The Effects of Gender and Society on the Sustainability of EcoSan Projects in Kenya

By:
Tyson Kanzaki
51209654

September 2011

Thesis Presented to the Higher Degree Committee

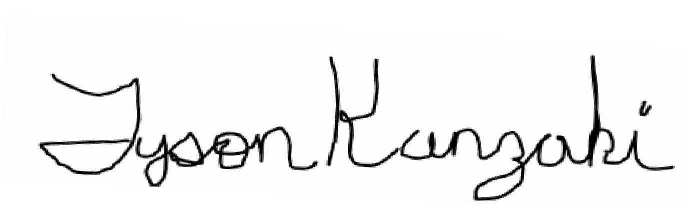
of Ritsumeikan Asia Pacific University

in Partial Fulfillment of the Requirements of the Degree of

Master of Science in International Cooperation Policy (IMAT) Specialization:

Environmental Policy and Administration

I, Tyson Kanzaki, hereby affirm that I am the author and editor of this thesis titled: *The Effects of Gender and Society on the Sustainability of EcoSan Projects in Kenya.* My master's thesis was written from May 1st 2011 to June 30th 2011 under the supervision of Professor Doctor Malcom Cooper of Ritsumeikan Asia Pacific University. All materials within this paper have been attributed to credible sources and I affirm that nothing has been plagiarized. I do not own any content or materials from: the European Union, UNESCO, WHO, GIZ, SIDA, SuSanA.org, or EcoSan contained within this thesis.

Signed: 

Date: August 17, 2011

Acknowledgements

I would like to thank the staff and members of the Institute for Applied Material Flow Management (IfaS) for their support and expertise in the field of wastewater management. I would also like to thank Dr. Elizabeth von Muench and Christian Rieck of *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) for their support and expertise in the field of EcoSan. Lastly, I would like to thank Professor Doctor Malcom Cooper for his guidance and supervision of this master's thesis.

Executive Summary

Ecological sanitation, or EcoSan, is a relatively new concept in the world, more so in developing nations. Rural residents in developing countries often do not have access to modern technologies and services that manage waste effectively and safely. The demands for freshwater are growing worldwide and those living in impoverished nations desperately need solutions for improved water access, quality, and conservation. EcoSan technologies and management concepts help to conserve precious water by reducing the demand for freshwater while capturing vital nutrients from waste. The result is that water resources are spared, less water is needed for agriculture, and excreta are safely and sanitarily contained. The beauty of EcoSan is that it is able to create several "win" situations with minimal funding and materials. Ecological sanitation is more a matter of management rather than expenses or technologies.

In regards to Kenya, there are numerous problems associated with poor sanitation practices. Deficient sanitation can lead to multiple problems such as disease, pollution, and other nuisances such as odor. The management of human excreta and overall sanitation in Kenya is done using conventional westernized techniques which are heavily reliant upon fresh water sources. EcoSan seeks to change prevailing methods of waste management into efficient and ecologically sound systems. A tool that is fundamental in changing the current sanitation systems to EcoSan models is capacity building.

Sustaining EcoSan projects in Kenya can only be done by educating the local people. Capacity building is more than simply passing the knowledge to the people. Lectures or campaigns will simply show them *what* is being done and *how* to replicate EcoSan. But, showing them *why* EcoSan is important and ultimately necessary is the core of capacity building. With proper sanitation knowledge alone, other aspects of Kenyan society can eventually benefit. Kenyan women

in particular have the potential to influence the projects for several reasons which can work for mutual benefit.

In Kenya, the task of procuring fresh water tends to be left to the family member that manages household chores which are usually women. It is therefore no surprise that women's groups made up a majority of the participants in EcoSan seminars. One of the main purposes for fetching fresh water is for regular household sanitation. EcoSan concepts are able to save valuable water or in many cases lessen the work load for the women. As there will be decreased demands for fresh water in the household, more water can therefore be saved for other purposes such as drinking or cooking. Thus women will have to spend less time for daily chores. In this one instance, the quality of life on a micro-scale can be drastically improved while providing education on environmentally friendly technologies.

Finally, EcoSan brings a new understanding of what waste really is. The projects show that there is no such thing as waste. Instead, "waste" is actually a resource in the wrong place at the wrong time. Human excreta have countless uses in daily chores such as farming. There are several valuable minerals in human waste that can be recaptured with proper techniques. The result is that the recovered materials can be used as fertilizers or soil conditioners. Human excreta can effectively and safely supplement precious food supplies. The improved availability of sustenance undoubtedly affects society and gender in positive ways that will usher in greater opportunities for the future.

EcoSan is a system focused on changing current practices in Kenya and the benefits are clearly multifaceted. Improved sanitation alone can bring health and prosperity. The recapturing of essential nutrients from excreta provides less fortunate farmers opportunities to increase their yields. The introduction of new environmental techniques and technologies will empower locals, especially women, as pseudo environmental managers. The women can then build upon their knowledge of sustainable sanitation which will lend numerous possibilities in enhancing their societal standing. Essentially, EcoSan is capable of bringing far more than just sustainable waste management to Kenya.

Table of Contents

Table of Acronyms, Units, Glossary, Key Locations

Acronyms

Organizations / Institutions

- **AI =** Amnesty International
- **CEDAW =** Committee on the Elimination of Discrimination against Women
- **CTLS =** Community-led Total Sanitation
- **EPP =** EcoSan Promotion Project
- **EU =** European Union
- **GIZ =** *Deutsche Gesellschaft für Internationale Zusammenarbeit* (German Agency for International Cooperation) [formerly GTZ]
- **HCES =** House Centered Environmental Sanitation
- **MDG =** Millennium Development Goal
- **NAWASCO =** Naivasha Water Services Company
- **SIDA=** Swedish International Development Cooperation Agency
- **SuSanA.org =** Sustainable Sanitation Alliance (official website)
- **UNESCO =** United Nations Educational, Scientific and Cultural Organization
- **WHO =** World Health Organization
- **WTSF =** Water Services Fund

Terms

- **BOD =** Biological (-chemical) Oxygen Demand
- **COD =** Chemical Oxygen Demand
- **DHO** = District Health Officer
- **HF =** horizontal flow constructed wetland
- **OD** = Open Defecation
- **ODF =** Open Defecation Free
- **UASB =** Up-flow Anaerobic Sludge Blanket Reactor
- **UD =** Urine Diversion/Diverting
- **UDDT =** Urine Diversion Dehydration Toilet
- **UV =** Ultraviolet
- **VF =** vertical flow constructed wetland

Units

- **g =** grams
- **kg =** kilograms
- **p.e. =** population equivalent
- **km =** kilometer
- **cbm (m3) =** cubic meter
- **Ksh =** Kenyan currency (Kenyan shilling)
- **EUR =** European Union currency (Euro)

Glossary

- **Aerobic =** presence of oxygen
- **Anaerobic =** in the absence of oxygen
- **Bellagio Principles =** a paradigm developed by an international panel of experts in 2000 in Bellagio, Italy. The paradigm set forth four distinct principles about wastewater and the need for sustainable management for wastewater.
- **Biodigester** = a containment tank or compartment in which organic matter can degrade and break down to produce biogas.
- **Biogas =** the gaseous byproduct of anaerobic processes
- **Biomass =** organic matter that can come from various sources such as: municipal solid waste or agriculture.
- **Biomethane =** the fraction of biogas that is pure CH_4. Roughly 50 - 60% of biogas is methane. It requires scrubbing processes to yield pure CH_4.
- **Black water =** wastewater containing urine and feces integrated
- **BOD5 =** the amount of oxygen that aerobic bacteria consume over a period of 5 days in a controlled setting.
- **Brown water =** wastewater containing only feces
- **Capacity Building =** the transferring of know-how to people or settlements that previously did not have the knowledge or know-how.
- **Constructed Wetland =** an innovative system which "polishes" wastewater before it is discharged to surface water. Wastewater is essentially inputted to the wetland and natural processes remove residual organic matter with little to no energy requirements before during operation.
- **Digester =** see biodigester
- **Ecofeminism =** ideals of ecology and feminism integrated. Coined in 1974 by French feminists, the concept essentially states that women and the environment metaphorically share similar burdens in terms of equivalent struggles.
- **Effluent =** residual wastewater after some sort of treatment has been done to it.
- **Fertigation =** fertilization and irrigation integrated

- **Gender =** a term referring not only to the sex of a person, but the social role or stereotype associated to the sex of the person.
- **Green water =** rainwater
- **Grey water =** wastewater from kitchen sinks, dishwashers, clothes washers, shower water, bathroom sink water etc.
- **Ground water =** water sources that are located below the surface. Ground water resources require some physical alteration of nature in order to tap it.
- **Know-how =** education or knowledge, usually in the field of engineering or sciences, that can be transferred via seminars, classes, media etc.
- **Onsite =** meaning that the boundary of activities is limited to the project's location and not for example at the company's headquarters.
- **Pilot =** usually small-scale, a project that is intended to test theoretical methodologies in practice as well as observe the acceptance of the project by locals so that it can be estimated if further projects would be feasible.
- **Sludge =** the residual matter accrued from wastewater, usually containing high amount of water, but more solids.
- **Surface water =** water sources that are located on the surface. These sources of water are usually in the form of rivers, lakes, oceans, etc.
- **Sustainable Development =** a disputed term that essentially means developing a range of entities (ex. social, industrial, financial, economical) with the foremost regard being held for future generations.
- **Wastewater =** the water that is flushed or transported away from systems such as: households, community living quarters, industries etc.
- **Yellow water =** wastewater containing only urine

Key Locations

- Gachoire Girls High School in Kiambu, Kenya (central Kenya)
- Khaimba Primary School in Butere, Kenya
- Naivasha Bus Park in Naivasha, Kenya
- Rachuonyo District, Kenya Ramba Boys High School in Ramba, Kenya

Table of Figures

Chapter 1: Introduction

Within the confines of ecological sanitation in Kenya, gender and key social factors positively influence the sustainability of EcoSan projects whereas it can potentially exacerbate current gender injustices as well. Gender equality in developing societies has multiple roles in adapting ecological solutions for environmental issues such as sanitation. The sustainable management of wastewater, which is foremost intended to improve sanitary conditions, can benefit the overall well-being of the Kenyan region. In particular, the capacity building element of the projects adds significant value to the social sphere due to the current conditions of gender equality in some rural Kenyan areas. EcoSan projects aim to sanitarily capture, contain, and reuse all flows of human waste for varying applications including energy production. Namely the sustainability of the projects is the underlying motive of EcoSan (UNESCO, 2006). The current EcoSan projects in Kenya serve as case studies that solidly link social conditions to sustainable sanitation. In the scope of gender equality, aspects such as societal and cultural norms, technology transfer, and capacity building should be considered before analyzing the sustainability of Kenyan EcoSan projects.

What is EcoSan?

EcoSan, which is short for ecological sanitation, is a management scheme that focuses on a sanitary and closed loop system of human waste. It is often regarded as a mindset, meaning that human excreta are not viewed as waste. Rather, excrements are managed as a resource that contains precious components for numerous applications. EcoSan employs a clever combination of innovative management schemes and technologies to improve sanitation conditions. The methodology of EcoSan is to first identify all wastewater flows and their potentials. The wastewater is then segregated into several distinct components which are mainly: yellow, brown, black (the combination of yellow and brown), and greywater. Sometimes greywater is also included in black water. Each component of wastewater carries valuable resources and materials that can be efficiently recovered or exploited. For example, yellow water that comes from urine flows can be separated at source using a specialized toilet. Brown water, which comes from feces, is thusly separated as well. The two main components of human excreta are used in several applications such as agriculture and landscaping. Greywater comes from dishwashing, clothes washing, shower water, and hand washing basins. It can be treated with UV light and filters mainly for reuse purposes only. Greywater does not have a high calorific value or significant amounts of nutrients. Lastly, rain water can also be collected and used for sanitation. All flows of wastewater are separable and therefore "recoverable" which is done using high-tech and low-tech approaches (UNESCO, 2006).

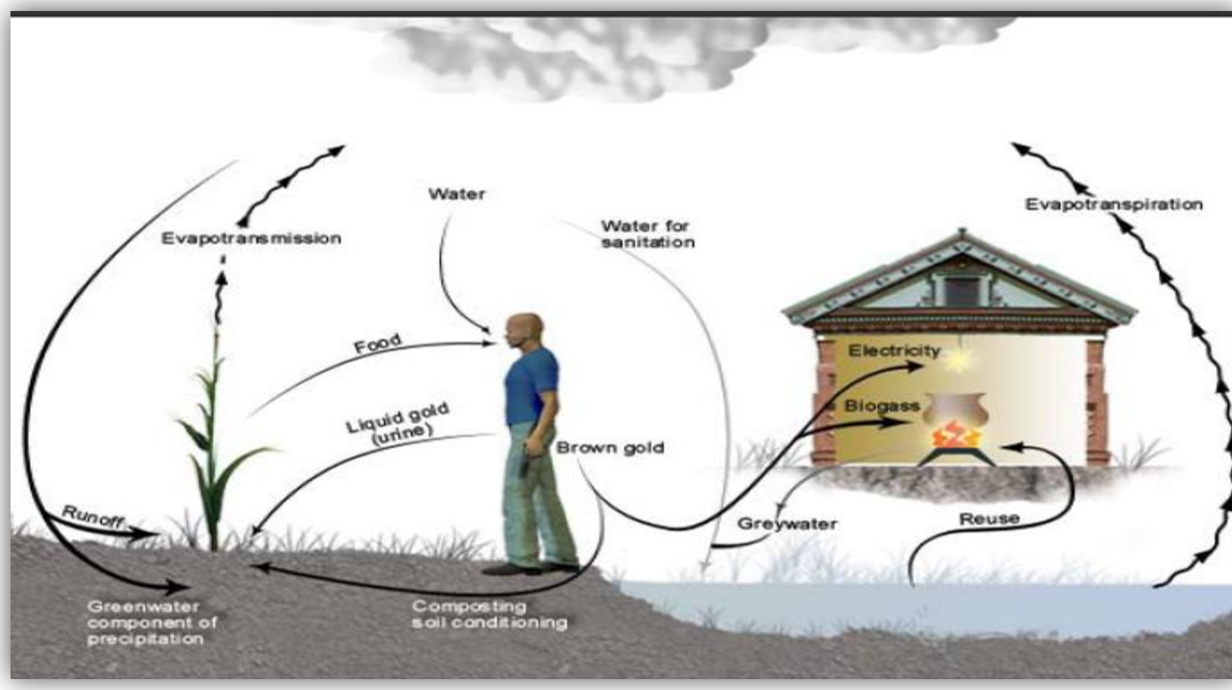


Figure 1: A micro-level guide showing where the various flows of human excreta end up and their applications
Note: the system is a closed loop. Greenwater is rain (Odhiambo et al, 2009).

EcoSan projects provide several types of technological solutions for sustainable human waste management. Some of the technologies are basic, low-tech, and low-cost solutions such as retrofitting old outhouses with better and more weather-proof toilets. Others incorporate a closed loop system where the human excreta are contained and treated so that it yields high amounts of biogas. Biogas contains a useable and non-useable fraction. Depending on conditions such as climate or material inputs (such as manure or organic waste) approximately 50-60% of the bio-gas is useable in the form of methane (in this case it is called biomethane since it was derived from biomass). The biomethane is used for onsite applications such as cooking or water heating. Regardless of the complexity of the waste system, it requires technology transfer. The successful transferring of technology relies upon several factors for functionality. Operation and mainten-ance must be able to be taught in order to provide complete usage. As well, the utility of the new systems must also be reinforced in a way that encourages people to believe in the potentials of human waste. For example, some high-tech systems treat waste and then use it for composting. In order to avoid possible groundwater or food supply contamination, careful monitoring and management are crucial to the success of the overall system of waste to sanitation to energy to food.

Projects using EcoSan are found throughout the industrialized and developing world. There are several reasons why most current wastewater systems need improvements. A primary reason is due to the fact that safe freshwater sources are dwindling worldwide. One study showed that by 2025 one in every three people will be living in countries with short supplies of drinking water (Devasia, 2002). Ecologically sustainable management of wastewater will not only im-prove sanitation conditions, it will also reduce dependence on water. Because of the relative scarcity of freshwater throughout the world, EcoSan has worked to develop methodologies that conserve water while preventing leaching/pollution to the environment. Starting in 2001, the German Federal Ministry for Economic Cooperation and Development commissioned GIZ to start an international EcoSan program. For example, in the GIZ (*Deutsche Gesellschaft fuer Internationale Zusammenarbeit* – German International Cooperation) headquarters in Eschborn Germany, UDDTs (urine diverting dehydration toilets) were installed as a testament to the organization's commitment to sustainable sanitation (Winker and v. Muench, 2009). EcoSan is strongly influenced by the Millennium Development Goals (MDG) in targeting sanitation for improvement. Ideally, EcoSan projects are intended to improve sanitation conditions that ultimately work towards other MDGs such as: reduced child mortality, enhanced primary education, and cleansing the environment. In the case of Kenya, GIZ works with several other organizations and government entities to implement EcoSan projects (V. Muench, 2009).

EcoSan concepts closely follow guidelines set forth by the "Bellagio Principles." The principles were founded in Bellagio, Italy in 2000. A group of international specialists developed a new paradigm in order to better achieve sustainability in wastewater management and reaching goals set by the MDGs. Specifically the House-Centered Environmental Sanitation Approach (HCES) closely mirrors those exhibited by EcoSan. The four principles are as follows:

- *Human dignity, quality of life and environmental security at household level should be at the center of the new approach, which should be responsive and accountable to needs and demands in the local and national setting.*
- *In line with good governance principles, decision making should involve participation of all stakeholders, especially the consumers and providers of services.*
- *Waste should be considered as a resource, and its management should be holistic and form part of integrated water resources, nutrient flow and sanitation.*

- *The domain in which environmental sanitation problems are resolved should be kept to the minimum practical size (household, community, town, district, catchment, city) and wastes diluted as little as possible* (UNESCO, 2006).

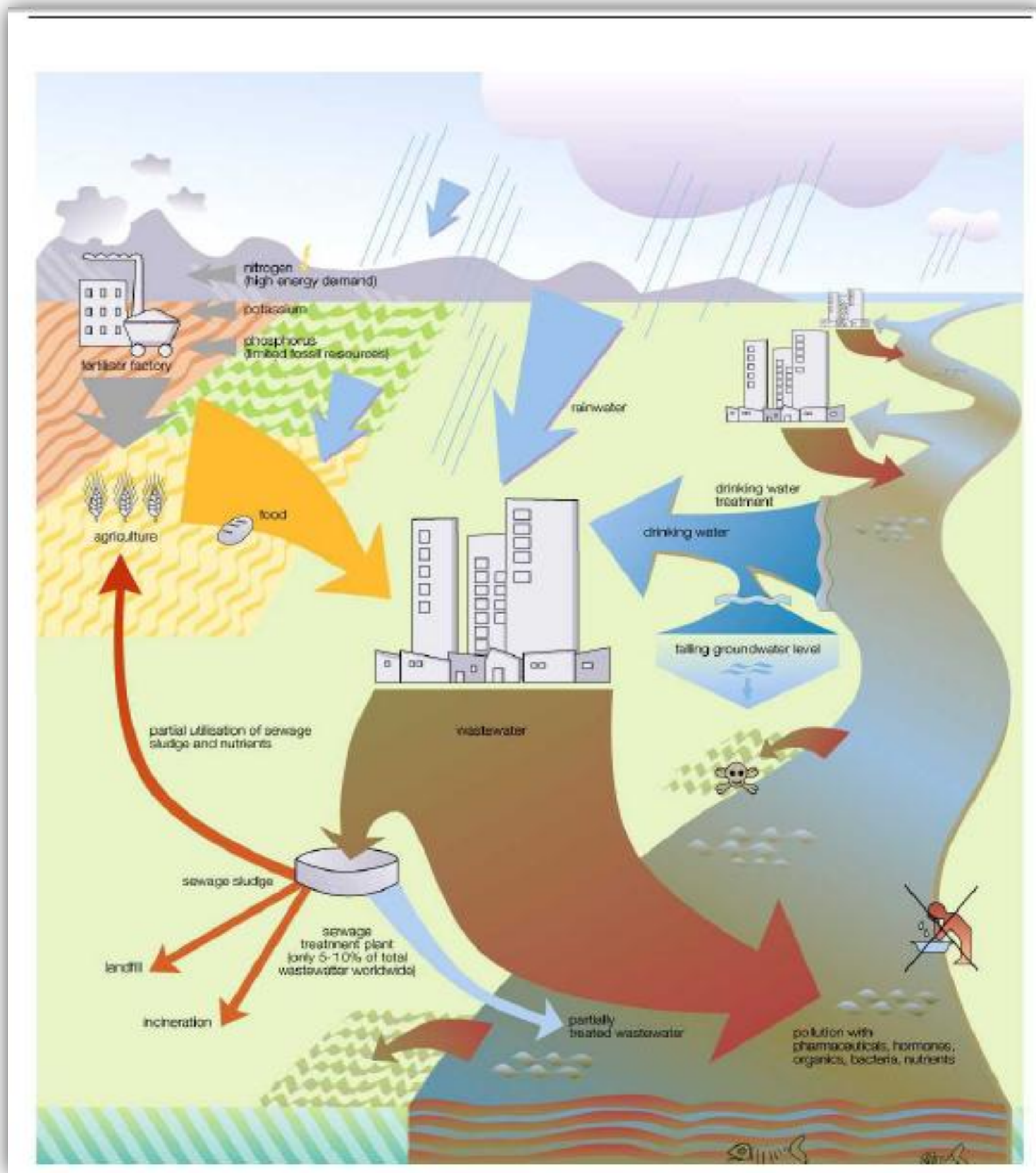


Figure 2: Region without EcoSan concepts implemented

The illustration depicts the potential effects of conventional wastewater treatment systems. Note: all regions upstream practice the same wastewater management schemes which affect every region downstream (Source: UNESCO, 2006).

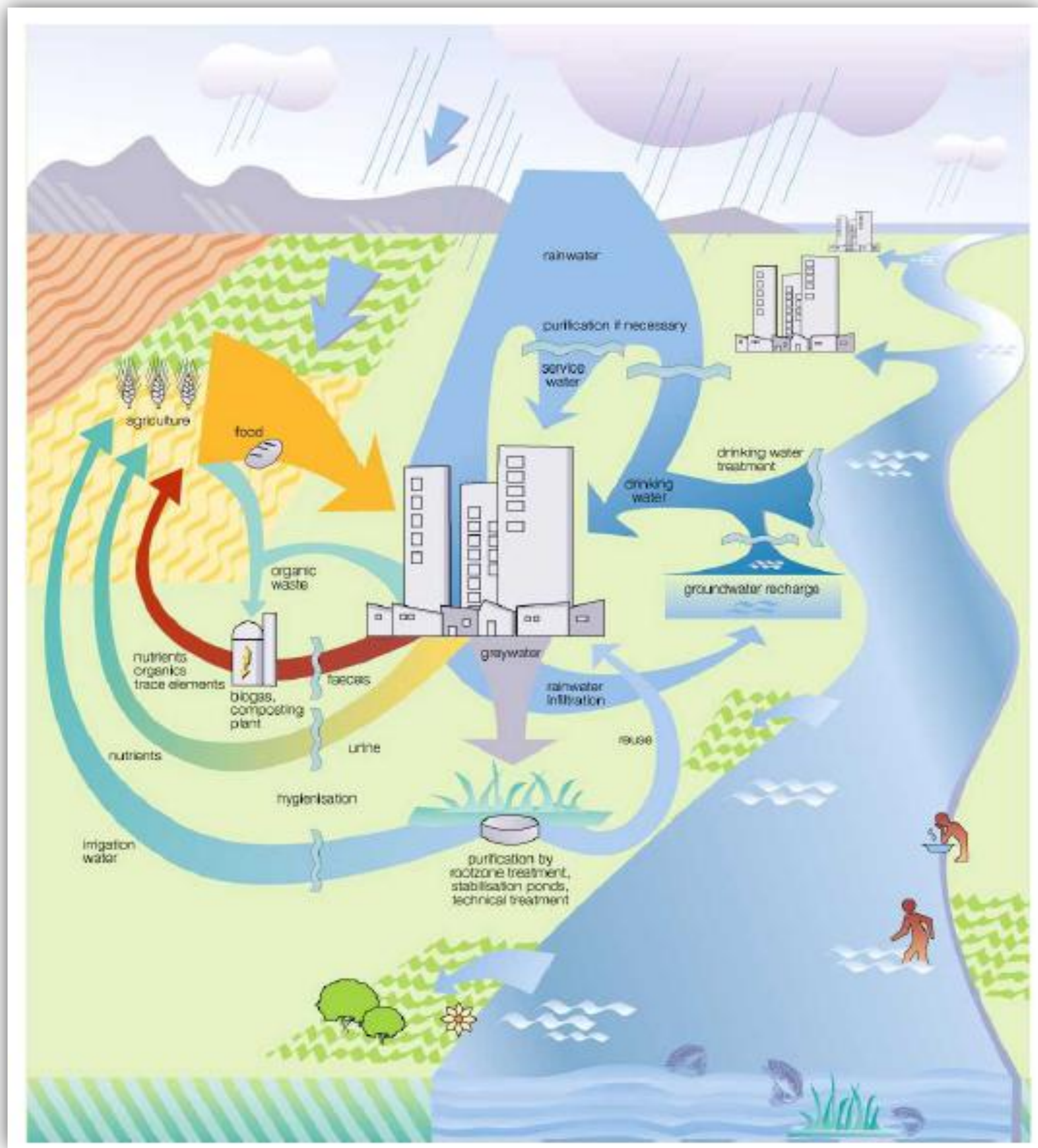


Figure 3: Region <u>with</u> EcoSan concepts implemented

All flows of wastewater are separated and reused. The result is that the adjacent bodies of water are left unpolluted and all regions downstream are therefore unpolluted (Source: UNESCO, 2006).

Some of GIZ's EcoSan goals include: knowledge management and information dissemination, networking via internet groups, raising awareness, and support for EcoSan projects. Knowledge management for EcoSan projects is crucial to the success of the programs. Information is disseminated by EcoSan through easy to access mediums such as DVDs, websites, seminars, and print media. EcoSan works closely with SuSanA.org, which is short for Sustainable Sanitation Alliance. The website acts as a networking medium in which all of the international EcoSan project developers, colleagues, affiliates, and academics can access and exchange information regarding EcoSan projects. Some of the countries that are partnered with SuSanA.org are: Australia, Austria, Brazil, China, Ethiopia, India, Japan, the United Kingdom, and the USA (SuSanA.org). Raising awareness on EcoSan is essential in the acceptance of its projects. Basically GIZ seeks to turn EcoSan concepts into conventional practices. A tool used by EcoSan project developers is capacity building (also called capacity development) in order to transfer knowledge or "know-how" to local users. If local users and engineers are unable to sufficiently operate and maintain EcoSan systems, the idea of sustainability is thusly lost. Lastly, EcoSan projects tend to start as "pilots." Most pilot projects are small-scale due to the fact that less overall investment is needed while it serves as a test of the theoretical side of projects. Pilot projects provide opportunities to demonstrate EcoSan concepts while simultaneously educating locals. In particular the capacity building element of project implementation is vital to the success of EcoSan because it implies sustainability. Regarding Kenya, the sustainability of EcoSan will eventually contribute to the overall sustainability of the region in terms of health and social welfare (v. Muench, 2009).

Chapter 2: Gender

One of the most prevalent societal norms in the world is gender inequality. Gender refers not only to the sex of people, but it also carries a social meaning. Naturally, the degree or extent of gender inequality can vary between cultures, especially between industrialized and developing nations (Suda, 2002). For example, most industrialized countries have outlawed any type of discrimination based on sex while several developing nations still have loosely interpreted gender – related rights. Since it is easier to discern prejudice based on the sex of a person, gender-related acts of discrimination are more frequent because they are difficult to prove. It is especially common in developing nations to have a sort of institutionalized and accepted system of gender inequality. For example in Kenya, the country has clearly defined laws that ban sex discrimination in the workplace (Onsongo, 2006). Statistics show significant gaps in employment numbers between males and females. Several studies have shown that the disparity in numbers is not a result of personal desire by women rather it is an institutional barrier (Goldsmith, 1999). The problems are that the laws are not strictly upheld and probably lack adequate monitoring methodologies. The inefficiencies therefore create some grey areas in the enforcement of the laws on gender discrimination (Mareng, 2010).

Generally, women today still face injustices such as underrepresentation, job immobility by the "glass ceiling," or workplace harassment (Suda, 2002). Predominantly in developing nations, women often lack several of the rights that their counterparts in the developed world have. For instance, non-discriminative and uninhibited access to education is a prominent issue. On average more women in the world are becoming educated and are even outnumbering the amount of males in higher education institutions. In spite of the rise of more women participating in higher education and thusly social mobility, gender inequality in learning establishments still remains (Mareng, 2010). It is also common that women in developing countries tend to lack a unified voice that can change institutional gender-related barriers. Thus, the formation of women's rights groups, organizations, and institutions have led the way in the advancement of gender equality.

There are several international support organizations that have historically worked for the empowerment and advancement of women everywhere. One internationally binding milestone was the 1981 United Nations Convention on the Elimination of All forms of Discrimination Against Women (CEDAW). The convention was aimed at institutionally tackling gender inequalities at the company level all the way to the national level worldwide (un.org). The injustices of gender inequality are profoundly echoed in Kenya. Institutionally or socially, most Kenyan women are subject to discriminative barriers. When analyzing the admissions statistics of public Kenyan universities alone, the issue of gender inequality is quantifiable with staggering results. Females make up approximately one-third of the total student population in some Kenyan universities. There is also a stark dichotomy between the fields of study chosen by female and male students. Male students gravitate in the direction of sciences or engineering in which both majors offer great potentials for higher pay, upward mobility, and advancement to further studies. Mostly female students choose the education and environmental faculties. The particular faculties do not lend the students the opportunity to have prestigious positions in the future or even further education such as PhD studies (Onsongo, 2006). With regards to EcoSan, it is expected that having more women in environmental sector jobs will lead them to better job mobility and hopefully higher social standing. Conversely, limiting women to waste management jobs or duties could act to hinder gender equality efforts and reinforce current gender biased practices (Kunst, 2002).

Women and the environment

As posited by Vandana Shiva, an award-winning quantum physicist, women are linked to the environment through resource management. Specifically, water is the resource that women throughout the developing world are responsible for procuring. The reliance on women to fetch water for daily chores and cooking makes women more or less managers of water resources (Burmester et al, 2002). Women also have the ability to give birth which can be directly linked to consumption since they are the ones bringing new consumers into the world. Thus, Shiva's thesis implies that women are much closer to nature and are therefore more capable of preserving it. The link between women and the environment is often not a clear or directly defined relationship. In Kenya, there are several ways that women are more or less linked to the environment such as: the high number of female students in environmental studies, societal expectations that women should be homemakers which means they will likely be managing natural resources, and the involvement of women's groups in environmental trainings to help keep their families healthy (Goldsmith, 1999). The perception of women being linked to the environment has been the subject of several studies which have produced diverse outlooks.

Ecofeminism was coined by a group of French feminists in 1974. The term helped to reinforce the theory that women share similar burdens that the environment does. In this theory, it basically says that women and nature are in a sense being dominated. Other authors expanded on the theory by concluding that Western culture views nature as something to be mastered. So, it is believed that nature is in a sense feminized in Western thought. Even sexually charged imagery such as "virgin forest," "raping of the Earth," and "penetrating nature" are commonly used terms in Western rhetoric (Okazawa-Rey and Kirk, 2006). A remark could be made about the common expression "mother nature." The expression indisputably bolsters the notion of women being compared to the environment. It implies that nature is something that produces or provides, similar to what any motherly figure naturally does.

Shiva argues that women's bodies are objectified in this manner. The Western development model commodifies "sources" (such as living things that can produce and sustain life) and their ability to be turned into "resources." For example, rivers or forests can be productive which makes them economically useful. But a river or forest that is not being exploited for its resources is fundamentally viewed as unproductive (Okazawa-Rey and Kirk, 2006). In addition to this argument, Bina Agarwal, a professor of Economics, posits that having ownership of resources means that one's economic independence is also enhanced. Access is important, but control over resources is vital to having complete leverage. Having economic bargaining power leads to a stronger voice in society as well as the household Agarwal argues. The study by Agarwal lends great attention to the implications of resource ownership. Her arguments do not include issues existing in reality such as prevailing practices. Social norms usually have the potential to become barriers for the acceptance of women gaining ownership of resources. A more contemporary approach to linking women to the environment is through the concept of sustainable development (Burmester et al, 2002).

Women are now being included in studies about sustainable development because of their ability to affect population growth. It is widely held that humans are likely the biggest environment-changing beings on Earth. The study of sustainable development accounts for the survivability of future generations. It must follow that women have the potential to affect the sustainability of the environment. In the case of EcoSan in Kenya, the reasoning behind welcoming particularly women for capacity building seminars was to work within the boundaries of Kenyan social norms.

Capacity building

Lastly, the challenge of capacity building can be daunting if innovative technologies and management schemes are the focus of the know-how transfer. Acceptance by the locals is crucial because the system ultimately fails without proper operation and maintenance. Practices that are heavily influenced by prevailing methods are often the first barriers to overcome. For example, capacity building that targets women in the training of the new waste management schemes can have several consequences (UNESCO, 2006). In Kenya it is common for women to manage household organic and human waste. Therefore it is convenient to target women in adopting the new waste management schemes. In the case that a complex technology is implemented, it is necessary to train local engineers. In Kenya, EcoSan has implemented projects that use anaerobic biodigesters powered by human excrements and waste (v. Muench, 2009). The operators must understand the intricacies of the technology to ensure functionality and to create energy from waste year round. Whether the technologies are high or low tech, the projects will not be economically sustainable if locals are not completely onboard with the new concepts. The proverb, "when you educate a man you educate the individual and when you educate a woman you educate a nation" accurately details the importance of capacity building in a developing region (Suda, 2002). The relation of gender equality to the sustainability of the region therefore involves participation of both men and women in capacity building.

Why Kenya

Recently, sanitation has been added as a basic human right by the UN after the Millennium Development Goals Summit in New York in 2000 and the World Summit on Sustainable Development in Johannesburg in 2002 (UNESCO, 2006). Much of the world's developing countries have problems with sanitation. EcoSan projects have helped to organize sustainable waste treatment in numerous countries already. As was posited by engineer Patrick Ombogo, the director of the Ministry of Water and Irrigation in Kenya, “EcoSan is not something new in the world; it is only new in Kenya” (susanavideos). Proper sanitation systems in Kenya are lacking in most parts of the country. Only a small percentage of Kenyan inhabitants have access to modern human waste sanitation. For the less affluent and rural inhabitants, it is common to utilize low-tech solutions such as makeshift ditches for latrines, otherwise called pit latrines (Republic of Kenya, 2009). Basically the concept is to dig a pit and fashion four walls around it with a roof placed on top. Oftentimes a platform made from wooden boards or plastic is placed over the pit. A hole is made in the center and a user can distribute waste through the hole via gravity. Once the pit reaches full capacity, it is covered with earth. The cycle is then repeated over another plot of land (UNESCO, 2006).

Figure 4: Common pit latrine structures in Kenya
This photo was taken at Muslim Primary School in Mumias (Kraft, 2010).

Another common practice of human excreta management in Kenya is by simply doing it in decentralized open pits, otherwise known as open defecation (OD). Open defecation is so common that institutional efforts are needed in order to combat it. In 2007, Plan Kenya, an organization that works to aid children's welfare and education in Kenya, began pilot projects to bring sanitation control to several Kenyan villages. The project sought to end open defecation by expanding on a preexisting certification concept called ODF (open defecation free) villages. Plan Kenya began by working with Community-Led Total Sanitation (CTLS) which is an organizational approach that deals with sanitation projects in developing countries. The CTLS had already implemented projects in neighboring Ethiopia and Tanzania. A Kenyan delegation attended their seminars and brought the concept back to Kenya in 2007. In 2007, there was only one village that was certified as ODF. In 2009 there were over 200 ODF villages. In terms of latrine units, there were a total of 300 in 2007, whereas in 2009 there were over 4,550 units. The reason that projects grew in the sanitation sector is because Kenya signed an Environmental Sanitation and Hygiene Promotion Policy. The aim of the policy was for 90% of Kenyan households to have access to sanitation by 2015. Together with governmental backing and the help of Plan Kenya, CTLS was implemented. Much of the success can be attributed to the approach of CTLS, namely regarding the socio-cultural angle taken by CTLS. Basically, CTLS helped to make open defecation a social taboo. The CTLS raised awareness among the communities on the possibilities of excremental matter entering their bodies through ingestion. It was shown that open defecation can contribute to: contamination of water supplies, houseflies transmitting pathogens, and poor personal hygiene. From a cultural aspect, poor fecal management even has supernatural consequences in the minds of some Kenyans. For example, in the village of Kilifi, witchcraft and other cultural beliefs are linked to fecal matter. It is believed that one's feces have the ability to curse one's being if mishandled or mixed with the wrong people's feces. So, the Kilifi people often resort to using only their own designated defecation site in order to avoid the possibility of being cursed by others (Bwire).

The work done by Plan Kenya and CTLS has helped depict the attitude and willingness of Kenyans to adopt a human excrement management system. The concept was to initiate a mass dispersion of latrines through provisions and teaching seminars. However, the concept does not provide a sustainable solution. The new system is cleaner than the previous open defecation methods, but does not mention what will happen when the latrines are full. In terms of socio-cultural barriers, the CTLS system reinforces that waste is bad and not a resource. In short, it was a quick and cheap fix which is notorious for not including complete sustainability analyses (Bwire).

It is clear that the current practices of waste management in Kenya are not sustainable. There are countless consequences for lacking proper sanitation. A major yearly problem for most rural Kenyan settlements is floods. Besides large amounts of water destroying housing, sustenance crops, and cash crops, pit latrines are also affected. Pit latrines are obviously vulnerable to the large influx of flood waters. The flood waters fill the pits causing excreta to flow freely wherever the water takes it. The result is that water-borne diseases thrive due to the high amounts of pathogens that thrive in excrements. The lack of adequate sanitation facilities and methodologies therefore has immediate and future effects on human welfare (Kraft, 2010).

Kenya is much like other developing nations with problems in access to sanitation. The country also has a significant ratio of women to men who are involved in daily household chores. The management of household excreta is normally the responsibility of women. Kenyan women have historically been expected to be second to men in the workforce because of their importance in the home. It must follow that the practice of sanitation will also be a burden for women exclusively. The prevailing setting of Kenya's social conditions has made it suitable to implement a sustainable waste management system that is dependent on manual labor (Suda, 2002). Therefore the EcoSan projects are capable of tackling multiple issues all at once. The primary goal of providing sanitation is met by introducing technologies and management schemes to prevent the excreta from being dispersed into the open environment. Since the excreta will no longer flow freely, there is no longer a widespread problem of diseases associated with poor sanitation. Next, know-how transfer is handled by the women since they are the ones who normally manage waste. The sustainability of the projects could be influenced by the women in such a way that future generations, who are currently children, will be operating and maintaining the systems. Therefore the sustainability element of the project is dependent on the acceptance of Kenyans today (UNESCO, 2006).

Chapter 3: Methodology

The EcoSan projects in Kenya are located in a diversity of settings which include: schools, hospitality sectors, and small municipalities. The following are some of the Kenyan institutions there were selected for EcoSan projects: Khaimba Primary School, Naivasha Bus Park, Gachoire Girls High School, Ramba Boys High School, and the district of Rachuonyo. The sites were chosen based on the scale of the projects. Each project services a small number of users, thereby making them all small-scale projects. Financing, support, and operation of the EcoSan Promotion Projects (EPP) come from the following entities: the European Union, GIZ, and Swedish International Development Agency (SIDA). The EPP is part of the Water Sector Reform Program in Kenya. The executing entities are the school administration board, education officers, and public health officers. All of the projects began as “pilots.” A pilot project is basically a test run to determine if the EcoSan theories and methodologies functioned adequately in practice. Primary and secondary schools were the first to have EcoSan implemented in their facilities. There were a total of 71 schools that participated in the pilot programs (Kraft, 2010). After the successful establishment of EcoSan in Kenyan schools, project developers expanded to commercial institutions and municipal applications.

Preconditions

Under the context that capacity building for grade school students deeply contributes to sustainable development, case studies of schools will be considered for the purposes of the methodology. In regards to education, teaching students “new norms” from early ages will inevitably promote acceptance of the EcoSan systems. As well, gender equality can be disseminated among the students using EcoSan as a sort of vehicle. At an early age, all students in the selected schools must familiarize themselves with the new systems (Mareng, 2010). For example, students were being tasked with maintaining the new EcoSan toilets. With more EcoSan projects gaining success in Kenya, future generations will be familiar with the concepts. In theory, girls and boys will be able to share the experiences of operating, maintaining, and ultimately benefitting from EcoSan. Projects in the business sector are also important because the children who have used EcoSan in their schools can experience the utility of EcoSan concepts with their parents or other adults. Therefore, the inclusion of schools with male and female populations along with businesses is necessary to emphasize the argument. Lastly, analyses of the technologies implemented by EcoSan are necessary because the new systems not only help to improve the quality of life of users, but their user-friendliness is crucial in capacity building as well (UNESCO, 2006).

Sustainability according to Kenyan EcoSan projects

The current situation of schools in Kenya is generally dismal in terms of adequate sanitation facilities. Sanitation in schools is particularly lacking as numerous campuses are without hand-washing basins or adequate sanitary excreta sinks. The lack of basic sanitation in schools leads to increased chances of infections and the spread of diseases. During the raining season, pit latrines used by the faculty and students are particularly vulnerable to infiltration and overflowing from rainwater (Kraft, 2010). The rate of contracting disease is usually higher during the raining season. Several schools also face the problem of overpopulation. Classrooms are often burdened up to 50% above the intended student capacity. The problems of overcrowding coupled with poor sanitation lead to diseases passing frequently between students. Diseases related to inadequate sanitation include: cholera, diarrhea, salmonella poisoning, dysentery, typhoid fever, and several others. Parasites also thrive in untreated fecal matter and can lead to the spread of hookworms, tapeworms, and roundworms (WHO, 2006). It must follow that without adequate sanitation, students will have difficulty performing in school. Female students are also at a disadvantage when basic sanitation facilities are not available. In a survey taken by Kenyan schoolgirls, over 500,000 had admitted that they stay home during their monthly menstrual cycles. Without the proper facilities to accommodate them, female students' education is adversely affected. It was estimated that the female students staying home during their menstrual cycles miss approximately 90 school days a year. In Kenya, 9 out of 10 children from poor homes do not complete their basic education. So, the overall high drop-out rates can be reduced by improving sanitation. Therefore it can be concluded that sanitation affects education which resultantly affects regional sustainability (Kraft, 2010).

Along with the education sector, selected municipalities also benefitted by engaging in EcoSan projects. Particularly the municipalities conducting capacity building seminars for women are crucial to the success of EcoSan. The following case studies analyze several situations in which EcoSan concepts, technologies, and gender share direct links which embodies their strong interdependence.

Case studies: Khaimba Primary School and Rachuonyo District

The case studies in the above sites utilize similar technologies and methodologies to improve sanitation conditions. For the purposes of the thesis' methodology, the two case studies were analyzed consecutively. The primary technology used in the case study regions is UDDT. The intended sink of the UDDT's output is fertilizer supplement.

Case study 1: Khaimba Primary School in the town of Butere

The UDDT project in Butere at the Khaimba Primary School was started as an EcoSan promotion project from 2006-2009. It was executed by the Kenyan Water for Health Organization and was the first EcoSan UDDT project constructed in a primary school in Kenya. The aim of the project was to demonstrate how UDDTs can be more cost effective than constructing, maintaining, and using pit latrines. Participants of the project include teachers, pupils, managers, and guests of a health club on campus. There are around 1,000 pupils and 25 teachers. A total of four UDDTs were constructed. Two of the UDDTs were built for students and the other two were for teachers. A 40 cbm rainwater tank was also augmented to the project for hand-washing (Wakala; Khaimba, 2010). A health club was constructed at the school in which guests have access to the UDDTs. The UDDTs used by health club members are cleaned, operated, and maintained by the students. The excreta are treated through natural processes and converted into compost. The compost is applied to a farm operated and maintained by students. Produce from the farm include: corn, spinach, and bananas. The food is used for a school feeding program while the surplus is sold. The money from the surplus is used to benefit the health club members by buying books and providing rewards (Odhiambo et al, 2009). Emphases were placed on educating and training the students throughout the project's crediting period. However, due to a change in school leadership, more follow-up training was needed (Wakala; Khaimba, 2010).

Case study 2: Rachuonyo District

In a baseline study by the University of Kisumu and Emory University of the Nyanza Province, the Rachuonyo district revealed that it was the most deficient in the province in terms of sanitation. It was found that only 15% of schools in this region were treating water for drinking. Few of the schools had working rainwater collectors that adequately functioned. Nearly all schools reported not having enough female student latrines. The current government limit is 25 female students to one latrine; the schools in the region reported over 60 female students to one latrine. All of the surveyed schools accounted an excess of nearly 70 male students to one latrine. The government standard is 30 male students to one latrine. Over 60% of the schools had a latrine with odor emissions. Lastly, over 50% of the schools had latrines that were unclean. For example, feces were often visible in the pits. Naturally, the lack of proper sanitation led to thriving fly populations around the latrines (Swashplus.org).

After the promotion of an awareness campaign on sanitation, UDDTs were introduced into several regions of Kenya. The campaign, called "Water Sanitation and Hygiene (WASH)," set in motion the principles of proper sanitation and was backed by several stakeholders. The District Health Officer (DHO), some local government officials, community leaders, and members of the regional Water Services Board all took part in setting pilot projects in regions that were particularly in need of sanitation. The introduction of UDDTs served as a pilot project for the Rachuonyo district and has yielded mostly positive results. All of the UDDTs in the district are in use. Specifically the participation of mainly local women's groups made sustaining the projects possible. Some of the women's organizations that participated include: Kanyonje Women Group, Tanglweti Women Group, and the Upendo Women Group. In this district, a house of 8 inhabitants takes approximately 1½ weeks to fill the urine tank. The size of the urine tank varies from house to house. The resulting flows of urine from the UDDTs have been used by local farmers. It was reported that the urine-based liquid fertilizer has yielded good results (Osumba; Rachuonyo, 2010).

Technology description of Khaimba Primary School and Rachuonyo District projects

There are two types of technologies employed within the EcoSan system. Urine diversion toilets and urine diversion dehydration toilets are the mainstays of EcoSan's technology. Urine diversion technology can operate with minimal use or without the use of water. The primary purpose of urine diversion is to separate urine and feces. If water is used for the operation of the urine diversion toilet, it is permissible to mix feces and water or urine and water. Feces and urine are never mixed in UDDT technology. There are several advantages of using diversion toilet technology which are: water savings, agricultural use of the urine and excreta, mitigate environmental pollution, and energy production (Winker and von Muench, 2009).

Water savings

Urine diversion provides the opportunity to use less water as well as securely storing it for later use. In conventional toilets, approximately 8-12 liters of water are used for flushing. With a urine diversion toilet, about 0.5-2 liters of water are needed for flushing. The use of toilet paper directly influences the amount of water used as it is normally flushed with the excreta. A solution that is currently in practice is to collect toilet paper in a bin to avoid higher water consumption. There are also methods of collecting rainwater to use for flushing (Winker and von Muench, 2009).

In the case of UDDT, no water is needed for operation. Therefore UDDTs do not require a flushing system per se. The UDDTs function by providing two outlets, one for urine and one for feces (and an optional anal wash water basin). Urine is directed towards a separate basin within the toilet bowl structure (in the case of a squatting toilet it is located at the front of the unit). The urine is collected in a separate container from feces. Feces are collected by depositing them directly to a separate container. People in certain regions of the world prefer to use water to cleanse their anuses after usage. So, one more basin is augmented to the toilet system in order to accommodate anal wash water users. Water from anal washing is piped separately from urine and feces. Water is actually detrimental to the UDDT system. If water mixes with urine or feces, it can exacerbate the growth and spread of pathogens. As well, the odor from feces increases significantly when wet. Wet feces also take longer to dry. After users finish, there is no flushing system, rather a substitute for flushing that serves the same function is needed (Winker and von Muench).

The medium in which waste is normally carried away in conventional toilets is water. Once the toilet is water-flushed it is essentially clean and odor free. UDDTs use air (via gravity) as the transport medium. The surfaces are made from materials that easily allow waste to slide downwards if any is deposited on the inner structure. Toilet paper users are supplied bins in which to deposit used paper. To mitigate odor, users are provided with sand, soil, or ash to cover their fecal matter. Ash is particularly abundant in countries where firewood is used for daily cooking such as Kenya. It is preferable to use ash as it serves several functions. Using ash not only helps to eliminate odors, it also speeds up the drying process. Dry fecal matter has less chances of fostering disease spreading bacteria, parasites, and pathogens. As well, flies are less likely to infest dried feces covered in ash. Later users of the toilets will have more comfort due to less flies, improved odor control, and aesthetics since the materials underneath them won't resemble feces entirely. In terms of agriculture, ash increases the pH value of the feces when integrated, thus creating more suitable compost. Once the feces are dry, they can then be used for composting (Winker and von Muench, 2009).

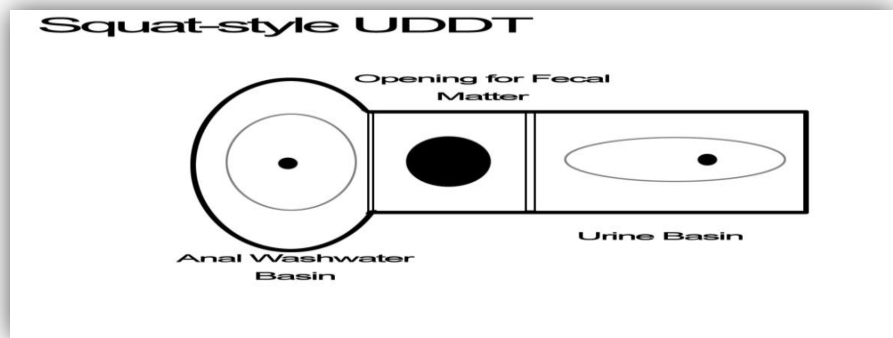


Figure 5: Aerial view of a typical squat-style urine diversion dehydration toilet (UDDT) (Odhiambo et al, 2009). [Art by Tyson Kanzaki]

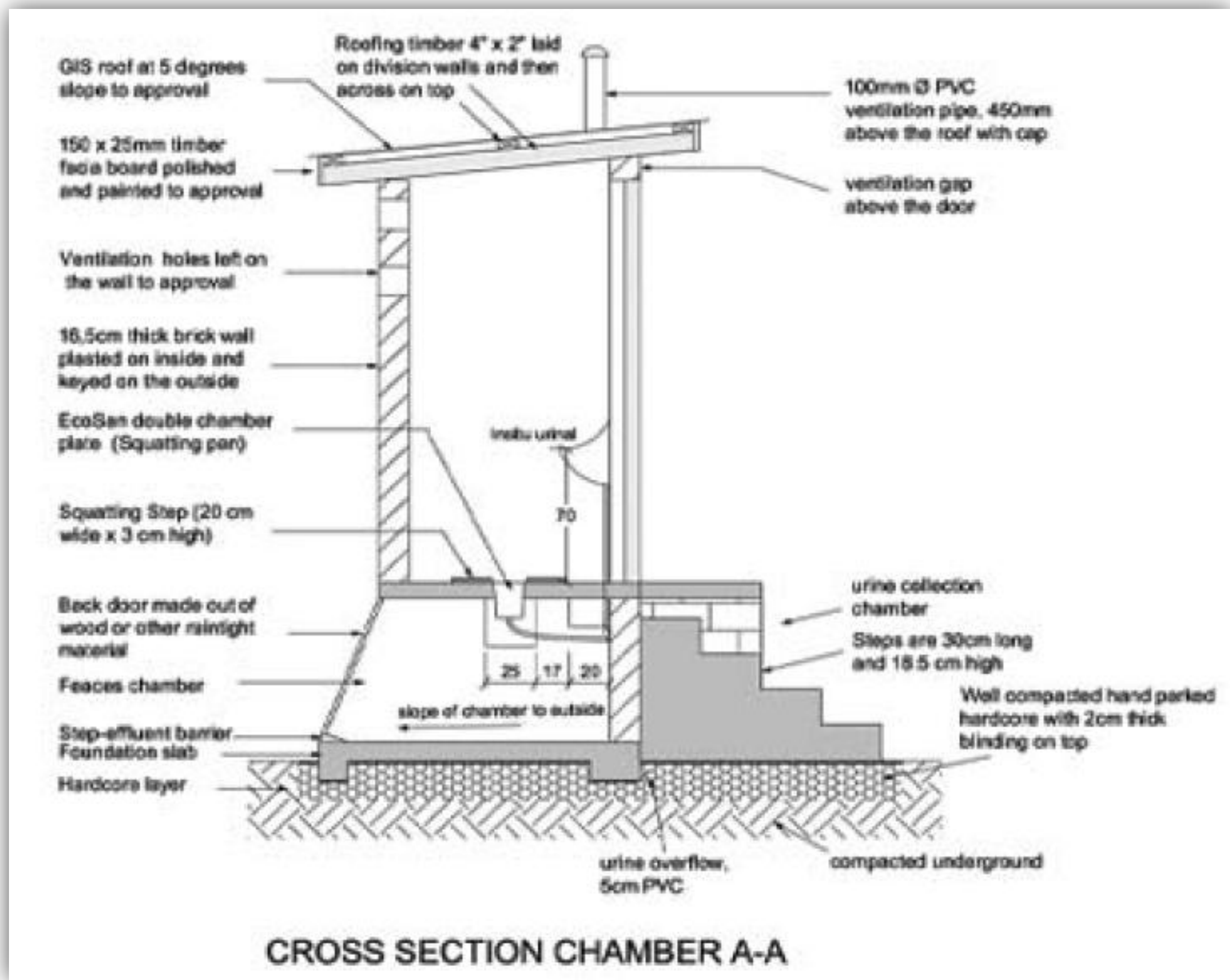


Figure 6: Side view of a UDDT facility
Note that the structure is elevated so that fecal matter and urine may be stored at ground level (Odhiambo et al, 2009).

Urine as a liquid fertilizer

Urine is high in nutrients and can be used as a resource for agriculture. The elements nitrogen, phosphorus, and potassium are necessary for crop production and all can be found in urine. In particular, poorer farmers that cannot afford to buy mineral fertilizers can use urine as a substitute, granted that his or her country's laws permit it. Urine is particularly useful because it has high amounts of nitrogen and median levels of phosphorus. When correctly applied to crops, urine has the potential to increase yields and heighten quality.

Phosphorus

It is postulated that in the near future phosphorus supplies will be depleted. Phosphorus is a key element in agriculture because it is required by nearly all plants. Namely high-grade phosphorus rock is dwindling which will cause mineral fertilizer prices to gradually increase. For example, in the United States, the economic reserve of phosphorus for agriculture is expected to be depleted in about 25-30 years. Capturing phosphorus from urine flows can be provided as a conditioner to enhance soil. Basically, the relatively median amounts of phosphorus in human urine can make a large impact on future mineral fertilizer prices. The methods and techniques in separating phosphorus economically from human urine are fast improving which will hopefully make recaptured phosphorus a market debut in the near future (Winker and von Muench, 2009).

Nitrogen

There is a high amount of nitrogen present in urine which is favorable for certain crops. For example, corn crops require sufficient amounts of nitrogen for good yields. Sodium and chloride are also present in urine which especially helps leafy green vegetables such as chard or spinach to grow. In terms of urine produced per capita and its effect on agriculture, one person is able to help fertilize high amounts of crops. Based on Swedish data, one adult person produces around 1.5 liters of urine per day. This means that a person can produce around 550 liters of urine per year. The amount of urine used on one square meter of land is about 1.5 liters. That means one person is able to fertilize 300-400 square meters of land. The range of 300-400 square meters of land can yield up to 250 kilograms of corn per year. One liter of urine contains about 7 grams of nitrogen. In this case, that means there are 10.5 grams of nitrogen (1/2 a liter = 3.5 g N, so 7 g N + 3.5 g N= 10.5 g N) being applied to one square meter of land. Therefore, in each hectare (10,000 m2) there are 105 kilograms of nitrogen per year. Ultimately, the capture and reuse of minerals in urine has the potential to alleviate costs for farmers and to help sustain a closed loop cycle (Winker and von Muench, 2009).

Pre-treatment of urine as a liquid fertilizer

In most cases, before urine is used as a fertilizer it must be treated. In order to treat urine for general agricultural purposes, it must be: free of pathogens and micro-contaminants, distilled so that nutrients are extracted, and reduced in volume if it is going to be transported so that it will cost less. One method of treatment is to store it either in an aerobic or anaerobic environment. Storage encourages the decomposition of urea into ammonia/ammonium and hydrocarbonate. The process is expedited by the natural enzyme urease. The result is that there is an increased pH value, which is around 9 (7 being neutral). Over time, the higher pH levels kill harmful bacteria and parasites. In the case that water is not integrated in the urine flow, the rate of killing the bacteria and pathogens increases. Storage is not only a low-tech solution, but it is also cheap. According to the recommended time table from WHO (World Health Organization), there is a one month storage period for urine (that has possibly been cross-contaminated with feces). The resulting urine fertilizer can be used on food and fodder crops. If one wishes to err on a safer margin, then up to 6 months of storage time is permissible. After 6 months of storage, the urine fertilizer can be used on crops. Naturally, there are some preconditions before assessing the utility of urine. For example, if the ammonia level is higher than 2 milligrams nitrogen per liter of urine, then one may err on a shorter time margin. In theory, if the procurer of urine is reassured that there was no cross contamination of urine and feces, then it can be applied immediately (Winker and von Muench, 2009).

Other methods of urine treatment employ more advanced technology. Biological agents can be introduced to encourage nitrification. Chemical treatment can be done to help precipitate struvite (phosphorus for agriculture). Specialized membranes that actively filter the urine are also a viable solution, particularly in the case that a presence of micro-pollutants is detected (Winker and von Muench, 2009).

Pathogens/Hormones

By capturing urine, the threat of water pollution by hormones and pharmaceutical residue substances expelled in human urine is avoided. Water pollution in this case implies the leaching of hormones and chemical substances from pharmaceutical residues into ecosystems and water supplies. The hormones and residue substances are categorized as micro-pollutants. It is estimated that nearly 2/3 of pharmaceutical residue substances in wastewater come from human urine. The other 1/3 is found in human feces. In most conventional wastewater treatment plants, the sludge is treated but not filtered for micro-pollutants. Therefore it is discharged into surface water systems which can infiltrate groundwater supplies. In Germany, the amount tolerated in groundwater supplies is 50 nanograms per liter. The health effects of micro-pollutants on humans have been postulated as being low, yet more studies need to be done on this matter. For example, in 2006 it was found that the ecosystem in the Potomac River, USA, was being affected by hormonal pollution. Hormones were found in sewage from humans as well as from dairy farms. Estrogen was identified as one of the hormones prevalent in the wastewater that was leached into the Potomac River. Scientists posit that the high influx of hormones could have disrupted the reproductive systems of fish. The effects of estrogen in the river system were theorized as not posing direct threats on human health. Tap water was also deemed safe. The amount of hormones or chemical residues in water and food supplies could have less of an effect on human health than conventional pesticides (Winker and von Muench, 2009).

Cost savings

There are numerous ways to save on costs by using urine diversion toilets. Depending on the region of the world, the costs for water are reduced due to the fact that water in dry climates for example is expensive. The potentials for saving money on fertilizers are particularly interesting for farmers. For example, urine fertilizers could be marketed as organic in some regions. The term organic is defined in two ways. Organic in one sense means that it is ecological whereas in the analytical chemistry sense it implies that the compound contains carbon with other elements such as: hydrogen, oxygen, or nitrogen. Urea [(NH2)2CO] is contained in urine and is therefore considered as organic. While in the stored urine technology, urea is dissipated and the resulting urine is then called a mineral fertilizer. The European Union does not accept urine as an organic fertilizer but in China it is. Semantics aside, urine still provides a new source of income because it was originally discarded. It can be expected that food prices could also be lowered since the farmers have less costs for agriculture. Energy savings is also a potential, but it heavily depends on the region and what their current wastewater treatment system is. In terms of capital costs, installation, operation, and maintenance, the urine diversion toilets are still cost competitive to the "business as usual" scenario of using standard flush toilets (Winker and von Muench, 2009).

Urine application to crops

Urine can be applied directly or diluted with water. Certain crops can withstand undiluted urine whereas others require a mix of water and urine. Normally, the ratio is between 1/3 urine and 2/3 water or 1/5 urine and 4/5 water. There are even instances where farmers will only use 1/15 urine. The advantages of integrating urine and water are: a reduced risk of damaging plants (plant burn), enabling of "fertigation" which means irrigation and fertilizing simultaneously, it can reduce odor pollution (only if the ratio is 1/5 urine), and it can minimize the risk of over fertilizing potted plants. Some mechanical steps are necessary to achieve the best results from urine/water mix fertilizers. For example, after the application of a higher ratio urine/water mix, it must be covered by soil to mitigate odor release. In most cases, irrigation water is still used (Winker and von Muench, 2009).

Case studies: Gachoire Girls and Ramba Boys High Schools and Naivasha Bus Park

The case studies in the selected institutions demonstrate EcoSan by using similar technologies and methodologies. Therefore, the three case studies are analyzed consecutively. The highlighted technologies of the regions are anaerobic biodigesters. The intended output of the biodigesters is clean effluent for irrigation and nutrient supplements.

Case study 3: Gachoire Girls High School

Another promotion project by EcoSan took place at an all-girl school near Nairobi, the capitol of Kenya. The Gachoire Girls High School comprises of 700 to 800 students and 40 teaching staff. Before the implementation of EcoSan at the school, the sanitary conditions were severely lacking. As well, nonrenewable sources such as liquid petroleum gas and firewood were used as cooking fuels. Nearly half of the school's expenditures were on food supplies. In 2007, EcoSan began the project that would accommodate some of the school's basic needs while adding value. The technologies proposed and implemented include: UDDT, a biogas settler, an anaerobic baffled reactor, and a vertical flow constructed wetland (Odhiambo et al, 2009).

The results of the project were mostly positive as the general sanitation of the school was improved. Input flows to the new wastewater treatment system come from black and greywater sources. The 30 pour-flush toilets also double as shower units. So the wastewater is integrated at source and is serviced by a central flushing system. The central flushing system is connected to a biogas settler which has a capacity of 124 cbm. The biogas settler works in conjunction with an anaerobic baffled reactor which further harnesses biogas. The processed water is sent to a constructed wetland for finishing. Once the water has been treated in the wetland, it is suitable for irrigation. The irrigation water is used at the school's farm. The residual solids left in the reactors have the capability to be used as compost, but are currently under research for safety reasons. The three UDDTs and a single urinal are used as a way to decentralize the wastewater flows while reducing dependence on water requirements. The UDDTs also provided a promotional aspect in which the students and teachers could learn about the advantages of separating waste flows (Rieck and Wakala, 2010).

Biogas produced by the anaerobic digester units is processed to yield biomethane. The biomethane is used onsite as fuel for cooking in two burners. The digesters can yield up to three or four hours of cooking gas per day. Wood and liquid petroleum gas are the primary sources of energy for applications such as cooking. So the methane acts as a supplement to offset the dependence on nonrenewable energy sources (Odhiambo et al, 2009).

After the sludge has yielded its useable fraction for biogas production, it can be used as compost. The solid matter contains nutrients vital for healthy crops such as phosphorus and potassium. In the school project, it is not mentioned if the sludge is used for agriculture. Sludge must be pretreated before it is used as compost due to high amounts of heavy metals contained in feces. Therefore, it can be assumed that the sludge is not being treated for compost since there is no technology accounted in the project's documents that is designed specifically for separating heavy metals (Wakala; Khaimba, 2010).

Case study 4: Ramba Boys High School

Located in the Siaya district, the Ramba Boys High School was also chosen as a pilot project by EcoSan. The school's sanitary conditions were lacking as is the case with several other schools in the district. There are over 900 students who are served by only 16 pit latrines. The latrine structures were also in a decrepit state. Without proper sealing systems of the pits, the odor of excrements made use of the facilities uncomfortable. Students normally removed their clothes before entering the latrines to avoid adsorbing the odors on their clothes. The surrounding walls and roof of the latrines were fashioned from iron sheets that were rusting and disintegrating. Pit latrines would have been buried when full. The prevailing system would then repeat as new pits would be dug and the cycle repeats (Wakala; Ramba, 2010).

Completed in February 2010, the proposed EcoSan project included several technologies that were implemented at the Ramba Boys High School. The technologies included a 90 cbm biogas digester and an anaerobic baffled reactor. In a status report from August 2010, most of the proposed technologies were in use. The school had yet to begin using the biogas for cooking, but the septic functions of the technologies were working as expected. Along with the technological aid, current latrines were renovated and retrofitted to comply with the new technologies. The new latrine systems feature a pour flush mechanism to carry excreta away. The water used in the pour flush system comes from collected rainwater. It was estimated that approximately 2.5 liters of water is used for each flush. After the wastewater is sent through the anaerobic baffled reactor, the water is sent to a small 30 cbm tank that has been augmented to the system. Water is stored here before being directed for irrigation. The resultant outflow of wastewater will be used onsite for irrigation at the school's farm. The overall acceptance of the EcoSan project is high among the students as they have reported positive feedback about the new latrines (Wakala, Ramba, 2010).

Case study 5: Naivasha Bus Park

The EcoSan pilot project at the Naivasha Bus Park is unique from most of the other projects as it is not being hosted by a school. It also differs in that there are several other stakeholders involved in this pilot project. The stakeholders are: Naivasha Water and Sanitation Company (NAWASCO), the Water Services Trust Fund (WSTF), Danida, GIZ, SIDA, UNICEF, and World Bank. Under its official title, urban pilot and demonstration project, one of the main goals is to promote capacity building. The project sought to integrate the interests of travelers, residents, and local water authorities. The interests of water sector institutions were met by formulating economic incentives from investments into the EcoSan project. Users of the improved sanitation systems benefit by having a reliable and safe waste management scheme that also provides added value (Onyango and Rieck; Naivasha, 2010).

The town of Naivasha has approximately 70,000 inhabitants and nearly all of the population is not connected to any sort of sewage conveyance system. The entire town is serviced by only five public toilets. The conditions of the toilets were severely lacking as they were not regularly maintained. For example, all of the toilets face regular blockages as they overflow with excreta. Visitors to the bus park were even using empty structures as depositories of excrements. The bus park's restroom serviced about 300 hundred visitors per day, all using the dilapidated facilities for free. The preexisting sanitation conditions of Naivasha were clearly lacking. The municipal entities disregard renovating the current toilets because there was no way to generate revenue from toilet usage and repairs. In order to circumvent obstacles by the municipality, management and authority was handed over to the Water Services Board due to existing legislation from the Ministry of Water and Irrigation (Onyango and Rieck; Naivasha, 2010).

With construction beginning in 2007, the pilot project brought several new technologies and management schemes into the Naivasha bus park. The new wastewater system operates in a closed-loop system in which all flows of water and materials are accounted. First, to deal with the lack of sanitation facilities, five new toilet cubicles were installed; two of the cubicles are for men and three are for women. Hand-wash basins and two shower units were also installed. The toilets use a flushing system which requires manual pouring of water from a provided bucket. The pour flush system was preferred as opposed to the UDDTs since the site is connected to an established sewer system. All of the wastewater from hand-washing basins, showers, and integrated blackwater are sent to a biogas settler unit underground. The settler's capacity is 54 cbm. The unit treats the water and reduces pathogens and organic fractions that are harmful to surface water life-forms. Once the water has been treated it is discharged into the existing sewer lines. The sewer line ends in a wastewater treatment pond. The sludge is removed from the biogas settler once a year. There are so far no uses of the sludge due to high transport costs. The resulting biogas from the settler unit is piped to a local café that services travelers. The biogas supplements the owner's fuel costs by providing several hours of cooking time. Coal and liquid petroleum gas were the main sources of fuel which had high costs and polluted the ambient environment. To supplement frequent water shortages, water kiosks were constructed onsite. Two tanks with a capacity of five cbm were placed above the new toilet facilities (Onyango and Rieck; Naivasha, 2010).

To offset costs of the investment in the new toilet facilities, users are charged a fee. The rates are: 5 Ksh (0.05 EUR) for a single use of the toilet, 10 Ksh (0.10 EUR) for a single use of the shower and for a 20-22 liter can of water, 2 Ksh (0.02 EUR). The operator's water fee is subsidized and costs 3 Ksh/ cbm (0.3 EUR/ cbm). The sale of the water is set at 100 Ksh/ cbm (1 EUR/ cbm). Therefore, the operator's profit is 70 Ksh/ cbm (0.70 EUR/ cbm). The operator pays the standard price of 8 Ksh/ cbm (0.08 EUR/ cbm) since he or she collects user fees to cover his or her cost of operating the toilet. The responsibility of the operator is to collect fees, uphold the facility, dispense toilet paper, and sell toiletries (Onyango and Rieck; Naivasha, 2010).

Technology description of Gachoire Girls and Ramba Boys High Schools, and Naivasha Bus Park projects

The technologies and methodologies utilized in the above case studies are similar to those used in the Khaimba Primary School and Rachuonyo district. All flows of human waste are collected and used in agricultural applications. The main difference is that an additional technology is used to maximize the value of human waste. Anaerobic biodigesters are employed to create energy from waste. The biodigester system is integrated with principles of sustainable sanitation. Thus the term biogas sanitation was coined. There are numerous advantages of having biogas sanitation onsite such as: it provides decentralized energy supply, it aids in greenhouse gas emission reduction, it works well with decentralized wastewater systems, and it provides education on innovative technology (Li and Mang, 2009).

Input material

Anaerobic biodigesters can utilize several materials to produce biogas. In several regions worldwide, sewage sludge from municipalities and industries is inputted. Depending on the country's sewage system, food waste (also referred to as the organic fraction) can be integrated through the home's wastewater system. For example, in the United States, most homes have an organic waste processor built into the sink. The result is that the organic waste is processed to a finer consistency and drained away. All forms of wastewater are integrated and sent as sludge to a wastewater treatment plant. The sludge provides excellent material for use in an anaerobic biodigester. Residues from agriculture also can yield high amounts of biogas. Namely animal husbandry provides large amounts of biomass yearly. Farmers can collect manure and input it to a biodigester to supplement energy demands on the farm. In the case of Gachoire Girls High School, Ramba Boys High School, and the Naivasha Bus Park, the input material to their onsite anaerobic biodigesters is integrated wastewater. Integrated wastewater consists of yellow, grey, and brown water, which is all sent for pretreatment before it is used as an input material to the anaerobic biodigester (Li and Mang, 2009).

Preconditions and pretreatment of input materials

Before biomass or sludge is inputted to a biodigester, it requires some pretreatment in order to get the optimum biogas yield. The three main criteria to fulfill are: hydraulic retention time, volumetric load, and sludge retention time. The hydraulic retention time refers to the total time it takes to yield the total maximum of gas. It is deduced by determining the type, temperature, and concentration of the input material. Once the parameters of the input material are defined, then the required volume of the digester itself can be determined. The logic is that biodigesters are designed to provide a balance between the volume of input and the biogas yielded. The hydraulic retention time is essentially used to determine the capacity of the unit. Approximately 20 days retention time is recommended. The sludge retention time indicates the time needed to promote the growth of methanogenic bacteria. During the process, hydrolysis (which is the breaking down of organic matter) and fermentation takes place. Temperature plays a crucial role in this stage because it affects the overall retention time as well as the quality of biogas yielded. Methanogenic bacteria work within three types of temperature zones which are psyhcrophilic (8-25 degrees Celsius), mesophilic (35-45 degrees Celsius), and thermophilic (53-65 degrees Celsius). For example, if the temperature is 25 degrees Celsius, the sludge retention time is 15 days. If the temperature is 15 degrees Celsius, the retention time is 75 days. However, if the temperature of the ambient climate is lower than 8 degrees Celsius the bacteria do not produce much methane. The bacteria yield biogas which is comprised of methane, carbon dioxide, and other gases. Normally the biogas must be purified before it can be used energetically (Li and Mang, 2009).

Types of biogas sanitation units

The three types of biogas sanitation units are: biogas settler (also called biogas septic tank), anaerobic baffled reactor, anaerobic filter, and up-flow anaerobic sludge blanket. The biogas settler and anaerobic baffled reactor were employed in most of the Kenyan EcoSan projects. The anaerobic filter and up-flow anaerobic sludge blanket were not reported as a technology currently employed in Kenya but it is being used in other EcoSan projects in the world (Li and Mang, 2009).

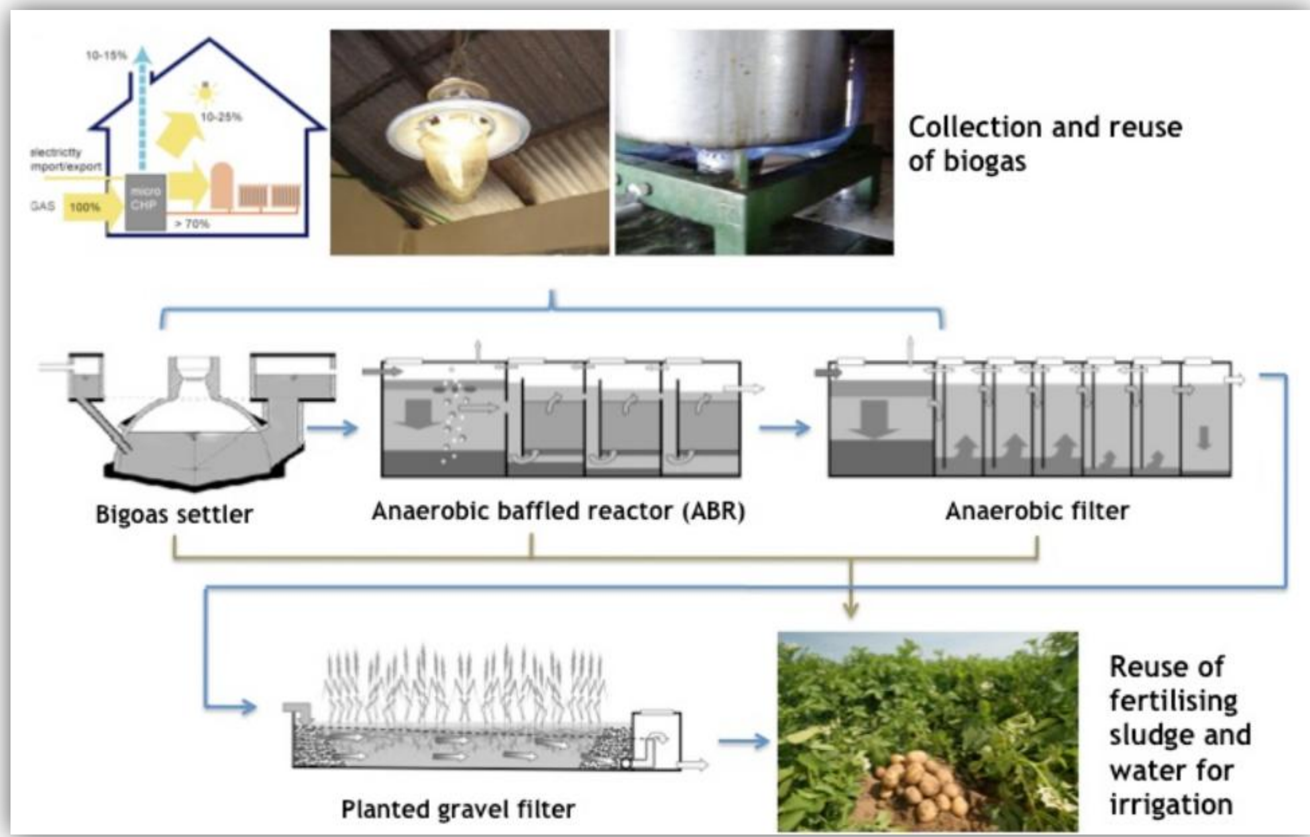


Figure 7: The fully integrated wastewater treatment system
Wastewater *- The three types of anaerobic biodigester systems and the planted gravel bed filter (constructed wetland) work in conjunction to pass wastewater through for irrigation* (Hoffmann et al, 2011). ***Biogas*** *- All three anaerobic digester units yield biogas during operation.* ***Residual sludge*** *- is taken from all three anaerobic digester units and used as compost* (Spuhler; Biogas Settler, 2011).

Biogas settler

Biogas settler technology is being used by Gachoire Girls High School for energy production. Biogas settlers function by using an airtight reactor to allow the wastewater or sludge to settle as a pretreatment step. The solids are separated from the liquid fraction by gravity. The liquid fraction is retained for only a short time because it goes on for further treatment while the solid fraction remains for priming. Essentially, the functionality of biogas settlers is the same as a conventional septic tank. The difference is that the biogas settler is designed to yield useable gases for energy while sending nutrient rich, pathogen-free, slurry to be treated further. Greywater can be added to the outflow of water from the biogas settler. The settler functions well onsite as part of a decentralized wastewater treatment system. It is also adaptable to a wide range of temperatures. Users and maintenance workers can learn the system easily which promotes capacity building. Investment costs of biogas settlers can vary, but the agricultural potentials as well as environmental benefits can alleviate costs in the future. The only time when professionals are needed is during the planning and construction phase. The biogas settler unit must be supported by other units of wastewater treatment to be effective. Some other advantages of biogas settlers include: biogas recovery, high biochemical oxygen demand (BOD) removal, fertilizer production, the water can be reused for irrigation and thusly fertilization, and low risk of odor leakage (Spuhler; Biogas Settler, 2011).

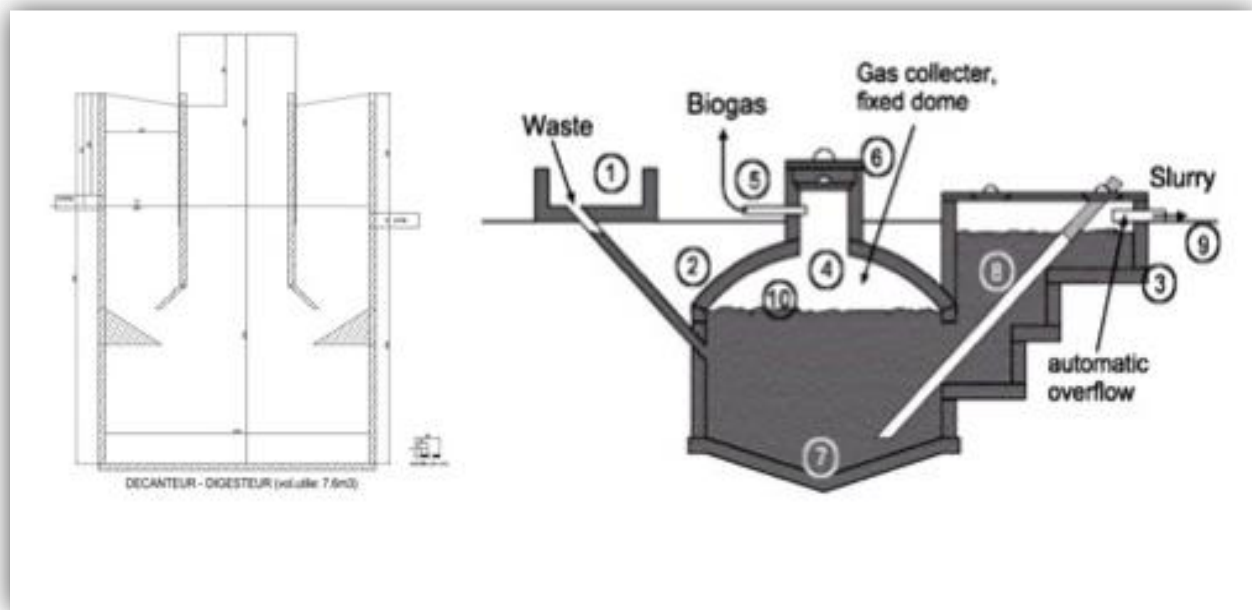


Figure 8: Biogas Settler
Wastewater is inputted through the (1) basin then the inlet pipe. The wastewater is directed to the (2) bioreactor. Biogas is yielded and contained in the (4) upper chamber. The biogas can be channeled to a pipeline from the (5) gas outlet. The (6) hatch on top of the digester unit is for monitoring purposes. The floating (10) scum settles to become a concentrated thick sludge at the bottom of the reactor. A (8) tube brings up the sludge to the (3) removal tank. The resulting slurry is discharged through the (9) outlet point (Spuhler; Biogas Settler, 2011).

Anaerobic baffled reactor

The anaerobic baffled reactor is currently in use at the Ramba Boys High School. The unit is similar to a septic tank, but vastly improved. First, the solids are allowed to settle in a pre-treatment tank before flowing to the next step. Once most of the solids have settled, the remaining water is then pushed into a series of upward and downward flowing baffles. Each time the water flows upwards, some solids are left behind on the ground level. So, within each upward and downward flow, there is less solid matter. The baffles create a sort of compartmentalized system that is able to delink the "solids retention time" from the "hydraulic retention time." Therefore the overall time it takes to anaerobically treat wastewater is shorter. The system functions by forcing suspended and dissolved organic pollutants to contact active biomass by flowing through it. The constant contact with the solids increases anaerobic degradation. As well the removal efficiency of non-settling organic solids is improved. Anaerobic baffled reactors are also flexible in various climate conditions. Similar to the biogas settlers, lower temperature climates affect efficiency. The system know-how is easy to transfer to local operators. Another similarity to biogas settlers is that the anaerobic baffled reactor must be augmented to a complete system of wastewater treatment. The unit provides several other advantages such as: stability and resilience in response to shock loading, high BOD removal, simplicity in construction, able to process industrial wastewater, longer retention time of the biosolids, reduced sludge output, and biogas output (Spuhler; Anaerobic Baffled Reactor, 2011).

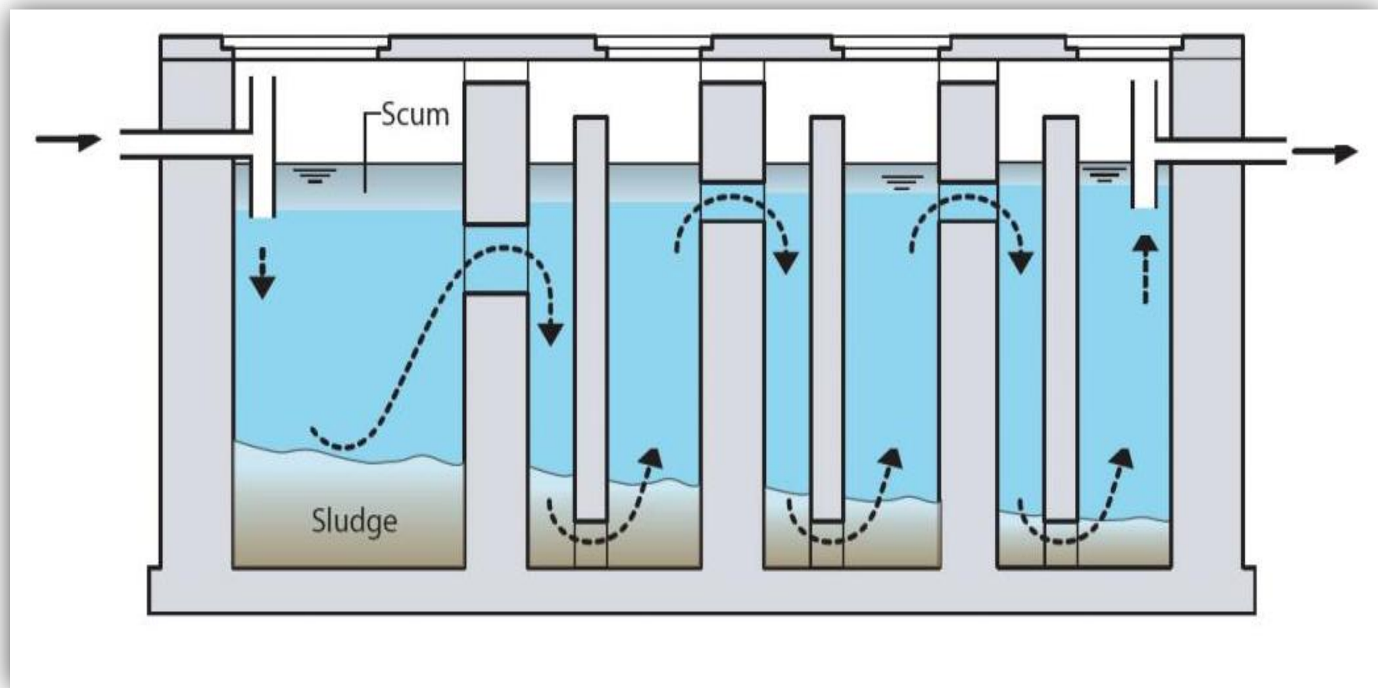


Figure 9: Anaerobic baffled reactor
Wastewater is introduced from the left side of the illustration. The solid matter from of the wastewater settles to create sludge on the bottom of the reactor. Each time the water is push up and through the baffles, an increasingly smaller amount of sludge settles until there is little left over at the end of the baffled process. While the wastewater is traveling through the reactor, biogas is being created (Spuhler; Anaerobic baffled reactor, 2011).

Anaerobic filter

The anaerobic filter functions by allowing dissolved and organic matter to be filtered by a sort of biofilm. The biofilm contains bacteria that anaerobically digest the materials. The unit has a high removal rate of solids in wastewater as compared to the anaerobic baffled reactor or conventional septic tanks. The units are used for secondary treatment of household black or greywater which means it is capable of being used onsite in a decentralized wastewater system. Although it can handle different types of wastewaters, it works best with inflows containing lower amounts of solids. So, pretreatment to remove solids may be necessary before sending wastewater through the unit. Advantages of an anaerobic filter include: resistant to shock loading, high reduction of BOD, outflow water is usable in irrigation and fertilization, long service life, reduction of odors if used properly, and low-cost of maintenance (Spuhler; Anaerobic Filter, 2011).

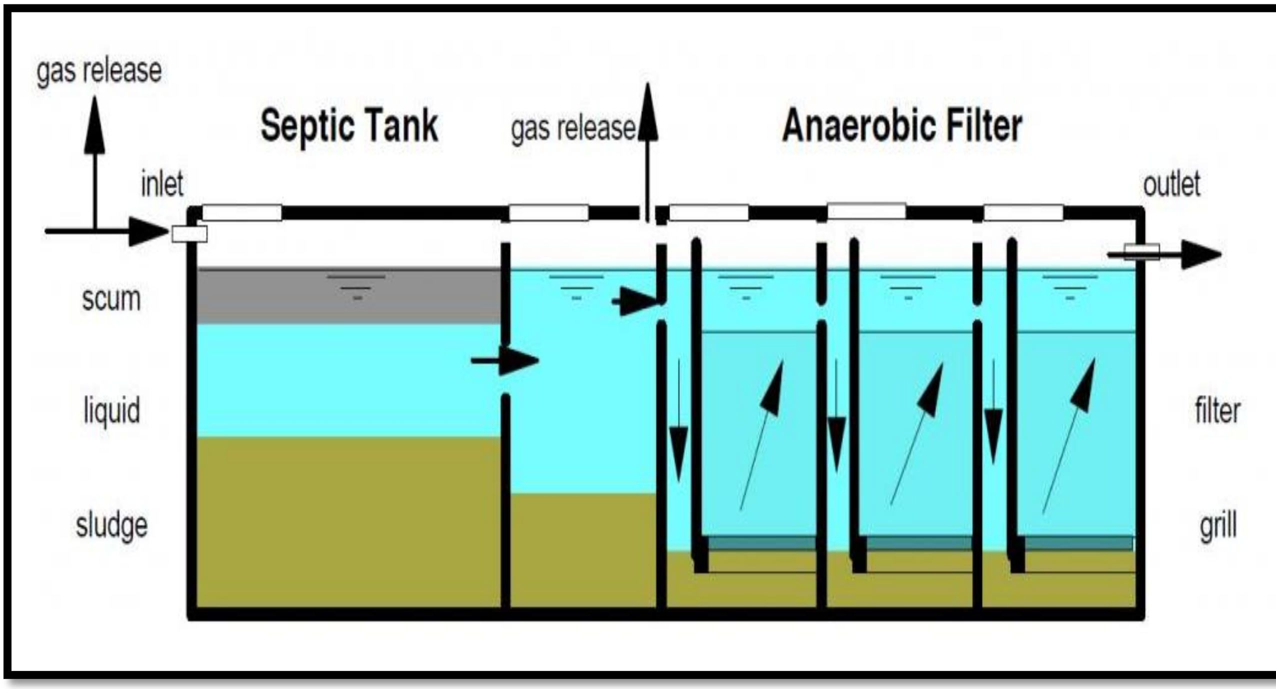


Figure 10: Anaerobic filter
The filter system is comprised of a conventional septic tank augmented to an anaerobic filter. The design is conceptually the same as the anaerobic baffle reactor in that the water is channeled through separate compartments. The difference is that the water is pumped through a biofilm (teal blue) which acts to purify the water without affecting the biogas output (Spuhler; Anaerobic filter, 2011).

Up-flow Anaerobic Sludge Blanket Reactor (UASB)

The UASB uses a tank that is filled with anaerobic granular or flocculent sludge. The wastewater is introduced at the bottom of the tank where it flows upwards through the tank. The water is then met by a sludge blanket while flowing upwards. Biogas is subsequently produced in this step as anaerobic digestion occurs within the sludge blanket. The sludge retention time in this technology is longer than the hydraulic retention time. The UASB can potentially produce higher quality effluent than the other technologies, mainly biogas settlers. The unit must be used in unison with other wastewater treatment components. One of the only drawbacks is that it removes the least amount of BOD in comparison to the other technologies (Li and Mang, 2009).

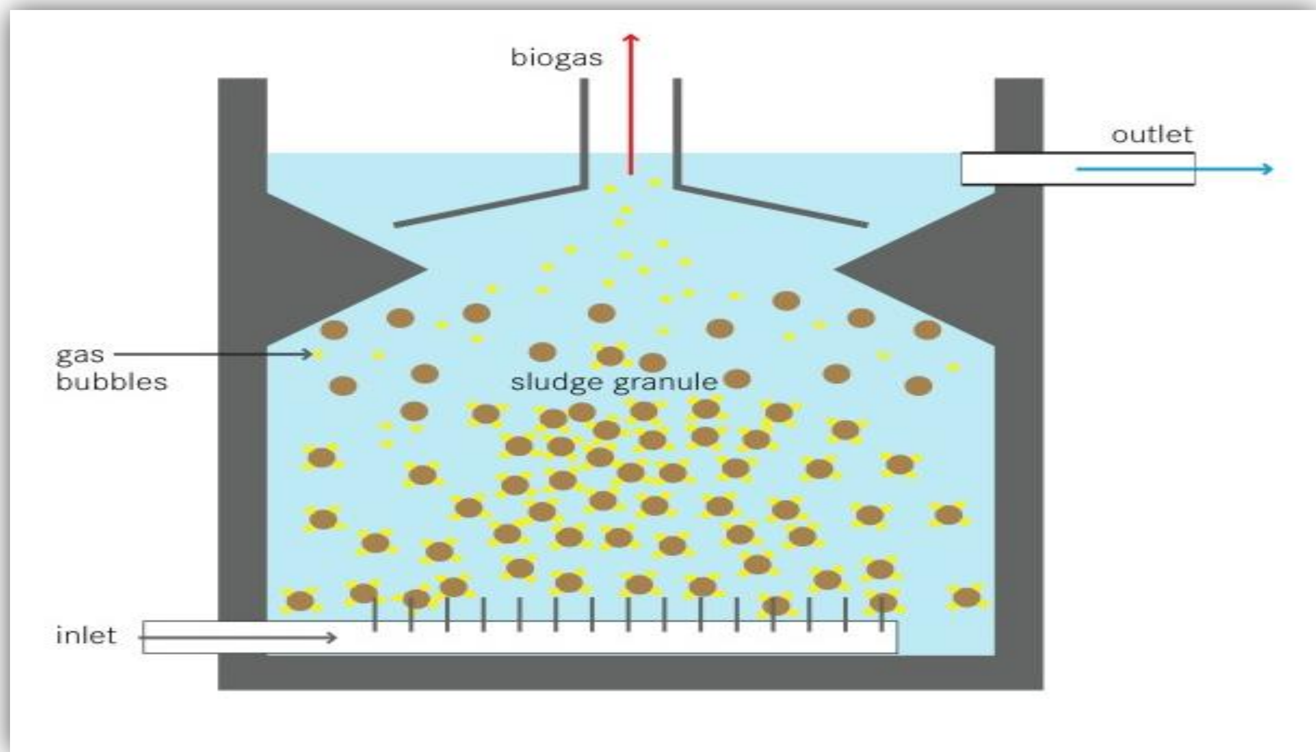


Figure 11: Up-flow Anaerobic Sludge Blanket
Wastewater is inputted at the bottom of the reactor. Sludge is formed into granules which becomes a sort of barrier between the inlet pipe and the upper compartment of the tank. Biogas is released through the top while effluent flows through the outlet (Spuhler; UASB reactor, 2011).

Constructed wetlands

The final treatment or polishing of wastewater can be done using a constructed wetland as it is done in the Gachoire Girls High School. The concept of constructed wetlands is to use natural materials and processes in the treatment of wastewater. Constructed wetlands are relatively low-tech as there is no usage of complex technologies for construction, operation, or maintenance. A simple lining is placed under the bed to prevent wastewater from leaching into the surrounding environment. Before wastewater is introduced into a constructed wetland, all of the solid material must be mechanically removed. For example, a simple grid-type grate is used to catch rubbish that has been discharged in municipal wastewater. The design parameter of a constructed wetland is based upon one population equivalent (1 p.e.). Essentially, one person will amount to how much space is required to treat his or her wastewater. The treated wastewater from constructed wetlands is normally discharged into surface water systems such as rivers or streams. There are mainly two types of constructed wetlands which treat certain elements of wastewater in slightly different ways. The two types of constructed wetlands are vertical flow and horizontal flow (Hoffmann et al, 2011).

Horizontal flow constructed wetlands are the most common type in use. Wetlands are especially promising for decentralized wastewater treatment. There is virtually no need for electricity in its operation. The horizontal flow constructed wetland functions by directing water through the bottom of the bed to the outlet. The bed is constructed by filling either gravel or sand into the constructed wetland. The function of gravel or sand is to create more surface area in which bacteria can thrive. The bacteria consume tiny bits of organic matter in the wastewater before it is discharged. The gravel or sand also provides stable grounding for plants to cover up the constructed wetland for aesthetic purposes. Horizontal flow constructed wetlands require significant amounts of space. Due to the larger area demand, this type of constructed wetland is more sensitive to high temperature climates, namely hot and dry climates. High rates of evapotranspiration as well as sensitivity to large influxes of precipitation during rainy seasons makes horizontal flow constructed wetlands more suitable for cooler climate zones (Hoffmann et al, 2011).

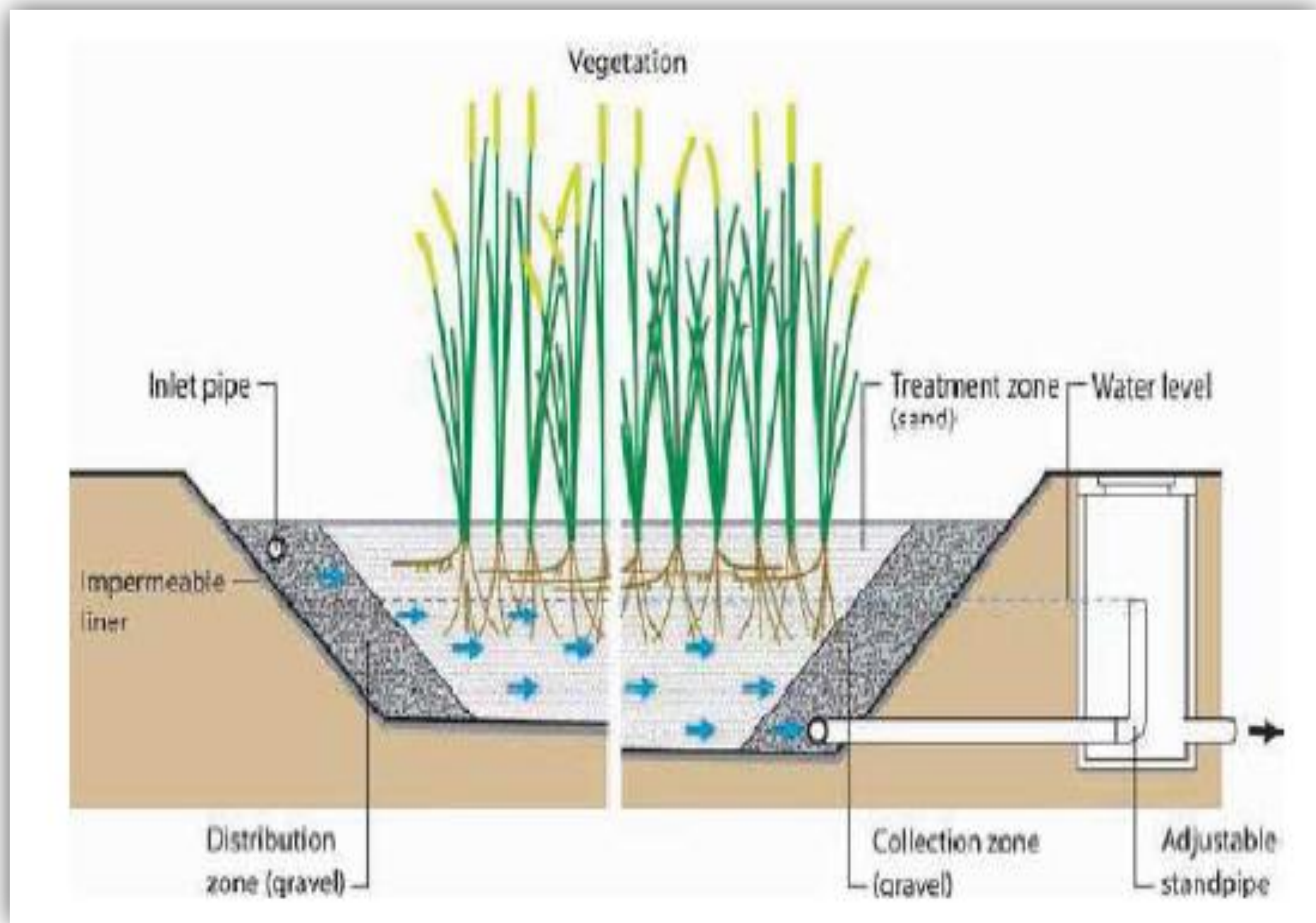


Figure 12: Horizontal flow constructed wetland
Water flows from the left of the pond to the right where it is cleansed by the bacteria mixed within the gravel bed. The water is discharged out to the right (Hoffmann et al, 2011). *The image is split in half.

Vertical flow constructed wetlands are similar in design to horizontal flow constructed wetlands in that the basis of the system is essentially the same. The vertical flow system introduces water from the top of the gravel or sand bed. The water then permeates through the sand or gravel by gravity. It is commonly assisted by the use of some plants that can use wastewater as a source of nourishment such as reeds. Reed type plants are preferred since they have long roots which can help to permeate the gravel bed. The permeation of the gravel or sand bed is essential to the process as it creates pathways for oxygen to flow freely throughout the bed. Oxygen is necessary in the nitrification of the wastewater which is when ammonia (NH3) is oxidized. Vertical flow constructed wetlands have a nitrogen removal rate at about 30%. If there is too much nitrogen in wastewater, it can deplete oxygen levels for aquatic life. Therefore, further treatment to remove nitrogen is usually needed before the water is discharged. Water flowing through the sand or gravel, is also acted upon by bacteria which consume tiny organic matter contained in the wastewater which treats it. Water is then discharged from an outlet below the surface of the bed. Operation of the wetland requires the use of a water pump, therefore energy is also required. The system introduces water in intervals in order to allow for even infiltration through the bed. Vertical flow constructed wetlands require less area in comparison with horizontal flow systems. The requirement of less space means that this type of constructed wetland is suitable for hotter climates (Hoffmann et al, 2011).

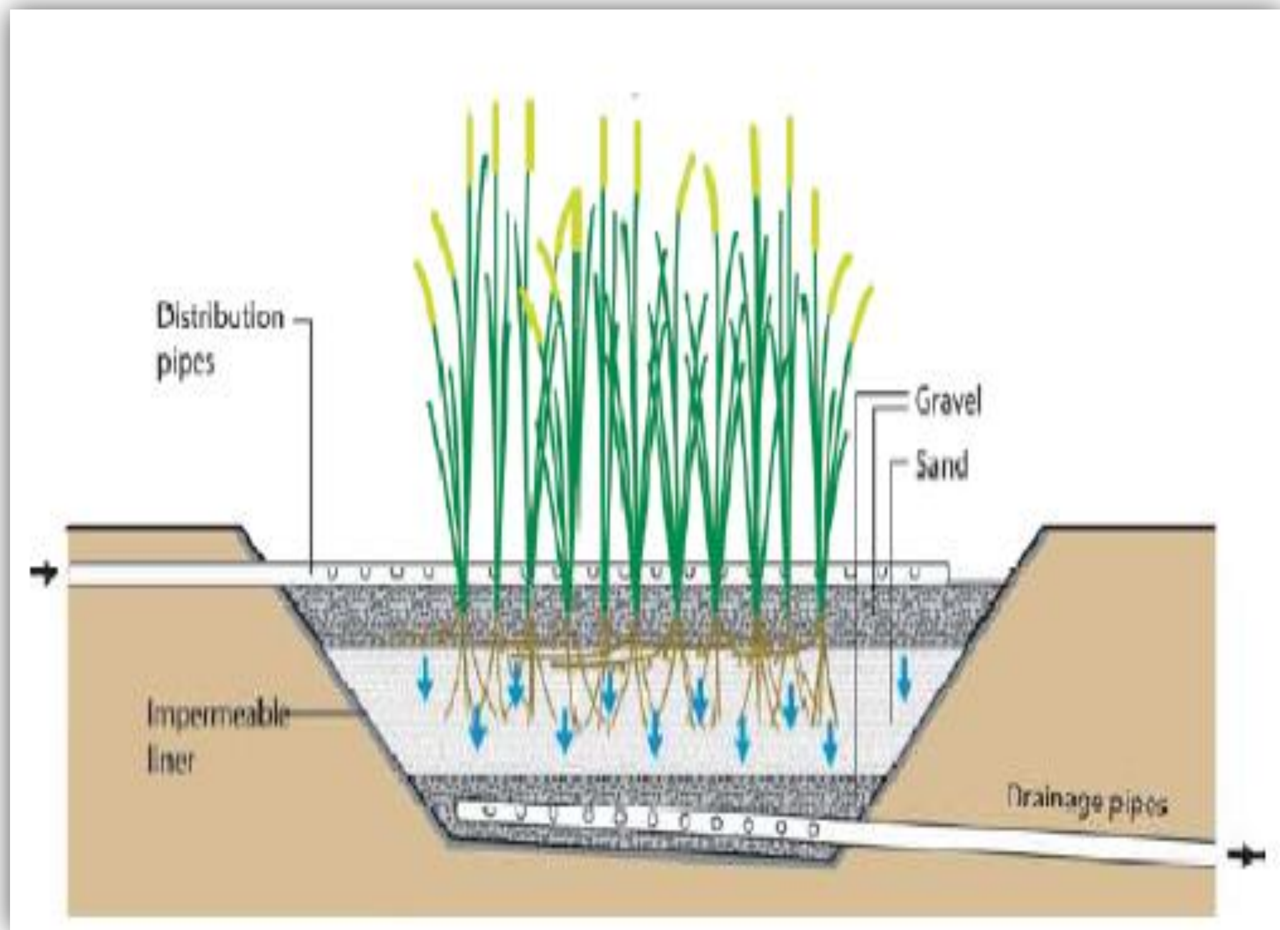


Figure 13: Vertical flow constructed wetland
Wastewater is distributed evenly on the top layer of the gravel bed. The wastewater seeps downwards, immersing the gravel. Bacteria on the surface area of the gravel eat the organic fraction of the wastewater and it is discharged via gravity (Hoffmann et al, 2011).

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

An important aspect of wastewater is its biochemical oxygen demand and its chemical oxygen demand. The two components are measures to determine water quality in terms of suitability for the environment. The BOD (also known as BOD5) is determined by measuring a sample of water and incubating it for five days. The bacteria present in the water will aerobically consume organic matter within the water. While consuming the organic materials, the bacteria also use the dissolved oxygen in the water. The dissolved oxygen is also what fish and other marine life breathe. Therefore, if the water in an ecosystem has a high BOD, the wildlife dependant on dissolved oxygen will suffer. Typically, wastewater has high a BOD if it is not treated due to the high amounts of organic materials contained within. Chemical oxygen demand (COD) is measured by using basic chemical testing methodologies that don’t require long times to get accurate readings. The COD determines the total quantity of oxygen that is required to oxidize all organic materials into carbon dioxide and water. Thus, COD values are higher than that of BOD values since all organic matter is accounted (Brown and Caldwell, 2011).

In the Naivasha Bus Park, an existing sewer grid carries wastewater away to a treatment plant near the city. The treatment plant empties its effluent into Lake Naivasha. With the introduction of the EcoSan system, the anaerobic biogas plant onsite helped to reduce the organic load of the wastewater being discharged into the sewer grid. The reduction of organic load in wastewater means that the BOD will be less. So, there will be reduced chances of polluting the environment as high BOD can affect the aquatic life in Lake Naivasha. Inhabitants depending on Lake Naivasha for daily sustenance and chores will have an improved quality of life due to EcoSan installations upstream (Onyango and Rieck; Naivasha, 2010).

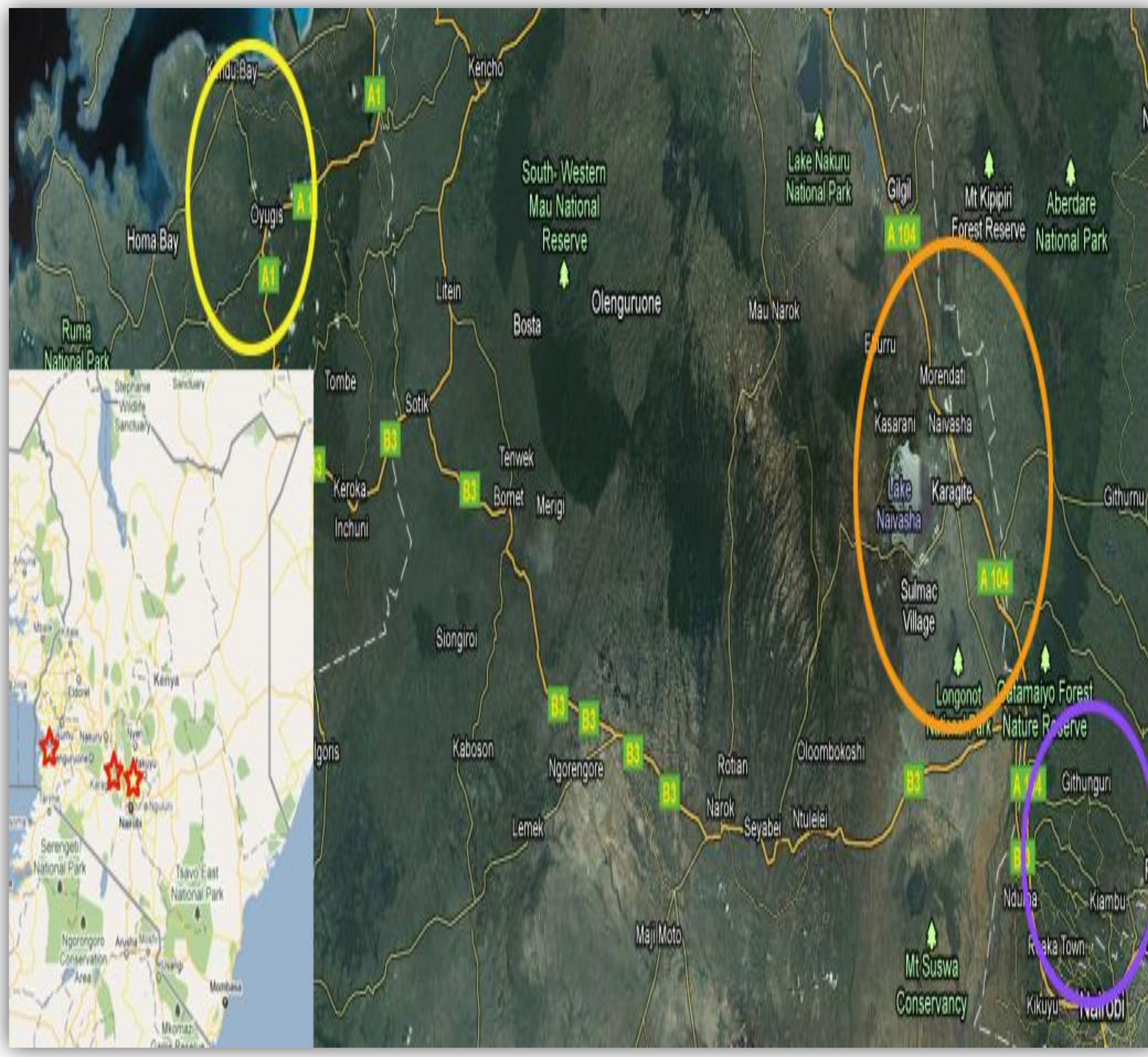


Figure 14: Project Sites of Rachuonyo District, Naivasha Bus Park, and Gachoire Girls High School

Yellow: Rachuonyo District Location

Orange: Naivasha Bus Park Location

Purple: Gachoire Girls High School Location (Map source: Google.com)

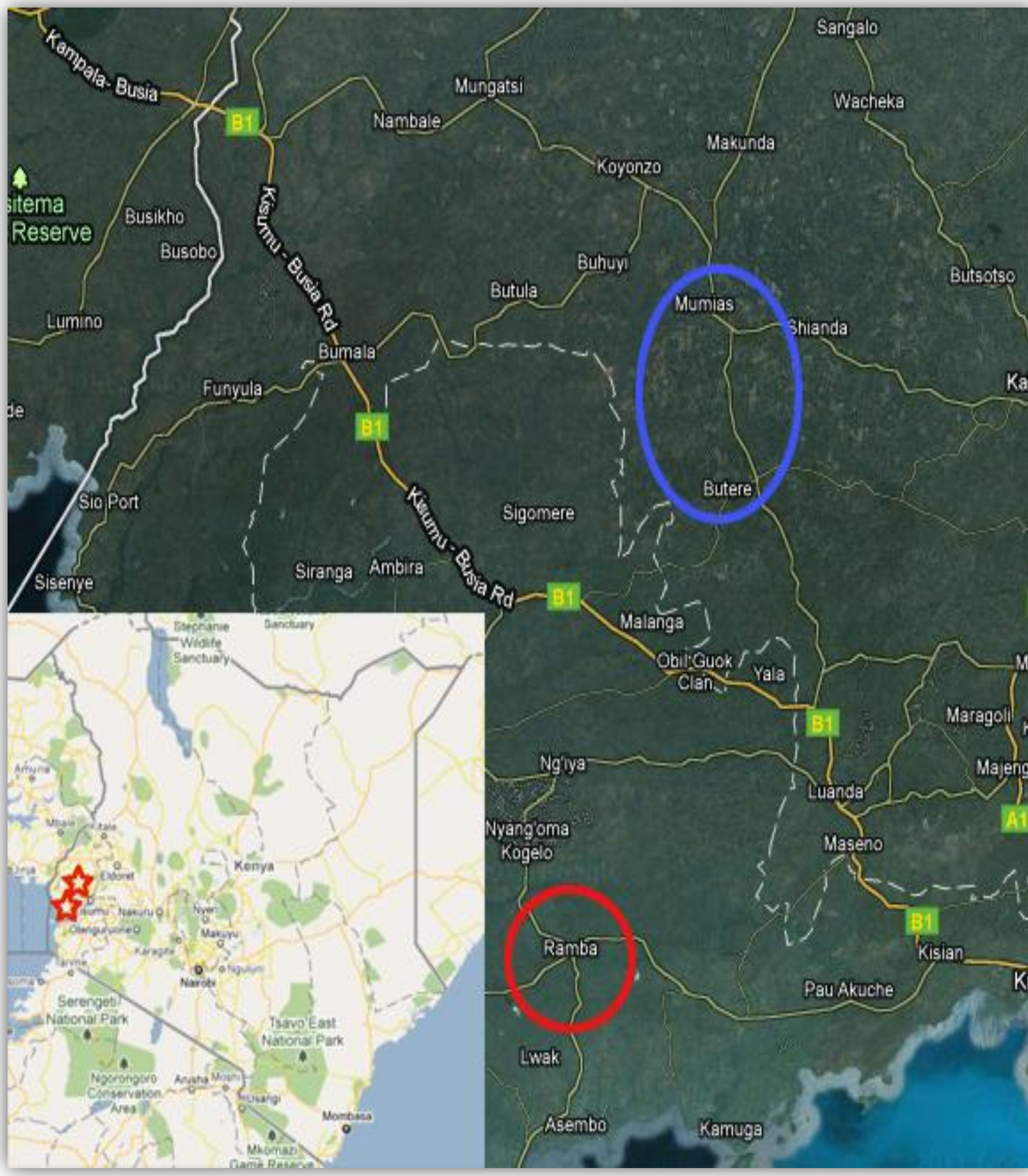


Figure 15: Project sites of Khaimba Primary School and Ramba Boys High School

Blue: Khaimba Primary School Location

Red: Ramba Boys High School Location (Map source: Google.com)

Chapter 4: Conclusions/Results

The link between social conditions and EcoSan projects in Kenya

In terms of the sustainability of EcoSan in Kenya, it must follow that the current conditions of gender equality are playing a vital role. As it was posited by Shiva, women, especially those in developing countries, are linked to the environment. For example, the management of environmentally straining practices is often left to women, which can only mean they directly influence nature on a daily basis (Burmester et al, 2002). The current conditions of gender equality worked in favor of successfully implementing EcoSan projects. Within the EcoSan concept, women are already informal managers of the environment which means they are capable of being converted into ecological sanitation specialists. In regards to EcoSan in schools, children learn that ecological sanitation is not something that is just for mothers to manage. Rather, EcoSan is only successful if everyone practices the concept. Thus, it is imperative that students are given strong examples by adults from which they can learn.

Rachuonyo District and Khaimba Primary School

The EcoSan projects in the Rachuonyo District and Khaimba Primary School utilize similar technological approaches in improving their sanitation conditions. The use of UDDTs for higher sanitary treatment along with the reuse of urine for agriculture has benefitted users in several ways. Farmers of the region now have access to fertilizer supplements which can improve yields and therefore livelihoods. All people of the region benefit due to the decreased risk of parasites thriving in feces and water born diseases. Perhaps the most influential impact of EcoSan in the Rachuonyo District and Khaimba Primary School is capacity building.

In the Rachuonyo District, women were the majority of people concerned with the implementation of EcoSan in their region. Women's groups in particular responded to calls for capacity building seminars on EcoSan toilets. At the seminars, women learned how to use the UDDTs as well as maintaining the units and affiliated structures. Like most regions in Kenya, women in the Rachuonyo District are in a sense, environmental managers. Much of their daily chores and tasks revolve around affecting the environment in some way. For example, women manage much of the biomass that comes from private farms (Goldsmith, 1999). Proper disposal or usage of the biomass is left entirely up to the women, which is a crucial part of EcoSan concepts.

According to a report in the Rachuonyo District Strategic Plan, women are still subject to "retrogressive socio cultural beliefs of the community." The women of the region are still not allowed to own land and they are limited in society to certain tasks such as managing households. Women and female children are still tasked with fetching water from long distances, sometimes up to 10 kilometers away (Kahuthu, 2010). The introduction of UDDTs has lessened the burden of water demand. For example the water demand for small scale agriculture is reduced because there is now a portion of the irrigation water which is substituted by urine. The result is that less water needs to be retrieved for daily use or the same amount of water can be fetched but applied to other water-intensive outlets. It allows the women to have more time to do other household duties.

Women are also given the power of knowledge. EcoSan concepts worldwide can only be successful if they work for future generations. In theory, the women who have learned the new EcoSan concepts will pass the knowledge to their families in hopes of making sustainable sanitation a cultural norm. With higher knowledge comes greater social mobility, which is a desired by-product of EcoSan. In this way, women can be helped by the new EcoSan system. On a follow-up investigation of the EcoSan projects in Rachuonyo District, it was found that the systems were working well. The only lacking factors were that more funding and capacity building was needed (Osumba; Rachuonyo, 2010).

The students at Khaimba Primary School were the main targets for implementing Eco-San's concepts. It is a commonly held belief that the education of children is the gateway to future success. So, capacity building of children is a necessity in the sustainability of EcoSan. According to the methodology of the EPP, the best way to teach children about EcoSan and its reliance on user competence is to implement the concepts in schools. While in school, teachers, male, and female students are tasked with cleaning the UDDTs. The students are also able to see tangible results of their labor as fecal matter and urine are reused onsite as compost. Thus, the students learning the new sanitation schemes can relay information about the benefits of EcoSan to their friends and families. As more people discuss EcoSan, community awareness is spread. Eventually EcoSan concepts can become common knowledge and practice. In the future, male and female students will have experiences with EcoSan in which they can share. Ideally, their relatable experiences can help bridge some understanding of gender equality.

The only issues surrounding the success of EcoSan at Khaimba Primary School centered on the need for more awareness training seminars and monitoring. Students and teachers began reusing the old pit latrines since the UDDTs were becoming clogged. The clogs were not a problem of technology, rather of operation and maintenance. The lack of proper management of the new toilets was due in part to a sudden change in school leadership. The new leaders of the school were not properly trained in the EcoSan concepts. The UDDTs were thusly overburdened and became deteriorated over a short time. School faculty and students reverted to old practices since there was an absence of maintenance of the UDDTs. Clearly, the students' actions are indicative of their leadership at school. The case study at Khaimba Primary School demonstrates the high importance of capacity building in sustainable waste management (Wakala; Khaimba, 2010).

Gachoire Girls and Ramba Boys High School, and Naivasha Bus Park

The case studies from Gachoire Girls High School and Ramba Boys High School show the utility of EcoSan in practice while offering valuable hands-on training. The methodologies for the Gachoire Girls High School and Ramba Boys High School differ from the Khaimba Primary School and Rachuonyo District case studies due to the use of more advanced technologies. Students at both of these schools are able to realize the versatility of human waste as it is used onsite for agriculture and energy production. The case study of Naivasha Bus Park is especially important as it is one of the few applications of EcoSan in a commercial setting. Users, managers, and beneficiaries of the EcoSan facilities now have reliable systems that make the bus park more welcoming. A figurative cycle begins as the young students become accustomed to EcoSan concepts while adults are able to see the concepts in practice. When the students become working adults, EcoSan will likely have become an established concept. In the absence of commercialized practice, mainly students and teachers would be the ones benefitting from EcoSan, which is not contributing to the sustainability of the projects.

The integrated wastewater management system in Gachoire Girls High School included: a biogas settler, an anaerobic baffled reactor, UDDTs, and a constructed wetland. Although several parts of the system functioned well and demonstrated the utility of EcoSan, other components failed which caused concern about the overall project. The integrated system suffered several setbacks as there were problems with the operation and maintenance of the systems. It was reported in a follow-up analysis that only one of the UDDTs was being used occasionally by male teachers while all others were locked. The report indicated that teachers and students quickly resorted to using a pit latrine near the UDDT facilities. Regarding the constructed wetland, failures were attributed to lack of management. The effluent from the anaerobic baffled reactor was not evenly controlled by manual operation. As a result, the wetland became clogged. The constructed wetland was also not large enough to handle the capacity of water inflows coming from the school. Aside from the user errors and technical failures, biogas from the anaerobic processes was able to be used. Food for breakfast and lunch were cooked using biomethane. The specialized stove unit that evenly burns biomethane had some uses-related problems. The stove was not maintained properly as it was covered in food waste, which prevents optimal usage of the device. Benefits of the project were able to be realized for a short time after the project crediting period ended. Lack of capacity building and awareness was the underlying cause of the project's shortcomings (Rieck and Wakala, 2010). Students at Gachoire Girls High School therefore follow the examples set by school authorities and do not completely embrace EcoSan concepts, a similar issue which is shared with the Khaimba Primary School.

In terms of sustainability, the female students learn hands-on utility of EcoSan concepts, but are limited in fostering the ideas for future waste management. Particularly, female students must learn the concepts of EcoSan since they will likely be working in a male-dominated society in the future (Mareng, 2010). For the sustainability of the environment and human welfare, the project must ensure capacity building above all else. The case studies at Gachoire Girls High School and Khaimba Primary School accurately demonstrate that education of EcoSan must start with children, but equally must be supported by the adults.

The case study from Ramba Boys High School demonstrates the effectiveness of collaboration between students and teachers. Factors contributing to the overall success of EcoSan at the school include: the dire need for improved sanitation and the satisfaction of the students and faculty. Students were observed as being cooperative and even embracing the new toilets. Before, the students had to remove their clothes before using the toilets for fear of carrying the odors of the pit latrines into the classroom. An incentive besides cleaner and user-friendly facilities is that the new toilets eliminate chances of embarrassment for students. The toilets are also pour-flush operated which means there are less chances of malfunction due to user errors (Wakala; Ramba, 2010).

There are several similarities between the case studies at Ramba Boys High School and Gachoire Girls High School in terms of the successful operation of EcoSan technologies. The follow-up analyses also took place nearly in the same time frames from their respective dates of implementation. The systems were analyzed about 2 months after their construction phases were completed. Both schools had successful output and usage of biomethane for cooking. However, there were several differences between the successes of the schools in the first two months of their operation. For example, the systems at Ramba Boys High School were not suffering from malfunctions or misuse due to human error. The new pour-flush toilets were of working order and appeared to be sustainable with the wastewater flows correctly being managed. The irrigation system using wastewater was adequate for usage on the school farm. Students and faculty seem to have adapted to the EcoSan concepts (Wakala; Ramba, 2010).

The main goal of EcoSan in both schools was to improve sanitation conditions and make it sustainable. In Khaimba Primary School, teachers were having compliance issues with the new system. Within a short time after the completion of the Khaimba Primary School project, teachers had resorted back to pit latrines after the UDDTs malfunctioned. Operation of the more complex systems such as the anaerobic baffled reactor also failed due to poor preliminary management. In comparison, the EcoSan systems in Ramba Boys High School are running strong and will likely succeed during the next follow-up evaluation. There was only one setback reported so far at Ramba Boys High School. A critical component of the biogas reactor was stolen. A security fence has since been installed. It must follow that students are important in the upkeep of the EcoSan systems, but acceptance by the teachers is crucial (Wakala; Ramba, 2010).

The EcoSan project in Naivasha Bus Park is particularly unique as it is in the commercial sector unlike the other projects that took place in schools. It was completed in 2008 and the most recent follow-up analysis was taken in July 2010. The follow-up report on Naivasha Bus Park showed a significant improvement in sanitation. There were few challenges that prevented optimal functioning of the project. Masonry and basic plumbing issues occurred, but were expected to be repaired. The overall impression of the project was optimistic because the toilets were profitable based off of user fees. Operators, hired by the local water management company also played an important role in regularly maintaining the toilets. The only missing elements of the bus park toilets are lighting for night users. The onsite biogas plant also lacked a financing mechanism although it has been under negotiations. The biogas plant is functioning well and has even pumped biomethane to an onsite café for cooking fuel. The constructed water kiosks above the toilet facilities experience shortages of water. The sale of water from the kiosks is therefore unpredictable. User acceptance and operation of the toilets are assisted by a prevailing practice of using pour-flush systems. The biogas plant's outlet is connected to the preexisting sewer grid which proves the region has been using water-based flushing. Thus it shows that user acceptance is the key to the sustainability of the project (Wakala; Naivasha, 2010).

Furthermore, it proves that if adults are able to adapt to the EcoSan system, then young people should also have no problems following suit. The children learning the EcoSan theories and concepts in school will be able to transfer the knowledge to the "real world." In terms of sustainability, the system works because one must be able to apply the theories he or she learned in order for it to become a normal practice. The inclusion of citizens to the health club at Khaimba Primary School afforded them the chance to practice ecological sanitation while the children were able to witness adults setting positive examples. As well, EcoSan projects were implemented in female schools and male schools, which help sensitize students to gender equality. The backbone of EcoSan is sustainability and it starts with the capacity building of every citizen, regardless of age, sex, social class, or education level (UNESCO, 2006).

Chapter 5: Remarks on sustainability and how EcoSan can be improved in Kenya

The approach and methodology of EcoSan is intrinsically complicated because it involves far more than just the simple installation of innovative sanitation systems. Success of EcoSan in Kenya requires the input of several stakeholders ranging from governmental and non-governmental entities to local water management companies. Aside from administrative and logistical obstacles, the implementation and sustainability of EcoSan in Kenya is dependent upon the acceptance of the people. Naturally, acceptance can be taught through capacity building seminars and daily applications such as those in schools and townships. The above case studies all demonstrate a means of capacity building. In particular, the capacity building efforts are geared towards those who are interested rather than being mandated. The law in Kenya has merely changed to ban open-defecation and to construct more latrines. However, there are no laws that enforce environmentally friendly solutions for the entire country. To local people, EcoSan is nothing more than volunteering to improve sanitation conditions. Hence, this is why it is crucial to have key people supporting the projects. The key people are the ones who will be affected the most by EcoSan projects. In the case of Kenya, it all comes down to women. The sustainability of EcoSan benefits from women while it also puts women at a potential disadvantage for the following reasons: it could perpetuate the idea that women should remain as homemakers and relying solely on women to take on new concepts does not necessarily mean that they will take on new roles which will hinder EcoSan in the future.

- EcoSan is effectively able to capitalize on the current gender equality situation in Kenya by exploiting the prevailing practices of women as homemakers. In Kenya, mainly women are in charge of household operations such as waste management or handling of biomass. Through cultural norms and theoretical approaches, women are valued in nearly the same way that the environment is in Kenya. The environment is used and exploited to keep society afloat. The over pressuring of women to be informal environmental managers has kept them in the role of homemaker in many a Kenyan home. It is likely that the new eco-friendly solutions are in a way end-of-pipe thinking in the household. Women who are homemakers will have an easier life due to lessened demand on daily chores such as fetching water. The result seems to be that women will just become better homemakers rather than better educated or liberated women.

- Although women have several positive impacts on the sustainability of EcoSan, the current gender practices could also hinder the future of EcoSan projects. The nature of EcoSan relies heavily on the efforts of volunteers, a majority of whom are women. With the staggeringly higher number of women and less men supporting EcoSan projects, it could exacerbate the gender inequality system altogether. Generally speaking, a likely scenario would be that current women's groups take an informal ownership of EcoSan while men simply benefit from it without the work. The lopsided approach is not sustainable and would cause the system to eventually fail. Men should be expected to at least understand the operation of low-tech systems such as UDDTs or pour flush toilets.

Conversely, EcoSan can also help change the current gender inequality situation in Kenya in several ways. There are numerous inequalities set within the Kenyan social system which can be eliminated by the help of ecological sanitation. Women will benefit from EcoSan because: they have more exposure to innovative technologies, it can open doors for future opportunities, capacity building for children will help to change the understanding of gender roles for the future, and it can even prevent violence against women.

- Due to its extensive capacity building, EcoSan is a way of advancing the knowledge of underrepresented women. As there are more Kenyan women trying to get into more science, math, and engineering related professions, EcoSan technologies often require knowledge of advanced science or engineering for maintenance. Women are now exposed to more advanced technologies such as biogas purification systems for onsite biomethane usage. With the strong relationship of women to the environment, working with environmental technologies lends them the capability to advance their knowledge of complex systems. It will also benefit women because the growing prevalence of renewable energies and eco-friendliness is becoming a lucrative market locally and worldwide for business.
- It can even provide women with a stepping stone into a more distinguished rank in society since they are primarily the ones fostering the new ecological sanitation concepts. The capacity building of women helps lead to rising education levels. Just as can be observed in developed nations, women who are gaining higher degrees of education are also earning higher incomes which can boost their leverage in the household (Mareng, 2010). The advancement of Kenyan women is not a western ideal being pushed upon the people as there are numerous local advocate groups fighting for the injustices against women all over the African continent (Goldsmith, 1999). EcoSan is able to contribute to the improvement of social conditions while tackling environmental problems. Additionally, a greater understanding of their eco-footprint has been proven to enhance the well-being of their

families. The improved sanitation concepts lead to lowered rates of water-borne diseases which keeps their children and dependents healthy. With healthier child-ren, it is assumed that school attendance rates will increase due to less ill students missing class (Mareng, 2010).

- Young students are perhaps the easiest to influence, especially when there are role models involved. The students at Khaimba Primary School and Ramba Boys High School have experienced the principle concepts of EcoSan with the strong support of adult figures. All of the students were responsible for cleaning the new toilets which helped to reinforce that sustainable sanitation is something should be done by all people. In short, if teachers practice the system, students will likely follow. Male and female students will gain a deeper understanding of the concepts as they will grow up having EcoSan as a fundamental and gender-neutral practice (Ma-reng, 2010).
- Lastly, the lack of adequate sanitation services and facilities especially impairs women living in rural Kenyan areas. In this case, harm can come to women in mental and physical ways. According to a study by Amnesty International, wom-en in particular require adequate sanitation facilities due to reasons such as their monthly menstrual cycles and the need for privacy. Using the existing makeshift toilets however can also be a direct danger for women. For example, Amnesty In-ternational’s report on women’s experiences in the slums of Nairobi shows that women are more at risk of being assaulted or raped than men are due to a lack of sanitation facilities. The current practice in several informal settlements is to ex-crete waste in the open or into pit latrines. The pit latrines tend to be in a centra-

lized location. Many people must walk several hundreds of meters to get to the latrines. Women in particular are affected by the distance of the latrines from their homes as there are justifiable fears of being assaulted or raped. Numerous cases of women experiencing gender-based violence or assault have occurred in transit between the latrines and their homes. Most women prefer using the latrines only during daytime, although there are also cases where women are still assaulted during the day. The physical and mental harm experienced by women will adversely affect their futures. There were no reported issues of violence against women in the EcoSan project sphere. However, rape and assault cases oftentimes go unreported. So, based off of Amnesty International's report, it can be assumed that women in the EcoSan project circle have possibly experienced gender-based violence caused by the lack of sanitation facilities. The introduction of EcoSan provides decentralized wastewater management that is able to be installed in virtually any location. Women will no longer have to travel long distances and risk putting themselves in danger just for a visit to the toilet. Thus, all people can expect the positive results of having a sustainable toilet system nearer to their homes (Amnesty International, 2010).

Chapter 6: Final Remarks

The overall methodology of EcoSan is effective because of its ability to create an "everybody wins" situation. The concept is to introduce desperately needed sanitation systems which will reduce environmental impacts and can lead to the mitigation of excreta-related diseases and foul odors. EcoSan started several pilot projects in schools not only as a means to provide needy children with adequate sanitation, but also to plant the seeds of the future so-to-speak. Without any concept of sustainability, EcoSan would be like a short-term project that would benefit only a limited amount of people. Therefore teaching young male and female students is vital for future successes of ecological sanitation in Kenya. Aside from organizational and administrative support for funding and certificates, EcoSan relies upon local peoples to operate and maintain the new wastewater/excreta systems. In the informal social sector, women were the majority of local citizens readily available to learn and use the EcoSan systems. It must follow that women and the changing of gender roles is necessary for the survival of EcoSan in Kenya.

Due to its reliance on volunteers and a few paid workers, EcoSan is clearly not a perfect solution for the environmental problems caused by inadequate sanitation. Cases of prevailing practices heavily outnumber successful EcoSan projects in Kenya. Basically, if an innovative approach fails, local people have no other choice but to resort to tried and tested methods of excreta management. So, capacity building can only reach people who are willing to learn. The voluntary nature of EcoSan is the first problem in getting the masses to accept the new system. There are currently no laws or punitive measures for those who do not follow the EcoSan system. If such laws existed, that would mean males and females equally must abide by the laws which would likely help to blur the lines of gender discrimination. It is clear that EcoSan project developers did not plan to rely on authoritative support to help sustain their projects. The purpose of the pilot projects was to expose locals to new ideas while showing children in schools that ecological sanitation is only successful if everybody does it. As was observed in Khaimba Primary School and Gachoire Girls High School, the students were not the cause of the less than acceptable results. Rather the teachers were at the root of the problems. After the project had matured past its crediting period, funds were no longer available to fix or maintenance the dilapidations done to the EcoSan technologies (Rieck and Wakala, 2010). Essentially, capacity building is the only solution to redeem the project. EcoSan must place more emphasis on capacity building seminars. The seminars should be more frequent and include more than just women's groups and volunteers. Perhaps the urgency of providing adequate sanitation systems was the foundation of starting the projects. Yet, a deeper analysis should have first been made regarding the potential of the people. Every EcoSan project in Kenya suffered some sort of setback due to constraints largely caused by operators and maintenance workers.

It was shortsighted to install innovative systems that cannot function without proper manual operation and occasional engineering. It is uneconomical and unsustainable to constantly bring foreign experts to the sites whenever failures occur. The people at the sites were accustomed to archaic methods and outdated social norms. In conclusion, EcoSan project developers need to have in-depth knowledge of the cultural and social behaviors of the locals before investing in complex projects, particularly in sectors where ecological sanitation is not mandated by law.

Suggestions for the future of EcoSan

It can be assumed that in most any institution, money is a powerful motivator. The underlying issue is that Kenyan people are not being taught how EcoSan can potentially earn them profits. The concepts of EcoSan are designed for the conservation of water, harnessing waste flows, and improving overall sanitation. In terms of money flows, EcoSan chiefly provides ways to save on costs by reducing the inputs of required materials such as fertilizers and water. Fertilizer supplements can come from the human excreta flows, but it is only a method of cutting costs. EcoSan rarely accounts for ways to consistently bring cash into the system. EcoSan has the potential to earn money for the region and local people. Rather than viewing sanitation as a burden, it can provide jobs for local wastewater system engineers, developers, project managers, and maintenance crews. The women who are getting involved with EcoSan volunteering seminars are essentially being trained as specialists. So, there will no longer be a need for foreign EcoSan engineers and project developers to make regular weekly or monthly visits to monitor and maintain the systems.

An opportunity for business

The local people, specifically women, must be endowed with valuable knowledge on the semi-complex processes of EcoSan in order for it to be sustainable. The local women's groups can turn their knowledge of EcoSan into a consultation business. The aim of their business would be to network with local and international stakeholders and foreign technology companies to implement sustainable sanitation solutions. The women's groups can therefore act as a middleman company that links EcoSan technologies to municipalities. Eventually, the women's groups could even develop their own eco-brand of sustainable sanitation products or management schemes. Their new enterprise could begin consulting and exporting to neighboring countries and regions. Funding for the projects could be procured from existing sources such as donations or governmental and non-governmental entities. Basically, EPP serves as a catalyst to inspire people and not just provide solutions on a small scale. The potential for business will make any environmentally related project superior to the trendy volunteer-based programs. If a proper business plan for environmental management is in place, then it creates an "everybody wins" situation. Municipal authorities are satisfied through income, locals will have more spending power, and everyone will have a cleaner environment.

PAGE LEFT INTENTIONALLY BLANK

References

- Agarwal, Bina. "Gender and Land Rights Revisited: Exploring New Prospects via the State, Family and Market." Journal of Agrarian Change, Vol. 3 Nos. 1 and 2 January and April 2003. Pgs 184 – 224. Retrieved on May 24th 2011 from http://www.binaagarwal.com/downloads/apapers/gender_and_lan_rights_evisited.pdf
- Aithal, Vathsala. *"ifu* – An Intercultural Innovation in Higher Education?" Pgs. 12-15. Sustainable Water and Soil Management. Springer-Verlag, Berlin Heidelberg, New York 2002.
- Amnesty International Publications. "Insecurity and Indignity: Women's Experiences in the Slums of Nairobi, Kenya." Amnesty International Publications, July 2010. Retrieved June 8, 2011 from http://www.amnesty.org/en/library/asset/AFR32/002/2010/en/12a9d334-0b62-40e1-ae4a-e5333752d68c/afr320022010en.pdf
- Brown and Caldwell. "Appendix B: Description of Commonly Considered Water Quality Constituents." Watershed Protection Plan Development Guidebook. Northeast Georgia Regional Development Center. Retrieved on May 29, 2011 from http://www.gaepd.org/Files_PDF/techguide/wpb/devwtrplan_b.pdf
- Burmester, Andrea; Kruse, Tanja; and Kunst, Sabine. "The Project Area Water."Pgs. 23-25. Sustainable Water and Soil Management. Springer-Verlag, Berlin Heidelberg, New York 2002.
- Bwire, Buluma. "Breaking Shit Taboos: CTLS in Kenya." Pgs. 91-96. Plan International Inc. Kenya, Kilifi Development Area. Retrieved May 23rd 2011 from http://pubs.iied.org/pdfs/G02800.pdf
- Devasia, Leelamma. "Rural Development with Special Emphasis on Women, Water and Environment." Pgs. 29-55. Sustainable Water and Soil Management. Springer-Verlag, Berlin Heidelberg, New York 2002.
- Goldsmith, Jane Esuantsiwa; Reynolds, Fiona. "Issues 3: Women and Sustainable Development – from Local to International Issues." Millennium Papers. Local Agenda 21 UK and Humanity, Environment, & the 21st Century: Gender 21, June 1999. Retrieved May 23rd 2011from http://www.stakeholderforum.org/sf/mediafiles/UNED%20millenium%20paper3.pdf
- Hoffman, Dr. Heike; von Muench, Dr. Elisabeth; Platzer, Dr.-Ing. Christoph and Winker, Dr.-Ing. Martina. "Technology Review of Constructed Wetlands: Subsurface Flow Constructed Wetlands for Greywater and Domestic Wastewater Treatment." Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ). Eschborn, Germany, February 2011. Retrieved on May 30, 2011 from http://www.gtz.de/en/dokumente/giz2011-en-technology-review-constructed-wetlands.pdf
- Kahuthu, Robinson; Muchoki, Thomas; and Nyaga, Catherine. "Rachuonyo District: District Strategic Plan 2005-2010 for Implementation of the National Population Policy for Sustainable Development." National Coordinating Agency for Population and Development Rachuonyo. HSK Consulting Ltd. Summit House University Way, Nairobi. Retrieved on June 5, 2011 from http://www.ncapd-ke.org/UserFiles/File/District%20Strategic%20Plans/Rachuonyo%20%20Final%20Modified.pdf

- Kanehl, Suzanne. "Endocrine Disruptors in Potomac River Fish." March 2007. Retrieved on May 26, 2011 from http://www.sprol.com/2007/03/bass-going-through-the-change/
- Kraft, Laura. "Case Study of Sustainable Sanitation Projects: UDDT Toilets and Decentralized Wastewater Treatment System for Schools in Kenya." SuSanA 2010. Retrieved on May 26, 2011 from http://www.susana.org/docs_ccbk/susana_download/2-750-2-750-en-susana-cs-kenya-schools-9-7-2010-1.pdf
- Kunst, Sabine. "Future Perspectives for Sustainable Water and Soil Management." Pgs. 315-317. Sustainable Water and Soil Management. Springer-Verlag, Berlin Heidelberg, New York 2002.
- Li, Zifu and Mang, Heinz-Peter. "Technology Review: 'Biogas Sanitation' - draft." Program "Sustainable Sanitation - EcoSan" of Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH. December 2009. Retrieved on May 27, 2011 from http://www.sswm.info/sites/default/files/reference_attachments/GTZ%202009%20Technical%20Overview%20on%20Biogas%20Sanitation_0.pdf
- Lugo, Chalres Charo. Part Three: Policy Issues. "Environmental Policy and the Law: A Gender Perspective." Pgs. 89-101. *Gender Inequalities in Kenya,* UNESCO 2006. Retrieved May 20, 2011from http://unesdoc.unesco.org/images/0014/001458/145887e.pdf
- Mareng, Chuei. "Development of Women's Education in Kenya." 16216 - 93 Street, Edmonton, AB, Canada T5Z 3M9, February 16th 2010. Retrieved on June 15th 2011 from http://www.academicjournals.org/ingoj/PDF/pdf2010/Mar/Mareng.pdf
- Odhiambo, Orodi; Oduor, Alex R.; Onyango, Patrick. "Technical Guide to EcoSan Promotion." EU-GIZ/SIDA EcoSan Promotion Project, Ministry of Water and Irrigation, Nairobi, Kenya, November 2009. Retrieved on May 25, 2011 from http://www.susana.org/docs_ccbk/susana_download/2-710-technical-guide-to-ecosan-promotion2.pdf
- Okazawa-Rey, Margo and Kirk, Gwyn. "Women and the Environment." Pgs. 533-543 Women's Lives: Multicultural Perspectives Fourth Edition. McGraw-Hill Humanities April 2006.
- Onsongo, Jane. Part One: Economy and Workplace."Gender Inequalities in Universities in Kenya." Pgs. 31-48. *Gender Inequalities in Kenya,* UNESCO 2006. Retrieved May 20, 2011from http://unesdoc.unesco.org/images/0014/001458/145887e.pdf
- Onyango, Patrick and Rieck, Christian. "Case Study of Sustainable Sanitation Projects: Public Toilet with Biogas Plant and Water Kiosk Naivasha, Kenya." SuSanA 2010. Retrieved on May 26, 2011 from http://www.sswm.info/sites/default/files/reference_attachments/RIECK%202010%20Public%20toilet%20with%20biogas%20plant%20and%20water%20kiosk%20Naivashsa%20Kenya.pdf
- Orchardson-Mazrui, Elizabeth. Part Four: Cultural Issues. "The Impact of Cultural Perceptions on Gender Issues." Pgs. 145-165. *Gender Inequalities in Kenya,* UNESCO 2006. Retrieved May 20, 2011from http://unesdoc.unesco.org/images/0014/001458/145887e.pdf
- Osumba, Wycliffe. "Rongo District Schools and Householders UDDTS. Follow-ups. June 2010 by Wycliffe Osumba. Submitted on 01-07-2010. EcoSan Network Kenya,

2010.Retrieved on May 29, 2011 from http://ecosankenya.blogspot.com/2010/08/rongo-district-schools-and-householders_16.html

- Osumba, Wycliffe. “Site follow-up and Awareness Creation on EcoSan Toilets/Biogas in Bondo, Siaya, Kisumu, and Rachuonyo districts by Wycliffe Osumba Submitted on 30-08-2010. EcoSan Network Kenya, August 2010. Retrieved on May 25, 2011 from http://ecosankenya.blogspot.com/2010/09/site-follow-up-and-awareness-creation.html
- Republic of Kenya. “Implementation Plan for Sanitation (IPS) 2009 (The Water Sector Sanitation Concept-WSSC).” Ministry of Water and Irrigation, August 2009. Retrieved on June 6th 2011 from http://www2.gtz.de/Dokumente/oe44/ecosan/en-mwi-kenya-sanitation-concept-2009.pdf
- Silberschmidt, Ph.D Margrethe. “Changing Gender Roles and Male Disempowerment in Rural and Urban East Africa: A Neglected Dimension in the Study of Sexual and Reproductive Behavior in East Africa.” XXIV IUSSP General Population Conference. Salvador, Brazil, 18-24 August 2001. Retrieved on June 15th 2011 from http://www.iussp.org/Brazil2001/s70/S78_01_Silberschmidt.pdf
- Spuhler, Dorothee. “Anaerobic Baffled Reactor.” Sustainable Sanitation and Water Management. Retrieved on May 29, 2011 from http://sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments-0
- Spuhler, Dorothee. “Anaerobic Filter.” Sustainable Sanitation and Water Management. Retrieved on May 29, 2011 from http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments/a
- Spuhler, Dorothee. “Biogas Settlers.” Sustainable Sanitation and Water Management. Retrieved on May 29, 2011 from http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/biogas-settl
- Spuhler, Dorothee. “UASB Reactor.” Sustainable Water Management. Retrieved on June 17th 2011 from http://sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments/u
- Suda, Collette. “Gender Disparities in the Kenyan Labor Market: Implications for Poverty Reduction.” University of Nairobi, Kenya, 2002. Retrieved on June 15, 2011 from http://www.njas.helsinki.fi/pdf-files/vol11num3/suda_02.pdf
- Susana.org. Retrieved on May 24, 2011 from http://susana.org/lang-en/intro
- Susanavideos.“Promoting Ecological Sanitation in Kenya-Part ¼” Uploaded by susanavideos on May 24th 2010. Retrieved on June 15th 2011 from http://www.youtube.com/watch?v=BoEcuYvoFq0
- Swashplus.org. “Rachuonyo District: Access to Safe Water, Sanitation and Hygiene for Schools and Children.” Sustaining and Scaling School Water, Sanitation, and Hygiene Plus Community Impact (SWASH) 2008.Retrieved on May 31, 2011 from http://www.swashplus.org/Documents/Baseline%20data%202008%20-%20Rachuonyo.pdf
- V. Muench, Dr. Elisabeth and Rieck, Christian. “Experiences with EcoSan Systems to Provide Sustainable Sanitation in Schools in Kenya and India.” Rahul Ingle GIZ EcoSan Programme. Retrieved on May 25, 2011from http://www.huussi.net/tapahtumat/DT2009/pdf/present_Rahul_Ingle.pdf

- V. Muench, Dr. Elisabeth. “Topic Sheet: EcoSan – recycling oriented wastewater management and sanitation systems.” Deutsche Gesellschaft fuer Internationale Zusammenarbeit GmbH, Division Environment and Infrastructure, February 2009. Retrieved May 23, 2011from http://www.gtz.de/de/dokumente/en-ecosan-topicsheet-2009.pdf
- UNESCO, 2006. “Capacity Building for Ecological Sanitation: Concepts for Ecologically Sustainable Sanitation in Formal and Continuing Education.” International Hydrological Programme of the United Nations Educational, Scientific, and Cultural Organization, France and Deutsche Gesellschaft fuer Internationale Zusammenarbeit GmbH, Germany 2006. Retrieved on May 25, 2011from http://unesdoc.unesco.org/images/0014/001463/146337e.pdf
- Wakala, Moses and Rieck, Christian. “Status Gachoire Girls High School.” EcoSan Network Kenya. Retrieved on May 25, 2011 from http://ecosankenya.blogspot.com/2010/12/status-gachoire-girls-high-school.html
- Wakala, Moses. “Gachoire Girls Secondary School” EcoSan Network Kenya. Retrieved on May 25, 2011 from http://ecosankenya.blogspot.com/2010/08/gachoire-girls-secondary-school.html
- Wakala, Moses. “Khaimba Primary School UDDT Post-training and Follow-up” EcoSan Network Kenya, November 2010. Retrieved on May 25, 2011 from http://ecosankenya.blogspot.com/2010/12/khaimba-primary-school-uddt-post.html
- Wakala, Moses. “Naivasha Public Toilet.” EcoSan Network Kenya, August 2010. Retrieved on June 9, 2011 from http://ecosankenya.blogspot.com/2010/08/naivasha-public-toilet.html
- Wakala, Moses. “DTS Monitoring Report – EcoSan Projects by Moses Wakala submitted on 15-09-2010.” EcoSan Network Kenya, September 2010. Retrieved on May 25th 2011 from http://ecosankenya.blogspot.com/2010/09/dts-monitoring-report-ecosan-projectsby.html
- WHO. “WHO Guidelines for the Safe Use of Wastewater, Excreta, and Greywater” World Health Organization, United Nations Environment Programme, and the Food and Agriculture Organization, 2006. Retrieved on May 25, 2011 from http://whqlibdoc.who.int/publications/2006/9241546832_eng.pdf
- Winker, Dr. –Ing. Martina and von Muench, Dr. Elisabeth. “Technology Review: Urine Diversion Components: overview of urine diversion components such as waterless urinals, urine diversion toilets, urine storage and reuse systems.” Deutsche Gesellschaft fuer Internationale Zusammenarbeit GmbH, Eschborn December 2009.
- www.kwaho.org. “EcoSan (ecological sanitation).” Kenya Water for Health Organization. http://www.kwaho.org/t-ecosan.html
- www.kwaho.org. “Project Description: Mumias Butere EcoSan Promotion Project.” Kenyan Water for Health Organization. http://www.kwaho.org/pd-buteremumias.html
- www.thisisafrica.me. “City Life: Gender Roles in Kenya: Men, What Would You Do If You Were A Woman?” April 6th 2009. http://www.thisisafrica.me/city-life/detail/532/Gender-roles-in-Kenya%3A-Men,-what-would-you-do-if-you-were-a-woman%3F

- www.un.org. "Convention on the Elimination of All Forms of Discrimination Against Women." December, 31st 2007. Retrieved on June 15th 2011 from http://www.un.org/womenwatch/daw/cedaw/