

# **PLASTIC TUBULAR** **BIOGAS DIGESTERS**

## **A Pilot Project in Uru, Kilimanjaro, Tanzania**

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The purpose of this project was to test the economic viability, cultural appropriateness and sustainability of biogas technology in the Kilimanjaro region of Tanzania. The extensive use of biomass materials for fuel and as a building material has made deforestation an essential issue in the Kilimanjaro region. A pilot project of ten plastic tubular biogas digesters was implemented in the farming village of Uru.

Through the installation and extensive assessment, Assida has found that tubular biogas digesters represent a source of renewable energy that has many benefits --- economic, environmental and quality of life --- which could potentially offset the costs of installation and maintenance. In order to make a definitive conclusion about biogas in Kilimanjaro, especially in comparison to other fuel-efficient technologies available, a more extensive study over a period of two to three years must be conducted. This report offers preliminary conclusions based on evaluative research done eight months after the original installation.

## **INTRODUCTION**

Assida, a non-governmental organization from the United States (please see Appendix A for more information), began a project in January 2008 in the Kilimanjaro region of Tanzania to assess the technical effectiveness, cultural appropriateness and economic viability of biogas digesters for cooking for rural farming families. It was hypothesized that farmers in the pilot project would enjoy the benefits of renewable energy – less time and money spent on firewood collection – and that the use of biogas in the place of traditional wood burners would not largely impact their daily life. It is further hypothesized that widespread use of biogas digesters would reduce firewood use and ultimately stem deforestation in Kilimanjaro.

### **Environmental Concerns in Tanzania, in particular in Kilimanjaro:**

As Tanzania develops economically and politically, significant strain is being put on the nation's environment, in particular, the nation's forests. Widespread use and limited governance of forests leads to extensive deforestation. Deforestation poses a significant threat to both individual families, particularly in rural Tanzania, that depend on the firewood, protection from erosion, and other marketable products that forests provide, and to the environment at large. The situation calls for immediate action to protect and preserve forests. Technological improvements, lifestyle changes and good governance are needed to maintain forest resources for future generations.

More than 50% of Tanzanian's 33.5 million hectares of forests and woodlands is on public lands where sufficient supervision does not exist and thus residents dangerously exploit forest resources.<sup>1</sup> Biomass, primarily wood and charcoal, is the main energy source for rural areas, amounting to 92 percent of national energy use<sup>2</sup>. Rural families depend on firewood and charcoal for most daily activities such as cleaning, bathing, and cooking. Given that 86% of the population is rural,<sup>3</sup> this dependence has significantly contributed to the region's deforestation. Furthermore, Forests provide 730,000 person-years of employment and forest products contribute to between 2.3 and 10 percent of Tanzania's exports. Forests also provide pasture for livestock, raw materials for industries, protection of watersheds, water for irrigation, electricity, control of soil erosion and nutrients<sup>4</sup>. In particular erosion can lead to reduced water supply. In the Kilimanjaro region where drinking and irrigation water comes from Mt. Kilimanjaro and is often in short supply, this use of forests is particularly important.

If they maintain their current lifestyles, rural Tanzanians are likely to be faced with a shortage of wood and increased difficulty feeding their families<sup>5</sup> and carrying on other daily activities. Additionally, there will be irreversible harm caused to the local environment. The needs of the people must be met in alternative ways that allow the forest to recover, leaving sizable and self-sustaining forestry for future generations.

On a larger scale, deforestation is also occurring across the continent of Africa and around the world and is a significant contributor to global warming. Forests serve as a natural carbon sink, so when forests are cut down, a significant amount of carbon is released into the atmosphere.<sup>6</sup> Climate change is expected to create more severe weather patterns and overall warming of the planet. This could potentially create a more intense rainy season and drier conditions in the semiarid portions of the continent. Resulting crop failure would make it difficult for local farmers to earn their livelihood, and could lead to further difficulty in obtaining water in dry regions. Beyond the effects on humans, climate change can disrupt ecosystems and adversely affect plant and animal life.

Specifically in Kilimanjaro in particular, the reduction of the glacier-covered area on the top of Mount Kilimanjaro<sup>7</sup> and other changing weather conditions put the region's vast amount of biodiversity is at risk.<sup>8</sup> Specifically in the Kilimanjaro region, where this pilot project took

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<sup>1</sup> . The remaining portion is comprised of forest reserves (13 million hectares), plantation forestry (over 80,000 hectares) and water catchment management (1.6 million hectares).

<sup>2</sup> Ibid.

<sup>3</sup> Tanzania's ETOA (Environmental Threats and Opportunities Analysis), USAID, Feb 2004.

<sup>4</sup> Environment. Retrieved July 15, 2008, from Official Online gateway of the United Republic of Tanzania Web site: <http://www.tanzania.go.tz/environment.html>

<sup>5</sup> This can be seen during the rainy season, when dry firewood is scarce and rural Tanzanians report eating less as a result, Uru interviews – August 2008

<sup>6</sup> Cramer, Wolfgang, Bondeau, Alberte, Schaphoff, Sibyll, Lucht, Wolfgang, and Smith, Benjamin. "Tropical Forests and the Global Carbon Cycle: Impacts of Atmospheric Carbon Dioxide, Climate Change and Rate of Deforestation." *Philosophical Transactions: Biological Sciences* 29 March 2004. 331-343. 15 November 2008. <<http://www.jstor.org/stable/4142186>>.

<sup>7</sup> Kaser, G, Hardy, D, Molg, T, Bradley, R, & Hyera, T (2004). Modern Glacier Retreat on Kilimanjaro as Evidence of Climate Change: Observations and Facts. *International Journal of Climatology*, 24, Retrieved November 15, 2008, from <http://www.geo.umass.edu/faculty/bradley/kaser2004.pdf>.

<sup>8</sup> Fields, Scott. "Continental Divide: Why Africa's Climate Change Burden Is Greater." *Environmental Health Perspectives* 113, 8 August 2005. A534-A537. 15 Nov 2008 <<http://www.jstor.org/stable/3436338>>.

place, government offices, NGOs and local communities are beginning to realize and address the problem of deforestation. (Please see Appendix B for policies regarding deforestation in Tanzania.)

### **Background Information on Biogas Technology**

Biogas technology uses organic waste matter to produce fuel that can potentially be used for heating, cooking, lighting, and other electrical needs. The organic waste is mixed with the appropriate ratio of water and added to an anaerobic environment, a large tube made of sheet plastic in Assida's model, and the waste is broken down in a two step biological process.<sup>9</sup> The biogas that is emitted is roughly 60% methane, which can then be burned as cooking fuel. Methane has 20 times more greenhouse gas potential than carbon dioxide, so the capture and burning of methane significantly reduces the greenhouse gas effect.<sup>10</sup>

This project employed plastic tubular digesters, described below, used primarily because of their low cost and status as a temporary structure; however there are many different biogas models that exist. (For description, please see Appendix D.) The biogas systems built in Uru use cow and sheep manure and require a water source as well as livestock.

Water and manure are mixed in a 2:1 ratio, and the resulting slurry is poured into the digester, a polyethylene tube, 10 meters long and 0.8 meters in diameter. The digester sits below ground level in an earthen ditch with a 1.5% slope, protected by a covering made from locally available materials including wood, banana leaves, and corrugated aluminum. The slight slope allows for the sludge to slowly travel through the digester at a rate that is calculated to allow complete digestion of the waste. A simple plastic hose connects the top of the digester to another polyethylene bag used for gas storage. At the storage bag, the gas pressure is controlled with a rope around the middle to increase pressure for cooking when desired, and a water bottle device bleeds off excess pressure to avoid ruptures and/or explosions. The methane is fed to a simple gas stove for cooking. Additionally, the process breaks down the manure, making the effluent waste an excellent, safe and nutrient rich fertilizer for the farmers' crops.<sup>11</sup>

The materials for each biogas system, excluding the stove itself, cost approximately 150 USD. The stoves used in this study were made from stone by a mason and included two burners, one for the biogas and one fuel-efficient wood-burning stove. The stove cost was between 50 and 150 USD, depending on the amenities included. Less expensive gas stoves (5-10 USD) could be attached to the digester and used instead. The biogas digester consists of the following parts, which can be substituted for local materials as deemed appropriate: digester bag made from polyethylene sheet plastic tubing, buckets for the inlet and outlet, hose, gas storage bag, water bottle, and materials to seal the connections. With the exception of the plastic tubing, all other materials were bought locally. Some parts were recycled or found objects, such as old water

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<sup>9</sup> First, the naturally present bacteria (acidogenic) in the waste break down the larger organic particles, producing smaller molecules and fatty acids. Next, another type of bacteria (methanogenic) break these smaller particles into methane, carbon dioxide, carbon monoxide, and trace amounts of other gases. (biogas manual, appendix F)

<sup>10</sup> [www.epa.gov/otag/climate/420f05002.htm](http://www.epa.gov/otag/climate/420f05002.htm)

<sup>11</sup> [www.training.gpa.unep.org/content.html?id=219&ln=6](http://www.training.gpa.unep.org/content.html?id=219&ln=6)

bottles for the safety gas release and stripped rubber tires for the bag-to-hose connections. (For full description of the construction of a biogas digester, see instruction manual in Appendix F.)

### **Background Information on Other Technologies:**

In addition to biogas, solar cooking and fuel-efficient stoves are other cooking technologies currently being explored by alternative technology engineers. In particular, fuel-efficient stoves that burn wood or charcoal are widely available in Tanzania. These stoves can reduce fuel consumption by twenty to eighty percent by providing insulation<sup>12</sup>. Simple clay and metal stoves are available for less than ten USD, and mud stoves can be even cheaper. Brick stoves can cost two to three times more, but provide better insulation and therefore more efficient firewood use. Fuel-efficient firewood stoves can also, for a higher price, include chimneys, which significantly reduce the health risks associated with smoke inhalation.<sup>13</sup>

Solar cookers are appealing because they are very inexpensive, do not pollute and require no fuel; however, there are many difficulties in using them. The simplest solar design can be constructed with a cardboard frame and tin foil, which can cost around 2 USD total. However, solar cooking takes longer than traditional methods (1.5 hours to boil rice), cannot fry foods,<sup>8</sup> and must take place outside during daylight hours. They are also difficult to use in cloudy or rainy weather, which is a major concern during the rainy season. Also, solar cookers do not produce a flame, and people accustomed to traditional cooking methods are less inclined to make the switch, creating a cultural barrier to the use of solar energy.

### **Project in Uru**

A group of farmers from the village of Uru in the Kilimanjaro region was chosen for this study. This farming village consists of families with small lots where they grow mostly bananas and coffee, along with other vegetables. The main sources of income for families in Uru are these crops and their livestock, mainly cows and sheep. The Kilimanjaro region, along with the neighboring Arusha region, are two of the few places in Tanzania where livestock are traditionally kept indoors, facilitating manure collection. Farmland in the village is irrigated through a system that corrals water running off of the slopes of Mount Kilimanjaro and is maintained by the same cooperative group of farmers who also participated in the biogas pilot project. The easily collected manure and the availability of water makes this region, from a technical perspective, well suited for biogas technology. The cooperative farming group worked together with Assida volunteers to construct the initial digesters for the pilot project.

Construction on ten biogas digesters was begun in Uru in January 2008. Seven months after this initial installation, in August 2008, an extensive assessment of the digesters was completed. (Please see Appendix C for more information on Assida's project.)

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<sup>12</sup> Women's Commission for refugee women and children. **Beyond Firewood: Fuel Alternatives and Protection Strategies for Displaced Women and Girls.** March 2006

<sup>13</sup> Poverty and the Environment: Understanding Linkages at the Household Level. Washington, DC: The World Bank, 2007.

## **RESULTS**

### **Uru Project**

In January the group of Uru farmers and Assida volunteers worked together on each digester, with the Assida volunteers teaching the farmers the technology. When the Assida team left after three weeks, four digesters were completely finished.<sup>14</sup> Four other digesters were left partially completed with all of the necessary materials on hand. Two digesters were left with completed ditches for the digesters, but no bags. The details of results for individual digesters can be found in the results table (pages 8-9), in which the digesters are numbered 1 through 10.

Of the four that were completely finished in January, three are running smoothly and will form the basis for our evaluation of biogas as a technology below (digesters 1,2,3). The fourth (digester 4) was completed, but had been neglected by its owner who reported only filling the digester every four to five days. No fertilized manure was coming out of the outlet end of the digester and the gas bag was relatively empty. Digesters 6, 7, 8 and 9 were not finished during Assida's January trip, and in fact were not completed until our arrival in Tanzania in August 2008. The completion of these digesters without assistance shows that the farmers understand the technology and affirms that the biogas-digester construction can be taught and spread, however the delay demonstrates that not all farmers are fully committed to using these digesters. All expected to be producing biogas within two weeks of our departure at the end of August.<sup>15</sup>

Digesters 5 and 10 were not completed when at the end of the first trip in August because there was a shortage of plastic bags. The bag for digester 5 had broken during construction in January and, for digester 10, Assida ran out of sheet plastic and was unable to construct a tenth bag.

Most of the completed trenches had coverings constructed by the farmers from various available materials including metal sheeting, banana branches and corrugated metal, which was sufficient to prevent animals from stepping on and crushing the holding bags.

Our study of the successful use of biogas digesters is based around the three digesters, which have been working consistently since the end of January, digesters 1-3. Since farmers maintained the manure levels of their digesters in varying amounts, the amount of gas in the gas storage bags differed in each case. For instance, the bag in digester 1 was the fullest because the owner had four cows, more than the other farmers, and filled his digester with three to four buckets of manure and six to eight buckets of water daily. He reported very favorable results. His family is able to use the gas to cook three meals per day, he does not have to tighten the gas bag to increase the pressure of the gas, and it only takes five minutes to make tea using the biogas stove. Farmers that only filled their digester two to three times per week, whether due to lack of manure, lack of time to fill it, or other reasons, only had gas sufficient to cook two meals per day.

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<sup>14</sup> A finished digester includes a completed ditch, a filled digester bag, a tubing connection to the gas bag, and a further connection to the stove.

<sup>15</sup> It takes two to three weeks for the mixture in the digester to be converted into gas and for the fertilizer to be emitted from the other end.

## URU RESULTS TABLE

Digester	Digester	Connection and Gas Bag	Animals	Regular Maintenance	Savings on firewood	Firewood reductions	Benefits
<b>1 Antoni</b>	Residue build-up Would like a top for his ditch and shoot for manure	Very Full	4 cows	3-4 buckets of manure/day = 1 hour	15,000 Tsh* per month	Only uses 1 bunch per week	
<b>2 Frank</b>	Works continuously	Moderately Full	1 Cow, 5 sheep	Puts in all his manure, which takes 15-20 minutes, feeds digester every 1-2 days	60,000 Tsh per month	80%	Mama now has mboga (vegetable) garden, sells some and family eats some. Earns additional 3,000-5,000 Tsh per day from her time saved.
<b>3 Komm</b>	Not covered	Full	No cows or goats – uses neighbor’s manure	Feeds digester 3 times a week, takes 25 minutes to fill	Time: about 12 hours per week saved,	30-50%  Before: 10 pieces/day  Now: 3-5 pieces/day	The family used to cut down firewood from trees on their property. Instead, the daughter can use time to wash family’s clothes.

\* Tsh = Tanzanian Shillings  
~ 1300 Tsh = 1 USD

<b>4 Oswald Mushi</b>	- Well covered, covering on end has fallen in - Fertilizer doesn't come out the other end	Relatively empty		2 buckets manure, 4 buckets water every 4-5 days			
<b>5 Massawe</b>	Bag broke in January						
<b>6 Minja</b>	Filled 1 month before	Connection Just finished, good	2 Cows				
<b>7 Ngowi</b>		Connection Just finished, good					
<b>8 Stephen Mushi</b>		Connection just finished					
<b>9 Peter Urio</b>		Connection just finished					
<b>10 Benedict Mushi</b>	Shortage of bags, so digester was not constructed although ditch was dug						

Note. Boxes are left empty due to incomplete information.

All participating farmers own cows except in the case of digester 2, in which the owner obtains cow manure from his neighbor a 3-4 times per week. Farmers also add sheep pellets to the mixture, but because of the harder consistency, they did not have as successful results. In order to obtain the maximum amount of gas from goat manure, the pellets must be mashed up before water is added and the slurry is added to the digester. (This information was conveyed to the farmers in August.)

Maintenance time varied among families since the trenches were filled in varying amounts and with varying frequency. On average, creating the water-manure mixture and filling the trench took between 30 to 60 minutes per digester filling. For all farmers, trench maintenance in the rainy season required significantly more work (up to two to three hours in one day) because the trench erodes with significant rainfall.

Through the use of biogas technology, families were able to reduce their firewood consumption. While a clear reduction was demonstrated, exact measurements of how much firewood consumption was reduced and how much money and time was saved are difficult to determine definitively for four main reasons. First, there was no standardized metric by which each farmer tracked and reported change in firewood consumption. Despite assistance from local NGO director Mr. Kimario, language and cultural differences made it extremely difficult to standardize the varying reports received. Second, the farmers were not tracking their firewood usage throughout the pilot project and thus asking them to speak retrospectively about their prior consumption of firewood was difficult and results were often unreliable. Third, it was difficult to determine how much firewood reduction was due to biogas and how much was due to the fuel-efficient stoves. Fourth, there were many different factors affecting each individual family. For instance, the family with digester 3 did not report much in terms of monetary savings, but were able to reduce the use of trees on their own property.

Despite these difficulties, our interviews indicate that families, in particular the women, were able to save up to 12 hours per week due to a decrease in firewood collection. Monetary savings from reduced purchasing of firewood ranged from 15,000 to 60,000 Tsh (12.50 to 50.00 USD) per month. Firewood reductions ranged from 30 to 80 percent. While it is difficult to make a more precise statement on firewood reduction, the results do clearly indicate that a substantial reduction occurred, and families with working digesters were able to save considerable time and money on firewood collection.

An additional measure of success is in the productive use of time no longer being used for firewood collection. With their extra time, women were able to do other activities, such as wash clothes or grow mboga (vegetable) gardens. Families are a portion of these additional vegetables and sold the rest. In the case of digester 2, the mother earns an additional 3,000 to 5,000 Tsh (2.50 to 4.00 USD) per day by selling the products of her vegetable garden.

Furthermore, families mentioned the stresses of the rainy season, when the rains are so intense that firewood collection is difficult and dry firewood is rare and as a result,

they generally consume less. While families also reported that the digesters produced less gas during the rainy season, which could be caused by a variety of reasons including colder weather that slows down the reaction in the digester, the biogas does provide a more consistent source of cooking fuel, and thus improved nutrition during this period.

Finally, the manure output from the biogas system is reportedly a better fertilizer for crops than untreated manure that has not undergone the biogas reaction however, the effects of the fertilizer on crops in Uru has not been determined, since it had only been seven months and not an entire year-long growing cycle. However, when asked if they thought the treated manure it made a difference in their crop growth, most farmers responded affirmatively.

One of the biggest complaints about the biogas digester was that there was only one biogas burner, given that most meals involve the cooking of more than one dish at a time. The stoves that were built contained two burners side by side, one biogas and one fuel-efficient wood burning. While the women said that they enjoy using biogas for most foods, they would use the wood stove when they had two dishes to cook simultaneously. Also, they found that the fuel-efficient wood-burning stove cooks hotter and faster than the biogas, which leads them to use the different burners to cook different foods. Families generally cook vegetables (mboga), rice (wali), bananas (nduzi), ugali (a traditional maize dough), meat (nyama), coffee and tea on their biogas burner, and hard foods, like makande (maize and beans) and beans (maharage), on the fuel-efficient wood-burning stoves.

### **Organization Visits**

The evaluation trip in August 2008 included meetings and occasional collaboration with about fifteen different organizations in Tanzania. Most were NGOs, primarily those whose work involves environmental issues. Others included government offices, including the National Environmental Management Council (NEMC).

In addition to wider environmental efforts, the organizations that Assida met with are all working to address and reverse deforestation in Tanzania. In particular, Assida's discussions with organizations focused on various alternatives to traditional cooking methods. The most common approach involves the development and promotion of fuel-efficient firewood and charcoal stoves. For example, the Tanzania Traditional Energy Development and Environmental Organization (TaTEDO) promotes a clay and metal stove that sells for 5 to 9 USD. TaTEDO has found fuel-efficient biomass stoves to be effective in reducing carbon emissions, creating new jobs (for those artisans constructing and selling the stoves), and in saving both time and money.<sup>16</sup>

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<sup>16</sup> "Biomass Energy Situation in Tanzania." [TaTEDO](http://www.tatedo.org). 2007. Tanzania Traditional Energy Development and Environmental Organization. 10 Jan. 2009 <[www.tatedo.org](http://www.tatedo.org)>.

In addition to Assida's project in Uru (in partnership with the Trans-Regional Environmental Technology Association (TRETA)), both TaTEDO and the Kilimanjaro Industrial Development Trust (KIDT) are running biogas pilot projects. Organizations whose work does not include biogas generally expressed interest and enthusiasm in the technology, however many had concerns about the cost of biogas and its potential to meet large-scale needs.

Floresta, an international nonprofit with a program based in Marangu, works to help local farmers organize farming cooperatives which boast village community banks and engage in sustainable practices. Assida visited a group of farmers participating in the Village Community Banking (VICOBA) program implemented by Floresta, a program that has the potential to help communities raise the required funds for biogas digesters. After a review of the technology in Uru, Floresta expressed enthusiasm for the technology and agreed that it is culturally appropriate, but felt that it would be difficult to succeed on a large scale because of the expense. TaTEDO, which works with biogas already and supports exploring the technology, was also present at the meeting and offered generally positive suggestions and opinions.

The Division of Environment is in charge of writing Tanzania's environmental policy, however the National Environmental Management Council (NEMC) handles the more technical aspects, including enforcement. In a meeting with Assida, James Ngeleja, who coordinates energy and environmental work for NEMC and deals with enforcement and compliance, expressed enthusiasm for the potential of a carbon market and for the work of the Programme for Basic Energy and Conservation in Southern Africa (ProBEC). He also cited the Kyoto Protocol and the U.N. Millennium Development Goals. The Tanzanian government works to promote improved stoves, and ProBEC promotes biogas where there is a concentration of people (such as schools and prisons). When asked about large scale biogas implementation, Ngeleja, said that it is "a good idea, but difficult to implement." He argued that cows are kept enclosed only in the Kilimanjaro and Arusha regions, and that the carbon offsets for an individual household are too small to warrant the implementation of such a project.

Overall, a lack of coordination between NGO and government policies and actions was both observed first hand by Assida and reported by many NGO's. Many organizations expressed a desire for more district level policy with tangible goals and results, criticizing the ineffectiveness of national environmental policy that largely results in little more than rhetoric. At least one NGO, PAMOJA Trust, is working to promote good governance by facilitating collaboration between local government, civil society and the private sector. All of these organizations and government offices recognize the environmental challenges facing Tanzania, and their ability to work together effectively is crucial to solving these problems.

## **CONCLUSIONS**

While the eight-month biogas pilot project does not provide enough information to make a final decision about the viability of biogas digesters in the Kilimanjaro region, a number of useful conclusions about plastic tubular biogas digesters can be garnered from the pilot project:

### **I. Benefits of Biogas**

*Use of biogas digester and fuel-efficient stove reduced firewood usage, saving resources, time and money*

Reported values from participating families on the amount of firewood saved, the amount of time (previously spent gathering firewood) saved, and the amount of money (previously used to purchase collected firewood) saved, show a 30 to 80 percent decrease in the amount of firewood used with the new biogas/fuel efficient combination stove compared with the traditional three stone burner. This wide range of firewood reductions demonstrates that participants used their digesters inconsistently, as discussed in the results section. Once families adjust to using the new technology, Assida believes that the majority of cooking will be done with biogas as opposed to firewood. Furthermore, many meals prepared in Uru required the simultaneous use of two burners. Assida believes that if the biogas fuel line was split to two burners, participants could use wood-burning stoves less. Reducing consumption of biomass and forest resources at the individual family level is an essential component to creating sustainable forestry resources for the future. This reduction on a large scale can help reverse the effects of deforestation -- decreased resources for energy, decreased water supply, erosion, species extinction and climate change -- and make essential resources available and affordable to rural families.

Digester maintenance time, while extensive during the rainy season, did not surpass the amount of time families saved by gathering less firewood. Participating farmers spent between thirty minutes to two hours a day on maintenance (the most is during the rainy season), mixing the slurry, filling the digester and maintaining the structure of the trench. Women in participating families previously spent approximately 20 hours per week gathering firewood without the biogas stove, so they now have time to grow vegetable gardens and be with their families more often. Produce from vegetable gardens is both consumed by the family and sold in local markets, providing an extra source of income for the family. Furthermore, families had to pay for each bundle of firewood they gathered as well. By purchasing less firewood, participating families saved between 12.50 USD and 50.00 USD per month. The monetary savings from collecting less firewood and from produce can be used towards family expenses, which are otherwise difficult for families to cover, including food, health care, clothing, school, and building materials.

*Biogas improves health of farming families*

Use of the biogas stove allows families to eat healthier during the rainy season. Even though farmers stock up on firewood during the dry season, there is never enough firewood to last through the months of rain. Although the amount of gas produced is reportedly reduced during the cold rainy season, the biogas stove allows families to cook during the rainy season without having to collect firewood or use up their reserves. While difficult to measure quantitatively, the health improvements of increased food consumption during the rainy season are a substantial benefit of biogas. Additionally, the smokeless cooking of biogas is better for the respiratory health of women in the Kilimanjaro region who often spend most of the day cooking over a flame. According to a World Bank publication, smoke inhalation from solid fuels is the fourth leading health risk factor in developing countries. While there is no way for us to measure the degree to which the use of biogas benefits respiratory health, we assume that it represents a health improvement. With further study, Assida hopes biogas to have a number of other unpredicted health and lifestyle benefits.

*The technology can be taught*

Participating farmers were able to fully understand biogas technology and how to construct the apparatus. This was proven in that they were able to finish constructing the digesters from January without assistance and used only locally purchased materials. In the future, the farmers will be able to teach neighbors and others who are interested how to build and use biogas digesters.

*Farmers show a commitment to their personal digesters*

The farmers' commitment to the technology is shown in their willingness to maintain their trenches daily and to perform even more extensive maintenance during the rainy season. Furthermore, the farmers' willingness to contribute a substantial portion of the cost of trench lining demonstrates their commitment to the technology.

**II. Obstacles and Potential for Improvement***Most materials are locally available*

All of the construction materials for the biogas pilot project were purchased in the Kilimanjaro region, with the exception of the plastic tubing. While such tubing is available in Tanzania and Assida has been in touch with a potential supplier, its cost and accessibility are still uncertain. Contact information for supplier is included in Appendix E.

*The dirt digester trenches erode, particularly during the rainy season*

In consultation with Uru farmers, Assida has designed a trench lining in the hope of making the current digesters more durable and decreasing maintenance time during the rainy season. The specified trench lining includes brick, soil and cement sides for all digesters, and a stone and sand bottom for digesters not yet installed and functioning. Assida believes this expense is worthwhile due to the commitment of the participating farmers in Uru to pay 30 percent of the cost of lining the trenches. The estimated total cost, including 30,000 TSh for labor, was 250,000 TSh (200 USD) each without a bottom (for currently functioning digesters which cannot be removed from trench), and 320,000 TSh (260 USD) with a bottom. Follow-up is necessary to observe the success or failure of these linings in preventing erosion. It would also be interesting to study trench durability with and without the proposed lining to reveal the specific benefits of lining the trench.

*Food cooks more slowly on a biogas burner than on a firewood burner*

The women in Uru reported that the biogas burner does not produce as much heat as the fuel efficient firewood burner or traditional cooking mechanisms and that they had difficulty cooking some traditional foods including meat (nyama) and beans (maharage) on the biogas burner. Assida thought that a tightening mechanism on the gas storage bag to increase the pressure of the gas would prevent this problem; however, families still notice the difference in their cooking. Biogas fuel is inherently less potent than fuel produced by burning biomass, so more technical study must be done to ensure that the digester system meets the needs of its users.

### III. Uncertainties

*The ratio of manure to water merits further study*

Some families were not adding all the manure produced on their property to the system, and therefore did not produce enough gas to cook three meals per day with biogas. In August, we explained to farmers that putting in more manure-water mixture will allow the production of more gas for cooking. Sources indicate that when using cow manure, the appropriate ratio of water to manure is 2:1, however, the participating farmers used sheep manure in addition to cow manure. When the manure is no longer purely bovine, the appropriate water- manure ratio is different due to the varying water contents. Some sources indicate that a 1:1 ratio<sup>17</sup> or even a 5:1 ratio may improve gas production<sup>18</sup> depending on water content in the manure.

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<sup>17</sup> Forst, Charlie. "Biogas Digester: Floating Drum." *EchoTech*. 2001. Echo Appropriate Technology. 16 Nov 2008 <<http://www.echotech.org/mambo/images/DocMan/Biogas%20-%20Floating%20Drum.pdf>>.

<sup>18</sup> Tanzania Association of Environmental Engineers interview.

*While biogas appears to be cost efficient compared to traditional three-stone technology, it is not clear yet whether it is cost efficient compared to fuel-efficient wood-burning stoves*

The benefits listed here must be weighed against the initial cost of the stove and ongoing maintenance. The materials for the biogas digester, excluding the gas stove, which can be purchased relatively cheaply, cost approximately 150 USD. Firewood savings alone ranged from 12.50 USD to 50.00 USD per month in our study. This leads to a payback period of three to five months. This alone makes biogas seem worthwhile, but because our pilot project implemented both the biogas and fuel-efficient stove simultaneously, it is difficult to isolate the firewood savings due to biogas. Given the low cost of fuel-efficient stoves in Tanzania today (as little as 5 USD), it is essential to evaluate the cost effectiveness of the two technologies in order to determine which is better suited for rural families in the Kilimanjaro region.

Fuel-efficient stoves will always require some use of biomass (firewood or charcoal) whereas biogas digesters have the potential to completely eliminate the use of firewood if maintained and employed properly. Additionally, the study suggests that biogas has many potential health benefits over fuel-efficient stoves that have not been specifically measured in our analysis. For instance, fuel-efficient wood-burning stoves may not be as helpful during the rainy season due to the difficulty of collecting firewood during this part of the year. However, despite these benefits, cheaper fuel-efficient wood stoves, available for purchase locally for a fraction of the price might be better suited for the needs of the people in the region. Given the high cost of installation and the fact that families in Uru still use some firewood, our incomplete information suggests that the technology may not be as cost-efficient or as easy to adapt to for the families in Uru.

*Not enough time has passed to declare a final opinion on the viability of the digesters*

The rainy season lasts from early February to early August, and therefore the digesters built in January 2008 have had limited exposure to the entire range of the Kilimanjaro climate. Therefore, we are unable to evaluate the digesters' full potential over the course of a year.

Furthermore, we do not believe that enough time has passed since the initial introduction of the new technology to allow families to fully adapt and learn how to utilize the biogas technology and stoves most effectively, and to see if families will accept the technology in their daily lives in the long run.

*The sample size was too small to evaluate the technology definitively*

With only ten digesters built, and only three functioning during our trip in August, inconsistencies in feedback are difficult to analyze and understand. While we gained key insights from the families using biogas, a larger sample will be needed in order to make a

well-informed decision of whether or not the technology is feasible, sustainable and worthwhile for the region.

#### **IV. Suggestions for Further Research**

- Split the gas line to allow each family to have two biogas burners to enable women to cook two dishes at once
- Further investigate the gas pressure control and gas quality to address the concern of cooking temperature and flame quality and understand if a lack of pressure is the reason that the women say the biogas flame does not burn as hot as the firewood flame.
- Introduce biogas technology as its own project without a fuel-efficient stove so that the effects of using biogas can be more easily compared to traditional cooking methods and to studies of fuel-efficient stoves.
- Quantitatively study the optimal ratio of manure and water for the types of manure used in Kilimanjaro.
- Look into the results of studies on different types of biogas digesters, such as the Vietnamese Vacvina design, in order to assess the quality of Assida's tubular plastic choice of digester.

#### **CONCLUDING REMARKS**

The positive results of the digesters and the uncertainties identified above have led Assida to believe that the use of biogas technology in Kilimanjaro merits further study and the pilot project in Uru needs to continue for at least one more year (preferably two) before a final judgment can be made. Assida still believes that biogas digesters have the potential to be a sustainable technology in the Kilimanjaro region with proper training, an internal financing mechanism, and locally available and affordable sheet plastic tubing. Overall, we are pleased with many of the findings of the project and believe that biogas technology should continue to be studied to determine if in fact it is an appropriate technology for the Kilimanjaro region.

The extension of the study would enable us to take into account differences in seasonal temperature and precipitation. It would further allow the farmers to determine if the amount of biogas produced depends on season, based on optimal conditions for the reaction rate, more time to become accustomed to using and cooking with the biogas, and potentially yield other unforeseen conclusions. Assida will continue to monitor the progress of the ten digesters in Uru as the functioning digesters continue to function and other participating farmers get started. Additionally, Assida will contribute 70% of the costs of linings for digester ditches in an effort to decrease the burden of maintenance time during the rainy season and increase the total benefit of the biogas technology. We

look forward to continued study of the pilot project in Uru, but also see the need for further research beyond this initial pilot project.

## **APPENDICIES**

### **Appendix A: Description of Assida**

Project Assida is concerned with the extensive deforestation in East Africa, particularly in Tanzania, and is working to develop appropriate technology to address this issue. In the fall of 2007, Lauren Kolodny, who graduated from Brown University in Providence, RI, USA in 2008, began researching cost efficient alternative forms of energy that would be appropriate in East Africa. She decided on temporary plastic tubular biogas digesters, a relatively inexpensive, temporary technology which, in theory, completely avoids the use of firewood. A pilot project to test the effectiveness of the biogas digesters, both technologically and culturally, was launched in January 2008. Ten digesters and stoves were constructed in the village of Uru in the Kilimanjaro region of Tanzania through a collaborative effort between Assida volunteers, the Trans Regional Environmental Technology Association (TRETA) and Uru's local farmers.

Since its inception, the project has changed dramatically. The project began in response to the particular issue of deforestation surrounding refugee camps in Uganda and Darfur. Deforestation leads women and children refugees far outside the camps to gather necessary firewood, risking their lives in dangerous territories. The final decision on tubular plastic biogas digesters was influenced by this focus. Refugee camps do not allow the construction of any permanent structures, so from the beginning, the idea of a cement digester was rejected. The pilot project in Uru highlighted the need for alternative energy in the politically stable yet environmentally hazardous climate of rural Tanzania, leading Assida to shift its focus from refugee camps, for the time being. With further research, Assida decided the technology was appropriate for the Kilimanjaro Region, and the current project began in January 2008 with the initial installation of biogas digesters. In August of 2008, a research team from Assida returned to evaluate the effectiveness of these digesters and their place in the re-forestation and environmental movement in Tanzania, focusing on how the biogas technology could influence, inform, and assist the current environmental movement in its efforts to reduce deforestation.

### **Appendix B: Tanzanian Environmental Policies**

The 1997 National Forestry Policy aimed to develop sustainable regimes for soil conservation and forest protection in order to prevent desertification and deforestation, preserve freshwater availability and biological diversity, and account for climate change in general.<sup>19</sup> Policy goals include maintaining a sustainable amount of forest products

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<sup>19</sup> The United Republic of Tanzania, Vice Presidents Office. National Environmental Policy. Dar es Salaam. Dec 1997. p. 25

and services through proper management of public lands, reforestation and afforestation programs, increasing employment through sustainable forestry and trade, protecting ecosystems through conservation, and developing the forest sector. These goals are to be achieved through land management, industries and products based on forest conservation, and human resources.<sup>20</sup>

According to the National Environmental Management Council, deforestation rates have decreased from around 100,000 hectares per year in 1998 to 90,000 hectares per year recently.<sup>21</sup> While these numbers encourage some public and private organizations, this reduction is not enough to ensure future sustainability of resources and the local environment. Government action since the 1997 Forestry Policy has been minimal. The private sector, NGO's and the public have been involved in planting trees and harvesting forest products.<sup>22</sup> It is clear that NGO and government conservation efforts, as well as public education on environmental concerns must continue and increase. Furthermore, many government offices and NGOs recognize that changes in daily activity must also be made.

## **Appendix C: Project Description**

### *Implementation: January 2008*

In January 2008, Project Assida sent a team of five Brown University students to Moshi, Tanzania to implement a pilot program for the biogas stoves. The students worked with a group of coffee and banana farmers in the village of Uru, about 10 kilometers from Moshi. The digesters were built through the combined efforts of student volunteers and Uru farmers through a training program. After the first demonstration digester, subsequent digesters were constructed with decreasing guidance from the students until the farmers were competent in the technology. Connected to the digesters is a fuel-efficient stove with two burners: one for biogas and one for firewood. Assida contributed a base price of 50 USD to the stoves, but if the farmers wanted to contribute more, they had the option of obtaining a more complex stove (i.e. with or without a chimney).

With the exception of the plastic tubing, all materials and tools were found in local shops and markets. The plastic tubing was brought from the United States because the students were not confident about its availability in Moshi, and did not want to have a significant delay in the project's implementation. Throughout the month-long trip, the group established contacts, experimented with and adapted the biogas technology, and recorded hours of footage of personal interviews and stove construction to be used for the

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<sup>20</sup> Environment. Retrieved July 15, 2008, from Official Online gateway of the United Republic of Tanzania Web site: <http://www.tanzania.go.tz/environment.html>

<sup>21</sup> James Ngeleja, directory of enforcement and compliance, National Environmental Management Council, August 13, 2008

<sup>22</sup> Ibid.

making of an instructional video. The digesters were built as part of a combined community and volunteer effort, so costs of labor have not been estimated for this technology. The digester materials cost around 150 USD, while the stove cost on average 50 to 150 USD, depending on any additional features added.

Assessment: August 2008

In August 2008, a group of four Brown University students from Project Assida returned to Tanzania to assess and evaluate the January biogas pilot project. In addition to a follow-up evaluation of the proper completion, use and function, as well as the cultural applicability of the plastic tubular biogas digesters, the August team sought to assess the place of biogas technology in the larger environmental movement to combat deforestation in Tanzania. The ultimate goal was to come to a conclusion about the effectiveness of biogas technology in the rural Kilimanjaro region and ascertain whether or not to expand Assida's work beyond the ten-digester pilot project.

The group spent four weeks in Tanzania. Three weeks were spent in Moshi meeting with local environmentally based non-governmental organizations (NGOs) and with the farmers who participated in the project in January. One week was spent in Dar es Salaam meeting with national NGOs, the National Environmental Management Council, and Professor Frederk Godfrey from the University of Dar es Salaam, who helped sponsor the project.

Evaluation work in Uru was done with the assistance of Mr. Vitalis Kimario, executive director of the Trans Regional Environmental Technology Association (TRETA). Mr. Kimario was instrumental in making the connections with the village of Uru that enabled the January project and in overseeing the project in January, August, and the intervening time. During approximately ten day-trips to Uru, we personally visited eight of the ten-digester sites, discussing their function and usage with the families to whom they belonged. Questions were asked to assess the following:

- Base criteria including quantity of livestock
- Firewood saved through use of the combination of the biogas stove and the fuel efficient stove
- Amount of time saved by collecting less firewood and additional income generated from that time
- Functionality of the digester, including digester maintenance time, cooking time and quality of the biogas burner and the fuel efficient stove
- Usage of the biogas, as opposed to fuel efficient stove or traditional three stone method
- Familial preference for type of stove used

Mr. Kimario was also instrumental in securing meetings with many of his colleagues in and around Moshi. Mr. Godfrey helped organize meetings with NGO's in Dar es Salaam. Other meetings were organized through our own research and personal

contacts. Through a combination of these efforts, we were able to visit and speak with fifteen environmentally concerned organizations. While some of these meetings had specific purposes, we generally asked about their perspective on environmental policy and the environmental movement in Tanzania, the general purpose of the organization, and specific efforts to combat deforestation. We also shared the details of our biogas pilot project and the results of our ongoing evaluation. Through discussion, we sought to ascertain the perspective of the NGOs on the role of biogas technology, both in the activities of the specific organization in question and within the context of the larger environmental movement in Tanzania. In particular, we hoped to compare biogas to the fuel-efficient stoves that many organizations were promoting.

### **Appendix D: Different Types of Biogas Technology**

One of the first models used was the fixed dome bio-digester, in which gas was stored in the same container as the anaerobic reaction that produced it. This model had problems with leakage and gas pressure build-up, which led environmental engineers to develop the tubular plastic digester (as used in Uru). Many engineers discounted this model because the thin plastic sheeting is easily damaged. Another model was implemented, the steel drum bio-digester. The problems with this digester included rusting and leakage. The Tanzania Traditional Energy Development and Environment Organization (TaTEDO), which has worked with biogas digesters in the past, is currently working on a new model, the design obtained from Vietnam, called Vacvina. Vacvina is comprised of a large rectangular digester made from poured cement, a plastic bag gas storage unit, and plastic piping. Although TaTEDO is working to implement the technology with burnt bricks, which will help to lower the cost, the Vacvina model currently costs 900 USD. While this model is more durable than the tubular digesters implemented by Assida in Uru, it is far more expensive.<sup>23</sup>

Other manure and food waste can also be used in the digesters, including human feces, which can help with waste management in areas without sewer systems. While this possibility was not addressed in the Assida project, it is an important point to be considered by anyone looking into biogas digestion.

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<sup>23</sup> Sanga, Godfrey and Bonfast, Steven. Tanzania Traditional Energy Development and Environment Organization. August 11, 2008.

## **Appendix E: Organizations and Government Departments Relating to Environmental Objectives: Tanzania**

### **Trans Regional Environmental Technology Association (TRETA)**

- Office in Moshi

*Email :* [treta88tz@yahoo.com](mailto:treta88tz@yahoo.com)

*Telephone :* +255 0784686551

- Assida worked with Vitalis Kimario, the executive director, throughout August 2008

TRETA takes on environmental technology projects and works with other organizations. In the past they have worked on a variety of solar technologies, and currently TRETA is interested in developing a relationship with Heifer International. TRETA developed a water control system for the village of Uru, and has provided the connection between Assida and the people in Uru.

### **Tanzania Traditional Energy Development and Environment Organization (TaTEDO)**

- Headquarters in Dar es Salaam

P.O. Box 32794

Dar es Salaam Tanzania

*Email:* [energy@tatedo.org](mailto:energy@tatedo.org)

*Telephone:* +255 22 2700771 or +255 22 2700438

*Fax:* +255 22 277440

*Website:* [www.tatedo.org](http://www.tatedo.org)

- Northern Zone office in Moshi
- Assida met with Thomas Makunda, an environmental engineer, on August 2 and 19, 2008

TaTEDO supports a variety of sustainable development projects in Tanzania, including projects involving biogas, biofuels, fuel-efficient stoves, solar PV and charcoal production. They emphasize the need for entrepreneurship in these areas. TaTEDO also works to improve district and national level policy in Tanzania, and they call special attention to current gaps at the district level.

TaTEDO is currently exploring a biogas technology called Vacvina that was developed in Vietnam. Rectangular digesters are built with cement bricks, and the unit typically feeds two burners. At the time of the meeting with Assida, TaTEDO had two pilot projects in Dar es Salaam involving digesters 9 and 12 cubic meters in volume. Each system costs about 900 USD, but TaTEDO aims to reduce the cost to 500 to 600 USD.

### **Action for Justice in Society (AJISO)**

New Street, Bondeni Ward Moshi Manispaa

P.O. Box 176, Moshi

*Email:* [ajisotz@yahoo.com](mailto:ajisotz@yahoo.com)

*Telephone:* +255 027 275094

*Fax:* +255 027 2752241

- Assida met with managing director Virginia Silayo on August 2, 2008

AJISO provides legal aid to those who cannot afford the cost of a lawyer. They work especially to empower women, whose legal rights are often unrecognized. AJISO identifies land ownership and scarcity as important issues in the Kilimanjaro region, and emphasizes that women are often the most affected by environmental problems.

### **Sustainable Moshi Programme**

- Office in Moshi
- Assida met with environmental engineer Viana Kombe on August 4, 2008

The Sustainable Moshi Programme works to support sustainable practices in the Moshi municipality. They explained that government environmental policy at the national level has not produced enough tangible results at the local level. When asked about energy sources, they cite charcoal, firewood, kerosene and hydroelectricity. They said that solar and biogas technologies are not well established and have not produced enough data.

### **Green Women's Project**

- Moshi
- Assida visited on August 5, 2008

The Green Women's Project includes work with fuel-efficient stoves. Assida visited a primary school where several of these stoves are in use.

### **PAMOJA Trust**

PO Box 8840, Moshi, Tanzania

*email:* [pamoja@pamojatrust.com](mailto:pamoja@pamojatrust.com)

*Telephone:* (+255) 027-2751419 or 027-2750447

*Website:* [www.pamojatrust.com](http://www.pamojatrust.com)

- Assida met with Johnson Mbalwe (Program Officer for Finance and Administration) and Linus Kiberenge (Program Officer for the Education Sector) on August 6, 2008

PAMOJA facilitates collaboration among local government, civil society and the private sector by promoting joint action and good governance. They work in three sectors: education, natural resource management and health. Their resource management work focuses on water use. Although biogas uses water, they point out that this can be an efficient use of resources. They said that the government sometimes thinks

that NGOs are working against them, so PAMOJA encourages cooperation instead. They also work to translate national policy to the grassroots level.

### **EnviroCare**

PO Box 9824, Makongo Juu  
Kinondoni district  
Dar es Salaam, Tanzania  
*Email:* Envirocare\_2002@yahoo.com  
*Telephone:* +255 222 70 1507

- Office in Moshi, headquarters in Dar es Salaam
- Assida met with Mariana at the Moshi office on August 6, 2008

EnviroCare has a variety of environmentally related projects. In the Kilimanjaro region, they have a forest management project in Kahe. They encourage the use of fuel-efficient stoves and have a charcoal production project. EnviroCare also works to facilitate the translation of traditional knowledge from elders to young people.

### **Kilimanjaro Industrial Development Trust (KIDT)**

Kilimanjaro Industrial Development Trust  
P.O. Box 7322, Moshi-Tanzania  
*Email:* [kidt@kilinet.co.tz](mailto:kidt@kilinet.co.tz) (Mr. Frank Elise)  
*Telephone:* +255 27 2752401

- Assida visited on August 6, 2008

KIDT has a biogas demonstration project supported by the United Nations Development Project. The biogas digester is a large plastic bag in a ditch lined with cement and bricks, covered by a low roof. The gas is stored in a large plastic drum floating in water. KIDT also builds brick stoves and manufactures bricks and fuel briquettes, as well as other ceramics.

### **Mazingera (formerly Kilimanjaro Environmental Development Association)**

- Outside Moshi
- Assida visited and met with Mr. Lyimo on August 7, 2008

Mr. Lyimo's work at Mazingera deals with soil and water conservation, fuel-efficient stoves and fodder for animals. Over 700 farmers have been trained on how to conserve soil. Mazingera also has a nursery where trees and other plants are grown.

### **Floresta**

4903 Morena Blvd, Suite 1215  
San Diego, CA 92117  
*Email:* info@floresta.org  
*Telephone:* +1 858-274-3718, +1 800-633-5319

*Fax:* +1 858-274-3728

*Website:* www.floresta.org

- Floresta project in Marangu (Masia Mamba)  
*Contact:* 0784832627
- Assida met with Floresta on August 7 and 19, 2008

Floresta is an international nonprofit working to reverse deforestation and poverty with programs in several countries. Their Tanzania program is based in Marangu. Floresta works with local farmers to organize, plant trees, utilize improved stoves and engage in other sustainable practices. They have implemented a Village Community Banking (VICOBA) system to provide financial resources for individuals. Assida visited a group of women farmers in Marangu participating in the VICOBA program. These women expressed enthusiasm for biogas and solar technologies.

Representatives from Floresta joined with Assida, TaTEDO and TRETa on August 19 for a meeting in Moshi and a visit with the farmers in Uru.

### **Tanzania Forest Conservation Group (TFCG)**

Plot No. 323, Masani Village

Old Bagamoyo Road

PO Box 23410

Dar es Salaam, Tanzania

*Email:* [tfcg@tfcg.or.tz](mailto:tfcg@tfcg.or.tz)

*Telephone:* +255 22 2669007

*Website:* www.tfcg.org

- Assida met with Executive Director Charles K. Meshack on August 12, 2008

The Tanzania Forest Conservation Group has several different programs, the largest of which is forest management. Other programs include community development, butterfly farming, fish farming and beekeeping. They promote tree planting and the use of fuel-efficient stoves, which they teach people how to build from available materials. TFCG has not promoted biogas, saying that many people do not have livestock and that improved stoves are much less expensive. They are critical of jatropha, arguing people would clear forests in order to grow jatropha for mass production.

### **Tanzania Association of Environmental Engineers (TAEs)**

PO Box 35454

Mlalakuwa, Survey

Kinondoni

Dar es Salaam, Tanzania

*Telephone:* +255 22 270 1967

*Fax:* +255 22 277 1614

*Website:* www.furaha.co.tz

- Assida met with director Deus Masige on August 13, 2008

Started in 2004, TAEES is a small but growing organization. They have various environmental and waste management projects and also offer consulting services. Although they had not worked with biogas at the time of the meeting with Assida, TAEES is currently studying the technology with hopes for a near future implementation. They suggested that communal digesters might be more likely to succeed because they would be more affordable and could benefit from government support.

### **National Environmental Management Council (NEMC)**

The National Environmental Management Council

Sokoine Drive

Tancot House

2nd and 3rd Floor

P.O. Box 63154

Dar es Salaam

Tanzania

*Website:* [www.nemctan.org](http://www.nemctan.org)

- Assida met with James Ngeleja on August 13, 2008

While the Division of Environment is in charge of writing Tanzania's environmental policy, NEMC deals with the technical aspects of the issues, including enforcement. Assida met with James Ngeleja, an engineer who works to coordinate enforcement and compliance regarding energy and environmental policy. He expressed enthusiasm for the potential of a carbon market and for the work of ProBEC in Southern Africa, also referencing the Kyoto Protocol and the U.N. Millennium Development Goals.

The Tanzanian government promotes improved stoves, and ProBEC promotes biogas for locations where there is a concentration of people (such as schools and prisons). Mr. Ngeleja thought that large-scale biogas implementation, is a good idea, but would be difficult to implement, pointing out that cows are kept enclosed only in the Kilimanjaro region.

### **AGENDA for Environment and Responsible Development**

P.O. Box 35131

Dar es Salaam, Tanzania

*Email:* [agenda@bol.co.tz](mailto:agenda@bol.co.tz)

*Telephone:* +255 22 2461 052

*Website:* [www.agenda-tz.org](http://www.agenda-tz.org)

- Assida met with Dorah Swai at AGENDA on August 13, 2008

AGENDA promotes sustainable development, honoring human health and the environment through responsible work. Issues addressed include deforestation, the depletion of natural resources, the rampant use of chemicals, health issues, and policy

issues and strategies. In general, AGENDA finds that Tanzania has good environment policies, but regulations are not properly enforced. In terms of deforestation, AGENDA plants trees, spreads awareness, and promotes fuel-efficient stoves through government agencies. Since these aspects are left up to the government, AGENDA feels that people are not properly informed about biogas and alternative technologies.

### **The International Collaborative for Science, Education and the Environment (ICSEE)**

- Program in Zanzibar

Ali Ayoub Omar

PO box 3658

Zanzibar Town, Zanzibar Tanzania

- Headquarters in USA

Robert Lange, President

12 Red Barn Road

Wayland, MA 01778-1122, USA

*Website:* [www.the-icsee.org](http://www.the-icsee.org)

- Assida met with Ali Ayub Omar on August 14, 2008

The ICSEE has many programs in Africa and around the world, including Zanzibar. ICSEE works with The Zanzibar Women Corporation (ZAWCO) and other NGOs. They discourage deforestation and promote the use of improved stoves. They have a program where participants can receive a credit of TSh 30,000 (about 25 USD) towards a solar panel system by constructing an improved stove.

### **Appendix F: Biogas manual:**

Rodriguez, Lylian and Preston, T.R. "Biodigester installation manual." Food and Agriculture Organization of the United Nations. University of University of Tropical Agriculture Foundation, Finca Ecologica, University of Agriculture and Forestry, Thu Duc, Ho Chi Minh City, Vietnam. 14 Dec 2007

<<http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/Recycle/bio dig/manual.htm#Protecting%>>.

**Appendix G: Contact Information:**

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For any mail, please address to Project Assida, followed by c/o and the name of the member of the group you are trying to reach.