Global Majority E-Journal, Vol. 5, No. 2 (December 2014), pp. 75-88

A Clean 5 Gallons a Day Keeps the Doctor Away: The Water Crisis in Kenya and Rwanda

Kianna Billman

Abstract

This article analyzes the impact of the water crisis in Kenya and Rwanda, where the lack of access to safe water increases mortality rates, especially due to exposure to water-borne diseases. The multi-faceted nature of the water crisis is discussed in relation to its impact on health and development. The five major causes of the water crisis will be evaluated, consisting of poor management of water resources, population growth and urbanization, droughts and floods that will become increasingly detrimental with future climate change, water contamination, and a lack of education about safe water consumption. The impact of these major contributors will be discussed in detail after the presentation of a brief literature review and some empirical background of both countries. The article closes with some solutions to reduce the short-term and long-term impacts.

I. Introduction

The lack of access to clean water is one of the main perpetuators of poverty and inequality in many developing countries due to the harmful, and often fatal, implications for health, as well as the highly restrictive effects on economic growth. Kenya is a drought-stricken country of about 43 million people in which an estimated 16 million lack access to safe water and about 10,000 children die each year from diarrhea due to the lack of access to safe water and sanitation. Not only is the scarcity of water an issue in Kenya, but an unequal distribution of water sources primarily to planned urban areas and wealthy rural communities has left urban slums and poor communities in a state of constant deprivation. Recent discoveries of large bodies of underground water have given Kenyan communities hope for revival. However, the existing policy framework limits a more equal distribution of this vital resource.

Although Rwanda has a smaller population of 11.5 million, it faces similar problems as 31 percent of their population, or 3.4 million, lack access to clean water and about 3,000 children die each year from diarrhea caused by a lack of access to safe water and an inadequate sanitation. Rain is not uncommon in Rwanda, so the main problem is not water supply, but the collection, storage, and catchment systems to capitalize on Rwanda's natural sources of water. Decentralization is

currently a main focus of the Government of Rwanda to delegate responsibilities to communities in an attempt to increase self-sufficiency. It has also been found that an increase in water rates can be afforded by many urban payers, which could then finance measures to alleviate the lack of clean water access by poor communities.

This article discusses the main causes to the water crisis in Kenya and Rwanda. Following this introduction, it begins with a brief literature review in section II. Some empirical background information on both countries is then provided in section III, followed by an analysis of the five major causes of the water crisis (section IV). Finally, closing statements are made in section V, focusing on some short-term and long-term solutions.

II. Brief Literature Review

Given the deep and long lasting water problems in Kenya and Rwanda, there are many useful publications addressing a variety of issues, including some detailed water sector reports by the governments of these two countries.[1] The following summaries cover some of the more scientific and analytical publications.

Makutsa et al. (2001) provide a field action report that analyzes the impact of Kenya's Safe Water System (SWS) that was implemented in 2001 as a part of the Water, Sanitation, and Education for Health (WASEH) Project that began in 1998. This consisted of treating water with sodium hypochlorite (chemical water treatment), a safe storage of household water in improved clay pots, and other behavioral change techniques. About one third of the communities adopted chemical water treatment and 18.5 percent adopted the use of the newly innovated clay pots for a safer water storage. The chemical treatment solutions were sold at US$0.33 and the modified clay pots were sold at US$2.53 (the equivalent to about 3 to 4 days wage for most individuals). A significant finding was the importance of marketing and promotional activities in encouraging the adoption of these new techniques. Social marketing tools were crucial such as posters, brochures, T-shirts, skits, dancing and visual art performances, athletic tournaments, health promoters, educational quizzes with prizes, and various other incentives to attract attention to the new implementations and their overall importance. Sustainability would require continual monitoring of the safe water and storage practices as well as active promotion of the new innovations, community mobilization, and constant access to the products. The results of successful implementation techniques in this project can be applied to other areas of safe water access and implementation in the future.

O'Reilly et al. (2007) examine a school-based safe water intervention program that was conducted in Nyanza Province in Western Kenya in 2006 to reduce the occurrence of diarrhea and to increase knowledge about safe water and hygiene practices. Initial and final evaluations of almost 400 students and their parents were collected and utilized for determining the effectiveness of school-based health and awareness programs on home practices. Improvements were observed as there was an increase from 21 to 65 percent of students who became more knowledgeable of correct water treatment procedures and knowing when to wash their hands. There also was an increase from 6 to 14 percent of parents who claimed to be treating their water, and a reduction of absenteeism in schools by 35 percent. The data gathered from the intervention program supports the conclusion that school-based safe water and hygiene programs are effective in improving school and home environments, increasing awareness and knowledge of safe practices, changing

[1] For example, the Government of Kenya, Ministry of Water and Irrigation (2006) prepared the *Kenya National Water Development Report 2005*, a 244 pages long document for the 2nd UN World Water Development Report.

behavior in the home through knowledge transfer from teachers to students to parents, and reducing absenteeism. Such programs could therefore improve safe water access and practices in schools with few latrines, insufficient water supplies, poor quality of water sources, water storage containers that are susceptible to contamination, and a lack of hand washing stations. The reduction of diarrheal diseases can increase school attendance and physical wellbeing, ultimately leading to cleaner, more educated, and more prosperous communities.

Sullivan et al. (2003) discuss the development and application of the Water Poverty Index (WPI) in relation to implications for local and national policymaking, interventions, and the prioritization of aid. Target 10 of Millennium Development Goals (MDGs) is to halve by 2015 the proportion of people without sustainable access to safe drinking water, and the WPI is a means of providing governments and agencies with accurate and transparent information regarding the progress and problems of a country's water needs. The WPI for each country takes into consideration resources (availability of water), access (distance to safe sources), capacity (effectiveness of water management), use (domestic, agricultural, and industrial uses), and environment (integrity and ecosystem goods). These categories can be compared a) individually as components of the WPI or b) together as a whole as given by the overall value of the WPI. In contrast to other indices, the WPI is locally rather than nationally-oriented, allowing decision-makers to make impartial choices based on a specific and transparent framework and allowing communities to lobby for action. Reliance on the WPI can help to monitor progress towards accomplishing the water target, and external donor assistance can be targeted towards countries and communities in which their contribution will have the greatest impact.

As Falkenmark and Widstrand (1992) explain in a *Population Bulletin*, rapid population growth in poor countries has a major impact on the water crisis in those countries. The climate, geography, soil type, latitude, and vegetation of different African countries affect water availability and distribution as well as human activities such as deforestation, agricultural practices, air pollution, irrigation, and population growth. Poor countries remain in a constant state of deprivation due to inadequate water resource management, poor sanitation, scanty hygiene, and a lack of family planning; and all these problems tend to perpetuate poverty. To improve access to safe water, there must be an implementation of better management to increase water accessibility and efficient use in the long-term, the establishment of cooperation between local and international governments and industries, and policies aimed towards reducing fertility rates to reduce the demographic forces fueling the water crisis.

The changes in water supplies from 1967 to 1997 in various East African urban communities were examined by Thompson et al. (2000). Both low and high-income communities (receiving both piped and un-piped sources of water) were examined. Thompson et al. found that water supplies had deteriorated in most locations from 1967 to 1997 because they received less water per day, spent more time collecting water, and paid higher prices. Families without piping receive their water from unprotected sources such as springs, seeps, streams, rivers, and lakes and are prone to water shortages in dry seasons as well as higher rates of contamination. The average cost of water is the highest for low-income urban households that receive un-piped water due to their reliance on vendors and kiosks, which comes at a significant financial cost. The unequal distribution of piped water services leaves some areas with access to water for only 5 hours a day, while more affluent areas have 24 hours of service. Furthermore, there are various other inequalities that result from poor water management and a lack of effective policies.

III. Empirical Background

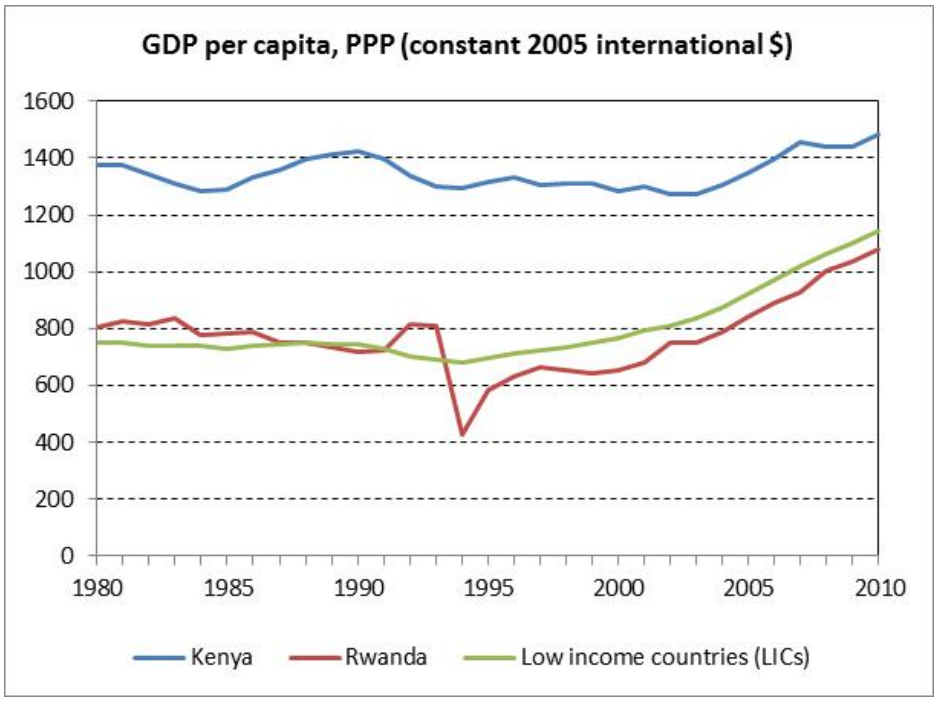
Kenya became independent in 1963 through the works of the founding president, Jomo Kenyatta. Kenya has undergone political struggles from being ruled as a one-party state (by the Kenya African National Union (KANU)) to constitutional reforms in 2010 that allocated power and resources to 47 newly created semi-autonomous counties. Kenya is located in Eastern Africa and has an area of 569,140 square kilometers (sq km). According to data gathered in 2003, 1,032 sq km of that land is irrigated and about 72.96 cubic meters (m^3) of freshwater per person per year are withdrawn from Kenya's water sources (CIA, 2014a). Agriculture has been a major factor for Kenya's economy as 48 percent of the total land area in 2009 was agricultural, contributing to 27 percent of the nation's GDP. However, water pollution (from urban and industrial wastes, pesticides and fertilizers) and soil erosion are constant environmental issues that continue to affect Kenya today. Uneven rainfall also affects water availability because in the two rainy seasons (from April to June and October to December) the average annual rainfall varies from 5 inches in the dry regions to 76 inches near Lake Victoria (Encyclopedia of the Nations, 2014a).

Rwanda gained independence from Belgium in 1962. The Hutu genocide of Tutsis in 1994 was followed by the Tutsi Rwandan Patriotic Front (RPF) gaining power in the following year. The first post-genocide elections were held in 1999 and the country joined the Commonwealth (a voluntary association of 53 independent countries) in 2009. Rwanda is located in Central Africa and has an area of 24,670 sq km, of which only 96.25 sq km are irrigated (CIA, 2014b). As of 2005, about 17.25 m^3 of freshwater per person per year were withdrawn from Rwandan water sources (CIA, 2014b). Agriculture accounts for about one third of total GDP, and agricultural land constituted 81 percent of the total land in 2009 (World Bank, 2013). However, periodic droughts continue to impact agricultural production despite the two rainy seasons (from February to May and November to December), in which the average annual rainfall may vary from 31 inches to 63 inches (Encyclopedia of the Nations, 2014b).

As shown in Figure 1, both Kenya and Rwanda have increased their GDP per capita (expressed in purchasing power parity (PPP) in constant 2005 international dollars), although Rwanda has made more progress than Kenya. In 1980, GDP per capita was US$1,375 in Kenya and US$805 in Rwanda, whereas in 2010 those values rose to US$1,509 in Kenya and US$1,132 in Rwanda. Hence, GDP per capita increased by only US$134 in Kenya, while it increased US$327 in Rwanda. Although increasing at a lower and more constant rate, Kenya has maintained a higher level of GDP per capita than the average low income country (LIC), whereas Rwanda started off slightly better in 1980 than the average LIC but dropped slightly below the average LIC in GDP per capita by 2010, due to the severe impact of the 1994 genocide.

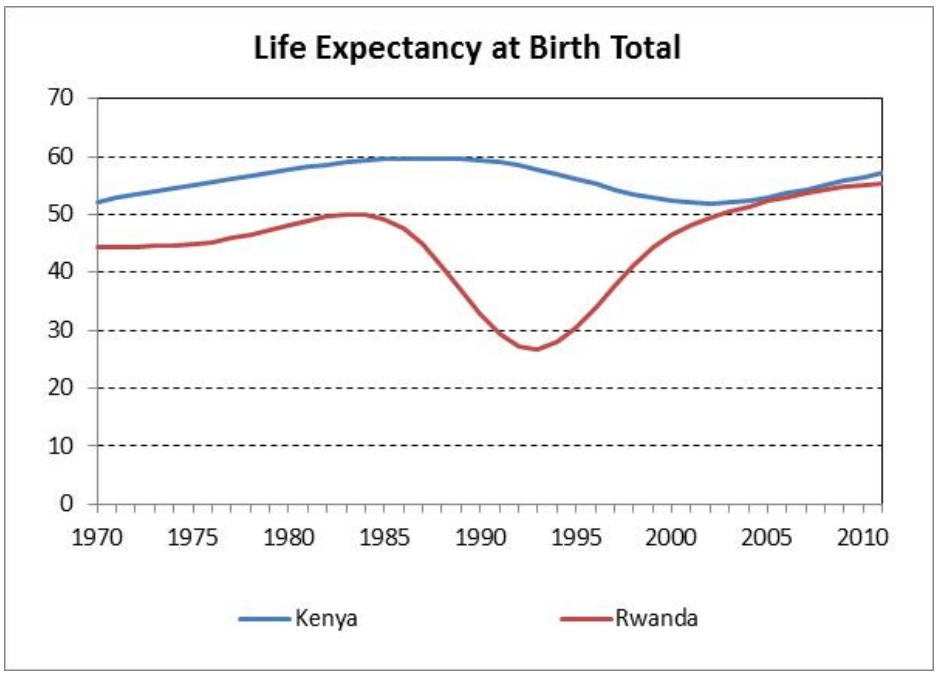
As Figure 2 shows, over the last 40 years, life expectancy at birth has been relatively flat in Kenya but more fluctuating in Rwanda. In 1970, life expectancy at birth was 52 years for Kenya and 44 years for Rwanda, but by 2010, both increased to 56 and 55 years, respectively. Like for GDP per capita, Rwanda demonstrated a greater net increase, but Kenya started off with a greater life expectancy. The similarity in life expectancy at birth by 2010 (the difference of which was only 1 year) could suggest that living conditions in both countries were similar enough to induce a similar outcome.

Figure 1: GDP per capita, PPP (constant 2005 international $) in Kenya, Rwanda, and LICs, 1980-2010



Source: Created by author based on World Bank (2013).

Figure 2: Life Expectancy at Birth in Kenya and Rwanda, 1970-2010

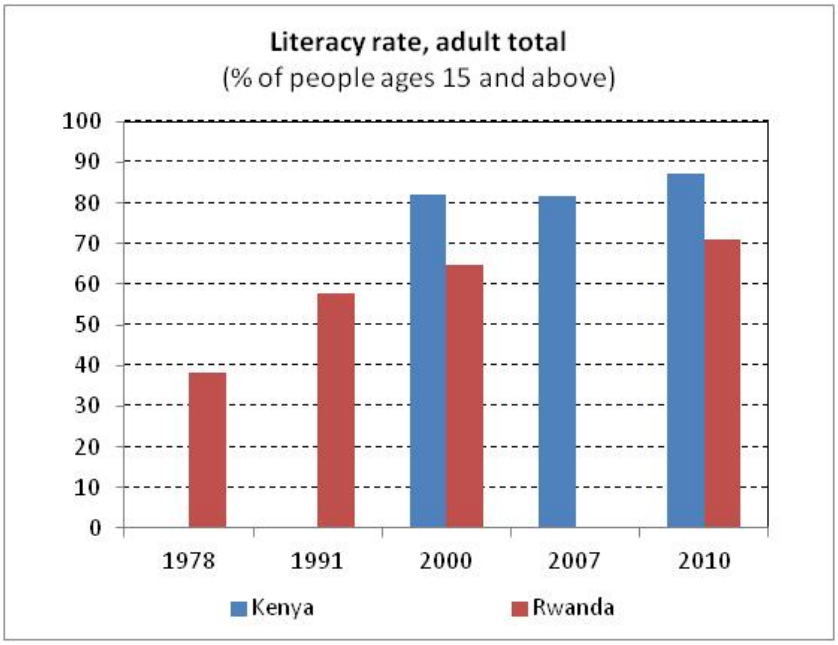


Source: Created by author based on World Bank (2013).

Data on literacy rates for the percentage of the total population (ages 15 and above) has been sporadic in both Kenya and Rwanda, as shown in Figure 3. However, an overall trend of increasing literacy rates can be seen from 1978 to 2010 in Rwanda, where literacy increased from 38 percent

in 1978 to 71 percent in 2010. In Kenya, literacy rates seem to have been stagnating around 82 percent during the mid-2000s, and increasing moderately to 87 percent by 2010. As was the case with GDP per capita and life expectancy, Rwanda displayed a greater net increase than Kenya.

Figure 3: Adult Literacy Rate in Kenya and Rwanda, available years



Source: Created by author based on World Bank (2013).

IV. Causes of the Water Crisis

In order to implement effective solutions to the water crisis in Kenya and Rwanda, the major causes must first be understood. This section analyzes the five major causes: poor management of water resources, population growth and urbanization, climate change (droughts, floods, and increases in temperature and rainfall), water contamination (particularly in urban slums), and little education about water treatment and safety. Areas of focus in implementing solutions are also outlined when applicable.

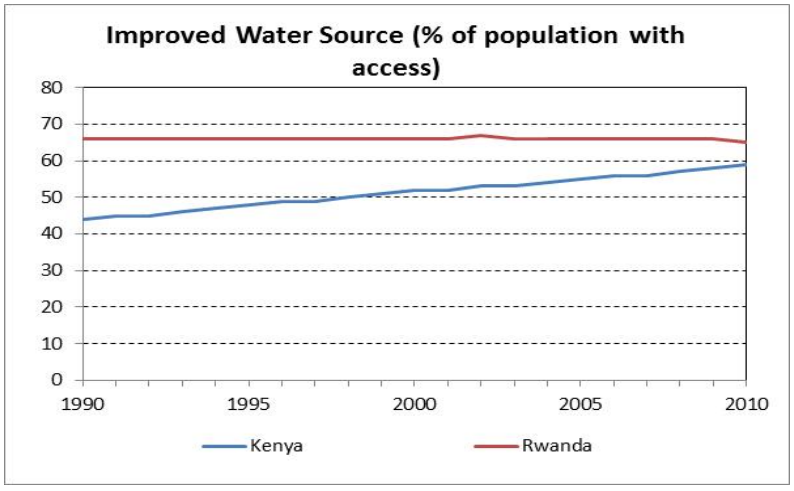
IV.1. Management of Water Resources

A report by the World Resources Institute (1994) demonstrated that the availability of freshwater sources has been declining in many Sub-Saharan Africa countries, including in Kenya and Rwanda. It was found that freshwater availability per capita was 647 m^3 in Kenya and 843 m^3 in Rwanda, as compared to the global standard of 1000 m^3, and projections indicated that those levels would drop to 235 m^3 per capita by 2025 if no corrective measures are taken. The lack of clear policies on water resource management has served to perpetuate the poor water availability conditions despite Kenya's 1970s government development goal to supply water to the entire population by 2000, and Rwanda's Vision 2020 to supply water to the entire population by 2020 (Rwanda's Management Information System, 2012). Kenya's Water Policy of 1999 and the Water Act of 2002 brought about reforms with a renewed focus on the fundamental principles of Integrated Water Resources Management (IWRM), and these principles identified key factors to

ensure effective and sustainable water resource management. The key factors were stakeholder participation, recognition of the vulnerability of water resources, and the consideration of water as a social and economic good. Kenya's Water Resource Management Authority (WRMA) incorporated these goals into operational use in 2005 (WRMA, 2009).

Despite attempts by various organizations to improve water availability, Figure 4 shows that Rwanda has experienced a reduction from 66 to 65 percent of the population with access to an improved water source. However, unlike Rwanda, Kenya has experienced an increase from 44 to 59 percent of the population with access to an improved water source. There are significant differences in improvements between rural and urban populations from 1990 to 2010. The percentage of the rural population with improved access increased in Kenya from 33 to 52 percent and decreased in Rwanda from 64 to 63 percent. In comparison, the percentage of the urban population with improved access decreased from 92 to 82 percent in Kenya and also decreased from 95 to 76 percent in Rwanda (World Bank, 2013).

Figure 4: Population with Access to Safe Water in Kenya and Rwanda, 1990-2010



Source: Created by author based on World Bank (2013).

To correct failed policy reforms and water management, other challenges must also be addressed in management approaches in order to take steps toward long-term improvement (Sano, 2012). Such challenges are as follows:

- Insufficient funding and decreasing allocations of the government development budget for water and sanitation.
- Funding agreements with development partners that will end in the near future.
- Disparities in access to water in both rural and urban areas.
- Low sustainability of water supply services in rural areas in conjunction with high infrastructure rehabilitation costs.
- High water tariffs in rural areas and water tariffs in urban areas that do not reflect operation and maintenance costs.

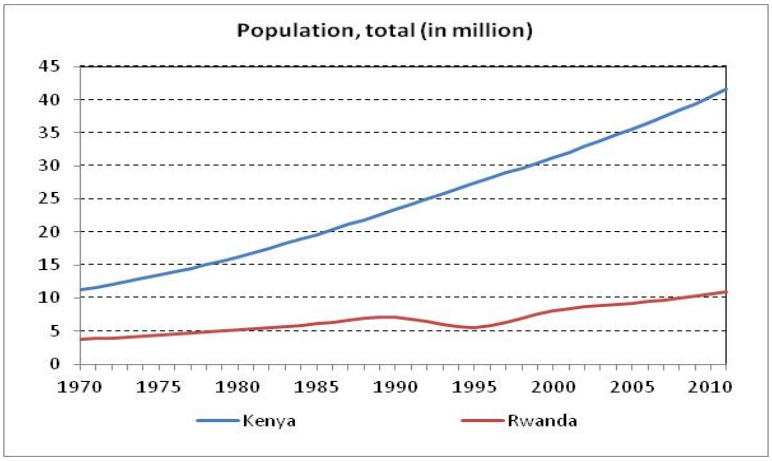
- Unplanned settlements in both urban and rural areas resulting in difficulty in reaching the entire population.
- Rapid increase of urbanization and population growth that leads to unplanned housing with high costs for water treatment.

An evident factor in many of the aforementioned challenges is population growth and urbanization, as it affects the population proportions in rural and urban areas.

IV.2. Population Growth and Urbanization

Both Kenya and Rwanda have experienced large levels of population growth in the past 40 years, which has negatively impacted the water crisis. From 1970 to 2011, the population of Kenya increased from about 11 million to 41.5 million, and the population of Rwanda increased from about 4 million to 11 million, as shown in Figure 5.

Figure 5: Total Population in Kenya and Rwanda, 1970-2011



Source: Created by author based on World Bank (2013).

Not only have the populations grown, but each country has demonstrated active urbanization in which a proportion of the rural population has migrated into urban cities. For instance, from 1970 to 2011 the percentage of the population that lived in rural areas decreased from 90 to 76 percent in Kenya and also decreased from 97 to 81 percent in Rwanda (World Bank, 2013). The increased concentration of people in urban areas has resulted in unplanned housing in cities, raising the cost of water treatment. Population growth in general has had major implications in both rural and urban settlements because not only are there more individuals who need access to water, but unplanned settlements that account for the increasing population also lead to a greater number of areas that lack access to established water systems (African Development Bank Group, 2012).

IV.3. Climate Change: Droughts and Floods, Increases in Temperature and Rainfall

Kenya is a drought-stricken country that experiences contrasting impacts, from extreme water shortages in the dry season to floods in the rainy seasons (from April to June and October to December). Since 1960, the temperature has increased by 1°C and is expected to increase by 2.8°C

by 2060. However, precipitation may have an even greater impact as it is expected that the annual rainfall will increase by up to 48 percent in some areas. Table 1 shows the observed and future projected trends in temperature and rainfall, indicating the large-scale impact of global warming and more extreme temperatures on future generations (McSweeney, New and Lizcano, 2010).

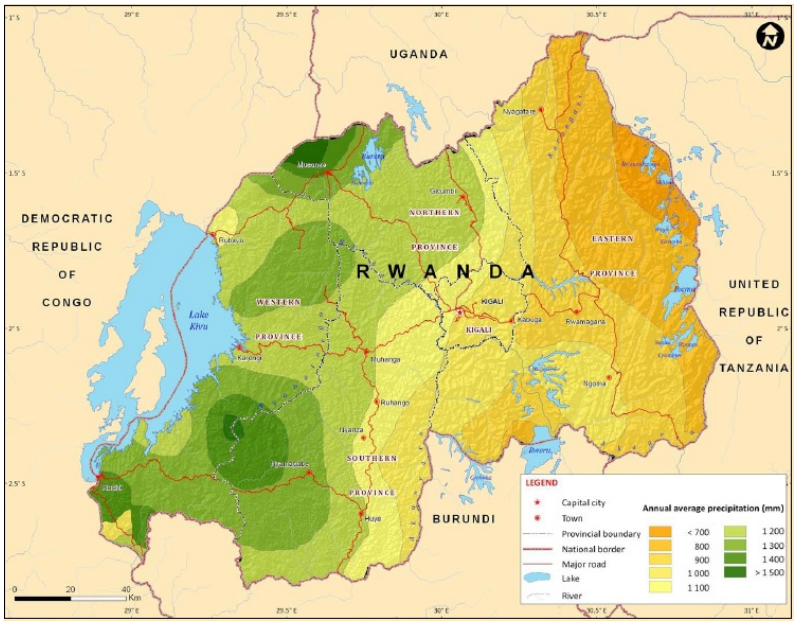
Table 1: Projected Changes in Temperature and Rainfall in Kenya, 2030s-2090s

	Observed Mean 1970-99	Observed Trend 1960-2006		Projected changes by the 2030s			Projected changes by the 2060s			Projected changes by the 2090s		
				Min	Median	Max	Min	Median	Max	Min	Median	Max
Temperature												
	(°C)	(change in °C per decade)		Change in °C			Change in °C			Change in °C		
			A2	0.9	1.2	1.5	1.8	2.4	2.8	2.8	3.7	4.5
Annual	23.9	0.21*	A1B	0.8	1.2	1.5	1.6	2.3	2.7	2.3	3.0	4.0
			B1	0.5	1.0	1.2	1.0	1.7	2.0	1.3	2.0	2.6
			A2	0.7	1.2	1.6	1.4	2.2	3.1	2.4	3.6	4.6
JF	25.1	0.22*	A1B	0.6	1.1	1.6	1.7	2.3	2.8	2.1	3.1	4.1
			B1	0.4	1.0	1.3	1.0	1.5	2.2	1.1	1.9	2.6
			A2	1.0	1.2	1.8	1.8	2.4	2.7	2.9	3.8	4.5
MAM	24.6	0.29*	A1B	0.5	1.3	1.6	1.6	2.3	2.7	2.3	3.0	3.9
			B1	0.5	1.0	1.5	1.1	1.6	2.0	1.4	2.1	2.8
			A2	0.9	1.2	1.6	1.9	2.5	2.8	3.0	3.9	4.7
JJAS	22.7	0.17*	A1B	0.8	1.3	1.7	1.6	2.4	2.7	2.3	3.2	4.4
			B1	0.6	1.1	1.3	1.0	1.7	2.1	1.5	2.1	2.7
			A2	0.6	1.1	1.3	1.7	2.2	2.8	2.6	3.4	4.3
OND	23.9	0.19*	A1B	0.8	1.1	1.3	1.4	2.1	2.6	2.0	2.7	3.8
			B1	0.2	0.9	1.2	0.8	1.5	2.0	1.2	1.8	2.5
Precipitation												
	(mm per month)	(change in mm per decade)		Change in mm per month			Change in mm per month			Change in mm per month		
			A2	-1	3	11	0	5	20	3	13	27
Annual	57.3	-1.5	A1B	-3	4	12	0	7	16	1	10	21
			B1	-3	2	10	-4	4	10	-1	5	15
			A2	-8	2	11	0	5	23	0	17	30
JF	29.0	-1.0	A1B	-3	6	17	-2	3	25	-4	10	20
			B1	-11	2	17	-3	6	14	-3	5	19
			A2	-12	3	18	-12	9	31	-12	15	47
MAM	95.7	-3.7	A1B	-8	7	21	-7	9	29	-13	12	35
			B1	-13	0	19	-8	2	23	-7	5	23
			A2	-5	0	12	-5	0	12	-2	3	22
JJAS	34.6	-0.8	A1B	-8	0	6	-5	1	11	-3	1	13
			B1	-4	0	7	-8	0	8	-4	2	6
			A2	0	11	19	-3	13	33	5	29	49
OND	67.2	-0.6	A1B	-6	8	29	0	9	30	6	21	32
			B1	-5	4	22	-8	12	19	-3	13	37

Source: McSweeney, New and Lizcano (2010).

Rwanda is dependent on rain-fed agriculture for rural sustainability and certain exports (such as tea and coffee), and half of its electricity is hydro powered. There has been a 1.4°C increase in temperature since 1970 – which is higher than the global average – and it is expected that the temperature will increase up to 2.5°C by 2050. During the rainy seasons from February to May and November to December, it is predicted that rainfall could increase by 20 percent by 2050, thus causing landslides, loss of crops, health risks, and damage to infrastructure (Republic of Rwanda, 2011). Figure 6 shows the current precipitation rates in Rwanda, but larger areas surrounding regions of high precipitation could become more affected in future years by increases in flooding during the rainy season.

Figure 6: Average Annual Precipitation in Rwanda (mm)



Source: Rwanda Environment Management Authority (2011), Figure 1.3, p. 4.

The striking dichotomy between droughts and floods leads to severe impacts on the Kenyan and Rwandan communities because the dry season brings more extreme water shortages while the rainy season can cause floods that lead to damage and contamination of water sources. Simultaneous increases in temperature can also lead to vector-borne and water-borne diseases, leading to increased health risks for humans and animals, decreases in crop yields, and negative impacts in the export sector of the economy (Government of Rwanda, 2011).

Some specific impacts of climate variability have been catchment degradation (which increases erosion and run-off), the drying up of rivers, receding lake levels, significant siltation of dams meant for hydropower and water supplies, and the deterioration of water quality (Government of Kenya, Ministry of Water and Irrigation, 2006). In order to become more resilient to climate changes, the following issues must be focused on in Kenya and Rwanda:

- Irrigation Infrastructure: Such infrastructure allocates more control of water resources to farmers, therefore reducing susceptibility to changes in rainfall. It also allows for crop diversification, efficient land and water use, and provides water to dry areas that otherwise would not receive it.
- Stronger Road Networks: Poor quality roads, such as dirt tracks, contribute to loss of products while in transit and an increased vulnerability of transportation routes in extreme weather. Constructing and maintaining stronger roads that are more resilient to extreme weather and future climate changes will promote economic development.
- Center for Climate Knowledge and Development: Insufficient data about projected climate changes (especially in Rwanda) prevents the ability to plan for the future, therefore hindering adaptation to future increases in temperature and rainfall. By providing more predictions and information, a wider array of policy options will be available for decision-makers to plan for future adaptation.

IV.4. Water Contamination, Particularly in Urban Slums

Although the water crisis is heavily focused on the lack of a sufficient amount of water, another key aspect is water quality. Water contamination is a major issue in many urban slums due to the close proximity of wells (from which water for household use is drawn) and pit latrines (holes dug into the ground into which excrement falls). Due to population growth and urbanization (as was discussed in section IV.2. above), increases in the percentage of the population living in urban cities results in overpopulation, unplanned housing, and ultimately the expansion of slums. Overcrowding results in the limitation of available land, and therefore wells and pit latrines are placed at distances that are too close to each other. The short distances between the wells and latrines allow bacteria and other micro-organisms to invade the water sources from the nearby latrines, resulting in contamination of communal water sources (Kimani-Murage and Ngindu, 2007).

Urban slums are informal settlements that do not receive governmental drainage, water, sewerage, and waste services, and the mortality rates are therefore higher than in rural populations because rural areas have enough land to safely separate water sources from waste disposal. Human excreta can cause diseases such as cholera, typhoid, hepatitis, polio, cryptosporidiosis, ascariasis, and schistosomiasis; diseases which contribute to the one-third of deaths in developing countries that are caused by drinking contaminated water.

Until governmental services and proper infrastructure are available to all residents regardless of their location of residency, certain guidelines should be followed in well and latrine placement. When coexisting, wells should be located no less than 2 meters (about 7 feet) above the water table and no less than 15 meters from pit latrines, as studies have shown that the greater the distance of separation, the lower the risk of contamination.

Table 2: Distance between Pit Latrine and Wells in Langas Slum, Kenya

Distance	Number	Percent
1–15 m	67	38.3
15–30 m	103	58.9
30 m and above	5	2.9
Total	175*	100

Source: Kimani-Murage and Ngindu (2007).

In one study done in Langas, Kenya, conducted by Kimani-Murage and Ngindu (2007), 192 households were selected and 31 shallow wells were tested, along with 4 deep wells and 5 taps (nearby kiosks). The World Health Organization (WHO) defines acceptable standards for drinking water as water in which there are no traces of *E.coli* or coliform bacteria. In this experiment, all of the shallow wells contained traces of these micro-organisms, indicating that the coliforms invaded the water sources via transport from the closely located pit latrines through the soil and into the wells. Similar studies have been conducted in Rwanda as well, showing contamination of water sources as a result of run-off from industrial and domestic waste (Namuwaya, 2012). As Table 2

shows, the contamination of the wells in Kenya was most likely due to their placement in relation to the pit latrines.

However, about one-third of the children were accustomed to excreting openly on the ground and many of the wells did not have adequate coverage for protection, resulting in the contamination of the wells from run-off of the excrement in the presence of rain. There could have been additional sources of contamination, such as contact between the children's dirty possessions and the water, withdrawing water with unsanitary containers, deposits of animal excrement near the wells, and the use of wells to wash clothes. Also, only 42 percent of well-users admitted to boiling their drinking water, leading to the next issue of the importance of education about water safety.

IV.5. Lack of Education

One of the root causes of the contraction of water-borne diseases is the lack of education about clean water and water treatment. Many individuals in developing countries use whatever water sources that are available, due to the lack of adequate resources as well as the lack of knowledge about the implications of drinking unsafe water. The SWS intervention program (as discussed in section II above) is a good example of how school-based education about water treatment and safe practices can lead to increased levels of safe practices in schools as well as in home environments. O'Reilly et al. (2007) described the result of the intervention as an increase in knowledge of correct water treatment from 21 to 65 percent of students, in conjunction with an increase in the percentage of parents who claimed to be treating their water. By emphasizing the importance of water safety interventions in developing countries, rates of water-borne disease contraction can be lowered and death tolls can be reduced until permanent infrastructure and government provided services can be provided to the entirety of every population.

V. Conclusion

Kenya and Rwanda are significantly impacted by the water crisis due to factors such as poor management of water resources, population growth and urbanization, climate change (that involves more droughts during the dry season, more floods during the rainy season, and increases in temperature), water contamination, and education about water treatment and safety. Changes in policy implementation and construction of more widespread and strengthened infrastructure can help to reduce the impacts of low water availability and poor management, but future conditions may further jeopardize the populations of these countries due to global warming. Steps must therefore be taken to create effective catchment, storage, and irrigation systems that will provide better adaptation to unexpected weather conditions.

Population growth will also continue to plague Kenya and Rwanda, even though both countries have made some progress in the last three decades with reducing their very high fertility rates, which exceeded 8 children per women in the early 1970s for Kenya and during all of the 1970s in Rwanda. A renewed focus on the importance of education for girls is essential to reduce fertility rates further and stabilize the population. Services to assist in family planning will also contribute to reducing population growth further, and thus heightened emphasis must be placed on the future educational and informational services for female children.

Finally, until long-term management, policy, and infrastructure changes can be made, short-term solutions must be employed. Such short-term solutions consist of educational awareness about safe water drinking and treatment habits, increased availability of chemical water treatments, and an

increased provision of clay pots for safer water storage along with filtration systems to clean drinking water. These relatively simple solutions will not only serve to reduce naivety to the water crisis, but they will also minimize the incidences of water contamination and contraction of harmful and fatal diseases.

References

African Development Bank Group (2012). Urbanization in Africa; available at: http://www.afdb.org/en/blogs/afdb-championing-inclusive-growth-across-africa/post/urbanization-in-africa-10143/.

Central Intelligence Agency (2014a). The World Factbook: Kenya; available at: https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html.

Central Intelligence Agency (2014b). The World Factbook: Rwanda; available at: https://www.cia.gov/library/publications/the-world-factbook/geos/rw.html.

Encyclopedia of the Nations (2014a). Kenya Climate; available at: http://www.nationsencyclopedia.com/Africa/Kenya-CLIMATE.html.

Encyclopedia of the Nations (2014b). Rwanda Climate; available at: http://www.nationsencyclopedia.com/Africa/Rwanda-CLIMATE.html.

Falkenmark, Malin and Carl Widstrand (1992). Population and Water Resources: A Delicate Balance. *Population Bulletin*, Vol. 47, No. 3, pp. 1-36.

Government of Kenya, Ministry of Water and Irrigation (2006). *Kenya National Water Development Report 2005* (United Nations Organization for Education, Science and Culture (UNESCO), World Water Assessment Programme, prepared for the 2nd UN World Water Development Report 'Water: A Shared Responsibility'); available at: http://unesdoc.unesco.org/images/0014/001488/148866e.pdf.

Government of Rwanda (2011). *Green Growth and Climate Resilience: National Strategy for Climate Change and Low Carbon Development* (Kigali, Rwanda: Government of Rwanda); as posted by the United Nations Conference on Sustainable Development: http://www.uncsd2012.org/content/documents/364Rwanda-Green-Growth-Strategy-FINAL.pdf.

Makutsa, Philip; Kilungu Nzaku; Paul Ogutu; Peter Barasa; Sam Ombeki; Alex Mwaki; and Robert E. Quick (2001). Challenges in Implementing a Point-of-Use Water Quality Intervention in Rural Kenya. *American Journal of Public Health*, Vol. 91, No. 10 (October), pp. 1571-1573.

McSweeney, Carol; Mark New; and Gil Lizcano (2010). *UNDP Climate Change Country Profiles: Kenya*; available at: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/UNDP_reports/Kenya/Kenya.hires.report.pdf.

Kimani-Murage, Elizabeth Wambui and Augustine M. Ngindu (2007). Quality of Water the Slum Dwellers Use: The Case of a Kenyan Slum. *Journal of Urban Health*, Vol. 84, No. 6 (June), pp. 829-838.

Namuwaya, Evaline (2012). Water Experts Blame Pollution on Poor Land Use. *The New Times: Rwanda's First Daily*, News story (December 17, 2012); available at: http://www.newtimes.co.rw/news/index.php?i=15209&a=61877.

O'Reilly, C.; M. Freeman; M. Ravani; J. Migele; A. Mwaki; M. Ayalo; S. Ombeki; R. Hoekstra; and R. Quick (2008). The Impact of a School-Based Safe Water and Hygiene Program on Knowledge and Practices of Students and Their Parents: Nyanza Province, Western Kenya, 2006. *Epidemiology and Infection*, Vol. 136, No. 1 (January), pp. 80-91.

Rwanda Environment Management Authority (REMA) (2011). *Atlas of Rwanda's Changing Environment: Implications for Climate Change Resilience* (Kigali, Rwanda: REMA); available at: https://na.unep.net/siouxfalls/publications/REMA.pdf.

Sano, James (edited by Joanna Esteves Mills, Bethlehem Mengistu and Nshuti Rugerinyange (WaterAid), and Richard Watts (Development Finance International)) (2012). *Financing of the Water, Sanitation and Hygiene Sector in Rwanda: Case Study*; available at: http://www.wateraid.org/~/media/Files/UK/Keeping%20Promises%20case%20studies/Rwanda%20the%20financing%20of%20the%20water%20sanitation%20and%20hygiene%20sector.pdf.

Sullivan, C. A.; J. R. Meigh; A. M. Giacomello; T. Fediw; P. Lawrence; M. Samad; S. Mlote; C. Hutton; J.A. Allan; R. E. Schulze; D. J. M. Dlamini; W. Cosgrove; J. Delli Priscoli; P. Gleick; I. Smout; J. Cobbing; R. Calow; C. Hunt; A. Hussain; M. C. Acreman; J. King; S. Malomo; E.L. Tate; D. O'Regan; S. Milner and I. Steyl (2003). The Water Poverty Index: Development and Application at the Community Scale. *Natural Resources Forum*, Vol. 27, pp. 189-199; available at: ftp://ftp.fao.org/agl/emailconf/wfe2005/narf_054.pdf.

Thompson, John; Ina T. Porras; Elisabeth Wood; James K. Tumwine; Mark R. Mujwahuzi; Munguti Katui-Katua; and Nick Johnstone (2000). Waiting at the Tap: Changes in Urban Water Use in East Africa over Three Decades. *Environment and Urbanization*, Vol. 12, No. 2 (October), pp. 37-52; available at: http://eau.sagepub.com/content/12/2/37.full.pdf+html.

Water Resources Management Authority (WRMA) (2009). *Strategic Plan 2009-2012* (Nairobi, Kenya: Water Resources Management Authority (WRMA)); available at: http://www.wrma.or.ke/images/wrma_strategic_Plan_2009_2012.pdf.

World Bank (2013). *World Development Indicators / Global Development Finance database* (Washington, DC: The World Bank); as posted on the World Bank website: http://data.worldbank.org/data-catalog/ (downloaded on April 3, 2013).

World Resources Institute (WRI) (1994). *World Resources* (New York: Oxford University Press); available at: http://www.wri.org/sites/default/files/pdf/worldresources1994-95_bw.pdf.