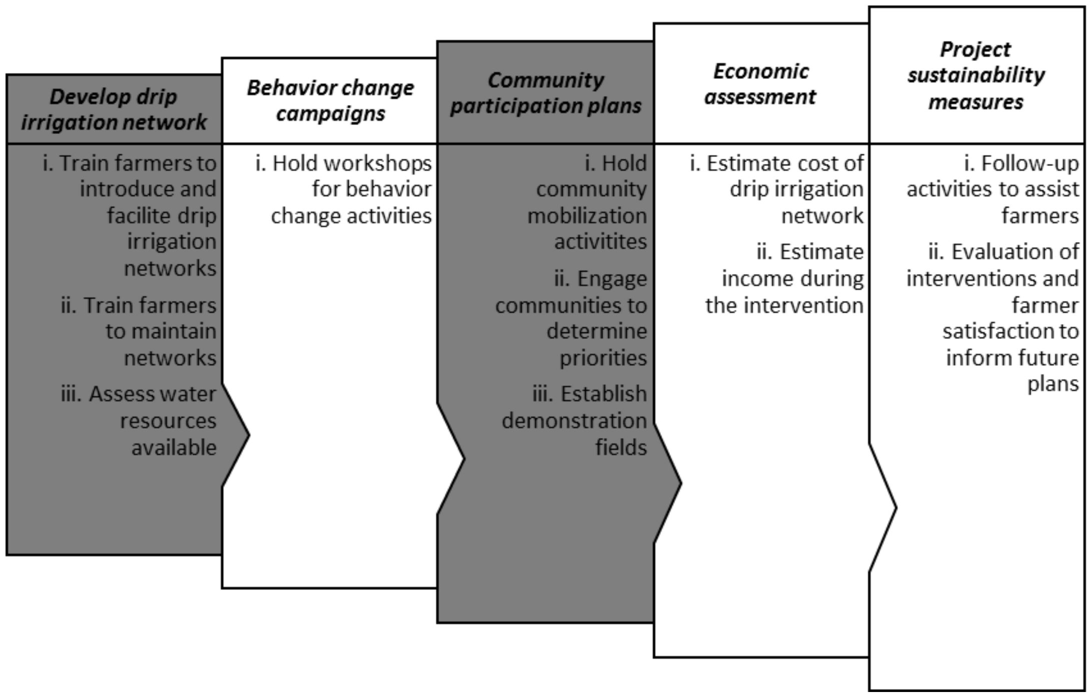

Figure 2.4: Project plan to achieve project goal – lessen the negative impact of water shortage through improved efficiency of water use in agricultural lands.
The bolded italicized sections represent the goal for different stages of the project and the boxes beneath each include specific activities to achieve the goals.

Table 2.3: Sample use of the diagnostic tool for the case study presented above

Project Plan	Enabling environment sub-elements	How project is impacted	What state level is element relevant	Actors involved	How can elements be modified or dealt with
			Formal Rules		
Train farmer to maintain drip irrigation systems	Regulations on water use	***Planning***: influences technical specifications of the drip irrigation networks ***Implementation***: influences how much water can be pumped out of wells (groundwater was the water source for this project) as unregulated pumping was a barrier to the project success ***Post implementation:*** influences the sustainability of the project as unregulated water use can cause water shortage	National and Local levels	***Leader***: agency lead (likely ministry of water or ministry of the environment) ***Implementer***: local authorities ***Influenced population***: Farmers, implementing organization	***If regulations are favorable to program objectives,*** no solutions necessary. ***If regulations are unfavorable or not optimal***: Modify drip irrigation specifications; modify modern irrigation method used; find alternate water sources
			Informal Rules		
Train farmer to introduce and facilitate drip irrigation systems	Social networks	***Planning***: influences the ability of the implementing organization to engage targeted farmers to adopt the new irrigation measures ***Implementation***:	Community level	***Leader***: Respected farmers, community change agents ***Implementer/Enforcer***: Communities ***Influenced population***: farmers, implementing organization	***If current social networks is favorable to program objectives***, no solution needed. ***If informal rules are unfavorable or not optimal:*** Determine stakeholder (e.g. farmers, community members) interests

		influences the continued success of the drip irrigation system as trust is essential when issues with the systems arise. ***Post implementation:*** ensures that after the implementing organization leaves the community, there are community members present to continue impelling farmers to the advantages of the systems			Engage relevant stakeholders, particularly change agents Communicate goals in a manner that highlights shared interests
	Individual values of farmers	***Planning:*** influences the choice of farmers ***Implementation:*** influences the compliance of the farmers to the new irrigation methods ***Post-implementation:*** influences chances of scaling up the intervention to additional villages	Individual and community	***Leader:*** individual farmers ***Implementer:*** self-enforced by individuals ***Influenced population:*** farmers, implementing organization	***If values is favorable to program objectives***, no solution needed. ***If informal rules are unfavorable or not optimal:*** Conduct behavior change activities Communicate goals in a manner that highlights shared interests
			The Physical Environment (Natural)		
Assess water resource availability	Water source quantity (in this case, groundwater was used)	***Planning:*** influences the type of irrigation measures taken ***Implementation:*** influences the amount of water used by farmers ***Post-implementation:*** influences the	Community level	***Influenced population***: Implementing organization, farmers	***If water source type is favorable to program objectives***, no solution needed. ***If water source type is unfavorable or not optimal:*** Select another water source and change planned infrastructure, if needed

		sustainability of the networks over time as rainfall is unevenly distributed over seasons			Diversify water sources
The Physical Environment (Built)					
Building drip irrigation networks	Road networks	***Planning:*** influences travel to and from community to assess feasibility of program ***Implementation:*** influences the transport of construction materials if not available in the community ***Post-implementation:*** influences availability of spare parts when repairs are needed	Community levels	***Influenced population:*** Implementing organization, community members, water committee	***If road networks are favorable***, no solutions necessary. ***If road networks are unfavorable or not optimal***: Use local materials, when possible

Through the activities carried out to improve the efficiency of water used and the barriers identified after project completion, we could identify elements of the enabling environment that impacted the project using the diagnostic tool. This can aid in future programming. In addition to this, the analysis highlighted the possible solutions to unfavorable environments which compels implementers to ask "how essential are these elements to the program? And how modifiable are they?" Figure 5 shows where resources are likely to have the greatest impact in enhancing project outcomes based on their essentiality and modifiability of the elements identified.

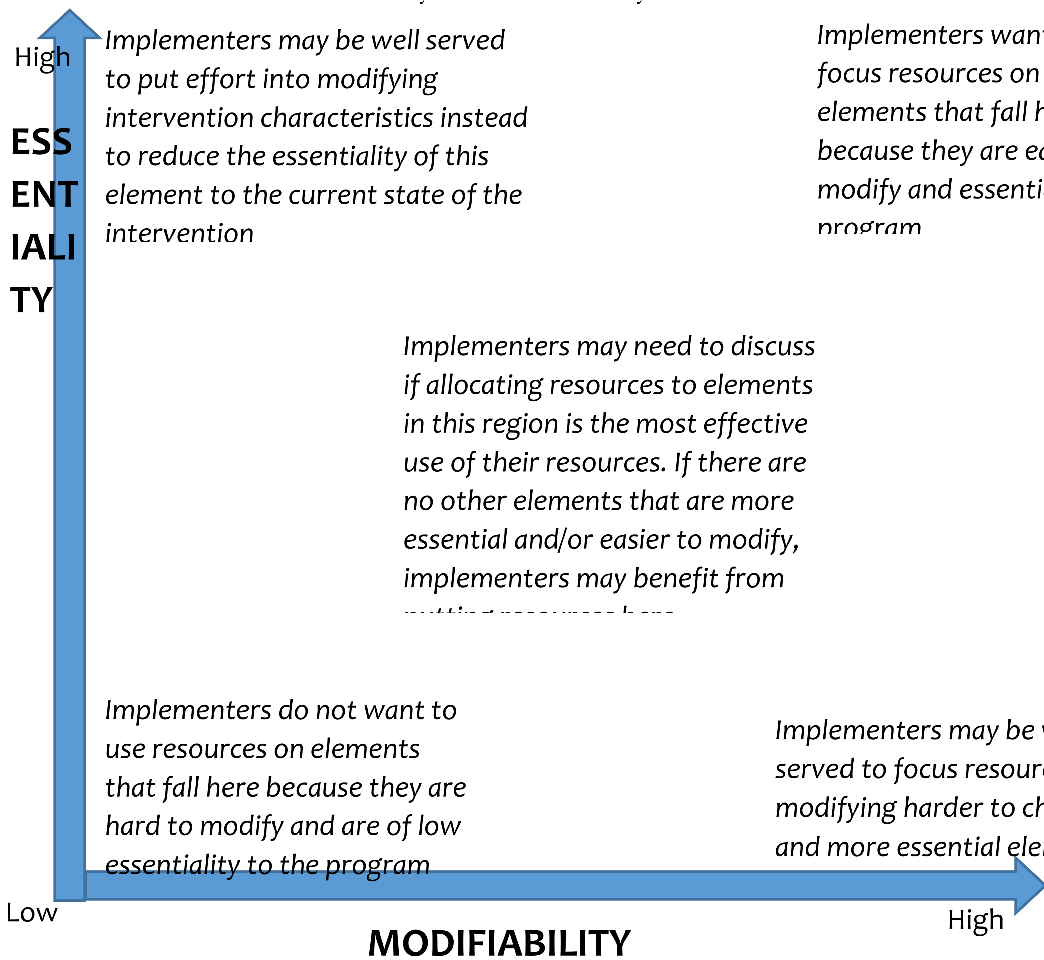

Figure 2.5: Schematic showing where and when resources should be put to shape the enabling environment.

Essentiality refers to the degree to which this enabling environment element is vital to the program objectives and modifiability refers to the degree to which the enabling environment element can be changed by the implementing organization, either directly or indirectly.

4. Important Reflections about the Enabling Environment

The notion of shaping an enabling environment is one of the most repeated ideas in the enabling environment literature. Enhancing an enabling environment is an aspiration that is shared in many in different fields (Asaolu & Ofoezie, 2003; Bertucci, 1998; Longfield, et al., 2011; Mutabingwa, 2005; Rao, et al., 2007). However, the modification of an enabling environment is influenced by the ease of changing the existing environment, the actors with the capacity to make changes, and the larger global environment in which the enabling environment of concern resides. These issues, modifiability, relevant actors, and the global environment, are discussed below.

4.1. Modifiability of the Environment

To enhance an enabling environment is to generate conditions that cause a shift from an unfavorable or neutral environment to one that is enabling or to further improve an environment that is already facilitating. This means changing unfavorable formal rules (e.g. policies, regulations, laws), informal rules (e.g. cultures, social norms), and physical environment (e.g. water sources) for the better. These are elements that can take as little as a few hours or days to change or as long as years. For example, to change a policy, one has to consider the entire policy cycle (agenda setting, policy formulation, decision making, policy implementation, and policy evaluation (Howlett & Ramesh, 1995) as well as policy lags (the delays that occur during the policy implementation cycle). This entire process can take many years. For example, a decade after a Palestine national plan authorized seven wastewater treatment plants, only one was operational (The World Bank, 2009). However, it can also take a shorter time, for example, the pollution of a water source. Floods can transport contaminants to a water source. When it comes to the physical environment, change is sometimes impossible as some elements of the physical environment cannot be changed by human influence (e.g. geography). This begs the questions: is the perfect enabling environment an unattainable ideal and should effort be put into shaping it? It is important to understand that change may not always be instantaneous or easy. Tripp (2003) notes that it may not be possible to change directly all the potential sub-elements that may be included in the enabling environment. It falls on organizations to determine the hierarchy of enabling environment elements and how these elements are to be targeted. The schematic accompanying the diagnostic tool (Figure 5) can help organizations in making this decision.

In addition to considering the extent to which elements of the environment can be modified, it is also important to determine how modifying the environment will affect project objectives because modifications do not always produce the desired outcomes. An example can be seen in the Indonesian case where the Government, in an attempt to promote public-private partnerships and private sector investments in water infrastructure, developed a guarantee fund mechanisms for any feasible PPP investing in water projects. A guarantee fund company shields the investors, in this case the private sector and partnering local government agency, from losses by absorbing any losses experiences by the investments. This did not motivate private sector investment, however, because it meant that the private sector depended on local government mandated tariff increases for profit (Sentiono, et al., 2012).

4.2. Actors Responsible for Shaping the Enabling Environment

Despite the frequent assertion that an enabling environment is needed for the achievement of objectives, little discussion is devoted to the actors that influence this environment. Jackson (1999) and Christopoulos et al. (2012) are two articles that explicitly identify actors with the authority to shape the enabling environment. According to Jackson (1999), the main actor is the government and Christopoulos et al. (2012) posits that the State is the authority to enhance this environment. Even though the government may be an actor that shapes the enabling environment in certain situations, other actors can shape the enabling environment as well. Because of the influence of formal rules in guiding organizational behavior, the government is partly responsible for shaping the enabling environment. Other actors that enforce informal rules (e.g. community leaders, heads of households) are also central to shaping the enabling environment.

4.3. The Regional and Global Environment

Assessments of the enabling environment are commonly made at local or national level. However, the multi-country, regional, or global environments can also play a role. This can be seen in the influence the MDGs had on country-level decision making. For example, 21 of the 39 countries surveyed in 2009 for the Global Analysis and Assessment of Sanitation and Drinking water (GLAAS) report stated that they have investment programs for urban water supply based on MDG needs and these programs are being operationalized (UN-Water, 2010). Regional and global physical environment factors such as global warming and climate change and their corresponding effects on drinking water access and use and the sharing of transboundary water sources among countries may also need to be considered. It is therefore, important that the environments outside the target country are also considered.

5. Conclusion

This is the first study to systematically assess the enabling environment for drinking water programs. We found the enabling environment to be the blend of formal rules, informal rules, and physical environment that impact the capacity of actors to carry out their responsibilities and achieve their objectives. The Institutional Analysis and Development (IAD) framework aided in clarifying the interactions that exist between the different elements of the enabling environment and between actors and the enabling environment elements. Additionally, we developed a tool for diagnosing the enabling environment for drinking water programs using lessons learned from applying the IAD framework.

We propose a definition of the enabling environment for drinking water programs and describe elements of the enabling environment to aid stakeholders in the drinking water field. These elements—formal rules, informal rules, and physical environment features—are shown to be relevant to drinking water programs based on examples found in the literature. A clear definition of the enabling environment can reduce confusion during discussions. Primarily, this will improve communication between those in the drinking water field and will reduce false expectations when the objective of shaping an enabling environment is set.

Using the IAD framework to assess the enabling environment for drinking water systems, we found that actors are central to understanding the enabling environment and shaping it. Formal rules are set by governments, informal rules are enforced by social leaders, and the physical environment can be altered by human interference. This analysis highlighted the importance of knowing the actors involved in drinking water programs, especially the actors that have the influence to shape the enabling environment. Additionally, we found that the enabling environment elements should not be viewed in isolation as these elements interact with each other.

We propose a comprehensive and systematic way to diagnose the environment that will influence the outcomes of drinking water programs, identify the actors that influence this environment and help determine if the environment is enabling. This is the first enabling environment diagnostic tool for drinking water programs. Implementers may need conduct formative research to accurately diagnose the enabling environment using this tool. We also present a graphic to assist implementers in determining where effort and capacity should be targeted based on how essential a particular enabling environment element is and to what extent it can be modified. This ability to identify the essentiality and modifiability of different elements allows implementers to better allocate resources. The tool provides a starting point for answering vital questions about the enabling environment and if and how it can be modified to complement a program.

Analysis of the enabling environment for drinking water programs revealed the need for more evidence based examples of the how formal rules, informal rules, and the physical environment impact drinking water programs. Assertions of importance are many but evidence of impact is lacking.

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CHAPTER 3: SUSTAINABILITY AND SCALE-UP OF HOUSEHOLD WATER TREATMENT AND SAFE STORAGE PRACTICES: ENABLERS AND BARRIERS TO EFFECTIVE IMPLEMENTATION[4]

1. Introduction

According to the WHO and UNICEF (2014) Joint Monitoring Programme report, more than 700 million people in the world do not use improved drinking water sources, that is, sources "that, by nature of their construction, are protected from outside contamination, particularly fecal matter." Analyses accounting for drinking water quality have shown that hundreds of millions with "improved" drinking water do not have access to a source that is microbiologically safe to drink (Onda et al., 2012 and Bain et al., 2012). The majority of those using unsafe water reside in developing regions and lack access due to the limited financial, institutional, and informational capacity to treat and provide safe water to households. As a result, the burden of disease from contaminated water falls heavily on developing countries. In 2012, there were approximately 842,000 diarrheal deaths as a result of inadequate water, sanitation, and hygiene (WaSH) practices worldwide and approximately 380,000 of these deaths were children under the age of five (Prüss-Üstün et al., 2014). Consuming unsafe water also has adverse effects on school attendance and economic development as illnesses like diarrhea lead to high rates of school absenteeism, missed workdays, and increased expenditures on healthcare (Hutton and Haller, 2004 and Monse et al., 2013).

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Providing universal access to safe, pathogen-free, reliable piped water supplies into households is the ideal solution to waterborne illness. However, the high capital and maintenance costs of piped supply systems mean that universal safe piped water is likely decades away for many developing regions. Household water treatment and safe storage (HWTS) practices – like boiling, chlorination, and filtration – provide an interim solution for managing water safety at home if carried out consistently and correctly (Sobsey, 2002). Some studies have shown that HWTS practices yield improvements in drinking water quality and reductions in diarrheal disease (Sobsey et al., 2008, Sobsey, 2002, Clasen et al., 2007 and Elsanousi et al., 2009). However, there have been studies that show that HWTS practices are not as effective in diarrheal disease reduction as is often claimed, especially when assessed over periods longer than those typical of HWTS studies (Boisson et al., 2013 and Hunter, 2009). The success of HWTS interventions in preventing disease is a function of many factors including efficacy of the practiced method at removing or inactivating pathogens of concern, rates of consistent and correct use, and the presence of other pathogen exposure routes (Enger et al., 2013 and Brown and Clasen, 2012). HWTS has the potential to improve water safety but does not increase access; as a result, it is a partial and interim solution to unsafe water while coverage of safe, pathogen-free, and reliable piped water is increased.

Humans have been treating drinking water through filtration, boiling and coagulation for centuries (Sobsey, 2002). In recent years, the availability and promotion of diverse HWTS products by governments, NGOs, industry and international organizations has increased markedly. Despite the introduction of diverse products and the advocacy and implementation efforts by NGOs, boiling is the only HWTS practice to achieve scale (Clasen, 2008). Additionally, many HWTS programs and studies have reported high initial uptake and use that declines rapidly over time (Sobsey et al., 2008 and Brown et al., 2009). An analysis of Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS) data from numerous countries by the WHO and

UNICEF shows that the burden of unsafe water supplies falls heavily on the poor. However, the proportion of the population that employs HWTS practices increases as wealth increases even though wealthy populations have access to improved water sources and as a result do not necessarily need to employ HWTS practices (WHO and UNICEF, 2011a and WHO and UNICEF, 2011b). There have been numerous studies on the factors that influence the adoption of specific HWTS technologies, (e.g., POUZN Project, 2007 and EAWAG SANDEC, 2002) but few studies on the factors relevant to holistically scaling up HWTS (e.g. Clasen, 2008 and Clasen, 2009).

This paper maps out enablers and barriers to sustaining and scaling up HWTS practices with the aim of improving decision making by HWTS practitioners and providing a useful resource to those planning and implementing HWTS programs. For the purposes of this study, sustainability refers to the ability to maintain an HWTS practice or technology in a community or country in a manner that does not require those external contributions that are unsustainable in the long-term. Scale-up refers to the extent to which HWTS can be made available to the target population as well as the extent to which it is adopted by that population and used correctly and consistently (Clasen, 2009). The results from this study add valuable information to the limited body of evidence currently available on the factors that affect the sustainability and scale-up of HWTS practices.

2. Methods

Key informant interviews, focus group discussions and online surveys were used for data acquisition. Only one of the aforementioned was used for each interviewee and the method used was based on interviewee-selected preferences. The interviews and focus group discussions were conducted using a semi-structured interview and semi-structured focus group guide (Supplementary section), respectively. The online survey was structured such that the conversational form of the interview allowed interviewees to elaborate on their responses and give more detailed descriptions of their experiences. The interview and focus group guides and online survey had two sections: the first focused on enablers to sustainability and scale-up and comprised questions on enablers to uptake of HWTS products, implementation of HWTS programs, and sustainability of HWTS practices. The second focused solely on barriers. Questions in the interviews and online surveys were open ended.

Interviews were conducted over the course of six months with three weeks of interviews taking place in each of Ghana and Tanzania. These countries were chosen because of the advanced state of government involvement in HWTS activities; presence of NGOs in the countries carrying out HWTS activities; and the diversity of HWTS products used. The countries also have similar socio-economic characteristics.

The inclusion criterion for study participants was personal experience with HWTS programs. All interested individuals that met this criterion were interviewed regardless of the regions in which they worked, type of organizations to which they belonged, and their role in the HWTS program. Participants were asked to give responses based solely on their own experiences and not based on perceptions or information from other sources. Participants were recruited through announcements at the October 2011 University of North Carolina at Chapel Hill Water and Health conference, through the WHO and UNICEF co-hosted HWTS Network listserv, and through personal contacts in government agencies and NGOs.

An online survey was developed using Qualtrics software. Interviews were recorded, transcribed and coded based on enablers and barriers identified by the interviewees. Responses from the online survey were also coded based on identified enablers and barriers. Two data management processes were carried out on the identified enablers and barriers. The first grouped enablers with their counterpart barriers, when present. A counterpart barrier is the negative equivalent of an enabler. The frequency of each factor was determined based on the number of times a distinct factor was identified by interviewees. This is referred to as the identification frequency (IF) in later sections of this report. The factors were then further grouped into domains based on the overarching category into which they belonged. This is a method used in similar studies about improved cook stoves (Rehfuess et al., 2014 and World Bank, 2011), a type of product used in developing countries that is in many ways similar to HWTS. The IF for a domain is the sum of the IFs for each of the factors that falls under that domain.

The responses from the interviews could not be independently verified; therefore, the triangulation method was used to validate interviewee responses. Evidence from HWTS literature, when available, was used to support interviewee responses. When evidence from HWTS literature was unavailable, literature on general water, sanitation, and hygiene (WaSH) practices were used, if available, and the links to HWTS explained. In cases where these validation methods were not possible, this is indicated. Sources and impacts of bias are discussed.

3. Results

1.1. Description of Interviewees

A total of 79 individuals were interviewed. Interviewees had experience in several regions of the world and in different settings (rural, urban, and peri-urban). They also worked for a range of organization types – academia, UN agencies, government agencies, etc. The majority of interviewees had carried out HWTS programs in Africa. Table 1 illustrates the experience of the interviewees.

Table 3.1: HWTS work experience of interviewees by region and organization type

Region Organization	Africa	Asia	Latin America	Other	**Total***
NGO (Implementing)	24	7	7	1	**29**
NGO (non-implementing)	2	2	1	0	**2**
Private sector organizations (implementing and sales)	7	5	1	1	**10**
Academia	7	6	2	1	**10**
Government	8	1	1	2	**10**

Sales (Retail and Wholesale only)	8	0	0	0	**8**
UN agency	1	1	0	1	**3**
Manufacturing	2	0	0	0	**2**
Other	3	2	2	3	**7**
Total	**62**	**24**	**14**	**9**	

* The total score for organizations given reflects the number of interviewees from that organization type. This cumulative sum for all organizations is less than the cumulative sum across regions because several interviewees had worked in multiple regions.

1.2. Enablers and Barriers: Identification, Grouping into Counterpart Factors, and Aggregation into Domains

Twenty-two enablers and twenty-five barriers were identified by the interviewees. A review of the identified enablers and barriers revealed that many of these enablers and barriers, collectively represented one factor with both positive and negative aspects. For example, “affordable products” was mentioned as an enabler and “cost of products” was mentioned as a barrier but these represent one factor – “affordability of products” which can either be positive or negative. The number of distinct factors for sustaining and scaling up HWTS practices decreased to 23 after accounting for counterparts. These 23 factors are shown in Table 2 along with the 47 enablers and barriers. Some of the 47 enablers and barriers did not have counterparts while some had multiple counterparts. It is for this reason 23 does not factor perfectly into 47. Table 2 illustrates the aggregation of the 23 factors into six overarching domains.

Table 3.2: List of factors identified that influence sustainability and scale-up of HWTS practices.
Enablers and Barriers were paired into a single Counterpart Factor when appropriate; factors were grouped into Domains. Numbers in parentheses represent the number of times the factors were identified during interviews

Identified Factors (grouped by counterparts)			Domains
Enablers	**Barriers**	**Counterpart factors[a]**	
User demand for HWTS (20)	Lack of motivation to improve health (5)	**User demand for HWTS (29)**	User preferences (51)
	Lack of understanding of economic benefits of HWTS (2)		
	Diarrhea not seen as a problem (2)		
Technology type (6)	Not understanding user preferences (8)	**User technology preferences (20)**	
	Difficulty in incorporating into normal routine (2)		
Aspirational products (2)	Lack of aspirational products (1)		
	Cultural barriers causing misunderstanding of individual needs (1)		
Field trials to gauge preferences (2)	----	Field trials to gauge preferences (2)	
Partnerships (14)	Lack of partnerships (2)	**Partnerships (23)**	Integration and Collaboration (41)
Leaders (community leaders, health workers, etc.) advocating HWTS (7)			
Integration into other programs (e.g. health, schools etc.) (8)	----	**Integration into other programs (8)**	
Community participation (4)	Lack of community ownership (1)	Community participation (5)	
Longstanding residence of implementers in communities (4)	----	Integration of organization into community (4)	
Private sector participation (1)	----	Private sector participation (1)	
Favorable political climate for HWTS (9)	HWTS not a government priority (5)	**Political climate for HWTS (17)**	Standards, certification, and regulations (32)
	HWTS not a long-term solution (3)		
Quality control carried out on HWTS products (2)	Ineffective technology (6)	**Product standards (9)**	
----	Location & climate not conducive to technology (1)		
----	Import barriers (3)	Import regulations (3)	

Certification of HWTS products (2)	----	HWTS product certification (2)	
----	Lack of agency/ministerial home (1)	HWTS specific home-agency(1)	
Affordable products (2)	Cost of products (11)	**Affordability of products (15)**	Resource availability (32)
	Continuous purchase of consumables (2)		
Available resources (human, money etc.) (7)	Limited resources (8)	**Organizational Availability of resources (15)**	
Cost effective implementation (1)	----	Cost effective implementation (1)	
----	No land tenure (negatively influencing HWTS investment) (1)	Household land tenure (1)	
Presence of a supply chain (10)	Lack of available spare parts (9)	**Supply chain (22)**	Market strategies (30)
Products made with local materials (3)			
----	Undermining competing technologies (6)	Competition between technologies (6)[b]	
Financing (no free distribution) (1)	Free distribution (1)	HWTS financing (2)	
Training on how to use HWTS products (8)	Lack of capacity building activities (3)	**Training on product use and HWTS practices (12)**	User guidance on HWTS products (24)
---	Limited information to make decisions (1)		
Carrying out behavior change programs (4)	Long time behavior change takes (3)	Behavior change activities (7)	
Household follow-ups (specifically for interventions) (5)	----	Household follow-ups (5)	

[a] Bolded factors are ten most identified factors. This is done simply to show the most identified factors and not to prioritize factors (prioritization is discussed under "All domains matter").
[b] Although none of the interviewees mentioned the positive impacts of fair market-based competition, there are documented examples of competition driving down prices and creating more options for HWTS users (Rangan & Sinha 2011)
---- No counterparts identified

Description of domains

The 10 most identified factors are bolded in Table 2 above; each domain includes at least one of the ten most identified factors.

User preferences

This domain refers to the preferences of the target individual, household or community with regard to HWTS practices[5]. Three factors fell into this category: user demand for HWTS, user technology preference, and preliminary field trials to gauge preferences. User demand for HWTS was the most identified factor of all with an identification frequency (IF) of 29. User demand refers to non-technological factors that drive demand for HWTS practices. Technology preferences were identified by 20 interviewees; these referred to ease of use of technology, ease of incorporating practice into normal routine, time taken to employ practice, and other technology characteristics that influence people's preferences. This domain had a total IF score of 51 (29 + 20 + 2).

Integration and collaboration

Although employing HWTS practices is a personal/household practice with primarily personal benefits and consequences, numerous actors are needed to make sustaining and scaling up HWTS practices possible (Ojomo et al., 2014). Collaboration is therefore essential. Two factors under this domain – partnerships (IF 23) and integration into other programs (IF 8) – were among the ten most identified domains. Other factors under this domain include community participation, private sector participation, and longstanding presence of implementing organizations in target communities. Domain related factors were identified by interviewees 41 times.

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[5] This domain does not include ability to pay for products and technologies as that factor is part of "resource availability" domain

Standards, certification, and regulations

This domain refers to the formal rules that guide individuals and organizations and are enforced by police and the courts; as well as voluntary standards by organizations that have been systematically developed. The total IF for this domain was 32 and there were 5 sub-factors under this domain: favorable political climate for HWTS, presence of standards for HWTS products and technology, certification of products and technology, favorable import regulations, and the presence of a governmental "home" for HWTS affairs. The most identified of the factors in this domain was favorable political climate; identified 17 times, it was the third most identified factor overall. "Standards for HWTS products and technologies" was also in the ten most identified factors with an IF of 8.

Resource availability

This domain refers to the availability of economic and human resources necessary for sustaining and scaling up HWTS practices. These are resources of HWTS product and technology users and organizations that carry out HWTS programs. The identified factors under this domain were organizational resource availability, affordability of products, cost-effective implementation, and willingness to invest based on permanency of home (e.g. land tenure). Affordability of products and organizational resource availability were two of the ten most identified factors, each with an IF of 15. The IF for this domain was 32.

Market strategies – Product supply

This domain refers to the processes used to bring the product to the consumer. Factors under this domain include effective supply chain, sustainable financing, and competition between technologies. Effective supply chain, which included continuous availability of spare parts and local manufacturing, was identified 22 times and was one of the ten most identified factors. The IF for this domain was 30.

User guidance on HWTS products

Factors related to this domain were identified 24 times. This domain refers to the ability of individuals/households to carry out technical activities related to HWTS practices. These include ability of individuals to effectively use products and technologies, behavior change activities, and household follow-up activities to ensure households effectively use products and technologies. Training individuals on how to use products and technologies was identified by 12 individuals and was one of the ten identified factors.

2. Discussion

2.1. Empirical Support for Domains: Evidence from Literature and Interviews

Each of the domains identified during the interviews is relevant to sustaining and scaling up HWTS practices as each one is relevant to some aspect of continuously getting the product to the consumer and/or increasing the customer base. Additionally, each domain includes at least one of the top ten identified factors. The relative importance of each is, however, dependent on the technology/practice being promoted, the community in which it is promoted, and the goal of the organization promoting the practice. Evidence from literature and interviewee responses for each of the domains is presented below.

2.1.1. User Preferences

Although efforts to increase demand for HWTS often focus on microbial treatment efficacy of products and on health benefits, promoting HWTS based on health and treatment efficiency is unlikely to generate sustainable demand as consumers often select an HWTS option based on the convenience of the practice and design appeal of the product rather than the efficacy (Wellin, 1955, Fgueroa and Kincaid, 2010, Center for Communication Programs, 2008, Albert et al., 2010 and Luoto et al., 2011). Albert et al. (2010) note that HWTS "product dissemination at scale to the poor will not occur until we better understand the preferences, choices, and aspirations of the at-risk populations." Interviewees in this study contributed examples from their own projects that were consistent with evidence in the literature. Interestingly, user preferences ranged from technology-related preferences to cultural drivers. Preferences highlighted during the interviews included examples related to: aesthetic product design and treated water, technological design of product, social status achieved from product ownership, and cultural and religious beliefs.

Aesthetic aspects of both HWTS hardware and the water produced were frequently mentioned as important drivers of adoption. For example, an interviewee from an NGO in Ghana reported that through their safe storage programs, it had been observed that containers are purchased based on the color even though they are not always used to store water. In short, they are bought for their aesthetic looks (Interviewee no. 1). In Tanzania, biosand filters were desirable to the population because they clarify turbid water, a common problem with water sources in these areas (Interviewee no. 2). These preferences vary by culture and context; for example, many interviewees noted that the smell and taste of chlorine was unacceptable in some cultures, leading to a lack of demand by these populations (Interviewees nos. 3–7). The significance of aesthetics is unsurprising as products not only achieve the technical goal for which they were designed but also carry a personal meaning for users (generally influenced by culture) and communicate the identity of the users (generally influenced by individual tastes) (Gotzsch et al., 2006).

Convenience of operation and contribution to social status were also mentioned. For example, in Tanzania, an interviewee (no. 2) noted that WaterGuard tablets are more popular than liquid WaterGuard because of the ease of using the tablets. The tablets are pre-measured for a specific volume of water whereas liquid WaterGuard™ needs to be measured prior to being added to water. In Morogoro, a city in Tanzania, owning biosand filters in some rural regions was viewed as socially advantageous; as a result, demand for biofilters increased in these places (Interviewee no. 8). Ensuring that HWTS products are seen as aspirational has previously been identified as important in generating demand (PATH, 2009 and Lee and Kotler, 2011).

To ensure sustained demand, it is therefore important that user preferences – whether technological, social, or economic – are adequately addressed. A similar conclusion was reached by Clasen (2008), who identified a "focus on users" as one of ten factors that warrant priority when considering scaling up HWTS. To "focus on users" one has to figure out what they want, need, and will use, and then deliver it. It is important to note that individuals have varying preferences and as a result, product variety is important. Product choice increases the likelihood of HWTS practices being employed as people have the option to choose the product or technology that suits their needs.

2.1.2. Integration and Collaboration

Partnerships are important for the successful adoption of the safe water program and essential in ensuring the in-country sustainability of a product or practice (POUZN Project, 2007). Interviewees and the published literature cite diverse types of partnerships, including those with governments, NGOs, community members and integration into health programs, as essential to the sustainability and scalability of HWTS interventions.

Interviewees cited partnerships with community leaders and other change agents, like teachers and health workers, as being vital to ensuring diffusion of the promotion messages as well as sustainability of the practice. In rural areas, partnerships with community chiefs are sometimes vital to changing behavior of community members. One example of this was given by an interviewee in Ghana who stated that, due to hierarchical structure of several communities in which the organization implements programs, the heads of the community needed to be consulted before the promoted HWTS product is accepted (Interviewee no. 11). Partnering with community members helps ensure that after implementing organizations leave, there are still individuals present to continue the message. Implementing organizations partner with leaders because they are well-respected and community members follow their lead (Interviewees no. 7 and no. 8).

Many other types of partnerships have also been cited as useful to effectively promoting HWTS practices. Partnerships with trusted spokespersons are important to product adoption and can improve rural penetration (POUZN Project, 2007). In Tanzania, an interviewee reported that through their organization's partnership with local charity organizations, there is greater reach to rural populations located in areas that are hard to access through failed road networks and other factors (Interviewee no. 6). This partnership has improved scale-up as a result. Certain organization types also bring particular expertise to the mix when partnerships are formed. For example, government-led and NGO-led HWTS programs can benefit from the marketing expertise of private sector firms. Public-Private Partnerships (PPPs) can be important in incentivizing the private sector to make greater investments in HWTS programs. In Kenya, the private sector is strongly encouraged by the government to get involved and submit proposals for HWTS partnership directly to the Ministry of Public Health and Sanitation (MoPHS) with importation waivers granted to manufacturers of proven technologies (WHO and UNICEF, 2011a and WHO and UNICEF, 2011b).

In addition to partnerships, interviewees noted that integrating HWTS programs into other WaSH and health-related programs is beneficial for sustaining and scaling-up HWTS practices. Interviewees noted that through integration, resources are maximized and are able to go farther than standalone projects. In a report put together by a number of organizations including Action Against Hunger, Action for Global Health, End Water Poverty, PATH, Tearfund, and WaterAid, it is stated that integrated approaches can be cost-effective for donors and more closely reflect and respond to determinants of disease (WaterAid, 2011). Integration is also an effective way of reaching specific populations of interest that can be useful in further promoting HWTS practices. In collaboration with UNICEF, CDC and PSI, the government of Malawi's Ministry of Health piloted a hygiene promotion program targeting mothers that attend ante-natal care (ANC) clinics. The initiative focused on key hygiene improvement interventions including treatment and safe storage of water at the household level and bottles of WaterGuard™ along with a water storage bucket were distributed to pregnant women. An increase in the number of women who had heard about WaterGuard™, treated their water correctly with WaterGuard™, and stored their drinking water correctly was observed a year later during follow-up (Sheth et al., 2010). A second follow-up survey conducted three years after the baseline survey, showed that WaterGuard use and purchase, as well as confirmed residual chlorine rates were higher than during the baseline survey period (Loharikar et al., 2013).

2.1.3. Standards, Certification, and Regulations

With numerous HWTS products and technologies available, it is important that consistent standards for quality and performance be established. According to Lantagne (2009), the consistency and quality of commercial bleach products available in developing countries is inadequate for use. In addition to potential health benefits not being realized, this inconsistency can produce skepticism about the efficacy of HWTS practices which in turn can negatively influence sustained use. Numerous benefits of mandatory and voluntary certification standards at varying scales (industry, national, and international) were reported during the interviews and in the literature. In response to this need for and the agreed upon benefits of consistent quality, stakeholders have started employing standards for HWTS products and technologies (Interviewee no. 11).

Government standards and regulations can ensure that only effective products are marketed in a country and, ideally, that these standards are enforced. Testing regimes in wealthy countries have long been used to certify water treatment devices. However, these may not be effective or appropriate for developing country markets for reasons including expense and regulatory capacity. In the absence of government involvement, voluntary standards set by manufacturers and implementing organizations can provide some of the same benefits. Filter manufacturers in Ghana and Tanzania note that standards are useful and do not pose a challenge for the manufacturing process. Instead, the standards help ensure that quality products are being produced consistently (Interviewees nos. 9–13). There is no evidence in the published literature for the benefits of voluntary HWTS standards but according to ITC (2010), between 2002 and 2007, growth rates of markets associated with sustainability claims such as organic products labelled products have doubled those of their counterparts. Some of the potential benefits include increased trust of consumers and consistent quality of product; standards, however, generally increase costs for manufacturers (ITC, 2010). Possible social desirability bias in the interviewee responses should be noted here as none of the costs or challenges of standardization were mentioned. Interviewees likely assumed that their responses would be favored if there was complete agreement with standardization. Although standards contribute to quality of products, certification informs the public that the products are of good quality. This can help increase confidence in products which maximizes the likelihood of adoption and sustained use (ITC, 2010). Additionally,Wessells et al. (2001) note that consumer organizations in many countries argue that customers have a right to know about the safety of purchased products. Products that have the "stamp of approval" from governments are viewed as being safer and more effective than products without this stamp (Interviewees no. 14 and no. 15). In Tanzania, the Tanzania Bureau of Standards (TBS) logo on products reportedly increases the trust of users (Interviewee no. 15).

In addition to government involvement through establishing standards and granting certification, governments can implement other policies that facilitate sustainability and scale-up of HWTS practices. EAWAG's Department of Water and Sanitation in Developing Countries (SANDEC) has found that scaling up is more likely where governments take greater ownership of the program because it typically yields more stable funding than most NGO-led programs (EAWAG SANDEC, 2002). Government involvement also takes advantage of existing resources, capacity, credibility and authority (Clasen, 2008). Along with the personnel of the government, the permanency of the government in the country makes having a government body in favor of HWTS key to consistent use of HWTS. The presence of policies specifically tailored to HWTS can help maximize the impact of efforts to promote and implement different HWTS practices. In Ghana, once HWTS is incorporated into District Plans by district authorities, these authorities can receive funding from national government to carry out HWTS activities (Interviewee no. 16).

The advantages of having clear policies are many and accrue to different actors involved in HWTS and fosters partnerships between actors. In Ghana and Tanzania, interviewees (no. 15, no. 17, no. 18) noted that, through national strategies and action plans, partnerships had been promoted and there was greater coordination of ongoing activities. Evidence of the formation of these partnerships can be seen in national strategies of several countries including Ghana. One of the guiding principles in the Ghanaian national HWTS strategy is forming partnerships that leverage both private and public sector resources (MLGRD Ghana, 2014). Effective implementation of policies related to HWTS requires that responsibilities towards HWTS are housed in an agency and clear roles of this agency and any supporting agencies are defined. For example, one interviewee (no. 15) noted that during implementation of an HWTS program, his organization reached out to, and received support from, a national ministry; however, the program was undermined when another ministry asserted leadership of HWTS affairs and that the program needed to end.

2.1.4. Market Strategies

Most early leaders of the global HWTS community came from the non-profit sector, disaster relief, government, the UN system, and academic departments of engineering and microbiology. Therefore, it should not be surprising that knowledge of market-based strategies for HWTS in developing countries lags behind other areas. The focus on market-based strategies within the HWTS community has increased over time as efficient mechanisms to sustain and scale-up HWTS practices have been investigated.

Robust market strategies depend upon effective analysis of a market. This comprises: (1) carefully choosing and understanding consumers; (2) developing products that are acceptable to consumers; (3) pricing products to be affordable and to recover costs; (4) ensuring effective supply chains; and (5) effectively promoting products to create demand (Borden, 1964). Items 1, 2, 3 and 5 have been described above; effective supply chain for HWTS and competition between technologies are discussed below.

The presence of an effective supply chain for a particular HWTS product or technology is dependent on several factors including: availability of raw materials for manufacture, availability of skilled human resources for manufacture, minimal import barriers and favorable import regulations (for foreign products), availability of wholesalers and retailers, and dependable transportation systems. For many HWTS technologies or products, there is a need for frequent purchase (e.g. chlorination tablets) or periodic replacement of parts, (e.g. ceramic filters) so ensuring that a supply chain is available is crucial to the sustainability of practicing HWTS. The high rate of breakage of ceramic filters noted in Cambodia (approximately 2% per month) suggests that sustainability of ceramic filter interventions is highly dependent on the availability of replacement parts and access to, and awareness of, a distribution point (Brown et al., 2007). The consumer's ability to adopt and sustain a promoted behavior depends on the existence and availability of products and technologies, and it is vital to not only consider the availability of supplies, but also the proximity of consumers to the distributors (Cogswell and Jensen, 2008). An interviewee, a distributor of chemical disinfectants, noted that although there was great demand for the product, occasionally products were not available and as a result sustainability was compromised. Many populations in need of safe water reside in remote locations; as a result developing an effective supply chain can be challenging. Using local materials can ease this challenge (Interviewee no. 10). Therefore, HWTS technologies that can be manufactured locally have an implicit advantage for sustainability and scale-up (Sobsey et al., 2008, Taylor et al., 2009 and Christopher, 2000). However, quality of products always needs to be guaranteed regardless of manufacturing location.

In addition to product availability, two other important aspects of the supply chain are import regulations and tariffs. With regard to the importing of products or spare parts, many study participants noted that a challenge was getting the products quickly when needed. To address import delays, a large stockpile of HWTS product had to be secured in anticipation of future in-country demand (Interviewees no. 19, no. 9, no. 11, no. 12, and no. 20). The presence of high tariffs also plays a role in affecting the supply chain because high tariffs increase the price at which products can be sold to retailers which in turn, increases the price retailers can sell product to consumers (Interviewee no. 21).

Some aspects of competition between technologies were identified by six interviewees as a barrier, specifically the "badmouthing" or otherwise undermining of competing products and practices. While diversity of HWTS options was mentioned as enhancing overall HWTS use (see User preferences discussion), competition was not identified by interviewees as an enabler to the sustainability or scalability of an individual HWTS intervention. However, fair competition has the potential to benefit consumers. Rangan and Sinha (2011) noted that due to competition between Hindustan Lever and Tata Swach, costs for filters were reduced to increase consumer base.

2.1.5. Resource Availability

The lack of resources in developing country markets has presented a persistent challenge to HWTS scale and sustainability. Both the literature and interviewees cite numerous cases in which limited human and economic resources produce barriers to the success of HWTS. As an example, Clasen (2009) notes that programs using pot-style filters have had limited success in achieving coverage for numerous reasons, one of which is a lack of technical expertise in the development of the technology.

Creative and inexpensive ways to leverage the human capital of the community at low cost have been reported. Community leaders, religious leaders and other prominent individuals may be willing to contribute to HWTS promotion efforts without formal compensation; involving prominent individuals in HWTS promotion at little to no cost may be possible and has been shown to be effective (Fgueroa and Kincaid, 2010 and POUZN Project, 2007). In some settings, this type of approach should be considered to address broader aspects of HWTS programs than just promotion. Interviewees (no. 2, no. 5, and no. 22) supported this and noted that through engaging churches and other local organizations, larger populations – particularly populations in hard to reach areas – were reached. Additionally, technical, marketing and other experts may be willing to volunteer their time for an HWTS project, if it is seen as a good cause or, for local experts, if it can provide connections and social capital within the community (Interviewee no. 20).

Economic resources are a persistent challenge in the communities most in need of HWTS. The most frequently identified barrier to HWTS uptake by interviewees was product cost. The clearest way for HWTS programs to become sustainable is for households to demand and be able to afford the product. However, diverse financing mechanisms have been necessary to ensure affordability of products. Some examples include free distribution (in which case organizations and partners determine ways for this to be done sustainably), provision of subsidies (e.g. need-based subsidies provided by the government), and provision of microfinance loans. One of the factors identified by Population Services International (PSI) as crucial to initiating a Safe Water System project is identifying appropriate target group(s) with both: high incidence of water-borne diseases and sufficient resources to regularly purchase the product (POUZN Project, 2007). Many populations in need of HWTS products simply do not have the resources to purchase HWTS technology or products. One way in which products have been provided to these populations is by demanding "sweat equity", i.e. consumers assist in the manufacture, transport and installation of technologies which reduces or eliminates any cash contribution that may have been required (Clasen, 2008). For populations that cannot afford HWTS products, this approach may prove more effective because research has shown that providing goods for free can undermine sustainability as a result of a lack of buy in or investment by users (Blanton et al., 2014). In Tanzania, an international NGO found that when biosand filters were given for free, they were not used; they report that use increased after they began selling the filters (Interviewee no. 8).

2.1.6. User Guidance on HWTS Products

Training is vital to ensure individuals adopt the practice correctly. This is true regardless of whether implementers view a particular HWTS technology or product as easy or intuitive to use. Numerous examples of incorrect use of technologies have been reported. Examples for solar disinfection (SODIS) include: users have been observed exposing bottles to the sun in an area that becomes shaded after a few hours, exposing the wrong side of the bottle to the sun, not closing bottles tightly, and partially filling bottles which could reduce UV-A radiation as a result of air bubbles (EAWAG SANDEC, 2002). Incorrectly using a technology or product could reduce or eliminate the health benefits of adopting water treatment at the household level, possibly decreasing demand for HWTS as skepticism on the efficacy of water quality interventions increases (Clasen, 2008).

Training on how to use HWTS products and technologies is viewed as important to ensure consistent use of the product or technology. Users may believe products are ineffective if they continue to get sick, even if the reason they are getting sick is incorrect use (Interviewee no. 10). For most HWTS products and technologies, leaflets or pamphlets are provided along with the products and technologies during sale and distribution that inform users on how to use the products or technologies and also clean and maintain them, where necessary. The effectiveness of these pamphlets for ensuring correct use is not well understood. An interviewee in rural Tanzania noted that recurrent training on how to use the different HWTS products and technologies was also found to be necessary, as user behavior lapsed over time. The interviewee provided no evidence of this knowledge lapse and there may be a number of reasons why knowledge lapse occurred including ineffective training initially and evaluation of skills of different consumers over time; however, programs like the Potter's for Peace (PFP) filter program in Nicaragua are beginning to implement follow-up training activities to improve knowledge about training and maximize effective practices (Lantagne et al., 2006). Apart from training on how to use water treatment products and technologies, training on safe storage is also vital. Interviewee no. 10 noted that water quality in storage containers could be just as unsafe as or even more unsafe than water from unimproved sources because of poor storage practices. Although no evidence was provided to support this finding in the specific case on which Interviewee no. 10 was reporting, this observation is consistent with the literature. Wright et al. (2004), through a systematic meta-analysis of 57 studies, found that the bacteriological quality of drinking water declines significantly after collection and this decline is sometimes partially explained by poor storage. Bain et al. (2014) also found that stored water contamination was more likely than contamination at the source. These findings illustrate the need for training in correct storage practices.

2.2. Diffusion of Innovation Theory and the Six Domains

Diffusion of Innovations (DOI) theory was popularized by Everett Rogers and seeks to explain how new ideas and technologies are taken up by a population as well as the reason for the uptake and the rate at which they spread. This theory has been used in various sectors to understand effective ways to motivate adoption of technologies and is one of the most popular theories used for explaining diffusion of products and technologies (Murphrey and Dooley, 2000, Dooley, 1999 and Al-Jabri and Sadiq Sohail, 2012). Other adoption theories include: (1) extension theory – focuses heavily on communication as the main mode for increasing adoption and does not provide a framework for studying adoption; (2) bounded rationality – developed by Herbert Simon in 1957 and focuses largely on the goals of the individuals and their available resources and how these play a role in decision-making; (3) theory of reasoned action – addresses the internal determinants of individual behaviors in different situations about different practices; and (4) consumer behavior theory – uses the needs of the producers as the starting point for evaluating the advantages and disadvantages of an innovation and assumes that prospective adopters actively search for information (Botha and Atkins, 2005). DOI theory is used to assess the six domains identified in this paper because it is comprehensively assesses the adoption process. It is appropriate for assessing HWTS adoption because it incorporates the technological aspects of the innovation as well as the social conditions necessary for adoption.

According to DoI theory, there are four main elements in the diffusion of an innovation: the innovation itself, communication channels, time, and the social system. Table 3illustrates how the six domains identified in this paper are supported by DoI theory and how the six domains relate to the four main elements in the diffusion of an innovation.

Table 3.3: Using DoI theory to assess defined domains for sustainability and scale-up of HWTS practices

Elements of diffusion	Relevant categories of the elements identified by Rogers (2003)	Domain supporting DoI elements[a,b]
The innovation	I. Relative advantage of HWTS in comparison with no HWTS or inadequate HWTS practices II. Compatibility with needs, existing values and past experiences of households III. Complexity of use of HWTS product or technology IV. Ability to be tried before investment V. Observability of results of HWTS practices	**User preferences** - Social status achieved from employing HWTS practices[I] - Aspirational products; easy to incorporate into normal routine[II] - Ease of use of HWTS practice[III] - Visual proof of water treatment or, potentially, improved health[V] **Resource availability** - Consumable HWTS technologies versus those with large initial capital investment[IV]
Communication channels	I. Interpersonal channels/face-to-face (effective in persuading individuals to adopt and innovation	**Integration and collaboration** - Partnerships with change agents, local NGOs, community leaders, etc.[I]
Time	I. Innovation-decision process i. First knowledge of HWTS practice/product ii. Attitude formation about the HWTS practice/product iii. Decision to adopt or reject of HWTS practice/product iv. Implementation and use of HWTS product v. Confirmation of the decision to adopt or reject HWTS practice/product	**Integration and collaboration** - Partnerships with leaders to promote practice/product[I-i] - Involving change agents[I-ii,I-iii] **Standards, certification, and regulations** - Certification to boost population confidence in product[I-ii] **User preferences** - Practice/product compatibility with users[I-ii,I-iii] - Social status strengthened[I-v] **Market Strategies** - Clear supply chain – consistent availability of products in the market[I-iv]

			Resource availability - Upfront cost and continued cost of practice/product[I-iv] **User training** - Correct and consistent use to see visual changes, if any, and to realize health benefits[I-v]
The social system	I.	Effects of formal and informal relationships	**Standards, certification, and regulations** - Partnerships with the government[I] **Integration and collaboration** - Partnerships with community leaders, teachers, health workers, etc.[II] **User preferences** - Religious and traditional beliefs about water treatment and/or water treatment products[III]
	II.	Relevance of change agents in diffusion	
	III.	Influence of cultural norms on diffusion	

In considering HWTS as an innovation, it is important to note that the target population needs to contemplate both the different HWTS practices possible and the numerous products available to carry out these practices. As a result, there are two boundaries to cross for adoption to take place. To illustrate this, a fictional example is presented. In a community with a turbid water source in which HWTS practices are promoted, a household may opt for filtration rather than chlorination because filtration has the relative advantage of reducing turbidity over chlorination, SODIS, and boiling. Filtration is also relatively simple to practice. After opting for filtration, the household then needs to decide between biosand filtration and ceramic filtration and consider the degree to which turbidity reduction can be observed. Therefore, for HWTS, there is a need for a double diffusion for adoption to occur. It is important to consider both the practice and the product being promoted to sustain and scale-up HWTS practices.

2.3. All Domains Matter

In a study to determine enablers and barriers to uptake and sustained use of improved cookstoves, Rehfuess et al. (2014) identified and defined seven domains, each of which was populated with multiple factors identified in the study. They concluded that "all domains matter and jointly influence" uptake and sustained use. Based on the discussion of each domain for sustaining and scaling up HWTS practices above, a similar conclusion can be made here. Interviewees comprised individuals from dozens of countries, diverse organizations, and various settings and despite this, at least one of the ten most identified factors fit into each of these domains, illustrating the significance of each. Prioritizing domains is beyond the scope of this study; however, the diverse cultures, beliefs, rules, resources, and preferences that define individual behaviors make prioritizing domains extremely difficult, and likely unhelpful. Additionally, Rehfuess et al. (2014) note that "broadly speaking, the evidence suggests that policies and programs must consider all factors" and that to prioritize, a suitable evidence base and knowledge of the relevant context is required. It is, therefore, important to consider all domains when implementing HWTS programs.

2.4. Study Limitations

Interview and survey responses could not be independently verified. This is one limitation of studies that use self-reported data. Confirmation bias in this study could have led to interviewees attributing positive or negative outcomes to specific factors that may or may not have been the main influence. Additionally, social desirability bias could potentially have led to reluctance of interviewees to report on failed HWTS programs in which they were involved. The study could also have benefited from increased access to under-represented categories of interviewees, particularly manufacturers. Fieldwork was carried out in countries with similar socio-economic characteristics and the study could have benefited from in-depth analysis of countries with diverse socio-economic characteristics.

3. Conclusion

This study used interviews, focus groups and online questionnaires with experienced HWTS practitioners and identified 47 enablers and barriers to HWTS sustainability and scale-up. The enablers and barriers were grouped into 23 factors and categorized into six domains. Collectively, all six domains consider individuals (target households and communities), organizations (implementing organizations, governments, etc.) and the formal and informal rules that guide individuals and organizations. Additionally, the domains identified in this study cover the major aspects of moving products from development to the consumers and are supported by Diffusion of Innovation theory.

Due to the comprehensive nature of the domains, it is important that each domain is considered for all programs that aim to sustain and scale-up HWTS practices.

This study showcases the importance of collaboration between different organizations regardless of the HWTS practice and product promoted. Strong collaborations can lead to sharing lessons learned, thereby, improving the likelihood of effectively promoting HWTS and subsequently enabling sustainability and scale-up of HWTS practices.

The results from this study were used to develop three tools that that can guide organizations in implementing effective HWTS programs. One enables rapid assessment of the feasibility of employing a product in a community, based on supply chain present. Another enables the assessment of the household and community conditions prior to program implementation to guide organizations in the planning and implementation processes of HWTS programs. The third enables assessment of the readiness of the national governments – in terms of government efforts and policies – to sustain and scale-up HWTS practices. These tools are yet to be piloted but can be made available to interested parties[2].

Future research can dig deeper to better understand the extent to which each of these domains play a role under different contexts. Additionally, research can look into ways to assess each of these domains. Piloting the tools developed during the study may facilitate some of this research in addition to validating the tools.

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CHAPTER 4: ADAPTING DRINKING-WATER SYSTEMS TO COASTAL CLIMATE CHANGE: EVIDENCE FROM VIET NAM AND THE PHILIPPINES[6]

1. Introduction

In its Fifth Assessment Report (AR5), the Intergovernmental Panel on Climate Change (IPCC) states that "coastal systems and low-lying areas will increasingly experience adverse impacts such as submergence, coastal flooding, and coastal erosion" (IPCC 2014, pp 17). Coastal areas are particularly important because of their economic significance and high population. Three-quarters of all large cities are located on the coast and more than 40% of the global population resides within 100km of the coast (UNEP, 2005; UN, n.d.). The large population and high urbanization of these regions cause land cover change, which reduces the coastal environment resilience to climate hazards (Lambin et al. 2001; USGS, 1999). For example, filling in wetlands for infrastructure development reduces the flood control ability of the environment. Coast-specific hazards, such as sea level rise, make these areas particularly vulnerable to the changing climate (EPA, 2015). Coastal climate hazards, such as coastal erosion and sea-level rise, damage infrastructure like drinking-water systems and cause salinization of drinking-water sources. Impacts on drinking-water systems include pipe breakage, system flooding, water source contamination, and power outages which hinder power-dependent pumping and treatment, all of which reduce the quality and/or access to drinking-water among the supplied population.

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According to the WHO and UNICEF Joint Monitoring Programme (JMP), more than 650 million people lack access to improved drinking-water sources, most in low-income countries (WHO & UNICEF, 2015). In 2012, approximately 842,000 diarrheal deaths resulted from inadequate water, sanitation, and hygiene practices worldwide, including approximately 380,000 children under the age of five (Prüss-Ustün et al., 2014). With the impacts climate hazards could have on drinking-water quality through water contamination from floods, these numbers could increase, especially since only a few drinking-water technologies are resilient to climate change (Howard et al., 2007). Consuming unsafe water also has adverse effects on school attendance and economic development, as illnesses like diarrhea lead to high rates of school absenteeism and increased expenditures on healthcare (Hutton and Haller, 2004; Monse et al., 2013). Lack of access near the home increases time spent collecting water which contributes to decreased school attendance (Sorenson et al., 2011). In addition to lower access to improved drinking-water sources, low-income countries have a higher likelihood of water system damage by climate hazards because of insufficient resources to adapt to and cope with these hazards. Adaptation is the process of adjustment of systems to actual or expected climate and its effects in moderating harm or exploiting benefits (IPCC, 2014). According to the IPCC AR5, "analysis and implementation of coastal adaptation has progressed more significantly in developed countries than in developing countries towards climate resilient …coasts." (IPCC 2014, pp 365).

To minimize the adverse impacts of climate hazards on drinking-water systems, effective adaptation should be employed. Additionally, as access to improved drinking-water sources is increased in low- and lower middle-income (LLMI) countries, water utilities may benefit from incorporating climate change into newly established systems to minimize costs of retrofitting systems in the future. However, the barriers to adaptation may delay adaptation. Biesbroek et al. (2011) notes the importance of understanding barriers to adaptation to ensure effective implementation. However, there is limited research on enablers and barriers in LLMI countries. Most of the literature focuses on high-income countries (examples include Bierbaum et al., 2012, Hunt and Watkiss, 2011, Jantarasami et al., 2010, Lawrence et al., 2015, and Measham et al., 2011). With the impacts climate change will have on LLMI countries, more research should be carried out because almost half of the world population (approximately 3.45 billion people) resides in LLMI countries (World Bank, 2015).

In light of the abovementioned, this paper assesses the enablers and barriers to climate change adaptation in coastal areas of LLMI countries, with evidence from Viet Nam and the Philippines. Because of the limited understanding of why these enablers and barriers exist, this study also explores some of the reasons for the existing factors.

The extensive coastal areas of Viet Nam and the Philippines make these countries vulnerable to coastal climate hazards. They are hit by numerous storms annually that cause extensive damage. Typhoon Haiyan, which hit the Philippines in 2013, affected over 16 million people and was one of the top ten most disastrous storms for the 1900-2014 period, in relation to the number of people affected (EM-DAT, 2014). According to the IPCC (2014), Viet Nam is one of the top five nations by population in coastal low-lying areas.

For this study, barriers to adaptation are defined as "those factors that actors experience as impeding the process of developing and implementing adaptation" (Biesbroek, 2011). Enablers are those factors that facilitate this process. Enablers and barriers to adaptation were determined through interviews with government officials and water utility personnel in Viet Nam and the Philippines. A framework developed by Moser and Ekstrom (2010) for diagnosing barriers to climate change adaptation was used to analyze the responses from interviews. While Moser and

Ekstrom's work addresses barriers to climate change adaptation, here we address both enablers and barriers as factors that influence adaptation.

Study results add valuable information to the evidence currently available on implementing adaptation in LLMI countries. It will aid water system managers in determining the kinds of resources that will facilitate effective adaptation.

2. Methods

2.1. Study Participants

Study participants were water utility personnel and government officials involved in climate and/or water programs in Viet Nam and the Philippines. Purposeful sampling—sampling information-rich participants—was used to select participants. Opportunity sampling, using information from a study participant to inform selection of additional participants, was also used. Participants were recruited through personal contacts in UN agencies, government agencies, and water utilities. This study received an IRB exemption from the University of North Carolina at Chapel Hill, IRB #14-0725.

2.2. Interview Guide Development

The interview guides (Online Resource 1) were developed after a review on climate change in coastal areas and corresponding effects on drinking-water systems. This review aided in identifying the relevant hazards for coastal areas, which helped in determining what questions should be posed. One major source of information was the Contribution of Working group 2 for the IPCC fifth assessment report, which provides information on impacts of climate change and climate hazards in coastal areas.

Questionnaires administered to water utility personnel and government officials differed slightly in content. Questions specific to drinking-water systems, such as system types, were asked of water utility personnel but not government officials. In addition to basic participant information, like organization and city, information on climate policies and enablers and barriers to adaptation was collected. All questions were open-ended. The interview was pilot tested with a post-doctoral researcher with experience in developing and evaluating technologies for low-cost water treatment and safe water access. Piloting aided in refining the questions; potentially leading questions were rephrased and close-ended questions were changed to open-ended questions to avoid forcing answers.

2.3. Data Collection

Data was collected through interviews or paper-and-pen survey. Interviews were semi-structured and recorded. The survey content was identical to the interview guide. The conversational form of the interview allowed respondents to expand on their responses, which was not possible with the paper-and-pen survey. Interviews were conducted over the course of three weeks (August 3rd-23rd 2014) in the Philippines and four weeks (August 25th-September 20th 2014) in Viet Nam.

Twenty-six interviews were carried out and three pen-and- paper surveys were completed. Eight interviews and surveys were administered to water utility personnel and twenty-one to government officials (Table 1). Sixteen interviews were conducted in Viet Nam and 13 in the Philippines.

Table 4.1: Study participants by country and organization type

	Country		
	Viet Nam	The Philippines	**Total**
Organization			
Water Utility	3	5	8*
Government agency	13	8	21
Total	**16**	**13**	**29**

* Three of these completed pen-and-paper surveys

2.4. Interview Analysis

Interviews were transcribed and analyzed using inductive coding, which involves analyzing the transcript to identify patterns and themes. Responses from the survey were similarly coded. Interview coding was carried out in Atlas.ti 7. These codes represent factors and sub-factors that influence effective adaptation implementation. In addition to the factors identified, reasons for the enablers and barriers noted were extracted from the responses. The frequency of identification for each factor was determined based on the number of respondents that identified at least one sub-factor. Each factor is counted once for a respondent regardless of how many sub-factors are identified by that respondent. Therefore, the total counts for sub-factors within a factor may exceed the counts for the factors.

2.5. Framework and Hypothesis

Moser and Ekstrom (2010) developed a framework (Figure 1) to comprehensively diagnose barriers to climate change adaptation and this was used to frame factors identified from interviews. The framework has three interacting structural elements: the actors directly or indirectly involved in the adaptation process, the larger context within which these actors perform, and the system of concern upon which they act. Based on the framework, we hypothesize that each of the structural elements of the framework will be relevant to at least one identified factor.

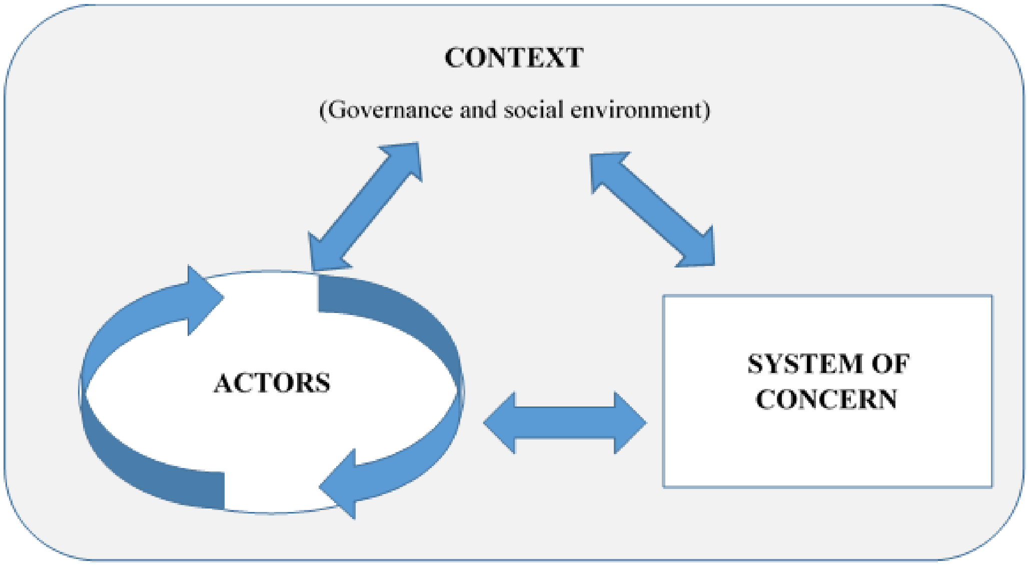

Figure 4.1: Structural elements of the framework. This framework has been modified for this study from a barrier diagnostic framework developed by Moser & Ekstrom (2010).

One goal of the Moser and Ekstrom framework is to aid in effective decision-making and as such is embedded within three common phases of a decision-making process: (1) understanding the problem at hand; (2) planning possible adaptation options; and (3) managing adaptation implementation. With each phase, the Moser and Ekstrom framework is applied to produce a comprehensive analysis of enablers and barriers to adaptation. This framework was used because it offers a systematic approach to analyzing factors relevant to adaptation and takes into consideration social and physical systems that may influence decision-making.

3. Results

3.1. Identified Factors Relevant to Water System Adaptation to Climate Hazards

Four barriers were identified by the respondents: insufficient funding, lack of political will and poor leadership, lack of climate change awareness, and inadequate human and technical resources (Table 2). One enabler—partnerships—was identified (Table 2). The reasons for these factors, identified by respondents, are also presented in Table 2. These enablers and barriers were renamed into neutral factors. For example, insufficient funding was renamed financial resource availability. The factors identified were financial resource availability, human and technical resource availability, climate change awareness, partnerships, and leadership and political will. Each of these factors was identified by both government officials and water utility personnel. These factors had sub-factors identified during the interviews that helped explain different features of the factors.

Partnerships include partnerships between stakeholders as well as in information sharing. Included are partnerships with local people, across different levels of government, and inter-sector collaboration. This factor was identified 24 times. Sharing information between developed and LLMI nations was mentioned 10 times.

Financial resource availability refers to the availability of financial resources to implement effective climate change adaptation. This factor was identified 24 times. This factor comprises resources for training, for making changes to water systems, and for carrying out environmental management practices to protect water systems.

Human and technical resources refer to the availability of staff as well as the ability of staff and other stakeholders to carry out activities related to adaptation. It also includes the availability of technical resources such as climate prediction tools to ensure appropriate adaptation activities are carried out. Overall, this factor was identified 22 times. Available human resources was identified 9 times, human technical capacity was identified 15, and availability of technical resources was identified 18 times.

Leadership and political will refers to the willingness and ability of those in leadership to deal with climate change issues as well as the policies they put in place to aid in adaptation. It includes leadership by the government as well as water system managers and the internal and external policies that guide water utilities. This factor was identified 16 times. Political will was identified 6 times, favorable policies 13 times and leadership 9 times.

Awareness of climate change refers to the awareness of local people, governments, water system personnel and other stakeholders about climate change and its impacts on the population, environment and water systems. This factor was identified 8 times.

Table 4.2: Identified factors relevant to climate change adaptation
Numbers in parentheses represent the number of respondents that identified factors.

Identified Factors		Reasons factors are relevant
Factors	**Sub-factors**	
Partnerships (24)	Partnerships with local people	Cross-cutting influence of climate change on different sectors
	Partnerships with international organizations and high-income countries	
	Inter-sector collaboration	
	Sharing lessons	
Financial resource availability (24)	Financial resources of the government	Competing priorities
	Financial resources of water corporations	
	Financial resources of water consumers	
Human and technical resource availability (22)	Available staff	Uncertainty in climate projections
	Human technical capacity	
	Technical resources for climate and impact projections	
Leadership and political will (16)	Political will	Distant timeframe of climate projections; Uncertainty
	Favorable policies of on climate change	
	Leadership and management of water system managers	
Awareness of climate change (8)	Awareness of local people, government, and water system personnel	Competing priorities with more certain impacts

3.2. Framing Factors within the Barrier Identification Framework

Three structural elements of the framework—actors, context, and system of concern—influence the implementation of adaptation based on the Moser and Ekstrom framework. Table 3 shows the types of actors and specific social and political environments (contexts), based on respondent responses, that are relevant to each of the factors presented in section 3.2. The system of concern was not specific to the factors; it spanned across all factors because it represents the system for which adaptation is being considered.

Table 4.3: Fitting the structural elements of the Moser and Ekstrom (2010) framework into the factors identified by respondents.

	Actors	Context	System of concern
Partnerships	Water system personnel; local people, government officials; stakeholders from water-related sectors; international organizations	Collaborative environment with governments	Drinking-water infrastructure and water source
Financial resource availability	Water utilities; government officials; local people	Government revenue for climate change; Private sector investments; aid (foreign partners and international organizations).	
Technical and human resource availability	Water system personnel; climate change educators and trainers; government officials.	Public and private workforce	
Leadership and political will	Water system managers; government officials	Favorable policies for climate change adaptation	
Awareness of climate change	Water system personnel; government officials; and local people.	Social norms, culture, education	

Moser and Ekstrom (2010) also show that factors influence adaptation at the different phases of the decision-making process: understanding the problem, planning the adaptation, and managing the implementation. Responses from the interviews show that each of the factors identified are relevant at specific phases of the decision-making process, with some factors being of importance in two or more of the phases. A correlation between the factors and each of the phases was made for all but one of the factors (Table 4).

Table 4.4: Relevance of each factor throughout the decision-making process

	Understanding the problem	**Planning the adaptation**	**Managing the implementation**
Partnerships	Knowledge transfer from climate researchers to water system personnel and government officials	Collaboration between water system personnel and other stakeholders* to decide on adaptation options	Partnerships with other actors that make use of the water sources to improve implementation success.
Financial resource availability	Financial resources for investment in climate projections and impacts research.	Prioritizing different adaptation options in addition to other development initiatives based on limited funds.	Resources to produce desired outcomes in government and water utility strategies.
Technical and human resource availability	Scientific knowledge about climate projections and impacts on water systems.	Ability to select and prioritize effective adaptation based on technical knowledge of systems.	Available and knowledgeable staff to carry out selected adaptation options.
Leadership and political will	Leadership to improve knowledge of stakeholders, through educational policies and making workshops available for technical staff	Presence of leadership to select and prioritize options effectively	Government and water utility leadership to facilitate effective adaptation
Awareness of climate change	Presence of awareness campaigns to improve understanding of the problem and sensitize people to impacts.	No correlation made	No correlation made

* These stakeholders generally include actors that make use of same water sources as utilities.

4. Discussion

4.1. Factors Relevant to Effective Climate Change Adaptation of Drinking-Water Systems

The factors are discussed below within the context of the decision-making process described in the Moser and Ekstrom (2010) framework.

4.1.1. Partnerships

Partnerships promote understanding of the problem by creating awareness of climate change and its impacts on water systems among stakeholders. Collaboration between climate scientists and water system personnel improves knowledge of climate projections and impacts on the system. Additionally, failing to form the required partnerships may lead to ineffective and, possibly, counterproductive adaptation actions (Adger et al., 2005). Respondents noted that policies that established inter-sectoral committees aid in improving understanding about climate change. One noted "climate change is a multi-sector issue, so nobody can be an expert for one sector and also for other sectors. That is why with the steering committee we invite people from different sectors and so we have a better discussion, better opinions in terms of climate change and its impacts." By ensuring that stakeholders from different sectors collaborate, diverse views are introduced, increasing the likelihood of comprehensive adaptation and reducing the risk of adaptation actions in one sector causing harm in another (Kates et al., 2012; Archie, 2014).

Partnerships are also relevant for planning and managing adaptation. Adaptation should not be carried out as stand-alone activities but rather be incorporated into existing cultural practices (Adger et al., 2013). Respondents noted that indigenous knowledge is beneficial to effective adaptation. Nyong et al. (2007) found that in the African Sahel, a region characterized by frequent droughts, local populations developed adaptation options, such as implementing different cropping patterns, that aided in reducing their vulnerability to climate variability. Indigenous practices are a major resource for adapting to climate change (IPCC, 2014). One reason for this is that indigenous people have a history of adapting to highly variable ecological conditions. However, the importance of this type of knowledge will be challenged by climate change impacts, particularly the increase in the frequency of extreme events (IPCC, 2014). By fostering partnerships that combine science and technology with indigenous knowledge, robust solutions can be developed.

Jantarasami (2010) concludes that, since the efficacy of adaptation is dependent on local climate impacts, a one-size-fits-all approach is inappropriate and establishing a system for sharing lessons will aid in effective decision-making. Based on this, indigenous knowledge may not be appropriate in every situation because of varying social contexts. In addition to using indigenous knowledge, respondents noted that partnerships with international organizations and high-income countries are important and was a recurring theme in the interviews. There was a general understanding that contexts would differ and so adaptation would have to be appropriately modified; however, these lessons would still be valuable. By sharing these lessons, new solutions to deal with issues can be explored and mistakes made can be avoided.

4.1.2. Financial Resource Availability

Financial resources are necessary to (1) conduct research on climate projections and impacts to improve understanding; (2) aid in prioritization and assessment of all possible adaptation options to ensure effective planning; and (3) implement, monitor, and evaluate adaptation options. Many studies identify financial resource availability as a factor in climate change adaptation (e.g. Ford and King, 2015, Archie, 2014, Marshall and Stokes, 2014; Antwi-Agyei et al., 2012, Gero et al., 2012, Huang et al., 2011, Jantarasami et al., 2010**).** In LLMI countries other priorities sometimes dominate investment, leaving little funding for climate change adaptation (Biesbroek et al., 2013). According to a respondent, "a challenge [to adaptation] is the lack of resources because in order to build the dike or the river bank and some other works in the remote areas, it costs a lot of money. So we let go of the funding for that [adaptation] in order to do all the work needed in the critical areas."

Resources identified by respondents include those of the government to support water utilities, resources of the utilities to ensure continued and safe water supply during and after disasters, and resources of consumers to make payments to keep systems functioning. Financial resource availability is relevant for LLMI regions because financial investments in infrastructure, training, and other requirements are sometimes lacking for the everyday maintenance of systems in the absence of climate change concerns. Prioritizing climate change impacts is, thus, not always a consideration. "It is known that the impact of climate change is long term and it is not what we see right now so it does not concern seriously the policy-makers and responsible agencies. This causes a lot of difficulties and challenges during the implementation process on issues such as the distribution of resources," noted a respondent. Availability of financial resources needs to be coupled with effective use of these resources to promote the implementation of effective adaptation. Burch (2009) noted that "addressing a lack of … financial… resources is less a matter of creating more capacity than of facilitating the effective use of existing resources." Countries, therefore, need to be aware of where finances should be invested, whether it be in improving climate change knowledge or carrying out mitigation and/or adaptation activities, and in what ways to ensure effective adaptation.

4.1.3. Human and Technical Resource Availability

According to Jantarasami et al. (2010) and Archie (2014), implementation of adaptation is hindered by limited technical information on climate change projections and impacts. This has brought about the concept of 'no-regrets' adaptation, that is, options that, even in the absence of climate change, will provide net societal benefits (Bapna and Mcgray, 2009). Some examples of this include improving management services and promoting resilient technologies (EPA, 2012; Howard et al. 2007). Even with no-regrets options, there is hesitation to invest in adaptation. "Climate change impacts are long-term. We are not fully aware what the future challenges will be" stated one respondent. The uncertainty inherent in projections makes investment in adaptation difficult as policy-makers are more concerned with short-term and certain challenges. Biesbroek et al. (2013), in a systematic review of barriers to climate change adaptation, found that only three were specifically climate change-related, one of which was the uncertainty of climate change. Several models for predicting climate change effects have emerged to reduce the uncertainties in climate science (IPCC, 2013). As model development continues, stakeholders would benefit from increased awareness of and investment in no-regrets adaptation since this is beneficial even in the absence of perfect climate models. This will also ensure timely adaptation is carried out, instead of leaving systems with no modifications to management and/or technology. The negative impacts of climate hazards can, therefore, be reduced with no-regrets adaptation.

With regard to human resources, respondents noted high turnover rates among staff because of a lack of incentives, particularly salaries. A respondent stated "for more than 10 years, the cost of living allowance has remained at 2000 Philippine Pesos per month. To reduce them leaving, maybe increase this or the salary. Employees on contract have no cost of living allowance and so no incentives to stay". Additionally, respondents noted that human technical capacity needed to be increased and can be done by adding climate change to the school curriculum. Due to the distant time frame of some adaptive needs, capacity building efforts amongst youths may be an effective use of resources. It will ensure they are trained before they become decision-makers, especially if education occurs in climate change-related fields. According to UNICEF (n.d), quality education on climate change is a key factor in ensuring that the skills necessary to adapt livelihoods to a changing environment are realized. Carrying out non-formal educational programs such as after-school activities that provide opportunities for research projects and internships engages youths in climate change issues. However, adding climate change to the school curriculum may overload curricula so it is important that the most appropriate issues are identified (UNESCO, 2012).

4.1.4. Leadership and Political Will

Political will and policies for actions will aid in planning and implementing adaptation (Dannevig et al., 2013; Archie, 2014; Ford and King, 2015). According to Biesbroek et al (2011), governments can support adaptation by developing and providing frameworks for action, creating awareness about climate change, and encouraging adaptation practices. One respondent stated "[Climate change] laws sparked a lot of activity, helped in planning for disasters and creating supportive local governments." Respondents noted that, although some regulations have helped in bringing adaptation to the front of national agendas, additional policies can be put in place to further facilitate adaptation. A respondent stated "in recent years awareness has increased and [climate change] has gained more attention from government agencies. Climate change plan is getting more support." If regulatory mandates that support adaptation efforts are absent or inadequate, as is sometimes the case, overcoming barriers that arise from limited capacity becomes more difficult (Few et al., 2007, Fünfgeld, 2010). According to a respondent, the "distant timeframe of climate change impacts makes government agencies focus on the 'right now' problems." There is, thus, a need for better communication of these impacts to those in leadership. Integrating climate change adaptation programs in national disaster risk reduction agendas can aid in ensuring that vulnerabilities of systems are reduced (Anderson, 2012; Baker et al., 2012).

Water utilities are guided by policies of local, state and national governments as well as their own internal policies. Respondents noted that willingness and determination of water utility leaders facilitate adaptation actions. To generate this determination, awareness activities for the heads of water corporations need to be carried out, according to respondents. One respondent noted that poor management can be seen in attempts to carry out too many activities that are not executable as a result of insufficient human and financial resources. Prioritizing activities ensures that whatever programs are carried out, even if few, are executed well. Based on these observations, in addition to training of water utility personnel, training of managers and government officials is also needed to aid in development and implementation of appropriate programs and policies.

4.1.5. *Awareness of Climate Change*

The significance of lack of awareness of climate change lies in its influence over some of the aforementioned and discussed factors. For example, poor awareness of the problem will lead to limited investments in solutions and to weak management and leadership of adaptation programs. According to a respondent, "awareness and policy have gained more attention from management and climate change is getting more support from organizations."

In the adaptation decision-making process, awareness of climate change is relevant to *understanding the problem*. Studies have found that by increasing awareness of the climate change problem, policy-makers, the public, and other stakeholders become engaged and resources to find solutions (Hamin and Gurran 2015). Respondents noted that people cut down trees for income and by raising awareness about climate impacts and providing incentives, reduction in tree cutting was observed. This is supported by outcomes from the Noell Kempff Mercado Climate Action Project. According to the Nature Conservacy (2009), deforestation was reduced in the park and alternative economic opportunities for the local population was provided along with provision of basic services such as health and education. Awareness is, thus, one of the foundational barriers to climate change adaptation and has been found in several studies to be an important barrier to adaptation (Antwi-Agyei et al. 2013, Biesbroek et al. 2011, Biesbroek et al. 2013, Moser et al. 2008, Watts et al. n.d.).

Glavovic (2015) stated that "knowledge and understanding about adaptation is constrained by the complexity of climate change." To increase awareness, effective communication is, thus, necessary. Studies have shown that individuals view problems through preexisting beliefs, norms, and experiences (Kahan and Braman 2006, Kahan 2010, Nielsen and Reenberg 2010). By knowing and understanding the recipients of the information, information generators and communicators are able to deal with whatever values and beliefs influence how the recipients perceive and interpret the information and what specific concerns they have (Moser and Ekstrom 2010).

4.2. Why Barriers Exist

An analysis of the responses from the interviews revealed that the main reasons why barriers exist include: the distant time frame of climate change projections, uncertainty inherent in climate change projections, and competing priorities. One respondent stated that "for climate change adaptation, it is a long-term vision and there is no idea what challenges may come." LLMI countries are faced with challenges, such as food insecurity, inadequate public infrastructure, and poor health and education services, many of which have immediate consequences that are well understood. The better understanding of other national and local problems can move climate change down the list of priorities. Increasing information on the links between climate change and other priorities like water quality and quantity, inequality challenges, and food availability will aid in facilitating adaptation programs. This is important for LLMI countries because, according to the UNDP (2011), climate change impacts could reverse decades of human development gains.

4.3. Equality in the Face of Climate Change

One recurring theme during the interviews was equality in the face of climate change. Interviews revealed areas of inequality in the absence of climate change as well as ways in which the changing climate could cause greater inequality. Respondents noted that capacity to deal with climate change is high in many areas relative to other areas, depending on available finances and geographic location. One respondent stated that, "provinces that are able to get funding deal better with climate hazards while poorer provinces do not." People who live in mountainous and/or remote areas are less likely to regain access to safe water after climate hazards, due to increased funding needed to provide service to these areas and high transportation costs.

With the changing climate, water utilities have the added challenge of having to balance extending service to unserved areas and maintaining and adapting existing infrastructure to strengthen resilience against climate hazards. If not maintained, the system would be susceptible to climate change hazards (WHO, 2009). However, extending service ensures that people without access gain access. Extending services generally requires substantial financial investment, investments that are not as substantial for system adaptation. Water suppliers may have to consider innovative financing mechanisms to ensure access is increased and adaptation of existing systems is carried out to ensure existing supplies are not compromised.

4.4. Study Limitations

This study relied on interview responses. Respondents could have identified enablers and barriers as responsible for outcomes for which they were not. Interviews in LLMI countries in other regions of the world would have allowed for a more comprehensive analysis of enablers and barriers relevant in the LLMI country context.

5. Conclusion

Five factors relevant to the effective implementation of adaptation of drinking-water systems were identified: partnerships; financial resource availability; human and technical resource availability; leadership and political will; and awareness of climate change. These factors span socio-economic, political and technical areas, showing the need for collaboration between different groups of actors and the relevance of context within which adaptation is being implemented. Results support the hypothesis that actors, the context within which they work, and the system of concern for which adaptation is being planned would be relevant to the enablers and barriers identified. We identified specific actors relevant to each factor. By knowing these actors, the right type of partnerships can be formed, when needed, to facilitate adaptation. The framework also aided in understanding how the factors fit into the phases of decision-making: understanding the problem, planning the adaptation, and managing the implementation. By viewing these factors in these phases, effective solutions to barriers can be better determined and implemented.

Results from this study can aid relevant stakeholders in understanding some of the challenges to climate change adaptation in LLMI countries. By identifying some of the reasons why barriers exist—distant time frame of climate change projections, uncertainty in climate change projections, and competing priorities—water utilities and governments can focus resources on dealing with the root cause of the barriers, whilst facilitating enablers.

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CHAPTER 5: RELATIONSHIP BETWEEN THE ENABLING ENVIRONMENT AND EXPENDITURES ON DRINKING-WATER AND SANITATION SYSTEMS: A MULTI-COUNTRY ANALYSIS[7].

1. Introduction

Targets 6.1 and 6.2 of the Sustainable Development Goals (SDGs) are to achieve universal and equitable access to safe drinking-water and adequate sanitation by 2030 (1). To achieve these, 1.8[8] and 2.4 billion people need to gain access to safe drinking-water and sanitation, respectively (2; 3). According to the United Nations (4), successful implementation of SDG activities will require an *enabling environment*, such as international cooperation to support developing countries and strengthened community participation in the management of water and sanitation (SDG targets 6.a and 6.b, respectively). According to the SDGs, this environment is also one in which policies supportive of investments, government accountability, clear roles of stakeholders, and clearly defined leadership exist (4).

The enabling environment is the blend of formal rules (e.g. policies), informal rules (e.g. cultures), and the physical environment (e.g. water resources) that impact the ability of organizations to achieve their objectives (5). As resources are focused on shaping the enabling environment to facilitate the achievement of the SDGs, it is important to know which enabling environment factors influence expenditures on drinking-water and sanitation (WatSan) systems to ensure effective resource allocation.

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[7] This chapter will be submitted to World Heallth Organization (WHO) Bulletin.

[8] This number is the sum of people that need to gain access to improved drinking-water sources and those that have access to improved but not safe drinking-water sources. Number from Onda et al (2012). This number does not take population growth into account and so is likely an underestimate.

There is increasing attention to the impact of formal rules on WatSan programs (6; 7; 8) and studies report the role of aid and national characteristics such as government effectiveness, on drinking-water access or change in access (9; 10; 11). However, no studies have used expenditures on WatSan systems, which take into account system construction and maintenance costs, as outcome measures. This study examines expenditures based on country-specific technology costs and WatSan access levels, emphasizing spending rather than access which is a more proximal outcome and less confounded than other outcomes such as access and health outcomes. Additionally, access alone does not capture all resource inputs. For example, approximately 19.2% and 27.3% of people in rural Haiti and Afghanistan, respectively, had access to adequate sanitation in 2015 but the 2015 expenditure per capita-to-date was estimated as 24.3USD and 17.3USD in Haiti and Afghanistan, respectively, due, partly, to technology cost differences. These costs include hardware costs, such as construction and maintenance costs, and software costs, such as supervision costs. Total expenditures are aggregated regardless of source such as taxes, tariffs, transfers and self-supply.

We aim to explore the relationship between formal rules and WatSan expenditure. Data on formal rules are obtained from Global Analysis and Assessment of Sanitation and Drinking-water (GLAAS) datasets (12).

2. Methods

2.1. Outcome Variables

Two outcome variables were used: 2015 per capita expenditure-to-date and change in per capita expenditure (between 2009 and 2015 and between 2011 and 2015 when the 2009 and 2011 datasets, respectively, were used). Change in per capita expenditure gives greater weight to countries with a large gain in access between 2015 and the dataset year, while per capita expenditure-to-date gives greater weight countries with a high level of access in 2015. By analyzing both of these outcomes, we consider countries that currently have high access to WatSan systems and countries that have made substantial progress in the past few years.

Per capita expenditure-to-date refers to funds used in providing and maintaining access to all WatSan systems in a country in a particular year. Expenditure is estimated based on unit construction and maintenance costs for new and existing technologies, respectively, and population coverage. Per capita expenditure is calculated by dividing expenditure by the population. The unit cost values were in 2010 United States dollars; using an 8% discount rate, unit costs were re-estimated for each year. Discount rates are used to determine the value of cash in one year based on the actual amount of cash in another year, in this case 2010. This rate takes into account the time value of money. We use 8% because this was the baseline value used by Hutton for unit cost estimates and cost estimates in his report.

We used 2015 as the year of interest for these analyses because it represents the latest available WatSan access information and is the farthest year from which the GLAAS datasets (2009 and 2011) were collected. By choosing the farthest year, we take into consideration possible policy lags, that is, the delay between policy implementation and observable impacts.

An illustrative example for the calculation of expenditure is presented in Figure 1. We use 2000 as the baseline year (i.e., we assume all infrastructure in 2000 was newly constructed) in our calculations because 2000 marked the start of more consistent monitoring of global access to WatSan such that estimates from this year onward are more accurate.

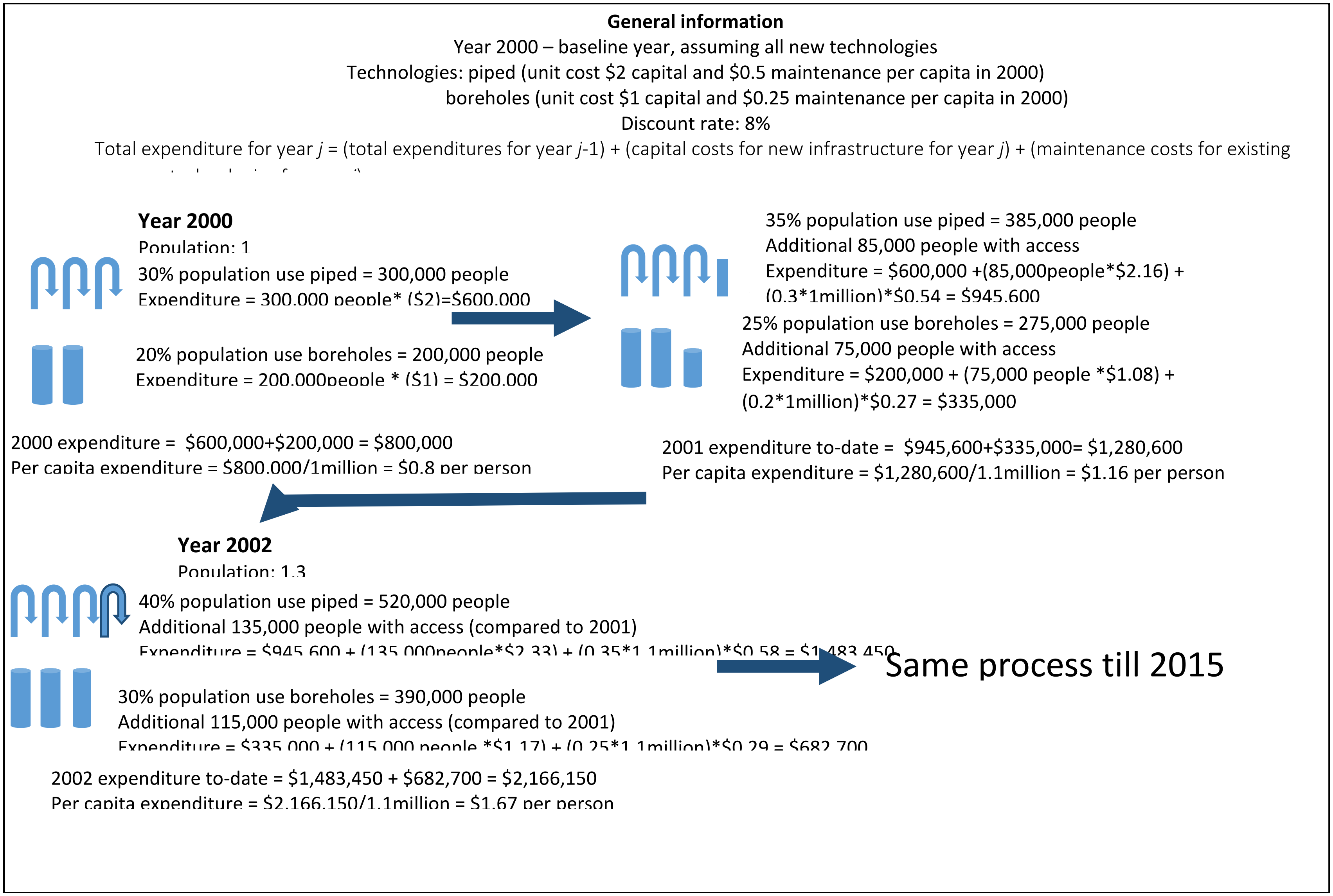

Figure 5.1: Method for estimating per capita expenditure in 2015

Coverage and population data were obtained from the World Health Organization (WHO) and UNICEF Joint Monitoring Programme (JMP) dataset (12). The JMP dataset does not distinguish between access to different improved non-piped drinking-water technologies or improved sanitation technologies. We assumed that the "other improved" sources for drinking-water are boreholes. Boreholes represent the most used drinking-water source, excluding piped systems, globally and cost data for this technology are available (13). Life span for piped water and boreholes were both 20 years and as such there was no replacement costs during the analysis period. We obtained country-specific unit cost data from Hutton (2012) which provides the most comprehensive list of country-level unit cost data for WatSan systems. However, when unit cost data for a country was unavailable, Hutton (2012) uses data from the most similar country. Hutton (2012) presents country-specific unit cost data for only sewerage and septic tanks for urban areas and septic tanks and pit latrines for rural areas. Septic tanks are more prevalent than sewer systems for populations with flush toilets in most sub-Saharan African countries, which make up a substantial number of the GLAAS surveyed countries, and in some Asian countries such as Indonesia and the Philippines (14; 15). Pit latrines are the most common sanitation technology in many developing countries, particularly in rural areas (16; 17). As a result, we used septic tanks and pit latrines for urban and rural settings, respectively. Lifespan for septic tanks and pit latrines were 20 years and eight years, respectively. The time period for estimating costs was 15 years in this paper, as a result, the only technologies that were replaced in the expenditure estimates were pit latrines.

By using these expenditure estimates rather than other estimates such as public expenditure data, we ensure that all infrastructure are taken into consideration regardless of financing mechanisms.

2.2. Predictor Variables

Predictor variables (Tables 1 and 2) were enabling environment variables (in this case government actions, such as policies, that guide individuals and organizations). These variables were obtained from the 2009 and 2011 GLAAS country survey dataset and were selected based on their categorization as socio-cultural, economic, administrative, political, and resource government actions as defined by Brinkerhoff[9] because these categories are often examined in the development literature (18). We excluded variables that reflect presence of policy with no consequent implementation. We aimed to have two variables, in each category. However, only one variable was available for the *political* category using the 2009 data. For the 2011 data, we added variables concerning participation of ministries of education, health, and water). These were not collected for the 2009 GLAAS dataset, but they have been found to impact WatSan programming (19; 20).

Table 3 lists the enabling environment variables and the corresponding GLAAS questions, where applicable.

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[9] *Socio-cultural* includes policies that build social capital and equity and encourage civic dialogue. *Administrative* includes policies that encourage cross-sectoral partnerships. *Economic* includes laws and policies supportive of investments. *Political* includes policies that support accountability and transparency. *Resources* include policies that ensure adequate funding.

Table 5.1: Description of predictor variables used in the study for drinking-water analyses

Variable	Brinkerhoff category	Urban/Rural disaggregation	Data source	Variable description
Clear roles and responsibilities[β]	Administrative	Yes	GLAAS 2009 &2011[δ]	This variable represents the presence of clear roles and responsibilities of sub-sector players such as local governments and water boards. (unitless)
Sector Wide Approach[β]	Administrative	Yes	GLAAS 2009 & 2011	This variable represents the presence of a sector wide approach that involves all development actors for drinking-water programs. (unitless)
Participation of ministry of health[β*]	Administrative	Yes	GLAAS 2011 survey	This variable represents the participation of ministry of health in drinking-water programs. (unitless)
Participation of ministry of education[β*]	Administrative	Yes	GLAAS 2011 survey	This variable represents the participation of ministry of education in drinking-water programs. (unitless)
Sub-sector review[β]	Political	Yes	GLAAS 2009 & 2011	This variable represents the presence of a review of sector performances that aids in setting future targets and activities. (unitless)
Decentralization[β*]	Political	Yes	GLAAS 2011 survey	This variable represents the degree to which decentralization of service delivery has been carried out. (unitless)
Domestic capital used[β]	Resource	Yes	GLAAS 2009 & 2011	This represents the 3-year average of domestic capital used for drinking-water programs. (unitless)
Official development assistance used[β]	Resource	Yes	GLAAS 2009 & 2011	This represents the 3-year average of official development assistance used for drinking-water programs. (unitless)
User participation[β]	Socio-cultural	Yes	GLAAS 2009 & 2011	This represents the presence and operationalization of procedures for informing and consulting with local communities and supporting local participation. (unitless)
Equitable funding[β]	Socio-cultural	Yes	GLAAS 2009 & 2011	This represents the presence of strategies to ensure funding in rural and urban areas is disbursed equitably to poor and other vulnerable populations. (unitless)
Investment programs[β]	Economic	Yes	GLAAS 2009 &	This variable represents the presence of an investment program for drinking-water programs. (unitless)

Variable	Brinkerhoff category	Urban/Rural disaggregation	Data source	Variable description
			2011	
Budget structure for water supply[β]	Economic	Yes	GLAAS 2009 & 2011 survey	This variable represents the presence a structure that allows for the identification of water supply specific budgets and investments. (unitless)
Average gross domestic product per capita	N/A	No	World Bank Open Data	This represents the average GDP per capita for years 2009-2014 for analysis using GLAAS 2009 data and average for years 2011-2014 for analysis using GLAAS 2011 data. (unit = US $)
Average government effectiveness	N/A	No	World Bank Worldwide Governance Indicators	This represents the average government effectiveness score for years 2009 -2013 for analysis using GLAAS 2009 data and average for years 2011-2013 for analysis using GLAAS 2011 data. Year 2014 is currently unavailable. (unitless)
Road density	N/A	No	CIA World factbook	This represents the length of roads in a country per country land area. (unit = km/km2)
Access to sanitation	N/A	Yes	WHO & UNICEF	This represents the average access to sanitation for years 2009 - 2015 for analysis using GLAAS 2009 data and average for years 2011-2015 for analysis using GLAAS 2011 data. This variable is used only for the water regression analyses. (unitless)

[β] These are the enabling environment variables used in this study. Other variables are predictor variables included in the study but are not categorized as enabling environment variables.

[δ] Specific GLAAS questions are presented in Supplementary Table 3.

* Data on these variables were not available in the 2009 dataset but their importance of cross-sectoral collaboration and decentralization highlighted in the literature warranted their addition to this study.

Table 5.2: Description of predictor variables used in the study for sanitation analyses

Variable	Brinkerhoff category	Urban/Rural disaggregation	Data source	Variable description
Lead agency defined[β¥]	Administrative	Yes	GLAAS 2009 & 2011 survey	This variable represents the clearly defined leadership to lead and coordinate programming. (unitless)
Sector Wide Approach[β]	Administrative	Yes	GLAAS 2009 & 2011 survey	This variable represents the presence of a sector wide approach that involves all development actors for sanitation programs. (unitless)
Participation of ministry of health[β]*	Administrative	Yes	GLAAS 2011 survey	This variable represents the participation of ministry of health in sanitation programs. (unitless)
Participation of ministry of education[β]*	Administrative	Yes	GLAAS 2011 survey	This variable represents the participation of ministry of education in drinking-water and sanitation programs. (unitless)
Participation of ministry of water[β]	Administrative	Yes	GLAAS 2011 survey	This variable represents the participation of ministry of water in drinking-water and sanitation programs. (unitless)
Sub-sector review[β]	Political	Yes	GLAAS 2009 & 2011 survey	This variable represents the presence of a review of sector performances that aids in setting future targets and activities. (unitless)
Decentralization[β]*	Political	Yes	GLAAS 2011 survey	This variable represents the degree to which decentralization of service delivery has been carried out. (unitless)
Domestic capital used[β]	Resource	Yes	GLAAS 2009 & 2011 survey	This represents the 3-year average of domestic capital used for sanitation programs. (unitless)
Official development assistance used[β]	Resource	Yes	GLAAS 2009 & 2011 survey	This represents the 3-year average of official development assistance used for drinking-water and sanitation programs. (unitless)
User participation[β]	Socio-cultural	Yes	GLAAS 2009 & 2011 survey	This represents the presence and operationalization of procedures for informing and consulting with local communities and supporting local participation. (unitless)
Equitable funding[β]	Socio-cultural	Yes	GLAAS 2009 & 2011 survey	This represents the presence of strategies to ensure funding in rural and urban areas is disbursed equitably to poor and other vulnerable populations. (unitless)

Variable	Brinkerhoff category	Urban/Rural disaggregation	Data source	Variable description
Investment programs[β]	Economic	Yes	GLAAS 2009 & 2011 survey	This variable represents the presence of an investment program for sanitation programs. (unitless)
Budget structure for sanitation[β]	Economic	Yes	GLAAS 2009 & 2011 survey	This variable represents the presence a structure that allows for the identification of sanitation specific budgets and investments. (unitless)
Average gross domestic product per capita	N/A	No	World Bank Open Data	This represents the average GDP per capita for years 2009-2014 for analysis using GLAAS 2009 data and average for years 2011-2014 for analysis using GLAAS 2011 data. (unit = US $)
Average government effectiveness	N/A	No	World Bank Worldwide Governance Indicators	This represents the average government effectiveness score for years 2009 -2013 for analysis using GLAAS 2009 data and average for years 2011-2013 for analysis using GLAAS 2011 data. Year 2014 is currently unavailable. (unitless)
Road density	N/A	No	CIA World factbook	This represents the length of roads in a country per country land area. (km/km2)
Access to water	N/A	Yes	WHO & UNICEF JMP dataset	This represents the average access to water for years 2009 - 2015 for analysis using GLAAS 2009 data and average for years 2011-2015 for analysis using GLAAS 2011 data. This variable is used only for the sanitation regression analyses. (unitless)

[β] These are the enabling environment variables used in this study. Other variables are predictor variables included in the study but are not categorized as enabling environment variables.

* Data on these variables were not available in the 2009 dataset but their importance of cross-sectoral collaboration and decentralization highlighted in the literature warranted their addition to this study.

Table 5.3: GLAAS questions linked to the enabling environment variables.

Enabling environment variable	GLAAS questions linked to enabling environment variable*
Clear roles and responsibilities (water)	Are the institutional roles of rural and urban players (national & local government, utilities, water boards, regulator etc.) clearly defined and operational?
Lead agency (sanitation)	Is there a government agency with a clear mandate to lead and coordinate the policy development and planning of sanitation with donors, other governmental institutions or non-state actors?
Sector Wide Approach	Does the government have a sector-wide approach (SWAp) or another similar sectoral framework for sanitation/water that involves all development partners?
Participation of ministry of health	Is the ministry of health participating in sanitation/water coordination?
Participation of ministry of education	Is the ministry of education participating in sanitation/water coordination?
Participation of ministry of water	Is the ministry of water participating in sanitation sub-sector coordination?
Sub-sector review	Is there an annual or biennial review in place to monitor sanitation/water sub-sector performance and to set new targets and/or undertakings?
Decentralization	Is funding available at local level from the national level?
Domestic capital used	What is the percentage of domestic capital commitments for sanitation/water utilized (three-year average)?
Official development assistance used	What is the percentage of official donor capital commitments for sanitation/water utilized (three-year average)?
User participation	Are there clearly defined procedures in laws, policies or plans for informing, consulting with and supporting participation by citizens and communities in planning, budgeting and implementing for sanitation/water at national and local level?
Equitable funding	Have criteria (or a formula) been agreed to allocate sanitation/water funding equitably to communities and is it being applied?
Investment programs	Is there an investment programme for sanitation/water that is agreed and published?
Budget structure for water supply and sanitation	Does the national budget structure allow for the identification of sanitation/water-specific budgets, investment and subsidies?

* Questions obtained from the 2011 GLAAS survey. Variables present in both 2009 and 2011 surveys have the same questions.

GLAAS survey responses are ordinal responses given values of 0, 0.5, and 1 in the dataset; however, they were recoded to binary variables. The 0 and 0.5 responses characterize policies that are not yet defined, defined and not yet operationalized, or only partially operational; these were recoded to 0. The only variables not representative of presence and operationalization of policies are percentage of domestic budget and official development assistance (ODA) used for programs. These were broken into three categories in the GLAAS dataset—under 50% used, 50-75% used, and over 75% used—and were not recoded into binary variables but left as categories 0, 0.5, and 1, respectively.

2.3. Data Analysis

Countries were included based on data availability. Sudan and South Sudan were excluded because of the division of Sudan into these two countries in 2011 which affected access values. To determine if lag time would influence results, analyses were conducted using the 2009 and 2011 GLAAS datasets separately.

Multivariable regression, using STATA 11.2, was used to determine the relationship between enabling environment variables and WatSan expenditure. Regressions were carried out for rural and urban settings, separately, and for water and sanitation systems separately.

$$\textit{Outcome variable} = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots.. + \beta_i x_i + \textit{constant} \qquad (1)$$

where β1-βi are the coefficient values for the predictor variables, x1-xi are the predictor variables, and constant is the value for the outcome variable when all predictor variables are 0. We used backward stepwise regression[10] with threshold p-value of 0.1 for deletion of variables from the model.

We determined if changes in government actions occurred between 2009 and 2011 by comparing country responses in 2009 to 2011.

[10] The model is run and the variable with the largest p-value is removed and the model is run again. The model continues this process of removing the variable with the largest p-value until only variables with p-values equal to or less than 0.1 remain.

3. Results

3.1. Multiple Regression Analysis

3.1.1. Regression Results Using 2009 GLAAS Data

Five of the nine enabling environment variables obtained from the 2009 GLAAS dataset had a significant effect (at 0.05 level) on at least one outcome variable (Table 4). Equitable funding, user participation, and sector review had significant effects on water but not on sanitation expenditure. Presence of a budget structure had significant effects on sanitation but not on water expenditure. The presence of a lead agency (for sanitation analyses) had a significant effect in urban settings but not rural. Although percentage of ODA used does not have a significant effect when all three groups are analyzed, there is a significant difference between countries that spend between 50 and 75% of ODA on programming and those that spend less than 50%.

Graphs of fitted values of the outcome variables against the data values are presented in Figure 2 and show goodness-of-fit of the model used. With the exception of Figures 2 (g) and (h), all models show fitted value to be in good agreement with the data. This indicates that the models used for the results graphed in Figures 2 (g) and (h) do not provide a good understanding of the relationship between the enabling environment and expenditures on sanitation systems, likely due to omitted variables.

Table 5.4: Multivariable regression results for assessing the relationship between the enabling environment and expenditures on drinking-water and sanitation systems using the 2009 GLAAS dataset^

	WATER				SANITATION			
	Rural		***Urban***		***Rural***		***Urban***	
	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure
Water and sanitation access proportion between 2009 and 2015	116.33*** (-13.23)	42.33*** (-6.82)	260.77*** (-67.07)	111.90*** (-24.1)	85.97*** (-21.56)	28.20*** (-7.06)	182.96 (-94.6)	
Average GDP between 2009 and 2014			0.02* (-0.01)		0.01*** (0)	0.002*** (0)		
Clear roles and responsibilities	25.00** (-7.17)	10.86** (-3.29)			N/A	N/A	N/A	N/A
Lead agency defined	N/A	N/A	N/A	N/A			59.21** (-19.24)	24.52* (-9.16)
Sector review	-25.66*** (-6.83)	-8.74* (-3.48)	47.23 (27.73)	18.46 (-10.64)				
User participation			63.08* (-30.04)	29.55* (-11.37)				
Presence of a budget structure						16.10* (-6.01)		
Official development assistance >50% but <75%[¥]				-21.78* (-11.71)				
Official development assistance >75%				-0.01 (12.37)				
Equitable funding		-7.53* (-2.97)						
constant	9.14	2.25	-17.18	-16.66	-37.39**	-13.57**	-116.96	12.53***

	WATER				SANITATION			
	Rural		*Urban*		*Rural*		*Urban*	
	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure
	(-6.13)	(-2.64)	(-32.1)	(-11.61)	(-14.02)	(-4.04)	(-83.67)	(-2.14)
N	**36**	**36**	**35**	**35**	**34**	**34**	**28**	**28**
Adjusted R squared	**0.6835**	**0.6551**	**0.6914**	**0.678**	**0.6458**	**0.6714**	**0.2643**	**0.1857**

^The blank cells mean the enabling environment values did not have an effect on the outcome variables at 0.10 significance level.
* p<0.05, ** p<0.01, *** p<0.001; standard error in parentheses.
¥ Based on the results in the table, there is a significant difference between the group that used ODA >50% but <75% and the reference group (group that used <50% ODA) but when all groups are taken into consideration, ODA does not have a significant effect (p-value=0.065).

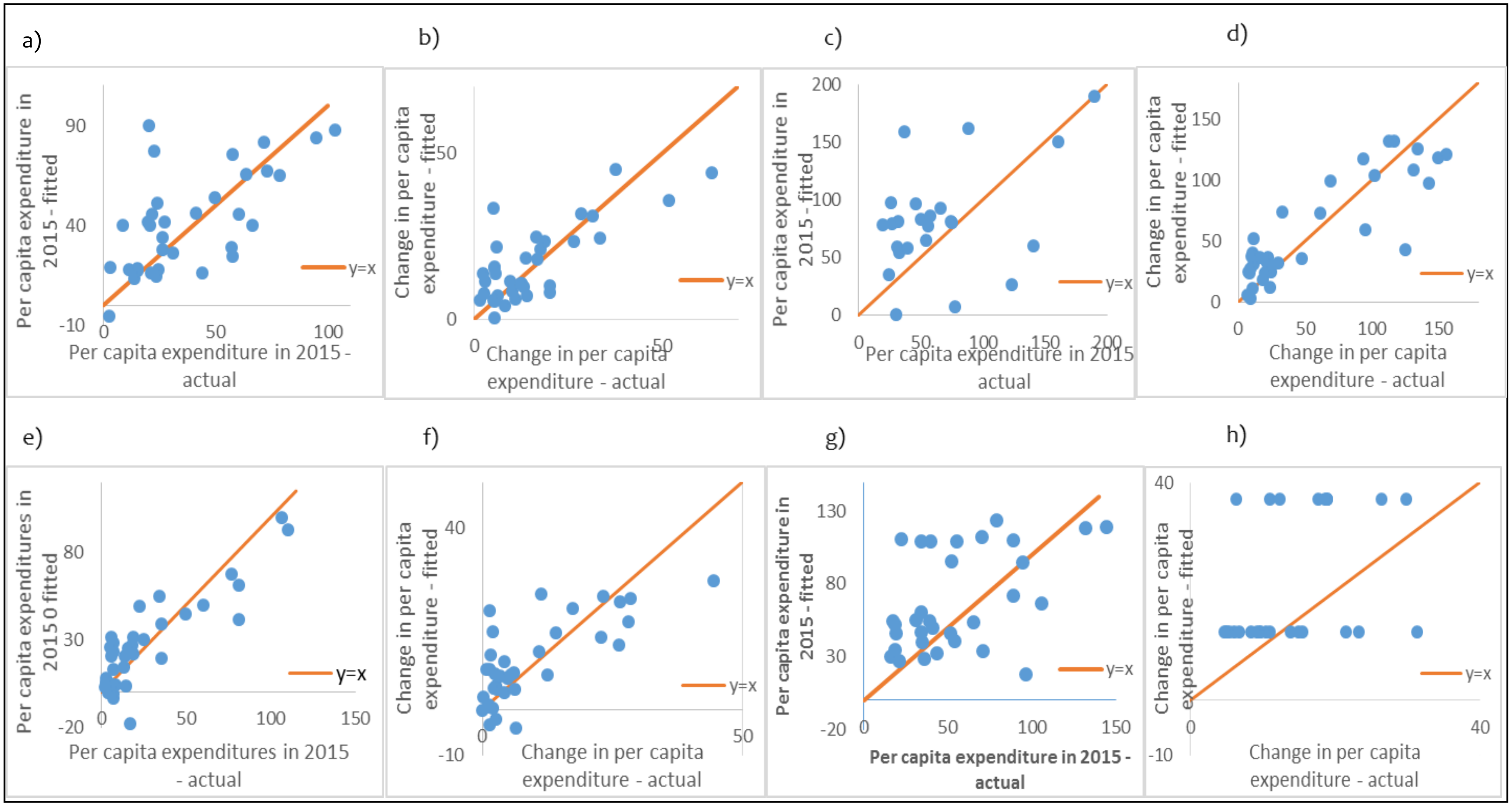

Figure 5.2: Fitted values against real values using 2009 GLAAS data for

a) per capita expenditures through 2015 for rural water; b) change in per capita expenditure between 2009 and 2015 for rural water; c) per capita expenditures through 2015 for urban water; d) change in per capita expenditure between 2009 and 2015 for urban water; e) per capita expenditures through 2015 for rural sanitation; f) change in per capita expenditure between 2009 and 2015 for rural sanitation; g) per capita expenditures through 2015 for urban sanitation; h) change in per capita expenditure between 2009 and 2015 for urban sanitation.

3.1.2. Regression Results Using 2011 GLAAS Data

Ten enabling environment variables from the 2011 GLAAS dataset were found to have a significant effect on at least one regression (Table 5). Participation of ministries of health and education had significant effects on both water and sanitation expenditure. The remaining eight had significant effects on either water or sanitation expenditures.

Graphs of fitted values of the outcome variables against the data values are presented in Figure 3 and show goodness-of-fit of the model used.

Table 5.5: Multivariable regression results for assessing the relationship between the enabling environment and expenditures on drinking-water and sanitation systems using the 2011 GLAAS dataset^

	WATER				SANITATION			
	Rural		***Urban***		***Rural***		***Urban***	
	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure
average GDP (2011-2014)	0.01** (0)	0.002*** (0)	0.03* (0.01)	0.01* (0)	0.003** (0)	0.001*** (0)	0.01*** (0)	0.003*** (0)
Sanitation/water access proportion (2011-2015)	79.29*** (-14.28)	25.20*** (-5.18)	211.07* (-83.78)	64.09** (-23.4)	74.51*** (-13.85)	20.42*** (-4.66)	267.57* (-126.24)	72.70 (-37.13)
Official development assistance >50% but <75%[¥]						***5.61**** ***(-2.06)***	67.87* (-28.2)	18.46* (-8.32)
Official development assistance >75%						***-4.15*** ***(-2.18)***	-7.16 (25.47)	-1.02 (7.76)
Participation of ministry of health	16.96* (-8.18)						66.31* (-25.00)	21.19** (-7.50)
Participation of ministry of education	-15.36* (-6.99)	-4.51* (-1.97)				3.19* (-1.55)		
User participation	-24.17** (-6.93)						49.01 (-25.28)	15.04 (-8.04)
Presence of sector wide approach						-2.82 (-1.53)	-62.08* (-29.68)	-18.66* (-8.88)
Participation of ministry of water							-89.94** (-31.86)	-25.02** (-9.05)
Presence of an investment program							52.64* (-24.65)	14.92* (-7.22)
Road density	-0.04*** (-0.01)	-0.01*** (0)						
Domestic capital >75%[δ]	***-37.38****** ***(-9.38)***	***-8.30***** ***(-2.03)***						
Domestic capital	***-29.90*****	***-4.95***						

	WATER				SANITATION			
	Rural		*Urban*		*Rural*		*Urban*	
	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure	2015 expenditure	Change in expenditure
>50% but <75%	***(-10.96)***	***(3.13)***						
Lead agency defined						4.58* (-2.13)		
Presence of a budget structure						-3.41* (-1.48)		
Decentralization							-40.57 (-22.36)	-12.66 (-6.55)
average government effectiveness (2011-2013)	28.27** (8.94)							
Equitable funding				-21.36 (-11.48)				
_cons	64.58*** (-12.05)	6.11*** (-1.58)	7.72 (-38.72)	0.36 (-11.18)	-29.24*** (-10.15)	-11.74** (-3.05)	-157.12 (-113.58)	-45.12 (-33.2)
N	**47**	**47**	**46**	**46**	**47**	**47**	**49**	**49**
Adjusted R squared	**0.7234**	**0.6375**	**0.5007**	**0.4754**	**0.5917**	**0.5401**	**0.5382**	**0.4801**

^The blank cells mean the enabling environment values did not have a significant effect on the outcome variables (i.e., p-values were greater than 0.1).

* p<0.05, ** p<0.01, *** p<0.001; standard error in parentheses.

[¥]Based on the results in the table, there is a significant difference between the group that used ODA >50% but <75% and the reference group (group that used <50% ODA) but when all groups are taken into consideration, ODA has a significant effect for only the bolded regression (p-value = 0.0090). There is no significant effect on the other outcome variables (p-value = 0.0716 for per capita expenditure-to-date for urban areas and p-value = 0.0958 for change in per capita expenditure-to-date for urban areas).

[δ] Percentage of domestic capital used has an overall significant effect (p-value = 0.0013 for per-capita expenditure-to-date for rural settings and p-value= 0.0041 for change in per capita expenditure-to-date for rural settings).

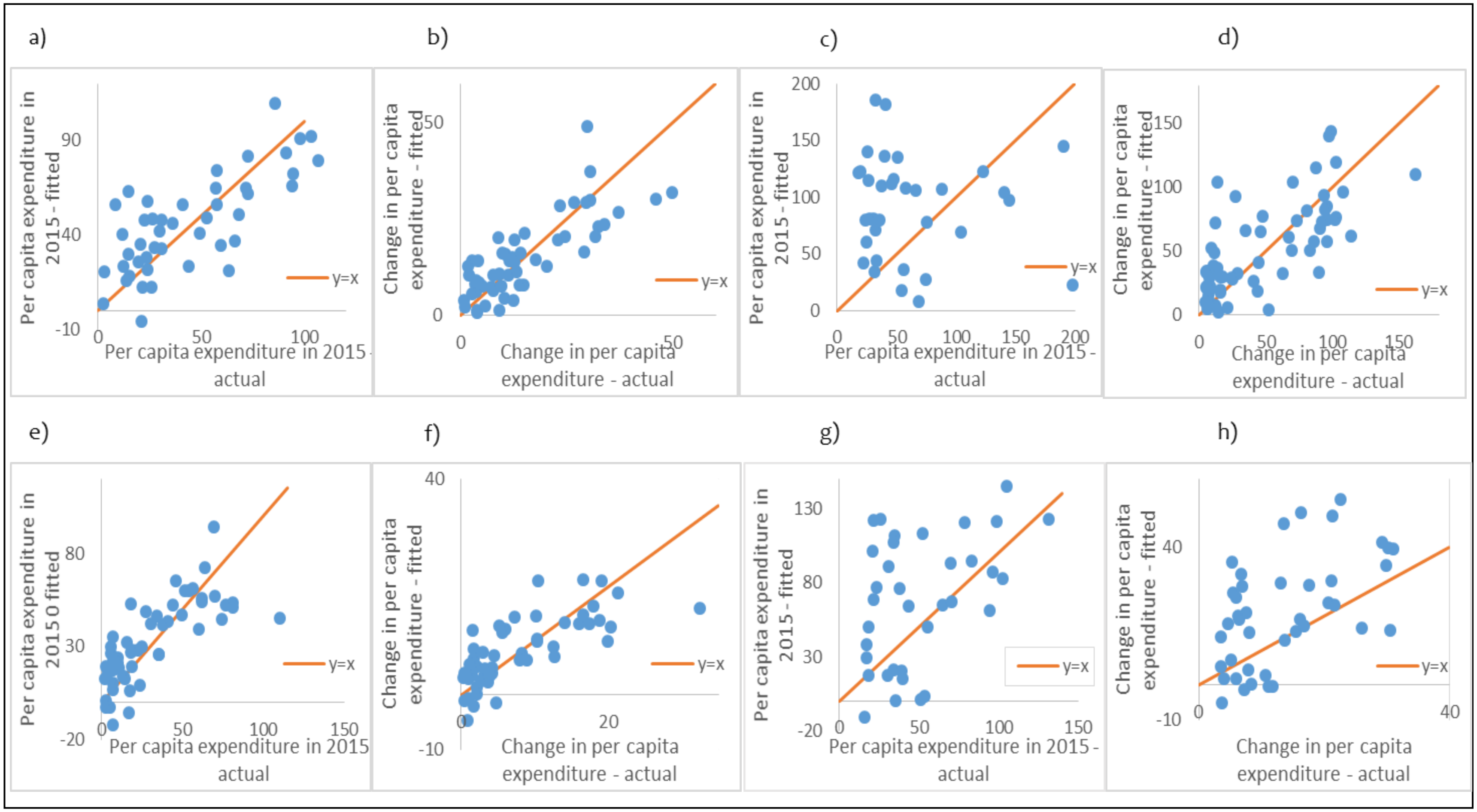

Figure 5.3: Fitted values against real values using
a) per capita expenditures through 2015 for rural water; b) change in per capita expenditure between 2009 and 2015 for rural water; c) per capita expenditures through 2015 for urban water; d) change in per capita expenditure between 2009 and 2015 for urban water; e) per capita expenditures through 2015 for rural sanitation; f) change in per capita expenditure between 2009 and 2015 for rural sanitation; g) per capita expenditures through 2015 for urban sanitation; h) change in per capita expenditure between 2009 and 2015 for urban sanitation.

Table 6 lists the enabling environment variables, the number of regressions over 2009 and 2011 in which they had a significant effect, and the type of effect. User participation, a defined lead agency, participation of ministries of health and education had significant effects on the most number of outcome variables. The type of effects was consistent for a defined lead agency and participation of ministry of health but varied for the other two.

Table 5.6: Number of outcome variables each enabling environment variables had a significant effect on and the type of effect for all regressions carried out in this study.

Enabling environment variable	Number of regressions with significant effect*	Type of effect
User participation	3	Positive (2), Negative (1)
Lead agency defined	3	Positive (3)
Participation of ministry of health	3	Positive (3)
Participation of ministry of education	3	Positive (1), Negative (2)
Budget structure	2	Positive (1), Negative (1)
Participation of ministry of water	2	Negative (2)
Investment programs	2	Positive (2)
Clear roles and responsibilities	2	Positive (2)
Sector wide Approach	2	Negative (2)
Sub-sector review	2	Negative (2)
Domestic capital used	2	Negative (2)
Equitable funding	1	Negative (1)
Official development assistance used	1	Depends on what groups are compared^
Decentralization	0	--

*Maximum number of regressions for an enabling environment variable to have a significant effect is 16 for all enabling environment variables except clear roles and responsibilities (8), lead agency defined (8), participation of ministry of health (8) participation of ministry of education (8), and participation of ministry of water (4).

^ There are three groups of countries for this variable. Determining direction of effect is dependent on comparing two groups to each other. For example, if the reference group is 1, it is possible for the effect to be positive when group 2 is being compared and to be negative when group 3 is compared to the reference group.

3.2. Comparing Expenditure and Change in Expenditures

On eight occasions out of 17, an enabling environment variable had an effect on 2015 per capita expenditure-to-date but not on change in per capita expenditure when results for the same year, setting, and system (drinking-water or sanitation) were analyzed. For five of these, the effect was observed for 2015 per capita expenditure-to-date. By comparing effects on these two outcome variables, we can determine if the significance of enabling environment variables is dependent on whether a country already has high access to WatSan systems or the country made large gains in access over the past few years. Table 7 lists the enabling environment variables that had a significant effect on only one of the outcome variables.

Table 5.7: Enabling environment variables that had a significant effect on only one outcome variable for a regression using the same dataset, for the same system, and the same setting

Enabling environment variable	Outcome variable with significant effect	Regression analysis
User participation	Per capita expenditure	2011 assessment for rural water
Participation of ministry of health	Per capita expenditure	2011 assessment for rural water
Presence of a lead agency	Change in per capita expenditure	2011 assessment for rural sanitation
Percentage of Official Development Assistance used	Change in per capita expenditure	2011 assessment for rural sanitation
Participation ministry of education	Change in per capita expenditure	2011 assessment for rural sanitation
Presence of a budget structure	Change in per capita expenditure	2009 assessment for rural sanitation
	Change in per capita expenditure	2011 assessment for rural sanitation
Equitable funding	Change in per capita expenditure	2009 assessment for rural water

3.3. Consistency between 2009 and 2011 GLAAS Data

Table 8 shows how country responses to the enabling environment variables changed between 2009 and 2011. As much as 40% of countries switch their responses from implementing a policy to not having and/or implementing that policy for some enabling environment variables.

Table 5.8: Number of countries with changes in policies and government actions between 2009 and 2011

Enabling environment variable*	Number (%) of countries that scored -1	Number (%) of countries that scored 0	Number (%) of countries that scored +1	Total Number (%) of countries
		Rural water		
Clear roles and responsibilities	5 (14.29)	19 (54.29)	11 (31.43)	35 (100)
Sector Wide Approach	2 (5.71)	21 (60.00)	12 (34.29)	35 (100)
Sub-sector review	3 (8.57)	25 (71.43)	7 (20.00)	35 (100)
Domestic capital used**	12 (37.50)	13 (40.63)	7 (21.87)	32 (100)
Official development assistance used**	7 (21.88)	13 (40.63)	12 (37.50)	32 (100)
User participation	4 (11.43)	23 (65.71)	8 (22.86)	35 (100)
Equitable funding	5 (13.89)	19 (52.78)	12 (33.33)	36 (100)
Investment programs	5 (14.29)	20 (57.14)	10 (28.57)	35 (100)
Budget structure for water supply	7 (19.44)	20 (55.56)	9 (25.00)	36 (100)
		Urban water		
Clear roles and responsibilities	3 (9.09)	23 (69.70)	7 (21.21)	33 (100)
Sector Wide Approach	3 (8.82)	20 (58.82)	11 (32.35)	34 (100)
Sub-sector review	5 (14.71)	21 (61.76)	8 (23.53)	34 (100)
Domestic capital used	12 (37.50)	16 (50.00)	4 (12.50)	32 (100)
Official development assistance used	12 (37.50)	14 (43.75)	6 (18.75)	32 (100)
User participation	3 (8.82)	24 (70.59)	7 (20.59)	34 (100)
Equitable funding	9 (25.00)	26 (72.22)	1 (2.78)	36 (100)
Investment programs	5 (14.71)	20 (58.82)	9 (26.47)	34 (100)
Budget structure for water supply	4 (11.43)	21 (60.00)	10 (28.57)	35 (100)
		Rural sanitation		
Lead agency	2 (5.71)	13 (37.14)	20 (57.14)	35 (100)
Sector Wide Approach	1 (2.94)	18 (52.94)	15 (44.12)	34 (100)
Sub-sector review	1 (2.86)	19 (54.29)	15 (42.86)	35 (100)
Domestic capital used	14 (42.42)	15 (45.45)	4 (12.12)	35 (100)

Official development assistance used	18 (54.55)	11 (33.33)	4 (12.12)	33 (100)
User participation	4 (11.76)	26 (76.47)	4 (11.76)	34 (100)
Equitable funding	3 (8.82)	31 (91.18)	0 (0.00)	34 (100)
Investment programs	3 (8.57)	29 (82.86)	3 (8.57)	35 (100)
Budget structure for sanitation	4 (11.76)	20 (58.82)	10 (29.41)	34 (100)
Urban sanitation				
Lead agency	3 (8.57)	16 (45.71)	16 (45.71)	35 (100)
Sector Wide Approach	1 (2.86)	21 (60.00)	13 (37.14)	35 (100)
Sub-sector review	2 (5.71)	18 (51.43)	15 (42.86)	35 (100)
Domestic capital used	13 (40.63)	15 (46.88)	4 (12.50)	32 (100)
Official development assistance used	14 (45.16)	13 (41.94)	4 (13.00)	31 (100)
User participation	1 (3.23)	22 (70.97)	8 (25.81)	31 (100)
Equitable funding	0 (0.00)	31 (93.94)	2 (6.06)	33 (100)
Investment programs	3 (8.57)	24 (68.57)	8 (22.86)	35 (100)
Budget structure for sanitation	3 (9.09)	20 (60.61)	10 (30.30)	33 (100)

* A score of -1 denotes a change from implementing a policy in 2009 to not having and/or not implementing that same policy in 2011. A score of 0 denotes no change in responses and a score of 1 denotes a change from not having and/or not implementing a particular policy in 2009 to implementing that policy in 2011.

** These variables are categorical variables with scores 0, 0.5, and 1 and so there are five possibilities when change is considered. For this table, a score of -1 denotes a reduction in the percentage of capital used for programs, a score of 0 denotes no change and a score of 1 denotes an increase in the percentage of capital used.

4. Discussion

4.1. Enabling Environment Variables with Significant Effects

User participation was the only enabling environment variable that had a significant effect on at least one regression regardless of WatSan system, setting, and GLAAS dataset year. The significance of user participation highlights the importance of SDG 6.b to strengthen user participation in WatSan programming. User participation in the planning and implementation of drinking-water programs had a positive significant on water expenditures in urban settings but negative in rural. The negative association may potentially be due to 'sweat equity'—contribution in a project through labor rather than financial investment—which is common in rural areas where water systems are often simpler (21; 22). Countries with lower percentage of rural areas by population (<=50%) have approximately 1.45 times (p=0.0004) and 1.64 times (p=0.0002) higher rural unit costs of piped water systems and boreholes, respectively, than countries with higher percentage of rural areas. More rural countries are more likely to have user participation programs (significant at 0.1 level) than less rural countries. These participation programs create opportunities for sweat equity to be employed. In considering sweat equity, labor-related costs need to be taken into account along with costs of invested time and opportunity costs, as the labor carried out is not the primary occupation of community members that contribute sweat equity. These costs would increase technology costs and were not mentioned in the Hutton report; it is unclear if they were included and therefore likely unit costs were underestimated for rural areas. Higher unit costs in rural areas of countries that are predominantly urban may also be due to high urban population in the country. Urban areas are generally more expensive than rural (23) and the high costs of urban areas may spread to rural areas.

In addition to user participation, other types of partnerships are strongly promoted in the SDG targets (4) and the relevance of partnerships in WatSan programming can be seen in the significant effect of partnerships with the ministries of education, health, and water on the per capita expenditure. Partnerships create opportunities for sharing lessons and sharing resources and have been found to be beneficial to WatSan programming (19; 24).

Analyzing usage of both foreign and domestic investments for WatSan programming, we find that both types of investments have significant effects on expenditures. Previous studies have found that volume of aid is not associated with access to WatSan when analysis controls for factors like GDP per capita (9; 10; 25). However, we find that the percentage of official development assistance used for programs had a significant effect on change in per capita expenditure for rural sanitation using 2011 GLAAS dataset. We analyze the ODA *used* for programming, not the amount *committed*; and we examined *expenditure* not *access*. Although levels of access contribute to expenditure, unit costs determine actual expenditure (see example in introduction).

The percentage of domestic capital used had a significant negative effect on water expenditures in rural areas using the 2011 GLAAS dataset. Domestic capital refers to central and local government funds used for water programs and does account for other sources such as direct household expenditure. Domestic capital typically goes towards infrastructure costs and an unknown proportion to salaries and other items (26). These latter costs may explain the effect observed. For example, in Ethiopia, between 2005 and 2008, such costs exceeded operational costs; and, operational costs increased six-fold while salaries increased ten-fold as a result of increasing the number of villages served and the number of staff employed at the village water agencies (26).

Policies that support partnerships and mobilize investments were identified as critical to achieving the SDG targets (4). Additionally, it was also identified in the SDG documents that countries made commitments to be accountable to citizens (4). Accountability mechanisms have been shown to improve programming outcomes through increased user satisfaction (27). Review of programs is one measure of accountability and was found to have a significant negative effect on water expenditures in rural settings. This effect is observed for the 2009 analyses but not the 2011. Twenty-nine percent of responding countries in 2009 changed their responses in 2011. About one-third of these countries changed responses from having a review to set new programs to not having a review. This may also account for the differences observed. Such reviews can enable efficient and effective allocation of resources. However, they require resources to execute which may mean less, although more effective, allocation for drinking-water system construction (28; 29; 30).

4.2. Comparing Expenditure and Change in Expenditure

The differences between enabling environment variables with significant effects on per capita expenditures and variables with significant effects on change in per capita expenditures were observed for rural areas alone. The types of policies implemented in rural areas differ from those in urban areas and this difference may affect the results seen here.

These differences were also observed predominantly in analyses using the 2011 GLAAS dataset. Analyses using the 2009 dataset denote earlier implementation and thus a longer implementing period when compared to analyses using the 2011 dataset. This may imply that implementation period impacts the type of outcomes that may be observed when policies are developed.

4.3. Unanticipated Results

Contrary to expected impacts, many enabling environment variables had a negative effect on WatSan expenditure. We examine the impact of formal rules on expenditures and find that the type of impact observed is dependent on type of system, settings in which systems are location, and the implementation period; however, informal rules interact with formal rules and affect the extent to which formal rules achieve the goals for which they are set (31; 32). The countries in the analyses have different systems of governments, are in different stages of development, and have varying priorities when it comes to WatSan. These differences may influence some of the results observed.

Our assessment included more than 30 'fragile countries' as defined by either the World Bank or by Fund for Peace in 2014 (33; 34). This may account for some of the negative effects observed because even when appropriate policies exist, fragile states have internal and external pressures that alter their expected effects (35; 36). Majority of the countries surveyed for the

GLAAS project are fragile states and as such make up a substantial proportion of the sample available for this study.

Table 8 shows many changes in responses between 2009 and 2011. Unexpectedly, each variable, excluding equitable funding for the urban sanitation programming, had at least one country change their response from implementing to not having and/or not implementing a given policy. Some variables had as many as 40% of countries that changed their responses in this manner. This finding brings into question the reliability of the responses to the GLAAS surveys or suggests higher variability to the implementation of formal rules than was expected.

4.4. Study Limitations

Rural and urban communities have different environmental and socio-economic characteristics and different approaches to service delivery; therefore, factors with a significant effect in rural settings may have the opposite effect or no significant effect in urban settings and vice versa. The GDP per capita, government effectiveness, and road density variables were national averages. This could affect results as these indicator estimates may vary across rural and urban settings and across sub-national regions.

In our estimates of expenditure, we assumed the lifespan of technologies presented in Hutton (2012). However, technology lifespan will vary across communities and countries based on quality of materials used in construction, maintenance of systems, and system usage. As a result of this assumption, only pit latrines were replaced in our estimates.

For the analyses conducted using the 2011 GLAAS dataset, four variables not available in the 2009 dataset, were included. This allowed analyses using all available data but may account for some of the differences in results between 2009 and 2011 analyses.

The datasets did not account for the types of implementation carried out for the policies. This lack of detail may affect the type of effects observed.

5. Conclusion

This is the first multi-country study to assess the effect of enabling environment factors on drinking-water and sanitation expenditure. Enabling environment variables with significant effects on expenditures varied by system type, the settings for which analyses were carried out, and the time period between implementation and outcome. Across all regressions, at least one enabling environment category—administrative, political, economic, socio-cultural, or resources—was found to be significant. This illustrates the relevance of considering different types of policies when planning and implementing WatSan programs.

Regardless of differences in the impacts of enabling environment variables by setting, types of system, and data year (time since implementation), user participation had a significant effect on the outcome variables for both rural and urban analyses. Although it is unclear what kind and level of participation is necessary to influence access to WatSan, this result highlights the importance of engaging users in the planning and implementation of drinking-water interventions. It confirms the importance of SDG target 6.b to support and strengthen local community participation in improving WatSan management.

In addition to user participation, we find that other enabling environment conditions highlighted in the SDG documents and/or targets were found to have a significant effect on expenditure. This implies that the approach taken with the SDGs are appropriate and it would be beneficial to determine suitable measures for shaping the environments required for achieving the SDG targets. Studies on effective participation mechanisms, investment measures, and appropriate accountability strategies would benefit stakeholders involved in WatSan program implementation.

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CHAPTER 6: COMPREHENSIVE DISCUSSION

The goal of the chapters 3 through 5 was to determine if and how the enabling environment, as defined in chapter 3, influences drinking-water programs. This chapter focuses on common themes across these chapters, points of differences observed, and overall lessons learned about the enabling environment impact on drinking-water programs. Due to the focus on the enabling environment, this chapter is concerned primarily with the formal rules, informal rules, and physical environment features—the enabling environment elements—that impact the capacity of individuals and organizations to carry out their activities to achieve the goal of improve access to safe drinking-water.

The chapter is broken into four sections: the first highlights common themes across the studies on evaluating factors that influence scaling-up and sustaining HWTS practices (qualitative), adapting drinking-water systems to climate change (qualitative), and expenditures on drinking-water systems (quantitative); the second concentrates on areas of divergence across the three studies; the third focuses on organization responses to an unfavorable enabling environment; and the chapter closes out with the fourth section on impacts of changing the enabling environment.

1. Common Themes across the Qualitative and Quantitative Studies

Results from the HWTS and climate change adaptation studies indicate that all elements of the enabling environment influence decision-making about adoption of HWTS practices and climate change adaptation of drinking-water systems (Table 1). This supports the conclusion reached in Chapter 2 that these three enabling environment elements influence drinking-water programs.

Table 6.1: Enabling environment elements identified in the three studies conducted

Enabling environment element	Identified in HWTS study	Identified in climate change adaptation study	Identified in expenditure on drinking-water systems study
Formal rules	Policies on cross-sector collaboration and other partnerships; standards and certification for HWTS products and technologies; Clear lead agency for HWTS	Policies on cross-sector collaboration and other partnerships; policies that promote funding; policies that support human capacity; Policies on leadership and clear roles of stakeholders.	Policies on user participation and cross-sector collaboration; Policies that ensure funding for disadvantaged populations; Sectoral review programs;
Informal rules	Cultural beliefs about water sources and HWTS product characteristics; social structures in target communities	Cultural beliefs about climate change	No informal rules used in this analysis
Physical environment	Water source type (turbidity); road networks	Road networks;	Road networks; sanitation infrastructure

1.1. Formal Rules

Formal rules that guide partnerships between actors involved in drinking-water programs were found to be influential in all three studies. For the HWTS study, this included cross-sector collaboration policies, policies to promote private sector participation in HWTS programs, and policies that guide the relationships between implementing organizations and government agencies. Cross-sector collaboration was also determined to be important to the achievement of goals in the climate change adaptation and expenditure on drinking-water system studies. The relationship between water and other sectors such as health and the environment, make setting guidelines for the interactions between these sectors important. An example of a successful collaboration brought about by change in policy is the establishment of the Interagency Coordinating Committee in Kenya for water and sanitation. This committee meets quarterly to share knowledge and experiences and is made up of government officials, donors, private sector and civil society organizations. The coordination among those in the committee has resulted in successful sanitation programming (Government of Kenya, 2015). Despite the potential for partnerships to enhance drinking-water programs, studies have shown that shared understanding of the goals of those involved in the partnerships is needed to foster collaboration. An example can be seen in the Indonesian case where the Government, in an attempt to promote public-private partnerships and private sector investments in water infrastructure, developed a guarantee fund mechanisms for any feasible PPP investing in water projects. A guarantee fund company shields the investors, in this case the private sector and partnering local government agency, from losses by absorbing any losses experiences by the investments. This did not motivate private sector investment, however, because it meant that the private sector depended on local government mandated tariff increases for profit (Sentiono et al., 2012). The partnership agreement in this case was not agreeable to all involved.

In addition to rules on partnerships, clarity of roles was found to have a significant effect on drinking-water system expenditure and this factor was identified in both the HWTS and climate change adaptation studies as important. A clearly defined lead agency for HWTS programs was noted as being beneficial as the lack of a "home" for these programs has, according to respondents, led to the unsuccessful implementation of interventions and to conflict between different ministries. For the climate change adaptation study, when roles were not clearly defined, there was duplication of programs and waste of resources and one agency could carry out activities that were in conflict with another agency. These benefits of leadership and clearly defined roles are supported by previous studies (de Loe et al., 2002; Timmer et al., 2007; Folifac, 2009). Folifac (2009) found that there was no clear leadership for water source protection in Buea, Cameroun, and as result, no coordination of agencies existed. Additionally, the lack of clear leadership created an environment in which there were poor policies in place to protect the water sources and enforcement of policies that did exist was limited.

1.2. Informal Rules

The quantitative study did not analyze informal rules as multi-country data were not available so this section discusses common themes related to informal rules identified in the HWTS and climate change adaptation studies.

Partnerships were a recurring theme in the HWTS and climate change adaptation studies and these included both formal and informal partnerships. Although the types of partnerships identified in both studies differed, the importance of informal partnerships was reiterated by the respondents. In the HWTS study, this included cooperation with leaders of the communities being targeted and with other change agents in the community. In the climate change adaptation study, this included collaborations between water utilities and other organizations to promote sharing lessons learned about effective adaptation practices and failed approaches. Although these partnerships are not guided for formal rules and the behaviors of those involved in the partnerships are not formally set, these partnerships can dictate the course of a program and influence its success. For example, respondents in the HWTS studies noted that community leaders, particularly in hierarchal communities, can decide if implementing organizations can carry out activities in their communities and can influence people's views of the practices being promoted. Informal partnerships have been shown to be beneficial in other studies. In the mid-1980s in Massachusetts, 35 towns partnered to share information and experiences on water management practices as well as to reduce costs of supplies by using their combined purchasing power and negotiating lower prices from vendors as a result of bulk purchases. Prior to the partnership, higher prices were paid for water treatment chemicals and laboratory supplies and there was no forum to share lessons. This group holds annual meetings in which challenges and best practices are shared (EPA, 2009).

1.3. Physical Environment

Across the three studies, road networks were found to impact people's ability to either adopt safe water practices or sustain these practices. In the HWTS study, it was noted that HWTS products, such as chlorine tablets and flocculation-disinfection products, require frequent purchase and so an effective supply chain is critical to the sustainability of these HWTS practices. Water filtration does not require purchases as frequent as consumables; however, there are reports of breakage of containers, spigots, and other parts that make availability of spare parts an important factor in ensuring continued employment of HWTS practices (Brown et al., 2007). The location of communities and ease of reach of communities was also noted as a barrier to providing and adapting water systems in remote areas in the climate change adaptation study. The presence of good road networks affects water supply delivery (UNDP, 2011). This influence of road networks was supported by the quantitative study in which there was a significant relationship between road density and expenditures on drinking-water system which was directly related to access to these systems. In 2012, approximately 42% of people that live in rural areas without road access in Lao People's Democratic Republic had access to improved drinking-water sources whereas that number is approximately 67% for people that live in rural areas with road access (MoH and LSB Laos, 2012).

In addition to road networks, it was noted that harsh conditions of the physical environment also drive people to adopt safe water practices. In the HWTS study, this harsh condition was characterized by the quality of the water, particularly turbidity. Respondents noted that people are more likely to treat turbid water than they are to treat clear water. In a study of over 300 people in Rural Kenya, DuBois et al. (2010) found that the adoption of flocculant-disinfectant treatment, a method that reduces turbidity as well as disinfects water, was significantly associated with water turbidity. For the climate change adaptation study, harsh conditions were characterized by the occurrence of natural disasters. Respondents stated that government interest in adaptation practices were heightened immediately following disasters, although this interest was generally short-lived.

2. Points of Difference across the Three Studies

In addition to the similarities between the enabling environment elements identified in the three studies to influence drinking-water programs, there were also differing themes and varying degrees to which different elements of the enabling environment was found to influence the drinking-water programs. This section highlights elements identified as influential in one study but not in the other two and provides insights into the reasons for the differences.

2.1. Contrasting Themes

The decisions to adopt and continue use of HWTS products and technologies by target households was driven primarily by individual preferences rather than the need to treat water from a health perspective, regardless of water quality, according to respondents in the study. The story is the opposite for the climate change adaptation study in which the aspiration to adapt drinking-water systems to climate change, was driven by the sense that adaptation was necessary, even in the face of barriers to adaptation. This difference in the perception about the need for these drinking-water programs—HWTS practices and climate change adaptation— influenced the types of enabling environment elements that affected the achievement of the objectives—scale-up and sustainability of HWTS practices and climate change adaptation of drinking-water systems.

In the HWTS study, the decision-makers—target individuals and households—are buying a product, one they are not always convinced they need but are sometimes motivated to buy, according to respondents. As such, the product needs to be compatible with the users, that is, consistent with their existing values, which are determined primarily by informal rules. These informal rules are, therefore, a major driver for the decision-makers. Clasen (2008) conducted reviews of published reports and interviews with individuals from implementing organizations, research institutions and consulting organizations to determine effective ways to scale up HWTS practices. His first recommendation was that implementing organizations focus on the users' needs and not prejudge that health is the ultimate goal, because many believe that diarrhea is not a problem. This idea of compatibility has been shown to be significantly correlated with adoption of practices. In a study to determine the motivations of mobile banking users, Al-Jabri and Sohail (2012) found that compatibility was significantly and positively associated with adoption. They surveyed 330 individuals in Saudi Arabia and asked questions related to how mobile banking matched their lifestyles and their values.

In addition to the characteristics of the product matching values, respondents in the HWTS study also noted that target individuals were motivated by social status and as such the effectiveness of the product was not necessarily the driver for adoption. This is markedly different from the responses from respondents in the climate change adaptation study.

It was noted by respondents in the climate change study that more information on types of adaptation, the benefits of the different types, and the impact on the overall environment was needed. As a result both formal and informal partnerships were a recurring theme in the study. The respondents believed that this partnership will facilitate effective adaptation as lessons can be learned about what works and what does not from organizations that have adapted their systems to climate change. Additionally, respondents noted the importance of including climate change in policies as this would improve the chances that adaptation would be funded. Formal rules were thus a recurring theme and seemed to have a major influence on decisions to adapt.

The motivations of decision makers in the HWTS and climate change study influenced the type of enabling environment elements as well as the degree to which these enabling environment elements influenced decisions.

2.2. Understanding the Difference in the Degree of Influence of the Enabling Environment Elements on HWTS and Climate Change Studies

In the climate change adaptation study, in which formal rules dominated, the government is a critical actor in bringing about effective adaptation of drinking-water systems. This study looked primarily at piped water systems and as a result, the water utilities were partially government funded and/or under government regulations. This is one reason why formal rules were prevalent and the role of governments was reiterated. Additionally, these utilities are formal organizations, specifically utilitarian organizations, bound by both internal and external policies. Utilitarian organizations are organizations with groups of individuals that receive compensation for work carried out. Although, individual cultures and values exist within these organizations, the individuals are bound by policies that dictate what they can do and how they should do it because they are compensated for their activities (Barkan, 2013). These drinking-water systems also provide water to hundreds, sometimes tens of thousands, of people and the health of these people with regard to drinking-water safety is dependent on the capacities of the organizations that manage the drinking-water systems. Because of this, the organizations are bound by rules on how to act to ensure that public health is safe (e.g. public service commission rule for the government of water utilities 150CSR7, West Virginia, U.S.A.) and these rules are put in place by both the organizations and governmental or government mandated organizations that can oversee organization actions and demand changes, if necessary.

This is considerably different from the HWTS context. The decision to adopt HWTS practices is made by one individual or one household and the rules that guide the decision-making of this individual/household regarding the choice to treat the drinking-water are not written contracts. These rules are unwritten but can be just as binding as the rules that guide the formal organizations that make decisions about adapting drinking-water systems to climate change. Nichter (1985) found that in Sri Lanka, there is a cultural belief about water temperatures that determine how people treat their water. For example, cold water from a deep well is not given to people suffering from a cold and hot water, from being exposed to the sun, is not given to people suffering from heating illnesses such as a fever. If cold water is the only available option, the water will be boiled but then cooled slightly, to tepid, with cool water before giving it to an ill person. This is done to reduce the shock effect of the cold water as this is believed to compound illness.

The impacts of the decision to treat drinking-water using HWTS products and technologies is generally limited to that individual/household. These are personal decisions that do not affect the general population and so even though governments give recommendations about improving the safety of drinking-water, they do not demand it.

3. Organization Response to "Unfavorable" Enabling Environments

Although the enabling environment influences drinking-water programs, this impact is sometimes detrimental. Responses from the interviews revealed two main reactions to a detrimental enabling environment—change the environment and change program characteristics to benefit from or cope with the existing environment. The degree to which these choices work is dependent on the type of enabling environment in place and the resources needed to modify the environment or the program.

3.1. Changing the Environment

The benefit of changing the environment, particularly unfavorable policies, over changing the program characteristics is that the change in the environment can bring about a more lasting change in how programs are carried out. Additionally, this may be beneficial for future investments as well as sustainability of current and past ones. For example, advocating for policies that promote collaboration among different stakeholders can, in time, create a collaborative and trusting environment in which sharing lessons and resources is more easily accomplished. This environment will be beneficial for a greater number of organizations and more programs carried out in the community than for that one program in which collaboration was beneficial. The lasting and wide-reaching influence of changing the environment can be seen in the Massachusetts case in which 35 towns formed a partnership to assist with resource savings and to share lessons. As a result of creating this collaborative environment, more towns have joined, growing the group, and some of the initial towns have left this group to form similar but smaller ones. In the climate change study, respondents noted that efforts are being made to change the enabling environment by increasing awareness of government officials to climate change and its impacts on water systems which will subsequently produce favorable policies that increase funding for climate change and bring about the incorporation of climate change into sectoral policies.

3.2. Changing Program Characteristics

Changing program characteristics was highlighted more frequently in the HWTS study than in the climate change adaptation study. The choice to change program characteristics is generally determined by the ease with which the environment can be modified to accommodate the program plans. According to a respondent in the HWTS study, there was a program in place to promote and sell black steel filters in a community. The color of the filters was chosen based on a general organizational belief that black is fashionable and will, therefore, be accepted in the community. The finding of the organization was that the filters were not acceptable in the community because they were black and contrary to the organization's belief that black is fashionable, the community viewed the color as denoting evil. The respondent noted that based on this field trial, the color of the filters were changed to a more culturally acceptable color and this spurred acceptance of the filters. This change was carried out before full implementation because the introduction of the filters to the community was done during a field trial. As such, the resources needed to make the change were not extensive. Changing program characteristics can also occur when the formal rules are unfavorable or when the physical environment is not amenable to the program plans. For example, in Bangladesh, switching wells from those contaminated with arsenic to those proven safe for drinking has been encouraged since arsenic contamination and the consequences of consuming arsenic contaminated water became known (van Green et al., 2002; Caldwell et al., 2006). In addition to switching wells, switching to other sources, when available is also encouraged. These are examples of when changing the environment is either impossible or difficult and changing the program instead is more feasible and cost-effective. Flanagan et al. (2012) note that technologies for removing arsenic would cost approximately four times more than delivering safe water from other sources over the span of 20 years.

4. Evidence for Impact on Drinking-Water Programs from Changing the Enabling Environment

From the qualitative and quantitative studies, enabling environment elements were identified that both positive and negative impacts on drinking-water programs. To strengthen these findings, information on the impact of modifying the enabling environment, when possible, is needed. This will reinforce the importance of the enabling environment and show that enhancing the enabling environment, when it is detrimental or when it is neutral, is a valid way to improve the success of drinking-water programs.

From the HWTS study, it was noted that creating an environment of collaboration between implementing organizations and health clinics, particularly in the promotion of maternal and child health, was beneficial to increasing use of HWTS products. In collaboration with UNICEF, CDC and PSI, the government of Malawi's Ministry of Health piloted a hygiene promotion program targeting mothers that attend ante-natal care (ANC) clinics. The initiative focused on key hygiene improvement interventions including treatment and safe storage of water at the household level and bottles of WaterGuard™ along with a water storage bucket were distributed to pregnant women. An increase in the number of women who had heard about WaterGuard, treated their water correctly with WaterGuard, and stored their drinking water correctly was observed a year later during follow-up (p-value <0.0001) (Sheth et al., 2010). A second follow-up survey conducted three years after the baseline survey, showed that WaterGuard use and purchase, as well as confirmed residual chlorine rates were significantly higher than during the baseline survey period (Sheth et al., 2010).

In the climate change studies, respondents noted that change in policies had improved collaboration and increased funding. One respondent noted that the development of a cross-sectoral steering committee on climate change improved communication between the different sectors and lessons were learned. Government officials became aware of the impact climate change had on the areas they were dealing with as well as on other areas. In addition, the link between different sectors were clarified during intersectoral meetings and the justification for collaboration was strengthened. Another respondent noted that with a new policy change, district governments were able to apply for funding for climate change related activities and this helped reduce some of the burden on the district governments. Prior to the policy, there were no clear means for the district governments to apply for funding and so this new policy simplified the process.

The importance of enhancing the enabling environment has also been documented in publications, although not many empirical studies of these in the drinking-water field. In Thailand, for example, sanitation was first put into policy in 1961 and since then coverage in the country has grown rapidly. This program increased access to sanitation in rural areas from 20% in 1970 to 98% in 1996 (PMNCH, 2013).By the late 1990s, there was almost universal coverage of sanitation in rural areas and this achievement has been attributed to the government's will and clear policies put in place for sanitation (Luong et al. 2002). The Government of Thailand invested in the national Rural Environmental Sanitation (RES) program which included the following key elements: inter-ministerial and cross-sector collaboration between the ministries at the central levels and municipal authorities at decentralized level; support of the Ministry of the Interior in establishing building regulations that ensure houses have sanitation facilities; and mobilization of resources from multiple government agencies (PMNCH, 2013). This program laid out a clear institutional framework and clear leadership for policy implementation. The program was implemented through the Ministry of Public Health (WaterAid and SHARE, 2013).

Change in the enabling environment does not always have the desired effect, however, as is evidenced by the PPP case in Indonesia. The failure of the new policy to encourage PPPs was attributed to different goals shared by those affected by the PPPs. In this case the way in which the enabling environment was changed was not effective and the new environment was no more effective than the previous enabling environment. These examples show that changing the enabling environment can have positive impacts but careful consideration needs to be taken into how to change the enabling environment.

5. Recommendations for Drinking-water Programing

Based on the comprehensive analyses of determinants of drinking-water program successes using qualitative and quantitative analyses, the following recommendations are made for drinking-water programming in light of the SDG target to achieve universal access to safe drinking-water. The recommendations are not listed in order of relevance.

1. National and state governments should be central to improving access to safe drinking-water: Formal rules were found to impact decision-making about drinking-water programs in all three studies conducted. Because formal rules guide the actions of organizations that aim to increase access to drinking-water and these rules are developed and enforced by governments, as efforts to achieve SDG target 6.1, governments should be considered when programs are being carried out. Partnerships with government agencies, when possible, will facilitate the progress of programs and government agencies can be helpful in removing barriers that may occur during program implementation.
2. Develop technologies that are compatible with cultures: As efforts are being made to increase access to safe drinking-water, it is imperative that systems being put in place are compatible with the culture of the target communities. An example of this can be seen in the Thailand case in which access to sanitation increased substantially over a 30 year period due to both government involvement and building sanitation systems that were culturally specific

to the Thai people. By promoting culturally acceptable systems, people are more likely to use and maintain the systems which would improve sustainability of the systems.

3. Integrate climate change adaptation into policies and water supply programs: As efforts are being made to increase access to safe drinking-water, utilities and other water service providers will be well served to incorporate climate change into the construction of new systems. This maximizes the likelihood that when climate change related hazards occur, the systems are resilient enough to cope with the disasters. Incorporation of climate change into plans may be as simple as elevating boreholes on platforms to avoid flooding. By incorporating climate change into new systems, future retro-fitting of systems to cope with climate-change related hazards will be minimal; as a result, retrofitting costs can be reduced.
4. Get to know decision makers and users: The analysis of HWTS programming and climate change adaptation programming highlighted the importance of knowing the decisions makers, understanding their values, and identifying the rules to which they are bound. When the primary decision makers, about adopting a particular practice, are individuals informal rules play a larger role in influencing people's decisions; however, when the decision makers are organizations, they are bound by both organizational policies and national policies. Understanding the decision-makers, their values, and their rules will aid in effective collaboration and implementation of programs.
5. Promote collaboration across state levels and among different actors: Partnerships were a recurring theme across all studies conducted and were identified as being vital to the success of drinking-water programs. The partnerships identified were partnerships across different sectors, among different actors, and across different state levels. Water resources are used by a variety of sectors so effective management of these resources will require communication among the relevant sectors. Additionally, there are lessons to be learned from actors that

have experience with specific drinking-water programs. For example, the private sector has had some success with promoting HWTS products in certain regions, primarily through market analysis and providing target individuals with different choices of HWTS products (PATH, 2012).

6. Document intervention and evaluation plans, successes, and failures: Sharing lessons learned can improve future programming efforts to increase access to safe drinking-water. There is limited empirical research on what factors influence drinking-water programs and how these factors influence programs. Many reports assert the importance of a number of enabling environment factors but few confirm the significance of these factors either through qualitative or quantitative research. There is need for better systematic assessment of intervention programming and documentation of these assessments.

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CHAPTER 7: CONCLUSION

The enabling environment for drinking-water programs had not been systematically defined prior to this study and the importance of this environment for drinking-water programs is poorly documented. This is the first attempt to provide a systematically developed definition of the enabling environment for drinking-water programs and to assess if and how the enabling environment impacted drinking-water programs using qualitative and quantitative evidence of multiple drinking-water programs. I found that the enabling environment is the blend of formal rules, informal rules, and physical environment that impact on the capacity of individuals and organizations to achieve their objectives. Based on the qualitative and quantitative studies carried out, I found that the enabling environment can have beneficial or detrimental impacts on drinking-water programs. For the qualitative studies, all enabling environment elements—formal rules, informal rules, and the physical environment—were found to affect scale up and sustainability of HWTS practices as well as adaptation of drinking-water systems to climate change. A quantitative analysis of the influence of formal rules and the physical environment showed that these elements influence expenditures on drinking-water systems. Based on these, it was concluded that all elements of the enabling environment impact drinking-water programs.

One recurring theme in all studies was the need for user participation and partnerships for the successful implementation of programs. User participation was the only enabling environment variable found to have a significant effect on drinking-water expenditure, regardless of setting (rural versus urban) and the year the data were collected (2009 versus 2011) which reflects lags that may occur between policy implementation and observable impacts. This finding highlights the importance of 6.b to strengthen and support local community participation in water management in achieving SDG target 6.1 of universal access to safe and affordable drinking-water by 2030. Partnerships included user participation in addition to cross sectoral partnerships, partnerships among different organizations, and partnerships among countries. These partnerships support SDG target 6.a to expand international cooperation to developing countries in water-related activities.

According to the SDGs, there is a commitment to carrying out activities in an enabling environment to ensure sustainability. Some elements of the enabling environment are mentioned in the SDG documents and are shown in this study to influence drinking-water programs. According to the UN, implementing SDG 6 (ensure water and sanitation for all), will require strong leadership, clear roles and responsibilities, and supportive policies. Evidence from the qualitative and quantitative studies show that all these have a positive impact on drinking-water programs. Additionally, the UN-Water notes that the enabling environment for achieving SDG 6 needs to include policies that facilitate the mobilization of adequate investments, an element that had a significant effect on expenditures on drinking-water systems. This study showed that the formal rules detailed in the SDG documents have positive impacts on drinking-water programs if they are implemented effectively. It also showed that although formal rules influence drinking-water programs, informal rules can have a greater influence. Based on this, it is important that as activities are being carried out to achieve SDG 6.1, informal rules, specifically cultures, social structures, and power relations, are considered alongside the formal rules.

Findings from this study show that as efforts are being made to achieve universal access to safe drinking-water, implementing organizations, governments, and other actors involved in drinking-water programs will benefit from shaping an enabling environment that facilitates access to drinking-water. This enabling environment will resemble one that is collaborative with clear roles defined for the leadership and other collaborators, accounts for and is respectful of informal rules and considers the physical environment. This kind of environment will increase shared knowledge of effective and ineffective drinking-water activities, thereby increasing the effectiveness of resource use for program planning and implementation. This environment would also promote monitoring of policies to ensure that policies are achieving the desired goals.

In the course of examining the enabling environment, I found that, although not explicitly part of the enabling environment, knowing what actors are involved in drinking-water programs is required for shaping the enabling environment because of the influence of actors on the enabling environment and in understanding the degree to which different enabling environment elements impact drinking-water programs. Formal rules are generally developed and enforced by governments, informal rules are enforced by social leaders, and the physical environment can be altered by a variety of actors. This further strengthens the need for partnerships, both formal and informal, in shaping an enabling environment.

While the ideal is to shape an enabling environment into one that is favorable, I found that this is not always possible or may require long-term commitment. In situations where shaping the enabling environment is impossible or may require long-term commitment, programs can be modified to improve compatibility with the existing environment. However, efforts to enhance enabling environment may be worthwhile due to the long-term implications of this environment on actors and future programs. As part of this study, I developed a framework for diagnosing the enabling environment for drinking-water programs as well as guide to assist implementers in determining where resources should be put to shape the enabling environment based on modifiability and essentiality of the enabling environment element. Modifiability refers to the ease with which the environment can be changed and can range from easy to impossible and essentiality refers to the degree of impact of a particular enabling environment on the achievement of program objectives and can range from trivial to necessary.

To strengthen my findings about the impact of the enabling environment on drinking-water programs to further show the consequences of shaping this environment, I assessed findings from the qualitative studies and found that changing the enabling environment from unfavorable to favorable will have positive implications for programs. This finding was supported by documented examples. However, this assessment of the impact of changing the enabling environment revealed the dearth of evidence on impacts of formal rules and informal rules on drinking-water programs. Although many studies assert the relevance of different enabling environment elements to facilitating drinking-water programs, few document how the programs are impacted by the change in the enabling environment. Based on this, there is a need to monitor the impact of policies and other elements of the enabling environment. This will aid in reducing assumptions about the type and degree of impact of certain enabling environment elements on drinking-water systems and as a result can aid in more effective use of resources in areas that actually make a difference.

APPENDIX 1: CHAPTER 3 INTERVIEW GUIDES

General interview guide used prior to field visit

a. Name: ____

b. E-mail address: __________________________________

c. Phone numbers: ___________________________________

d. Organization name:_________________________________

e. To which of the following does your organization/agency belong?

National government

State government

Local government

Non-Governmental Organization (NGO)

UN agency

Donor agency

Private sector organization

Academia/University

Advocacy Organization

Other:______________________________

f. What is your role in the organization? (e.g project management, research, monitoring and evaluation, administration, fund-raising etc.) _______________________________________

g. In which region do you primarily work? Check all that apply.

Africa

Asia

Latin America

Middle East

Small Island Developing States

Other:______________________________

h. Please name countries in which you have worked on HWTS projects.

____

_____

i. In what setting(s) was the HWTS project(s) you worked on? Check all that apply.

Rural

Urban

Peri-urban

1. Recall an HWTS intervention you considered a success, what factors evidently facilitated the success of the HWTS intervention? Consider factors that affected intervention uptake, implementation, scale up, and sustainability.

2. Recall an HWTS intervention you've worked on, what factors evidently limited and/or hindered the success of the HWTS intervention? Consider factors that affected intervention uptake, implementation, scale up, and sustainability.

INTERVIEWS CONDUCTED DURING FIELD VISITS

Interview Guide for HWTS Manufacturers

INTRODUCTIONS (~5 minutes)

- Introductions and Consent – Introduce myself and read the consent script to participant
- Let interviewee know the interview will be recorded
- Purpose of interview – talk about HWTS and the different factors that influence success of HWTS interventions
- Thank interviewee for time

INTERVIEW (~30 minutes)

Background on Manufacturer

1. How long have you worked in manufacturing? How long in manufacturing HWTS products? What percentage of your business is HWTS?
2. Are there any more manufacturers of HWTS products in the area? Who are they?
3. Are the products made here mostly used locally, elsewhere in the country or exported?
4. What types of HWTS products and/or technologies are manufactured by your business?
5. Do you sell spare parts for the technologies you sell? (Or just sell the whole product?)
6. How many products are produced in a month/year? Does production vary between seasons? If yes, to the best of your knowledge, is there a reason for this?
7. Are there standards for the products you manufacture? IF YES, do these standards impact manufacturing?

8. What are your major challenges in manufacturing HWTS products? What are your motivations for manufacturing HWTS products?

Demand

1. How many products and/or technologies are sold in a month/year?
2. Has demand increased/decreased/stayed the same in the past few years? If increased or decreased, do you know why?
3. Does demand vary between seasons? **IF YES**, to the best of your knowledge what is the reason?
4. Who are your main customers? (Pharmacists, small store owners, supermarkets, individuals, etc.?)
5. What products are sold the most? Do you know why? How much are the products sold for?
6. Do you sell on credit? What percentage of your customers buys on credit?

Product Access and Availability

1. Are the raw materials available locally?
2. **If NO**, do you get the raw materials from a middle man or do you import? If you import, how difficult is the import process (use Likert scale). **Very difficult – Difficult – Neither Easy Nor Difficult – Easy – Very Easy**
3. **IF YES (or get from a middle man)**, is it difficult to get the raw materials for manufacture? How far is the location you get the raw materials from?
4. Does importing or obtaining the raw materials ever negatively affect manufacturing? E.g. delay manufacture, for example?

CONCLUSION

Is there anything else you'll like to say about HWTS manufacturing?

Thank interviewee for their time.

Interview Guide for HWTS Implementers and Government Officials

INTRODUCTIONS (~5 minutes)

- Introductions and Consent – Introduce myself and read the consent script to participant
- Let interviewee know the interview will be recorded
- Purpose of interview – talk about HWTS and the different factors that influence success of HWTS interventions
- Thank interviewee for time

INTERVIEW QUESTIONS (30 minutes)

Intervention type

1. What HWTS product or technology are you currently promoting? If more than one, are all the products and technologies being promoted in all communities or as some products being promoted in some communities and others in other communities?
2. How long have you been promoting these products? (Possibly ask them to choose the most successfully and the least successfully implemented products).
3. Do you have any insights into why some interventions have been successful and some less so?
4. Were any of these programs carried out by integrating into other WaSH, health or education programs?
5. What are the success trends over time in different products? That is, how have different products been accepted over time?
6. Are the interventions being carried out in rural, urban, or peri-urban areas? Or in two or all three? If in more than one area, do the challenges with carrying out the interventions in different areas differ? If yes, how?

7. Do you provide users with guidance/training on how to use the products?

Demand

1. What percentage of people in the communities you work in are currently using the products?
2. Have sales increased over the years or months?
3. Does demand vary throughout the year or does it stay the same? If demand changes, what is the main reason to the best of your knowledge?
4. To the best of your knowledge, what is the primary motivation for people who choose to utilize different HWTS methods?
5. To the best of your knowledge, what is the primary deterrent for people who choose not to utilize HWTS practices?

Partnerships and policies (For Non-government implementers – policy and partnership questions for government workers follow)

1. FOR GHANA – Are you aware that the national government has a national HWTS strategy? If yes, did the government strategy influence your decision to implement HWTS? (NOTE: May not be necessary for those who have been doing HWTS for a long time.)
2. Has the development of the national HWTS strategy affected your interventions? Has it affected the interventions of others that you are aware of?
3. FOR GHANA and TANZANIA – Do you anticipate that the HWTS national strategy will affect you and other HWTS implementers in future? If yes, in what way?
4. Are you currently partnering with other NGOs? If yes, how has this influenced your intervention?

5. Are you currently partnering with the government? If yes, what does this partnership look like and how does it affect the intervention? If no, do you think partnering with the government will benefit you?

Product Access and Availability

1. Are all of the products you promote produced in the country?
2. **IF YES** – Where do you source your products? Directly from the manufacturer or from a middleman? (IF Middleman – does he/she import the products from another country?)
3. Can you please describe any challenges (or successes) in your supply chain?
4. Are replacement products and spare parts available to users of the technology? From whom? Are they available in the local market? If not, how do they obtain them?
5. **IF NO** – Do you import products from other countries?
6. Do import regulations hinder or make difficult product import? Can you please describe any challenges (or successes) in your supply chain?
7. Are replacement products and spare parts available to users of the technology? From whom? Are they available in the local market? If not, how do they obtain them?
8. When your organization completes the intervention, will there still be a clear distribution chain, i.e. will individuals still have access to products and technologies?

CONCLUSION

Thank the interview for their time.

Interview Guide for HWTS Retailers

INTRODUCTIONS (~5 minutes)

- Introductions and Consent – Introduce myself and read the consent script to participant
- Let interviewee know the interview will be recorded
- Purpose of interview – talk about HWTS and the different factors that influence success of HWTS interventions
- Thank interviewee for time

INTERVIEW (~30 minutes)

Background on Salesperson Market

1. How long have you sold HWTS technology and/or products?
2. What types of HWTS technology and/or products do you sell?
3. Can you operate the HWTS technologies and/or products you sell? Who gave you guidance on how to use them?
4. Do your buyers ever ask you for assistance on how to use the HWTS technologies and/or products? Do you provide them guidance or tell them where they can get guidance?

Demand

1. Who are your main customers? Women, Men, elderly, the rich etc. (based on gender, wealth, etc.)

2. What HWTS technology is purchased the most? Do you know why? If they don't know why – are cheaper products sold more? Or ask them to show us what products are sold most and compare prices.
3. On average, how many HWTS products do you sell a week? (maybe with regard to products like PuR)
4. On average, how many HWTS technologies do you sell a month? (maybe with regard to filters)
5. Do sales vary by season? If yes, to the best of your knowledge, what is the reason for this variation?
6. Have sales increased, decreased, or stayed the same over the past few years? If increased or decreased, do you know why?
7. Do you sell on credit? If Yes, what percentage of your customers buy on credit?

Product Access and Availability

1. Are the products and/or technology you sell produced in the community or country?
2. **IF NO**, Do you import the products and/or technologies? If yes, how difficult is the import process? How does this affect your product availability/sales?
3. How far is the manufacturer or wholesaler you buy the HWTS products from?
4. Is it difficult to get more HWTS products and/or technology when you run out?
5. Do you sell spare parts for the HWTS technologies like filters?
6. If Yes, do you get spare parts from the same place as the technologies?

CONCLUSION

Thank the interviewee for their time

APPENDIX 2: CHAPTER 4 INTERVIEW GUIDES

WATER UTILITY INTERVIEWS

Name:

Email address:

Phone number:

Organization:

Job title/Organization position:

District location: Coastal Inland Other:

Section I: Drinking water system description

1. Describe the drinking water system you manage

a. Goal of the organization in terms of drinking water safety and access

b. type in terms of piped, boreholes;

c. water sources (quantity/quality);

d. number of people served (describe consumer population)

2. Any other information about the system you'd like to share?

Section II: Coastal characteristics and policies

1. Do you know of land characteristics that help reduce

a. flood impacts? If yes, please describe.

b. Impacts from ocean waves? If yes, please describe.

2. Do you know of any man-made structures that reduce

a. flood impacts? If yes, please describe

b. High ocean waves? If yes, please describe.

c. What is their current working condition? (high performance, in need of repair?)

3. Do you know of laws/policies that protect against floods? Against high wave impacts?

a. Are there any documents available to view these policies? Please list them

4. To the best of your knowledge,

a. why were these structures built (any particular disaster cause them to be built)?

b. why were the policies developed?

Section III: Climate hazards on drinking water systems

1. To the best of your knowledge, have there been any high ocean waves (for example – caused by typhoons, storms, etc.) in the past 10 years? Please recall one to be used for the rest of the survey. If none in the past 10 years, please recall any occurrence of high ocean waves that may have occurred previously, if any.

2. Was there rainfall during the period of this disaster?

3. For this disaster:

a. Describe how the drinking water system was affected.

b. Were people able to obtain drinking water from these systems during the disaster? If no, how long before people were able to get water? What did people do to access water during this period?

4. In the past 10 years, has there been a period of heavy rainfall with no high ocean waves (storm surge)? Please recall just one rainfall occurrence. If none in the past 10 years, please recall any occurrence of heavy rainfall with no high ocean waves that may have occurred previously, if any.

a. Describe how the heavy rain affected the drinking water system.

b. Were people able to obtain drinking water from these systems during the disaster? If no, how long before people were able to get water? What did people do to access water during this period?

5. In the past 10 years, has there been a period of high ocean waves (storm surges) with no rain? Please recall just one occurrence. If none past 10 years, please recall one that may have occurred previously, if any.

a. Describe how this disaster affected the drinking water system.

b. Were people able to obtain drinking water from these systems during the disaster? If no, how long before people were able to get water? What did people do to access water during this period?

Section IV: Drinking water system adaptation

1. Describe what has been done to make the drinking water system work/perform when there are:

a. heavy rains?

b. High ocean waves?

c. Floods?

d. any other kind of disaster?

Section V: Enablers and barriers to adaptation of drinking water systems

1. For the things you described above that make your system work during and after climate disasters, what things enabled their development?

2. For the things you described above that make your system work during and after climate disasters, what challenges made their development hard?

3. Does the government play a role in making the system work during and after disasters? If yes, please describe.

4. Describe the role of other organizations/utilities and collaboration?

Section VI: Desired Adaptation mechanisms

1. What are your goals as an organization when it comes to making sure the drinking water system works during disasters?

2. Are you aware of any methods employed by other water utilities to make their systems work during disasters?

3. What are some things that can be done to further protect drinking water systems against

a. high ocean waves?

b. Against heavy rainfall?

c. Against floods?

4. What are some reasons these are not being done currently?

5. What can be done to make it possible?

Section VII: Additional information

1. Is there a way for utilities and government officials to work together to promote measures that protect the drinking water system against climate disasters?

2. Is there any additional information you would like to provide about climate effects of drinking water systems or mechanisms that can reduce negative effects?

3. How can a study like this be made practical for you?

GOVERNMENT INTERVIEWS

Name:

Email address:

Phone number:

Organization:

Job title/Organization position:

District location: Coastal Inland Other:

Section I: Historical climate data & Policies

1. Is there a record for climate disasters that have affected this community/region/country?

2. Are there any policies on climate change in the country? If yes, please describe

a. is the policy document available? If yes, please list the documents

3. Are there any policies on climate change for the water sector? If yes, please describe.

a. is the policy document available? If yes, please list the documents

4. Are there any policies on climate change for coastal areas? If yes, please describe.

a. is the policy document available? If yes, please list the documents

Section II: Coastal characteristics and policies

1. Do you know of land characteristics (e.g. mangroves, wetlands, marshes, etc.) in your region that help reduce:

a. flood impacts? If yes, please describe

b. Impacts from high ocean waves? If yes, please describe.

2. Do you know of any man-made structures (e.g. seawalls, dykes, levees, etc.) that reduce

c. flood impacts? If yes, please describe

d. High ocean waves? If yes, please describe.

c. What is their current working condition? (high performance, in need of repair?)

3. Do you know of laws/policies that protect against floods? Against high wave impacts?

d. Are there any documents available to view these policies?

4. To the best of your knowledge,

e. why were these structures built (any particular disaster cause them to be built)?

f. why were the policies developed?

Section III: Enablers and barriers to adaptation policies

1. For the climate change policies you described above, what factors helped their development?

2. For the climate change policies you described above, what challenges made their development hard?

3. Describe the role of other organizations in developing these policies

Section IV: Additional information

1. Is there a way for utilities and government officials to work together to promote measures that protect the drinking water system against climate disasters?

2. Is there any additional information you would like to provide about climate effects of drinking water systems or mechanisms that can reduce negative effects?

3. How can a study like this be made practical for you?