Battling Climate Change:

Sustainable Water Resource Management at Ilkerin-Loita Boarding Primary School, Kenya

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Abstract

The primary goal of this research is to examine current water resource management at Ilkerin-Loita Boarding Primary School (Ilkerin-Loita, Kenya) and to seek potential solutions for its future development. Research methods included interviews with the members of the local community and the school, and field visits to nearby dams and villages. Also, to analyze the water demands five years into the future, information on the average student enrollment growth rate of the last five years and the estimated student daily water consumption were collected. The findings showed that the school's water resource management has employed different water management strategies to cope with its steadily increased water demand and continuously changing climate. However, the school will confront a water crisis in the next two years. While the school needed to improve its water supply maintenance and replace damaged water storage equipment, it has to find a permanent water source to increase its climate change resistance and sustain its development in the long-term.

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Water management in Kenya has been studied intensively [1]. According to the World Bank statistics 2006, Kenya is classified as a water-scarce country because of its low level of freshwater supplies and development. The country's renewable freshwater supplies are less than 647 cubic meters per capita, compared to average availability of 7000 cubic meters per capita worldwide. Of the limited freshwater resources, only 15% of them are developed. As a fundamental element of the country’s social-economic development, and further poverty reduction and human living condition improvement, Kenyans demand quality water resource management [2].

Many factors influence water management, such as government policy, construction techniques, and administrative skills, but a major factor is climate impact, which is characterized by floods and droughts in Kenya. Approximately 80% of the total land area of Kenya is arid and semi-arid land featured with scant vegetation cover. In the rainy season, intense storms cause flooding and heavy run-off. Between the rainy seasons, dry seasons often induce droughts and water shortage [3]. From a global view, climate is changing and the temperature will rise 1.8 to 4.0 °C by the year 2100 based on the result of various studies [4]. This change means a significant impact on global climate and socio-economic activity. It may be more intensive in tropical regions, such as Kenya, because the cycle of flood and drought has already been problematic. In last two decades, Kenya has experienced eight droughts and the cycle appears to have sped up, leaving less time for local people to recover from one drought to next [5].

Ilmarai, an Ilkerin-Loita Maasai community, which occupies an area of 230 km^2 in southeast Kenya, is especially vulnerable to climate impact because of its unique environment and social as well as cultural activities. Although the lands in the region are semi-arid and arid, its rich volcanic soil allows excellent vegetation growth, which is attractive to wildlife in their migration season and people to herd livestock. Traditionally, Maasai people herd livestock, such as cattle, goat and sheep between grazing land based on seasonal rotation. During last a few decades, because of shrinking grassland and by encouragement of the government the Maasai have been rapidly converting their grazing land to agricultural cropland [6]. As a consequence, the Maasai benefit from crop growing as they gain more income by selling grains and they are able to send their children to school as they settle permanently. However, in the long term, water resource management, in the context of sustainable development, becomes a critical element for the settlement and development of the community.

For last ten years, the climate in Ilmarai area has been changing and the weather has become unpredictable; rainfall has been decreasing annually while the dry season has been elongating gradually. The six-month rainy season, which usually starts from December to May, has shrunk to four or five months. At the same time, the dry season, which used to range from August to October, about three months, has increased to four or five months. The climate changes put pressure on an already weakened water system and increase climate vulnerability in the area. In years of severe drought, water shortage causes crop failure and livestock deaths, which leads to food shortage and sometimes famine; also, it induces human and livestock diseases and high mortality, which results in abnormal population growth and destruction of the community. For example, in the severe drought year of 2002-2003, 60% of livestock died from dehydration or drought-related disease [7]. These drought-related issues further influence the

Maasai family's decision of permanent settlement as water is very important to their daily lives, and their choice of education since students may perform poorly because of the missing classes that they have when school is forced to close due to the shortage of drinking water. Thus, in order of sustaining its settlement and long-term development, Ilmarai community needs to find a way to secure its water resource and increase water storage capability to satisfy community water needs.

Sustainable water management indicates that a community is able to keep its water supplies and demand in balance, while it takes into account its ecosystems and future development [8]. To the Ilmarai Maasai community, sustainable water resource management means capturing water, both surface and ground, in water storage structures to support community use in the dry season. Its ultimate goal is to increase its capability of resistance to climate impact and promote the socio-economic development of the community as a whole.

Although sustainable water resource management is significant to the Maasai community development and resistance capability to climate change, little research has been done on the relationship of sustainable water resources management and Maasai community development, especially on community school development. Thus, this study will focus on water resource management in Ilkerin-Loita Boarding Primary School (ILBPS), with the purpose of seeking efficient water resource management to meet the needs of school's physical and academic development. Because school enrollment is an excellent indicator of school population development, it will be used to calculate school water consumption demands. Through an evaluation of the school's current water supplies and resource management, this study yields important insights into the understanding of climate-adaptive water management and sustainable development at the school and local community level.

Method

Interviews and Field Trips

We conducted ten interviews about water resource development at ILBPS and within the surrounding community. The interviews were with:

Abel Ithinji, Ilkerin-Loita Boarding Primary School Head teacher, on the topics of school enrollment from 2008 to 2012, and the school's current water resource management and development plan;

Daniel Siloma, Ilmarai Community Committee member, on the topic of future community water resources development;

Moses Koroine, Ilmarai Community Assistant Chief, on the topic of historical Ilmarai water resources management and development, climate change and impact on Maasai farming, herding and settlement in the area;

Julius Turuni, Ilmarai Community Motivator, on the topic of Enroseremai Borehole management and payment records from 2004 to 2011;

Daniel Ngoet, Early Childhood Development teacher, on the topic of general water resource management information in the Ilmarai sub-location of Ilkerin-Loita;

Charles Saitabau, Loita Council of Elders member, on the topic of climate change in Ilmarai, and the optimal water resources development in the area;

Mary Sintame , Ilkerin- Loita Boarding Primary School Kitchen helper, on the topic of school daily water using and students water consumption behaviors;

James Levoncho Murkuk, Osukuwua village committee representative, on the topic of Osukuwua dam water management and existing management issues;

Willam Selci, Pastoralist, on the topic of climate change and impact on his family settlement, and his preference of water supplies;

Jonas Putuai, Farmer, Businessman, on the topic of community dam construction and management;

Kashu family, Farmer, Pastoralist, on the topic of Empaash dam water management and their preference on water supplies;

We had meetings with the school Board Committee and collected general information about current school water supplies and demand and its relationship with community water resource management.

Ten field trips were conducted, including trips to two dams (Empaash dam and Osukuwna dam), one spring (Empaash Spring), and one borehole (Enkoseremai borehole) for visualizing the availability of water and water resource maintenance in these locations; trips to four villages (Empaash village, Osukuwna village, Enkoseremai village, and Olmesutie village), one market (Ilkerin Monday Market), and one community center (Ilkerin –Loita) for interviewing villagers and listening to their opinions on local water resources management, community and school development.

Materials and Procedure:

Information gathered from interviews and field trips were organized and analyzed. Student enrollment at Ilkerin- Loita Boarding Primary School (ILBPS) during last five years, from 2008 to 2012, was compared and used to calculate the enrollment growth rate. The total water consumption during the dry season was calculated by multiplying the total student water consumption with the sum of the days in a dry season. Based on the school's estimation, average daily water consumption per student is a minimum of 5 liters per day, and a dry season is about four months, 120 days, from late July to late November [9].

To predict the next five years of school water demands, we used daily water consumption multiplied by future enrollment of students, based on an assumption that school enrollment would steadily increase in an average rate of the last five years.

Result

For last five years, ILBPS's enrollment growth rate was 12.89%. The statistics of annual enrollment and average growth rate are given in Table 1.

Year	2008	2009	2010	2011	2012	Average Growth Rate
Commute Student	326	381	379	395	549	13.68%
Boarding Student	164	187	195	214	255	11.09%
Total	490	568	574	609	804	12.89%

The estimated enrollment of future five years (2013-2017) and water consumption in dry season (120 days) were given in table 2.

Year	2013	2014	2015	2016	2017
Estimated Enrollment	908	1025	1157	1306	1474
Estimated Daily Water Consumption	4540	5125	5785	6530	7370
Estimated Water Consumption (120 days)	544,800	615,000	694,200	783,600	884,400

In 2012, ILBP School had water storage capacity of 100,000 liters. There were nine tanks in school for storing water. Two of them were cement tanks, which were constructed in 2002. The tanks were used for storing water pumped from Empaash Dam nearby. Both tanks together had a capacity of 30,000 liter. The water stored in these tanks was muddy and become very dirty at the end of the dry season when dam water was used up. For the purposes of hygiene and disease prevention, the school employed both chemical and boiling methods to purify this water for student consumption. The tanks were refilled on a weekly basis and provide about 480,000 liters of water for school in a dry season of four months.

Beside these cement tanks, seven plastic tanks, with total capacity of 70,000 liters, were used to store rainwater from its established water harvest system. Two of the harvest tanks were installed in 2004, and five were installed in 2009. In a rainy season, rainwater is collected into tanks by leading gutters, which were constructed around the roof of school buildings. These tanks were covered when they were full or when the weather was dry. Water could be fetched from a faucet at the bottom of each tank. School allowed students to directly take the tank water for drinking and reported that no case of illness was related to using this water source.

Both the water harvest system and refilled cement tanks supply total 550,000 liters of water for school in a dry season of four months, based on an assumption that the cement tanks were refilled weekly for sixteen weeks.

After conducting analysis on the school's current water supplies and future water demand, we found that the school's water demand exceeds its supplies after 2014 (550,000< 615,000), while it has the ability to meet its water demand in 2013 (550,000> 544,800). The gap between school demand and supply starts from 60,000 liters in 2014 to 144,200 in 2015 and further to 233,600 in 2016 and 234,400 in 2017.

Three water resources in the Ilmarai area were of potential use for school water supplies, including Empaash Spring, Osukunua Dam, and Enkoseremai Borehole. Empaash Spring is located at the edge of Empaash Dam, and provides spring water year-around. Two years ago, the pipe that carried water out from underground was broken and had not been repaired until the time of our visit.

The Osukunua dam, a major water resources for the nearby, most populated villages is located about 2 kilometers away from the school. Without a water pipe, its distance creates a physical barrier for school to fetch water in severe drought. The school only uses this dam water when the Empaash dam dries out in a severe drought.

Enkoseremai Borehole is located about 7.5 kilometers from school and is a permanent water resource for Ilmarai community. It was constructed in 2000 after the community was hit by several severe droughts and suffered big losses of both human life and livestock. The borehole has a water capacity of 6.5 km^3, and provides 50,000 liters of water daily through a pumping machine. To improve on the local community's resilience to climate change, Enkoseremai Borehole water committee planned to invest in a water piping system, an estimated 4-5 million Kenya shilling (approximately $50,000- $ 60,000) investment, to transport water to nearby villages and schools [10].

Discussion

For the last three decades, ILBPS water resource management has employed different water management strategies to cope with its steadily increased water demand and continuously changing climate. Fetching water from the dam was once a sufficient method to sustain its small number of students' needs when the school first opened its doors. The construction of two cement tanks reduced a big amount of labor and time cost for students, and, indeed, it improved the school's water supply capability and climate change resistance. As the most significant step for the school, the installation of a water harvest system enabled the school to have multiple water resources to sustain its long-term growth.

Although ILBPS has managed to meet its water needs, it has to find a more effective way to satisfy its increased water demand because it will confront a water crisis in the next two years. Finding problems that exist in current water resource management and seeking a permanent water source can be crucial factors to the development of the school and the Ilmarai community as a whole.

Two major issues that exist in current water resource management at ILBPS are the high dependence on dam water and an improperly maintained water supply. First, school highly relies on dam water, which is only a seasonal and finite resource. About 87% of school water supply is from the Empaash dam, which is also a water resource for people of nearby villages. Villagers fetch dam water for their daily consumption while they feed their livestock by herding them to the dam at a daily basis. As the dry season lengthens and the population of the village increases, the dam water will become insufficient to sustain all water needs, especially in severe drought. For example, in 2009, a year of severe drought, Empaash dam was completely dried out; school had to buy water from other places and pay for transportation. In total, it cost ILBPS about 100,000 Kenya shillings (approximately $1200) [9]. In the dry season, dam water has a higher evaporation rate which means less water storage in an elongated dry season and fast dry out time. Therefore, dam water is not an infinite resource due to the seasonal climate changes and increased human consumption.

Also, the current water pumping system that carries dam water to school is not reliable. The pumping machine is aged and breaks down frequently which results in no dam water supply during the repair time. The only machine for both Empaash and Osukunua Dams is often moved between the two dams in order to pump water for both local communities. Sometimes, this cause temporary water shortage when there is no machine pumping water for the school refilling.

Second, improper school water supply is linked to the problem of waste. The dam water often overflows out of the cement tank because of the lack of a monitoring system. Due to limited financial resources, cement tanks cannot be repaired immediately when they are damaged or have cracks, which cause a certain amount of water waste. Some of the buckets that carry water from tanks to classroom or dorms are overused or damaged which leads to the leakage of water.

To improve the school's water resources management, school needs to improve its water supply maintenance and replace damaged water storage equipment to prevent water waste. A student in-charged water-use monitor system may be implemented to oversee the quality of the water tanks and supplies and inform any water-use related issue to the school administration. The system can help school to save water on a daily basis and prevent the leakage of water storage structures.

Nevertheless, the most important strategy for school is to find a permanent water resource to increase its climate change resistance and to meet its demands in the future. ILBPS is exploring two options for this, including piping water from Enkoseremai borehole and constructing an underground tank on campus. Enkoseremai borehole is a permanent water resource for the Ilmarai community, and it can supply enough clean, underground water for school if the water piping system is installed. ILBPS also has a plan of installing underground tanks since there is enough land that allows for this construction [11]. Underground tanks can store water in a relative sterile environment, which can reduce bacteria growth and decrease the water evaporation rate. Both plans offer solutions for ILBPS to improve its water resource management and increase its climate change resistance capability. From the Ilmarai community point of view, school improvement will lead to increased settlement and population growth; as a consequence, this will lead to the development of the community as a whole.

Some possible limitations in the research should be mentioned. First, the enrollment growth rate for future five years was based on the average enrollment growth rate of last five years, so there will be a disparity when the actual school enrollment is increased or decreased which will also lead the changes of the school water demands.

Second, the total 480,000 liters water supply from Empaash Dam was estimated according to its ideal refilling ability that the two cement tanks would be refilled in every week for sixteen weeks in a dry season. In reality, the actual water supply may less than this estimation due to the unreliable pumping system and the dam's continuously deteriorated water storage condition.

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