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Finding appropriate solution to Sub-Saharan water problem: A case for lifecycle sustainability design and management of water infrastructure

Israel Dunmade *

Mount Royal University, Calgary, Canada

Abstract

Billions of dollars have been invested over the years towards the provision of potable water in Sub-Saharan Africa. However, despite the huge investment in water infrastructure, only about 50% of the populace have access to potable water in the continent. This study examined the state of water infrastructure and issues affecting water supply in Sub-Saharan Africa. The study then researched how the identified water supply issues can be addressed in a sustainable manner. It was discovered that addressing the problem from lifecycle sustainability point of view is one of the best approaches to solving water problems in the sub-Sahara Africa. In this article, we presented issues affecting water accessibility in Africa and how the use of lifecycle sustainability concept in the design, development and management of African water infrastructure would go a long way in finding an enduring solution to the lingering water supply problem. Lifecycle sustainability approach to solving water problems would provide the platform for case-by-case examination of all water issues from multi-stakeholders perspectives and thereby provide opportunities for arriving at satisfying solution(s) that are acceptable to all stakeholders. Doing so is would result in sustainable water supply in Africa, put an end to several years of economic wastes, reduce ecological footprints associated with water supply, improve public health and lead to an overall improved standard of living.

Keywords: Lifecycle, Water, Infrastructure, Sub-Saharan Africa, Sustainability

* Corresponding author. *E-mail address:* Israel_dunmade@yahoo.ca, idunmade@mtroyal.ca

1. Introduction

Access to adequate water is one of the basic needs that significantly affect socio-economic development and quality of life (Frohlich, 2001; Hanjra, et al., 2009; IFC, 2012; Ishaku et al., 2011). Figure 1 illustrates the importance of water to our lives. Water is a medium for various processes. Water provides nourishment for animals and plants. It serves as a mode of transport and energy is generated from water. It contributes to economic growth and provides a platform for improved living conditions. In fact is life. Despite the enormity of the importance of water to life, adequate water supply is still among the major problems in Sub-Saharan African countries (Akinwale, 2010; AWDROP, 2014; Bademosi, 2013; Banerjee and Morella, 2011; Gbeneol, 2014; Ishaku et al., 2011; Maino, 2015;Marks et al., 2014; Mwangi, 2009; Ndeokwelu, 2013; Ochela, 2014; Okparaocha, 2014; Water.org, 2015). Many people are going through excruciating hardship of finding potable water for their daily needs. Many people have to trek miles and spend hours to fetch water. Significant percentage of Sub-Saharan African population is suffering from waterborne diseases such as cholera due to consumption of unsafe water from unwholesome sources (IFC, 2012; Schaetti et al., 2013; Skinner, 2009). There is acute shortage of water supply in Africa. “Only 58 percent of people have access to safe drinking water and these levels are actually declining in many cities” (World Bank, 2014a, b).

Figure 1. An Illustration on the Importance of Water

The difficulty in obtaining potable water as well as infections from waterborne diseases are causing significant reduction in the overall productivity and public health of people living in developing sub-Saharan Africa, especially people living in the rural area. A high burden of disease and mortality, combined with loss of work time due to poor water and sanitation are taking both a human and economic toll on the development of affected countries. Efforts have been made and efforts are being made to address these problems (IFC, 2012; Marrie-Nelly, 2014; NAN, 2014). International organizations, governments at all levels, corporate organizations and Non-governmental agencies all over the world have been investing in projects and in water infrastructure such as boreholes and big water projects over a number of decades with the aim of eliminating water supply problems and associated health issues. An example of collaborations of international agencies with local organizations aimed at addressing African water problems is Cooperation in International Waters in Africa (CIWA). The multi-donor trust fund established in 2011 is a partnership of the World Bank with governments of Denmark, Norway, Sweden, the Netherlands, and the United Kingdom that supports ECOWAS, East Africa Community (EAC) among other African implementation partners. Other similar collaborations include the Infrastructure Consortium for Africa Water Platform (ICA's WP) and the African Water Facility (AWF). The focus of ICA's WP involve all aspects of water infrastructure development right from water provision for consumption, sanitation and irrigation to water resource management and climate change. The African Water Facility, an initiative of the African Ministers Council on Water managed by the African Development Bank is another effort aimed at meeting water needs (AWF, 2010). United States Agency for International Development and a number of others have also been involved in a number of water projects in Africa. One may then ask: what have being the outcomes of these efforts and initiatives involving several millions, if not billions, of dollars investments in water projects? In a nutshell, the initiatives have yielded a mix of successes and failures. In other words, they are yet to yield the desired positive outcomes (Fall et al., 2009a, b; Glaand Fugelsnes, 2010; Kelly, 2009; Mutamba, 2014; Powell, 2013; Rutten, 2014; UN Water Africa, 2015). Water supply in many African cities and sub-urban centres is still characterized by low levels of access. Water supply services, where they exist, are still unreliable and of low quality. This trend is expected to continue unless something drastic is done to abate it. There is a need to identify reasons for the mixed results and to determine appropriate steps necessary to address the problems.

Scholars and technocrats have advanced several reasons for these outcomes. Access to safe water and poverty alleviation can only be realized if water supplies are sustained. Sustainable water supplies cannot be attained without the sustainability of the facilities that are used in treating and supplying the water. To buttress the point that sustainable infrastructure is necessary for effective water service delivery, Marks et al. (2014) stated that "low access to improved water supplies in Africa can be attributed in part to poor sustainability of water infrastructure." Water infrastructure in Africa is not sustainable because of management problems, operation and pricing issues, and failure to recover costs. Many water supply systems have extensive deterioration and operate far below installation capacities. The deterioration and poor capacity utilization has been attributed to broken down equipment, and lack of power or fuel for pumping. The ballooning operating cost of many African water agencies were caused by erratic power supply that necessitated the need to rely on diesel generators or even having to build their own power plants. Another reason for high operating cost is poor equipment and pipe network maintenance that causes intermittent supply and high levels of non-revenue water. Other problems include dependence on high cost imported equipment and financial constraints that make water agencies defer maintenance and limit new investment (Esposto, 2009; World Bank, 2000; World Bank, 2014a, b). Furthermore, water agencies are finding it difficult to meet the financial needs for maintaining, extending and upgrading new and ageing water systems in the face of growing water scarcity, and stricter regulatory requirements (Cashman and

Ashley, 2008). Many of the African water infrastructure are centralized "giant" supply-based system. Supply driven based approach to water infrastructure design and development has been faulted as one of the main causes of premature failure of water infrastructure in Africa (Therkildsen, 1988). Many of these water projects suffered from poor planning, inadequate funding, carelessness and adoption of inadequate technology which failed to meet the local needs and didn't fit into the local culture (Cranes and Jones, 2014; Ishaku et al., 2011; Kelly, 2009; Marks et al., 2014; Perkins, 2008). This has been due to lack of consultation with local people that would use the facility. A number of governments and donors prioritize rapid construction and expert advice over community engagement and users' input. The dependence on foreign experts without consultation with the users has led to bad construction, unaffordable operating cost, poor maintenance, epileptic and poor quality of water supply, abandonment and socio-political issues. As a result, over 50,000 water supply points non-functioning because 20% - 70% of sub-Saharan handpumpsnot working. Similarly, there are several other "white elephant" abandoned big water projects all over Africa (Kelly, 2009; Keener et al., 2010; Lewis, 2014; Sutton, 2005; Torres, 2014).Figure 2 and Table 1 reveal the enormity of the problem in a number of Sub-Saharan African countries. Abandonment of these equipment pose significant environmental risks and makes the water facilities to have high ecological footprint (Figure 3).

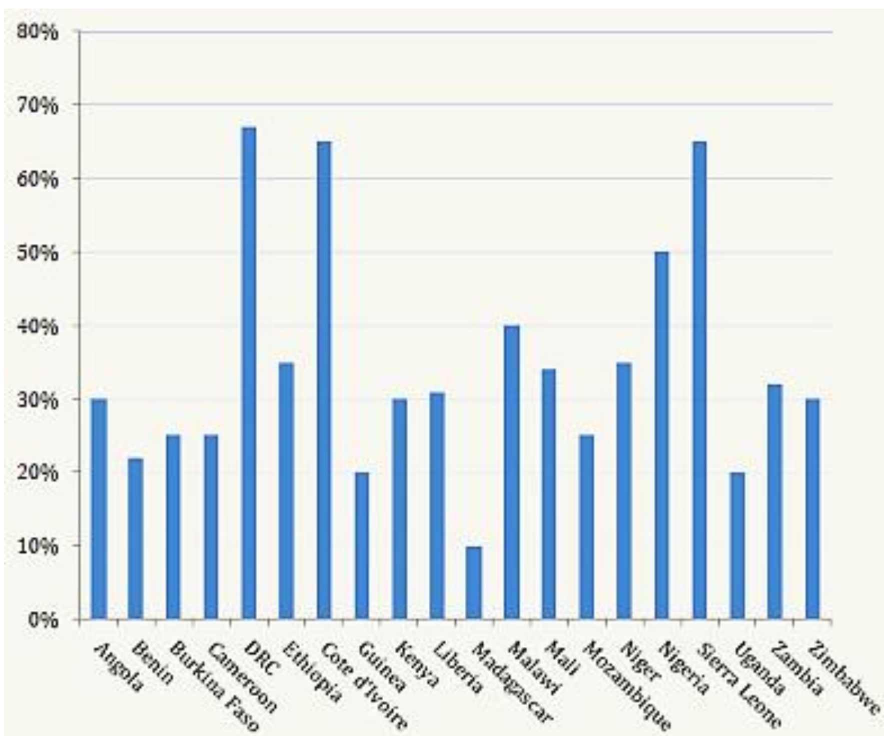

Figure 2. Percentage of Non Functioning Hand pumps in Sub-Saharan Africa
(Source: https://improveinternational.wordpress.com/handy-resources/sad-stats/)

Table 1. Statistics of water Failures in 3 DR Congo Provinces
(Source: https://improveinternational.wordpress.com/handy-resources/sad-stats/)

Percentages/Number	**Province Bas Congo**	**Province Equateur**	**Province Kinshasa**
Water Points	295	480	1276
Non-functional or partially functional protected water points	68%	14%	24%
Non-functional or partially functional boreholes	100%	52%	33%
Potability of protected water points	39%	NA	32%
Protected water points without management system	41%	22%	10%
Protected water points without a water payment mechanism	66%	28%	35%

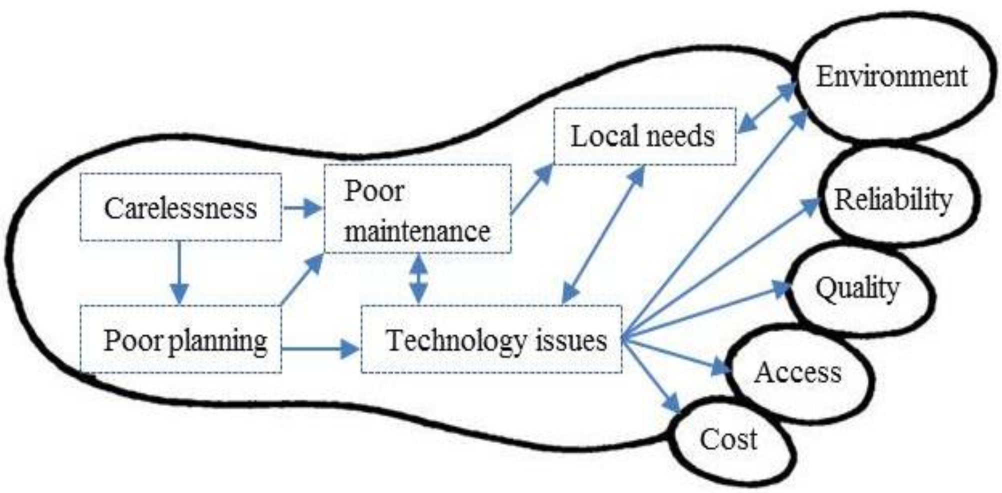

Figure 3. An illustration of interconnected issues affecting Sub-Saharan African water supply

As disappointing and as grim as the situation is, it calls for a renewed vigour in finding a long lasting solution to the seemingly insurmountable water problems in Africa (Estache, 2005, 2006; Ezekwesili, 200). An in-depth study and reminiscence on African water supply problems and how to solve the excruciating water hardship in a sustainable manner undertaken in this study pointed to the need for a different and more pragmatic approach. According to Frohlich (2000), “the number of people around the world who still do not have access to basic water facilities, despite enormous global effort over more than two decades, is sufficient evidence that conventional approaches and solutions alone are unable to make a sufficient dent in the service backlog which still exists.” Utilization of lifecycle sustainability concept in the design, development and management of Sub-Saharan African water infrastructure is postulated as a way out of the doldrums. The multi-faceted nature and multi-stakeholder characteristics of lifecycle sustainability concept makes it an apparent credible approach to addressing the hitherto insurmountable water supply problems. It is expected to yield a long lasting affordable and sustainable solution to the African water supply problems. This paper discusses why and how lifecycle sustainability assessment is considered the most appropriate approach to solving African water infrastructure problems. The necessity for lifecycle sustainability management of water infrastructure is explained in the next section. Details on how lifecycle sustainability will help in solving African water infrastructure problems and water supply issues were elucidated in section 3. The article was ended with conclusions on the implications of the discovery and potential outcomes of applying lifecycle sustainability concept in addressing African water infrastructure management issues.

2. Necessity for Lifecycle Sustainability tool for Water Infrastructure Design and Management

The term "sustainability" is much used, and sometimes misused, especially in discussions concerning global development and the environment. Sustainability is a core issue on the political agenda, and this interest was also echoed at scientific levels as many approaches and methods are being proposed and developed. Despite all successes in the political arena, there remains the need for quantification or operationalization of sustainability in order to avoid wrong claims.

Sustainability is characterised by complexity, uncertainty and urgency. None of the available analytical methods can address all of these aspects alone. Bruins et al. (2010) and Seager (2008) was of the opinion that an interdisciplinary integration is necessary to address all the sustainability aspects. Interdisciplinary integration contributes to solving complex problems by providing a systematic approach to combining and interrelating insights that are grounded in commonalities while taking into account differences (Bruins et al., 2010). Lifecycle thinking approaches products and processes evaluation across the value chain from a systemic point of view. The three decades of lifecycle assessment development activities were essentially directed at methodology improvements and consensus building which has resulted in the development of ISO standard 14040s in 1997. However, the original lifecycle approach has been focused on environmental issues alone. There has been clamour for the incorporation of social and economic issues in the LCA process because doing so would make it adequate for sustainability assessment (Assefa and Frostell, 2007; Graedel and van der Voet, 2010; Koroneos and Rokos, 2012; Lee and Kirkpatrik, 2001; Parkin et al., 2000; Weidema, 2006).

Klöpffer (2003) initiated the discussion on life cycle-based methods for sustainability assessment. The development in this field has resulted in the need to establish the importance of a life cycle approach in sustainability assessment and the necessity for an interdisciplinary integration. The subject area on Life Cycle Sustainability Assessment was launched in 2012 (Zamagni, 2012) in order to provide a platform for scientists from different disciplinary fields to discuss the main challenges in addressing sustainability with a life cycle perspective. According to Zamagni et al. (2013), the need for research in this area was premised on two facts: “(1) sustainability has become crucial in any decision making situation and the scientific community has to provide its contribution in demonstrating what might be sustainable and how to measure it with a scientific approach; (2) the life cycle approach is considered to provide a valuable support in integrating sustainability into the design, innovation, and evaluation of products and services, as can be seen in several environmental policies at the European and international level in which life cycle thinking represents the backbone.”

Zamagni (2012) argued that sustainability, as a global concept that involves present and future generation, require a system-wide analysis. He reiterated that a system perspective is necessary to be at the core of the life cycle approach, in order to provide valuable support in the sustainability evaluations. The present state of lifecycle sustainability assessment (LCSA) framework defined by Klopffer (2008) and updated by Guinée et al. (2011) and Halog and Manik (2011) provides a good starting point for integration. However, the framework has so far been applied to limited number of simple products and processes. There is a need to broaden the scope of its development and application. Koroneos and Rokos (2012) argued that going beyond the present state of the art is necessary “to address complexities and sustainability questions along the full range of scales - encompassing at minimum environmental, economic and social dimensions, but also including governance, manufacturing,” and a vision of worth living integrated development (Figure4). Consequently, more research is necessary to make these frameworks operational. The proposed application of lifecycle sustainability concept to water infrastructure design and management provides an ample opportunity to further expand and apply the lifecycle sustainability concept in a practical manner.

The need to approach tackling Sub-Saharan Africa’s water infrastructure problems from lifecycle sustainability point of view were well captured in Andre Pottas’ article entitled “Addressing Africa’s Infrastructure Challenges” and Adam Smith international (ASI)’s article entitled “ Tackling poor infrastructure is vital for developing countries.” These authors indicated that poor decisions or analysis early in infrastructure development can have significant cost ramifications. They are of the opinion that the rules, systems and strategies that many developing countries’ governments use to develop infrastructure are weak, cumbersome and counter-productive. Moreover, records of water infrastructure investments made and failed/lost are sufficient indications that the current approaches are not working well and they are unsustainable(Ihuah and Kakulu, 2014; Keener et al., 2010; Lewis, 2014; Torres, 2014; Uhunmwuangho and Ekpu, 2012). There is therefore a need to assist infrastructure operators and investors by developing a comprehensive framework for collaborative sustainable design, for evaluating the value chain of downstream outcomes and impacts, and for effective and sustainable management of water infrastructure in developing African countries (ASI, 2014; Dunmade, 2010, 2012; Esposto, 2009; Foster and Briceno-Garmendia, 2010;Kees, 2014; Levin, 2011; Mbaku, 2014; Ochoga, 2014; Pottas, 2014).

Figure 4. Lifecycle Sustainability Concepts

3. How Application of Lifecycle Sustainability Concept would help in solving water infrastructure problems in a Sub-Sahara Africa

Figure 5 shows two pathways of water supply and wastewater disposal system lifecycle. The bluish arrows pathway is a modern conventional pathway while the reddish arrow pathway is a typical pathway for many rural and sub-urban water-wastewater pathways in many developing countries. While the conventional pathway is supply based, costly and faulted, the reddish pathway are many times unhealthy and laborious. There are several areas along these pathways that have significant economic, ecological and social impacts. Most of the issues are better addressed from a collaborative and systemic point of view. These scenarios present opportunities for hybridization that eliminates the weaknesses and reinforces the strengths. Such platform is provided by lifecycle sustainability approach. Lifecycle Sustainability tool would provide a means for multi-stakeholders involvement in a project from the cradle to reincarnation. It would facilitate an examination of the inter-relationship between the environmental, the governmental, the economic and the social dimensions of water infrastructure development and management problems as well as how science and technology can contribute to the solutions (Figure 6). The collaborative lifecycle sustainability framework starts with the assemblage of users, donors, government, technology developers, technocrats/managers, environmental and social group as well as other relevant stakeholders that examine various water supply options. Evaluation of the options includes an assessment of various sources of water available to the community, their volumetric adequacy and seasonal variations. It also examine the amount of processing required, various stages of processing, as well as materials and machinery required at each stage of water treatment.

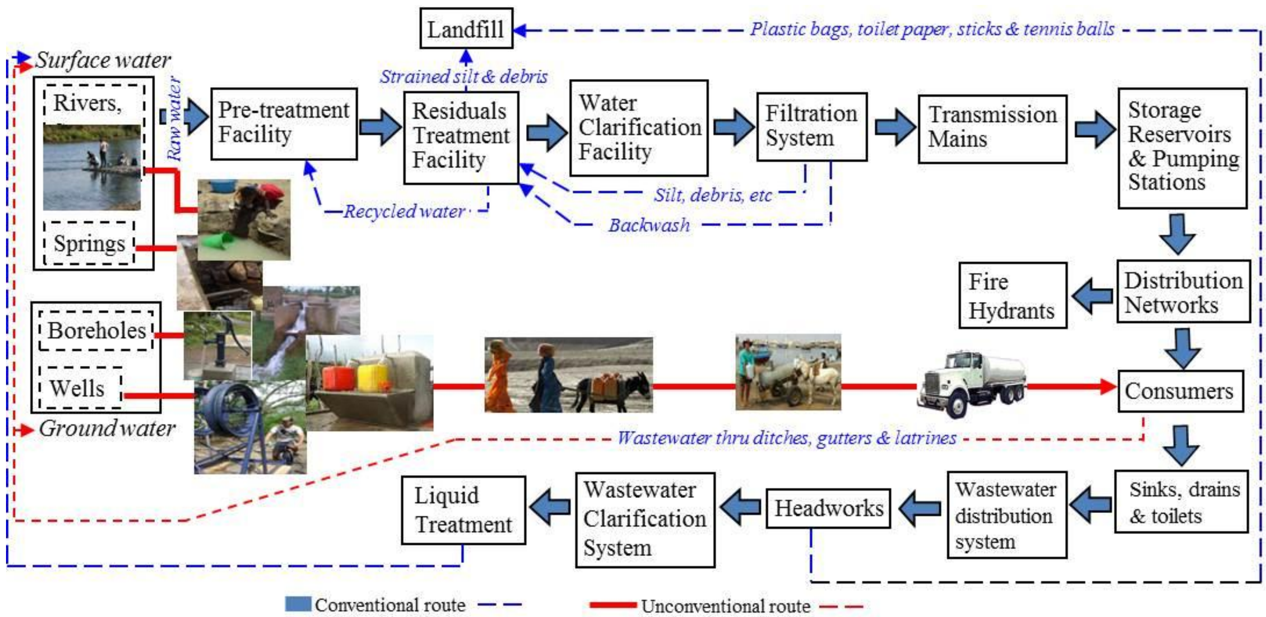

Figure 5. Water Supply and Wastewater Disposal Process Lifecycle

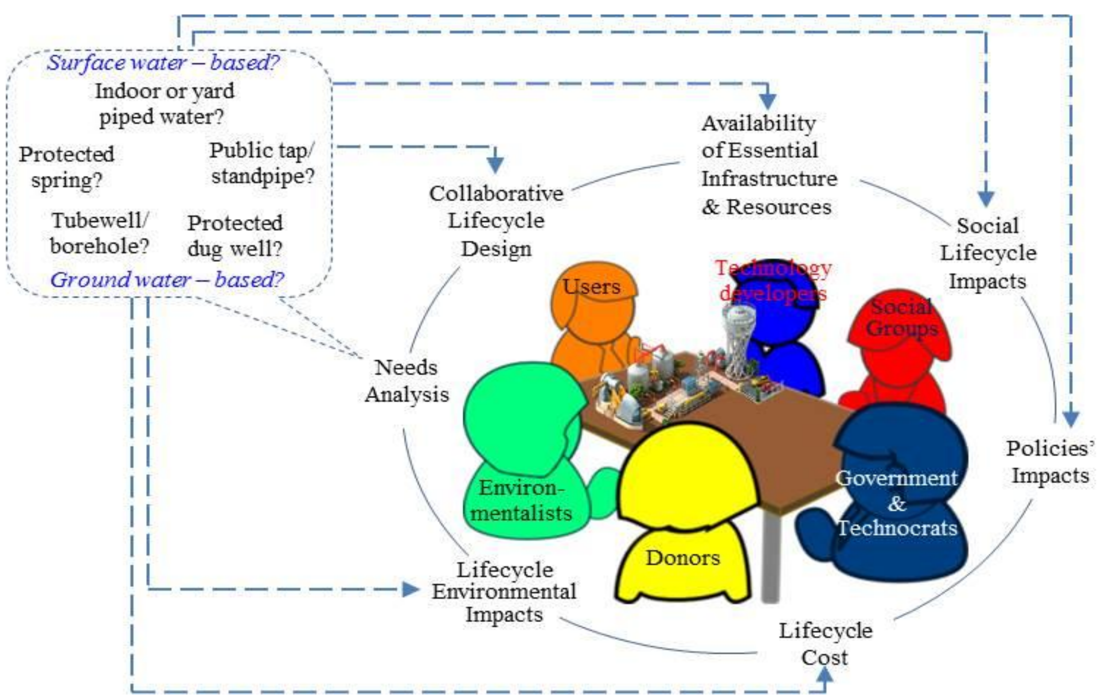

Figure 6. Lifecycle Sustainability – based Water Infrastructure Design & Management

In addition, availability of the resources and adequacy of energy infrastructure needed to operate the water facility in the locality is also examined. Furthermore, it assesses the technical know-how for operational effectiveness, maintainability and redesign for upgrading in the locality. It then assess the potential economic, social and ecological impacts of each option at each stage of the lifecycle before compiling the overall sustainability score for each option and ranking the options on the basis of collective assessment of their potential sustainability performance. By taking the aforementioned steps, the lifecycle sustainability tool would provide a platform for developing and evaluating water infrastructure plan. It can also be used to monitor changes as the process develops and to provide feedback for effective, sustainable management. Moreover, it would provide metrics that can be effectively used to foster the design of an appropriate water infrastructure. Other benefits of using lifecycle sustainability approach to water infrastructure design and development include its facilitation of effective management of efficient, resilient and sustainable facilities. It would result in optimal use of resources and reduce wastes. It would also enable operators of water infrastructure to learn and collaborate to develop, operate and maintain their facilities in a sensible, cohesive and integrated way. It will enable them to see that committing to sustainable infrastructure development is a key strategy for maintaining healthy competitiveness as well as providing environmental and community stewardship (Dunmade, 2001, 2002, 2010, 2013; Hirji et al., 2002).

4. Conclusion

Collaborative lifecycle sustainability design and management tool is a comprehensive tool with great potential to finding an appropriate and sustainable solution to Sub-Sahara African water supply problems. Its application would provide a platform for collaborative work among the stakeholders. It would also provide an avenue for the consideration of situation based site specific issues affecting water supply. Consequently this would result in the design of water infrastructure that is suitable for each specific location. Moreover, extending the use of lifecycle sustainability concept to solve infrastructure problem in a developing economy, especially for infrastructure design and development and associated technology acquisition would assist policy makers, planners and managers in making informed choices. It will also elongate the lifespan and viability of infrastructure that would thereafter be developed on the basis of the principles of lifecycle sustainability. At the end, it would stem the tide of economic wastes, alleviate suffering associated with water supply, improve public health and living standard in many African countries, and minimize ecological footprint of water services. This would eventually help the continent to meet the millennium development goals.

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