Engineering Education as a Pathway to Sustainable Solutions

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Abstract – Mercer University School of Engineering instated a Master of Science in Engineering for Environmental Engineering in the Fall 2009 Semester. The vision for this program would not be solely scholastic, but would allow Environmental Engineering Master's students to engage in hands-on experience, working closely with representatives from various developing countries and aiding these communities by providing sustainable designs to fit their needs. Guided by the United Nations' "Millennium Development Goals" and the concept of "Quick Wins", these projects will not only provide an unparalleled experience for the student, but more importantly, they will yield programs, solutions, and sustainable technology that will aid in the UN's goal of reducing the effects of poverty by the year 2015. The first project pursued in this program is the creation of water supply and filtration tools for the Sisit and Loongeiwuan communities in the Northwest Rift Valley Province of Kenya.

Keywords: Service-learning, study-abroad, sustainable design

INTRODUCTION

Water is fundamental for life and health. The human right to water is indispensable for leading a healthy life in human dignity. It is a pre-requisite to the realization of all other human rights.
- The United Nations Committee on Economic, Cultural and Social Rights, Environment News Service, 27 Nov 02

In many parts of the world, potable water is a precious commodity. Much like gold, diamonds and oil, wars have been fought and people killed over the pursuit of clean water. Vital to human health, growth and development, water composes two-thirds of the human body, is useful for cleaning, cooking and drinking, and is integral to the agricultural industry. Proper provision of potable water and effective sanitation serves to reduce and correct illnesses due to ingestion or contact with contaminated water, from cholera and dysentery to guinea worms and other parasites. At bare minimum, the World Health Organization (WHO) estimates the average human needs at least 7.5 liters of water a day for drinking, cooking, and hygiene [7]. This requirement is easily met in the United States, where the population is provided with a seemingly inexhaustible supply of potable water—it is cheap, abundant, and readily accessible from any number of faucets in a home, business, or public building. Regulated by governmental standards and regulations, water is collected and treated to ensure it is safe and healthy for the public. American citizens use approximately 15 billion gallons of water a day for personal use, 36 billion gallons of water for manufacturing and industrial processes, and 100 billion gallons for agriculture and farming.

In other countries, however, water that is readily accessible for a community is often polluted—if not with human or animal waste, sometimes with industrial or toxic waste—especially as people who lived in rural communities

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gravitate towards jobs and homes in suburban slums. It is estimated that 2.5 billion people—or half of the developing world's population—lack proper sanitation facilities, and over 884 million people use water from unsafe sources [5]. As a result, retrieving potable water can be a rather involved task. Heavy machinery is often necessary to dig deep enough to access the aquifer needed to create a well supplied with groundwater. If a well is not readily available, it is common for an individual to walk anywhere between 1-5 kilometers to access a potable water source. 18% of Sub-Saharan Africans must travel to a water source at least half an hour away from their home, which often reduces the amount of water collected, since it must then be returned that same distance [WHO, 9]. According to the WHO, water scarcity also encourages people to store water in their homes for long periods of time, which increases the risk of providing a breeding ground to mosquitoes, carriers of malaria and dengue fever [8]. The lack of readily available potable water is also connected to feminine illiteracy and subsequently poverty, since women and girls are often expected to collect water, deal with refuse, and attend to those in the home who are sick and ailing. As a result, girls may stay home from school in order to complete chores on behalf of the family, spending long hours in line at the water source and then making the lengthy journey home, often sacrificing the ability to escape the chain of poverty through education.

Unfortunately, the need for potable water isn't the only issue that directly impacts world poverty. It is estimated that more than one-sixth of the world's population still lives in extreme poverty, which beyond clean water, implies the need for proper nutrition, health care and social requirements necessary for life, like education [United Nations, 3]. In 2000, determined to help halve the number of people living in extreme poverty by the year 2015, the United Nations resolved to pursue eight goals, known as Millennium Development Goals (MDG).

The eight goals seek to:

- eradicate extreme poverty and hunger
- achieve universal primary education
- promote gender equality and empower women
- reduce child mortality
- improve maternal health
- combat HIV/AIDS, malaria and other diseases
- ensure environmental sustainability
- develop a global partnership for development

Although there are only eight goals, they are obviously expansive and daunting in themselves. As a companion to the MDG, the United Nations has also provided a list of "Quick Wins"—projects that could efficiently bring aid to thousands of people while contributing to the MDG. A few of the Quick Wins are outlined, below:

- Training large numbers of village workers in health, farming, and infrastructure (in one-year programmes) to ensure basic expertise and services in rural communities.
- Eliminating user fees for basic health services in all developing countries, financed by increased domestic and donor resources for health.
- Eliminating school uniform fees to ensure that all children, especially girls, are not out of school because of their families' poverty
- Setting up funding to finance community-based slum upgrading and earmark idle public land for low-cost housing.
- Establishing, in each country, an office of science advisor to the president or prime minister to consolidate the role of science in national policymaking.
- Empowering women to play a central role in formulating and monitoring MDG-based poverty reduction strategies and other critical policy reform processes, particularly at the level of local governments.

A comprehensive account of Quick Wins may be found at the United Nations Millennium Project website [4]. As evidenced by this short list of goals, it is a tall order to provide for a poverty-free world. Therefore, it is necessary to enlist aid in all its forms: public and private, including businesses, churches, and universities.

PROJECT GOALS

Continuing in its strong tradition of academic excellence, the Mercer University School of Engineering (MUSE) instated a Master of Science in Engineering for Environmental Engineering in the Fall 2009 Semester. The vision for this program would not only provide students with a Master's degree, but also with the opportunity to engage in hands-on, service-learning experiences, working closely with representatives from various developing countries and aiding these communities by providing sustainable designs to fit their needs. Guided by the United Nations' MDG and the concept of Quick Wins, these projects will not only provide an unparalleled experience for the student, but more importantly, they will yield programs, solutions, and sustainable technology that will aid in the goal of reducing poverty by the year 2015.

The first project pursued under the scope of this service-learning option is concerned with providing potable water for communities in Kenya, and will be implemented by students participating in Mercer On Mission, a course option for undergraduate students that "blends service learning and study abroad," providing class credit for students while they engage in "serving peoples and cultures around the world" [Mercer University, 2]. After being accepted to the program, students spend two to three weeks on campus—studying under the professors who will join them on the trip to their given country of service—and then participate in a three week trip abroad. Through Mercer on Mission, students have provided prosthetics to amputees in Vietnam, served orphans in Guatemala, and will install a wind turbine to generate renewable energy for a school in Liberia. Trips have also been taken to South Africa, Kenya, Moldova, Brazil, Greece, and Thailand, with plans to add Malawi and Mozambique to the list of countries Mercer serves by this coming summer.

During the 2009 Mercer on Mission trip to Kenya, the team of students and professors worked with the "Kutana" Program through Africa Exchange, an organization whose mission is to "exchang[e] information, ideas and resources across cultures to promote mutual understanding and respect, resulting in works of Christian compassion among the poor and marginalized in sub-Saharan Africa" [Africa Exchange, 1]. Founded by Sam and Melody Harrell, Africa Exchange serves marginalized communities in each of Kenya's eight provinces. A small sampling of the services Africa Exchange has provided for the communities in the area include constructing integrated child development centers (ICDCs), assembling water catchment systems for the supply of potable water, and working with community members towards sustainability through income generation projects such as bee keeping and fish farming. Many of the programs and ideas developed by Africa Exchange are founded heavily in the United Nations' MDG and Quick Wins, with particular effort towards MDG #4, which pertains to infant mortality. According to their website, Africa Exchange wishes to focus on Quick Win targets including:

- Providing micro-nutrient (especially zinc and vitamin A) supplementation for pregnant and lactating women as well as for children under five;
- Providing regular annual de-worming to all school children in affected areas to improve health and educational outcomes;
- Distributing free, long-lasting, insecticide-treated bed nets to all children in malaria-endemic zones to cut decisively the burden of malaria;
- Providing free school meals for all children using locally produced foods with take-home rations;
- Eliminating school uniform fees to ensure that all children, especially girls, are not out of school because of their families' poverty;
- Providing access to electricity, water, sanitation for schools and other social service institutions using off-grid diesel generators, solar panels, or other appropriate technologies; and
- Providing community-level support to plant trees to provide soil nutrients, fuel wood, shade, fodder, watershed protection, windbreak, and timber.

In pursuing these goals, the next projects that Africa Exchange desires to implement aim to provide clean water to the people living in Sisit and Loongeiwuan, two villages in the Northwest Rift Valley Province. Loongeiwuan is located near Kenya's Lake Baringo, and Sisit is 75 miles to the northwest, neighboring the town of Sigor. The locations of these communities can be seen on the next page, in Figure 1. In Sisit, the project entails designing a system that will pump water from an irrigation raceway to a nursery school a half a mile away, as well as providing surrounding homes with water filtration systems. In Loongeiwuan, the goal is to identify and implement a method of using saline water to irrigate crops. In partnership with the MUSE, Africa Exchange plans to ensure the projects

are sustainable within the communities, and therefore, their solutions must be effective, while also simple in construction and use, low cost, and composed of locally available materials.

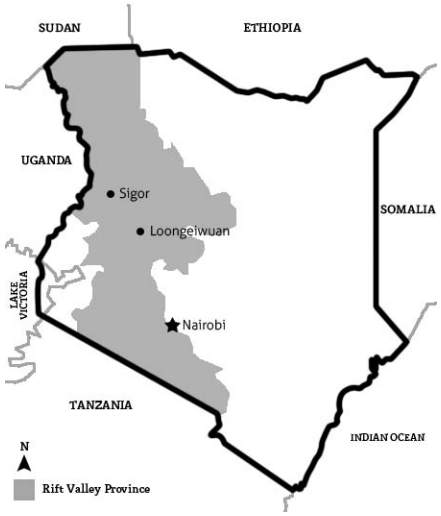

Figure 1. Kenya Project Locations

PROJECT SPECIFICATIONS

Kenya, like many other countries in Africa, is often subjected to a scarce potable water supply, due to recurring drought and also flooding during rainy seasons. Many areas are impacted by water pollution from urban and industrial wastes and degradation of water quality from increased use of pesticides and fertilizers [The World Factbook, 6]. The communities in Sisit and Loongeiwuan are fortunate, as they have a source of water within a reasonable distance from their villages. The people in Sisit draw their water from the Wei-Wei River, and the Loongeiwuan community has water provided by a borehole installed previously by Africa Exchange.

Sigor

Sigor's Sisit community, with help from Africa Exchange, hosts a nursery school where young children are taught according to the preferred curriculum for early childhood education. Without this early education, the children in the community would be at a disadvantage if and when they begin attending the local primary school. The nursery school—referred to as a CONSEP, or Community Operated Nursery School Enhancement Project—is currently supported through church and community donations. The teacher's salary, lunches for the students, and school supplies, are funded through these donations. A picture of the Sisit Nursery school may be seen below, in Figure 2.

Figure 2. Sigor CONSEP
Source: http://www.africaexchange.org/Sigor.htm

In line with the Quick Wins listed previously, Africa Exchange desires to provide a pathway for the Sisit CONSEP to operate in a self-sustaining manner, while encouraging the growth and health of the surrounding community. One

way this goal is being reached is through the creation of a water supply system that will generate revenue for the school while ensuring the village of Sisit has potable water for its inhabitants.

Currently, the girls and young women in Sisit walk half a mile to the Wei-Wei River to collect water, which includes a drop in elevation around 330 feet. Pumping water to the nursery school will provide water to the children and community, removing the burden of fetching water from the female population and encouraging them to pursue education. The water and household filtration systems will also be a source of income for the school; filters will be simple to construct and may be sold for a nominal fee to the families in Sisit. The proceeds could then be used for the expenses listed previously, including the teacher's salary and students lunches.

Due to the fact that electricity is not readily available in remote areas, the water supply system must be operated without the aid of electricity. Currently, the goal is to use a water-driven turbo pump to relay water from the irrigation raceway to the school. A connection point will also be provided so as to distribute water to the nearby Sangat community.

The filtration systems will be simple to construct and will be manufactured on site at the nursery school. Currently, the goal would be to pursue the water purification program through AquaClara International, which encourages a sustainable solution through locally available materials, training community members in construction and repair, and low capital, maintenance, and operation costs. An image of AquaClara filters in action can be seen in Figure 3, below. More information about AquaClara International may be found at their website, http://www.AquaClara.org/.

Figure 3. AquaClara Filters
Source: http://aquaclara.org/where-we-work/see-photos-of-our-site-work/

Loongeiwuan

Loongeiwuan, like Sisit, provides education for pre-primary school aged students. Currently, water is supplied through a borehole, solar pumped to a 15,000 liter tank located 6 meters above ground, and then gravity fed to another 4400 liter tank bone-char filter, which serves to remove fluoride from the water supply. Africa Exchange hopes to use the water at Loongeiwuan for irrigation of crops, further encouraging the community to become self-sustaining. A photograph of the system in use at Loongeiwuan may be seen in Figure 4, on the following page.

Figure 4. Water Supply Tower at Loongeiwuan

While the water is currently acceptable to drink post-filtration, it has a high sodium absorption ratio, which has thus far prevented its use for irrigation of crops, since the extended application of salt in the soil can potentially kill any plants and destroy the soil quality.

Thus, the challenge in Loongeiwuan is to provide a method of either bioaccumulating the salt through the use of plants that will not be harmed by salt water, or by desalinating the water before it is administered to the crops. While reverse osmosis is costly and requires a large amount of energy to operate, there is evidence of some low-cost filtration systems—namely the Dutyion Root Hydration System—that will allow for the removal of salt from a water supply as it waters the crops through drip-irrigation. Further research into the Dutyion Root Hydration System is required. More information can be found at Dutyion's website: http://dti-r.com/.

CONCLUSION

With close to five years remaining before the United Nations' deadline of 2015, the Millennium Development Goals are still far from being reached. It is of vital importance that those with the time, knowledge and resources join in the vision and push to engage the most marginalized in hopes that world poverty can be solved and subsequently eradicated. Mercer University desires to pursue for the provision of sustainable solutions to communities in need, through programs like Mercer on Mission and the service-learning opportunities offered through the Mercer University School of Engineering.

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