**UPDATE OF ACTIVITIES**

**USAID Funded Activities**

1) *MSc student identified*
   W2E Uganda Ltd has recruited and interviewed Mr. Josephat Musinguzi, an MSc agricultural student at Makerere University to begin work at the W2E site. Mr. Musinguzi brings years of experience working at the National Agricultural Research Organization, which is Uganda's premier public agricultural extension and research laboratory. Mr. Muzinguzi has experience testing fertilizer products in both the field and the lab, and has worked with local farmers to introduce new farming practices.
2) *Baseline testing initiated*
   A baseline analysis of water quality (National Water& Sewerage Company), soils (National Agricultural Research Organization), and fertilizer composition (ChemiPHAR Labs) has been completed. These baseline readings will enable W2E to test our fertilizer's impact on soils, crops, while ensuring testing does not impact local water sources.
3) *Implementation plan completed*
   Implementation plan has been updated to reflect project goals.

**Other Activities:**

1) W2E has completed an Environmental Impacts Assessment and submitted this certified document to the National Environmental Management Agency.
2) Through support from the University of Wisconsin, four undergraduates from Makerere University and five undergraduates from the University of Wisconsin have been sponsored to work together on the installation of the micro-scale biogas system at a government school near Kampala. This training opportunity gives students and the community an opportunity to work with biogas at a small scale. Students are conducting waste audits, conducting interviews with community members, and assisting with fertilizer analyses and design plans, including some exciting innovations that should improve the performance of the system at W2E site.
3) Three volunteer engineers have initiated research on new technologies for energy distribution that could improve the W2E business model

**PROJECT INDICATORS:**

1) Tons of organic waste collected (Oct-Nov): 3 (from Mpigi town), 10 from Kalerwe market
2) Number of women entrepreneurs trained: 0
3) Cubic feet of biogas generated: unknown, as gas meter arrived last week and is to be installed next week
4) Kgs of fertilizer produced: 2000 (fertilizer still needs additional composting to be prepared for fields)
5) Nutrient content of W2E fertilizer: Please see attached reports
6) Ugandan undergraduate and graduate students trained: 5
7) American undergraduate and graduate students trained: 7
8) Community members trained in principles of biogas production: 150

IMPLEMENTATION PLAN

**November-December 2013:**
**Ramping up fertilizer analysis while training new talent.** W2E will interview and hire a Makerere University graduate student project assistant to assist with fertilizer analyses. The team will conduct detailed nutrient analyses of compost samples at the Makerere University soils laboratory while using the industry-standard Solvita "Soil Life" and "Compost Maturity" rapid test kits to monitor compost quality at the project site. The agronomist will work with the project assistant to ensure that s/he understands how to apply the fertilizer and monitor its effect on plant growth and health.

**January-February 2014:**
**Land preparation and fertilizer application at the W2E site.** The agronomist will work with the Makerere and Madison project assistants to prepare the W2E property for test plots, set up test plots, and apply the fertilizer. The project assistants will be primarily responsible for applying the fertilizer to ensure they understand how to do it, under the direct supervision of the agronomist. Baseline soil testing will also occur prior to planting and fertilizer application.

**March –April 2014:**
**Identifying and recruiting women farmer associations/cooperatives.** During the growing season, the project assistants will work alongside the agronomist to identify suitable local farmer associations/co-ops (5-10) and establish initial contact to assess interest in our organic fertilizer product. The agronomist and project assistant will initiate this search by first contacting the National Organic Movement of Uganda (NOGAMU), which has the largest contact network of organic growers in the nation. The team will visit these cooperatives and interview leaders about their fertilizer needs. The agronomist and project assistant will then invite leaders to visit our project site to see the set-up of our tests plots.

**May 2014:**
**First seminar to discuss the W2E women entrepreneurs program.**
Representatives from each of the interested farmers co-ops will be invited to a formal seminar to introduce the proposed program. To begin, representatives will tour our project site, where they can observe the growth of crops grown with our fertilizer, without our fertilizer, and with chemical fertilizers. We hope that this tour will provide a compelling visual demonstration of the yield improvements associated with our organic fertilizer product.

Next, the terms of participation in the project, including a clear presentation on roles, responsibilities and expectations, will be articulated. During this meeting, the agronomist and project assistant will inform the co-op leaders that W2E is seeking fifty female farmer volunteers who would be interested in receiving free fertilizer, fertilizer application training, and fertilizer sales training from W2E in exchange for their participation on our program. Volunteers would be asked to use W2E fertilizer on a portion of their crops for the next planting season (August/September 2014). In return, those volunteers would be asked to (1) attend eight monthly meetings that will teach these volunteers practical fertilizer application skills as well as fertilizer sales skills, (2) complete a mobile phone survey that tracks their experiences using and marketing the fertilizer, and (3) allow W2E staff to visit their farms to assess soil quality and changes in yield in response to fertilizer application.

Participants will be asked to discuss our proposal with their co-op members and the agronomist and project assistant will follow-up with each co-op individually to see how many members are interested in

participating. The enrollment in the program will be capped at 50 women. Preference will be given to collective farms over individual holdings. The agronomist and project assistant will follow-up with the co-ops to obtain the contact information of all the volunteer women farmers. If these women were not part of the congregation that originally visited our site, arrangements will be made to bring them at a time of their choosing. The agronomist and project assistants will also visit all of the volunteers' farmers (or collective farm) to conduct baseline soil testing and to measure yields as the Nov/Dec harvest occurs.

**June-July 2014:**
**Assessing impacts on yields at the W2E site.** The agronomist and project assistants will measure effects of the fertilizer on the crops grown at the W2E site. Yields, crop size/quality and soils will be tested. The agronomist and project assistant will then invite leaders to visit our project site to see the effects of our fertilizer on final yields, soil quality and crop quality.

**August 2014:**
**On-farm fertilizer application training of 50 women farmers.** The volunteer women farmers will be invited to attend the first of four meetings at our project site in Mpigi. This initial training will focus on proper fertilizer application. Through a hands-on demonstration at our project site in Mpigi, each woman will gain the confidence to apply fertilizer to her own crops.

The agronomist and project assistants will also provide the women farmers participating in the fertilizer pilot program with fertilizer and assist them at their farms with application. TargetMobi, a Ugandan start-up company, will assist with a mobile phone platform that will enable us to offer timely reminders to the farmers and also elicits feedback (at no cost to the women) about the process. If any of the women farmers wants to ask the agronomist, PAs, or other women a question or solicit advice about fertilizer or agriculture, she can do so with an SMS message at no cost. Through Target Mobi, we will also offer random prizes (like mobile phone airtime) for feedback. Under the supervision of the Chief Operating Officer, the Madison project assistant will begin conducting interviews with vendors and market committees in the markets from which we collect waste in order to assess their experiences/ideas about hygiene about midway through the project. The Madison project assistant will also conduct daily monitoring of waste displaced from the market. This activity will occur monthly through August 2014.

**September-November 2014:**
**Monthly entrepreneurship workshops.** During the period of crop growth, up to 50 volunteer women farmers interested in becoming part of our woman-to-woman commissioned sales force will be trained in sales techniques and customer management by a local business expert who will be identified and recruited by the agronomist and project assistants. This expert will offer twice-a- month workshops at a convenient location for our women farmers, which will always be attended by the agronomist and both project assistants. Women will be asked to attend one of the two workshops each month. We envision this expert, most likely a woman, to be an MBA student at Makerere University, a small-business owner, or prominent local member of the community who understands the art of sales and business management in Uganda. These interactive workshops will offer the women a chance to develop pitches and practice sales techniques on each other. The project assistant and agronomist will develop and refine sales materials (heavily visual, intended for illiterate or semi-literate audiences) which the women can use to sell the fertilizer. The women will be expected to give feedback on the sales materials so that they can be modified and refined.

**December 2014:**

**Assessing impacts on yields, initiating customer contact.** Our volunteer women farmers will be harvesting at their farms. The agronomist and project assistants will go the women's farms and measure yields and crop quality of the maize and beans grown with our fertilizer as compared to the unfertilized harvest. Women who have elected to be part of the woman-to-woman fertilizer sales force will be encouraged to show their neighbors and potential customers the demonstrable impact of our fertilizer on yields as part of their sales strategy. These women will identify potential customers who are interested in a complimentary soils analysis as part of the sales process.

**January 2015:**
**Making the sale.** As soil preparation begins for the next growing season, our saleswomen will begin selling our fertilizer to interested friends and neighbors. The agronomist and project assistants will conduct complimentary soils analyses for these new customers. At the end of the month, a final evaluative workshop will be held to solicit feedback on sales and sales materials and check in on successes and challenges associated with the first round of fertilizer sales. The top saleswoman/women will be rewarded with an appropriate incentive, such as, but not limited to cash bonuses, mobile phones, fertilizer, cloth, etc.

**End of Project Deliverables** With support from DIV, W2E is poised to deliver the following within one year:
• Highly-visual fertilizer application guide and set of educational materials targeted at aiding rural smallholders in understanding the benefits of fertilizer and the proper way to utilize this agro-input
• Quantified impacts of our fertilizer on critical food security crops (maize and beans) from two full growing seasons
• Quantified assessments of gas production and changes in waste management in response to program activities
• Training of an American graduate student on how to work with professionals, urban poor, and rural smallholder farmers in developing countries
• Trained Ugandan masters student in the field of agronomy
• Identification of best agronomic practices as identified by the women farmers in conjunction with the professional agronomist and the agronomy MSc student

### 4.3.2 Soils

Kiringente Sub-county soils are generally of high productivity. The dominant soil types are red gravel loam; reddish brown sandy loam and yellowish sand with quartz gravel. The soils in the wetlands include gray sands whose parent material is alluvium and peat sands and clay formed from papyrus residue and river alluvium. The proposed site has wetland type of soils and reddish brown sandy loam soils.

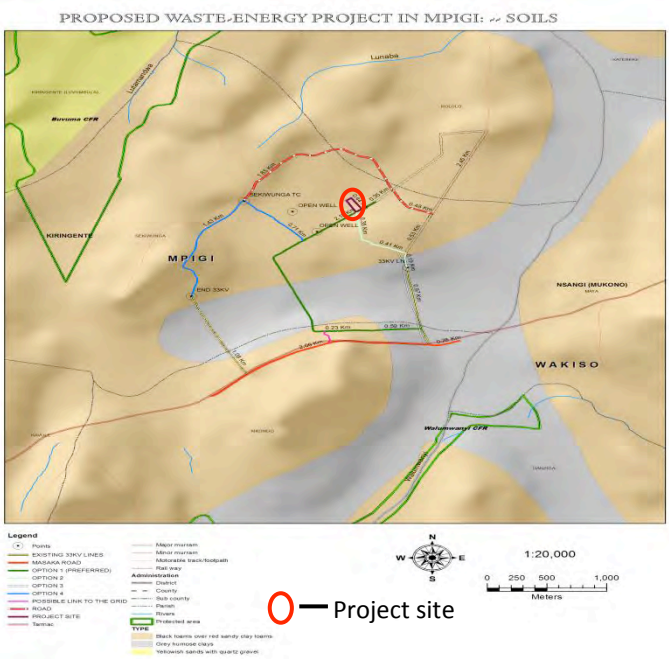


Figure 4.2: Map showing the soil types of the project area

### 4.3.3 Physical and chemical properties of soils around project site

Twelve (12) soil samples were collected and taken to Kawanda Agricultural Research Institute(KARI) lab for analysis to benchmark physical and chemical properties of project site soils and its surrounding. Six samples were collected from the actual project site while six others were collected from areas outside the site to act as controls. The methods used for analyzing these soils are presented in **Annex 4.**

#### 4.3.3.1 Summary of soil analysis findings

1. The results for the test samples are in line with those of the control samples with some even having far much less levels meaning that there shouldn't be any negative impact to the environment as far as chemical composition is concerned. This means that the site's soils are not polluted in any form basing on the parameters tested.

2. All the environmental contaminants analyzed lie within expected ranges therefore there is no likelihood of toxication as far as the analysed parameters are concerned.

3. All the land that was sampled is acidic and also very poor in the key plant nutrients (P and K), which means that one has to invest heavily in fertilizers or manures to

realize any agricultural profits otherwise it should fit the intended purpose.

### 4.3.4 Climate

Kiringente Sub-county receives two rainfall seasons, that is, March – May and September – November. The remaining months are generally dry. The mean annual rainfall is 1320 mm though in many areas of the lake zone it is between 1750 and 2000 mm. The average monthly days of rainfall are 10. The minimum temperature in the area is $21^0$C while the maximum recorded is $33.3^0$C.

### 4.3.5 Fresh Water Resources

In Mpigi district, Water and swamps cover 719sq.km. The open fresh water bodies include Lake Victoria, Lake Wamala, and parts of River Katonga. The district still depends on streams and springs (protected and unprotected), hand dug and hand augured wells, boreholes and water holes for their water supply. Though with some abundance of water resource, there are great disparities in availability and use as water resources are unevenly distributed. For this matter therefore, people greatly rely on fresh water that comes from seasonal rains. The rainfall pattern greatly influences the local land use pattern and management and this influences economic growth.

### 4.3.6 Wetlands Resources

Wetlands cover 719 km2 (including open water). Most permanent wetlands lie on the fringes of Lake Victoria forming one major wetland drainage system, the Lake Victoria Drainage System. Wetlands in Kiringente Sub-county are mainly papyrus and swamp forest type: they include Kagaba, Mabuye, Nakirebe, Nsimbe (includes project area), Namwabula, Luvumbula, Nama, Nakabiso, Kavule, Nsujjuwe, Kyeyitabya, Buvuuma and Galatiya. They are mainly used for water sources, natural habitats, fishing, waterways, medicinal, gene pool, cultural, crafts, deforestation, reclamation for farming, hunting, grazing, sand extraction, brick-making, burning and a source of building materials. Most of them are still intact but threatened by the hunters who live near the systems. Other key issues are ownership, capacity and community and Sub-county management.

Several activities of consumptive nature have resulted in pits as a result of sand/gravel extraction creating breeding grounds of disease vectors, accidents to Livestock and humans and destruction of vegetation. Burning has resulted in loss of biodiversity as some of the flora and fauna lose their habitats. About 15% of the 2 acre piece of land where the proposed project will be situated is located in a wetland. This wetland is very important because it is used as a source of water for the downstream users although the developer will sink a production borehole at the project site to supply water for project activities.

### 4.3.7 Water quality assessment

Water samples were picked from different water points around the project site. 2 Samples were collected from the stream at the eastern side of the project site. Other water points considered were community wells around the project site. One of the well is 411 meters south west of the site just after the eucalyptus plantation along the boundary road of Nsimbe Estates while the other is 469 meters west of the project site. Baseline water quality was analyzed at Notational Water and Sewerage Corporation (NWSC) to determine the physio-chemical and bacteriological characteristics of the sources. Specifically, the samples

were analysed for pH, Electrical Conductivity, Colour, Turdbidity, Total Dissolved Solids, Total Suspended Solids, Alkalinity, Hardness, Calcium, Magnesium, Bi-Carbonate, Chloride, Fluoride, Total Iron, Sulphates, Nitrates, Copper, Lead, Zinc, Oil and grease and Faecal coliforms. The results were compared with National Standards for portable water (Table 4.1). Table 4.2 below presents a summary of the results. Detailed results of the laboratory tests for each sample and parameters tested is presented in **Annex 3** against permissible standards.

**Table 4.1: Maximum permissible standards for selected parameters for potable water**

| Parameter | Units | National Standards for Portable water (Maximum permissible) |
|---|---|---|
| PH | - | 6.5-8.5 |
| Alkalinity: Total as $CaCO_3$ | mg/L | 500 |
| Bicarbonate as $CaCO_3$ | mg/L | 500 |
| Calcium: as $Ca^{2+}$ | mg/L | 75 |
| Chloride | mg/L | 500 |
| Biochemical Oxygen Demand (BOD) - 5 days at $20^0C$ | mg/L | Not specified |
| Bicarbonate as $CaCO_3$ | mg/L | 500 |
| Colour (apparent) | Pt/Co | 15 |
| Copper (Cu) | mg/L | 1.0 |
| Electrical Conductivity (EC) | uS/cm | 2500 |
| Fat, Oil & Grease (FOG) | mg/L | 0.0 |
| Fluoride | mg/L | 1.5 |
| Hardness: Total as $CaCO_3$ | mg/L | 500 |
| Iron: Total | mg/L | 1.0 |
| Lead (Pb) | mg/L | 0.05 |
| Magnesium: as $Mg^{2+}$ | mg/L | 50 |
| Nitrate - N | mg/L | 5.0 |
| Ortho-Phosphate: Reactive | mg/L | 1.0 |
| Sulphate: $SO_4^{2-}$ | mg/L | 200 |
| Total Dissolved Solids (TDS) | mg/L | 1200 |
| Total Suspended Solids (TSS) | mg/L | 0 |
| Turbidity | NTU | 10 |
| Zinc (Pb) | mg/L | 5.0 |
| Faecal coliforms | No./100mL | 0 |
| Cadmium (Cd) | mg/L | 0.001 |

***Note: Several samples were analyzed and their properties were compared against these standard in Annex 3***

**Table 4.2: Water quality assessment for the sources within and around the project site**

| Name & location of stream/swamp | Coordinates at which sample was taken | Hydrological particulars of the stream | Water quality results |
|---|---|---|---|
| Wetland/streams to be crossed by the transmission line | | | |
| **Swamp water, Up stream** | E: 434115<br>N: 30214<br>H: 1169 | Originates from the upper catchments of Kagaba and Nakirebe.villages via Sekiwunga and drains into river Tangara in the lower far eater side of Nsimbe Estates It's a permanent wetland with a stream across it. Water in the swamp is neither used for cooking nor for other domestic purposes. | The sample showed satisfactory physical-chemical characteristics of the source except for colour (due to turbidity, Iron content, suspended solids) & faecal coliform count which failed to meet the National Standards for water quality (Untreated). For details of the water quality results, refer to Annex 3. |
| **Swamp water, Down stream** | E: 434146<br>N: 30222<br>H: 1170 | Originates from the upper catchments of Kagaba and Nakirebe.villages via Sekiwunga and drains into river Tangara in the lower far eater side of Nsimbe Estates It's a permanent wetland with a stream across it. Water in the swamp is neither used for cooking nor for other domestic purposes. | The sample showed satisfactory physical-chemical characteristics of the source except with higher colour (due to turbidity, iron content & suspended solids) & faecal coliform count which failed to meet the National Standards for water quality (Untreated). For details of the water quality results, refer to Annex 3. |
| Other wetlands in the project area | | | |
| **Community well 1** | E: 433786<br>N: 29946<br>H: 1177 | This is an open well formed as a result of water percolating through soil aquifers. It was dug and is frequently cleaned by the community. It is a permanent swamp. No fishing activity. Harvesting of papyrus is done. This is another key water source for the community. People use water from this well for all domestic use including drinking and cooking. | The sample showed satisfactory physical-chemical characteristics of the source except for color (due to turbidity, suspended solids) & mild faecal coliform count which failed to meet the National Standards for water quality (Untreated). For details of the water quality results, refer to Annex 3. |
| **Community well 2** | E: 433582<br>N: 30196<br>H: 1193 | This is an open well formed as a result of water percolating through soil aquifers. It was dug and is frequently cleaned by the community. It is a permanent swamp. No fishing activity. Harvesting of papyrus is done. This is a | The sample showed satisfactory physical-chemical characteristics of the source except for color (due to turbidity, suspended solids ) & faecal coliform count which failed to meet the National Standards for water quality(Un treated). For details of the water quality results, refer to Annex 3. |

| Name & location of stream/swamp | Coordinates at which sample was taken | Hydrological particulars of the stream | Water quality results |
|---|---|---|---|
| | | key water source for the community. People use water from this well for all domestic use including drinking and cooking. | |

Plate 4.3: Water sampling from a community well near the project site

Plate 4.4: Assessment of hydrological systems around the project site

Plate 4.5: Water sampling from a stream around the project site

Plate 4.6: Water sampling from a community well 400 meters from the project site

# NATIONAL WATER AND SEWERAGE CORPORATION

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Tel: 257548, 341144. Fax: 256 41 255441
E-Mail: waterquality@nwsc.co.ug

## CERTIFICATE OF ANALYSIS

**CLIENT:** W 2 E (U) Limited

**Serial No:** INV/2013/510-1

**Sample Source:** Swamp Water, **Upstream**

**Sampled by:** Client

**Date Sample Received:** 23-09-2013

**Date of Report:** 27-09-2013

Table of Analytical Results

| **Parameters** | **Units** | **Site: Swamp – Upstream E 434115 N 30214** | **National Standards for water (Untreated)** |
|---|---|---|---|
| **WS Sample Nr** | -- | **K3210/13/C/B** | |
| pH | -- | 5.34 | **6.5 – 8.5** |
| Electrical Conductivity | µS/cm | 35 | **2500** |
| Colour (apparent) | PtCo | 891 | **15** |
| Turbidity | NTU | 134 | **10.0** |
| Total Dissolved Solids | mg/L | 19 | **1500** |
| Total Suspended Solids | mg/L | 46 | **0** |
| Alkalinity: total as $CaCO_3$ | mg/L | 12 | **500** |
| Hardness: total as $CaCO_3$ | mg/L | 10 | **500** |
| Calcium: $Ca^{2+}$ | mg/L | 2.4 | **Not Specified** |
| Magnesium: $Mg^{2+}$ | mg/L | 0.9 | **150** |
| Bi-Carbonate: as $CaCO_3$ | mg/L | 12 | **500** |
| Chloride: $Cl^-$ | mg/L | 0.0 | **500** |
| Fluoride: $F^-$ | mg/L | 0.0 | **1.5** |
| Iron: total | mg/L | 6.86 | **1.0** |
| Sulphate: $SO_4^{2-}$ | mg/L | 0 | **200** |
| Nitrate – N | mg/L | 0.00 | **5.0** |
| Ammonia – N | mg/L | 0.36 | **1.0** |
| Total Phosphorus (TN) | mg/L | 0.10 | **Not Specified** |
| Copper | mg/L | <0.001 | **1.00** |
| Lead | mg/L | <0.001 | **0.05** |
| Zinc | mg/L | <0.001 | **5.00** |
| Oil & Grease | mg/L | <1.0 | **1.0** |
| $BOD_3$ | mg/L | 2.6 | **Not Specified** |
| COD | mg/L | 7.7 | **Not Specified** |
| Faecal coliforms | CFU/100mL | 120 | **10** |

**Remarks:**

The sample showed satisfactory chemical characteristics of the source, except with higher colour (due to iron content, turbidity & suspended solids) & faecal coliform count which failed to meet the National Standards for water (Untreated).

Lance E. Okwerede
**PRINCIPAL QC OFFICER**

NATIONAL WATER AND SEWERAGE CORPORATION
27 SEP 2013
THE CENTRAL LABORATORY

Christopher Kanyesigye
**QUALITY CONTROL MANAGER**

NB: The NWSC certificate of analysis by no means constitutes a permit to any person or undertaking to conduct business

# NATIONAL WATER AND SEWERAGE CORPORATION

CENTRAL LABORATORY - BUGOLOBI.
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E-Mail: waterquality@nwsc.co.ug

## CERTIFICATE OF ANALYSIS

**CLIENT:** W 2 E (U) Limited

**Sample Source:** Swamp Water, **Downstream**

**Date Sample Received:** 23-09-2013

**Serial No:** INV/2013/510-2

**Sampled by:** Client

**Date of Report:** 27-09-2013

Table of Analytical Results

| **Parameters** | **Units** | **Site: Swamp – Downstream E 434146 N 30222** | **National Standards for water (Untreated)** |
|---|---|---|---|
| **WS Sample Nr** | -- | **K3211/13/C/B** | |
| pH | -- | 5.56 | **6.5 – 8.5** |
| Electrical Conductivity | µS/cm | 61 | **2500** |
| Colour (apparent) | PtCo | 774 | **15** |
| Turbidity | NTU | 139 | **10.0** |
| Total Dissolved Solids | mg/L | 34 | **1500** |
| Total Suspended Solids | mg/L | 65 | **0** |
| Alkalinity: total as $CaCO_3$ | mg/L | 16 | **500** |
| Hardness: total as $CaCO_3$ | mg/L | 12 | **500** |
| Calcium: $Ca^{2+}$ | mg/L | 2.4 | **Not Specified** |
| Magnesium: $Mg^{2+}$ | mg/L | 1.4 | **150** |
| Bi-Carbonate: as $CaCO_3$ | mg/L | 16 | **500** |
| Chloride: $Cl^-$ | mg/L | 0.0 | **500** |
| Fluoride: $F^-$ | mg/L | 0.0 | **1.5** |
| Iron: total | mg/L | 4.387 | **1.0** |
| Sulphate: $SO_4^{2-}$ | mg/L | 0 | **200** |
| Nitrate – N | mg/L | 0.01 | **5.0** |
| Ammonia – N | mg/L | 0.92 | **1.0** |
| Total Phosphorus (TN) | mg/L | 0.15 | **Not Specified** |
| Copper | mg/L | <0.001 | **1.00** |
| Lead | mg/L | <0.001 | **0.05** |
| Zinc | mg/L | <0.001 | **5.00** |
| Oil & Grease | mg/L | <1.0 | **1.0** |
| $BOD_3$ | mg/L | 3.1 | **Not Specified** |
| COD | mg/L | 9.0 | **Not Specified** |
| Faecal coliforms | CFU/100mL | 140 | **10** |

**Remarks:**

The sample showed satisfactory chemical characteristics of the source, except with higher colour (due to iron content, turbidity & suspended solids) & faecal coliform count which failed to meet the National Standards for water (Untreated).

Lance E. Okwerede
**PRINCIPAL QC OFFICER**

NATIONAL WATER AND SEWERAGE CORPORATION
27 SEP 2013
THE CENTRAL LABORATORY

Christopher Kanyesigye
**QUALITY CONTROL MANAGER**

NB: The NWSC certificate of analysis by no means constitutes a permit to any person or undertaking to conduct business

## Annex 4: Soil analysis results

NATIONAL AGRICULTURAL RESEARCH ORGANISATION

NARO

NATIONAL AGRICULTURAL RESEARCH LABORATORIES - KAWANDA

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E-mail: karidir@imul.com

Our Ref: SSFMP/W2E/13

Your Ref: .....

### Soils and Soil Fertility Management Programme

REPORT OF SOIL ANALYSIS FOR

W2E (U) LTD

2/10/ 2013

**INTRODUCTION**

12 soil samples were brought for analysis to ascertain any likelihood of toxication/ assess the impact to the environment when setting up Biogas Plant for power generation by W2E (U) LTD in Sekiwunga village, Kiringene sub county, Mpigi district.

**SOIL SAMPLING PROCEDURE**

A total of 12 soil samples were systematically collected from 2 points in the area where the plant is to be setup. Six(6) of the samples were picked from the test area and the other 6 picked a distance away from the test area to act as control samples for comparison purposes following the same sampling procedure.

**METHODOLOGIES**

The soil samples were analyzed using routine analytical methods for soil texture (% sand, clay, silt), soil pH (soil acidity / alkalinity), soil organic matter content (% OM), total nitrogen content (% N), extractable phosphorus (P), and availabe bases (K, Ca, and Mg).The available cat ions and available P were extracted using mehlich 3 extraction method with pH 2.5. Organic matter analysed using walkey black method, pH was read from a 2.5:1 soil:water extract.

***Preparation:*** The soil samples were dried at 45$^{0}$C for 2 days and later ground and passed through a 2mm sieve.

**P,K,Ca,Mg,**

***Extraction***

3 g of a well ground (passed through a 2 mm sieve) soil was weighed and 30mls of mehlich 3 extractant added. The solution is then shaken at 200rpm for 5 minutes and then left to settle for 10 minutes before centrifuging at 2000 rpm for 5 minutes.

MANDATE: CONDUCTING RESEARCH AND PROVIDING SERVICES ON SOILS AND AGRO-METEOROLOGY, AGRICULTURAL ENGINEERING PLANT GENETIC RESOURCES, POST HARVEST, FOOD BIOSCIENCES, BIOCONTROL, BIOTECHNOLOGY AND AGRICULTURAL RESEARCH INFORMATION

**K,Ca,Mg determination**

Using a precision pipette 0.75ml of the sample and standard was added to 25ml glass vials and rinsed with the same aliquot of 1000ppm Lanthanum chloride solution into the same glass vial. 13.5mls of 1000ppm Lanthanum chloride( suppressant solution) was further added to the glass vials. The respective cations are then quantified on the atomic absorption spectrophotometer at 766.5nm, 422.7nm, 285.2nm respectively.

**Phosphorus determination**

Using a precision pipette 1ml of the sample and standard was added into 25ml glass vials and then rinsed with the same aliquot of distilled water into the same glass vial. 8 mls of Murphy-riley working solution(Sulphuric acid ,Ammonium molybdate, potassium antimony tartarate and ascorbic acid) was added. After 30 minutes the absorbance was read at 860nm using UV/ visible spectrophotometer.

**SOILS**

***Heavy metal analysis***

The soils were finely ground to less than 0.060mm and then digested with aqua ragia (1:3 $HCl:HNO_3$) / hydrogen peroxide and later quantified using the Atomic Absorption Spectrophotometer (SHIMADZU AA-6800).

**DISCUSSION OF RESULTS.**

- **Soil pH (acidity/alkalinity)**
  Soil pH in the test samples ranges between 4.3 and 5.7 whereas controls range between 4.1 and 5.9. Most crops grow well on soils of pH 5.2 –7.0. This is also the pH range at which most plant nutrients are easily available to crops.

- **Soil organic matter content (% OM)**
  Soil organic matter is an important source of plant nutrients in the soil. It also plays many other important roles in the soil, e.g. improving soil physical characteristics, increasing the soil moisture holding capacity and providing a good habitat for soil micro and macro-organisms. Therefore it is very necessary to have good amounts of it in soils.
  A soil is considered to have high soil organic matter content when it has 5.15 % or more OM and a soil with organic matter content below 1.7%, is considered to be low in organic matter and is likely to show response to additions of organic materials.
  Soil organic matter content in these soils is high (ranging between 2.8 and 3.7%), i.e. mostly above the critical value of 1.7%.

- **Extractable (available) phosphorus content (P):**
  A good soil is supposed to have at least 230ppm extractable (M-3) P while any soil with less than 90ppm of extractable (M-3) P is considered to be poor and is likely to give good responses to P fertilizers. In both areas the phosphate content is ***very low*** . This means that crop response to phosphate fertilizers like TSP or organic materials rich in P, e.g. poultry manure is expected to be high in both the test area and control.

- **Extractable (available) bases (K, Ca and Mg):**
  A good soil is supposed to have at least 150ppm of potassium (M-3 K) while the critical value is 95ppm. Extractable potassium, another important plant nutrient from the soil, is therefore ***low*** in both the control and the test area i.e. below the critical value as highlighted in the analysis sheet. Therefore there is a very high likelihood that crop response to K fertilizers will be high in all these areas.

  Extractable Calcium (M-3 Ca) content all the sub layers is generally low but good in the top layers for both control and test samples. The critical value for (M-3) Ca is 655 ppm while a good soil should have at least 1640ppm.
  Extractable Magnesium (M-3) Mg just like M-3 Ca is high in both the control and test samples of the area sampled and no further amendments are required as far as magnesium is concerned.

**Iron(Fe),Copper(Cu),Manganese(Mn),Zinc(Zn),Lead(Pb)**

Looking at the analysis, it is clear that all the heavy metals analysed are within the expected ranges for both control and test samples as seen in the table below.

| Range of concentrations in soils of inorganic elements, which sometimes occur as Environmental Contaminants Common range | |
|---|---|
| **Soils** | **Ranges** |
| | **mg kg-1** |
| Copper | 2 – 100 |
| Lead | 2 – 200 |
| Manganese | 100 – 4,000 |
| Zinc | 10 – 300 |
| Iron | 5,000 – 50,000 |

**Source: Allaw, WH. 1970; Brady, NC 1974, 1996**

## CONCLUSION

1. The results for the test samples are in line with those of the control samples with some even having far much less levels meaning that there shouldn't be any negative impact to the environment as far as chemical composition is concerned.

2. All the environmental contaminants analyzed lie within expected ranges therefore there is no likelihood of toxication as far as the analysed parameters are concerned.

3. All the land that was sampled is acidic and also very poor in the key plant nutrients (P and K), which means that one has to invest heavily in fertilizers or manures to realize any agricultural profits otherwise it should fit the intended purpose.

Attached are the results

4

Prepared by:

NATIONAL AGRICULTURAL RESEARCH LABORATORIES INSTITUTE
03 SEP 2013
P.O. BOX 7065, KAMPALA UGANDA

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**APRIL 2014 MILESTONES REPORT:** AID-OAA-F-13-00056 "Sustainable Alchemy: Transforming Africa's Waste Problem into Energy and Fertilizer Opportunities

| **Project Indicators** | **Outcomes (Feb-April)** |
|---|---|
| Number of tons of organic waste collected | • **12 tons**<br>• One (1) ton per week for the past 12 weeks<br>• Waste sources:<br>  o 4 tons: Mpigi market vendors' waste<br>  o 8 tons: Kalerwe market Nsooba Slaughterhouse waste |
| Number of women entrepreneurs recruited | • 0 women farmers recruited<br>• Although two farming cooperatives have been identified, recruitment will not occur until fertilizer product is fully tested for efficacy, consistency, and safety<br>• 3 female recent graduates have been hired and trained by W2E |
| Cubic meters of biogas generated | **226 m3** |
| Kg of fertilizer produced | **10,000 liters (kgs)** |
| Percent increase of maize yields | n/a Test plots were planted in March and will be harvested in July/August |
| Nutrient content of W2E fertilizer | **2.485 g N/l** |

**KEY ACTIVITES**

From February to April, the team engaged in the following key activities:

- **TRAINING & EDUCATION: New jobs for recent university graduates**
  Four (4) final-year Ugandan undergraduate students from Makerere University, Ndejje University, and Uganda Christian University have joined the W2E team. These hard-working students began as interns, but have recently been hired for a one-year contract with the company. We are currently training our newest team members in gas production monitoring, microbiology, applied chemistry, interview methodology, and agronomy. Other recently filled positions include a full-time project manager and administrator, as well as a site manager. Of the six recently filled positions, three new hires are women. W2E remains committed to recruiting and training Uganda's top female talent and promoting gender equity within our company. In addition to the Ugandan staff, the W2E team continues to work with a team of 5 American volunteer interns from the University of Wisconsin-Madison. These students have been working alongside their Ugandan counterparts on various research projects.

American and Ugandan student interns host a workshop and brainstorming session for 30-40 biogas stakholders at Makerere University, Kampala, Uganda. Attendees included representatives from local and national government agencies, international aid agencies, biogas system owners, professors, students, and local leaders. W2E has since hired 4 of our Ugandan interns for a one-year contract with W2E.

- **FERTILIZER PERFORMANCE: Design & planting of maize field plots**
  In collaboration with agronomy experts at Makerere University and the University of Wisconsin-Madison, W2E has initiated the first set of 24 field plots to test the efficacy of its bioslurry fertilizer. Field tests are designed to (1) identify the appropriate application rates for the fertilizer product, (2) compare our natural slurry to conventional chemical fertilizer, and (3) assess the impacts of bioslurry on soil quality (soil moisture, pH, total solids) and plant health (pest resistance, yields). These rigorous tests will yield data that will be published in a peer-reviewed journal. Harvest begins in late July/early August, and the second round of field tests will begin in early October. Field plots in the second growing season will assess the efficacy of new formulations of the fertilizer product, including separated solids.

**Top Right:** Recently hired Makerere agronomy graduate, Doreen Nampamya prepares field plots in March. **Top Left:** The W2E team applies first round of fertilizer to test plots. **Bottom Center:** Maize plot growth as of April 30th, 2014.

- **FERTILIZER SAFETY: Microbiology training & preliminary analysis.**
  Staff are now trained to quantify fecal coliform and *E. coli* present in the fertilizer. Inputs (waste/cow dung) and outputs (slurry) are being tested each month to quantify reductions in these indicator species and to ensure that the fertilizer product conforms to international levels of safety. Preliminary testing has revealed mixed results. Indicator organisms are present in some slurry samples, raising questions about the safety of the fertilizer product. However, more advanced testing for the presence of known pathogens (Vibrio cholera, Giardia, Cryptosporidium, Salmonella, Shigella etc.) and heavy metals testing have not revealed any safety concerns. The team will continue to monitor the slurry for the next year. In the coming months, we will be experimenting with new methods of solid-liquid separation and other post-digestion treatments to reduce the burden of indicator species in the fertilizer.

(From left) Daniel Nzamuye (undergraduate, Makerere), Doreen Nampamya (undergraduate, Makerere), CFO Sarah Stefanos, Gideon Monday (undergraduate, Ndejje), and CEO Aleia McCord. Microbiology expert and CEO, McCord, trains the team on fecal coliform and E. coli monitoring at the National Water and Sewerage Lab in Kampala, Uganda.

- **ELECTRIFICATION: Installation of a biogas generator**
  A small 3KW biogas generator has been installed at the company site. Although the generator did work to maximum capacity for some time, an issue arose with the starting mechanism and the generator has failed to produce electricity for the past two months. Efforts to fix the generator have not been successful. We were from the beginning suspicious about the quality and cost-effectiveness of this technology. Thankfully, this effort was simply one experiment of many to determine the viability of different business models surrounding the use of biogas systems. The current data suggest that the production of electricity is not the most cost-effective use of the gas, and the team is exploring new, more productive end-uses of the gas.

(From left) UW-Madison undergradaute Ian Frye, Makerere University undergraduate Daniel Nzamuye, Makerere University graduate student Josephat Musinguzi, and biogas system manager John Bihemu turn on a biogas-powered light buld for the first time in Mpigi, Uganda.

**AUG 2014 MILESTONES REPORT:** AID-OAA-F-13-00056 "Sustainable Alchemy: Transforming Africa's Waste Problem into Energy and Fertilizer Opportunities

| **Project Indicators** | **Outcomes (May-Aug)** |
|---|---|
| Number of tons of organic waste collected | • **16 tons**<br>• One (1) ton per week for the past 16 weeks<br>• Waste sources:<br>o 4 tons: Mpigi market vendors' waste<br>o 8 tons: Kalerwe market Nsooba Slaughterhouse waste<br>o 4 tons: local cow manure |
| Number of women entrepreneurs recruited | • 0 women farmers recruited<br>• Although two farming cooperatives have been identified, recruitment will not occur until fertilizer product is fully tested for efficacy, consistency, and safety<br>• 1 additional female recent graduate has been hired and trained by W2E to participate in ongoing research activities. That brings the total number of female W2E local staff to 4 |
| Cubic meters of biogas generated | **800 m3** |
| Kg of fertilizer produced | **50,000 liters (kgs)** |
| Percent increase of maize yields | **300% increase in maize yields.** Test plots were harvested in early August. Preliminary analysis suggests that slurry performs comparably—or slightly better than—conventional chemical N-P-K fertilizer, while increasing yields by over 3 fold when compared to control plots (no fertilizer). |
| Nutrient content of W2E fertilizer | **2.485 g N/l**<br>Solids content of W2E fertilizer has increased considerably. |

**KEY ACTIVITES**

From May to August, the team engaged in the following key activities:

- **TRAINING & EDUCATION: Jobs for talented women and engagement with schools**

W2E has hired another highly qualified Ugandan woman to assist with ongoing research and outreach efforts. Sheila Nantambi is leading an effort to quantify the impacts of biogas system installation on indoor air quality. Now that Sheila has joined our team, nearly 60% of W2E staff are women. Undergraduate and graduate students at the University of Wisconsin in the USA and graduate students in Aberdeen University in Scotland are collaborating with Sheila on this air quality study. W2E continues to foster close ties between Makerere University, Wisconsin, and Scotland.

As part of our ongoing efforts to quantify the potential benefits of biogas technology for end-users, W2E has enrolled launched research efforts at eight existing biogas systems around the Kampala area. Most of these systems are at local schools, enabling the W2E team to engage with primary school teachers and students as part of the research process. Systems are monitored for performance (gas production, temperature, feeding regime, slurry management, financial impacts), slurry safety, and air quality impacts. Preliminary results from each of these studies is presented below. Understanding and quantifying the performance of existing systems is an essential step in the process of developing a robust business model for W2E's future activities.

*W2E staff Gideon Monday (right) gives a presentation on biogas to a group of eager students at Lweza Primary School. Lweza has a biogas system and has enrolled in the ongoing research study*

- **FERTILIZER PERFORMANCE: Bioslurry outperforms conventional fertilizer**

In collaboration with Makerere University and the University of Wisconsin-Madison, W2E has harvested maize from its first set of 24 test plots at the company property in Mpigi, Uganda. The first growing season explored various rates of bioslurry application and compared yields to those of crops grown using conventional N-P-K fertilizer. On average, the addition of bioslurry to maize increased the grain harvest to around 5500 kg/ha, a 3700 kg/ha increase over the control treatment (no fertilizer) which produced only 1800 kg/ha. It is important to note that the vast majority of smallholders in Uganda do not use fertilizer. Thus, our first growing season results suggest that if farmers start

using our bioslurry, they can increase yields by threefold! All bioslurry application rates performed equally as well as the national recommended N-P-K application guidelines for conventional fertilizer. In fact, several of the bioslurry application rates outperformed conventional fertilizer, with yields increased by as much as 2500 kg/ha when compared to fields fertilized with conventional N-P-K.

The team is currently working with faculty members from Makerere and UW-Madison to verify these results, which will become part of a peer-reviewed publication after the end of three growing seasons. The team has now begun planting for the second growing season. In addition to repeating the experiments described above, 24 new test plots will be added during the Aug-Dec growing season, which will assess the efficacy of new formulations of the bioslurry product, including separated and composted solids.

- **FERTILIZER SAFETY: Microbiology analysis reveals both success and concerns**

W2E continues to monitor its slurry as well as the slurry from eight other biogas systems around Kampala in order to assess the safety of the product. The team is using internationally accepted wastewater analysis protocols to screen slurry products for the indicator species (fecal coliform and *E. coli*) as well an array of common enteropathogens. Slurry was also screened for heavy metals. After several months of negative tests, it was determined that contamination with heavy metals is not of concern. Preliminary results have not revealed the presence of pathogens in the slurry. In addition, the process of anaerobic digestion appears to generally reduce indicator species prevalence by approximately 2 log (99.9% reduction). It is important to note that this reduction is in some cases sufficient to meet some of the requirements for US-EPA biosolids Class B standards (please note that we are not able to completely verify compliance with the full range of tests required in the USA for Class B biosolids status, because of limited lab capacities in Uganda). In the United States, Class B biosolids are deemed safe to apply to certain food crops under certain circumstances. However, none of the slurry products we have tested would comply with the more stringent Class A biosolids standards. Class A biosolids in the USA enjoy unrestricted use; they can be applied to any food crop at any time in the growing season. The Ugandan government does not have equivalent standards for fertilizer safety, which is why the W2E team is using the EPA standard as a benchmark. The concentration of indicator species in the slurry suggests very large seasonal and locational variation. In other words, the preliminary data do not seem to indicate that anaerobic digestion is a uniformly efficient process for waste processing. At this time, we do not have enough information to state with confidence whether or not our fertilizer product conforms to international safety standards. We can state with confidence that our fertilizer is definitely safer to handle than raw wastes. This study is ongoing. As additional samples are processed over the next eight months, we hope to have a clearer picture of the potential risks and benefits of this technology.

- **FERTILIZER PRODUCT DEVELOPMENT: Solid-liquid separation offers benefits**

One way that we hope to further reduce the presence of indicator organisms and pathogens in our fertilizer product is by focusing on UV treatment by separating the solid and liquid portions of the bioslurry. Our team has piloted a new, low-cost, solid-liquid separation system that will also help reduce the demand for freshwater additions to our system. We know from experience that freshwater requirements are often the reason that previous biogas systems in the region have failed. In the next growing season, we plan to test our new batch of solids for both their impact on yields as well as for safety indicators.

*The new low-cost solid-liquid separation system enables the team to retain a solid fertilizer product while re-using wastewater from the system.*

- **AIR QUALITY RESEARCH: Co-benefits of technology are quantified**

W2E has launched a new air quality research project that seeks to quantify how the introduction of biogas into institutional kitchens impacts fine particulate matter and sulfur dioxide emissions. In 2012, indoor air pollution was responsible for the deaths of over 7 million people worldwide—more than died from malaria! Biogas has great potential to mitigate this risk by introducing a cleaner burning source of renewable energy to kitchens around the globe. We are in the process of quantifying the improvements to air quality that are realized after the installation of a biogas system. This study was launched in late August and preliminary data are not yet available.

*Local kitchens using firewood (left) and biogas (right). The air quality study quantifies the obvious improvements to particulate matter emissions in response to biogas use.*

1 March 2015
Aleia McCord, Sarah Stefanos, and Vianney Tumwesige

AID-OAA-F-13-00056-W2E
"Sustainable Alchemy: Transforming Africa's Waste Problem into Energy and Fertilizer Opportunities"

**FINAL MILESTONES REPORT, ENVIRONMENTAL MITIGATION AND MONITORING REPORT, and FINAL EVALUATION AND SCALING REPORT**

## FINAL MILESTONES REPORT

| Project Indicators | Outcomes (Sep 2014- end of Feb 2015) |
|---|---|
| Number of tons of organic waste collected | • **20 tons**<br>• One (1) ton per week for the past 20 weeks<br>• Waste sources:<br>  o 8 tons: Mpigi market vendors' waste<br>  o 12 tons: Kalerwe market, Nsooba Slaughterhouse waste |
| Number of women entrepreneurs recruited | • **0 women farmers recruited**<br>• Recruitment cannot occur because the fertilizer product is still being fully tested for efficacy, consistency, and safety. The fertilizer product is also currently unsuitable for sales via a distribution network because of costs and difficulties associated with its transport<br>• **1 recent female university graduate in Microbiology/Parasitology trained on microscopy techniques** |
| Cubic meters of biogas generated | **900 m3** |
| Kg of fertilizer produced | **60,000 liters (kgs)** |
| Percent increase of maize yields | • **When compared to control treatments (no fertilizer), bioslurry application at a rate of 37.6 kg available N/ha increased yields by 108% in growing season one and 76% in growing season two.**<br>• **When compared to conventional application of N-P-K chemical fertilizer, bioslurry application increased yields by 19% in growing season 1 and 6% in** |

| | |
|---|---|
| | **growing season 2. Thus, bioslurry *outperformed* conventional chemical fertilizer.** |
| Nutrient content of W2E fertilizer | **2.3 g N/l** |

**KEY ACTIVITIES**

From September to the end of February, the team engaged in the following key activities:

- **TRAINING & EDUCATION: New training on parasite detection for talented female recent university graduates**
  All of the W2E employees are continuing to do excellent work in air quality monitoring, microbiology, applied chemistry, interview methodology, and agronomy. Whether they are working at the National Water and Sewerage Corporations' laboratory, the Agricultural Department's laboratory at Makerere University, or in the field, the employees are troubleshooting problems and finding ways to consistently generate high quality data. We recently decided to train some of our microbiology employees on the internationally-accepted standard of parasite detection in fecal samples. This parasite detection technique is a natural complement to the microbiology work that helps us identify *E. coli* and fecal coliforms. Our goal with the flotation parasitology technique is to determine whether biogas systems are effective in reducing and/or eliminating the parasite load of the inputs to the system (human feces, manure, or cow). We hired a talented female veterinary technician, Barbra Alapo, to conduct the training and introduce our mostly female staff to the basics of microscopy. We also invited a recent Makerere University graduate from the Veterinary school, Ritah Esmie, to receive training on fecal flotations and parasite identification with a microscope.

Training on parasite egg identification in fertilizer at the National Water and Sewerage Corporation's laboratory. **Left**: Ritah Esmie, recent Makerere University Microbiology/Parasitology graduate. **Foreground:** Trainer and parasitology expert, Barbra Alapo. **Background**: W2E team member Miriam Kawala.

- **FERTILIZER PERFORMANCE: Second growing season – replicating the first season's successes**

  In collaboration with agronomy experts at Makerere University and the University of Wisconsin-Madison, W2E initiated the second set of 24 field plots to test the efficacy of its bioslurry fertilizer. Field tests are designed to (1) identify the appropriate application rates for the fertilizer product, (2) compare our natural slurry to conventional chemical fertilizer, and (3) assess the impacts of bioslurry on soil quality (soil moisture, pH, total solids) and plant health (pest resistance, yields). These rigorous tests will yield data that can be published in a top-tier peer-reviewed journal should the grant be extended until the end of 2015 (so that data from a third growing season can be collected). Planting occurred in November 2014 and harvest occurred in mid to late February 2015. Delays in rains and drought conditions proved to have negative effects on the second growing season, with overall yields that were lower than last season's. Nonetheless, like the previous season, we found that plots which received the equivalent of 37.6 kg of available N/hectare of bioslurry outperformed all other plots, including plots that received traditional NPK synthetic fertilizer.

This is significant and surprising for two reasons. One, this level of slurry fertilizer application represents a lower nitrogen content than is typically recommended for nitrogen fertilizer application (50 kg of available N/hectare) in Uganda and in many developing countries. The plots that received relatively small amounts of bioslurry, even outperformed plots that received far more bioslurry, suggesting that nitrogen uptake from bioslurry in maize may be more efficient than previously realized, to the extent that plots which receive higher concentrations of bioslurry performed slightly poorer than plots which received this lower concentration of bioslurry. Two, in the second growing season, the difference in maize grain yields between plots that received 37.6 kg of available N/hectare of bioslurry and plots that received synthetic NPK was statistically significant. This is surprising because even though plots that received bioslurry consistently outperformed bioslurry, confirming anecdotal evidence, we have not found any studies to date that report a statistically significant difference in performance.

W2E team members make holes for planting maize seeds during the second growing season. **From left to right**: Josephat Musinguzi, John Nsengiyunva, Sarah Stefanos, and Doreen Nampamya.

- **REDUCING WATER DEMANDS OF BIOGAS SYSTEMS**:
  One way that we hope to further reduce the presence of indicator organisms and pathogens in our fertilizer product is by focusing on separating the solid and liquid portions of the bioslurry fertilizer. Our team has piloted a new, low-cost, slurry separation technology that will also help reduce the demand for freshwater additions to our system. This is in direct response to conversations with local women smallholder farmers and urban biogas system owners who have visited the W2E site and seen the biogas system; they have told us that a major problem is that these biogas systems require an abundance of water. Every kilogram of manure must be

mixed with a kilogram of water in order for the current systems to function properly. These water demands are overwhelming for two reasons:

(1) Even in a tropical climate like Kampala, access to clean water is limited. Urban biogas system owners are either paying for piped water or investing in rain catchment systems. Either way, these end-users are loathe to waste this precious resource by mixing it with manure. Not only is mixing freshwater with manure expensive, but it is politically unpalatable in a country where 27% of residents living in urban areas lack access to safe water.[1]

(2) Correspondingly, the high volume of liquid inputs results in unmanageable volumes of liquid outputs (bisoslurry). Biogas system owners who had been sold on a vision of improved sanitation find themselves instead saddled with giant, uncovered slurry pits. Although these digested wastes are safer to handle and less odorous than raw manure, they still present a burden. Because the slurry fertilizer is liquid, it cannot be stored, packaged, or transported effectively. Even institutions that had hoped to use their slurry on-site in urban gardens find themselves overwhelmed with the volume of liquid; frequent use results in oversaturated soils and crops that fail to grow.

As a result of these two limitations, many institutions have either abandoned their biogas systems or started dumping their slurry into open city sewers. **Rather than enabling green energy production and boosting urban agriculture while improving public sanitation as promised, urban biogas systems are dumping valuable nutrients into local waterways, contributing directly to eutrophication of the Lake Victoria watershed.**

In August last year, we began piloting the first prototype of our Slurry Separation Technology kit at our W2E field site. Our goal is to enable biogas system end-users to extract the valuable, nutrient-rich solid fertilizer from their slurry while recirculating the liquid portion of the slurry back into the biogas system. This technology improves slurry storage and handling by extracting solids, while virtually eliminating the need for additional water inputs into the system. Our technology is designed to fit into a biogas system's mixing tank, separating the solids immediately. The liquid effluent is then re-circulated using a low-cost hand-pump. This innovation still allows a biogas system user to use the liquid effluent to irrigate urban gardens during dry periods, but it eliminates the need for application of large volumes of liquid fertilizer to already flooded fields during wet seasons.

In this last quarter, we have introduced the Slurry-Separation Technology at the biogas system that we built at Lweza Primary School. Presently, the Slurry Separation Technology kit contains four components (a) 1 $m^2$ of dewatering fabric, (b) a manual bilge pump, inclusive of 20 meters of tubing, (c) an interlocking plastic

frame to hold the dewatering fabric, and (d) A simple, picture-based instruction manual appropriate for all biogas system users, regardless of literacy.

Piloting the technology at Lweza Primary School and at the W2E site is enabling us to understand the strengths and limitations of the product. One of our primary goals with the product is to generate separated fertilizer solids that can be easily stored, packaged, and transported, creating new opportunities for potential revenue. Most importantly, our technology is designed to protect the limited freshwater supplies by reducing the demand for freshwater in the system. To date, we are trying to devise a method of improving the dryness of the separated fertilizer solids once they have been removed from the liquid portion of the slurry.

- **ASSESSING BIOGAS SYSTEM PERFORMANCE**:
  One unanswered questions about small-scale biogas systems is how well they are performing without heating systems or insulation. Biogas systems need to operate within thermophilic (50-60 degree Celsius) or mesophilic (30-40 degrees Celsius) temperature ranges for optimal biogas production. Most small-scale biogas systems in tropical regions (like central Uganda) are assumed to be operating within the mesophilic range due to normal, warm climate conditions. However, these assumptions about the temperature at which these systems operate are rarely validated. In December, we conducted a month-long activity in to assess the internal temperatures of 7 small-scale urban, micro-scale biogas systems in Kampala (using LogTag thermometers that were placed in the expansion chambers of the systems). We found that temperature fluctuations between day and night in the system were rather small (a couple of degrees) and that generally, there were few significant temperature fluctuations.

  The temperatures *between* systems were also fairly consistent – all the systems averaged a monthly temperature between 25 and 28 degrees Celsius. This is an important finding, suggesting that systems need a slight increase of heat to perform within a more optimal mesophilic range. We are going to continue collecting data on these systems' internal temperatures and these data will help us determine if there are any simple, cost-effective heating modifications that could help these systems increase their gas yields.

## ENVIRONMENTAL MITIGATION AND MONITORING REPORT

1. Field and laboratory testing was done to test fertilizer samples for human health safety. These analyses included biological safety testing (fecal coliform and *E. Coli*), heavy metals testing (cadmium, lead, etc.) and nutrient analyses (total N, P, K). The fertilizer was regularly screened to ensure that it conforms to the highest international standards of safety. Anaerobic digestion of organic wastes in a biogas system significantly decreased the prevalence of fecal coliform and *E. Coli*,

by as much as 99.4-99.6%. Field tests were conducted by agronomy experts after it was confirmed that product was safe to handle with gloves, gums and other proper safety gear. No fertilizer product was released to rural farmers as safety testing is still ongoing.

2. Results of the periodic tests can be found attached in the raw datasets.
3. Safe handling and transportation of animal and organic wastes was undertaken. Workers were provided with protective clothing such as gloves, gum boots, coveralls and masks. Workers were also trained on the safe handling of organic and organic waste.

## FINAL EVALUATION AND SCALING REPORT

**Project Improvement:**

<u>Success to Date</u>

To date, this project has been very successful and we are very proud of what the W2E team has accomplished. Over the tenure of its USAID-DIV grant, the W2E team has:

- Built a biogas system at the company site in Mpigi, producing thousands of liters of fertilizer and hundreds of meters of biogas.
- Built a second biogas system at Lweza Primary School (in Mukono). This was one of the first biogas systems in the country to be built at a poorer public school in a farming area – and it has also produced thousands of liters of fertilizer and hundreds of meters of gas.
- Provided training in entrepreneurship, microbiology, parasitology, air quality monitoring, agronomy, chemistry, and engineering to a dynamic, 8 member, majority female team of recent Ugandan college graduates.
- Worked closely with the local smallholder farmer community for 9 months in ensuring the sustainability of the Lweza Primary School system in Mukono.
- Worked with the local market and government in Mpigi district to separate organic from inorganic wastes, and relieved the market of more than 50 tons of organic waste by transforming it into energy and fertilizer at our site.
- Provided extensive trainings on biogas system basics and management to hundreds of schoolchildren.
- Held a conference at Makerere University for more than 50 different stakeholders from around Uganda working in the biogas system sector.
- Conducted two full field seasons of bioslurry fertilizer testing at the company site in Mpigi.
- Performed regular testing of bioslurry fertilizer from 7-8 sites for fecal coliforms and *E. coli*.
- Rigorously tested small particular matter (PM) – air quality – in institutions with and without biogas systems.

- Conducted nutrient analyses of bioslurry fertilizer from 7-8 institutions in Uganda.
- Tested how biogas might be used to run a small-scale generator to produce electricity and potentially power batteries.
- Conducted interviews in Mpigi market to assess vendors' and customers' interest in a portable biogas-powered battery pack for home use.
- Developed a prototype a Slurry Separation Technology (SST) for fertilizer for the small-scale biogas market.

Exceeding Expectations

For this grant, we were expected to provide data from two growing seasons on the maize yield improvements associated with bioslurry fertilizer application. We have far exceeded this expectation. Not only have we assessed maize grain yield improvements, but we have also measured stover yields, soil pH, and changes in nitrogen (N), phosphorous (P), and potassium (K) in our soils at mid-maturity and final maturity during the growing season.

A second expectation was to assess the nutrient value of W2E fertilizer. We have conducted these nutrient analyses consistently not only for our own site, but also for an *additional 6-7 sites*. Whenever possible, we have also tested for heavy metals and trace elements in the bioslurry from all the sites.

The data that we have gathered from the two field seasons have been extensive. However, we were unaware before the start of the grant that the standard in the agronomic sciences for reporting results is a minimum of **three** field seasons of data. As such, to meet scientific standards, we would need to do one more field season of work before publishing any recommendations and results for a bioslurry manual or in a peer-reviewed journal.

As we have already collected data for two field seasons, it would be a shame not to collect data for a third growing season in order to produce **publishable** results. Beyond the **final disbursement ($11,043.30), we do not need any further funding to do another field season of fertilizer testing. As such, we kindly request a no-cost extension from USAID-DIV until 31 December 2015.** This would enable the team to publish the full results of data collected under USAID-DIV purview. It would also enable a richer dataset for publication of results of our fertilizer safety (microbiology) and air quality (biogas system) studies.

Unforeseen Circumstances

We have met all the expectations of this project and far exceeded many of them, but we have taken longer than anticipated due to factors beyond our control. For one, our lab analyses at the National Water and Sewerage Corporation and at Makerere University have been hampered by frequent power outages. We tried many different ways of remedying this problem, including offering to pay the fuel for a generator but the

infrastructure problems are more systemic than simple lack of fuel. Our team has worked around this problem to the greatest extent possible, changing their schedules to work during off-peak hours (nights and weekends) even, in order to produce the best results possible. However, it means that our data cannot be processed as quickly as we would like.

Another problem that we have encountered is climate change and its deleterious effects on crop yields and on being able to properly plan for a growing season. Between November 2014 and February 2015, there were drought conditions in central Uganda. This meant that planting was delayed for the second growing season with our fertilizer and that harvest was also delayed. It also meant that there were overall reductions in yield; we estimate that drought conditions lowered our yields by about 30% in comparison to those from the first growing season. Plots with bioslurry still far outperformed the control and even plots that received synthetic NPK fertilizer, but the yields were "only" twice as high, not thrice as high. The climate conditions and the delays they caused have also meant that our final soils analyses from the second growing season are still underway.

Our original goal of having a centralized bisoslurry-fertilizer production facility at our site and empowering a network of women entrepreneurs turned out to be unfeasible. However, we learned something very important through this discovery: for bioslurry fertilizer to reach smallholder farmers in Uganda and throughout the world, a distribution sales team is not what is required. Rather, **distributed production** of fertilizer is what is required for natural, organic fertilizer like bisoslurry to reach smallholders. This comports with an overall trend in the energy sector, especially in the developing world, for distributed renewable energy production and management (through, for example, microgrids and on-site electricity generation).

<u>R&D Results: Critical information for the biogas sector in East Africa</u>

Our team was able to conduct a rigorous analysis of the safety and efficacy of bioslurry, generating critical data that was heretofore missing from the sector. Specifically, we:

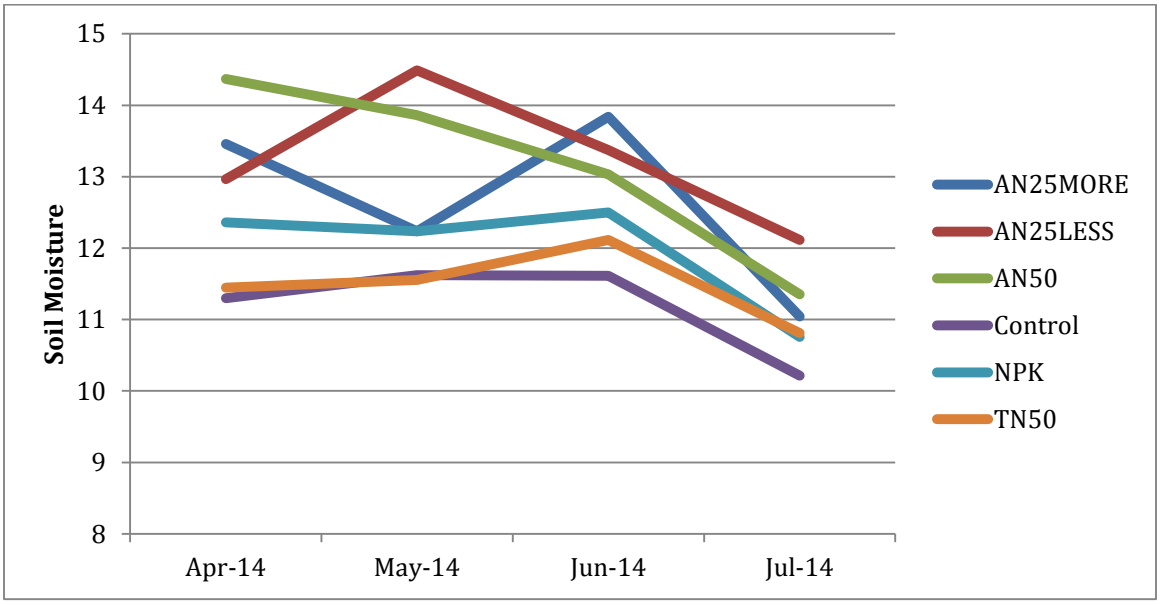
(1) Screened biogas system inputs (manure) and outputs (slurry) at eight institutional biogas systems in Uganda for indicator organisms and common waterborne enteric pathogens to assess the pathogen destruction efficiency of these systems,
(2) Developed agronomic application rate recommendations for slurry based on two growing seasons of agricultural test-plot data in Uganda using local slurry and local varieties of maize (a USAID Feed-the-Future food security crop),
(3) Monitored gas production, system performance, and system maintenance regimes, and conducted in-depth interviews with managers at eight institutional biogas systems around Kampala,

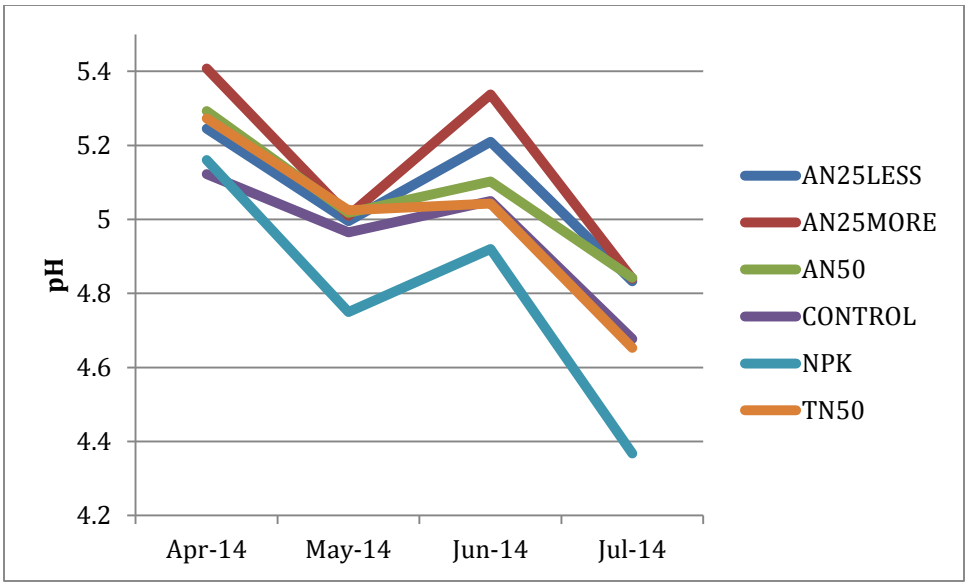
Prior to our work, actors in the biogas sector have been making decisions based on unsubstantiated theoretical claims about the development impacts of this technology.

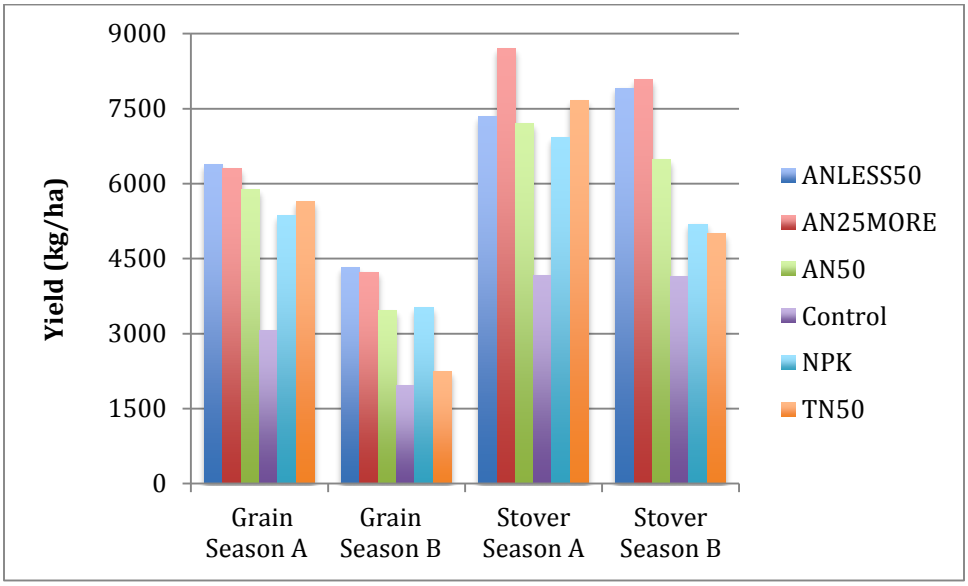
Our research has quantified the actual impacts of micro-scale anaerobic digestion, thereby enabling the industry to have the robust and reliable that is required to make informed business and policy decisions. With the assistance of public sector partners at Makerere University and the University of Wisconsin-Madison, our team will be publishing the results of these studies in peer-reviewed journals over the coming months and years. In brief, the preliminary results of these studies are as follows:

(1) **Pathogen destruction.** We surveyed inputs and outputs at eight institutional biogas systems. Anaerobic digestion significantly decreased the prevalence of indicator organisms (fecal coliform and *E. coli)* at all sites. However, the degree of pathogen destruction varied within and among systems. High performing systems consistently removed 99.4-99.6% of indicator organisms (3log+ reductions) as measured by the MPN/g (most probable number of bacteria per gram of solids) in inputs and outputs. Other systems performed less reliably, only removing 40-50% of indicator species (<1 log reduction). Indicator species removal is reported as both log reduction and percent reduction, as per industry standards. A higher log reduction corresponds with a higher percentage of indicator species killed. Effluent with less than 1000 MPN/g of *E. coli* meets international standards (WHO/EPA) for safe handling and application to food crops. None of the systems performed to this rigorous standard, but handling with gloves and gum boots is considered appropriate and safe.

(2) **Agronomic Application Recommendations.**






When compared to control treatments (no fertilizer), bioslurry application at a rate of 37.6 kg available N/ha ("ANLESS 50" bar in the chart) increased yields by 108% in growing season one and 76% in growing season two. We also found that when compared to conventional application of N-P-K chemical fertilizer at 50 kg available N/, bioslurry application at the 37.6 kg available N/ha ("ANLESS 50" bar in the chart) increased yields by 19% in growing season 1 and 6% in growing season 2. Thus, bioslurry applied at lower levels of nitrogen *outperformed* conventional chemical fertilizer applied at higher application rates of nitrogen.

<u>Lessons Learned and Action Steps</u>

We have learned an enormous amount during the course of this grant and are continuing to learn more. Over the course of two growing seasons, we have learned that

plots that receive bioslurry fertilizer almost always have higher maize grain yields than plots that receive synthetic NPK fertilizer. Out of all plots over two growing seasons, we only saw one instance when bioslurry application resulted in lower yields than NPK application – during drought conditions and when bioslurry plots received 20 kg of available N/ha versus NPK plots received 50 kg of available N/ha. We have also learned that bioslurry fertilizer is far safer than application of raw manure to fields, but reductions in pathogen loads are not significant enough to deem bioslurry completely safe for raw handling. As such, we are beginning to experiment with composting bioslurry for 4-12 weeks, which results in pathogen reductions high enough to meet international Class A biosolids standards of safety. We have also learned that using biogas in kitchens is far safer than using firewood, and even using a mixture of biogas and firewood in the kitchen is appreciably better than just cooking with firewood. We have also learned through our experiences with 7-8 institutions with biogas systems in Uganda that there is an extensive and intensive need for better training for biogas system end-users. It is only with this better training with end-users that biogas technology will become a truly *sustainable* renewable energy option

Biogas systems offer wonderful opportunities for institutions, facilities, and households that can use the biogas and the bioslurry fertilizer *on-site, or within a very short distance*. As such, making biogas systems more readily accessible to *more potential users at more potential sites* is the key to making biogas and fertilizer available to Ugandan smallholder farmers, for schools that want to help reduce firewood usage and improve or start school gardens, and to any other institution where people are concentrated and need for fertilizer exists. In the section on Scaling found later in this report, you will find a proposal that offers a way forward on how we might make biogas systems a food-security, energy-security, and health-security technology that is widely available to millions of the world's poor.

**Cost effectiveness:** (Please see attached Biogas System Estimated Payback Period)

This development intervention is highly cost-effective. We estimate a cost of $0.94 per 1% percent increase in crop yields. This figure was calculated based on the following assumptions. The initial cost of an institutional size biogas system is $10,000. A biogas system of this size (appropriate for a 4 hectare farm or a school with four hectares of property) would use feedstocks that were available for free on site, i.e. crop residues, cow dung, and/or fecal material. As such, operational costs for the system would be estimated at $15/month, for the labor involved in feeding the system for about half an hour per day. We conservatively estimate that an institution or farm of this size would spend about $200/month for firewood for cooking.

In estimating the cost of a biogas system intervention, it is important to take into account both the savings associated with displacing most of the firewood usage in the kitchen and also the generation of the bioslurry fertilizer and its impacts on crop yields. We estimate that the biogas system would displace 90% of the firewood needs of the

institution, for a savings of $180/month. Thus, the effective cost of the biogas system per month would be $20 ($200-$180) + $15, for a total of $35. (These calculations do not take into account the substantial health benefits, especially for women, associated with cooking almost entirely with gas instead of with firewood.)

Based on our analyses and our data to date, we estimate an average 92% increase in crop yields per hectare per growing season (in growing seasons one and two, we found that bioslurry 108% increases in yield and 76% increases in yield, respectively, over the control). There are two growing seasons per year in central Uganda. Biogas systems of this type (underground, fixed dome) have an average lifespan of 30 years.

We find that the costs associated with the biogas system intervention are as follows:

$10,000 initial investment + ($20/month for firewood + $15/month for system labor) (12 months/year) (30 years) = $22,600 over the 30-year lifespan of the system.

To arrive at the cost of the intervention per 1 (percent) increase in crop yields:

$22,600/ ((92 (percent) average increase in crop yields per hectare per growing season) (4 hectares) (2 growing seasons/year) (30 years)) = **$1.02 per 1% increase in crop yields.**

The unit cost per 1% increase in yields simply takes into account the cost of the intervention, to generate the additional yields/maize grain weight. It does not take into account what the 1% increase in yield will generate or save for the institution, We estimate that every $1 spent on increasing crop yields by 1% will generate for an institution $5 from avoided costs of buying food (for an institution like a school or tourist lodge) or the profit from selling the additional food (for a farm). **As such, a $1 investment in a biogas system nets about $4.**

This calculation is further clarified in an attached Excel spreadsheet. It should also be noted that the same institution or farm that does <u>not</u> purchase a biogas system would spend $200/month *just* for firewood for 30 years, at a total cost of **$72,000** over 30 years *without any increase in crop yields*. Constructing a biogas system, on the other hand, would be only a **$22,600** investment over the same 30 years, and would pay itself back in only *3.07 years* from the savings associated with increased crop yields and displacement of firewood usage.

Our project has also been very cost-effective given the number of activities that we were able to complete and our ability to leverage the grant for further funding. With only slightly more than $110,000 from USAID-DIV, we have completed 14 activities. Leveraging this grant, we have also managed to secure several additional grants. Specifically, we were two awarded two grants from the Wisconsin Energy Institute totaling $100,000 to (1) test the cost-effectiveness of using biogas for electrical production, and (2) to pilot a low-cost heating system to improve gas production. In

addition, we received a $65,000 Ira & Ineva Baldwin Award to construct a pilot system at an underserved school in Mukono, Uganda. These awards enabled us to bring to Uganda an agricultural engineering professor from the University of Wisconsin-Madison, which is one of the premier agricultural universities in the world. Five senior undergraduates from this university were also able to work alongside our Ugandan team for several months.

By way of comparison, many of the testing activities above can **each** cost $30,000-$40,000. We have managed to be far more cost-effective than alternatives by leveraging some of our assets (land and a vehicle), keeping overhead expenses very low, and hiring local talent instead of external consultants. Furthermore, we have trained our staff do rigorous scientific and entrepreneurial work instead of outsourcing that labor. In so doing, we have built strong partnerships with public Ugandan institutions like Makerere University Agricultural Department, the Center for Research on Energy and Energy Conservation (CREEC), and the National Water and Sewerage Corporation, whose laboratories we have worked in extensively.

**Scaling:** (Please see attached: Projected Financial Pro Formas and Sales, Current Income Statement, and Projection of Demand)

We received no income because were unable to sell the bioslurry fertilizer because it is still being tested for efficacy, consistency and safety.

We have realized that initial our idea of using a distribution network of women entrepreneurs who sell fertilizer from a centralized biogas systems is untenable. First, we and others are still working on better understanding bioslurry's grain yield effects, soil quality effects, and safety. Bioslurry fertilizer also cannot be moved over any substantial distance because of its liquid form, which makes transport heavy, messy, and exceedingly expensive. Even though we have prototyped a Slurry Separation Technology, it is still in its early testing stages and needs further refinement before we can confidently produce dried solid fertilizer from bioslurry fertilizer.

What **is** possible, however, is making biogas systems *themselves* more accessible to the small farming communities or schools where there is a demand for fertilizer **on-site.** Our project has greatly clarified many of the gaps associated with bioslurry fertilizer, including ascertaining its nutrient content and its safety. Now the remaining missing piece is making biogas systems easier to access and procure.

*The Problem*

Significant initial capital costs remain the primary deterrent to widespread small-scale biogas system adoption throughout the developing world. A biogas system that will produce enough fertilizer (and clean-burning fuel) to supply a small farming community or school will typically cost $10,000-$15,000. For many of these communities or institutions, paying that amount of money for a biogas system upfront is impossible,

despite the fact that they will realize substantial savings in the long run for avoided fuelwood and fertilizer costs.

Many potential biogas-system users have expressed strong interest in a financing model of system procurement, whereby the system would be built after an initial down payment (40-60% of total cost) and the balance paid off in installments. One of W2E's primary partners, Green Heat Uganda Ltd, is its technology partner for building biogas systems. Vianney Tumwesige, the owner and founder, is also a co-founder of W2E. He has also been very interested in exploring a rent-to-own model of biogas systems but he also cannot afford the risk and expense of covering the entire initial capital outlay of a system for a client.

*Our Proposed Solution – Third Party Financing for Dramatic and Sustainable Scaling of Biogas Systems*

Given these limitations to growth in the small-scale biogas system sector, we at W2E have a highly innovative concept that has the potential to make small-scale biogas systems more accessible to *millions* of potential users in the developing world. W2E would like to pilot a third-party financing model for small-scale biogas systems. Under this model, W2E would partner directly with Green Heat, the local technology provider. Potential clients (for example, a school in a farming community) would be thoroughly evaluated on the suitability of a biogas system for their premises (I.e. Is there sufficient waste and water to feed the system?) and their ability to pay. The client would then make a down payment on the system (40-60% of total system cost) to W2E, which would then provide the full outlay of the system costs to Green Heat, so that Green Heat could build the system as expediently as possible. Once the biogas system has been built, the client will begin making weekly or monthly payments to W2E for a specific amount of time delineated in the contract until the system has been paid in full. (The monthly payment would be less than what the client typically spends on firewood; as this amount is frequently greater than $500, we imagine that a typical monthly payment would be $500, and the contract would last one year.)

While the client is making payments, W2E would manage the system's feeding and ensure a specific amount of gas production. Once the client has completed all of its payments and owns the system outright, it can then choose whether it prefers to manage the system on its own or continue paying W2E a weekly fee to manage it on its behalf. W2E would take a 20% fee for its services – thus, if Green Heat were to charge a client $10,000 for a system, the total system cost to the client would be $12,000. The financing model is sustainable once a few systems have been successfully paid in full, because a critical amount of capital will then have accrued which permits a revolving fund for biogas system construction.

This third-party financing model for small-scale biogas systems has potential to be a game-changing innovation in the sector. In the commercial-scale biogas system sector, third-party financing has existed for some time. We believe that the perceived risk of

lending money to less affluent customers has prevented any third-party financing models from being attempted. The success of micro-financing, however, shows that giving opportunities to the non-wealthy offers incredible opportunity for upward mobility and poverty-alleviation: people are eager to pay back loans that are helping them become more financially stable. What is needed now is start-up capital for a third-party financier.

**With a grant of $40,000 from USAID, W2E could pilot a "proof-of-concept" for a third-party financing model for small-scale biogas systems with 5 clients in Uganda in less than one year.**

*Projected Demand*
As of 2008 there were 22,409 schools in Uganda. The primary schools (13,553) alone serve an estimated 7,215,262 students. (Please see attached document – "Projected demand" – for more information. We request that USAID keep this document confidential as data collection is ongoing.)

Now, in 2015, the number of schools in Uganda has increased substantially, given that Uganda's population growth rate is the second highest in the world. Faced with increasing costs of firewood and meager crop yields on school gardens, school leaders are quickly learning about biogas and have begun demanding them for their schools. While Uganda's Ministry of Energy is commissioning biogas system installations at some of the poorest schools (10 in 2014, 10 in 2015), many schools, especially private schools, are ready to pay for at least half of the upfront costs of a biogas system. Even if only 5% of the (2008) estimated schools of 22,409 school leaders were willing and able to pay for a biogas system in installments, they would still represent a potential 1,120 clients for this third-party financing model. (We have not even included demand from other potential clients like restaurants and tourist lodges.)

We have already preliminarily identified many potential biogas system users (private schools) that are also financially stable and have expressed very strong interest in paying for a biogas system in installments. Construction of systems for 5 private school clients by Green Heat would be completed by the end of September, thereby giving us three months of data on rates of repayment, from October to the end of December 2015.

*Projected financial pro formas, sales and cost effectiveness*
Receiving a grant of $40,000 from USAID-DIV this year would enable us to be incredibly cost-effective, as about three-quarters (an estimated $30,000) of the grant would be used directly for biogas system construction. The remainder would be used for marketing, writing and securing contracts with a lawyer, staff training, including training on monitoring and evaluation of the model, and minor additional expenses. As a direct cost-share, we are leveraging W2E resources that can support overhead and staff-salaries until the end of 2015, enabling us to make enormous strides in testing this

potentially revolutionary model for making natural fertilizer and clean-burning fuel available to those who would normally be excluded from their benefits.

The attached Excel spreadsheets Financial Pro Formas and Sales contain budgets, cash flow statements, profit and loss statements, and balance sheets for both Green Heat and W2E for this third-party financing model.

For each biogas system installation, the client would pay Green Heat, upfront, $6,000. This would represent half of the total amount ($12,000) that the client would have to pay. W2E would then pay Green Heat, upfront, $4,000 for each system. This enables Green Heat to immediately receive what it would normally sell the system for - $10,000 – and construct the clients' systems expeditiously. Meanwhile, the client would pay its balance - $6,000- directly to W2E in installments, which would enable W2E to realize a $2,000 profit per system.

If W2E were to receive the $40,000 grant this year, 2015, it would enable it to fund Green Heat to build 5 biogas systems while generating a projected profit (for W2E) of $26,500 by the end of the year. Then, if W2E received $200,000 in grant funding in 2016 to take the model to scale, the company would realize end-of-year profits of $275,600, based on financing of 30 biogas systems. By 2017, the model becomes self-sustaining, as W2E take $240,000 of its 2016 end-of-year profits to fund another 60 biogas system installations. From there, the revolving fund for biogas system financing would only continue to grow.

Green Heat would also have a more financially sustainable model for system installation through this partnership with W2E. Starting in 2016, Green Heat would pay 80% of the salary of a new Sales/Marketing Director (with W2E funding the remainder). By 2017, Green Heat would pay 90% of this director's salary. Green Heat would also share the costs with W2E for a Biogas System Manager who would be responsible for system management at the clients' sites while the client is still making payments on the system. The spreadsheet for Green Heat outlines all the financials associated with just the biogas systems associated with this third-party financing model. As such, Green Heat's projected profits - $9,500 in 2015, $43,300 in 2016, and $137,490 in 2017 – would represent a *supplement* to the company's normal profits.

*Risk mitigation*

Naturally, there are some risks associated with this model – namely, clients' defaulting on payments – but we will have several measures in place to mitigate such risk. As mentioned earlier, potential clients will be vigorously screened for financial solvency and ability to pay. All clients would also be required to have two at least two guarantors and all would be held liable for the weekly payments on the system. If, for example, the client defaulted on the payments for the biogas system, the guarantors would be liable for the debt.

**Data:** (Please find attached Maize and Stover Yield Data, Bioslurry Fertilizer Nutrient Analyses, Soil Nutrient Analyses, Soil pH and Moisture Data, and Microbiology Analyses).

**Conclusion:**

We at W2E are extraordinarily grateful for the opportunity to have worked with USAID-DIV on this grant. We have received excellent support and have been greatly encouraged by field visits by DIV representatives. We hope to continue working with you until the end of this year and look forward to more opportunities to work with you in the future. Please do not hesitate to contact us for any further information or clarification.