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Article

Improving Water Supply Systems for Domestic Uses in Urban Togo: The Case of a Suburb in Lomé

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Abstract: The rapid urbanization facing developing countries is increasing pressure on public institutions to provide adequate supplies of clean water to populations. In most developing countries, the general public is not involved in strategies and policies regarding enhancement, conservation, and management of water supply systems. To assist governments and decision makers in providing potable water to meet the increasing demand due to the rapid urbanization, this study sought to characterize existing water supply systems and obtain public opinion for identifying a community water supply system model for households in a residential neighborhood in Lomé, Togo. Existing water supply systems in the study area consist of bucket-drawn water wells, mini water tower systems, rainwater harvesting, and public piped water. Daily domestic water consumption in the study area compared well with findings on water uses per capita from Sub-Saharan Africa, but was well below daily water usage in developed nations. Based on the surveys, participants thought highly of a large scale community water tower and expressed interest in maintaining it. Even though people rely on water sources deemed convenient for drinking, they also reported limited confidence in the quality of these sources.

Keywords: community; drinking water; water supply; developing country; Africa

1. Introduction

Clean water is an essential element for human survival and wellbeing [1]. Although water is the most widely occurring substance on earth, only 2.5% is freshwater [2] with less than 1% being readily accessible for direct human uses [2]. Nearly 20% of the world's population does not have easy access to drinking water, and 40% lack proper sanitation facilities [3]. The majority of these people live in developing nations [4].

Approximately 1.1 billion people, mostly concentrated in African and Asian countries, are at risk of water related disease and death attributable to limited access to safe drinking water. According to the World Health Organization, more than 3.5 million people die each year from water-related disease, of which 84% are children [5,6]. The same organization reported that nearly 90% of all death cases associated with diarrheal diseases occur in the child population of the developing world [6].

One of the major challenges driving water stress in developing nations is rapid urbanization [3]. Approximately half of the world's 7 billion people live in urban areas. Predictions of the world's future urban population classified Asian and African countries as high urban concentration areas [7]. The increasing number of people living in urban areas is associated with increasing water demand and difficulties for many people to access adequate supply of clean water and sanitation [3].

Togo, a Sub-Saharan country on the west coast of Africa, shares the same struggles. Urban growth in Togo has significantly increased during the past 40 years such that more than 50% of the 6.8 million Togolese are urban dwellers [8]. The urban population increased from 9% in 1960 to 21% in 1970, 25% in 1981, and 50% in 2010 [7,9]. Lomé, the capital, is the largest city with more than 1.6 million inhabitants and more than 54% of the country's urban population [10,11]. The population of Lomé is expected to reach nearly 3 million people in 2020 [12]. The increasing urban population and rising living standards are direct sources of a variety of social and economic problems along with environmental concerns. While the rapid urbanization has fueled developments of new residential communities, making real estate a lucrative business, the construction of these new communities did not come with a careful and foreseeable plan to ensure access to safe drinking water for this growing urban agglomeration. Problems relating to water for consumptive use in Togo include scarcity, increasing water supply costs, difficulties to access water sources, pollution of existing sources, inadequate management of water resources, unsustainable policies and programs, and insufficient education and training. More than 60% of people in urban Togo do not have access to clean drinking water [13], indicating that the level of coverage and services for water supply for domestic uses must be addressed.

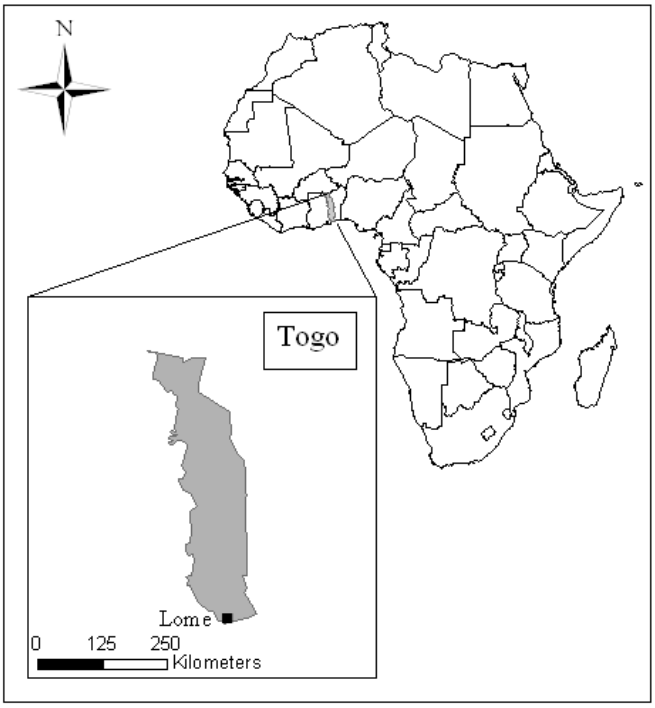
The overall goal of this study was to conduct a feasibility study for the development of community level water supply systems in urban Togo. The specific objectives were to: (1) characterize existing water supply and management systems; and (2) obtain public opinion for the feasibility of a community level water distribution system in a residential neighborhood in Lomé.

2. Background

Togo is located in West Africa and has an area of 56,785 km^2 (Figure 1). Togo is bordered by Burkina Faso to the north, Benin to the east and Ghana to the west. The southern border of Togo

embraces the Gulf of Guinea, in the Atlantic Ocean, on which Lomé is located (Figure 1). Besides being the capital, Lomé is also the principal industrial and commercial center with the main waterfront harbor which operates 24 hours. Lomé is built on the quarter system (equivalent of subdivision or neighborhood in the United States), and surrounding small towns and villages automatically become quarters as the city grows. The population of Lomé grew rapidly from 30,000 inhabitants in 1950 to 200,000 by 1970, and more than 1,000,000 in 2000 [10]. Today, more than 50% of the urban population or 25% of the entire population of Togo is concentrated in Lomé, with a rate of urbanization of 29% in 1980, 43% in 2000, and predicted to be 50% in 2020 [10]. This growing urban population comes with high water quantity and quality demands [3].

Figure 1. Location of Lomé, Togo.



3. Methods

3.1. Study Area

The study was conducted in the Yokoè Quarter, a suburb located in the northwest of the city of Lomé. This quarter, among others, was outside the city of Lomé, roughly 30 years ago. Today, the majority of surrounding towns and cities become integral parts of the Greater Lomé Metropolitan due to the rapid urbanization recorded in the country for the past few decades. At the time of the study, Yokoè includes approximately 400 family homes and rental complexes with nearly 2,000 inhabitants. These numbers are expected to increase with the increase of vast construction activities taking place in the area. Typical household sizes vary between 1 and 30 residents. The large households are agglomerations of multiple small size families (parents and children), generally from the same ancestry, living in the same compound. They were regarded as one household as they share common water sources and latrines. These households are certainly the remainder of the village structure before

the community became a suburb. The majority of residents in Yokoè are working class people with an average annual income based on the standard of the country. Like the remainder of the country, readily available clean water for domestic uses is a concern for most residents of the Yokoè quarter, forcing them to rely on any water supply sources deemed convenient.

3.2. Survey

Quantifying public opinion through surveys requires a complete randomization so that each individual in the population has an equal opportunity of been selected. This sampling method is feasible and appropriate in contexts where advances in communication such as telephone, mail, and internet become an integral part of daily living. A completely random sampling is not possible at the community level in Togo due to the organization of communities and available resources for this study. Therefore, convenience sampling, a nonprobability sampling technique, was used to select the households [14]. Public opinions and attitudes have been previously assessed in Sub-Saharan Africa with similar techniques [15,16]. The choice of the convenience sampling in this study was driven by the availability of participants and our safety. To achieve random samples in the context of the convenience survey, we used personal judgment to select households that are spatially distributed to cover the entire study area, and maximize the chances to capture diverse responses on the subject matter during the survey while being respectful to the local cultural context. This study used an explanatory approach to identify in an inexpensive manner what water supply system people want or wish to have through responses given by the participants, not how many people in the community want a particular water supply system. The aim of this study was not to describe the extent to which the entire population in the community is represented.

To obtain inputs from the residents of Yokoè regarding the most feasible community level water supply system, a survey was conducted in the community in July 2011. The survey was a one-time face-to-face interview [17], in which participants were asked a series of questions. These questions were asked in common visit setting and participants answered the questions with friends and relatives surrounding them. All survey questions were straightforward to ensure that respondents could comprehend and readily respond [18,19]. Forty households were selected as randomly as possible for the survey. Previous studies reported that a sample of 30 or 40 people is an acceptable number to gain valuable insights about patterns of tendency in a given population [15,20,21] using a questionnaire in the form of statements [15,20,22] or direct questions [15,16,22,23]. Prior the survey, a public announcement was made by the chief of the Yokoè Quarter in the community and at local churches to inform residents and ensure their consent and voluntary participation in the survey. This is a common practice in the country, especially in small communities such as Yokoè. The survey was designed in collaboration with the community development association of Yokoè (Association du Quartier Aflao Adidogomé-Yokoè), a community organization created in 2009 for the development of Yokoè. The association established contact and completed preliminary and necessary protocols with officials and residents of Yokoè for the study.

During the survey, residents between 0 and 17 years old were considered minors, and residents 18+ of age were considered adults. Adult men and women, having varying age and professional occupations, were interviewed. The sample consisted of clothing designers, small business owners, students,

construction workers, hairdressers, pastors, teachers, medical assistants, office clerks, welders, seamstresses, nurses, carpenters, electricians, entrepreneurs, photographers, soldiers, herbalists, taxi drivers, and gardeners. At the beginning of each interview, the subject matter was first explained to ensure that participants understood the purpose of the study and to maximize objectivity of the responses. Preliminary questions were also asked to participants to help estimate the average daily water usage per person in the community and allow comparison of domestic water usage in other locations of the world. The survey consisted of two parts. Part 1 of the survey consisted of 14 statements that encouraged residents to express their opinion using a scale from 1 to 5, where 1 through 5 indicated "Strongly Disagree", "Disagree", "Neutral", "Agree", and "Strongly Agree" respectively (Table 1). The second part required residents to rank 6 proposed water supply system models from the most to the least preferred and feasible for the community. The first two models with highest ranking scores in the first position were considered the most preferred and feasible for the community (Table 2). These activities allowed residents to provide their inputs for the feasibility of a community water distribution system.

Table 1. Survey Questions Asked to Each Participant within the Yokoè Quarter.

No.	Statement
Q1	I have to travel to get the majority of my water
Q2	The majority of water I use comes from a Poly Tank
Q3	I trust the quality of the water that I use
Q4	I am willing to treat my water
Q5	I define all sources of water as clean and safe drinking water
Q6	I am aware of the role of community based organizations in water quality
Q7	I am aware of the health problems that accompany poor water quality
Q8	Disposing of food and other waste into the street has no affect on water
Q9	Having a clean environment is important to me
Q10	I think that information and awareness campaigns can positively change behavior
Q11	Selling water is a good idea
Q12	I think that water is fairly priced
Q13	Fronting your own money and pooling it together through: a. A Community fundraising event b. A Community farm with profit c. Applying for a grant
Q14	I would be willing to help maintain a water system

Table 2. Proposed Models for Water Supply Systems for the Yokoè Quarter.

ID	Model	Description
EWS	Protected and Monitored Existing Water Sources	This model requires a collective effort to protect, monitor, maintain, and improve existing community and private water supply systems. Examples include fencing off community water wells, covering them, and testing water quality regularly in these sources.
RH	Rainwater Harvesting with Household Cistern Systems	Centralized cistern systems are encouraged within or among two to three houses for rainwater collection in exchange of a small contribution fee. Water quality testing is to be conducted regularly to assure the quality of the water.

Table 2. *Cont.*

ID	Model	Description
WK	Water Kiosks	Simple small stores/stations will be strategically installed at access points for the distribution of potable water to paying customers using currently available water sources.
CWS	Expansion of Existing Community Water Supply Systems	A bucket-pulley system will be added to an existing community water pump or a water pump and a pulley system will be added to existing community water well. Water quality testing is to be conducted regularly to assure the quality of the water.
WDS	Water Delivery Service	Small business groups will run a system to fetch and distribute potable water from existing sources to paying customers.
MWT	Community Water Tower	A large and centralized elevated drinking water storage container will be constructed to hold water, withdrawn from the ground, at a height sufficient to pressurize a water distribution system. The water will be piped and distributed to individual households. The system operates as a running water system in developed nations, and residents of the community are responsible for a one time fees covering the installation of the piping system to their individual houses from a main pipe. They are also responsible for small contributions for maintenance of the system and water quality testing.

4. Results and Discussion

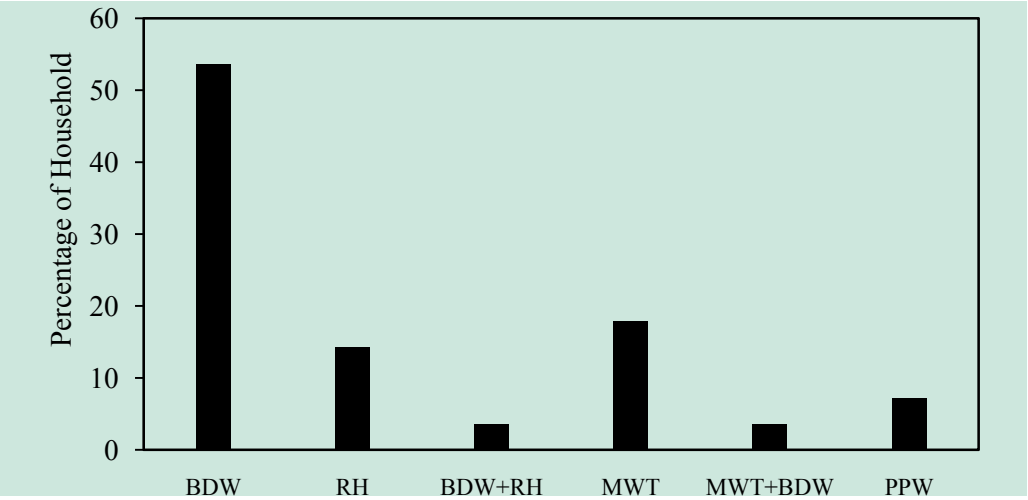
4.1. Characterization of Existing Water Supply Systems

The most common water supply systems in the Yokoè Quarter consist of bucket-drawn water wells (BDW), mini water tower systems (MWT), rainwater harvesting (RH), and public piped water (PPW) (Figure 2). Beside two community BDWs constructed at strategic areas accessible to the members of the community, the remaining BDWs are privately owned and located on private properties. More than 50% of the households surveyed rely on BDWs for their daily water needs (Figure 2). The BDW system is the most widely used water supply option in Yokoè because it is relatively inexpensive and requires very low maintenance.

Another water supply system in vogue in the community is the MWT system referred to as Poly Tank in the area. With 18% of the respondents identified as daily users of Poly Tank, the MWT is the second most widely used water supply system in the community (Figure 2). The system is relatively expensive for an average resident but seems to be the most appreciated as all water selling businesses in the Yokoè Quarter are Poly Tank systems. The MWT is a small elevated water storage unit to pressurize and pipe the water through the house with an electronic pump. A large scale unit can provide water to the entire community as proposed above in Model 6.

Rain water harvesting is also a common practice for the residents in Yokoè, and 14% of the households surveyed depend exclusively on this practice (Figure 2). The RH allows savings of money, energy and time that would be used to fetch water from close and distant places. This practice is a very old approach used worldwide to capture rain water for reuse.

Figure 2. Existing Water Supply Systems in the Yokoè Quarter.



Very few of the respondents (7%) use the PPW from the national water utility. The rapid urbanization has put intensive pressure on public institutions which were not able to plan sound water management and service for providing adequate supply of clean water to residents in these new suburbs like the Yokoè Quarter. Eight percent of the respondents rely equally on the combination of BDW and RH, and MWT and BDW for their daily water usage (Figure 2). The majority of the residents in the community using the MWT purchase water from a few other residents who owned the system.

4.2. A Community-Based Model for Household Water Supply System

The results from the surveys were grouped and discussed by question type: factual questions on daily domestic water usage (preliminary questions); access to water source (Q1,2); water quality concerns (Q3–10); water price and maintenance of water sources (Q11–14); and proposed water supply system models. The daily water usage per capita was estimated based on metal water buckets and barrels commonly utilized in the community to fetch and store water. A bucket is approximately equivalent to 19 L and a barrel is roughly 117 L. Based on the number of buckets or barrels provided by survey participants for their daily water uses, the average daily water consumption per capita was nearly 32 L in the study area. This water consumption compares well with findings on daily water usage from Sub-Saharan Africa, but was well below water consumption in developed nations such as European countries and the United States. For example, Kärkkäinen [24] reported 18 L for daily water usage per capita in Benin in 1995, 48 L in Cameroon, 20 L in Burkina Faso, 34 L in Ghana, 34.7 L in West Africa, and 148 L for the world as a whole. The large amount of water usage in developed nations could be explained by the readily available and easy access of water, as well as habits and technologies that require large amounts of water such as toilet flushing and personal hygiene habits.

In developing nations, water is not readily available. Thus, it is often treated with care. Survey results pertaining to access to water source indicated that almost half of the respondents (48%) must travel to get their daily water. While the MWT system was appreciated and widely used currently for drinking in the community as suggested by Q2 (The majority of water I use comes from a Poly Tank) of the survey (65%), the quality of this water source did not gain the confidence of the respondents.

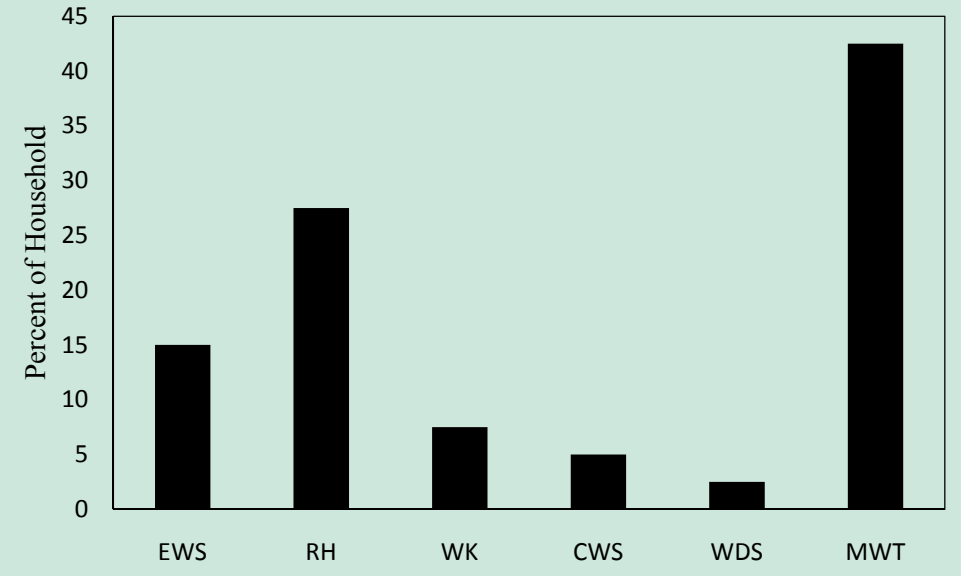
Questions regarding water quality (Q3–10) showed that people were aware that their water may need to be treated and were willing to do so to minimize health impacts and waterborne diseases. They were also aware of the causes and effects of poor water quality; however, the majority of the community usually has no choice but to use the water source they own or the one easily accessible or deemed convenient. This is because they either cannot afford a better household system, or a better household water system does not readily exist. The effects of rapid urbanization in Lomé and the lack of public policy and systems to meet the increasing water demands were frequently expressed during the course of the survey. Participants expressed widespread concern about the inefficiency and lack of national strategies to promote equitable and adequate access to clean water through community water quality and distribution systems in newly developed suburbs.

Although 65% thought that water should be merchandised, 45% did not agree with the selling price, pointing to evidence that water should be saved and conserved as expressed in Q9 (Having a clean environment is important to me) of the survey. Maintenance of water source questions (Q13–14) suggested that respondents were willing to fund, maintain, and pay for a community level water supply system. This is supported by the choice of the two most feasible proposed water supply models which are the CWT and RH (Figure 3).

The CWT, or the large scale Poly Tank system, was the favorite of the respondents. This model to meter and pipe water to households was the most preferred by the community. With the rapid urbanization and transfer of new technologies from developed nations, the choice of this water supply model was more likely motivated by the growing interest to incorporate modern technologies into living standards such as modern toilets and modern bathrooms. It should be recalled that 48% of the respondents have to travel to get their daily water. The system also allows easy access, minimizing the time to travel, and reducing the water transportation task if the water would be fetched from elsewhere to the house. The selection of the RH system as a second most feasible model was more likely directed by the convenience of the system. Not only is RH an old practice in the community, but also it is relatively inexpensive, if not free, and allows saving time and energy that would be used for fetching water. In addition, this practice is already ingrained in people's habits. The only drawback of this system is that water would not be available at all time as water replenishment in the system is controlled by rainfall, while the CWT would provide water permanently during both rainy and dry seasons. Based on the surveys, the CWT appeared to be the community water distribution infrastructure that best fit the needs of the community.

It should be noted that socially desirable responses of willingness to pay may not translate into actual willingness to pay because people who are willing to pay may not have the means to pay. In addition, the amount of payments can mean different things to different people depending on their income. The responses given by participants may also be influenced by the presence of relatives and friends as participants answered the survey questions in front of these family members. With the convenience sampling, the population was assumed to be homogeneous; suggesting that survey results may be extrapolated to the entire population [14]. Results from this study should be used with caution as the study allows us to demonstrate preferences in water supply systems for the community. Further investigation is recommended to determine the proportion of the general community who want the selected systems.

Figure 3. Community-Based Water Supply Systems Selected by Preference During the Surveys in the Yokoè Quarter.



5. Implications for Achieving Sustainability

Access to safe drinking water can make a difference in the lives of communities by reducing rates of morbidity and disability caused by waterborne diseases. Water is a vital resource for human survival, the most basic element of any form of life [1]. With a reliable water source, the amount of time and energy involved in fetching water for daily household uses can be reduced and thus invested in other activities. The benefits of water availability combined with reduction of disease burdens will improve public health, productivity, quality of life, and many other areas, leading to a positive impact on personal economic growth and prosperity.

The success of this project relied heavily on the integrated collaboration with local partners and community leaders. Montgomery and Elimelech [25] reported that collaboration provides an avenue for understanding local community needs and learning from local ingenuities to develop projects that can be managed and sustained by locals. Projects are more effective and sustainable when they engage communities in solving their own problems using local resources and technologies. During the course of the present project, feedbacks received from the local community association leaders were extremely helpful in developing a working plan and piloting the survey questions.

This project provides preliminary information to help derive a strategic plan and a working model for developing and implementing community level water supply systems. Water systems that will be owned and operated by communities with low-cost maintenance and affordable technologies to enable the treatment, distribution, and storage of clean and safe drinking water, will empower people and serve as the foundation of small businesses for income generation. At this time of globalization, it is important to focus of long-term capacity building of local inhabitants and start engaging these local ingenuities and resources to solve local problems [26]. By doing so, this will encourage wider behavioral change in individuals, institutions, governments and societies for potable water distribution in developing countries.

6. Conclusions

A feasibility study through one-time face-to-face interviews to characterize existing water supply systems and obtain public opinion for identifying a model of community-level water supply systems was conducted in a suburb of Lomé, the capital city of Togo. This study reveals that the most common water supply systems are bucket-drawn water wells. Other water supply systems include mini water tower systems, rainwater harvesting and public piped water. The survey indicates also that people are aware of the causes and effects of poor water quality. Although residents in the study area were not completely convinced about the quality of the water sources that they are currently using, they have no other choice as these water sources are what they own or deemed convenient to access. Survey participants also expressed a desire to fund, maintain, and pay for a community level metered and piped water distribution system for households. They thought highly of the model of the community water tower which is referred to as Poly Tank in the community, and expressed interest in maintaining it. This particular model was recommended as the best community water distribution infrastructure for the Yokoè Quarter. It is hoped that the results of this study will help build the foundation for more research and the implementation of such water supply systems through similar projects in similar communities around the world.

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